

ALPOLIC™

Technical Manual

 MITSUBISHI CHEMICAL

www.alpolic.com

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ALPOLIC™

Technical Manual

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The determination of suitability for use, design, fabrication, installation, and interface with other products of the ALPOLIC materials is the sole responsibility of the purchaser. The information contained on this Technical Manual is for conceptual use only. Mitsubishi Chemical Corporation shall have no responsibility or liability for the products usage or infringement of any patent or other proprietary right.

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Section 1 Outline

ALPOLIC™ is an Aluminum Composite Material (ACM) for the construction industry worldwide. It is not only a reasonable alternative to solid aluminum sheet, but also an individual material characterized by its own unique features. Its lightweight, high rigidity, excellent flatness and long lasting coating qualities are just what the construction industry has been looking for.

ALPOLIC™/fr is a fire-retardant ACM which has an improved core, and meets the fire-safety requirements for external claddings in several countries. ALPOLIC™/fr is an external and internal cladding and a roof covering material of choice, ensuring fire safety without losing the original features of ALPOLIC™.

ALPOLIC™ A2 is a high fire-retardant ACM which has high mineral filled core, and meets the fire-safety requirements for external and internal claddings and roof covering in new buildings and retrofit applications.

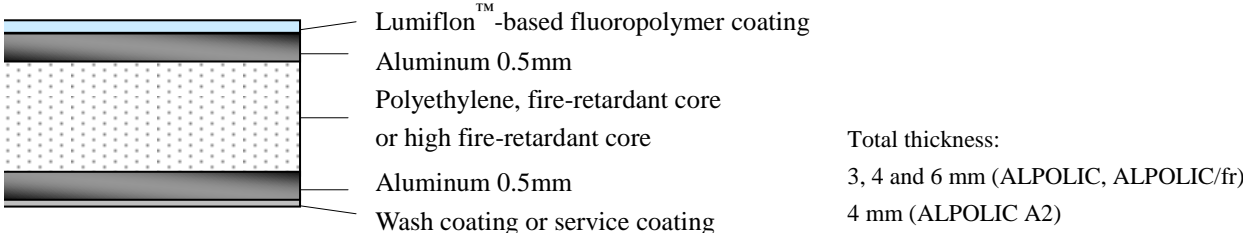
ALPOLIC™, ALPOLIC™/fr and ALPOLIC™ A2 are often simply referred to as “ALPOLICs” or “ALPOLIC products” in this brochure, if the context is applicable to both products. We will use the respective ALPOLIC, ALPOLIC/fr or ALPOLIC A2, if we need to mention each of them separately.

1. Material composition

ALPOLIC is composed of thermoplastic core of low-density polyethylene sandwiched between two skins of 0.5 mm thick aluminum. ALPOLIC/fr is composed of a fire-retardant core with a small amount of low-density polyethylene sandwiched between two skins of 0.5 mm thick aluminum. ALPOLIC A2 is composed of a high mineral filled core with a small amount of low-density polyethylene sandwiched between two skins of 0.5 mm thick aluminum. The core of ALPOLIC is black and those of ALPOLIC/fr and ALPOLIC A2 are gray and white containing a mineral. Thus, we can discern each product by appearance. The total thickness is 3, 4 and 6 mm.

Topside of ALPOLICs is finished with a paint called Lumiflon™-based fluoropolymer paints as standard and backside is finished with a thin polyester coating (wash coating) or a service coating. The topside is covered with a protective film.

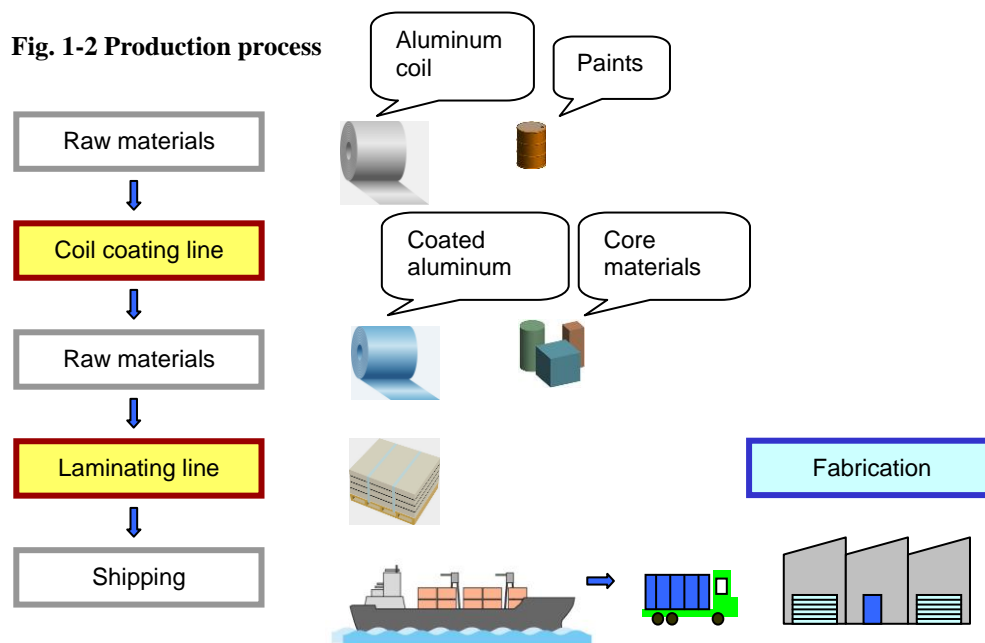
Fig. 1-1 Composition of ALPOLIC, ALPOLIC/fr and ALPOLIC A2



2. Production process

The production process of ALPOLICs consists of two production lines: a coil coating line and a laminating line. In the coil coating line, Lumiflon™-based fluoropolymer paints are applied to continuous aluminum coils. In the laminating line, the low-density polyethylene or the fire-retardant core is laminated between two coated coils, resulting in the finished composite material.

After laminating, the finished products are packed in wooden cases and shipped to customers' workshops. Thus, ALPOLIC products are shipped as flat panels and processed in local workshops according to project drawings.



3. Features

ALPOLICs have a number of unique features:

Flatness: The continuous laminating process results in excellent flatness of the panel.

Color uniformity: The coil coating process ensures complete color consistency.

Rigidity: As one of the attributes of ACM, ALPOLICs are light and strong sheet materials, reducing the weight by 6% (ALPOLIC A2) to 15% (ALPOLIC/fr) compared to solid aluminum sheets with equivalent rigidity.

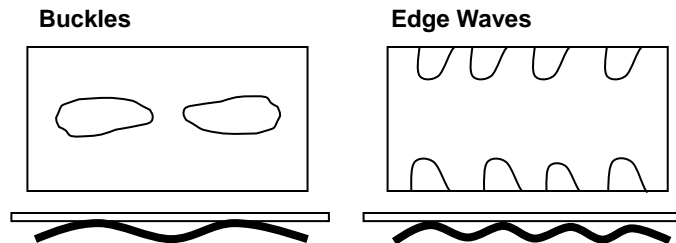
Workability: ALPOLICs are easy to cut, bend, groove and shape with regular aluminum working and woodworking machines and tools.

Fire safety: With the fire-retardant core, ALPOLIC A2 and ALPOLIC/fr meet fire code requirements in several countries including Europe, North America, Middle East and Japan without any restrictions.

(1) Flatness

ALPOLICs are very flat. Generally speaking, ensuring the flatness of sheet materials is not easily realized. Solid aluminum sheet, for example, has a slight distortion stemming from its rolling process: buckles, edge waves and overall warping are common. ALPOLICs are extremely flat due to the thinness of the aluminum sheets (0.5mm) and our lamination process in which most of such distortions are eliminated.

Fig. 1-3 Distortions often found in aluminum sheets (Excerpt from ISO standard)



(2) Rigidity

ALPOLICs are highly rigid compared to solid aluminum metal sheets. As shown in the diagram below, two sheets of aluminum skin behave like a small H-section when pressure is applied on the panel. Consisting of 2 sheets of 0.5mm thick aluminum, ALPOLICs 4mm thick deliver the rigidity equivalent to an aluminum sheet of 3.3mm thick.

Fig. 1-4 Rigidity of ACM

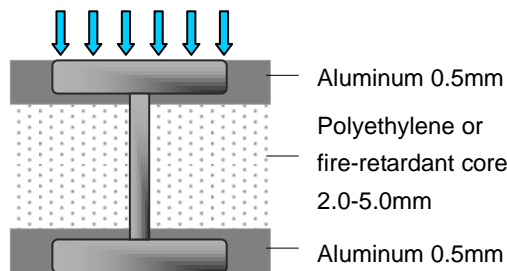


Table 1-1 Comparison of rigidity between ALPOLICs and solid aluminum sheet

Material	ALPOLICs		Solid aluminum sheet		Weight ratio Solid aluminum =100%
	Thickness mm	Weight kg/m ²	Equivalent thickness, mm	Weight kg/m ²	
ALPOLIC A2	4	8.4	3.3	8.9	94%
ALPOLIC/fr	3	6.0	2.7	7.3	82%
	4	7.6	3.3	8.9	85%
	6	10.9	4.5	12.2	89%

Note 1: How to read the above table: ALPOLIC/fr 4mm is equivalent to aluminum sheet 3.3mm in rigidity. Hence, the weight percent of ALPOLIC to solid aluminum is 85%.

Note 2: ALPOLIC A2 is heavier in weight than ALPOLIC/fr due to high mineral content in the core.

(3) Workability

The workability of ALPOLICs is one of its outstanding features. It can be cut with circular saws. It can be folded after grooving with a groove cutter or a router. It can be bent with a 3-roll bender and press brake. For joining, we can choose the most suitable method from several alternatives. For details, refer to Section 3 “Fabrication and installation.”

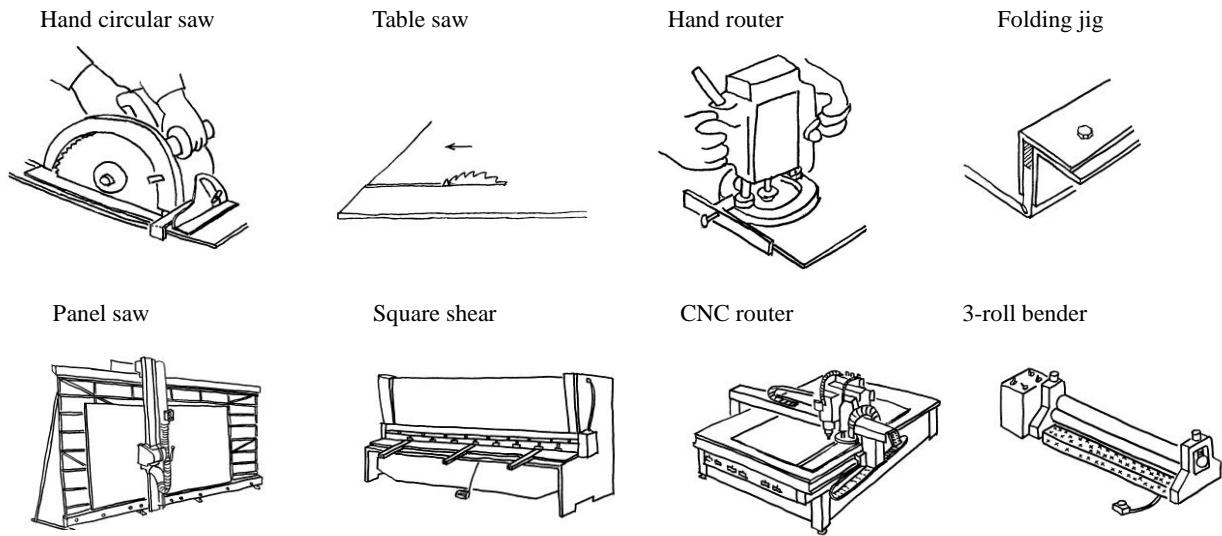


Fig. 1-5 Tools and machines used for processing ALPOLICs

(4) Fire safety

ALPOLIC A2 and ALPOLIC/fr are fire-safe materials which pass mandatory requirements for exterior and interior in several countries. Though the core material does contain a small amount of combustible polyethylene, the main ingredient of the mineral does not permit the proliferation of flame and restricts the development of smoke detrimental to evacuation activities.

ALPOLICs are composed of two aluminum skins which retard the spread of fire. Extensive fire tests have been performed on ALPOLIC/fr and ALPOLIC A2 in accordance with requirements in various countries. Refer to Section 2 “Characteristics” for details.

Example of fire test for exterior



Example of fire test for roof



Example of fire test for interior

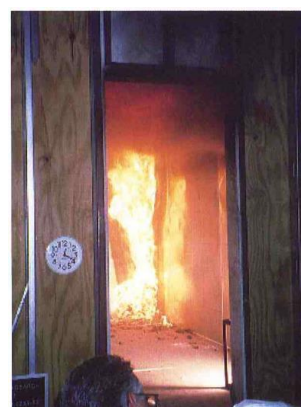


Fig. 1-6 Examples of fire tests applied to ALPOLIC/fr

4. Surface finishes

(1) Lumiflon™-based fluoropolymer coating

ALPOLICs have a coating finish of Lumiflon™-based fluoropolymer paint as standard. This paint is known for its high performance in outdoor applications.

Since long ago, polyester, acrylic and polyurethane paints have been popularly used for building industries. These conventional paints are easy to apply and less costly. But if we use these paints for outdoor applications like external claddings, the coatings will show deterioration in appearance during outdoor exposure and will require re-coating every several years.

Fluoropolymer coatings are very durable and they will last much longer time in outdoor applications without such deterioration. In fluoropolymer paints, two types of resins are commercially available: Lumiflon™ and PVDF. Among the two types of fluoropolymer paints, Lumiflon™ type is wider in color range, easier to repair, and adjustable in a wider gloss range, between 15 to 80%. The following table shows general comparison between conventional paints, PVDF paint and Lumiflon™ paint.

Note 1: Lumiflon™-based fluoropolymer coating has a coating warranty for 20 years.

Note 2: ALPOLICs are finished with Lumiflon™-based fluoropolymer paint as standard, but polyester and other coatings are also available as an option. Refer to “Appendix 2: Optional coatings” in Section 4.

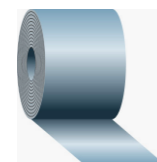
Table 1-2 General comparison between conventional paints and fluoropolymer paints

Paint type	Conventional paints (such as polyester paint)	Fluoropolymer paints	
		PVDF (Kynar)	Lumiflon™
Weatherability	3-5 years	20 years	20 years
Gloss	25 - 90 %	25 - 35 %	15 - 80 %
Color Range	Wider	Limited	Wider
Repair coating	Can be done	Difficult	Can be done
Pencil hardness	2H	F	H
Bendability	2T	1T	2T

(2) Consistent coating quality

Consistent coating quality is maintained through the continuous application of paints to the aluminum coil in the coil coating line. The “Die Coating” process that occurs on this line employs a unique technology developed by Mitsubishi Chemical that ensures a smooth, fine coating.

Coated coil



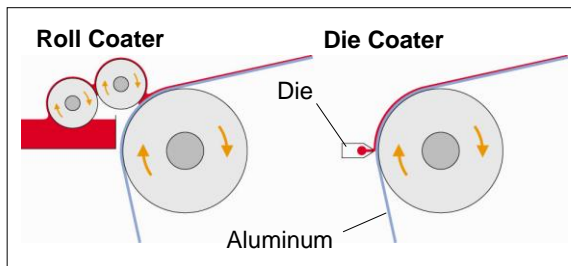


Fig. 1-7 Roll Coater and Die Coater

Roll Coaters are widely used in the aluminum industry and produce an adequate quality with reasonable efficiency. But Die Coater excels Roll Coater, permitting direct coating on aluminum surface that ensures smoother and finer finishes without grain lines.

(3) Color variation

Lumiflon™-based fluoropolymer coating has four types of colors: Solid (Enamel) Colors, Metallic Colors, Sparkling Colors, Prismatic Colors, and Patterns like Stone, Timber, Metal, and Abstract images. Refer to the Color Chart for the standard colors. All types of colors are produced in our continuous coil coating line with Lumiflon™-based fluoropolymer paints. In addition to the standard colors in the Color Chart, custom colors are available, subject to the minimum quantities and color match. Contact local distributors or our office for custom color request.

Fig. 1-8 Example of each color type



(4) Patterns (Stone, Timber, Metal, & Abstract)

Patterns were developed as an alternative to natural granites, timbers, metals, and abstract images. The patterns are produced with a unique image transfer process. The paints are applied to the aluminum coil in our coil coating line with the Lumiflon™-based fluoropolymer paint. While these finishes are highly decorative, they have the same coating performance as that of our plain color products like Solid, Metallic, Sparkling, and Prismatic Colors.

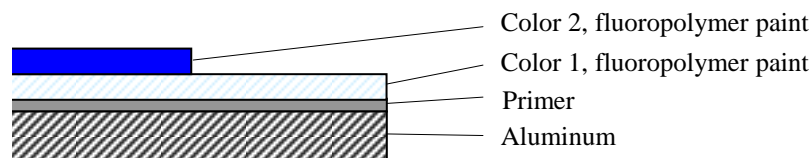
Fig. 1-9 Patterns, Pink Granite



(5) 2 to 3-color coating

2 to 3-color coating is available with ALPOLICs, in which two separate colors are coated on one panel. Clear interface between colors is accomplished in 2 to 3-color coating of ALPOLIC, stemming from Die Coating.

Fig. 1-10 Coating system of 2-Color Coating



(6) Touch-up paint

We can use Lumiflon™-based touch-up paints when we need to repair scratches during fabrication and installation. But please be aware that touched-up portions may not completely match the original finish in appearance. Especially in Metallic, Sparkling, and Prismatic Colors, even an exactly matched paint may show a slightly different appearance. In Patterns (Stone, Timber, Metal, and Abstract), we use an intermediate solid color diluted with a clear paint for touch-up. Refer to “9. Touch-up coating method” in Section 3 and “Appendix 9: Touch-up coating method” in Section 4 for details.

(7) Paint options

Apart from the above Lumiflon™-based fluoropolymer paints, we can supply ALPOLICs coated with the following distinctive paints as an option. Refer to “Appendix 2: Optional coatings” in Section 4 for details.

Table 1-3 Paint options other than Lumiflon™-based fluoropolymer paints

Coating type	Characteristics	Suitable application
Conductive fluoropolymer coating	Electrically-conductive (3×10 ⁷⁻⁸ ohms)	Interior walls and partitions in factory
PVDF-based fluoropolymer coating	Ultra-weatherability and matte finish	Outdoor (external cladding, roof)
Polyester coating	Matte finish	Interior and light outdoor applications

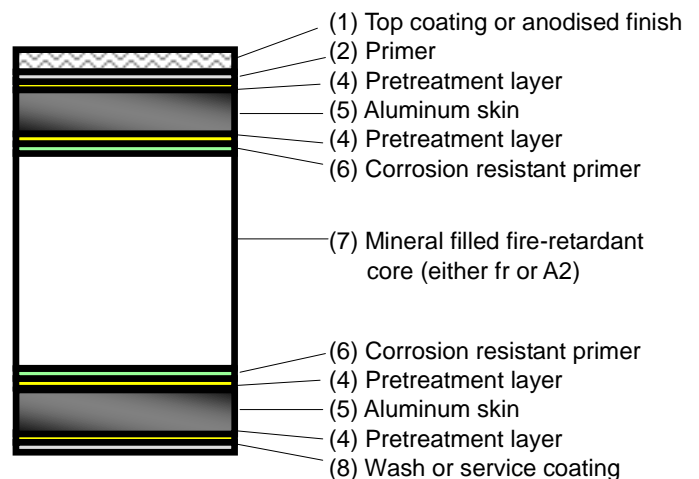
(8) Anodised finish (ALPOLIC/fr reAL anodised)

The surface is finished with an anodic oxide layer by continuous process on an aluminium coil. Continuous anodising builds and enhances the surface oxidation using an electro-chemical process under precisely controlled conditions.

5. Prevention from edge corrosion

The integrity of lamination between the aluminium skins and the core is strictly controlled to maintain the adequate value in ALPOLIC products. But, when Aluminum Composite Materials (ACMs) are used in a corrosive atmosphere, corrosion normally takes place at the cut edge and tends to penetrate inside, finally resulting in de-lamination between the aluminum skins and the core material. To protect from this type of corrosion, ALPOLICs feature a corrosion resistant primer (layer (6) in Fig. 1-11) behind aluminum skins.

Fig. 1-11 Cross-section of ALPOLICs



Although protected by the primer, to enhance long-term durability we still recommend that the cut edge is not exposed to corrosive or outdoor atmosphere. If it is likely that the cut edge will be continuously exposed to moist conditions, a suitable corrosion protection will be necessary in the panel design or the fixing detail.

6. Thermal expansion/contraction

ALPOLICs have the same linear thermal expansion coefficient as aluminum metal, so movement will not occur between aluminum accessories and ALPOLICs due to thermal expansion/contraction. But a certain amount of movement will occur with steel and concrete, because the thermal expansion of steel and concrete is smaller than that of ALPOLICs. This movement is normally very small (approx 1.0mm/m), but it should be relieved with a suitable method such as relieving with loose holes.

Table 1-4 Thermal expansion/contraction:

Material	Linear thermal expansion coefficient, /°C	Elongation or shrinkage per 1 meter per 50°C
ALPOLIC A2	19×10^{-6}	1.0 mm
ALPOLIC/fr	24×10^{-6}	1.2 mm
Aluminum	24×10^{-6}	1.2 mm
Steel	12×10^{-6}	0.6 mm
Stainless steel (304)	17×10^{-6}	0.9 mm
Concrete	12×10^{-6}	0.6 mm
Glass	9×10^{-6}	0.5 mm
Acrylic sheet	70×10^{-6}	3.5 mm

7. Perforated panel

Perforated panels of ALPOLIC/fr have a pattern of holes at regular intervals. This provides ventilation and permits vision through the panel. Refer to “Appendix 3: Perforated panel” in Section 4 for details. Note that ALPOLIC A2 is not suitable for perforated panels due to slight water permeable of the core.

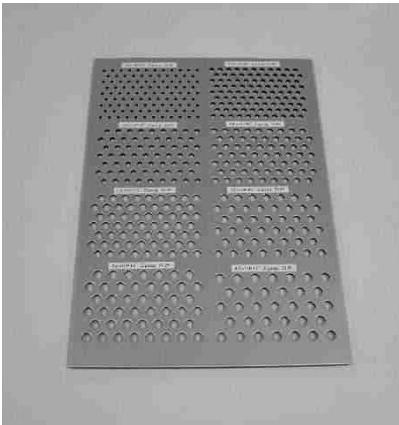


Fig. 1-12 Perforated panel and application example (A residential building)

8. Affiliated products

This technical manual pertains to ALPOLIC A2, ALPOLIC/fr and ALPOLIC mainly used for external claddings, interior surfaces and signs, but we would like to outline their affiliated products including TCM, SCM, ZCM, ALPOLIC/fr LT, AL-LEADER and ALPOLIC/fr RF. For details, refer to the respective catalogues.

(1) TCM (Titanium Composite Material)

a. General

ALPOLIC/fr TCM is composed of fire retardant core sandwiched between 0.3mm thick titanium sheet on the topside and 0.3mm thick stainless steel on the backside. Titanium metal quickly forms a stable oxide film (called “passivated film”) at room temperature and is known for its unparalleled corrosion resistance. TCM is suited to the exterior cladding and roofing of buildings located in highly corrosive environments.

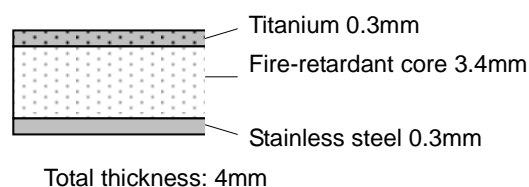
b. Product dimension

Thickness:	4 mm
Panel width:	1000 mm
Panel length:	Less than 5000 mm

c. Surface finish

Dull finish

Fig. 1-13 TCM



d. Notes on processing method

Note 1: To cope with the lower machinability of titanium and stainless steel, we have to use **special cutting and grooving methods** for TCM. We normally use a square shear or a CNC router for cutting, and a CNC router or a V-cut machine (planer) for grooving.

Note 2: Use stainless steel rivets for assembly. Aluminum rivets, if used for TCM panel assembly, may be corroded with the galvanic corrosion. Refer to the separate TCM brochure for details.

(2) SCM (Stainless Steel Composite Material)

a. General

ALPOLIC/fr SCM is composed of fire retardant core sandwiched between two sheets of 0.3mm thick stainless steel. The topside stainless steel of NSSC 220M (similar to SUS445J2, a highly rust-resistant ferric stainless steel) has outstanding rust resistance superior to that of stainless steel 316. SCM is suitable for exterior walls and roofs of buildings.

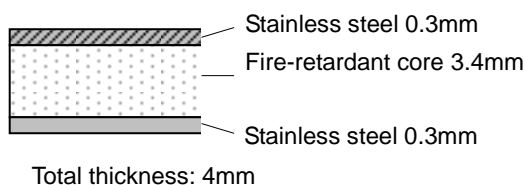
b. Product dimension

Thickness:	4 mm
Panel width:	1000 mm
Panel length:	Less than 5000 mm

c. Surface finish

Hairline finish and Dull finish

Fig. 1-14 SCM



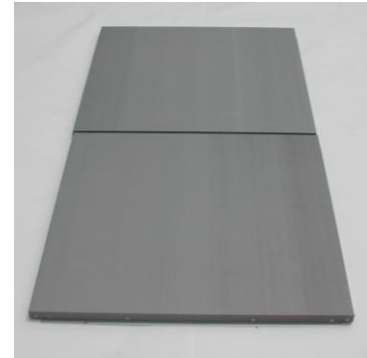
Note 1: (Other surface finishes) For other finishes, please contact local distributors or our office.

Note 2: (Processing method) For processing SCM, use the same methods as those for TCM. Use stainless steel rivets. Refer to the separate SCM brochure for details.

(3) ZCM (Zinc Composite Material)

a. General

ALPOLIC/fr ZCM is composed of fire retardant core sandwiched between a chemically-weathered zinc metal on the topside and zinc metal on the backside. The topside zinc alloy is initially weathered with a chemical conversion process, which later develops to a distinctive gray appearance through natural weathering. ZCM is suitable for use in exterior applications such as soffits, awnings, parapets, rain screens, external claddings and roofs.

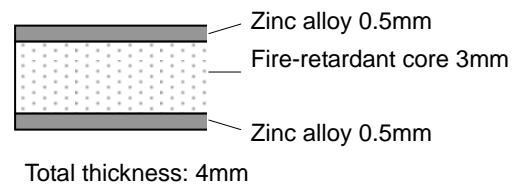


ZCM fabricated samples

b. Product dimension

Thickness: 4 mm
 Panel width: 965 mm
 Length: 3708 mm

Fig. 1-15 ZCM



c. Composition

ZCM has single grade, namely Z-Z below:

ZCM Z-Z is composed of two pieces of 0.5mm thick zinc alloy and a fire retardant core. The core has the same contents as ALPOLIC/fr.

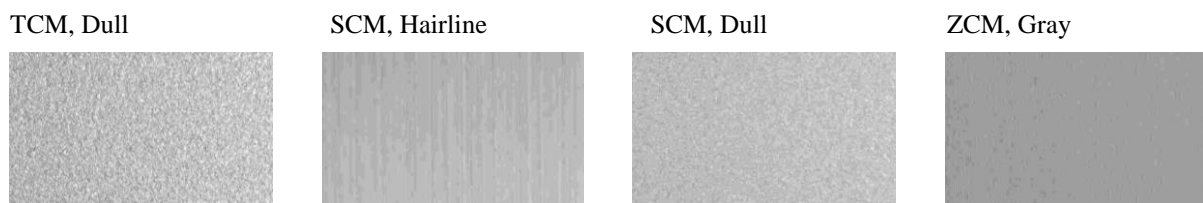
d. Surface finish

Gray formed by a chemical conversion in the production line.

e. Note on processing method

We can process ZCM with the same machines and tools that we use for ACM, because the machining performance of zinc metal is quite similar to that of aluminum metal. The working parameters are also the same, as long as the processing method is within the usual range. Please refer to the separate ZCM brochure for details.

Fig. 1-16 Surface finishes of TCM, SCM, ZCM



(4) ALPOLIC/fr LT

a. General

ALPOLIC/fr LT is the new lightweight ACM for use on interior walls, columns, ceilings and partitions in shops, offices and factories, and for such light outdoor applications as soffits, awnings, parapets and signs.

b. Composition

ALPOLIC/fr LT is composed of a fire retardant core sandwiched between two skins of 0.3mm thick aluminum. The core, indispensable for fire safety of interior applications, is gray in color, with a touch of carbon black for an aesthetically pleasing cut edge. The effective sides are finished with polyester coatings and covered with translucent protective films.

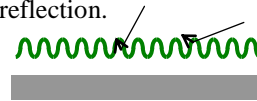
c. Product dimension

Thickness: 3 mm
Panel size: Panel size: 1220×2440 mm
(except Aluminum Hairline P: 914×2438mm)

d. Surface finishes

ALPOLIC/fr LT is available with Solid, Metallic, Stone and Timber finishes. All finishes are polyester coatings produced in our continuous coil coating line. Some of the standard colors are matte finish produced with a new coating technology in which microscopic wrinkles emerge over the entire surface during the baking stage in the coil coating line.

Fig. 1-17 Matte finish: Due to the different hardening speed between the outer and inner layers of the paint, microscopic wrinkles emerge over the entire surface. The wrinkled surface results in a matte appearance due to irregular light reflection.



Refer to the separate ALPOLIC/fr LT brochure for details.

Fig. 1-18 Examples of surface finishes of ALPOLIC/fr LT

Solid color



Metallic color



Stone



Timber



(5) AL-LEADER™

a. General

AL-LEADER is an ACM that offers a substantial reduction of weight and cost by thinner aluminum skins and the foamed plastic core. It is finished with polyester coatings and has excellent flatness. It is suitable for signboards, guide signs and other facing panels. It is actually used for a wide variety of industrial applications, too.



POP indoor sign with AL-LEADER

b. Composition

AL-LEADER is composed of a thermoplastic core of foamed polyethylene core sandwiched between two skins of approximately 0.1mm thick aluminum.

c. Product dimension

Thickness:	3 mm
Panel size:	1220×2440 mm

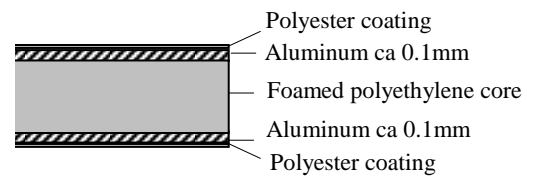
d. Surface finish

EX-White (30% gloss on one surface and 70% gloss on another surface), PC-Black, PC-Silver

All colors are coated with polyester paints in our coil coating line.

Refer to the separate AL-LEADER brochure for details.

Fig. 1-19 AL-LEADER



(6) ALPOLIC/fr RF

a. General

ALPOLIC/fr RF is a reflective-effect panel used mainly for interior ceilings. Its reflective effect enables a luminous wide interior space with lightweight and shatterproof panels. For processing, ALPOLIC/fr RF is easy to cut and drill with regular aluminum working and woodworking machines and tools. ALPOLIC/fr RF constructed of fire-retardant core completely meets fire code requirements for interiors in Japan.

Note: We cannot use ALPOLIC/fr RF in a humid atmosphere like a bathroom and those areas where dew condensation may frequently take place, or areas where cleaning never takes place.



Ceiling in a restaurant

b. Composition

The panel is an aluminum composite material (ACM) composed of two skins of aluminum and the core material. The decorative surface is an anodized mirror-look finish.

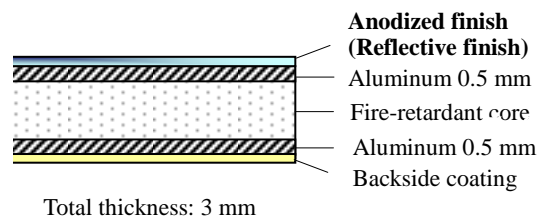


Fig.1-20 ALPOLIC/fr RF

c. Product dimension

Thickness: 3 mm
Size: 1220 × 2440 mm



Refer to the separate ALPOLIC/fr RF brochure for the details.

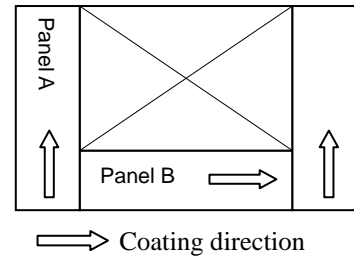
9. Recycling

ALPOLIC and its affiliated materials are virtually 100% recyclable. In our ALPOLIC production plants, we recover both aluminum (and other metals) and the core materials by means of our original recycling system. Furthermore, our ALPOLIC production plants are ISO 14001 approved, and one is designated as a country-wide industrial wastage disposal facility. Therefore, we can take back scraps from customers in Japan for recycling in our facilities under the proper operating standard.

10. General notes (Very important!)

(1) Coating direction

In Metallic Colors, Sparkling Colors, Prismatic Colors and Patterns (Stone, Timber, Metal, and Abstract), slight color differences will be noticeable if the panels are installed in different directions (like Panel A and B in the diagram). Install panels in the same direction as marked in the protective film. In our Solid Colors, any color difference due to coating direction is negligible.



(2) Protective film

The protective film on ALPOLICs consists of two polyethylene layers of white and black. Do not peel off the protective film during fabrication and installation to protect the surface from scratching and soiling. Under normal weather conditions, the protective film will withstand 6 (six)-months of outdoor exposure without losing any of its original peel-off characteristics or causing stains or other damage. However, peel off the protective film as soon as possible after completion.

(3) Gloss increase due to plasticizer

Do not stick, put or apply PVC tapes, polyurethane sealant or modified silicone sealant onto our protective film. The plasticizer contained in these materials can permeate the protective film and cause a gloss change in the coating.

Note: The above precautions pertain to ALPOLIC A2, ALPOLIC/fr and ALPOLIC. The affiliated products including TCM, SCM, ZCM, ALPOLIC/fr LT, AL-LEADER and ALPOLIC/fr RF have their respective precautions. Refer to the separate brochure of the respective products for details.

ISO 9001 Certified

The production of ALPOLICs is ISO 9001 compliant throughout the design, development, manufacture and sales.

ISO 14001:

ALPOLICs are produced in plants that have ISO14001 certificate.

Section 2 Characteristics

1. General

As mentioned in the previous section, ALPOLIC, ALPOLIC/fr and ALPOLIC A2 are Aluminum Composite Materials (ACM) composed of aluminum sheets and the polyethylene core or the fire-retardant core. We will introduce various properties of ALPOLIC/fr and ALPOLIC A2 which are mainly used for architectural applications with fire safe characteristics in this section. These properties are summarized in “Appendix 1: Summary of specification data” in Section 4, too.

ALPOLIC/fr and ALPOLIC A2 are often simply referred to as “ALPOLICs” or “ALPOLIC products” in this brochure, when the context is applicable to both products. We will use the respective ALPOLIC/fr and ALPOLIC A2, if we need to mention each of them separately.

Note

The material properties or data in this Technical Manual are portrayed as general information only and are not product specifications. Due to product changes, improvements and other factors, Mitsubishi Chemical Corporation reserves the right to change or withdraw information contained herein without prior notice.

2. Material composition

ALPOLICs are composed of aluminum skins and a core material. The material compositions of the standard products are listed in Table 2-1. This technical manual is about the standard products listed in Table 2-1.

Table 2-1 Material composition

Product	Thickness mm	Component thickness, mm			Aluminum material	Core material
		Aluminum	Core	Aluminum		
ALPOLIC A2	4	0.5	3.0	0.5	Aluminum alloy	High fire-retardant core
ALPOLIC/fr	3	0.5	2.0	0.5	3005-H14	Fire-retardant core
	4	0.5	3.0	0.5	3105-H14 or	
	6	0.5	5.0	0.5	5005-H14	

Note 1 (Total thickness): 8mm thick ALPOLICs are available as a custom-order. Please contact local distributors or our office for details.

Note 2 (Aluminum thickness): ALPOLIC/fr composed of 0.3mm thick aluminum skins is a standard product as ALPOLIC/fr LT. Refer to the ALPOLIC/fr LT brochure for details.

Note 3 (Skin material): ALPOLIC/fr composed of different metal skins is available as TCM, SCM and ZCM. Refer to the separate brochure of the respective products.

Note 4 (Foamed polyethylene core): AL-LEADER is composed of a foamed polyethylene core to further decrease the weight. Refer to the separate brochure for details.

3. Physical properties

(1) Summary

The following table is a summary of physical properties of ALPOLICs.

Table 2-2 Summary of physical properties

Physical properties	Method	Unit	ALPOLIC A2	ALPOLIC/fr		
			4mm	3mm	4mm	6mm
Specific gravity	-	-	2.10	1.99	1.90	1.81
Weight	-	kg/m ²	8.4	6.0	7.6	10.9
Thermal expansion coefficient	ASTM D696	×10 ⁻⁶ /°C	19	24	24	24
Thermal conductivity	JIS A1420 ISO 8990	W/(m·K)	0.63	0.95	0.85	0.76
Deflection temperature	ISO 75-2 ASTM D648	°C	110	115	116	109

(2) Specific gravity

The following table is the comparison of specific gravity between various materials.

Table 2-3 Specific gravity

Material	Specific gravity	Material	Specific gravity
ALPOLIC A2	2.10	Granite	2.9
ALPOLIC/fr	1.81-1.99	Glass	2.5
Aluminum sheet	2.71	Acrylic sheet	1.2
Steel sheet	7.9	Gypsum board	0.86
Stainless steel (304)	7.9	Plywood	0.7-1.0

(3) Thermal expansion/contraction

ALPOLICs have the same expansion/contraction rate as aluminum metal. The following table shows the expansion/contraction of various building materials.

Table 2-4 Thermal expansion/contraction

Material	Linear thermal expansion coefficient, 1/°C	Expansion per 1 meter with 50°C change, mm/m
ALPOLIC A2	19×10 ⁻⁶	1.0 mm
ALPOLIC/fr	24×10 ⁻⁶	1.2 mm
Aluminum	24×10 ⁻⁶	1.2 mm
Steel	12×10 ⁻⁶	0.6 mm
Stainless steel (304)	17×10 ⁻⁶	0.9 mm
Concrete	12×10 ⁻⁶	0.6 mm
Glass	9×10 ⁻⁶	0.5 mm
Acrylic sheet	70×10 ⁻⁶	3.5 mm

(4) Thermal conductivity

ALPOLICs have a lower thermal conductivity than solid metals like aluminum and steel. However, this does not fully reflect the better heat resistance of ALPOLICs, because in an actual building heat transmits not only through thermal conduction but also through thermal radiation and convection. We will discuss overall heat transmission in “5 Applied properties, (1) Heat transmission” in this section.

Table 2-5 Thermal conductivity

Material	Thermal conductivity W/(m·K)	Material	Thermal conductivity W/(m·K)
ALPOLIC A2	0.63	Concrete	1.6
ALPOLIC/fr	0.76 - 0.95	Brick	0.28
Aluminum	210	Glass	1
Steel	45	Gypsum board	0.13
Stainless steel (304)	17	Rock wool / Glass wool	0.04

(5) Deflection temperature

The deflection temperature of ALPOLICs is approx. 110°C. Therefore, ALPOLICs can resist boiling water for short time, if there is no burden on the ALPOLIC panels. However, in a situation where ALPOLICs will be actually heated, please follow the guidelines below.

If the heating duration is shorter than 30 min., allow 90°C at maximum.

If the heating duration is longer than 30 min., allow 70°C at maximum.

(6) Sound transmission loss

ALPOLICs have a large sound insulation per unit weight, compared to steel sheet, aluminum sheet and plywood. The charts show airborne sound transmission loss measured on ALPOLIC. According to the classification method specified in ASTM E413, STC (standard transmission class) is given as follows:

Table 2-6 STC of ALPOLIC/fr and ALPOLIC A2

Thickness	ALPOLIC/fr		ALPOLIC A2
	4mm	6mm	4mm
STC	27	29	27

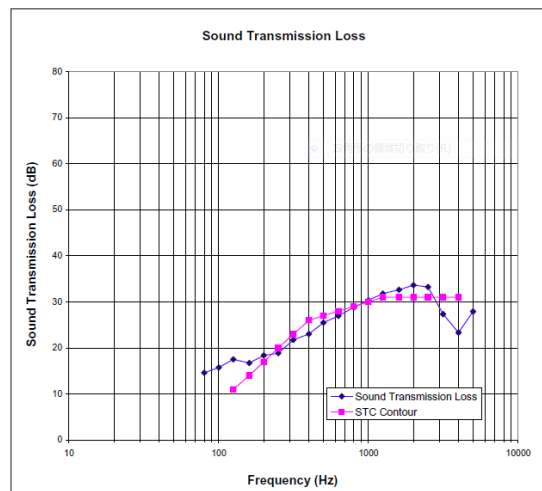


Fig. 2-1 Sound transmission loss (ALPOLIC A2)

(7) Vibration damping

ALPOLICs have a vibration damping effect that absorbs the vibration energy by converting it into thermal energy.

The chart is ALPOLIC/fr's vibration damping property in comparison with other metals. As shown in the chart, ALPOLIC/fr has a larger vibration loss than solid metals such as aluminum, steel and stainless steel.

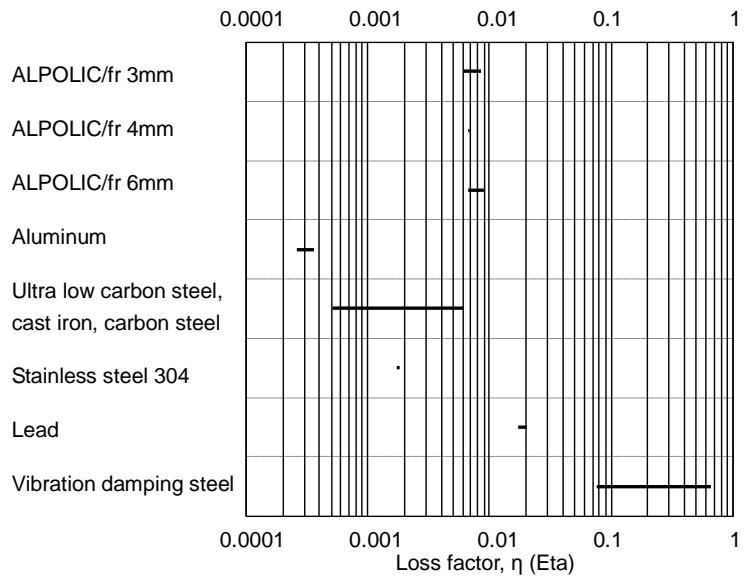


Fig. 2-2 Vibration damping property

Note 1: Test method: JIS G 0602 Test standard for

vibration-damping property on laminated damping steel sheets of constrained type

Note 2: On the chart, ALPOLIC/fr's data are the measured values, and others are cited from Nikkei Mechanical August 1986.

4. Mechanical properties

(1) Mechanical properties of ACM

ALPOLICs have the following mechanical properties as composite panels.

Table 2-7 Mechanical properties of composite panel

Mechanical property	Method	Unit	ALPOLIC A2	ALPOLIC/fr		
			4mm	3mm	4mm	6mm
Tensile strength	ASTM E8	MPa or N/mm ²	43	61	49	29
0.2% proof stress	ASTM E8	MPa or N/mm ²	41	53	44	26
Elongation	ASTM E8	%	3.8	4	5	2
Flexural elasticity, E	ASTM C393	GPa or kN/mm ²	38.5	49.0	39.8	29.1
Punching shear strength	ASTM D732	N/mm ²	37	36	32	20

(2) Mechanical properties of aluminum skin: Alloy 3005-H14, 3105-H14, or 5005-H14

We use aluminum alloy 3005-H14, 3105-H14, 5005-H15 for ALPOLICs. Our aluminum alloy has the following mechanical properties, and we often use these properties for our structural calculation of ALPOLIC panels. Refer to “7. Panel strength” in this section.

Table 2-8 Mechanical properties of aluminum skin

Mechanical property	Method	Unit	Aluminum 3005-H14, 3105-H14 or 5005 H14
0.2% proof stress	ASTM E8	MPa or N/mm ²	150
Flexural elasticity	ASTM E8	GPa or kN/mm ²	70

(3) Rigidity and panel weight

Based on the above mechanical properties, we can calculate the flexural rigidity (bending strength) of ALPOLICs. The following table shows the rigidity of ALPOLICs in comparison with solid metals of the same rigidity. As we see in the table, ALPOLICs have high rigidity with lightweight.

Table 2-9 Comparison of rigidity and weight

ALPOLICs			Solid metals of the equivalent rigidity					
ALPOLIC/fr & ALPOLIC A2 Specific gravity=1.81-2.1 E=29-49 GPa or kN/mm ²			Aluminum Specific gravity=2.71 E=70 GPa or kN/mm ²			Stainless steel (304) Specific gravity=7.89 E=190 GPa or kN/mm ²		
Products	Thickness mm	Weight kg/m ²	Thickness mm	Weight kg/m ²	Weight ratio %	Thickness mm	Weight kg/m ²	Weight ratio %
ALPOLIC A2	4	8.4	3.3	8.9	94	2.4	18.9	44
ALPOLIC/fr	3	6.0	2.7	7.3	82	1.9	15.0	40
	4	7.6	3.3	8.9	85	2.4	18.9	40
	6	10.9	4.5	12.2	89	3.2	25.2	43

Note (How to read the table): ALPOLIC/fr 4mm is equivalent to 3.3mm thick aluminum in rigidity. Hence, the weight percent of ALPOLIC to solid aluminum is 85%.

(4) Impact resistance

We obtained the following data with the Du-pont method, in which we drop a steel ball from a certain height onto specimen and gauge the dent depth.

Du-pont test instrument



1 kg iron plummet

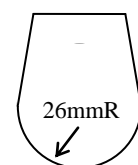


Table 2-10 Impact resistance by means of Du-pont test

Steel ball weight, kg	Height mm	Dent depth, mm			
		ALPOLIC A2		ALPOLIC/fr	
		4mm	3mm	4mm	6mm
0.3	300	0.2	0.8	0.5	0.4
0.5	500	1.0	1.6	1.3	1.0
1.0	300	1.3	1.8	1.4	1.2
1.0	500	2.1	3.1	1.9	1.6

In addition to the above test, we had another impact test using a 1 kg iron plummet in accordance with JIS A 5703. The test includes other sheet materials for comparison. Refer to the test result attached in “Appendix 4:

Impact test with iron plummet” in Section 4. As shown in Appendix 4, ALPOLICs never crack, break or fracture by the impact of the iron plummet.

(5) Bendable limit

We can bend ALPOLICs by means of a press brake or a 3-roll bending machine. In bending with a press brake, the bend-ability depends on ALPOLICs’ thickness and the core material. We define the bendable limit as the radius when wrinkles first appear on the aluminum skin. The smallest bending radius (internal radius) is as follows.

Table 2-11 The smallest bending radius with press brake

Thickness	The smallest bendable radius (internal radius) mm	
	ALPOLIC/fr painted finish	
	Transverse	Longitudinal
3mm	50	70
4mm	80	100
6mm	100	140

Note 1: “Transverse and Longitudinal” shows the bending direction toward the roll (coating) direction.

Note 2: Press brake is not available to ALPOLIC A2 nor ALPOLIC/fr reAL anodised.

In 3-roll bending, the bendable limit depends on the bending roll diameter, roll length and type of bending machine. But the bendable limit of 4mm ALPOLIC/fr painted finish is approx. 300mm and that of 4mm ALPOLIC A2 is approx. 600mm in radius in most 2500mm long machines.

5. Applied properties

(1) Heat transmission

ALPOLICs help to reduce the energy consumption of buildings. When we use ALPOLICs for external or internal claddings, the air space between ALPOLICs and the backing wall forms a thermal insulation layer and increases the wall system’s energy conservation performance.

Generally, heat transmits through a building wall with three steps of R1 to R3 shown in the diagram.

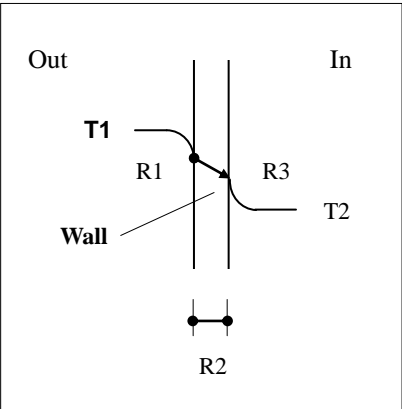
R1: Heat transmission of interface between the outer air and the wall

R2: Heat flow inside the wall by thermal conductance

R3: Heat transmission of interface between the wall and the inner air

The overall heat transmission is the sum of R1 to R3.


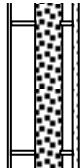
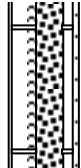
Fig 2-3 Heat Transmission



In the same manner, we can calculate the heat transmission of actual wall systems. Table 2-11 is a calculated example. The calculated value is called the heat transmission coefficient, U-value ($W/m^2 \cdot K$) or K-value ($kcal/m^2h^{\circ}C$). A lower U-value means less heat flow or higher heat resistance. As we can

see in the table, covering the wall with ALPOLIC cladding improves the thermal insulation effect by approx. 15%, and installing a heat insulation material behind ALPOLIC increases the insulation effect by more than two times.

Table 2-12 Heat transmission through external wall

Wall system, wall component and its thickness	RC wall only			ALPOLIC cladding			ALPOLIC + Heat insulation		
	out	in		out	in		out	in	
			RC wall (100) Air space (50) Gypsum board (12)			ALPOLIC (4) Air space (100) RC wall (100) Air space (50) Gypsum board (12)			ALPOLIC (4) Air space (75) Glass wool (25) RC wall (100) Air space (50) Gypsum board (12)
Calculated U-value	2.5 W/m ² ·K			2.1 W/m ² ·K			0.92 W/m ² ·K		

Note: We can convert U-value into K-value with the following equation.
 $K\text{-value (kcal/m}^2\text{h}^\circ\text{C)} = 0.86 \times U\text{-value (W/m}^2\cdot\text{K)}$

(2) Non-permeability

ALPOLIC/fr is non-permeable. Under humid atmospheric conditions, ALPOLIC/fr do not absorb moisture at all. The following is the test result of the freezing and thawing cycle test, which confirms the complete non-permeability of ALPOLIC/fr.

- a. Freezing and thawing test
- b. Exposure cycle: -20°C×1.0hrs for freezing and +10°C×1.5hrs for thawing
- c. Test result:

After 300 cycles, the sample does not show any change in weight, thickness or appearance.

Note: If you use ALPOLIC/fr in a humid condition like in a bathroom where the edge of the panel may be always wet, it is important to design the fixing detail to drain the moisture and to keep the edge dry. Please consult local distributors or our office about practical methods of suitable fixing details.

(3) Fire performance

ALPOLIC A2 and ALPOLIC/fr are fire safe materials that pass mandatory requirements for exterior and interior use in most countries. Although the core material does contain a small amount of combustible polyethylene, the main mineral ingredient does not permit the proliferation of flame and restricts the development of smoke detrimental to evacuation activities. ALPOLIC, on the other hand, is composed of 2 skins of aluminum that retard the rapid spread of fire, although less effectively than ALPOLIC A2 and ALPOLIC/fr.

a. Fire test results of ALPOLIC A2 and ALPOLIC/fr

We have had extensive fire tests of ALPOLIC A2 and ALPOLIC/fr in accordance with requirements in various countries. ALPOLIC A2 and ALPOLIC/fr have passed the following fire tests.

Table 2-13 Fire tests for general and external cladding material (ALPOLIC A2)

Country	Test standard	ALPOLIC A2 specimen	Results & classification
EU	EN 13823, EN ISO 1716, EN 13501-1	4mm	Class A2-s1, d0

Table 2-14 Fire tests for general and external cladding material (ALPOLIC/fr)

Country	Test standard	ALPOLIC/fr specimen	Results & classification
EU	EN 13823, EN ISO 11925-2, EN 13501-1	4mm, 6mm	Class B-s1, d0
United Kingdom	BS476 Part 7	4mm, 6mm	Class 1
	BS476 Part 6	4mm, 6mm	Class 0
USA	NFPA 259-93 British Thermal Unit	4mm	Passed
	ASTM D1781-76 Climbing Drum Peel Test	4mm, 6mm	Passed
	ASTM E84, Steiner Tunnel Test	4mm, 6mm	Class A / Class 1
	ASTM E-108, Modified	4mm	Passed
	UBC 26-9 & NFPA 285, ISMA Test (Intermediate Scale Multi-story Apparatus)	4mm, 6mm	Passed (Subject to a fixing system)
Canada	CAN/ULC-S 134-92, Full-scale Exterior Wall Fire Test	4mm	Passed
China	GB8625, GB8626 & GB8627	4mm	Class B1
Japan	Heat Release Test for Non-combustible Material (ISO 5660-1)	4mm, 6mm	Passed. Certificate No. NM-1933

Table 2-15 Fire tests for other categories (ALPOLIC/fr)

Category	Country	Test Standard	ALPOLIC/fr specimen	Results & classification
Fire resistant rating wall	USA	ASTM E119, 1-hr Fire Rating and 2-hr Fire Rating	4mm	Passed
Roof material	USA	ASTM E108, Fire Test for Roof Covering	4mm	Passed Class A
Interior material	USA	UBC 26-3, Interior Room Corner Test	4mm	Passed
		Combustion Toxicity Test, New York State Uniform Fire Prevention and Building Code	4mm	Passed
	Japan	Heat Release Test for Non-combustible Material (ISO 5660-1) & Toxicity Gas Test	3, 4, 6mm	Passed. Certificate No. NM-1933

b. Comments on the fire tests of ALPOLIC/fr

(i) External cladding

The ISMA Test (Intermediate Scale Multi-story Apparatus, NFPA 285) is a mandatory test for external cladding in US building codes. This test is a simulation test to check the fire propagation using 2-story mock-up model installed with the building material specimen.

A big concern in external cladding is the upward extension of flames over the vertical exterior wall, as shown in Fig. 2-4. Through the ISMA test in Fig. 2-5, we can evaluate the fire extension performance over the external cladding in a controlled environment. ALPOLIC/fr passes this test and has an approval for external claddings without height restrictions.

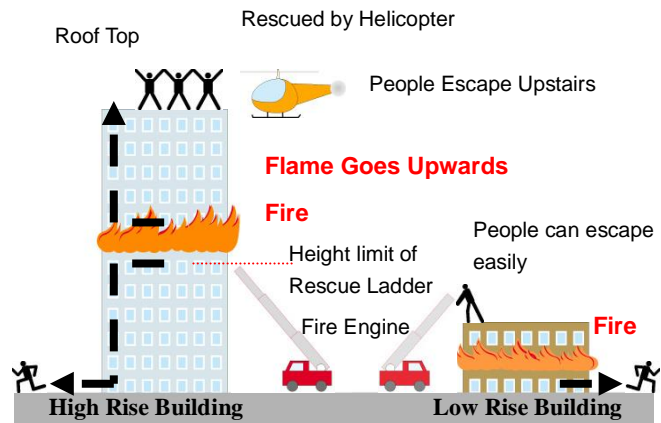
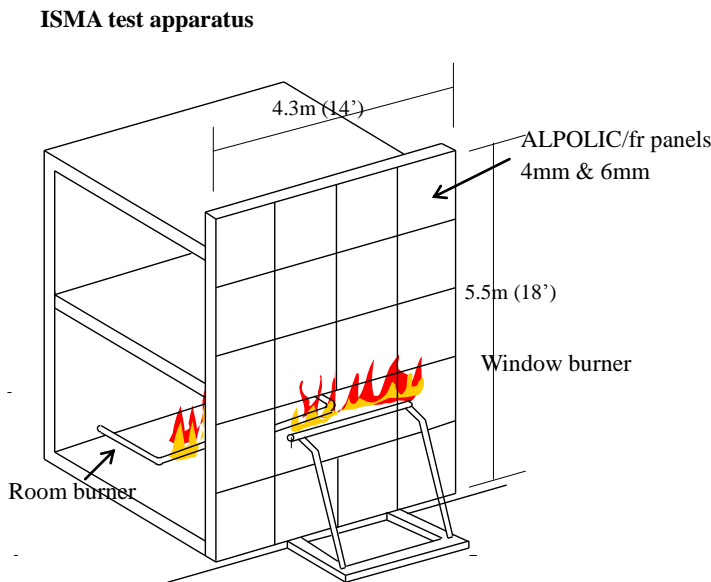


Fig. 2-4 Evacuation from fire

Fig. 2-5 Intermediate-scale Multistory Apparatus



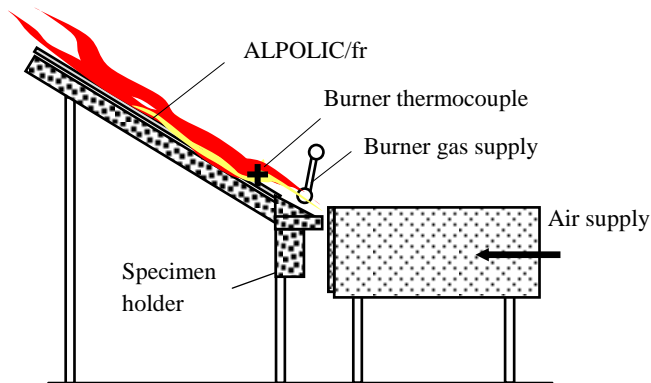
25 minutes after ignition



(ii) Roof covering material

ALPOLIC/fr passes the fire tests in ASTM E108, which examines the fire performance as roof covering materials. It consists of three types of fire tests: a burning brand test, an intermittent flame test and a spread of flame test.

Fig. 2-6 ASTM E108 Fire test for roof covering
Intermittent flame test & spread of flame test



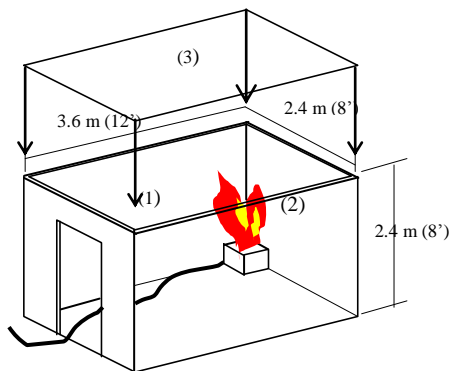
Burning brand test



(iii) Interior material

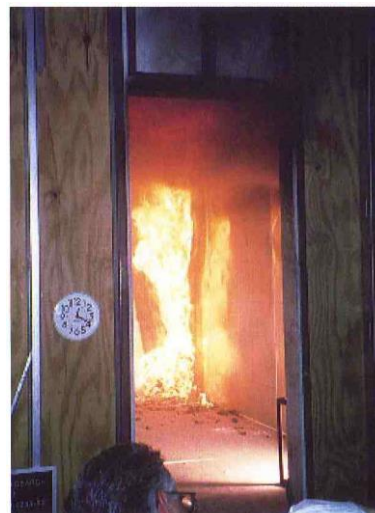
UBC26-3 Interior Room Corner Test is a fire test that verifies the hazardous flashover performance of interior finishing materials. If a fire is generated at a corner of a room, the flame will grow gradually until a certain critical point called a flashover. When the fire has reached the flashover point, it suddenly expands toward the opening door like an explosion. This test simulates this phenomenon and examines the flashover performance of interior finishing materials.

Fig. 2-7 UBC26-3 Interior Room Corner Test



Testing conditions:
 Heater: Gas burner or 30lb wood crib
 Time: 15 min
 The interior is finished with the testing material
 (1) Side wall, (2) Front wall, (3) Ceiling: Optional

Example of Interior Room Corner Test



(iv) Fire approval in Japan

ALPOLIC/fr passes Japan's cone calorimeter test ISO5660-1, a standard fire test for building material classification. It also passes Japan's toxicity gas test and has approval as a non-combustible material for external cladding, roof covering and interior with Certificate No. NM-1933.

Fig. 2-8 Fire test in Japan, ISO 5660-1



6. Coating performance

(1) Color variation

ALPOLICs have a coating finish of Lumiflon™-based fluoropolymer paints as standard. The coating has four types of colors: Solid (Enamel) Colors, Metallic Colors, Sparkling Colors and Patterns (stone, timber, metal, and abstract). Refer to the Color Chart for the standard colors. All types of colors are produced in our continuous coil coating line with Lumiflon™-based fluoropolymer paints. In addition to the standard colors in the Color Chart, custom colors are available, subject to minimum quantities and color match. Contact local distributors or our office for custom color request.

Note: ALPOLICs are finished with Lumiflon™-based fluoropolymer paint as standard, but polyester and other coatings are also available as option. Refer to “Appendix 2: Optional coatings” in Section 4 for details.

(2) Coating system

Our Lumiflon™-based fluoropolymer coating includes three types of coating systems.

a. Solid (enamel) colors

3-coat 3-bake system; the total dry film thickness is 30 microns minimum with a top clear coating.

b. Metallic colors, Sparkling colors, and Prismatic colors are a 3-coat, 3-bake system, and the total dry thickness is 28 microns minimum.

c. Patterns (Stone, Timber, Metal, and Abstract) are coated with a unique image transfer process, and the total dry film thickness is 45 microns minimum.

Note: Lumiflon™-based fluoropolymer coating has basically a coating warranty for 10 years. However, 20 year-coating warranty is available subject to several conditions.

(3) Coating performance

Lumiflon™-based fluoropolymer paint is known for its high weatherability. We apply this paint in our continuous coil coating line for all finishing types, which ensures uniform quality of the coating. The Lumiflon™-based fluoropolymer coating meets the following criteria.

Fig. 2-9 3-coat, 3-bake system for Solid & Metallic Colors

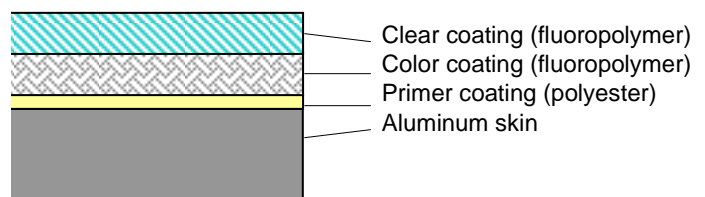


Table 2-16 Coating performance**A. General properties**

Dry film property	Test method	Criteria
Gloss (60°)	ASTM D523	15 to 80%
Formability (T-bend)	NCCA II-19 ASTM D1737	2T, no cracking
Reverse impact-crosshatch	NCCA II	No pick off
Hardness-pencil	ASTM D3363	H
Adhesion		
Dry	ASTM D3359, method 8	No pick off
Wet	37.8°C, 24 hrs.	No pick off
Boiling water	100°C, 20 min.	No pick off
Abrasive resistance	ASTM D968 (Falling sand)	40 liters/mil
Chemical resistance		
Muriatic acid, 10% HCl, 72hrs	ASTM D1308	No change
Sulphuric acid, 20% H ₂ SO ₄ , 18hrs	ASTM D1308	No change
Sodium hydroxide, 20% NaOH, 1hr	ASTM D1308	No change
Mortar, pat test, 38°C, 24hrs	AAMA 2605	No change
Detergent, 3% solution, 38°C, 72hrs	ASTM D2248	No change

B. Weatherability

Dry film property	Test method	Criteria
Weather-o-meter test		
Colour retention:	ASTM D2244	Maximum 5 units after 4000 hrs.
Gloss retention:	ASTM D523	70% after 4000 hrs.
Chalk resistance:	ASTM D4214	Maximum 8 units after 4000 hrs.
Salt spray resistance	ASTM B117	Blister-10, scribe-8, after 4000 hrs., 35°C salt fog
Humidity-thermal	ASTM D2246	No blister, no cracking After 15 cycles of 38°C 100%RH for 24 hrs. and -23°C for 20 hrs.
Humidity resistance	ASTM D2247	No change After 4000 hrs., 100%RH, 35°C

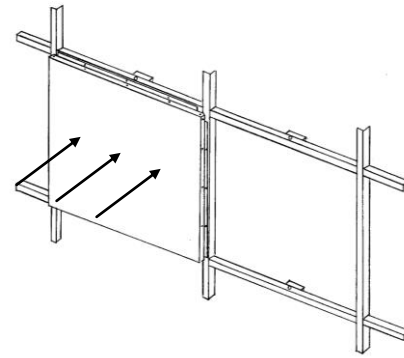
7. reAL Anodised finish

The top surface is finished with anodic oxide layer and it is produced in a continuous anodising line on an aluminium coil. Continuous anodising builds and enhances the surface oxidation using an electro-chemical process under precisely controlled conditions. The anodic oxide layer is 8 micron thick. Comparing with conventional batch anodising process, the continuous anodising finish has excellent color uniformity.

8. Panel strength

When we use ALPOLIC panels outdoors, the panels must withstand the wind load. When the wind blows toward the panels, the wind will exert a positive pressure on them. On the other hand, a negative wind load will cause suction on the panels. These wind loads will cause deflection of the panels to a certain extent, and if the deflection is small enough, the panels will return to the original position when the wind load is off. We normally confirm the adequacy of the panel strength by calculating the strength under given conditions.

Fig. 2-10 Wind load on ALPOLIC panels



(1) Calculation of permanent deformation

In calculation, we assume that the strength of ALPOLIC panels lies in its aluminum skins. Namely, if the stress exerted on the aluminum skins is smaller than the permissible value, permanent deformation will not occur. In this calculation, the permissible value is given as 0.2% proof stress (or yield strength) of aluminum skin divided by a safety factor. 0.2% proof stress depends on the aluminum alloy and the hardening condition. The following aluminum alloy is used in ALPOLICs:

Table 2-17 0.2% proof stress value for calculation of permanent deformation

ALPOLIC A2 and ALPOLIC/fr	Aluminum alloy and hardening condition	0.2% proof stress
A2: 4mm fr: 3mm, 4mm and 6mm	3005-H14, 3105-H14 or 5005-H14	150 MPa or N/mm ²

Note: In our calculation, we use the same parameters and equations for both ALPOLIC A2 and ALPOLIC/fr, because we ignore the role of the core in our calculation. As a result, we obtain the same calculation result with ALPOLIC A2 and ALPOLIC/fr.

If the calculated stress becomes larger than the permissible limit, further study is required to lessen the stress. One solution is to reinforce the panel with stiffener. Generally, the panel strength depends on the following environmental and geometrical factors in addition to the 0.2% proof stress of the aluminium skin:

- A. Wind load
- B. ALPOLIC total thickness
- C. Supporting condition
- D. ALPOLIC panel size

The actual calculation method is outlined in “Appendix 5: Panel strength” in Section 4. If you need a structural calculation, please contact local distributors or our office.

(2) Calculation of panel deflection

Permanent deformation is a completely undesirable condition. On the other hand, panel deflection depends on the requirements of the project. If the maximum deflection is specified in the project, we

have to study whether the expected deflection conforms to the project specifications or not. In this calculation, we use the following flexural elasticity as a composite panel.

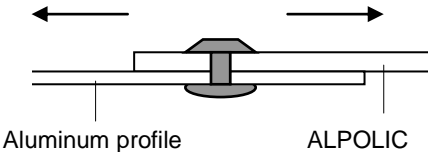
Table 2-18 Flexural elasticity (E) for calculation of deflection

ALPOLIC A2 and ALPOLIC/fr	Flexural elasticity, E GPa or kN/mm ²
3mm (fr)	49.0
4mm (fr & A2)	39.8
6mm (fr)	29.1

The calculation method of panel deflection is outlined in “Appendix 5: Panel strength” in Section 4. If you need a deflection calculation, please contact local distributors or our office.

(3) Strength of joining holes

When suction pressure is exerted on ALPOLIC panels, the joining hole of the rivet or screw must withstand the tension. Otherwise, the joining hole will tear and the panel will separate from the structure.

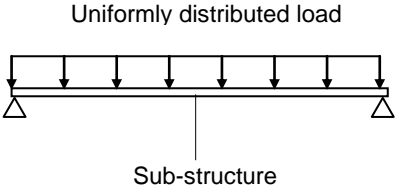


In actual installation work, the position of joining hole is important. When the hole is positioned in the proximity of panel edge, its strength will be lessened and may be unsatisfactory. Normally, the distance from hole-center to panel edge (e) should be larger than twice the hole-diameter (D). Namely, $e > 2 \times D$. Refer to “Appendix 6: Strength of joining hole” in Section 4.

Note: In order to prevent from galvanic corrosion of ALPOLIC, use rivets, screws or bolts/nuts made of aluminum or stainless steel for joining. If ALPOLIC is connected to dissimilar metals like steel, lay a coating film 25 microns (1 mil) or thicker on the metal.

(4) Strength of sub-structure

Normally, ALPOLIC panels are installed on a sub-structure made of steel or aluminum. The sub-structure must withstand the wind load as well as ALPOLIC panels do. The strength of sub-structure depends on the following factors:



- A. Rigidity of sub-structure (material and section)
- B. Supporting (anchoring) interval of sub-structure
- C. Wind pressure loading on sub-structure

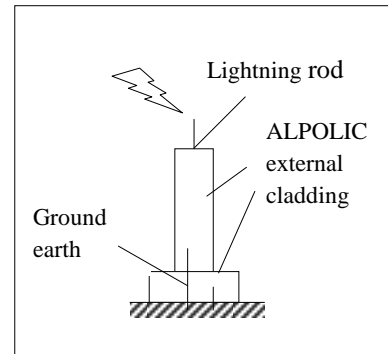
As the sub-structure is normally deemed to be a part of structure, the maximum deflection must meet the L/200 rule: namely, the maximum deflection must be smaller than the supporting interval divided by 200 (or 0.5% of supporting interval).

9. Lightning and earthquake

(1) Lightning

In the event that a lightning should strike an ALPOLIC panel installed on a building, what will happen on the panel and the building? According to our study, as far as the aluminum skin is connected to the ground earth through the sub-structure system, the electricity will be discharged to the ground earth. The electric conduction of the sub-structure system is large enough to discharge the lightning energy, and accordingly, considerable damage will not occur in most of the ALPOLIC panels in the building. But the impact of the lightning is so intense that the struck panel itself will be completely damaged.

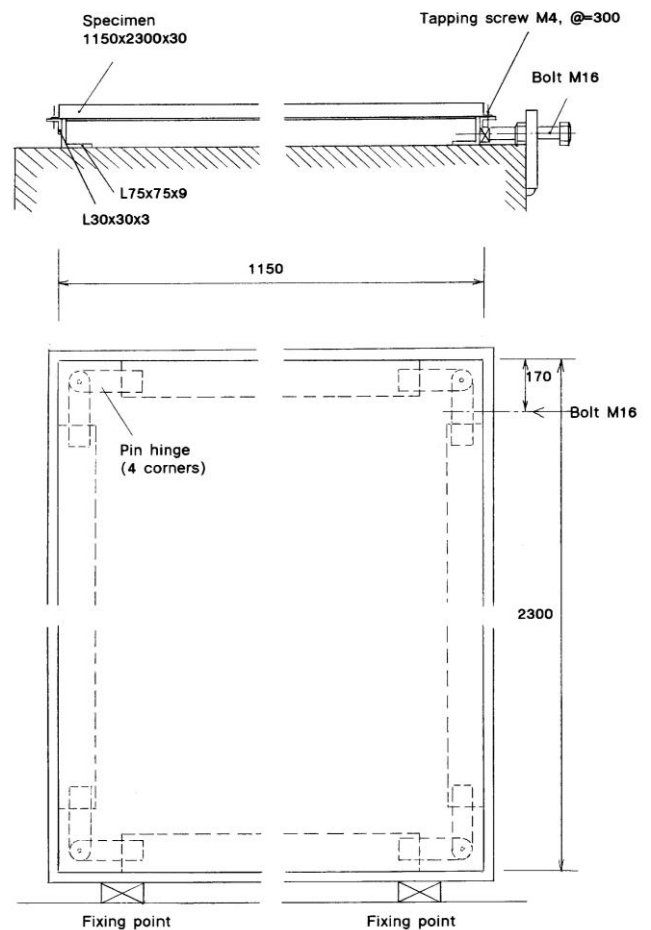
Fig. 2-11, Lightning and external cladding



(2) Earthquake

In those areas where earthquakes are possible, the external panels must withstand the shearing force parallel to the panel surface. According to our test in accordance with JIS A1414 “Deforming test of non-bearing wall panel due to shearing force parallel to panel surface,” the displacement is absorbed in ALPOLIC’s deflection, and ALPOLIC panels are completely restored to the original position when the displacement is eliminated. The test has shown that ALPOLIC panels withstand the shearing forces with a displacement range between 1/400 and 1/50.

Fig. 2-12 Test of shearing force for earthquakes



Section 3 Fabrication & installation

1. General

We can process ALPOLIC/fr and ALPOLIC A2 panels with regular machines and tools for aluminum and wood. We can cut the panels with a circular saw, fold them after grooving with a router, and bend them with a 3-roll bender. In order to join aluminum extrusions to ALPOLIC panels, we can choose a suitable joining method from several alternatives. For installation, various types of fixing methods suitable for Aluminum Composite Material (ACM) have been put forward and improved on for years. We will look over basics of the processing methods and installation methods in this section.

ALPOLIC/fr and ALPOLIC A2 are often simply referred to as “ALPOLIC” or “ALPOLIC panels” in this section, because the fabrication and installation methods applicable to ALPOLIC mostly hold true to ALPOLIC/fr as well. Regarding the product dimension and tolerance required for planning (design) work of fabrication and installation, refer to “11: Panel dimension and tolerance” at the end of this section.

Note

The determination of suitability for use, design, fabrication, installation, and interface with other products of the ALPOLIC materials is the sole responsibility of the purchaser. The information contained on this Technical Manual is for conceptual use only. Mitsubishi Chemical Corporation shall have no responsibility or liability for the products usage or infringement of any patent or other proprietary right.

2. Handling

ALPOLIC is a rigid panel, but a physical impact may cause an edge deformation. Inclusion of hard particles such as grains of sand and cutting chips caught between ALPOLIC panels may cause visible dent-damages in one or more adjacent panels. Take note of the following precautions while handling ALPOLIC during fabrication and installation.

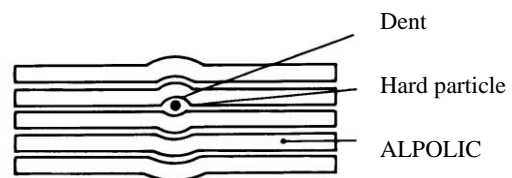


Fig. 3-1 Dent caused by inclusion of particle

(1) Unpacking and repacking

- a. Do unpacking and repacking works in a clean place.
- b. Remove dusts and chips from ALPOLIC and the packing paper. Any hard particles between panels will cause a dent-damage on ALPOLIC panels.
- c. Handle ALPOLIC on a worktable. Do not handle it on the floor.
- d. ALPOLIC should always be handled by two people with external face upward to avoid possible rubbing of the ALPOLIC surface during handling.

(2) Transport

- a. For transport, lay the packed ALPOLIC horizontally and do not place heavy goods on it.
- b. Mark “Handle with Care”, “Keep Dry”, “No Hooks” and “This Side Up” clearly on the packing.

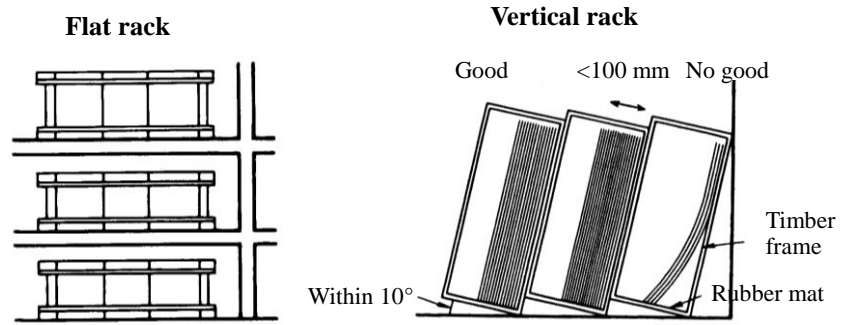
(3) Fabrication

- a. Prior to fabrication, clean off the worktable, temporary stand and both sides of ALPOLIC.
- b. Ensure that cutting chips generated from saws, routers and drills are completely removed from the interface between ALPOLIC and tools.

(4) Storage

- a. Store ALPOLIC panels indoors with a flat rack system or a vertical rack system shown below.
- b. In a flat rack system, pile the same size of panels on a rigid palette. Do not pile up different sizes together. Our wooden crates can usually be stacked up to four crates high.
- c. In a vertical rack system, lean panels closely against an inclined backing material within 10°. The total thickness of leaning panels should not exceed 100 mm thick. Use veneer for backing cover and place rubber mat on the bottom. Avoid scratches when pulling out from the rack and restoring it.

Fig. 3-2 Proper storing method



(5) Protective film

The protective film of ALPOLIC, consisting of two polyethylene layers of white and black, withstands outdoor exposure for approx. 6 months. However, store the panels in dry and indoor atmosphere, to minimize the natural-degradation of the protective film by moisture and direct sunlight during storage.

(6) PVC tape

Do not use adhesive tapes made of PVC (polyvinyl chloride) on the surface of protective film at any time during storage, fabrication or installation. The plasticizer (an additive) in PVC tape will permeate the film and attack the Lumiflon™ coating, which causes a gloss change problem on the coating. Any types of PVC tapes may cause this problem, including duct tape, packing tape and insulation tape.

3. Processing method



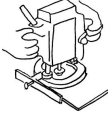

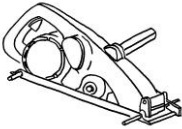
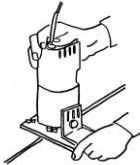

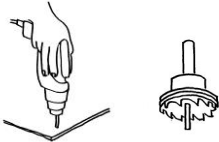
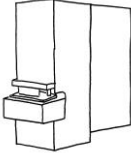
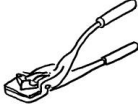

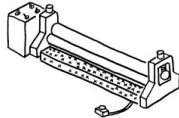
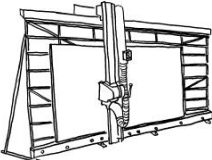
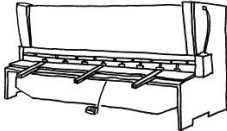
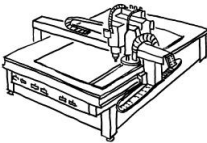
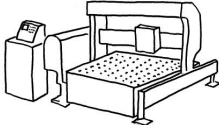
(1) Summary

We can use wide variety of machines and tools to process ALPOLIC panels. We can classify these machines and tools into conventional ones and automated ones. Generally, automated machines enable high efficiency in large quantity analogous work. On the other hand, conventional machines and tools are versatile and flexible. The former requires a costly investment for the machine, and the latter requires skill for good work. The main machines and tools are as shown in the following table.

Table 3-1 Summary of machines and tools

Conventional tools and machines		
Processing	Tools or machines	No.
Cut	Table saw	1
	Hand circular saw	2
	Hand router	3
	Hand jigsaw	4
Groove	Grooving machine	5
	Hand router	3
Chamfer	Hand trimmer	6
	Plane	7
Make hole	Hand drill	8
Punch	Punching machine	9
Notch	Notching tool	10
Bend	Press brake	11
	3-roll bender	12

Automated machines		
Processing	Tools or machines	No.
Cut	Panel saw	13
	Square shear	14
	CNC router	15
Groove	Panel saw	13
	CNC router	15
Perforate	Turret Puncher	16

1. Table saw 	2. Hand circular saw 	3. Hand router 	4. Hand jigsaw 
5. Grooving machine 	6. Hand trimmer 	7. Plane 	8. Hand drill 
9. Punching machine 	10. Notching tool 	11. Press brake 	12. 3-roll bender 
13. Panel saw 	14. Square shear 	15. CNC router 	16. Turret puncher 

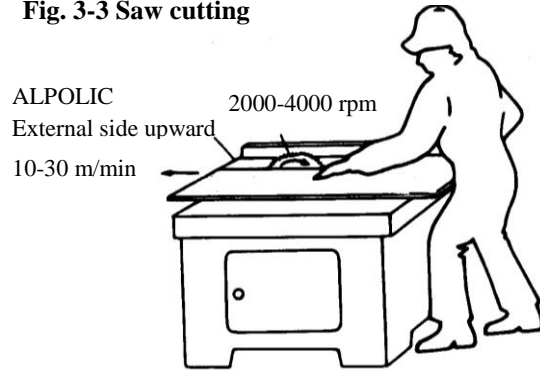
(2) Saw cutting

We can cut ALPOLIC with various types of circular saws such as table saws, hand circular saws and panel saws. A suitable saw blade is a carbide-tipped blade for aluminum or plastic use.

Example of suitable saw blade:

Blade diameter	255 mm
Number of teeth	80 to 100
Cut width	2.0 to 2.6 mm
Rake angle	10°
Tip	Carbide
Operating conditions	
Rotation of saw blade	2000-4000 rpm
Feed speed	10-30 m/min

Fig. 3-3 Saw cutting



Notes on saw cutting:

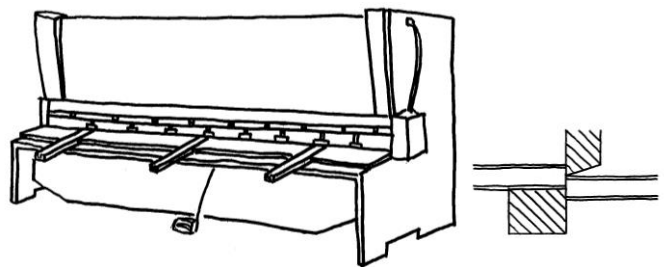
- Do the cutting operation with the external side facing upward to prevent the panel from scratches and the protective film from peeling off.
- Remove cutting chips from ALPOLIC carefully after cut, to avoid dents during storage and assembly.
- Sharpen or replace the saw blade, when it becomes dull. Dull blades will result in a large burr or distortion at the cut edge.

(3) Shear cutting

A square shear permits an efficient sizing work. Generally, the most suitable clearance and rake angle are as follows:

ALPOLIC thickness	Clearance	Rake angle
3mm	0.04 - 0.1mm	1°
4mm	0.04 - 0.1mm	1° 30'
6mm	0.2mm	2° 30'

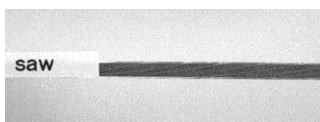
Fig. 3-4 Shear cutting



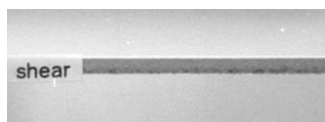
(4) Trimming of cut edge

After saw cutting, a burr appears on both sides of the edges. After shear cutting, either a droop or a burr appears on each edge. If we install the panel with the cut edges exposed, we have to control the edge conditions.

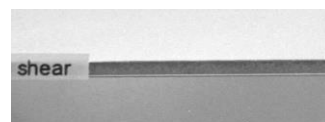
Burr after saw cutting



Droop after shear cutting



Burr after shear cutting



Namely, in saw cutting we should keep the saw blade sharp enough to have a proper edge. In shear cutting, we should adjust the clearance of the die properly. If we need further trimming of the cut edge, we have to trim the edge with a trimmer, plane or sandpaper.

In Solid, Metallic, Sparkling Colors, deep trimming like chamfering may have an aesthetic effect. Use a trimmer with a ball bearing chamfering bit or a plane for woodwork. In working with plane, a guide ruler will help to ensure a uniform edge.

In Stone and Timber, generally, deep trimming is not suitable, because deep trimming harms the appearance of Stone and Timber. If it is possible that passers-by may hurt their fingers on the cut edges in Stone and Timber, make the edges dull with fine sandpaper. Normally, droop edges by shear cutting are mild enough to ensure the safety of cut edges.

(5) Curving cut

Hand routers and trimmers can cut ALPOLIC in curving lines. A guide template will help you to stabilize this work. Jigsaws are also useful for cutting complex shapes.

Notes on guide template:

- a. Put the guide template on the external side of ALPOLIC, to do the routing work through the guide template.
- b. Remove the particles caught between the template and ALPOLIC surface, to prevent dents and scratches.

(6) U-grooving

We can fold ALPOLIC after U-grooving in the backside. Two types of machines are available for U-grooving. One is a circular cutter type and the other is a router type. The former includes hand grooving machines and panel saws, and the latter includes hand routers and CNC routers.

Note: A panel saw is not recommended for grooving ALPOLIC A2.

Fig. 3-5 Hand trimmer and chamfering bit

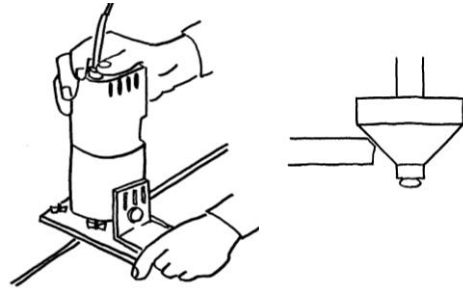


Fig. 3-6 Chamfering with plane

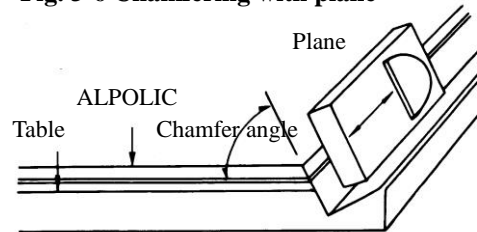
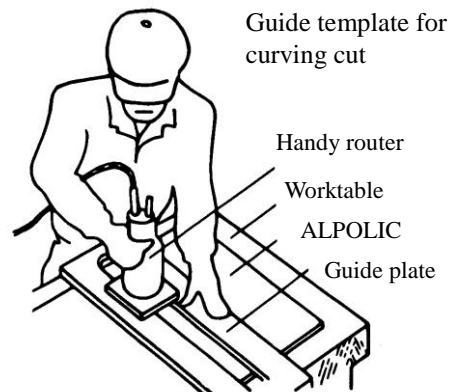
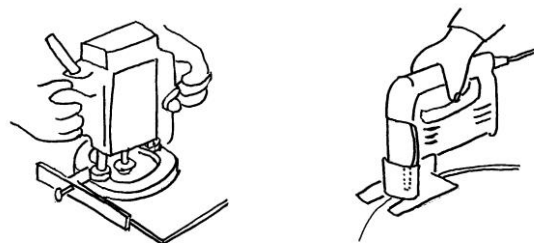


Fig. 3-7 Curving cut

Hand router

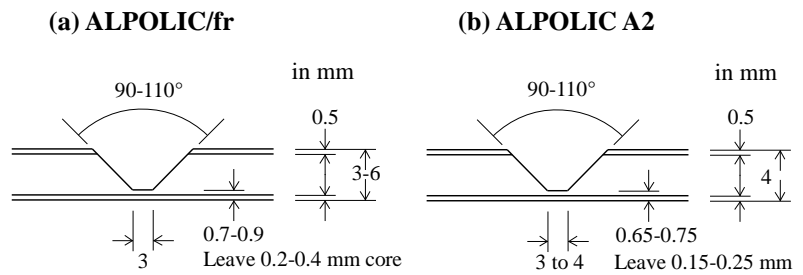
Hand jigsaw



U-groove shape

The diagram (in Fig. 3-8) shows a typical U-groove shape suitable for folding ALPOLIC panels. It is important to leave appropriate thickness of the core. We recommend 90-110° grooves for 90° bending.

Fig. 3-8 Typical U-groove shape



Hand grooving machine

Hand grooving machines can groove ALPOLIC. Use a cutter blade having the proper groove shape as shown in Fig. 3-8. An example of suitable cutter blades and operating conditions are as follows:

Cutter blade:

Outside diameter	110-120 mm
Number of teeth	4
Material	Carbide tip

Operating conditions

Rotation	5,000 - 9,000 rpm
Feeding speed	5 - 20 m/min.

Hand router

Hand routers can groove both straight lines and Curving lines. Use a custom router bit having the groove shape shown in Fig. 3-8. The suitable bit and operating conditions are as follows:

Router bit:

Number of teeth	2 - 4
Material	Carbide tip

Operating conditions:

Rotation	20,000 - 30,000 rpm
Feeding speed	3-5 m/min.

Panel saw

Panel saws enable efficient and precise grooving. Typical conditions are as follows:

Cutter blade:

Outside diameter	220 mm
Number of teeth	8
Material	Carbide tip

Operating conditions:

Rotation	2,500 - 5,000 rpm
Feeding speed	30 m/min.

Fig. 3-9 Hand groove machine and groove cutter

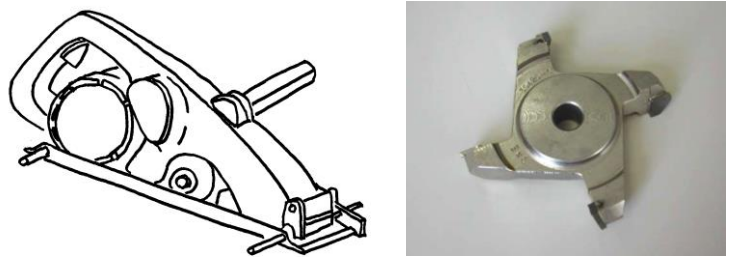


Fig. 3-10 Handy router and router bit

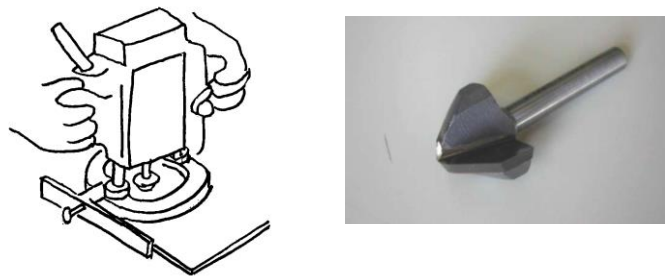
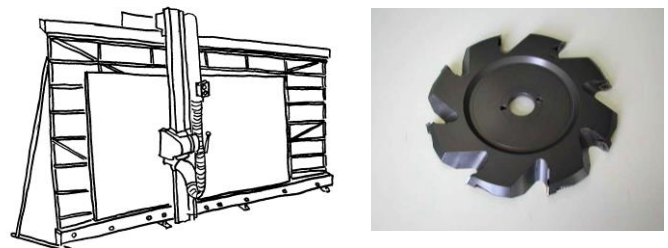


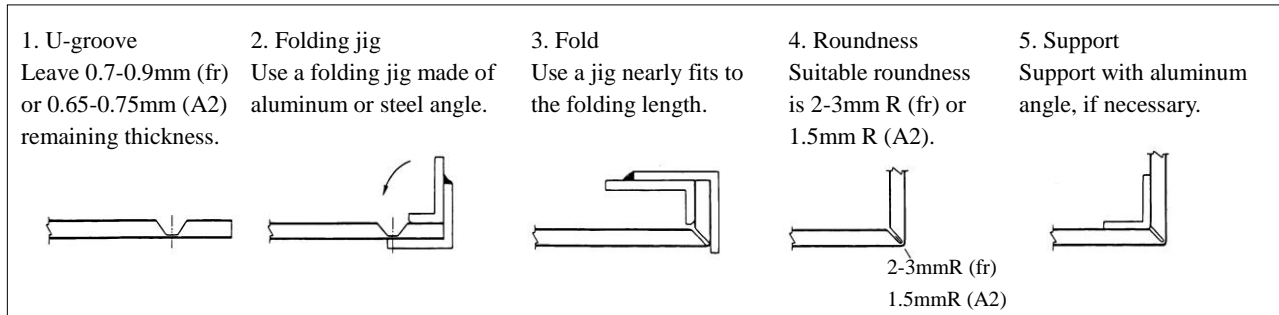
Fig. 3-11 Panel saw and groove cutter



(7) Folding

After U-grooving, we can fold ALPOLIC with a folding jig. The typical folding procedures are as follows.

Fig. 3-12 Folding procedures

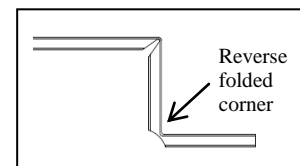


Notes on folding:

- Fold ALPOLIC panels on a flat and rigid worktable, because, if we fold a warping panel, the folding centerline will not be straight.
- The folded corner should have a suitable roundness of 2 - 3 mm (ALPOLIC/fr) or 1.5 mm (ALPOLIC A2) in radius. If the roundness is too small, the coating may have a crack on the folded corner. Check your U-shape and grooving depth.
- Cracks may occur when we carry out the folding work at a low temperature. Have your folding work at 10°C or higher.
- Folding after U-grooving entails slight elongation. The elongation is 0.5 - 1.0mm per fold. Pre-adjust the position of the grooving line in your fabrication drawing.

(for ALPOLIC/fr reAL anodised)

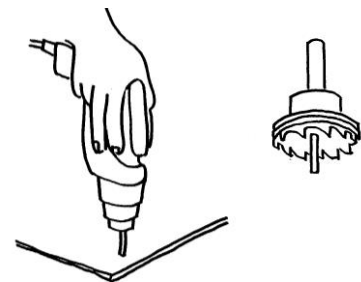
- The anodic film on the surface of the ALPOLIC/fr panels is brittle and there will be some surface cracking at the bent edge when doing a rout and return. Folding should only be once.**
- Reverse folding will cause some surface cracking on the anodic film at the folded corner as well. Also straight line at the reverse folded corner will be unstable. It is better to avoid reverse folding at visible portions.



(8) Making hole with drill

We can make holes with a hand drill or a drill press, equipped with a drill bit, a hole-saw and a circle cutter. Use drill bit for metals. Making a hole from the external side will reduce the burr.

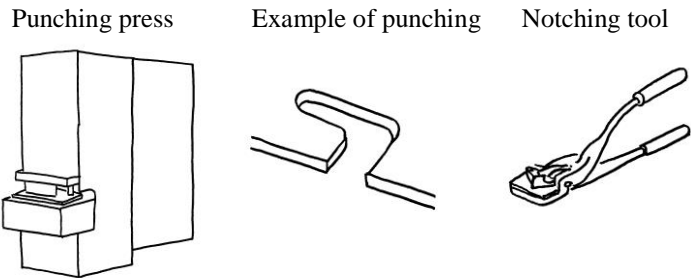
Fig. 3-13 Making a hole



(9) Punching and notching

We can use a punching press for notching and cutting out. The suitable clearance between punch and die is 0.1mm or smaller (material thickness × approx. 2%). A small droop will appear at the punched edge. We can also use a notching tool for removing the corner.

Fig. 3-14 Punching press and notching tool



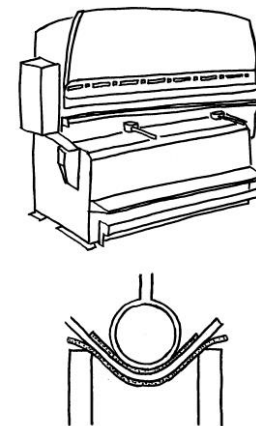
(10) Bending with a press brake

We can bend ALPOLIC/fr painted finish with a press brake. The bend-ability depends on the thickness and the core material. The smallest bendable radius (internal radius) with press brake is as follows:

Table 3-2 Smallest bendable limit with press brake

Thickness	Smallest bendable radius (internal radius) mm	
	ALPOLIC/fr painted	
	Transverse	Longitudinal
3mm	50	70
4mm	80	100
6mm	100	140

Fig. 3-15 Press brake bending



Note: Press brake is not available to ALPOLIC A2 and fr reAL anodised.

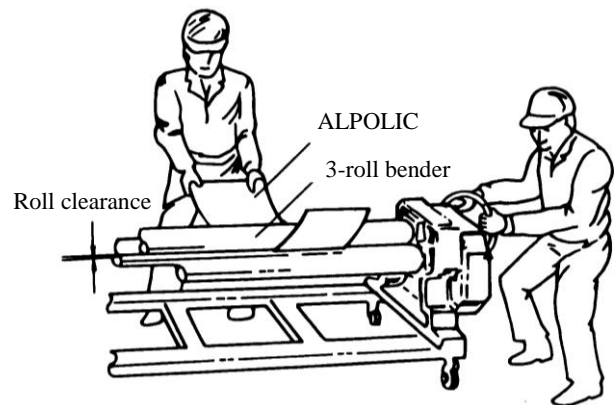
Notes on press brake bending:

- “Transverse” and “Longitudinal” show the bending direction toward the rolling (coating) direction printed on the protective film.
- The smallest bendable radius means the limit at which visible wrinkles appear on the aluminum surface of ALPOLIC/fr. Cracks will appear at a slightly smaller radius than this value.
- Use the top die (punch) with an almost similar radius to the desired radius. If the radius is much smaller, the bending radius partially goes beyond the above limit, and cracks may occur.
- Use a urethane pad for the bottom die, or place a rubber mat between ALPOLIC/fr and the bottom die.
- Use a scratch-free top die. Polish and wipe the top die. Do the bending work without peeling off the protective film of ALPOLIC/fr.
- When we carry out the bending work at a low temperature e.g. 15°C, the coating surface may change to a haze-like appearance. Warm the panel to 20° or higher, and the haze-like appearance will disappear.
- In metallic colors, slight color difference can be seen between bent and flat surfaces due to the difference of reflection angle.

(11) Bending with 3-roll bender

We can use manual or electric-drive 3-roll benders for bending ALPOLICs. The smallest bendable radius of 4mm ALPOLIC/fr painted finish is approx. 300mm and that of 4mm ALPOLIC A2 is approx. 600mm in 2500mm long machines. The exact bendable limit depends on the bending roll diameter, roll length and the type of bending machine. ALPOLIC/fr reAL anodised is not applicable for bending.

Fig. 3-16 Bending with 3-roll bender



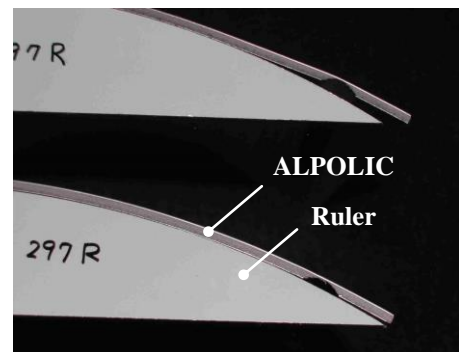
Notes on 3-roll bending:

- Prior to a bending operation, wipe the roll surface carefully.
- Remove any burrs at the ALPOLIC edge that may cause dents while rolling.
- Remove the cut particles stuck on ALPOLIC and smooth any wrinkles on the protective film, which may cause dents.
- Do not constrict ALPOLIC panel between rolls (in thickness direction). Extreme compression may cause a physical damage of the core. Adjust the clearance between rolls to be the panel thickness plus some allowance (approx. 0.5 mm).
- If a notch is desired in the panel, cut the notch after bending. Cutting the notch before bending will result in a distorted curving.
- Generally, small radii will need gradual bending by adjusting the elevation of the bending roll several times.
- In most 3-roll benders, the curve near the edge tends to be straight. We can reduce this straight portion to some extent by overlapping another auxiliary sheet material and bending together with ALPOLIC. If we require a consistent curve near the edge, we have to do additional edge bending after regular bending. Refer to Fig. 3-17.
- When we carry out the bending work at a low temperature e.g. 15°C and with small radius e.g. 250mmR, the coating surface may change to a haze-like appearance. Warm the panel to 20° or higher, and the haze-like appearance will disappear.
- In metallic colors, slight color difference can be seen between bent and flat surfaces due to the difference of reflection angle.

(Notes for ALPOLIC/fr reAL anodised bending/ curving)

- Due to the brittle nature of an anodic layer, bending or curving of anodised ALPOLIC/fr is not recommended. The anodic layer will fracture creating a visually objectionable surface.

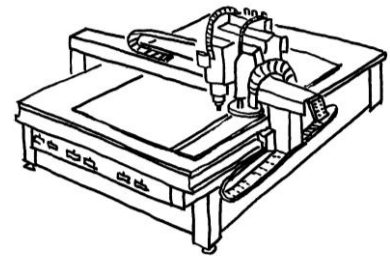
Fig. 3-17 Additional edge bending
Top: Before, Bottom: After



(12) CNC router

We can cut and groove ALPOLIC panels with CNC routers. As all the procedures are computer-controlled by a program, CNC router is suitable for repetition of analogous work. The suitable bit and operating conditions are the same as those for hand routers.

Fig. 3-18 CNC router



(13) Turret puncher

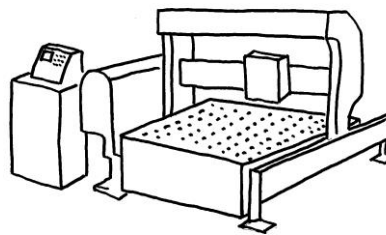
Turret puncher, also computer-controlled, can be used for perforation of ALPOLIC.

The suitable clearance between punch and die is 0.1mm or smaller (material thickness \times 2%). A small droop will appear at punched edge.

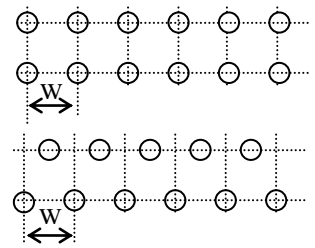
Regarding the perforated panels of ALPOLIC, refer to “Appendix 3: Perforated panel” in Section 4.

Fig. 3-19 Turret puncher and perforation

Turret puncher



Example of perforated pattern



(14) Others

Water-jet cutting: A plunge cut (piercing at the starting point) in water-jet cutting may cause a certain degree of de-lamination between the aluminum skin and the core material. Therefore, we have to plunge at a disposable area or start at panel edge. After penetrating through panel, a water jet can cut ALPOLIC.

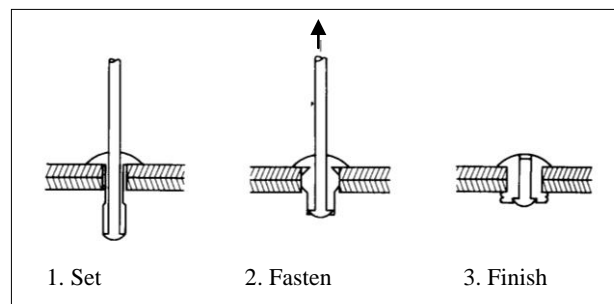
Laser cutting: According to our tests, we have so far concluded that ALPOLIC is not suitable for laser cutting, because the fumes generated from ALPOLIC might harm the sophisticated optical instrument in the laser system.

4. Joining method

(1) Rivet and bolt/nut

We often use rivets, bolts/nuts and tapping screws for joining between ALPOLIC and other material like aluminum extrusions. For rivets, use aluminum blind rivets. We can do riveting work from one direction as shown in Fig. 3-20. For screws, use bolts/nuts and tapping screws made of aluminum or stainless steel.

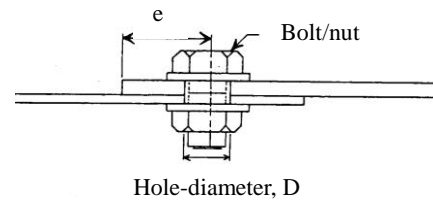
Fig. 3-20 Rivet work with blind rivet



Strength of joining hole

A joining hole of 4mm in diameter withstands approx. 500 - 800 N (50 - 80 kgf) per point depending on ALPOLIC thickness. The strength of the joining point depends on the position of the hole. The joining hole located near the panel edge will easily tear and will not show a sufficient strength. According to our test, the distance from the panel edge to the hole-center (e) should be larger than twice the hole-diameter (D) for sufficient strength, which is expressed with the equation, $e > 2D$. In actual assembly work, we have to choose the position of the joining holes based on this idea. Refer to “Appendix 6: Strength of joining hole” in Section 4 for details.

Fig. 3-21 Proper position of joining hole



In the installation of interior, countersunk rivets and screws will be used more often than round-headed ones. The strength may lessen with countersunk rivets and screws.

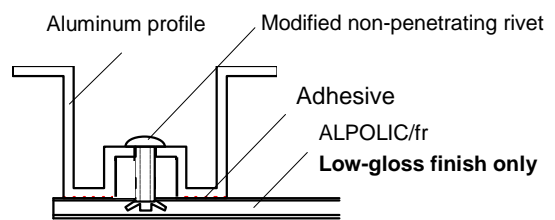
Prevention from galvanic corrosion

If ALPOLIC contacts a dissimilar metal in a humid atmosphere, the galvanic (electrolytic) corrosion may accelerate the corrosion of aluminum skin. To prevent this, the contact surface of the dissimilar metal like steel should have a paint coating thicker than 25 microns, galvanized coating or electric insulation, before fixing ALPOLIC panel onto the metal surface.

(2) Modified non-penetrating rivet

A non-penetrating rivet is applicable for joining if the surface finish is low-gloss (30% gloss or less). Non-penetrating rivets are an alternative method to double-sided tapes and adhesives, but this rivet functions like a mechanical fixing, ensuring the design strength of approx. 300 N/piece. Therefore, this rivet is suitable for areas where a reliable fixing is indispensable even in the event of fire or other accidents.

Fig 3-22 Modified non-penetrating rivet



It is important that this non-penetrating rivet is usable only on low-gloss finishes as shown in Table 3-3, because the fastened trace is visible from the front side in medium and high-gloss finishes. Refer to “Appendix 7: Modified non-penetrating rivet” in Section 4 for details.

Table 3-3 ALPOLIC/fr suitable for non-penetrating rivet

ALPOLIC/fr thickness	Applicable gloss level
4mm, 6mm	Low-gloss (30% gloss or less)

(3) Adhesives

General note: The determination of suitability for use, design, fabrication, installation, and interface with other products of the ALPOLIC materials is the sole responsibility of the purchaser.

We can use commercial adhesives for joining and assembling ALPOLIC. However, some types of adhesives may corrode aluminum and do not suit ALPOLIC. For example, vinyl acetate type, widely used for timber and styrene foam, corrodes aluminum. The main adhesives suitable to adhesion between ALPOLIC and other materials are as follows.

Table 3-4 General adhesives applicable to ALPOLIC

Adhesive type		Epoxy	Chloroprene	Silicone RTV	Cyano-acrylate
Example of commercial brand		Araldite	Contact Cement	All Purpose Silicone	Aron Alpha
Material to be adhered	Metal	S	S	S	S
	Timber	S	S	S	S
	Gypsum board	S	S	No	No
	Styrene foam	S	No	No	No

S: Suitable No: Not suitable

Apart from the above adhesives, we have successfully used the following adhesives for fabrication and assembly work of ALPOLIC. However, these adhesives are only locally available in Japan. If you are interested in these adhesives, please contact local distributors or our office.

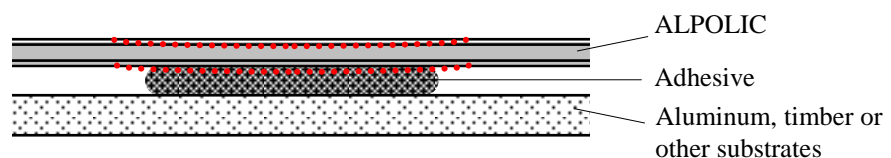
Table 3-5 Adhesives used for assembling work of ALPOLIC in Japan

Brand name	Adhesive type	Manufacturer	Remarks
Diabond SG350	Acrylic	Nogawa Chemical	2-part, 5-15 min curing
Super X No.8008	Silyl-modified	Cemedine	1-part, 1-2 hrs. curing

Notes on adhesives:

- Prior to adhesion work, remove all the foreign matter such as dust, particles, grease, water, etc. from the area to be adhered.
- Select the most appropriate adhesive that ensures the necessary adhesion power in the atmospheric conditions. The adhesion power depends on the surface conditions of the substrate. Follow the adhesive manufacturer's instructions.
- When ALPOLIC is adhered to a dissimilar material, it is possible that ALPOLIC will show a deflection due to the thermal expansion difference or dimension change of the material. Pre-test the adhesive before fabrication and installation.
- Some adhesives may cause a distortion after hardening, as shown in the diagram. Some epoxy adhesives, polyurethane adhesives and silicone adhesives may show this kind of distortion. This distortion is usually very slight, and its visibility depends on the gloss level of the finish, the visual angle and the circumstances.

Fig. 3-23 Distortion due to adhesive



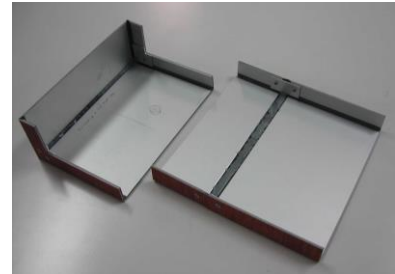
(4) Welding of core

One end of ALPOLIC can be adhered to another end of ALPOLIC by welding the core with hot melt adhesive (glue). Prior to heating a glue stick, we have to preheat the core surfaces for good adhesion. Normally, mechanical reinforcement is necessary after welding.

(5) Double-sided tape

Double-sided tape like 3M’s VHB tape is widely used in assembling work of ALPOLIC. Generally, VHB tape simplifies the joining work. The thicker ones even allow movement of the adhered two materials to some extent. The adhesion test shows that 3M’s VHB Y-4920 (0.4mm thick) is compatible with both topside and backside of Lumiflon™-based fluoropolymer coated ALPOLIC.

Fig. 3-24 Welding of core with hot melt glue



(6) Hook/loop fastener

Hook/loop fasteners like Velcro tape is useful for guide signs and displays. This type of fastener is removable and restorable.

(7) Sealing material

In order to ensure waterproofing of joints between panels, normally a sealing material is used. The sealing material shall meet the performance required for the atmospheric conditions.

Table 3-6 below shows general performance of sealing materials. Silicone, modified silicone and polysulfide sealant are often used for outdoor installation. The compatibility tests with these sealing materials have shown a good adhesion with Lumiflon™-based fluoropolymer coated ALPOLIC, but some of the sealing materials need primer for good adhesion. In addition, some are 2-component type that consists of a base component and a curing agent. Regarding the joint design such as proper joint width and thickness, please follow the sealant manufacturer’s specifications.

Note: Gloss increase due to plasticizer of modified silicone and polyurethane sealant

In tooling work of modified silicone and polyurethane sealant, do not smear the protective film of ALPOLIC with surplus sealant. The plasticizer, an additive in these sealing materials, permeates the protective film and causes a gloss increase on the Lumiflon™-based fluoropolymer coating.

Table 3-6 General performance of sealing materials

General performance		Sealing Materials			
		Silicone	Modified silicone	Polysulfide	Polyurethane
Restoring ability		A	A - B	B	B
Degradation	Due to aging	VS	S - M	M	M
	Due to temperature	VS	S - M	M-L	M
Shrinkage after filling		S	S	S	S
Serviceable temperature (long-term)		-40/120 °C	-30/90 °C	-20/80 °C	-20/70 °C
Weather-ability		A	A - B	A - B	B
Fatigue resistance		A	A - B	B	A - B

Note 1: A: Excellent B: Good C: Normal VS: Very small S: Small M: Medium L: Large

Note 2: The above is excerpt from Sealing Material Handbook, Japan Sealant Manufacturers’ Association.

5. Surface processing

(1) Screen-printing

In screen-printing, 1-component vinyl type or 2-component polyurethane type inks are suitable for all the finishes of ALPOLIC. We obtain normal adhesion with these inks after drying at 80°C for 30 min and curing at room temperature for 24 hrs. The typical printing procedures are as follows:

- a. Remove all dust and dirt with a soft cloth. Oily dirt, if remaining, causes printing defects.
- b. Cure or dry under proper conditions. Follow instructions from the ink manufacturer.

Notes on screen-printing:

- a. Keep the curing temperature below 90°C for less than 30 min.
If the curing temperature is higher, deflection of the panel may occur.
- b. Select the ink suitable for the atmospheric conditions where the panel is to be located.

(2) Cutting film

Various types of cutting films are applicable to the ALPOLIC surface. If you are going to fold the ALPOLIC panel after you apply the film, the film may change color at the folded corner. Confirm it with pre-testing.

(3) Digital print with ink jet printer

Various types of decorative films and wallpapers printed with ink jet printers can be applied on ALPOLIC. Confirm the fire approval conditions of the film. Direct digital printing is also possible with special ink jet printers.

6. Overall fabrication works

(1) Typical fabrication process

Actual fabrication work of an ALPOLIC panel is an integrated work consisting of various machining procedures, assembling and inspection. Fig. 3-27 is a typical fabrication process for a standard tray type (rout and return) ALPOLIC panel.

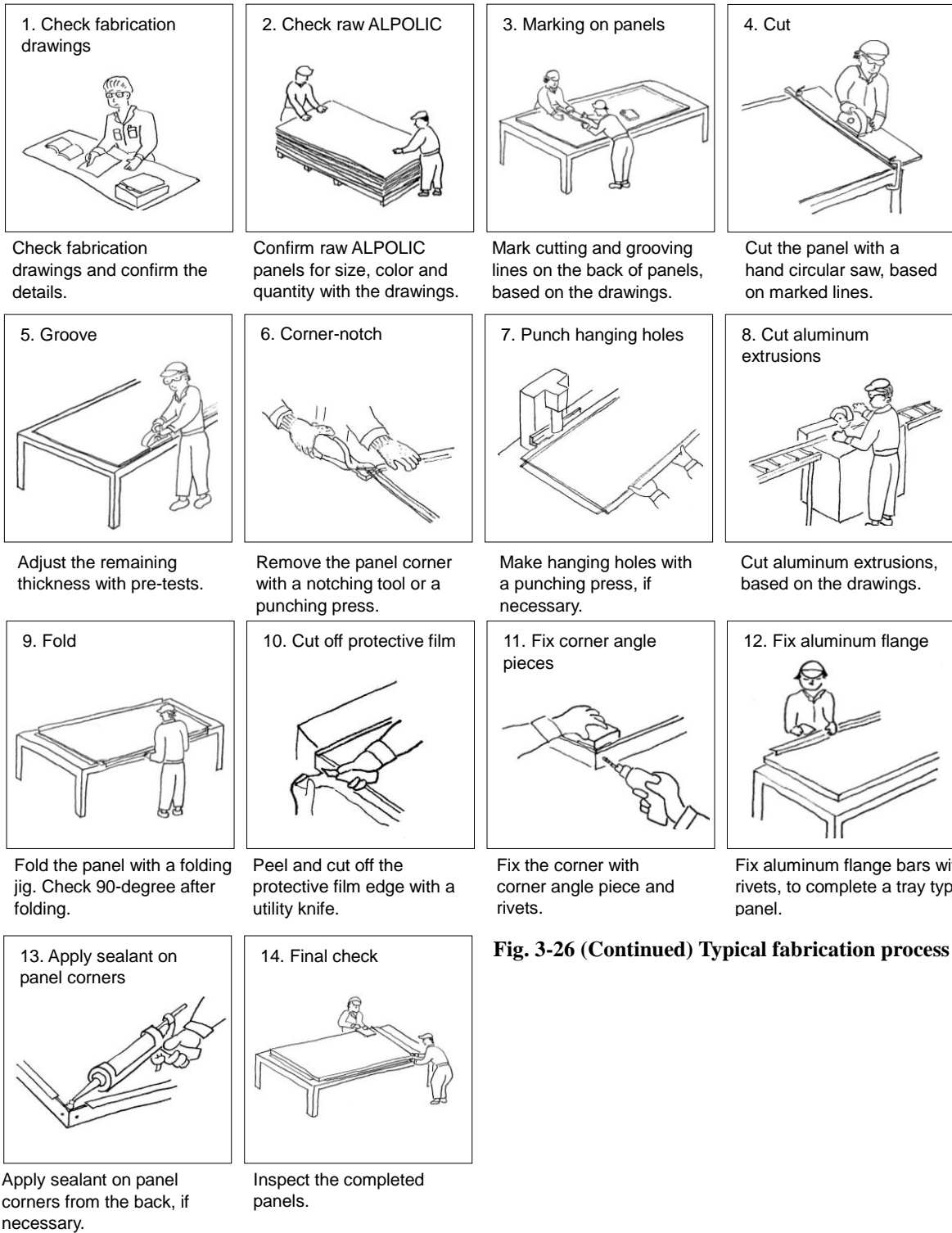
Fig. 3-25 Screen-print on ALPOLIC



A convenience store, interior sign, Japan



Guide sign in subway stations, Tokyo

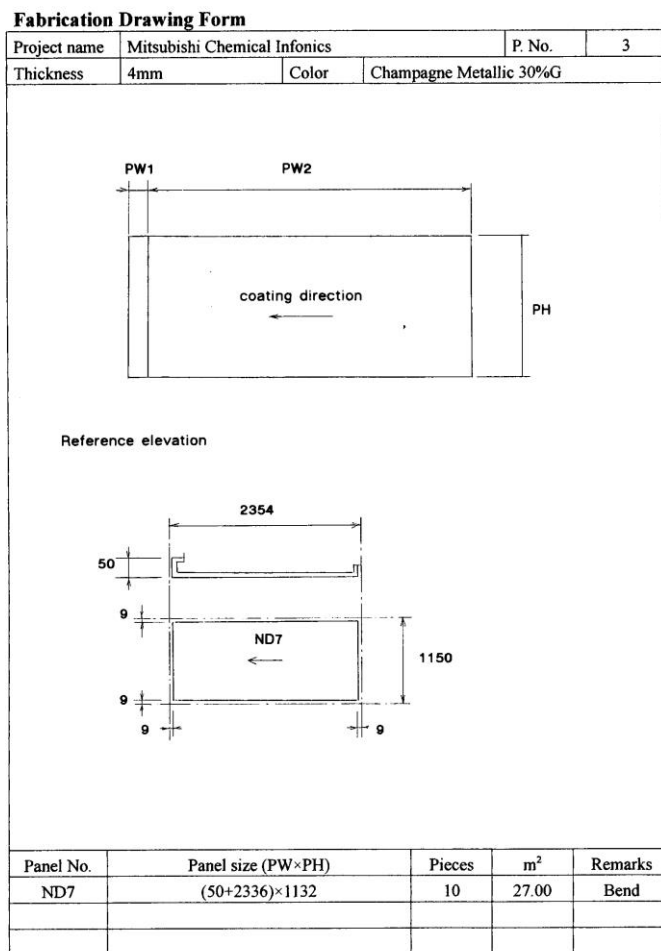


(2) Fabrication drawing

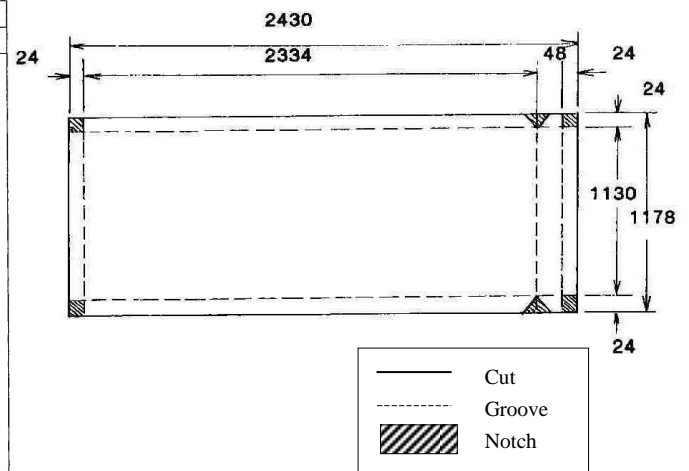
We have to prepare fabrication drawings prior to every fabrication work. Fabrication drawings specify details of processing and assembly method of each ALPOLIC panel. Normally, we specify the following items in fabrication drawings.

- Raw ALPOLIC panel (thickness, color, dimension) to be used for the fabrication
- Panel name, shape, dimensions and quantity of the completed panel
- Cutting, grooving and other processing details including its coating direction

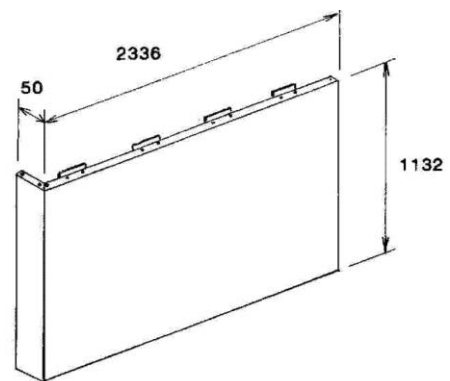
Fig. 3-27 Example of fabrication drawing



Actual processing method based on the drawing



Completed panel based on the drawing



In addition to the above items, we can get unspecified information about subsidiary materials from fabrication drawings through simple calculations. Thus, we can use fabrication drawings not only for processing and assembly of ALPOLIC panel but also for preparation of subsidiary materials, final inspection work of completed panels and some office work including inventory control of raw ALPOLIC panels.

Fig.3-27 above shows an example of a fabrication drawing and the actual panels based on the drawing. Fabrication drawings are normally prepared for internal use, and so, many other forms are successfully used. However, every form should facilitate the drawing work and should be easily understood

without confusion.

(3) Adjustment of dimensions

ALPOLIC panels elongate through folding and bending. Generally, we find the following elongations:

In folding after grooving; 0.5 - 1.0 mm per point

In 3-roll bending; 0.3-0.4 % of arc length (300 - 700 mm R)

In order to compensate the elongation, we have to adjust (shorten) the cutting and grooving position based on the fabrication drawing. Thus, the actual cutting and grooving dimensions are smaller than those of the complete panel. As the elongation values depend on the grooving shape and bending method, we have to determine the exact values by pre-testing.

(4) Panel details

When we work with fabrication drawings, we have to determine the fabrication details of ALPOLIC panels. Normally, the details applicable to ALPOLIC are slightly different from solid aluminum panels, mainly because ALPOLIC panels are pre-coated products, while solid aluminum panels are post-coated products. Some panel details may need approval from customers with the fabricated samples showing the details. We will look over some of the main details below.

Corner detail

In a tray type (rout and return) panel, we can select a corner detail from two alternatives: 90 deg. square and 45 deg. diagonal. After cutting, grooving and notching 4-corners in the respective manner below, fold the perimeter and fix the four corners with aluminum angle pieces and aluminum rivet. Refer to Fig. 3-28 below.

Fig.3-28 Corner detail of tray type panel

(1) 90 deg. square

(2) 45 deg. diagonal

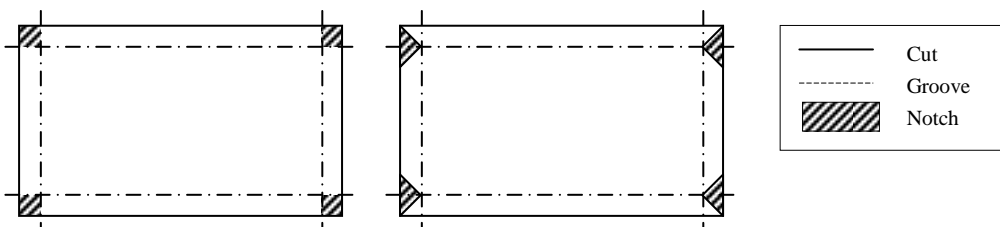
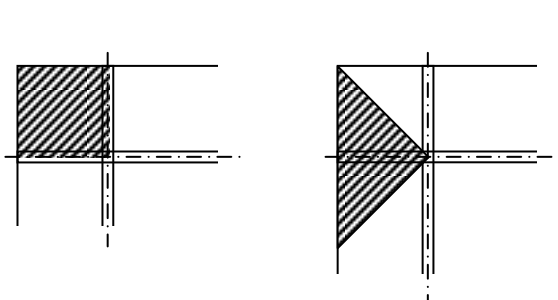


Fig.3-29 Corner detail of tray type panel (Continued)

(1) Notch for 90 deg. square (2) Notch for 45 deg. diagonal



90 deg. square (left) and 45 deg. diagonal

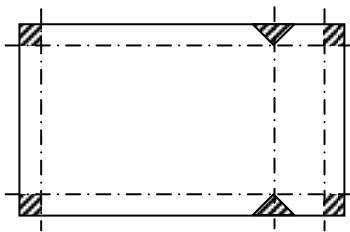


Outside angle

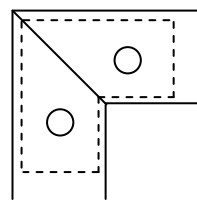
In outside angle panels, we need additional notches at the top and bottom of the outside angle line. After assembling the grooved panel in the same manner as a regular tray panel, we finally fold the outside angle line. Check the folding angle and reinforce the outside angle with support plates made of aluminum on the top and bottom of the outside angle line. Refer to Fig.3-30 below.

Fig. 3-30 Outside angle

Notching for outside angle



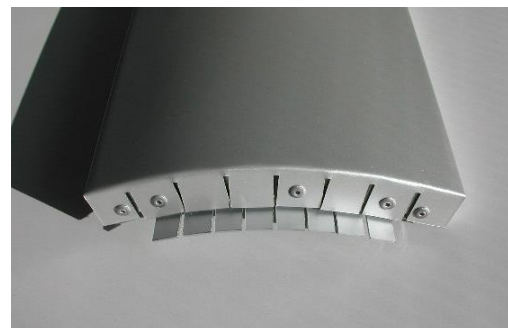
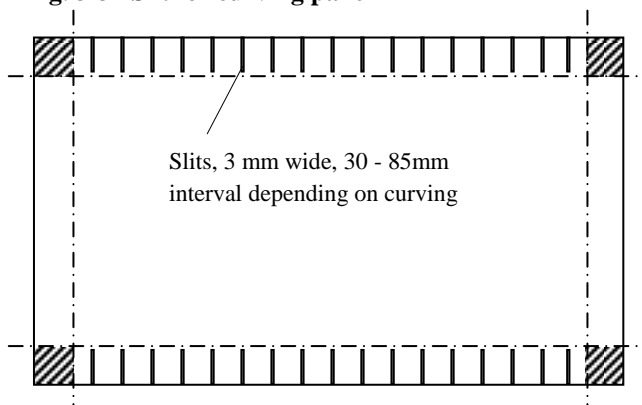
Support with aluminum plate



Curving panel

There are several alternative methods for designing curved panels, depending on the curve radius. However, the slit method below is versatile and applicable to a wide range of curving radii from 300 mm (for ALPOLIC/fr) or 600 mm (for ALPOLIC A2) to 3000 mm R. In this method, prior to bending, we make 3mm-wide slits on the top and bottom at a certain interval. The suitable interval depends on the curving radius and it is 30 to 85 mm (in 300 to 3000 mm R). We use an equation to calculate the suitable interval of slits. If the curving radius is larger than 3000 mm R, we can bend the panel without slits with a regular 3-roll bender. Refer to Fig.3-31 below.

Fig. 3-31 Slit for curving panel



Special panel details

We sometimes encounter unusual designs including 3-dimensional shapes. Mostly, the required quantity is only several pieces, but we wish to try to fabricate the ALPOLIC panels in such a manner that they achieve long-lasting performance with satisfactory appearance. Several examples are attached in "Appendix 8: Examples of complicated panels" in Section 4 for your reference. If you have similar difficulties in an actual project, please contact local distributors or our office. We would like to study together.

7. Examples of fixing method

As for the installation of Aluminum Composite Material (ACM), many advanced methods have been proposed and improved on for years. We will introduce some of the most common methods suitable for ALPOLIC below.

Contents of drawing:

- (1) External wall cladding – wet sealant joint
- (2) External wall cladding – hanging method
- (3) External wall cladding – dry gasket joint
- (4) External wall cladding – narrow open joint
- (5) Roof covering
- (6) Back panel of glass curtain wall
- (7) Sunshade or cornice
- (8) Ceiling panel with non-penetrating rivet
- (9) Parapet and soffit, renovation
- (10) Corporate shop front signboard
- (11) Roof of pedestrian passage

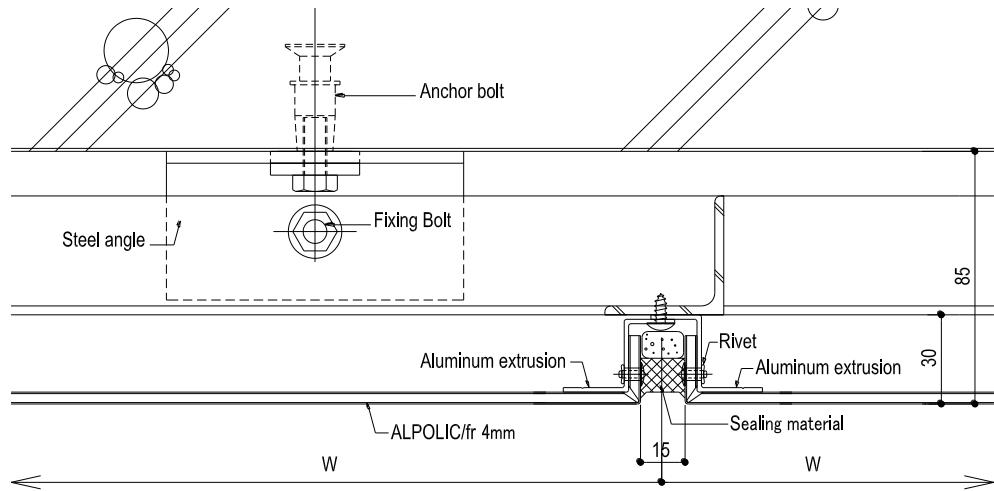
Note

The determination of suitability for use, design, fabrication, installation, and interface with other products of the ALPOLIC materials is the sole responsibility of the purchaser. The information contained on this Technical Manual is for conceptual use only. Mitsubishi Chemical Corporation shall have no responsibility or liability for the products usage or infringement of any patent or other proprietary right.

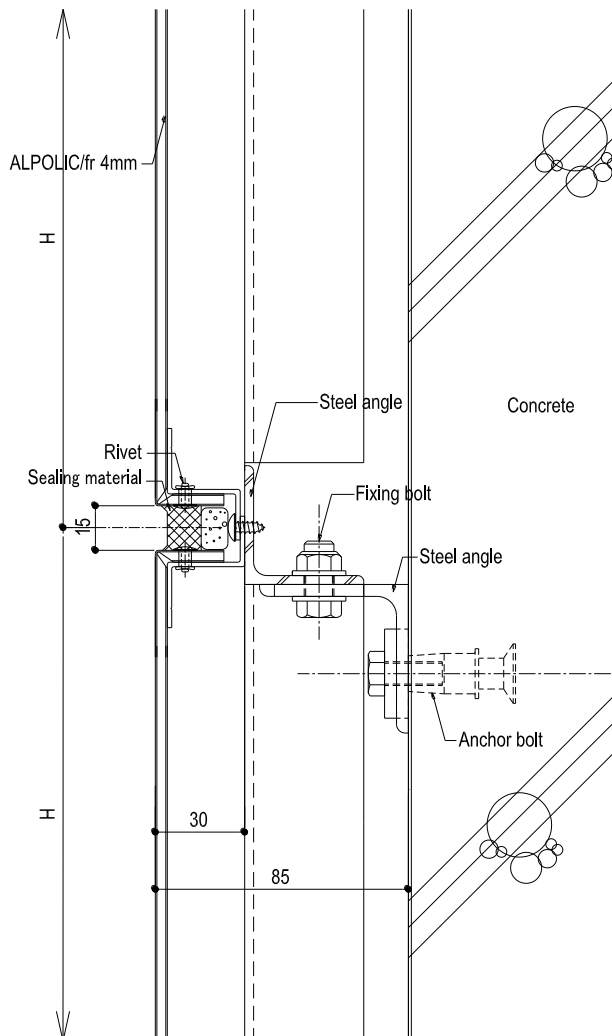
(1) External wall cladding - wet sealant joint

This installation system, with tray type (rout and return) panels and sealing joints, is one of the most common methods and it is available for a wide range of new buildings and renovation projects. After fixing ALPOLIC panels on the substructure, we apply a suitable sealing material to the joints in order to ensure water-tightness.

Horizontal section



Vertical section

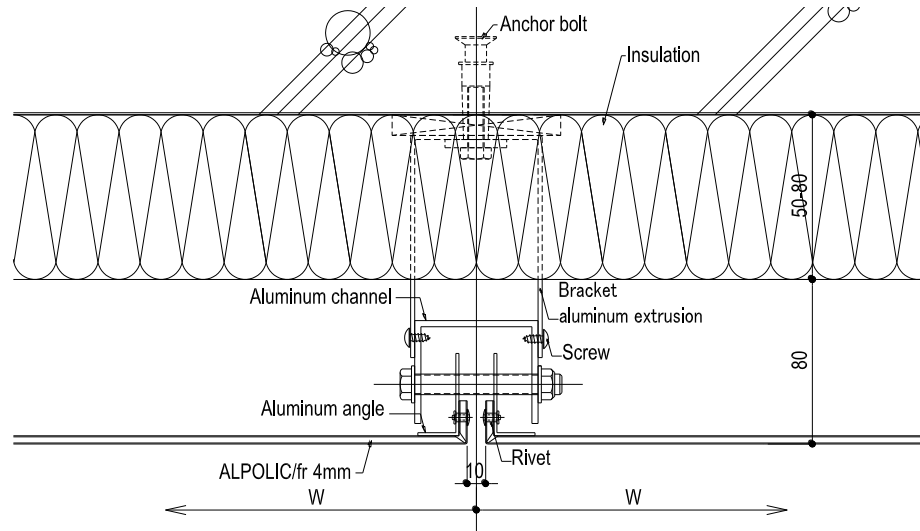


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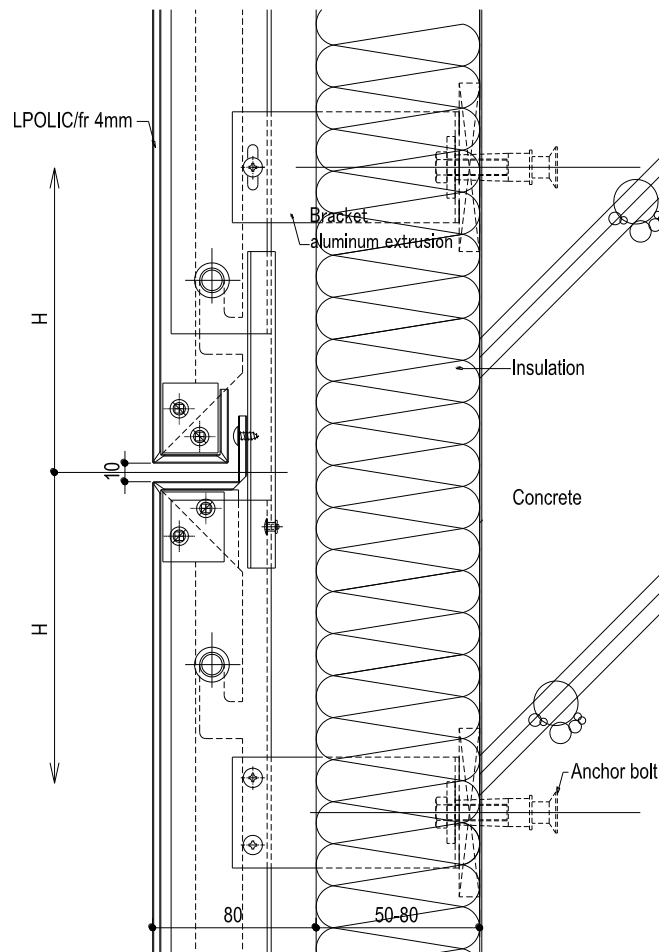
(2) External wall cladding - hanging method

The hanging system is also one of the most common fixing methods. It simplifies the installation work at the construction site and hence we can shorten the installation period. It is easy to loosen the movement due to thermal expansion/contraction with this method, because panels are not tightly fastened to the sub-frame but are simply suspended.

Horizontal section



Vertical section

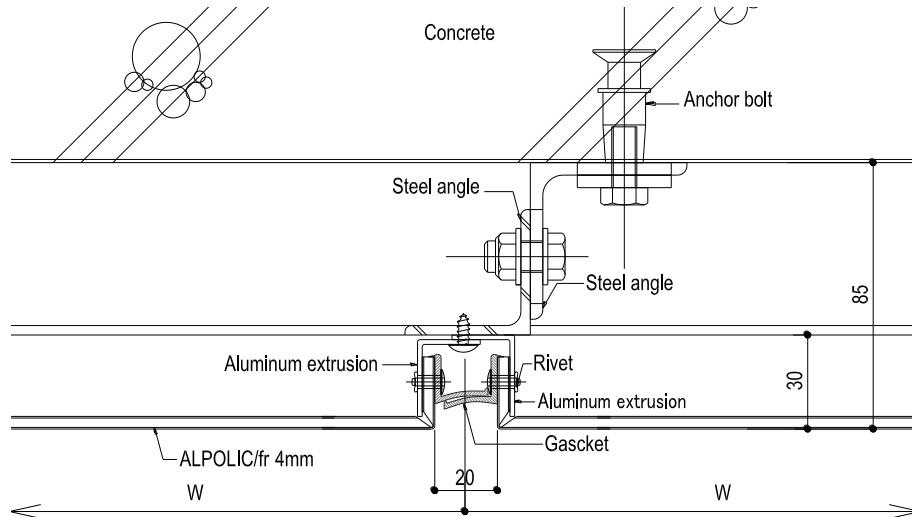


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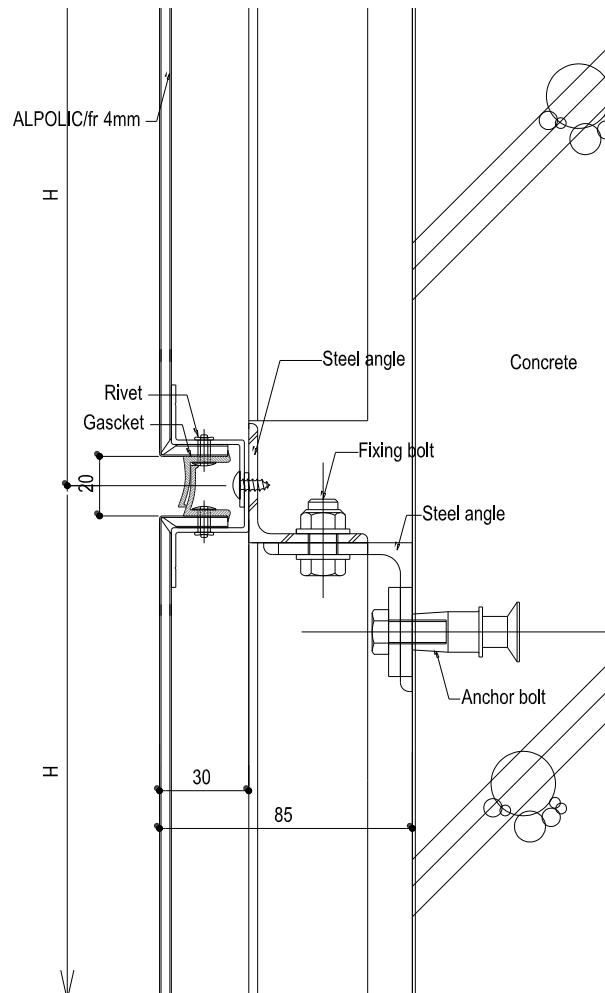
(3) External wall cladding - dry gasket joint

In this method, we use gaskets in the joints instead of sealants. The durability of EPDM gaskets is comparable to that of the sealant, in addition, the gasket joint reduces the amount of dirt or stain on ALPOLIC surface.

Horizontal section



Vertical section

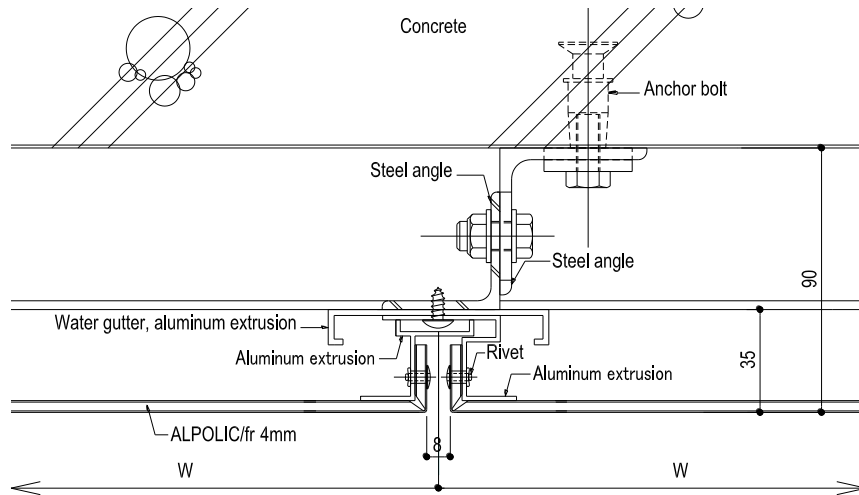


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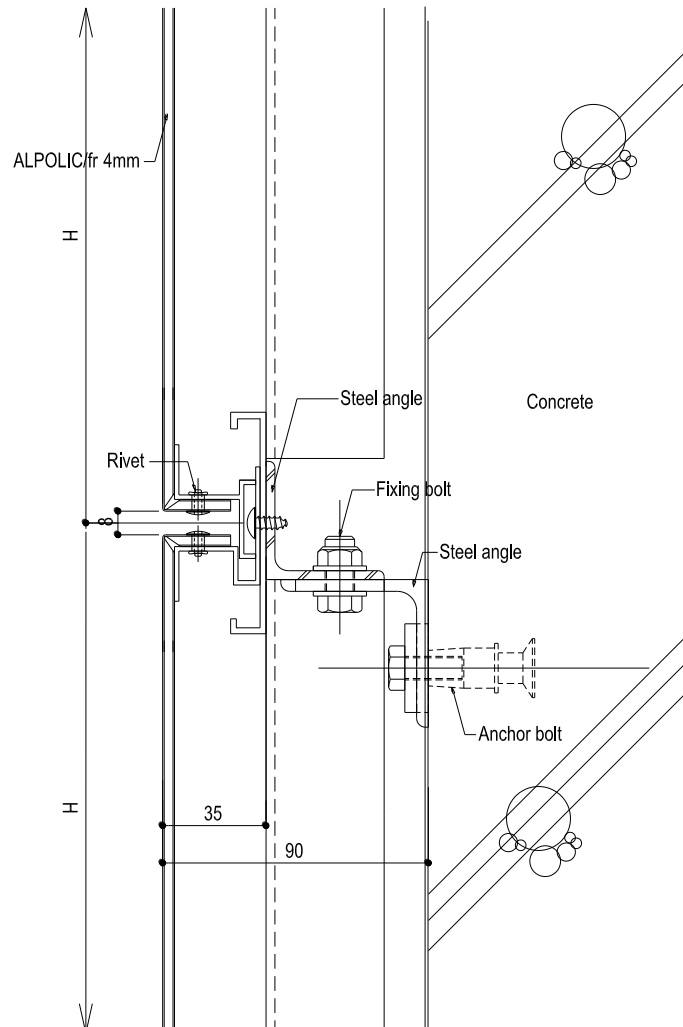
(4) External wall cladding – narrow open joint

Generally, this kind of method is suitable for Stone and Timber-patterned ALPOLIC panels in which narrow joints between the panels are aesthetically effective. According to need, we apply a sealing material or EPDM gasket to the joints.

Horizontal section



Vertical section

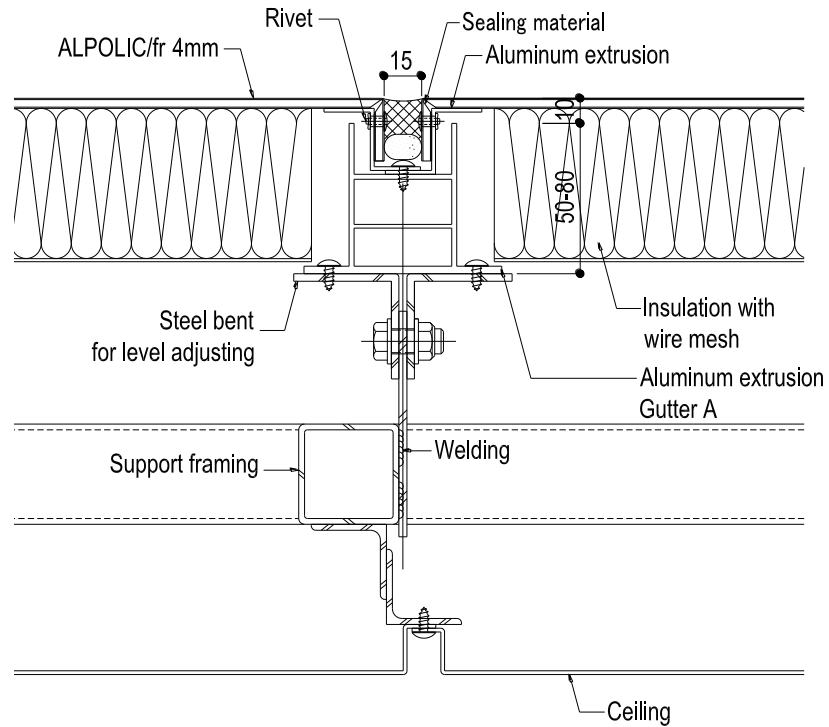


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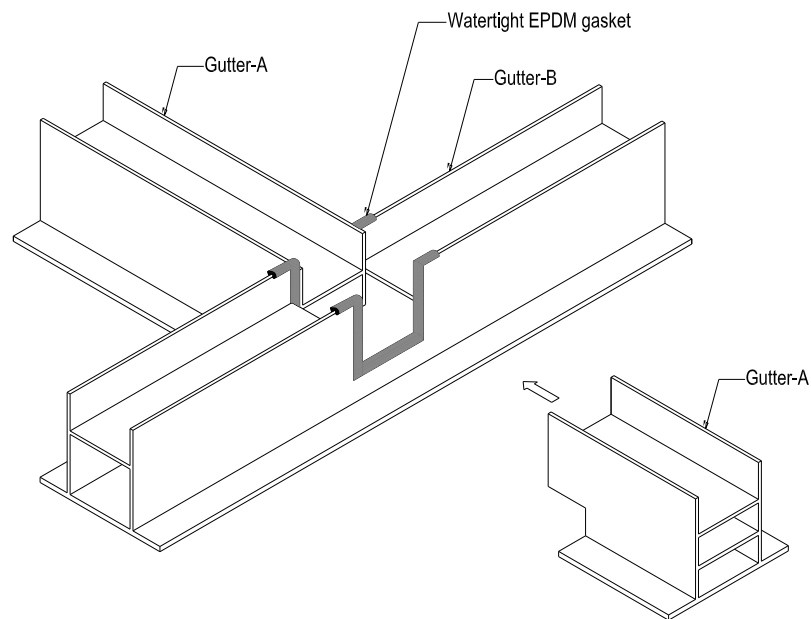
(5) Roof covering

ALPOLIC has been used for roof covering in prestigious projects such as airports and stadiums. In roof applications, we install a water gutter or waterproof sheets behind ALPOLIC panels so that leaked water can drain outside.

Typical section



Gutter system

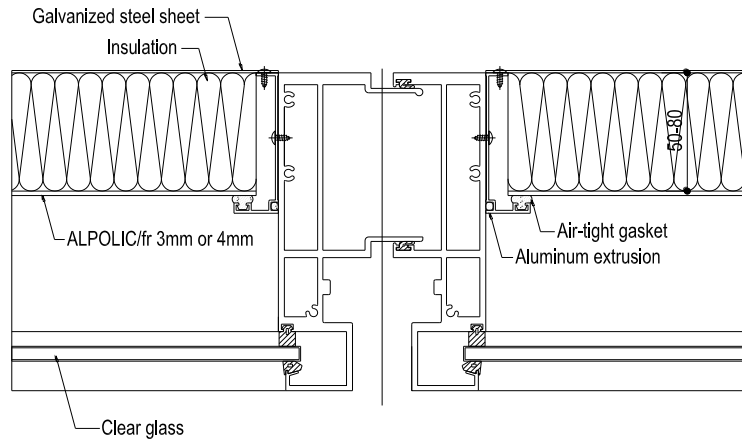


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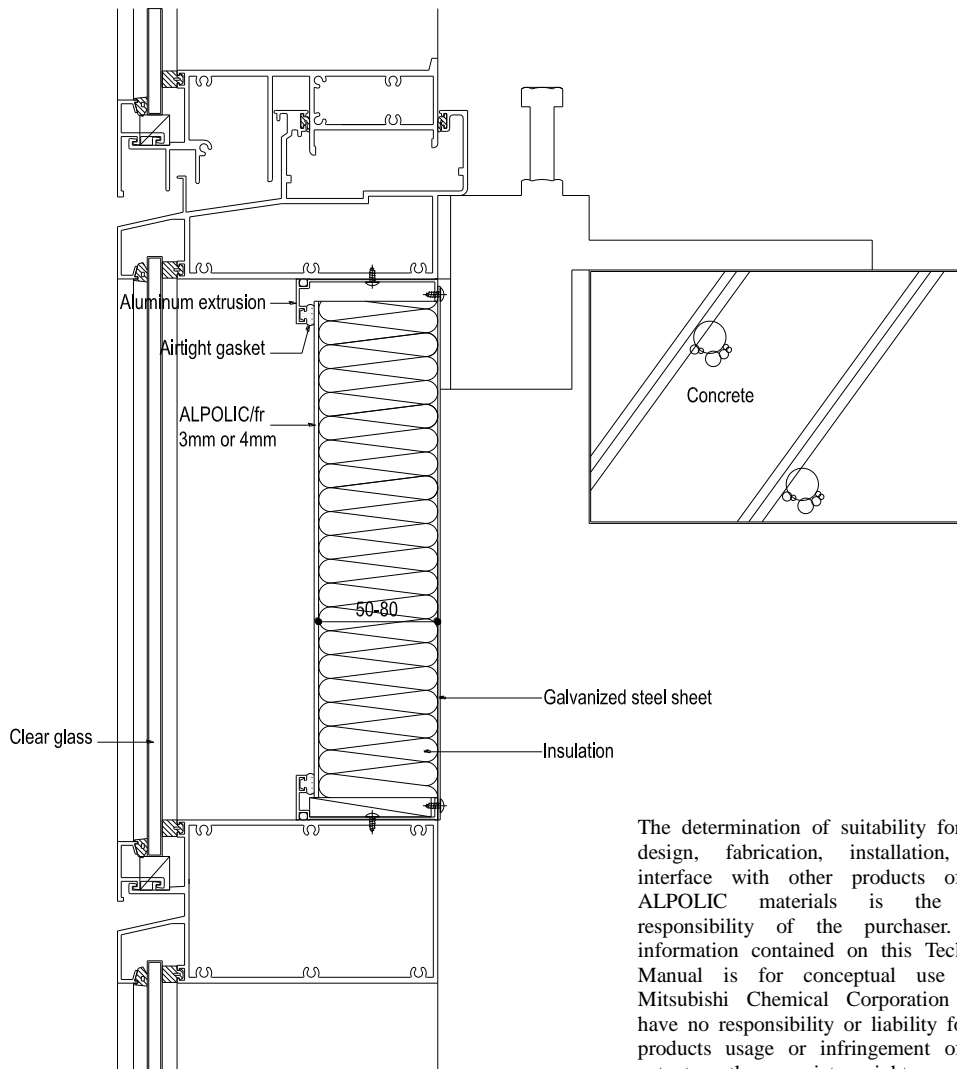
(6) Back panel of glass curtain wall

Glass curtain walls sometimes need an opaque spandrel panel (back panel) behind glass for aesthetic and energy-saving purpose. The spandrel back panels behind the glass must be very durable especially to UV exposure, because it is hard to replace them after the building is completed. ALPOLIC is the perfect material for such applications.

Horizontal section



Vertical section

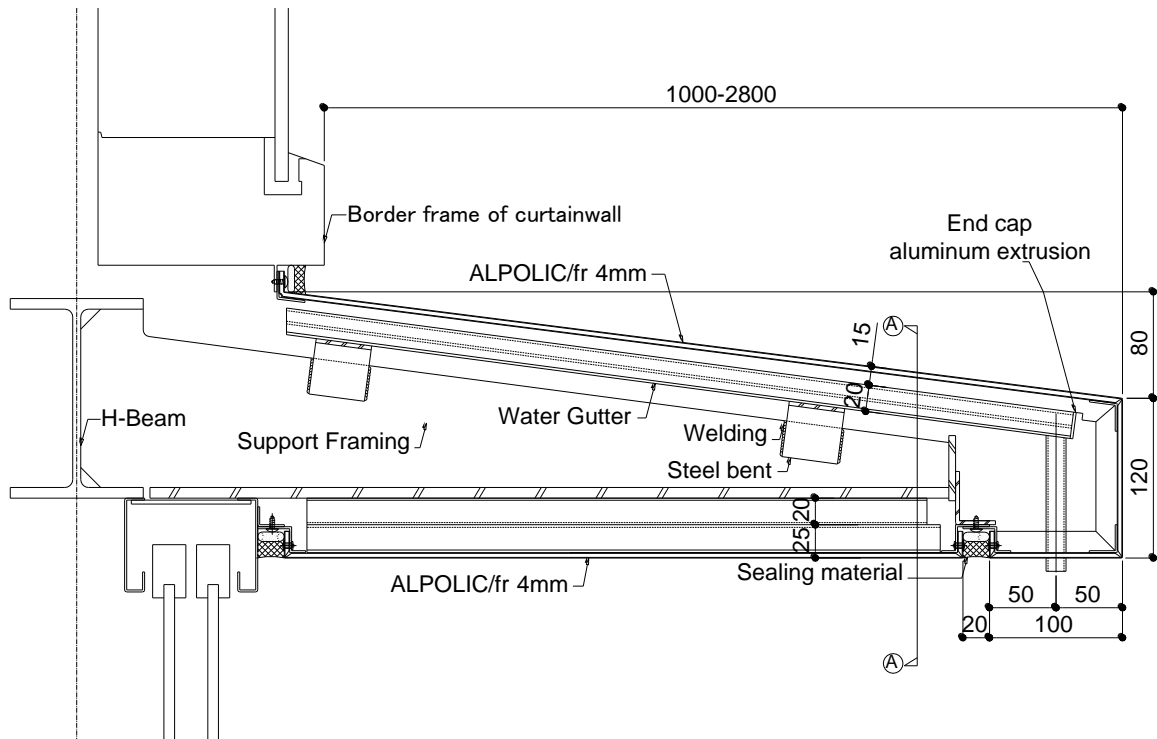


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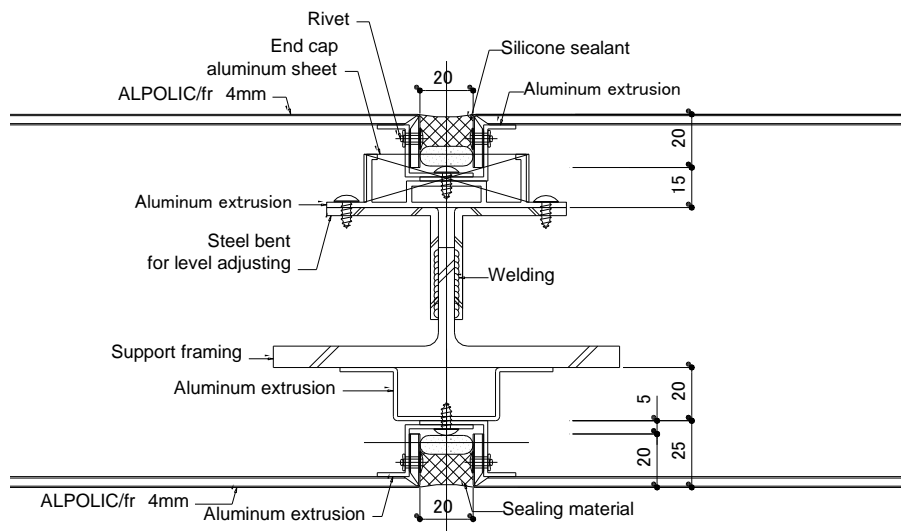
(7) Sunshade or cornice

ALPOLIC is sometimes used for sunshade or the cornice of a building wall. In this type of application, normally steel or aluminum frames are used as reinforcement behind ALPOLIC.

Typical section



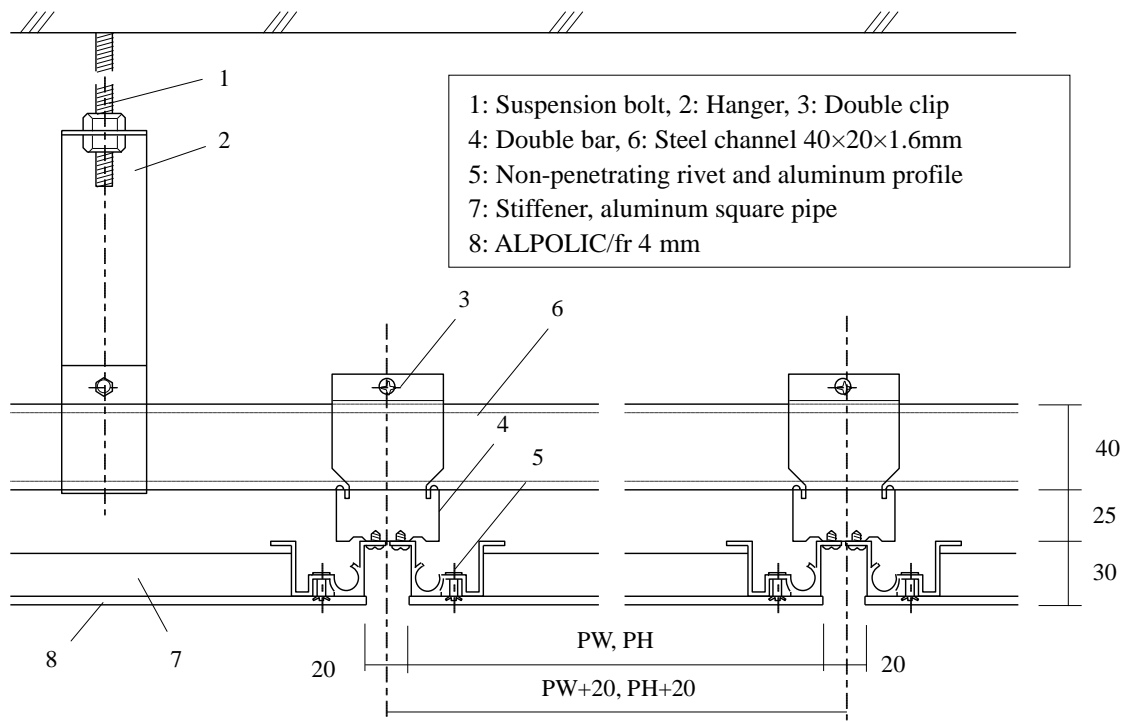
A-A section



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(8) Ceiling panel with non-penetrating rivet

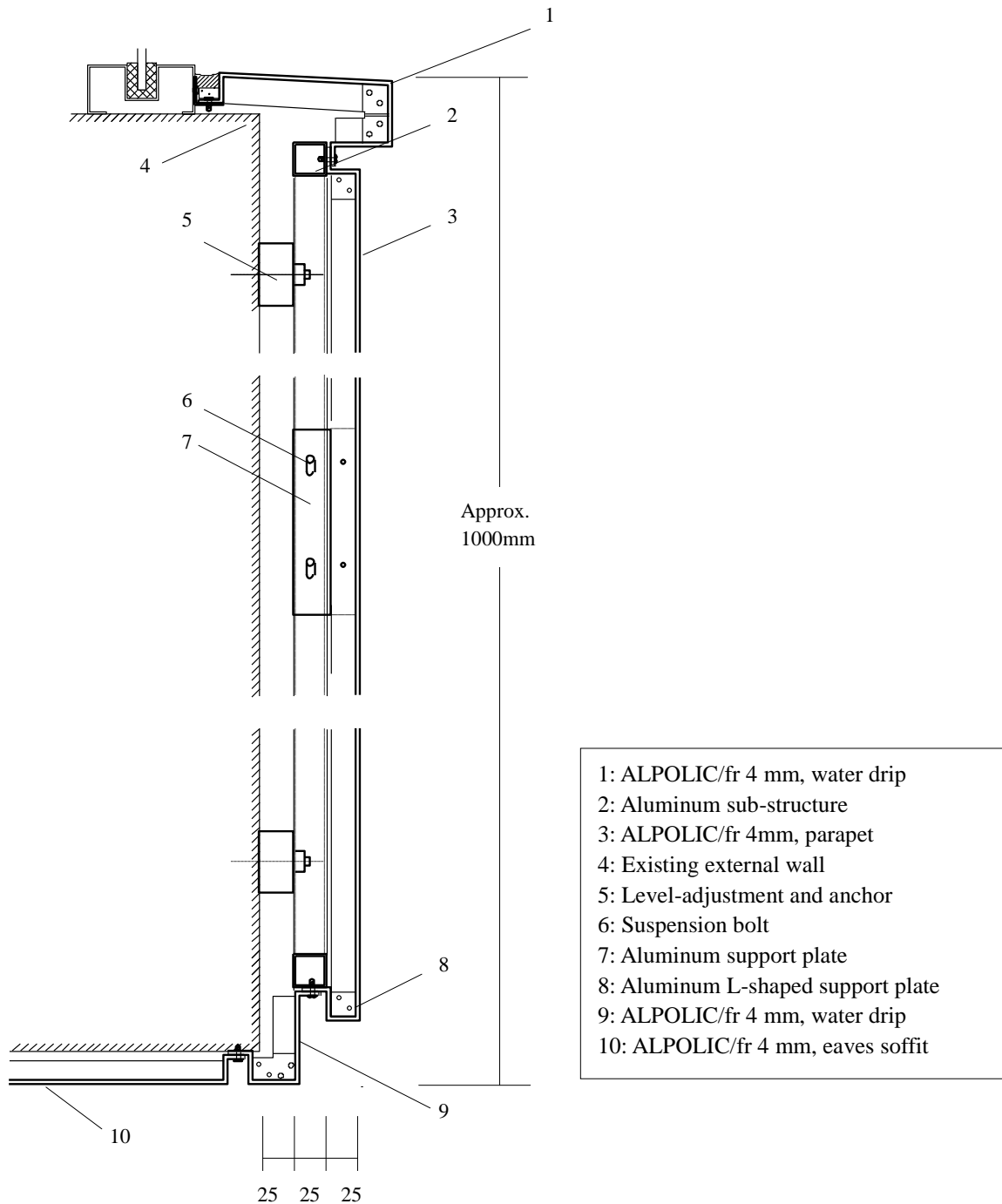
When we use ALPOLIC for indoor ceilings or soffits, non-penetrating rivets simplify the panel details. Non-penetrating rivets are usable **only on low-gloss finishes (30% or less)**. If we use these rivets on medium to high gloss products, the trail of the concealed rivet is visible from front. The design strength of the non-penetrating rivet is approx. 300 N/piece not including the safety factor. Refer to “Appendix 7: Modified non-penetrating rivet” in Section 4. In this method, we install fabricated ALPOLIC panels on lightweight suspension bar ceiling systems.



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(9) Parapet and soffit, renovation

ALPOLIC is widely used for parapets and soffits in building renovation. ALPOLIC is used for the water drip, parapet and soffit in the following detail.

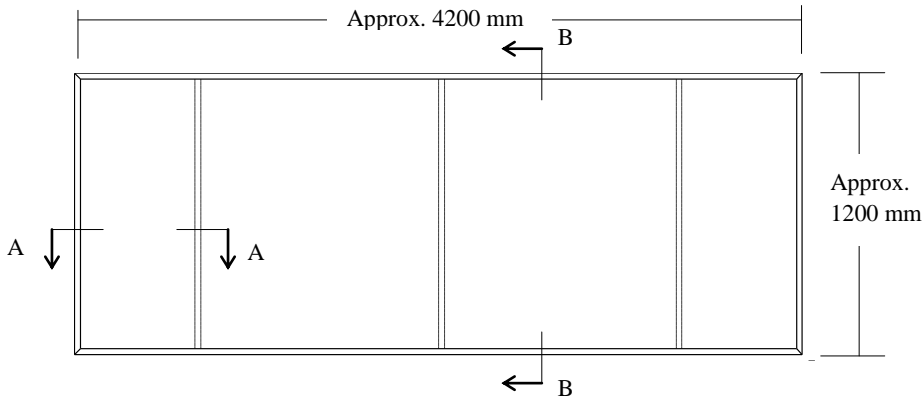


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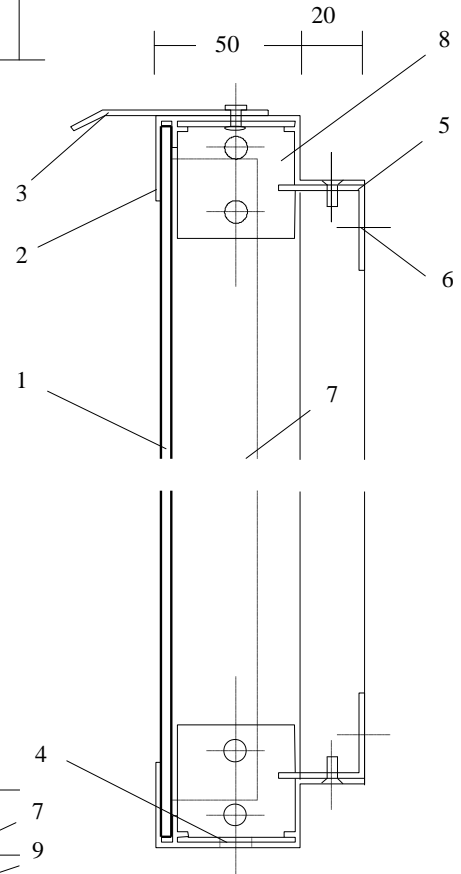
(10) Corporate shop front signboard

This corporate signboard is a shop front sign of a countryside newspaper company in Japan. The signboard has signs by 3M's Scotchcal film. The aluminum flanges are coated with the same color as ALPOLIC.

Elevation

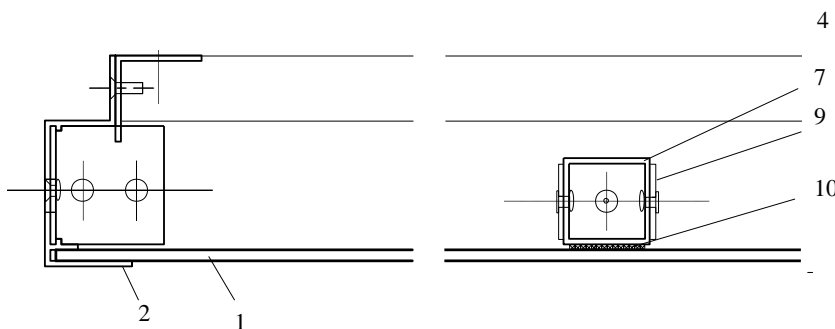


B-B section



1. ALPOLIC 4 mm having signs (logotype, letterings) by Scotchcal film
2. Aluminum flange coated with the same color of ALPOLIC
3. Water drip
4. Drain hole
5. Steel sub-structure, L-30×30, coated
6. Anchor
7. Stiffener, aluminum square pipe, 30×30×2
8. Corner support plate, aluminum L-40×40
9. Aluminum channel (top & bottom only)
10. VHB tape

A-A section

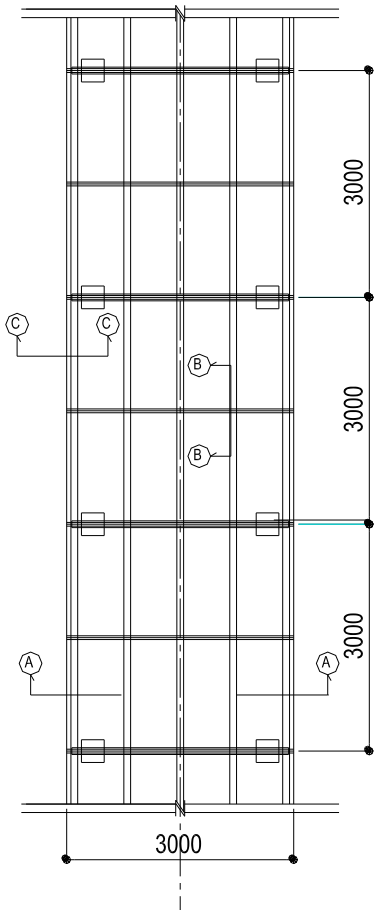


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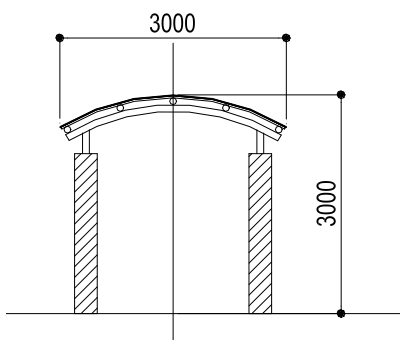
(11) Roof of pedestrian passage

ALPOLIC has been used as roof panels of public pathways and bus stations. Refer to an application photograph in P. 11. ALPOLIC panels are just clamped between sub-frames and aluminum extrusions. In most projects, the curving panels can be naturally curved without a mechanical bending.

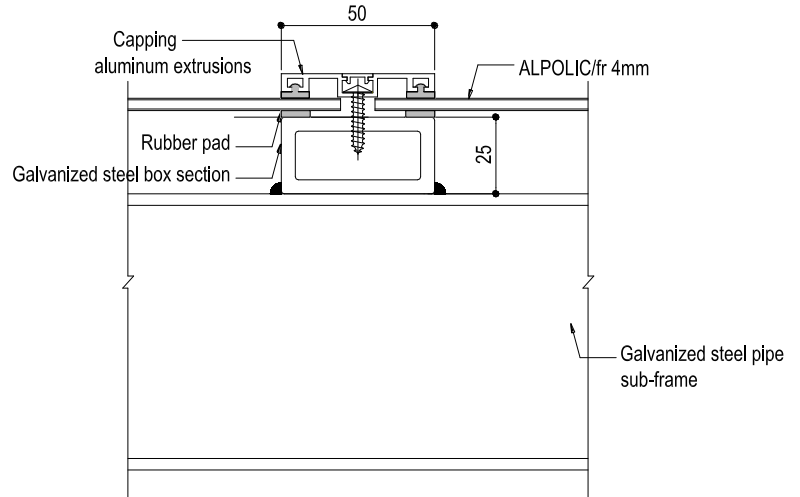
Plan



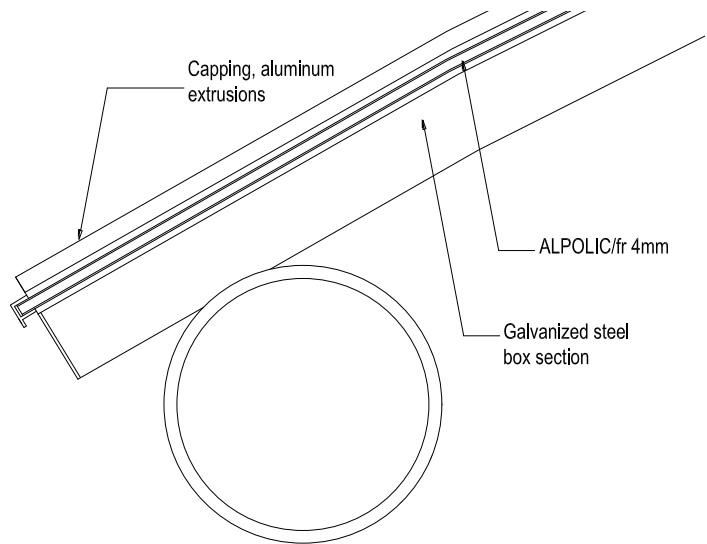
A-A section



B-B section



C-C section



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8. Overview of installation work

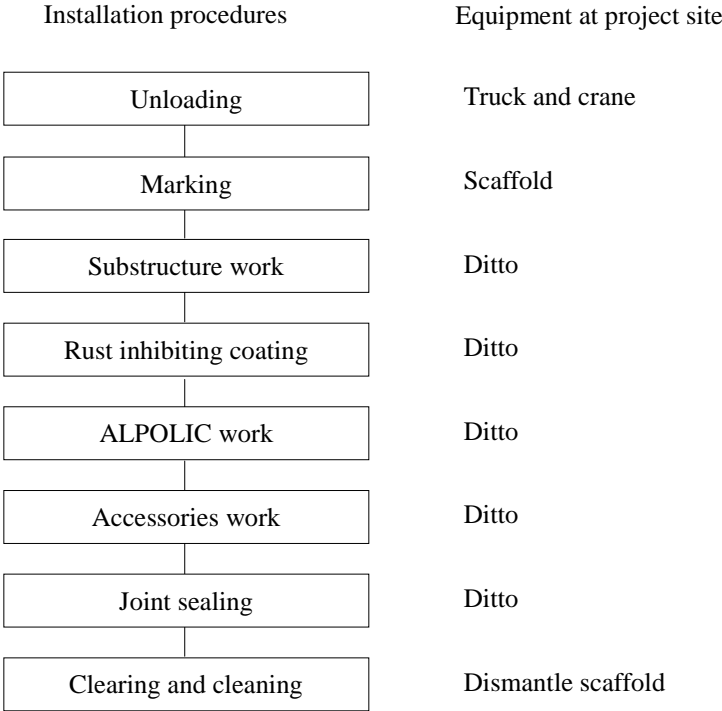
(1) General

Installation work accounts for a substantial part of the entire ALPOLIC work. Supposedly, the best installation procedures will be chosen from many aspects including quality, construction period and its cost. In this chapter, we would like to look over the basics of installation procedures of ALPOLIC, taking a small to medium scale external cladding project as an example.

When we install fabricated panels at project site, we implement the installation work in accordance with the drawings and specifications of the project. In the event that we find some discrepancy between drawings and the actual conditions at project site, we have to report to and consult with the project controller.

(2) Installation procedures

General installation work consists of the following procedures:



(3) Comments on each procedure

a. Unloading

Unload ALPOLIC panels on the roof, on each floor or suitable places on site. The unloaded panels on each floor will be just those required for the relevant floor. Fasten the panels together with rope and a covering sheet for protection.

b. Marking

Confirm the reference line in the presence of a superintendent. Mark the installation line, based on the reference line and the approved shop drawing.

c. Substructure work

In order to install the substructure, weld steel bracket pieces onto hole-in anchors (example of bracket: L-50×50×4 mmt, L = 70 mm). Weld continuous steel angles onto the brackets (example of continuous angle: L-40×40×3 mmt). All the angles will be finished with rust inhibiting coating, which conforms to the project standard. To prevent fire during welding, pay attention to sparks that drop on the cover sheet and veneer. During the substructure work, check the level with a flush thread and plumb-bob line, or water level, if necessary.

d. Rust inhibiting coating

Apply rust inhibiting paint onto all the welded points including the back and edge. The paint and coating thickness must conform to the project standard

e. ALPOLIC work

Mark the installation line in accordance with the shop drawing. Fix ALPOLIC panel onto the substructure with self-tapping screws, 4 mm in diameter, after confirming the position of the panel (left, right, top and bottom). The fixing interval will be normally 300 – 400 mm depending on the strength calculation. After confirming the fixed conditions, peel off the protective film and clear the removed film.

f. Accessories work

Bring the accessories to the scaffold passage, as indicated in the shop drawing. The quantity of accessories brought to the scaffold passage must be kept to a minimum to avoid dropping and other accidents. Lay large accessories diagonally on scaffold passage.

Mark the installation line onto the substructure to meet the position of the window frame. Fix the accessory with self-tapping screws, 4mm in diameter, with @300mm interval. After installation, check the installed level and precision. After the check, peel off the protective film. Clear the removed film.

g. Joint sealing

Use the sealing material as specified in the project and apply the joint design (width and height) as instructed from the sealant manufacturer. Typical sealing work includes cleaning of the joints, inserting back-up material, applying masking tape, applying primer, filling with sealant, tooling with palette knife, removing masking film and curing. As improper sealing work will affect the appearance and the waterproofing performance of the joint, the sealing work must be conducted exactly based on the instructions from sealant manufacturer.

h. Clearing and cleaning

Clear and clean the working area every day after work. Especially, when the work is complete in a zone, clear, clean and transfer the area smoothly to the next location, in order to avoid hindering the next stage. Collect and clear unnecessary remains to the dump point everyday or transport out of the site immediately.

9. Touch-up coating method

When we need to repair scratches on the coating surface of ALPOLIC, we can repair (touch-up) them at room temperature. We use an air-cured type of Lumiflon™-based fluoropolymer paint for repair coating. The air-cured type paint consists of 2 components: main agent and hardener. Mix them with 13:1 ratio (main agent: hardener) and stir the mixture before use.

After application, the air-cured type paint will reach surface dry in 1 hour and will show a satisfactory coating performance in a couple of weeks. However, the touched-up portion may show a slightly different appearance, because the coating appearance depends on the coating method. Especially in Metallic Colors and Sparkling Colors, even an exactly matched paint may show a slightly different appearance. In Stone, Timber and Metal finishes, we use an intermediate solid color diluted with a clear paint for touch-up. The suitable dilution rate is, depending on the color, 10 - 90% of clear content. Regarding the touch-up procedures, refer to “Appendix 9: Touch-up coating method” in Section 4.

10. Cleaning method

(1) Removal of light surface soiling

Prior to applying a cleaner, we recommend a forceful water rinse cleaning from top to bottom. Low water volume with moderate pressure is better than considerable water volume with little pressure. Simultaneous physical rubbing is also effective. Use a soft sponge or soft rags fully soaked in water.

- a. Apply a water rinse with moderate pressure to dislodge the soiling. If this does not remove the soiling, test a simultaneous water rinse with a sponge. If the soiling is still adhering after dry, test a diluted mild detergent.
- b. When you use a diluted mild detergent, use it with soft sponges or soft rags. Wash the surface with uniform pressure and clean the surface in a horizontal motion first and then in a vertical motion.
- c. Minimize the drip and splash of the mild detergent and rinse the rundown immediately to avoid streaking. Clean the surface from top to bottom and follow with a thorough rinse with clean water.

(2) Cleaning of medium to heavy surface soiling

In order to remove medium to heavy soiling caused by grease and sealing material, some type of alcohol such as IPA (Isopropyl Alcohol), ethanol or N-hexane is used. Dilute these alcohols by 50% with water. Strong solvents or solvents-containing cleaners may have a detrimental effect on the coating surface. Do a spot test on a small unseen area. Wash the residues with mild soap and rinse with water.

(3) Caution

- a. Strong solvents and strong cleaner may cause damage to the coating. Do a spot test on a small unseen area.
- b. Avoid abrasive cleaner. Do not use household cleaners containing abrasives.
- c. Do not rub excessively as it may change the coating appearance.
- d. Avoid drips and splashes. Remove the rundown as soon as possible.

- e. Avoid extremely high and low temperatures. Extremely high temperatures will accelerate the chemical reaction, evaporate water from the solution and cause streaking. Extremely low temperatures will result in a poor cleaning effect. Perform cleaning work on a shaded side of the building under moderate temperatures.
- f. Do not use paint removers, strong alkali or acid cleaners. Do not use strong organic solvents such as MEK (Methyl Ethyl Ketone), MIBK (Methyl Isobutyl Ketone), Treclene (Tri-chloroethylene) or thinner.
- g. Make sure that cleaning sponges and rags are grit free.
- h. Do not mix cleaners.

(4) Practical cleaning method

Cleaners and detergents are normally local products. A cleaner or a detergent widely available in one country may not be available in another country. We attached an example of a practical cleaning method in “Appendix 10: Example of practical cleaning method” in Section 4. To confirm the harmlessness of your cleaner, contact local distributors or our office. We will perform a test with your cleaner sample.

11. Panel dimension and tolerance

For your planning (design) work of fabrication and installation, we excerpt the panel dimensions and tolerances here from the product specifications.

(1) Product dimension

	ALPOLIC A2	ALPOLIC/fr		
Thickness (mm)	4	3	4	6
Weight (kg/m ²)	8.4	6.0	7.6	10.9
Width ^{Note 1}	965, 1270 or 1575 mm (for user’s selection)			
Length	Less than 7200 mm (for user’s selection)			

Note 1: Custom width is available between 914 mm and 1575 mm subject to minimum quantity. Contact local distributors or our sales office.

Note 2: (Edge condition) ALPOLIC has cut edges without aluminum sheet displacement or core protrusion.

(2) Product tolerance

Width:	±2.0 mm
Length:	±1.0 mm/m
Thickness:	±0.2 mm in 3 and 4 mm thick, ±0.3 mm in 6 mm thick
Bow:	Maximum 0.5% (5mm/m) of the length or width
Diagonal difference:	Maximum 5.0 mm

ALPOLIC™

Section 4 Appendices

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Appendix 1: Technical Data Sheets

[Technical Data Sheet - ALPOLIC™/fr Painted Finish]

1. General

ALPOLIC™/fr is an aluminum composite material (ACM) with a fire-retardant core, used as exterior and interior claddings and roof covering in new buildings and retrofit applications. The material is manufactured by Mitsubishi Chemical Corporation, and furnished by approved dealers or distributors.

Note: This summary of technical data is about ALPOLIC™/fr. If you need ALPOLIC™ composed of polyethylene core, which is mainly used for signage applications, please kindly contact our local distributors or our office.

Technical data may be changed in part without affecting the material quality.

2. Product composition

ALPOLIC/fr is composed of a fire-retardant core sandwiched between two skins of 0.5mm thick aluminum alloy:

Composition	Skin material:	0.5 mm thick aluminum alloy (3005-H14 or 3105-H14)
	Core material:	mineral-filled fire-retardant core

ALPOLIC/fr consists of approximately 70% of mineral ingredients within the core material. The core contains a trace of carbon black additives that improves its durability.

The surface is finished with a high-performance Lumiflon™-based fluoropolymer coating as standard, and the back side is a wash coating or a service coating. ALPOLIC/fr is available in finishes of: Solid Colors, Metallic Colors, Sparkling Colors, Prismatic Colors and Patterns. In these finishes, Lumiflon™-based fluoropolymer paints are applied in manufacturer's continuous coil coating lines.

The back side of ALPOLIC/fr, which will face the structural wall or steel when it is installed as a cladding panel, has a polyester-based wash coating or a service coating to protect it from possible corrosion problems.

The surface is protected with a self-adhesive peel-off protective film consisting of two polyethylene layers of white and black. According to weathering tests under normal outdoor conditions, the protective film will withstand six months' exposure without losing its original peel-off characteristic or causing stains or other damages.

3. Product dimension and tolerance

(1) Panel thickness: 3 mm, 4 mm and 6 mm

(2) Panel size: Width = 965, 1270 and 1575 mm, Length = less than 7200 mm

Note: Custom width can be accepted between 914 mm and 1575 mm subject to minimum quantity. Please contact local distributors or our office.

(3) Product tolerance

Width: ±2.0 mm

Length: ±1.0 mm/m

Thickness: ±0.2 mm in 3 and 4 mm thick, ±0.3 mm in 6 mm thick

Bow: Maximum 0.5% (5mm/m) of the length or width

Square-ness (diagonal difference): Maximum 5.0 mm

Surface defect: The surface shall not have any irregularities such as roughness, buckling and other imperfections in accordance with our visual inspection rules. ALPOLIC/fr is supplied with a cut edge and without aluminum sheet displacement or core protrusion.

4. Principal properties

(1) Panel weight:

	Unit	3mm	4mm	6mm
Panel weight	kg/m ²	6.0	7.6	10.9

(2) Thermal expansion: $24 \times 10^{-6} / ^\circ\text{C}$

(3) Mechanical properties of Aluminum Composite Material (ACM):

	Unit	3mm	4mm	6mm
Tensile strength (ASTM E8)	MPa or N/mm ²	61	49	29
0.2% proof stress (ASTM E8)	MPa or N/mm ²	53	44	26
Elongation (ASTM E8)	%	4	5	2
Flexural elasticity, E (ASTM C393)	GPa or kN/mm ²	49.0	39.8	29.1

(4) Mechanical properties of aluminum alloy (3005-H14 or 3105-H14):

0.2% proof stress (ASTM E8): 150 MPa or N/mm²

Flexural elasticity (ASTM E8): 70 GPa or kN/mm²

(5) Deflection temperature: 115°C in 3mm, 116°C in 4mm and 109°C in 6mm

(6) Sound transmission loss (ASTM E413):

Thickness	4mm	6mm
STC (Standard Transmission Class)	27	29

5. Summary of fire tests

Extensive fire tests have been performed in accordance with standards in various countries. ALPOLIC/fr has passed the following fire tests around the world:

Table 5-1 Fire tests for general and external cladding material

Country	Test standard	ALPOLIC/fr specimen	Results & classification
EU	EN 13823, EN ISO 11925-2, EN 13501-1	4mm, 6mm	Class B-s1, d0
United Kingdom	BS476 Part 7	4mm, 6mm	Class 1
	BS476 Part 6	4mm, 6mm	Class 0
USA	NFPA 259-93 British Thermal Unit	4mm	Passed
	ASTM D1781 Climbing Drum Peel Test	4mm, 6mm	Passed
	ASTM E84, Steiner Tunnel Test	4mm, 6mm	Class A / Class 1
	ASTM E-108, Modified	4mm	Passed
	UBC 26-9 & NFPA 285, ISMA Test (Intermediate Scale Multi-story Apparatus)	4mm, 6mm	Passed (Subject to a fixing system)
Canada	CAN/ULC-S 134-92, Full-scale Exterior Wall Fire Test	4mm	Passed
China	GB8625, GB8626 & GB8627	4mm	Class B1
Japan	Heat Release Test for Non-combustible Material (ISO 5660-1)	4mm, 6mm	Passed Certificate No. NM-1933

Table 5-2 Fire tests for other categories

Category	Country	Test Standard	ALPOLIC/fr specimen	Results & classification
Fire resistant rating wall	USA	ASTM E119, 1-hr Fire Rating and 2-hr Fire Rating	4mm	Passed
Roof material	USA	ASTM E108, Fire Test for Roof Covering	4mm	Passed Class A
Interior material	USA	UBC 26-3, Interior Room Corner Test	4mm	Passed
		Combustion Toxicity Test, New York State Uniform Fire Prevention and Building Code	4mm	Passed
	Japan	Heat Release Test for Non-combustible Material (ISO 5660-1) & Toxicity Gas Test	3, 4, 6mm	Passed Certificate No. NM-1933

6. Paint finish

(1) Coating system

The surface is finished with Lumiflon™-based fluoropolymer coating as standard; the back is a wash coating or service coating. ALPOLIC/fr is available in finishes of: Solid Colors, Metallic Colors, Sparkling Colors, Prismatic Colors and Patterns (Stone, Timber, Metal, and Abstract). In these finishes, Lumiflon™-based fluoropolymer paints are applied in the manufacturer's coil coating lines.

The coating system of each finish is:

A. "Solid Colors" with three-coat three-bake system

The thickness is 30 microns (1.18 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based fluoropolymer coating and a clear coating.

B. "Metallic Colors", "Sparkling Colors" and "Prismatic Colors" are a three-coat three-bake system.

The thickness is 28 microns (1.1 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based metallic coating and clear coating.

C. "Patterns" is coated with a unique image transfer process.

The thickness is 45 microns (1.77 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based fluoropolymer coating and a clear coating including the image transfer layer.

Note 1: Lumiflon™-based fluoropolymer coating has basically a coating warranty for 10 years. However, 20 year-coating warranty is available subject to several conditions. Please contact local distributors or our office.

Note 2: ALPOLIC/fr is finished with Lumiflon™-based fluoropolymer paint as standard, but polyester and other coatings are also available as an option.

(2) Color and gloss

Standard colors are provided in the Color Chart. Custom colors are available for all finishes upon request subject to respective minimum quantities. The standard gloss is 30% for Solid and Metallic Colors, 30 to 80% for Sparkling Colors, 80% for Prismatic Colors, 15 to 80% for Patterns (Stone, Timber, Metal, and Abstract). Custom gloss is available between 15 and 80% in all colors upon request subject to minimum quantities. Please contact local distributors or our office for custom color requests.

(3) Coating performance

The Lumiflon™-based fluoropolymer coating meets the following criteria:

Table 6-1 General properties

Dry film property	Test method	Criteria
Gloss (60°)	ASTM D523	15 to 80%
Formability (T-bend)	NCCA II-19 ASTM D1737	2T, no cracking
Reverse impact-crosshatch	NCCA II-5	No pick off
Hardness-pencil	ASTM D3363	H
Adhesion		
Dry	ASTM D3359, method 8	No pick off
Wet	37.8 °C, 24 hrs.	No pick off
Boiling water	100 °C, 20 min.	No pick off
Abrasive resistance	ASTM D968 (Falling sand)	40 liters/mil
Chemical resistance		
Muriatic acid, 10% HCl, 72 hrs.	ASTM D1308	No change
Sulphuric acid, 20% H ₂ SO ₄ , 18 hrs.	ASTM D1308	No change
Sodium hydroxide, 20% NaOH, 1 hr.	ASTM D1308	No change
Mortar, pat test, 38 °C, 24 hrs.	AAMA 2605	No change
Detergent, 3% solution, 38 °C, 72 hrs.	ASTM D2248	No change

Table 6-2 Weatherability

Dry film property	Test method	Criteria
Weather-o-meter test		
Colour retention	ASTM D2244	Maximum 5 units after 4000 hrs.
Gloss retention	ASTM D523	70% after 4000 hrs.
Chalk resistance	ASTM D4214	Maximum 8 units after 4000 hrs.
Salt spray resistance	ASTM B117	Blister-10, scribe-8, after 4000 hrs., 35 °C salt fog
Humidity-thermal	ASTM D2246	No blister, no cracking After 15 cycles of 38 °C 100%RH for 24 hrs. and -23 °C for 20 hrs.
Humidity resistance	ASTM D2247	No change After 4000 hrs., 100%RH, 35 °C

The material properties or the test data in this leaflet are portrayed as general information only and a guide without warranty. Due to product changes, improvements and other factors, Mitsubishi Chemical Corporation reserves the right to change or withdraw information contained herein without prior notice.

[Technical Data Sheet - ALPOLIC™/fr reAL anodised]

1. General

ALPOLIC™/fr reAL anodised is an aluminum composite material (ACM) with a fire-retardant (fr) core, used as exterior and interior claddings and roof covering in new buildings and retrofit applications. The material is manufactured by Mitsubishi Polyester Film GmbH with the address, Kasteler Strasse 45/E512, 65203 Wiesbaden Germany, and furnished by approved dealers or distributors.

Technical data may be changed in part without affecting the material quality.

2. Product composition

ALPOLIC/fr is composed of a fire-retardant core sandwiched between two skins of 0.5mm thick aluminum alloy:

Composition	Skin material	(Top) 0.5mm thick aluminum alloy (5005-H14 or equivalent) (Back) 0.5mm thick aluminum alloy (3005-H14, 3105-H14, 5005-H14 or equivalent)
-------------	---------------	--

	Core material	mineral filled fire-retardant gray core
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ALPOLIC/fr consists of approx. 70% of mineral ingredients within the core material. The fire-retardant gray core contains a trace of carbon black additives that improves its durability but does not impair the original mechanical properties and fire performances.

The surface is finished with an anodic oxide layer by continuous process on an aluminium coil. Continuous anodising builds and enhances the surface oxidation using an electro-chemical process under precisely controlled conditions.

The back side of ALPOLIC/fr, which will face the structural wall or steel when it is installed as a cladding panel, has a polyester-based wash coating or a service coating to protect it from possible corrosion problems.

The surface is protected with a self-adhesive peel-off protective film consisting of two polyethylene layers of white and black. According to weathering tests under normal outdoor conditions, the protective film will withstand six months' exposure without losing its original peel-off characteristic or causing stains or other damages.

3. Product dimension and tolerance

- (1) Panel thickness: 4 and 6 mm
- (2) Panel size: Standard width = 1270 and 1575 mm
Maximum length = up to 7300 mm

(3) Product tolerance

Width: ± 2.0 mm

Length: ± 1.0 mm/m

Thickness: ± 0.2 mm in 4 mm thick, ± 0.3 mm in 6 mm thick

Bow: Maximum 0.5% (5mm/m) of the length or width

Square-ness (diagonal difference): Maximum 5.0 mm

Surface defect: The surface shall not have any irregularities such as roughness, buckling and other imperfections in accordance with our visual inspection rules. ALPOLIC/fr is supplied with a cut edge and without aluminum sheet displacement or core protrusion.

4. Principal properties

(1) Panel weight:

	Unit	4mm	6mm
Panel weight	kg/m ²	7.6	10.9

(2) Thermal expansion: $24 \times 10^{-6} / ^\circ\text{C}$

(3) Mechanical properties of ALPOLIC/fr:

	Unit	4 mm	6 mm
Tensile strength (ASTM E8)	MPa or N/mm ²	49	29
0.2% proof stress (ASTM E8)	MPa or N/mm ²	44	26
Elongation (ASTM E8)	%	5	2
Flexural elasticity, E (ASTM C393)	GPa or kN/mm ²	39	29

(4) Mechanical properties of aluminum alloy:

0.2% proof stress: 150 MPa or N/mm²

Flexural elasticity: 70 GPa or kN/mm²

(5) Deflection temperature: 116 °C in 4 mm and 109 °C in 6 mm

(6) Sound transmission loss (ASTM E413):

Thickness	4 mm	6 mm
STC (Standard Transmission Class)	27	29

5. Summary of fire tests

ALPOLIC/fr fluoropolymer coated finish has passed the following fire test.

Country	Test standard	Results & classification
EU	EN 13823, EN ISO 11925-2, EN 13501-1	Class B-s1, d0

As the top anodised layer has no organic components, ALPOLIC/fr reAL anodised can meet the fire performance requirement of the above test standards.

6. Anodised finish

The top surface is finished with anodic oxide layer and it is produced in a continuous anodising line on an aluminium coil. Continuous anodising builds and enhances the surface oxidation using an electro-chemical process under precisely controlled conditions. The anodic oxide layer is 8 micron thick. Comparing with conventional batch anodising process, the continuous anodising finish has excellent color uniformity.

7. Notes

- Panels from different production lots should not be mixed on a building elevation.
- Brake bend or other forming operation shall cause visible cracking on the surface.
- The panels should not be fabricated at temperatures lower than 10 deg. C.
- Panels should be stored flat in a dry indoor environment.

The material properties or the test data in this leaflet are portrayed as general information only and a guide without warranty. Due to product changes, improvements and other factors, Mitsubishi Chemical Corporation reserves the right to change or withdraw information contained herein without prior notice.

[Technical Data Sheet - ALPOLIC™ A2]

1. General

ALPOLIC™ A2 is an aluminum composite material (ACM) with a high fire-retardant core, used as exterior and interior claddings and roof covering in new buildings and retrofit applications.

Technical data may be changed in part without affecting the material quality.

2. Product composition

ALPOLIC A2 is composed of a superior fire-retardant core sandwiched between two skins of 0.5mm thick aluminum alloy:

Composition	Skin material:	0.5mm thick aluminum alloy (3005-H14 or 3105-H14)
	Core material:	high mineral filled fire-retardant core

The surface is finished with a high-performance Lumiflon™-based fluoropolymer coating as standard, and the back side is a wash coating or a service coating. ALPOLIC A2 is available in finishes of: Solid Colors, Metallic Colors, Sparkling Colors, Prismatic Colors and Patterns. In these finishes, Lumiflon™-based fluoropolymer paints are applied in a continuous coil coating line.

The back side of ALPOLIC A2, which will face the structural wall or steel when it is installed as a cladding panel, has a polyester-based wash coating or a service coating to protect it from possible corrosion problems.

The surface is protected with a self-adhesive peel-off protective film consisting of two polyethylene layers of white and black. According to weathering tests under normal outdoor conditions, the protective film will withstand six months' exposure without losing its original peel-off characteristic or causing stains or other damages.

3. Product dimension and tolerance

- (1) Panel thickness: 4 mm
- (2) Panel size: Standard width = 1270 and 1575 mm (JP)/ Maximum width = 2050 mm (DE)
Standard length = 3099 mm/ Maximum length = up to 7300 mm (DE)

Note: Custom width can be accepted between 914 mm and 1575 mm subject to minimum quantity. Please contact local distributors or our office.

(3) Product tolerance

- Width: ±2.0 mm
- Length: ±1.0 mm/m
- Thickness: ±0.2 mm
- Bow: Maximum 0.5% (5mm/m) of the length or width
- Square-ness (diagonal difference): Maximum 5.0 mm
- Surface defect: The surface shall not have any irregularities such as roughness, buckling and other imperfections in accordance with our visual inspection rules. ALPOLIC A2 is supplied with a cut edge and without aluminum sheet displacement or core protrusion.

4. Principal properties

- (1) Panel weight: 8.4 kg/m²
- (2) Thermal expansion ratio: $19 \times 10^{-6} / ^\circ\text{C}$

(3) Mechanical properties of ALPOLIC A2 as an aluminum composite material:

Item	Unit	
Tensile strength (ASTM E8)	MPa or N/mm ²	43
0.2% proof stress (ASTM E8)	MPa or N/mm ²	41
Elongation (ASTM E8)	%	3.8
Flexural elasticity (ASTM C393)	GPa or kN/mm ²	38.5

(4) Mechanical properties of aluminum skin metal:

0.2% proof stress: 150 MPa or N/mm²
 Elasticity: 70 GPa or kN/mm²

(5) Deflection temperature (ISO 75-2): 110 °C

(6) Sound transmission loss (ASTM E413): STC (Standard Transmission Class) 27

5. Summary of fire tests

ALPOLIC A2 has passed the following fire tests:

Table 5-1 Fire tests for general and external cladding material

Country	Test standard	Results & classification
EU	EN 13823, EN ISO 1716, EN 13501-1	Class A2-s1, d0

6. Paint finish

(1) Coating system

The surface is finished with Lumiflon™-based fluoropolymer coating as standard; the back side is a wash coating or a service coating. ALPOLIC A2 is available in finishes of: Solid Colors, Metallic Colors, Sparkling Colors, Prismatic Colors and Patterns (Stone, Timber, Metal, and Abstract). In these finishes, Lumiflon™-based fluoropolymer paints are applied in the coil coating lines.

The coating system of each finish is:

A. “Solid Colors” are three-coat three-bake system.

The thickness is 30 microns (1.18 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based fluoropolymer coating and a clear coating.

B. “Metallic Colors”, “Sparkling Colors” and “Prismatic Colors” are a three-coat three-bake system.

The thickness is 28 microns (1.1 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based metallic coating and a clear coating.

C. “Patterns” is coated with a unique image transfer process.

The thickness is 45 microns (1.77 mils) minimum and consists of a conversion coating, an inhibitive primer, a Lumiflon™-based fluoropolymer coating and a clear coating including the image transfer layer.

Note 1: Lumiflon™-based fluoropolymer coating has basically a coating warranty for 10 years. However, 20 year-coating warranty is available subject to several conditions. Please contact local distributors or our office.

Note 2: ALPOLIC A2 is finished with Lumiflon™-based fluoropolymer paint as standard, but polyester and other coatings are also available as an option.

(2) Colors and gloss level

Standard colors are provided in the Color Chart. Custom colors are available for all finishes upon request subject to respective minimum quantities. The standard gloss is 30% for Solid and Metallic

Colors, 30 to 80% for Sparkling Colors, 80% for Prismatic Colors, 15 to 80% for Patterns (Stone, Timber, Metal, and Abstract). Custom gloss is available between 15 and 80% in all colors upon request subject to minimum quantities. Please contact local distributors or our office for custom color requests.

(3) Coating performance

The Lumiflon™-based fluoropolymer coating meets the following criteria:

Table 6-1 General properties

Dry film property	Test method	Criteria
Gloss (60°)	ASTM D523	15 to 80%
Formability (T-bend)	NCCA II-19 ASTM D1737	2T, no cracking
Reverse impact-crosshatch	NCCA II-5	No pick off
Hardness-pencil	ASTM D3363	H
Adhesion		
Dry	ASTM D3359	No pick off
Wet	37.8°C, 24 hrs.	No pick off
Boiling water	100°C, 20 min.	No pick off
Abrasive resistance	ASTM D968 (Falling sand)	40 liters/mil
Chemical resistance:		
Muriatic acid, 10% HCl, 72 hrs.	ASTM D1308	No change
Sulphuric acid, 20% H ₂ SO ₄ , 18 hrs.	ASTM D1308	No change
Sodium hydroxide, 20% NaOH, 1 hr.	ASTM D1308	No change
Mortar, pat test, 24 hrs.	AAMA2605	No change
Detergent, 3% solution, 38 °C, 72 hrs.	ASTM D2248	No change

Table 6-2 Weatherability

Dry film property	Test method	Criteria
Weather-o-meter test		
Colour retention:	ASTM D2244	Maximum 5 units after 4000 hrs.
Gloss retention:	ASTM D523	70% after 4000 hrs.
Chalk resistance:	ASTM D4214	Maximum 8 units after 4000 hrs.
Salt spray resistance:	ASTM B117	Blister-10, scribe-8, after 4000 hrs, 35°C salt fog
Humidity-thermal	ASTM D2246	No blister, no cracking After 15 cycles of 38 °C 100%RH for 24 hrs. and -23 °C for 20 hrs.
Humidity resistance:	ASTM D2247	No change After 4000 hrs., 100%RH, 35 °C

7. Certificate

German Zulassung number: Z-33.2-1216

Note: the maximum panel size up to 1575 × 7200 mm.

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Appendix 2: Optional coatings

ALPOLIC A2 and ALPOLIC/fr have a coating finish of Lumiflon™-based fluoropolymer paints as standard, but we can supply ALPOLIC A2 and ALPOLIC/fr coated with the following distinctive paints as an option.

Table Paint options

Coating type	Characteristics	Suitable application
Conductive fluoropolymer coating	Electrically-conductive ($3 \times 10^{7-8}$ ohms)	Interior walls and partitions in factory
PVDF-based fluoropolymer coating	Ultra-weather-ability and matte	Outdoor (external wall cladding, roof covering)
Polyester coating	Matte finish	Interior and light outdoor applications

1. Conductive fluoropolymer coating

ALPOLIC/fr coated with conductive fluoropolymer paint is used on interior walls, partitions and ceilings of clean rooms and warehouses. With an electrically-conductive surface, the panel also has high rigidity and fire safety. The conductive paint can be applied on both sides of the panel, if necessary.

Principal coating performance:

- (1) Pencil hardness: 3H
- (2) Surface electric resistance: $3 \times 10^{7-8}$ ohms
- (3) Chemical resistance:
 - Sulfuric acid, 5% H_2SO_4 : No change
 - Sodium hydroxide, 1% $NaOH$: No change

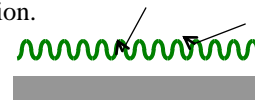
2. PVDF-based fluoropolymer coating

PVDF-based fluoropolymer coating has weatherability. The coating resists long-term exposure to outdoor conditions. Solid (enamel) and metallic finishes are available. The paints are applied in ALPOLIC's continuous coil coating lines. Contact local distributors or our office for details.

3. Polyester coating

Matte finish is available with polyester coatings, although polyester coatings have less weather-ability than fluoropolymer coatings. Matte finish is produced with a new coating technology in which microscopic wrinkles emerge over the entire surface during baking in the coil coating line. Matte finish is available with solid (enamel), metallic and timber-patterned products.

Matte finish: Due to the different hardening speed between the outer and inner layers of the paint, microscopic wrinkles emerge over the entire surface. The wrinkled surface results in a matte appearance due to irregular light reflection.



Appendix 3: Perforated panel

Perforated panels of ALPOLIC/fr have a pattern of holes at regular intervals. This provides ventilation and permits vision through the panel, making it suitable for balconies, staircases, partitions and ceilings. A perforation is not recommended in ALPOLIC A2 due to a characteristic of water permeable of the core.

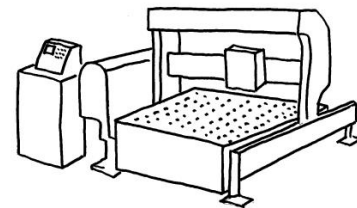
1. Panel size

- Maximum width: 1270mm (55")
- Maximum length: Approx. 3000 mm (118")
- Practical examples of sizes: 1000×300 mm, 1000×500 mm, 1000×700 mm, 1000×1000 mm

2. Perforation process

As introduced in Section 3, "3. Processing method", we normally use a turret puncher for perforation of ALPOLIC/fr and ALPOLIC. Suitable clearance between punch and die is 0.1mm or smaller (material thickness × 2%). A small droop will appear at the punched edge.

Turret puncher



3. Examples of perforation pattern

The typical hole-arrangement of circle-shaped holes is as follows:

Direction	Pattern	Hole diameter	Interval (W)	Perforation ratio
Square		20 mm	40 mm	19.6 %
60° Zigzag		5 mm	10 mm	22.6 %
		6 mm	10 mm	32.6 %
		7 mm	10 mm	44.4 %
		7 mm	12 mm	30.8 %
		8 mm	12 mm	40.2 %
		8 mm	16 mm	22.6 %
		10 mm	15 mm	40.2 %
		15 mm	25 mm	32.6 %

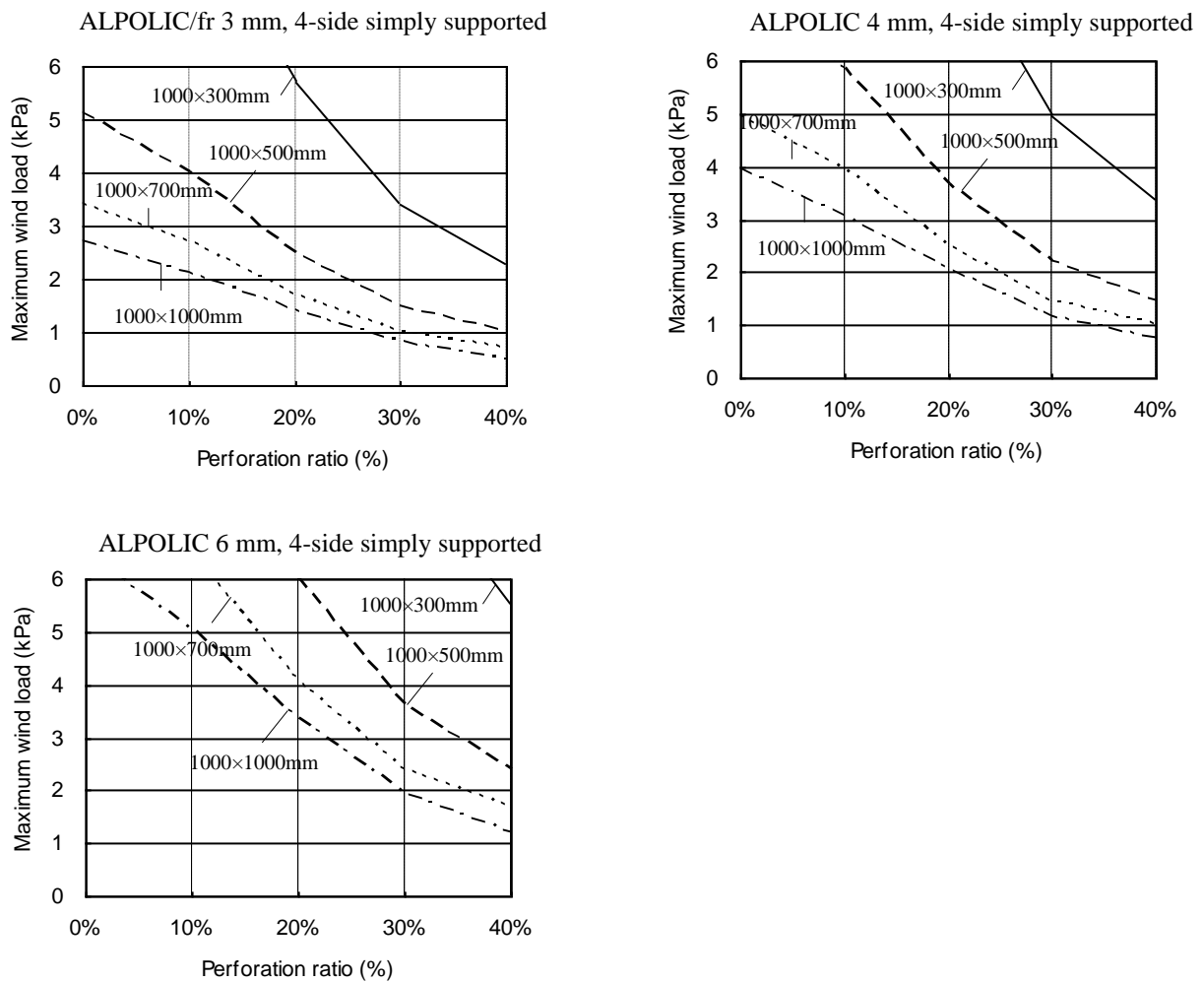
Note: Perforation ratio is % of the total area that is perforated.

4. Panel strength:

Panel strength is lessened after perforation. Namely, the permissible load of ALPOLICs becomes smaller dependent on the perforation ratio (perforated area per total area). The following charts show the maximum limit of uniformly-distributed load, like a wind load, without causing permanent

deformation. As shown in the chart, 20%-perforated ALPOLIC loses one half the original strength.

Fig. 4-1 Maximum wind load of perforated ALPOLIC/fr



Note: The above maximum load includes the safety factor of 1.25.

5. Notes on perforated panels

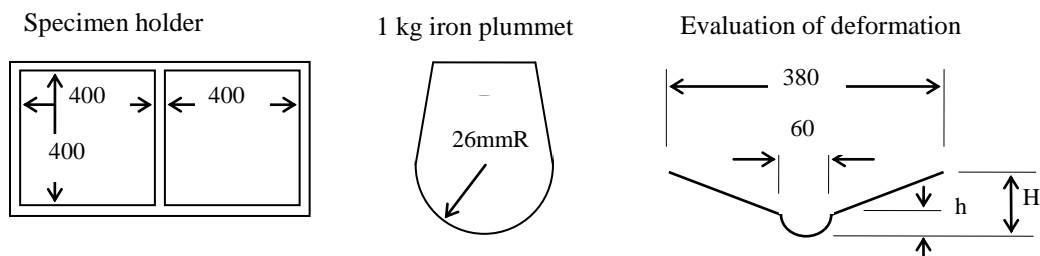
- (1) Effective surfaces are protected with protective films. Remove protective film immediately after installation.
- (2) Align the coating direction in the case of Metallic, Sparkling Colors and Patterns (Stone-Timber-Metal) Finishes, to avoid color difference due to coating direction.
- (3) Use aluminum or stainless steel rivets or screws for joining. If aluminum skin has contact with other metals in a humid atmosphere, corrosion of the aluminum might be accelerated by galvanic corrosion.
- (4) When re-coating ALPOLIC Perforated Panel, use air-curing type paint and dry it at 90 °C or lower, to prevent the core material from overheating.

Appendix 4: Impact test with iron plummet

We conducted this test in order to check the impact resistance of ALPOLIC/fr in comparison to other building materials. As the test result shows, ALPOLIC/fr panels never crack, break or fracture by the impact of an iron plummet.

1. Testing method

- (1) Testing standard: JIS A 5703 “Plastic laminated or printed boards for inside use”
- (2) Specimen: 450×900 mm, placed in a specimen holder shown below.
- (3) Iron plummet: 1 kg weight shown below
- (4) Procedures: Drop the iron plummet onto a specimen from 1 or 2 meters height.
- (5) Evaluation: After the test, the specimen is evaluated on the following items:
 - a. Break or fracture by impact
 - b. Deformation of the entire area (H)
 - c. Deformation of the dropping point (h)



2. Test result

Material	Thickness (mm)	Weight (kg/m ²)	Fracture	Deformation H & h (mm)			
				1	2	3	4
ALPOLIC/fr	4	7.6	No	○—△	○—△		
Aluminum sheet	2	5.4	No	○—△	○—△	○—△	
	3	8.1	No	○—△	○—△		
Steel sheet	1.0	7.9	No	○—△	○—△		
Veneer	15	7.5	No	○—△			
Gypsum board	12	8.9	Yes/Both (1m)	Not available			
Calcium silicate board	8	10.3	Yes/Both (2m)	○—△			
Acrylic sheet	3	3.6	Yes/Both (1m)	Not available			

Dropping height ○: 1 m △: 2 m Deformation H: —○—△ h:○.....△

Note: In the “Fracture” column shown in the table, “Both” indicates that fracture was found both in front and back. “Not available” means that it is impossible to measure the deformation value due to fracture.

Appendix 5: Panel strength

1. General calculation method

(1) Calculation to check the possibility of permanent deformation

In order to check that ALPOLIC panels can withstand the wind load condition, we calculate the maximum stress that may arise in aluminium skins of ALPOLIC with the design wind load. We use the following equation for this purpose. In our calculation, we use the same equation and parameters for ALPOLIC A2 and ALPOLIC/fr, because we ignore the role of the core in this calculation.

$$\text{Stress} = B \cdot w \cdot b^2 / t^2$$

- Stress: Stress that may arise in aluminum skin, in MPa or N/mm²
- b: Panel width or height, whichever is shorter, in mm
- B: Coefficient dependent on a/b ratio (panel width/height) and supporting condition, as shown in Table 4-6.
- w: Wind pressure, in MPa, 10⁻³kPa or N/mm²
- t²: Square of apparent thickness of ALPOLIC, given in the following table:

ALPOLIC Thickness	t ² (mm ²)	0.2% proof stress (MPa or N/mm ²)
3 mm	6.33	150
4 mm	9.25	150
6 mm	15.17	150

If the stress value calculated with the equation is not larger than 0.2% proof stress above, aluminium skins withstand the wind load and the permanent deformation will not occur. A suitable safety factor should be taken into account herein.

(2) Maximum deflection

The maximum deflection of ALPOLIC panel can be calculated with the following equation:

$$\text{Deflection} = A \cdot w \cdot b^4 / E_{AP} t_{AP}^3$$

- Deflection: Deflection that may appear in ALPOLIC panel, in mm
- b: Panel width or height, whichever shorter side
- A: Coefficient dependent on a/b ratio (panel width/height) and supporting condition, as shown in Table 4-7.
- w: Wind pressure in MPa, 10⁻³kPa or N/mm²
- E_{AP}: Flexural elasticity of ALPOLIC, shown below
- t_{AP}: Thickness of ALPOLIC

ALPOLIC Thickness	E_{AP} (N/mm ²)	$E_{AP} \cdot t_{AP}^3$ (N·mm)
3 mm	49.0×10^3	1323×10^3
4 mm	39.8×10^3	2546×10^3
6 mm	29.1×10^3	6287×10^3

Table 4-6 Coefficient B to calculate the stress

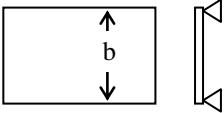
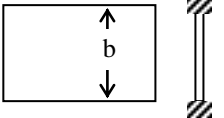
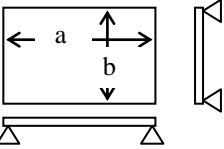
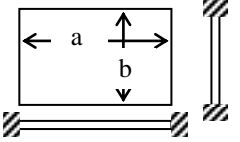
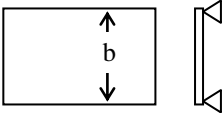
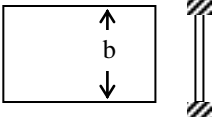
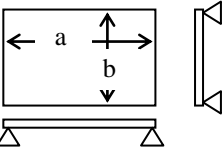
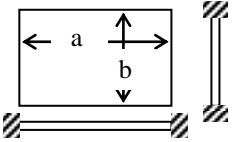
Support condition		Equation and B value	
2-side simply supported and 2-side free		Stress = $0.75 \cdot w \cdot b^2 / t^2$	
2-side fixed and 2-side free		Stress = $0.5 \cdot w \cdot b^2 / t^2$	
4-side simply supported		Stress = $B \cdot w \cdot b^2 / t^2$	
		a/b	1 1.2 1.4 1.6 1.8 2.0 3.0
		B	0.2874 0.3762 0.4530 0.5172 0.5688 0.6102 0.7134
4-side fixed		Stress = $B \cdot w \cdot b^2 / t^2$	
		a/b	1 1.2 1.4 1.6 1.8 2.0 >2.0
		B	0.3078 0.3834 0.4356 0.4680 0.4872 0.4974 0.5000

Table 4-7 Coefficient A to calculate the deflection

Support condition		Equation and A value	
2-side simply supported and 2-side free		Deflection = $0.156 \cdot w \cdot b^4 / (E_{AP} \cdot t_{AP}^3)$	
2-side fixed and 2-side free		Deflection = $0.0313 \cdot w \cdot b^4 / (E_{AP} \cdot t_{AP}^3)$	
4-side simply supported		Deflection = $A \cdot w \cdot b^4 / (E_{AP} \cdot t_{AP}^3)$	
		a/b	1 1.2 1.4 1.6 1.8 2.0 3.0 >3.0
		A	0.044 0.062 0.077 0.0906 0.1017 0.1110 0.1335 0.1422
4-side fixed		Deflection = $A \cdot w \cdot b^4 / (E_{AP} \cdot t_{AP}^3)$	
		a/b	1 1.2 1.4 1.6 1.8 2.0 >2.0
		A	0.0138 0.0188 0.0226 0.0251 0.0267 0.0277 0.0284

2. Calculation results of stress

The following tables are calculated results of stress on the following cases.

Table 4-8 ALPOLIC 3 mm, 4-side simply supported and 4-side fixed

Table 4-9 ALPOLIC 4 mm, 4-side simply supported and 4-side fixed

Table 4-10 ALPOLIC 6 mm, 4-side simply supported and 4-side fixed

If you need exact calculations, calculations entailing stiffener, and calculations of deflection, please contact local distributors or our office. The calculation requires the following parameters: (A) Wind load, (B) ALPOLIC thickness, (C) Supporting condition, (D) ALPOLIC panel size.

Table 4-8 ALPOLIC 3 mm

Supporting condition: 4-side simply supported

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm									
		900	1200	1500	1800	2100	2400	2700	3000	>3000	
1.0 (102)	600	28	35	38	41	43	43	43	43	43	
	900	37	55	68	78	82	87	91	96	96	
	1200	55	65	90	110	126	139	145	151	> 171	>
	1500	68	90	102	134	161	> 184	> 202	> 217	> 267	>
1.5 (153)	600	41	52	56	61	64	64	64	64	64	
	900	55	82	103	117	124	130	137	144	144	
	1200	82	98	135	166	> 190	> 208	> 217	> 226	> 256	>
	1500	103	135	153	> 201	> 242	> 276	> 303	> 325	> 400	>
2.0 (204)	600	55	69	75	81	85	85	85	85	85	
	900	74	109	137	156	> 165	> 174	> 183	> 192	> 192	>
	1200	109	131	180	> 221	> 253	> 278	> 289	> 301	> 341	>
	1500	137	180	> 204	> 267	> 322	> 368	> 404	> 434	> 533	>

Supporting condition: 4-side fixed

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm									
		900	1200	1500	1800	2100	2400	2700	3000	>3000	
1.0 (102)	600	26	28	28	28	28	28	28	28	28	
	900	39	53	61	64	64	64	64	64	64	
	1200	53	70	90	103	110	113	114	114	114	
	1500	61	90	109	136	155	> 166	> 173	> 177	> 178	>
1.5 (153)	600	39	42	43	43	43	43	43	43	43	
	900	59	80	91	95	96	96	96	96	96	
	1200	80	105	135	154	> 165	> 170	> 171	> 171	> 171	>
	1500	91	135	164	> 204	> 232	> 250	> 260	> 265	> 267	>
2.0 (204)	600	51	57	57	57	57	57	57	57	57	
	900	79	107	121	127	128	128	128	128	128	
	1200	107	140	180	> 206	> 219	> 226	> 227	> 227	> 227	>
	1500	121	180	> 219	> 273	> 310	> 333	> 346	> 354	> 355	>

How to read the table: “>” indicates that the maximum stress becomes larger than 0.2% proof stress of aluminum skin (150 N/mm²). Stiffener will be required in this range. In other ranges where calculated stress is lower than 150 N/mm², the panel will withstand without stiffener. Take into account a safety factor.

Table 4-9 ALPOLIC 4 mm

Supporting condition: 4-side simply supported

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm								
		900	1200	1500	1800	2100	2400	2700	3000	>3000
1.0 (102)	600	19	24	26	28	29	29	29	29	29
	900	25	37	47	53	56	59	62	66	66
	1200	37	45	62	76	87	95	99	103	117
	1500	47	62	70	92	110	126	138	148	182 >
1.5 (153)	600	28	36	39	42	44	44	44	44	44
	900	38	56	70	80	85	89	94	99	99
	1200	56	67	92	113	130	142	149	155	> 175 >
	1500	70	92	105	137	165	> 189	> 208	> 223	> 274 >
2.0 (204)	600	38	47	52	56	58	58	58	58	58
	900	50	75	94	107	113	119	125	131	131
	1200	75	89	123	151	> 173	> 190	> 198	> 206	> 234 >
	1500	94	123	140	183	> 220	> 252	> 277	> 297	> 365 >
2.5 (255)	600	47	59	64	69	73	73	73	73	73
	900	63	93	117	134	141	149	156	> 164	> 164 >
	1200	93	112	154	> 189	> 216	> 237	> 248	> 258	> 292 >
	1500	117	154	> 175	> 229	> 275	> 315	> 346	> 371	> 456 >
3.0 (306)	600	57	71	77	83	88	88	88	88	88
	900	76	112	141	160	> 169	> 178	> 187	> 197	> 197 >
	1200	112	134	185	> 227	> 260	> 285	> 297	> 309	> 350 >
	1500	141	185	> 210	> 275	> 331	> 377	> 415	> 445	> 547 >

Supporting condition: 4-side fixed

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm								
		900	1200	1500	1800	2100	2400	2700	3000	>3000
1.0 (102)	600	18	19	19	19	19	19	19	19	19
	900	27	37	42	44	44	44	44	44	44
	1200	37	48	62	70	75	77	78	78	78
	1500	42	62	75	93	106	114	119	121	122
1.5 (153)	600	26	29	29	29	29	29	29	29	29
	900	40	55	62	65	66	66	66	66	66
	1200	55	72	93	106	113	116	117	117	117
	1500	62	93	112	140	159	> 171	> 178	> 181	> 182 >
2.0 (204)	600	35	39	39	39	39	39	39	39	39
	900	54	73	83	87	88	88	88	88	88
	1200	73	96	123	141	150	155	> 156	> 156	> 156 >
	1500	83	123	150	187	> 212	> 228	> 237	> 242	> 243 >
2.5 (255)	600	44	48	49	49	49	49	49	49	49
	900	67	91	104	109	109	109	109	109	109
	1200	91	120	154	> 176	> 188	> 194	> 195	> 195	> 195 >
	1500	104	154	> 187	> 233	> 265	> 285	> 296	> 302	> 304 >
3.0 (306)	600	53	58	58	58	58	58	58	58	58
	900	81	110	125	131	131	131	131	131	131
	1200	110	144	185	> 211	> 225	> 232	> 234	> 234	> 234 >
	1500	125	185	> 225	> 280	> 318	> 342	> 356	> 363	> 365 >

How to read the table: “>” indicates that the maximum stress becomes larger than 0.2% proof stress of aluminum skin (150 N/mm²). Stiffener will be required in this range. In other ranges where calculated stress is lower than 150 N/mm², the panel will withstand without stiffener. Take into account a safety factor.

Table 4-10 ALPOLIC 6 mm

Supporting condition: 4-side simply supported

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm								
		900	1200	1500	1800	2100	2400	2700	3000	>3000
1.0 (102)	600	12	14	16	17	18	18	18	18	18
	900	15	23	29	33	34	36	38	40	40
	1200	23	27	38	46	53	58	60	63	71
	1500	29	38	43	56	67	77	84	91	111
1.5 (153)	600	17	22	24	25	27	27	27	27	27
	900	23	34	43	49	52	54	57	60	60
	1200	34	41	56	69	79	87	91	94	107
	1500	43	56	64	84	101	115	127	136	167 >
2.0 (204)	600	23	29	31	34	36	36	36	36	36
	900	31	46	57	65	69	73	76	80	80
	1200	46	55	75	92	106	116	121	126	142
	1500	57	75	85	112	134	153	> 169	> 181	> 222 >
2.5 (255)	600	29	36	39	42	44	44	44	44	44
	900	38	57	71	81	86	91	95	100	100
	1200	57	68	94	115	132	145	151	> 157	> 178 >
	1500	71	94	107	139	168	> 192	> 211	> 226	> 278 >
3.0 (306)	600	35	43	47	51	53	53	53	53	53
	900	46	68	86	98	103	109	114	120	120
	1200	68	82	113	138	158	> 174	> 181	> 188	> 214 >
	1500	86	113	128	167	> 202	> 230	> 253	> 272	> 334 >

Supporting condition: 4-side fixed

Maximum stress (N/mm²)

w, kPa (kg/m ²)	Panel width (b) in mm	Panel length (a) in mm								
		900	1200	1500	1800	2100	2400	2700	3000	>3000
1.0 (102)	600	11	12	12	12	12	12	12	12	12
	900	16	22	25	27	27	27	27	27	27
	1200	22	29	38	43	46	47	47	47	47
	1500	25	38	46	57	65	69	72	74	74
1.5 (153)	600	16	18	18	18	18	18	18	18	18
	900	25	33	38	40	40	40	40	40	40
	1200	33	44	56	64	69	71	71	71	71
	1500	38	56	68	85	97	104	108	111	111
2.0 (204)	600	21	24	24	24	24	24	24	24	24
	900	33	45	51	53	53	53	53	53	53
	1200	45	58	75	86	92	94	95	95	95
	1500	51	75	91	114	129	139	145	148	148
2.5 (255)	600	27	30	30	30	30	30	30	30	30
	900	41	56	63	66	67	67	67	67	67
	1200	56	73	94	107	114	118	119	119	119
	1500	63	94	114	142	162	> 174	> 181	> 184	> 185 >
3.0 (306)	600	32	35	36	36	36	36	36	36	36
	900	49	67	76	80	80	80	80	80	80
	1200	67	88	113	129	137	142	142	142	142
	1500	76	113	137	171	> 194	> 208	> 217	> 221	> 222 >

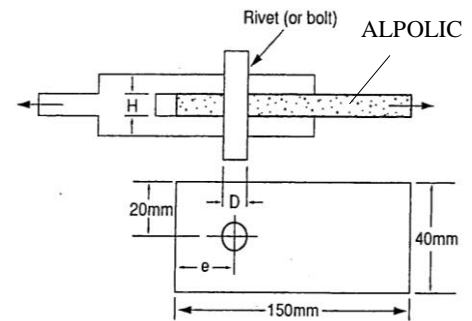
How to read the table: “>” indicates that the maximum stress becomes larger than 0.2% proof stress of aluminum skin (150 N/mm²). Stiffener will be required in this range. In other ranges where calculated stress is lower than 150 N/mm², the panel will withstand without stiffener. Take into account a safety factor.

Appendix 6: Strength of joining hole

Rivets, bolt/ nuts and tapping screws are quite often used for joining between ALPOLIC panels and aluminum profiles. When a tensile force loads on the joining point, stress will be placed on the joining hole of the ALPOLIC panel. In order to evaluate the maximum elastic limit of the joining hole, we performed the following tensile test.

1. Test method:

Do tensile tests with 5mm and 10mm holes (D) that are located different distances from edge (e). Determine the maximum elastic limits by means of stress-strain curve.



2. Test result:

The following table shows the maximum elastic limits.

Hole diameter (D) in mm	Hole center to edge (e) in mm	e/D	Maximum elastic stress, (S) MPa or N/mm ²			Max. tensile force (F) in N		
			3 mm	4 mm	6 mm	3 mm	4 mm	6 mm
5	5	1	21	23	18	320	430	530
	10	2	48	44	38	720	880	1150
	15	3	55	46	40	820	920	1210
10	10	1	20	21	17	590	820	1000
	20	2	38	33	25	1150	1330	1530
	30	3	39	38	25	1170	1530	1470

3. How to use the above data:

To utilize the above data, we convert the above value to meet our particular case with the equation:

$$F = S \times t \times D$$

S: Maximum elastic stress in MPa or N/mm²

F: Maximum tensile force in N

t: Thickness of ALPOLIC in mm

D: Diameter of hole in mm

Calculation example:

Premise: ALPOLIC 3 mm, D = 4 mm, e = 8 mm,

Result: $F = S \times t \times D = 48 \times 3 \times 4 = 576$ N per joining point (Take a safety factor).

According to the above table, a sufficient hole-strength cannot be expected, if the position is quite near the edge. In order to ensure a reasonable strength of joining hole, the distance from hole-center to edge (e) should be larger than twice the hole-diameter (D). Namely, we should keep $e > 2 \times D$.

Appendix 7: Modified non-penetrating rivet

1. General

The modified non-penetrating rivet method offers a new fixing method of ALPOLIC panels. This fixing method is an alternative to adhesives and double-sided tapes, but this non-penetrating rivet, unlike adhesives or double-sided tapes, functions as mechanical fixing. Therefore, the non-penetrating rivet is suitable for areas where a reliable fixing is required even in the event of fire or other accidents.

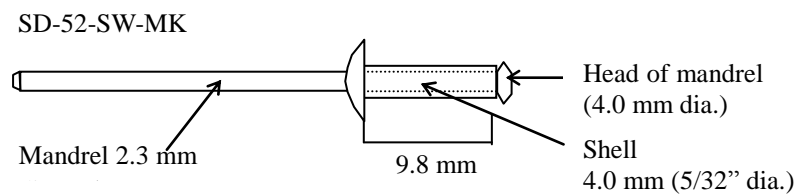
It is important that this rivet is not usable on all ALPOLIC panels, but usable only on the low-gloss finishes, because the trail of concealed rivet is visible from the front, if the surface is glossy. This modified non-penetrating rivet is suitable only to the following ALPOLIC products.

ALPOLIC/fr thickness	Applicable gloss level
4 mm, 6 mm	Low-gloss (30% gloss or less)

2. Installation method

(1) Rivet

Use the rivet, SD-52-SW-MK, (4 mm) shown in the diagram.

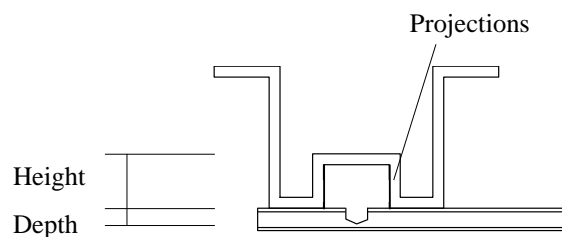


(2) Aluminum profile

Although many shapes are applicable, the aluminum profile must allow the following fixing height and must have projections, as shown in the diagram to prevent lifting of the aluminum skin.

Suitable fixing height and depth

ALPOLIC thickness	Height, mm	Depth, mm
4 mm	7.5	3.0
6 mm	6.0	4.5



(3) Riveting procedures

Refer to Fig. 4-2 and 4-3 below.

4. Design strength

Use the following pulling strength for design as a net value. It includes a processing factor of 1.3, but it does not include a safety factor. Divide it by the safety factor, if necessary. Keep the distance from the rivet center to the edge at least 20 mm to ensure this strength.

ALPOLIC/fr thickness	Design strength/piece
4 mm, 6 mm	330 N

Fig. 4-2 Riveting procedures

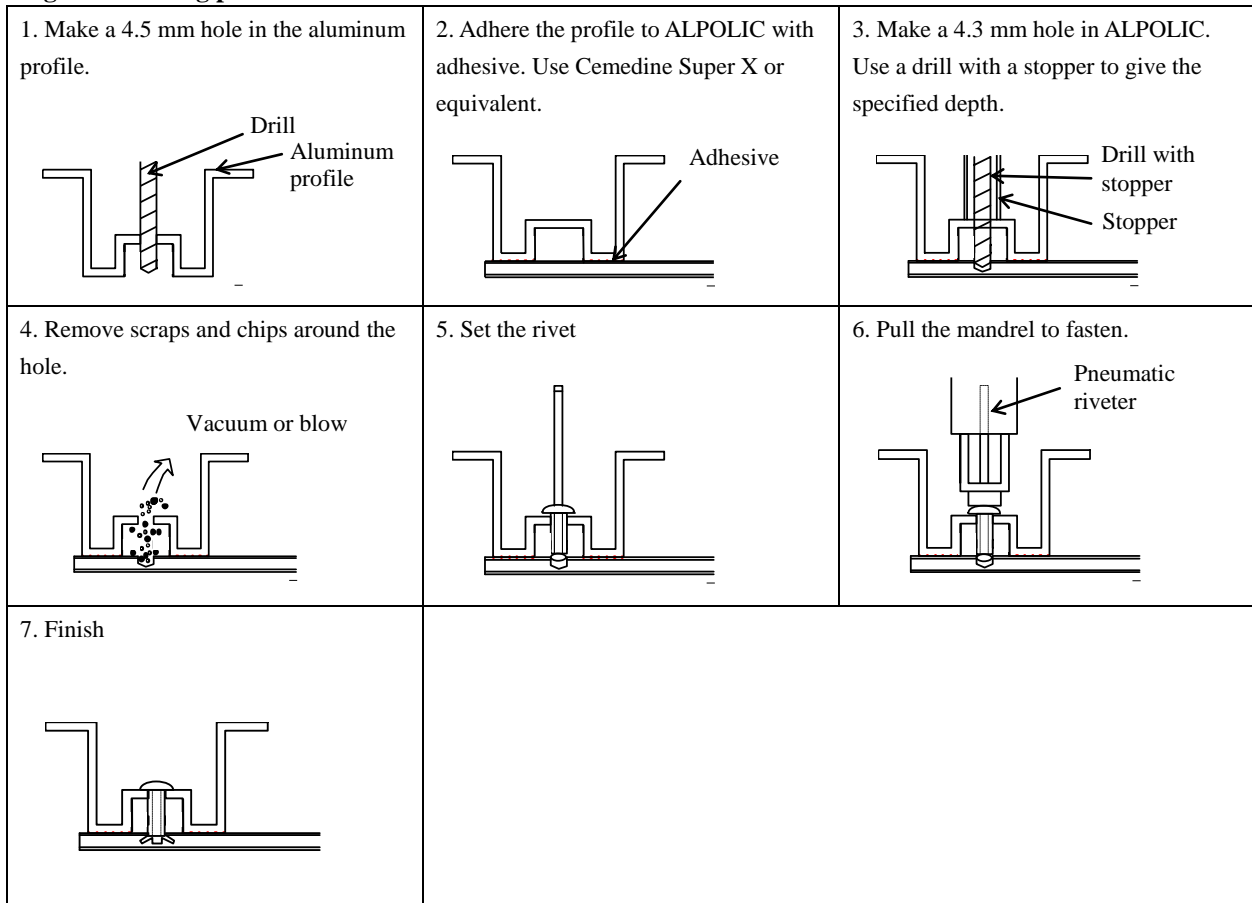
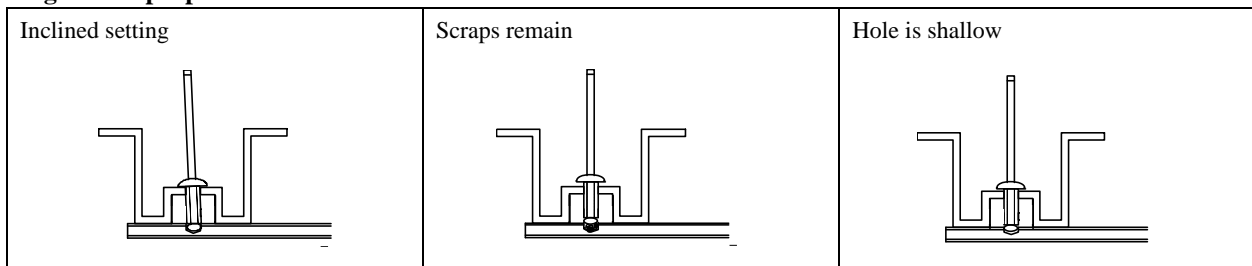


Fig. 4-3 Improper installation



Appendix 8: Examples of complicated panels

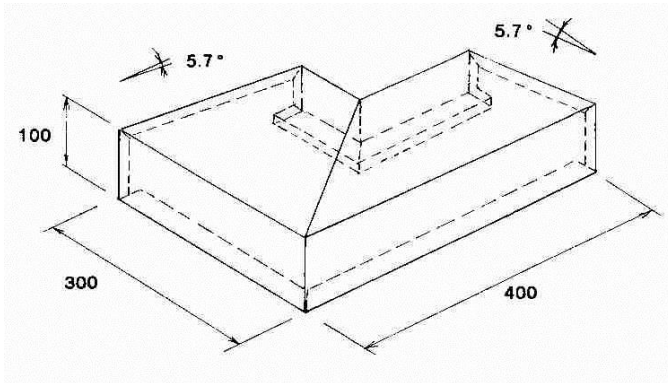
We sometimes encounter unusual designs including 3-dimensional shapes. Mostly, the required quantity is only several pieces, but we wish to fabricate the ALPOLIC panels in such a manner that they achieve long-lasting performance with satisfactory appearance. Examples of these panels are attached here for your reference. If you have similar difficulties in an actual project, please contact local distributors or our office. We would like to study together.

The attached examples are based on those panels produced for actual projects. We scaled down the panel size by 1/2 to 1/5 for transportation. Please correct the dimensions so as to fit to your case.

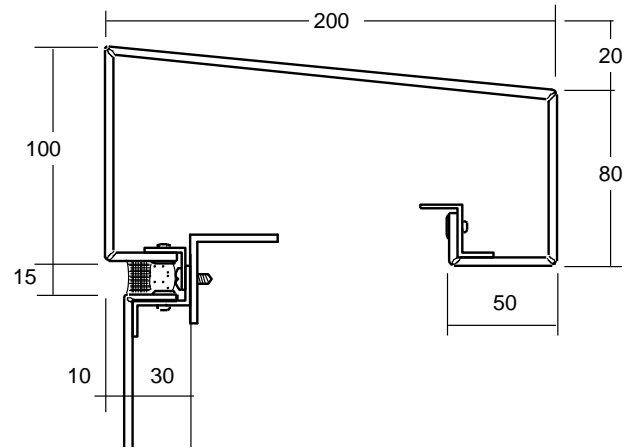
- Example 1: Outside angle panel of coping
A corner panel of coping that is located on top of buildings
- Example 2: Outside angle panel of sunshade (cornice)
A corner panel of a sunshade above an entrance or window
- Example 3: Outside angle panel with water drip
A corner panel with a water drip that is normally located at the lower portion of buildings
- Example 4: Inside angle panel for recessed windows
Recessed windows sometimes require this type of panel, depending on the position of the vertical and horizontal joints.
- Example 5: Three-dimensional curved panel
This is a convex panel with a flat return (folded edge). This panel is applicable when the curve radius is larger than 1300 mmR in 4 mm thick ALPOLIC.

Example 1: Outside angel panel of coping

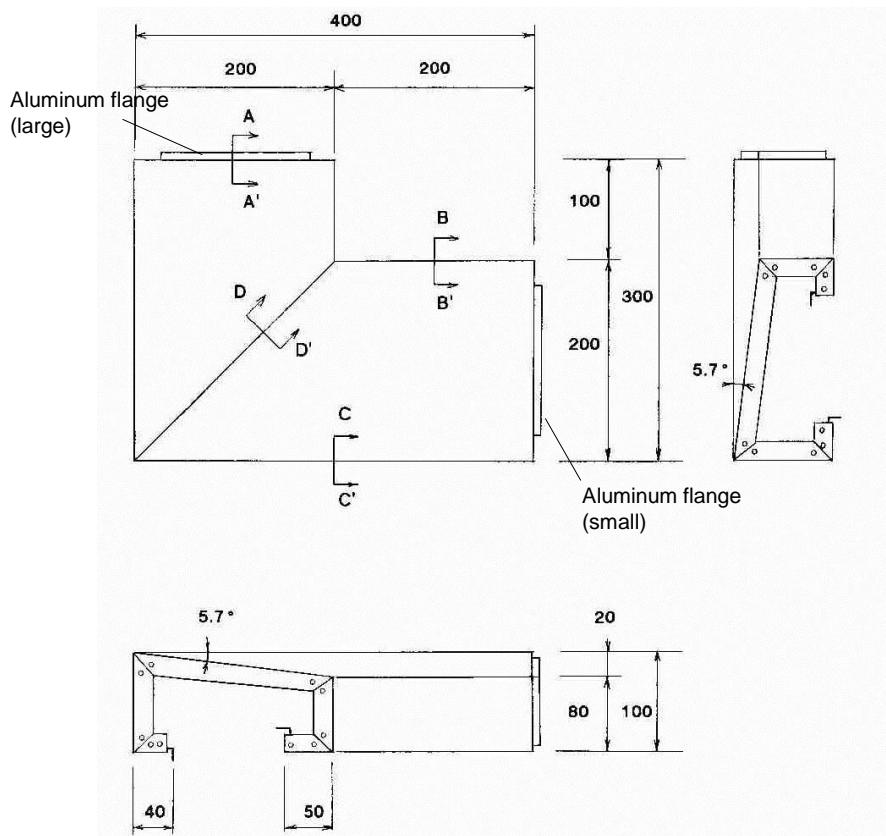
Completed panel



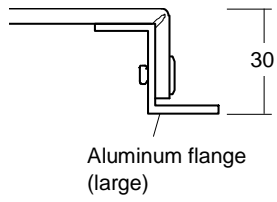
Section detail



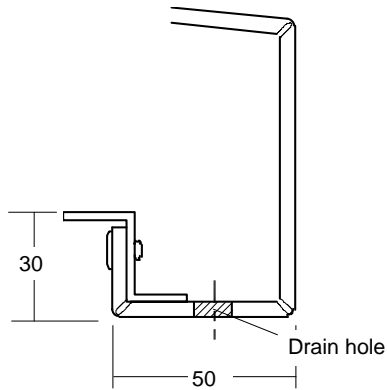
Elevations and plan



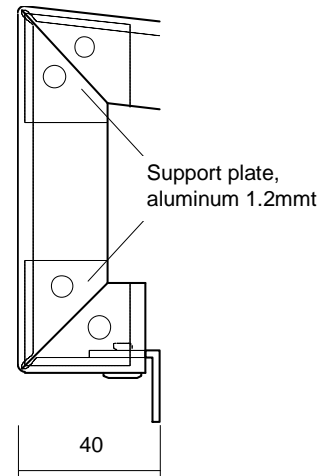
A-A' detail



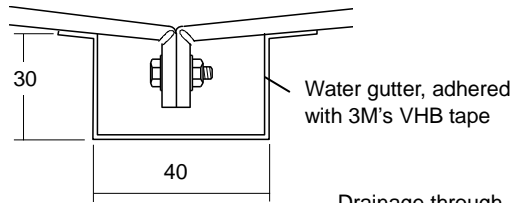
B-B' detail



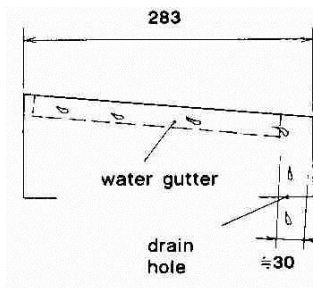
C-C' detail



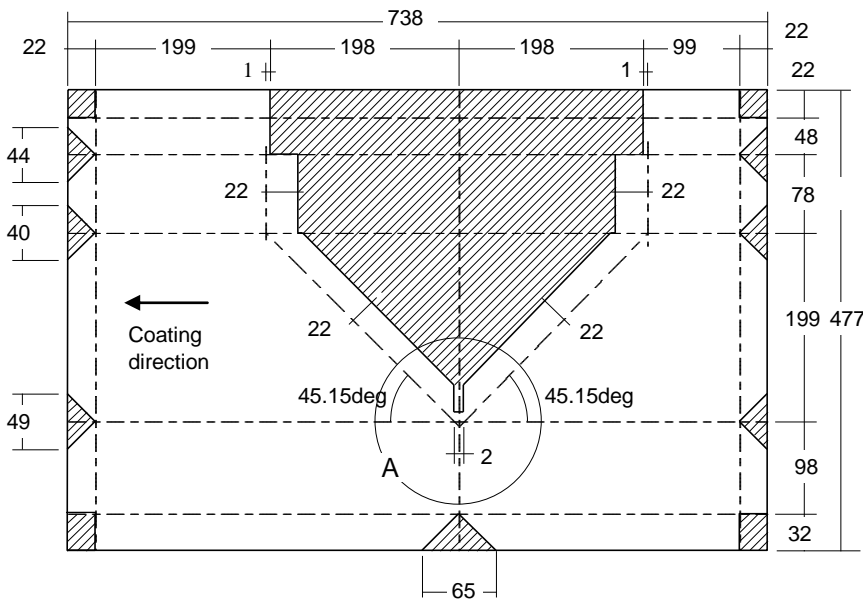
D-D' detail



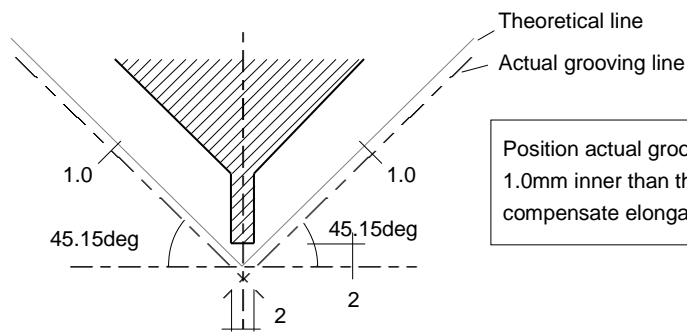
Drainage through gutter and hole



Cut & groove



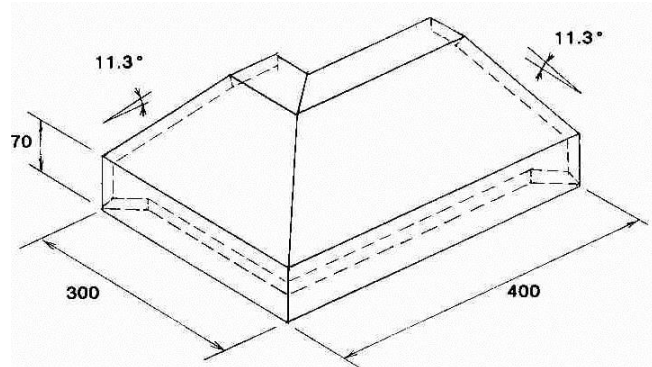
A detail



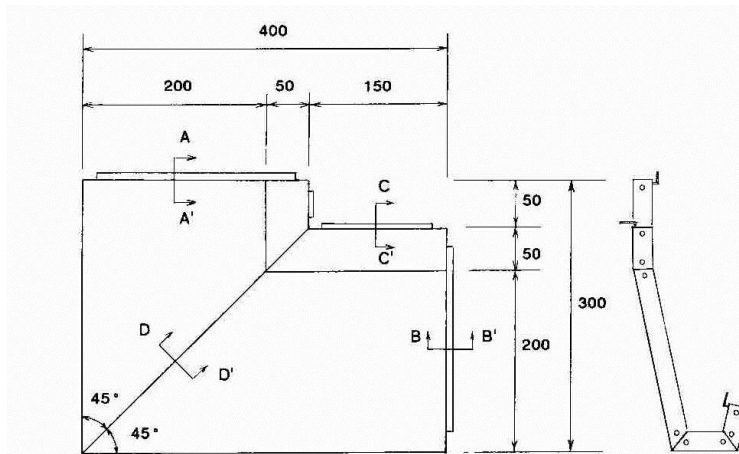
Position actual grooving center line 1.0mm inner than the theoretical line to compensate elongation after folding

Example 2: Outside angle panel of sunshade (cornice)

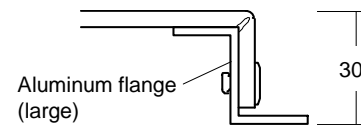
Completed panel



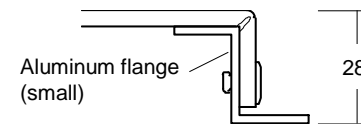
Elevations



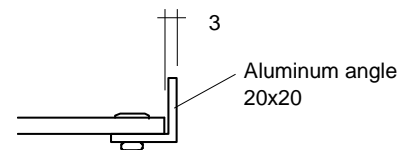
A-A' detail



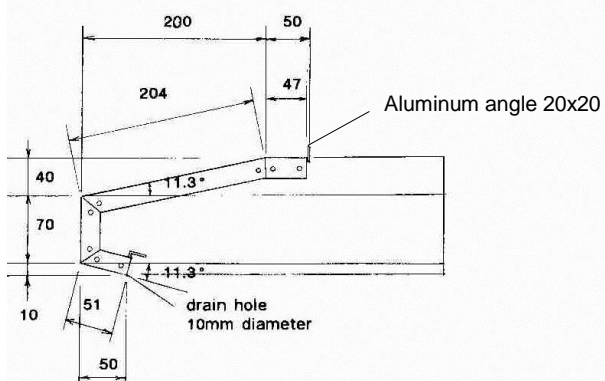
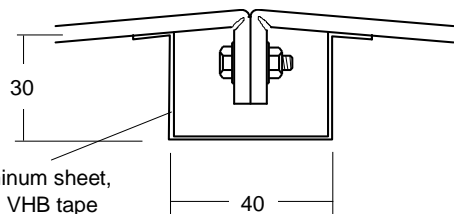
B-B' detail



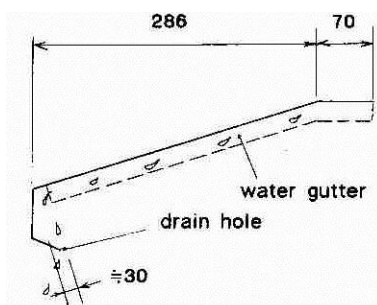
C-C' detail



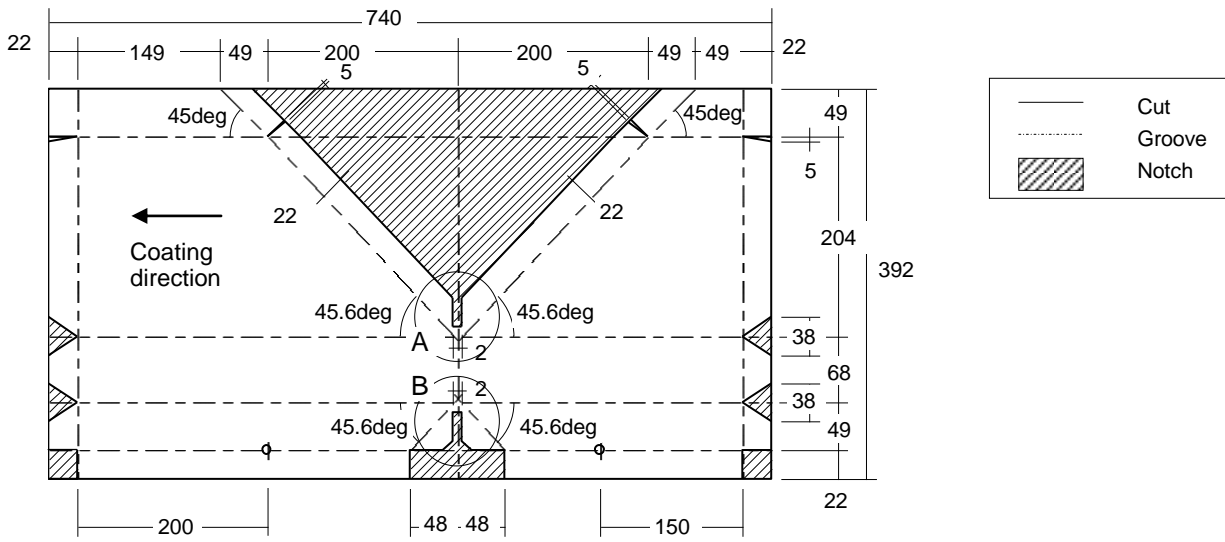
D-D' detail



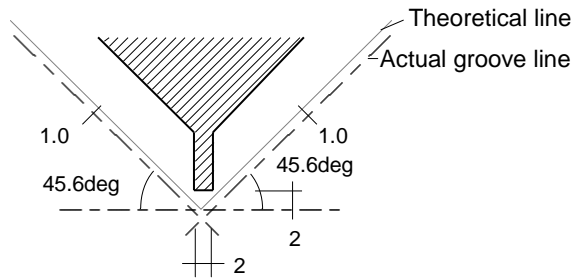
Drainage through gutter and hole



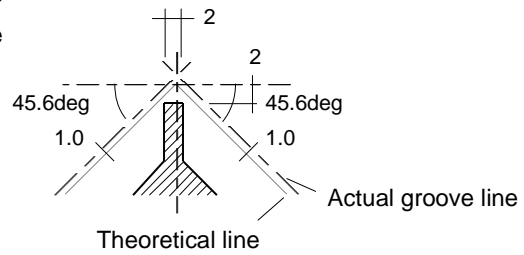
Cut & groove



A detail



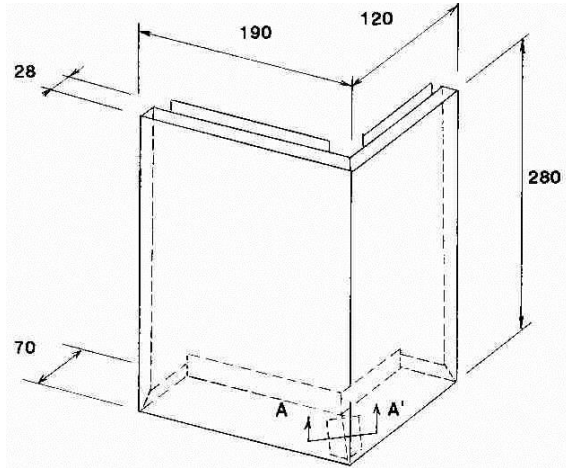
B detail



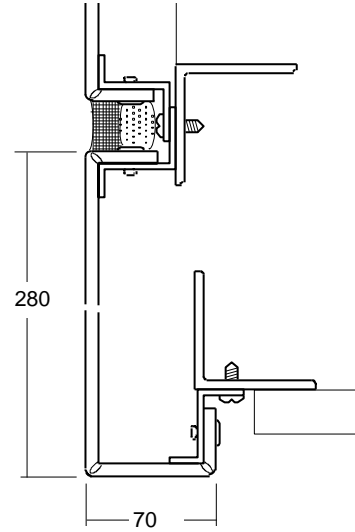
Position actual grooving center line
1.0 mm inner than the theoretical line
to compensate elongation after folding

Example 3: Outside angle panel with water drip

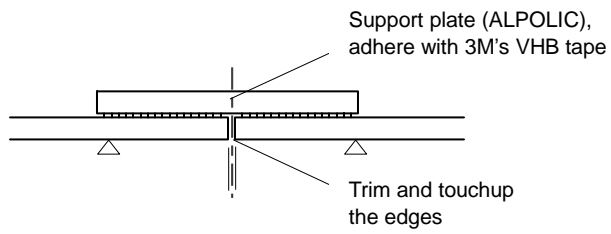
Completed panel



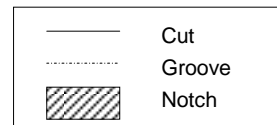
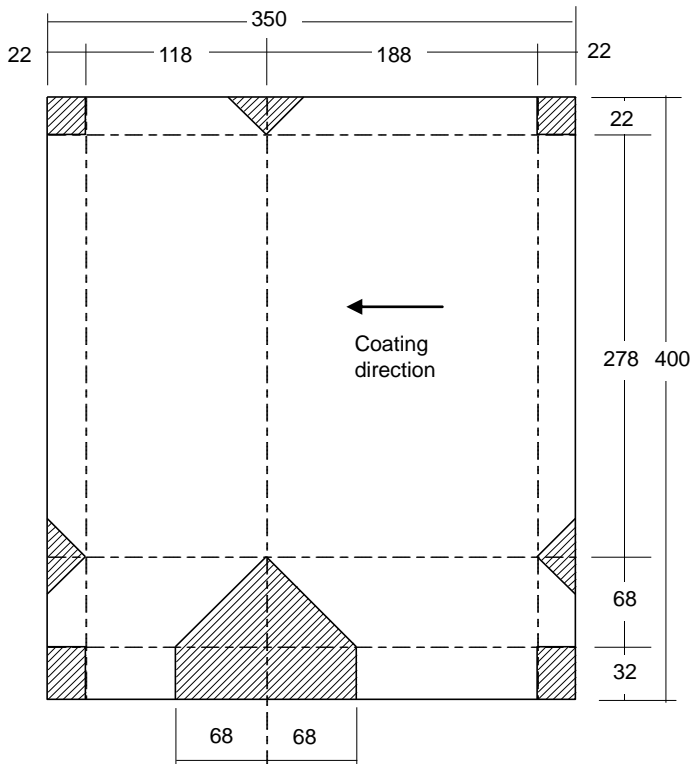
Section detail



A-A' detail

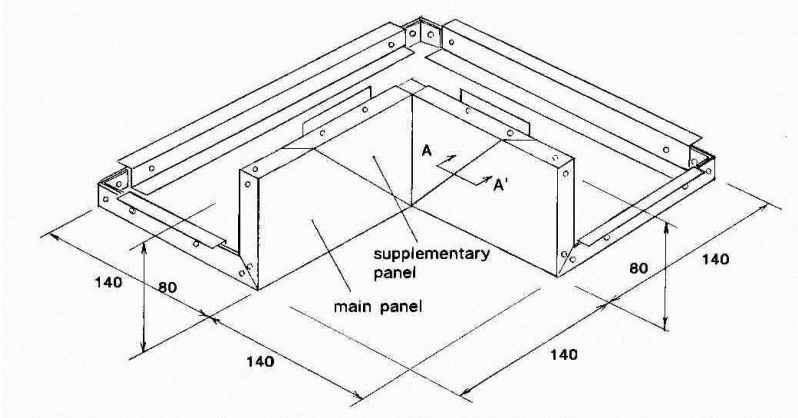


Cut & groove

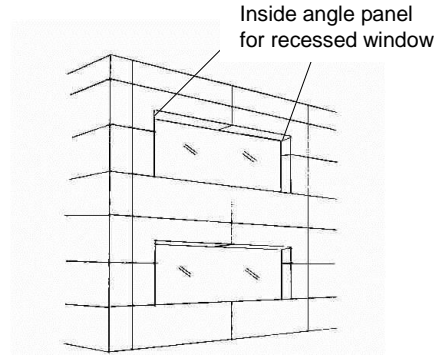


Example 4: Inside angle panel for recessed windows

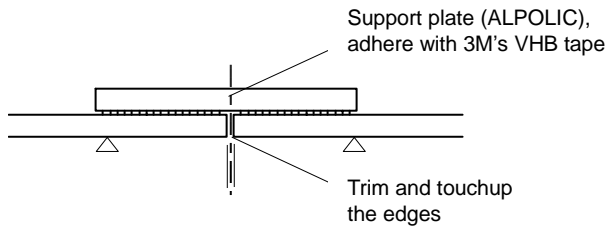
Completed panel



Application example

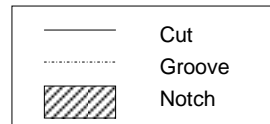
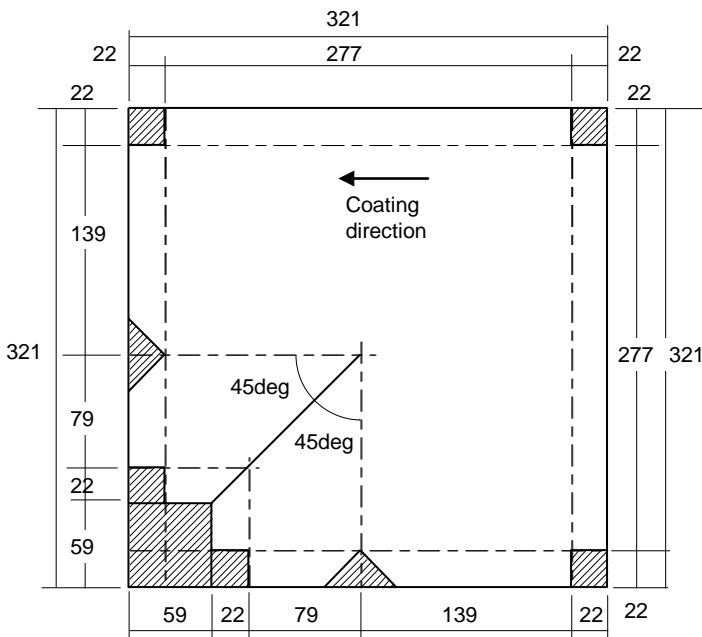


A-A' detail

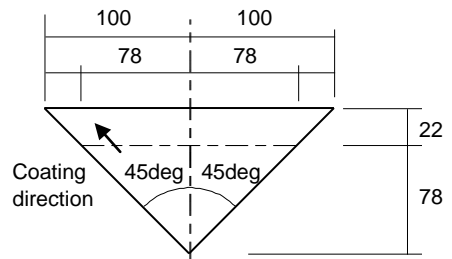


Cut & groove

Main panel



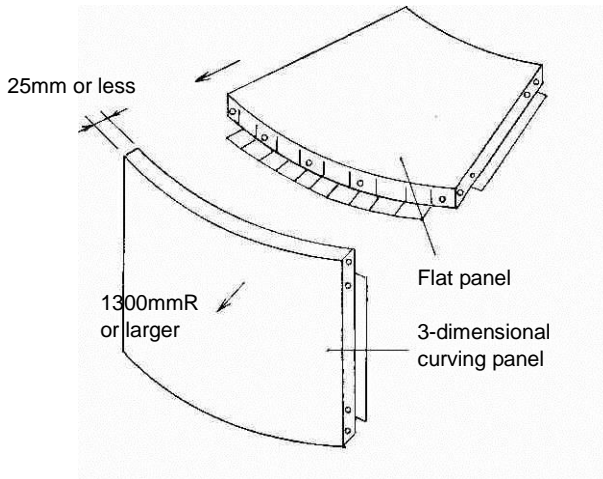
Supplementary panel



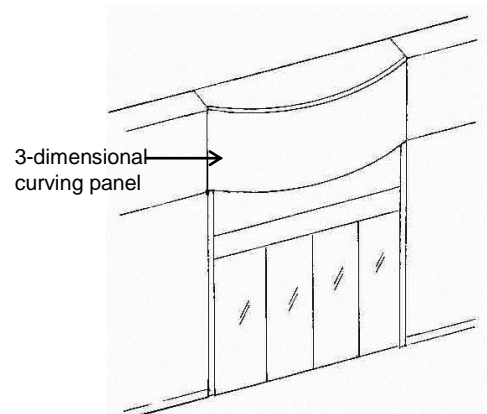
Example 5: Three-dimensional curving panel

This panel is applicable when the curving radius is larger than 1300 mmR in 4mm thick ALPOLIC. We use a regular 3-roll bending machine.

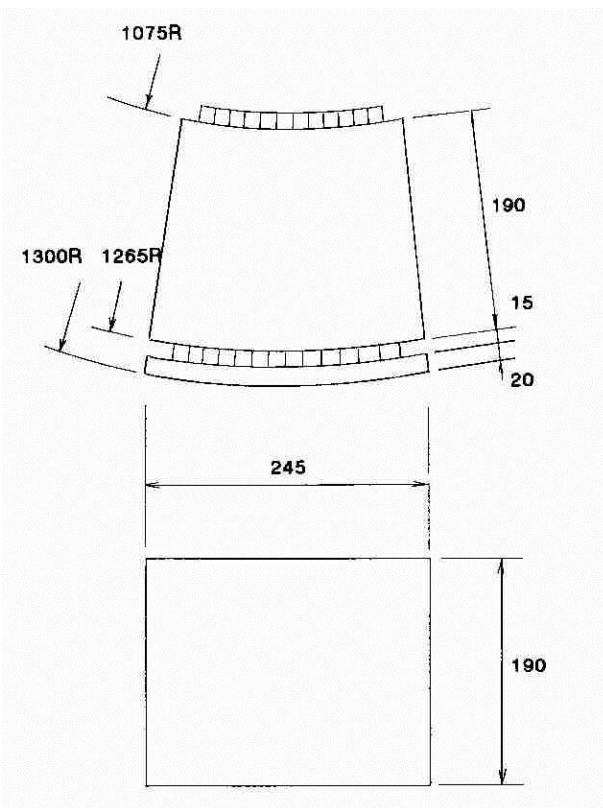
Front view



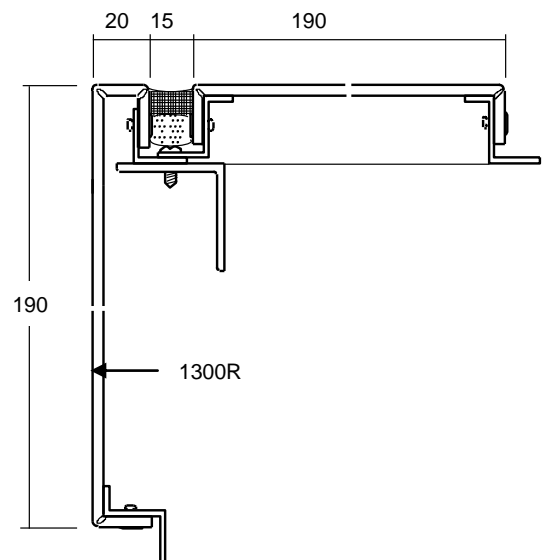
Application example



Elevation and plan

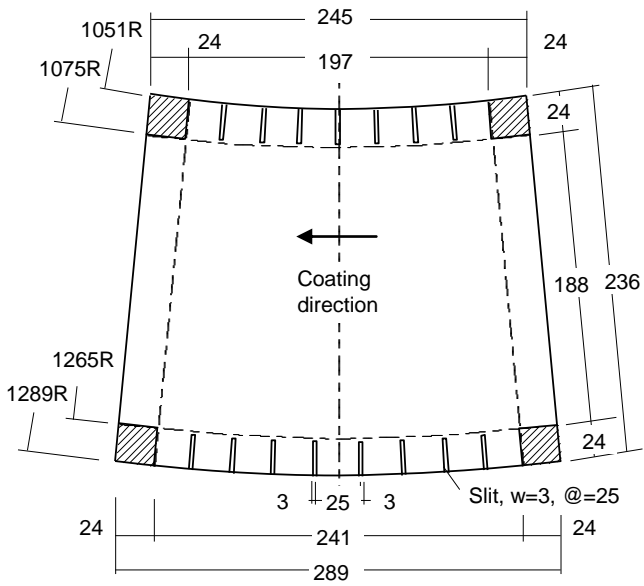


Section

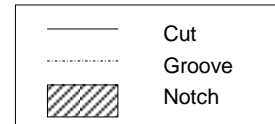
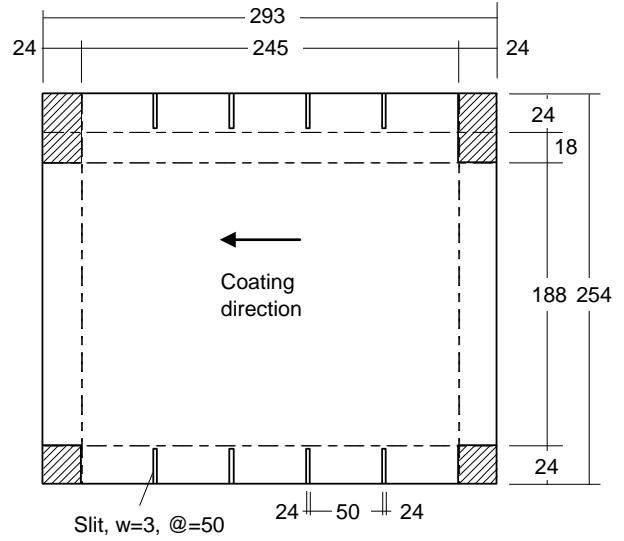


Cut & groove

Flat panel

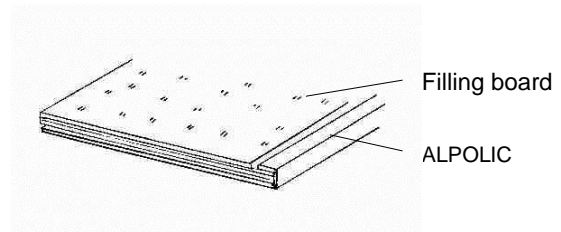
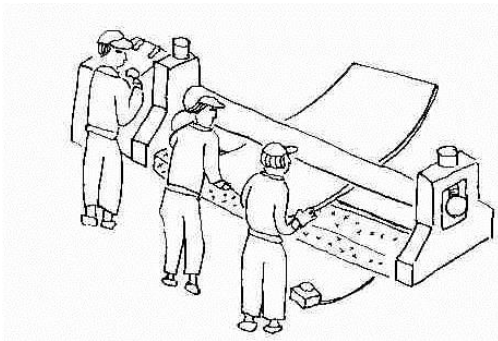


3-dimensional curving panel



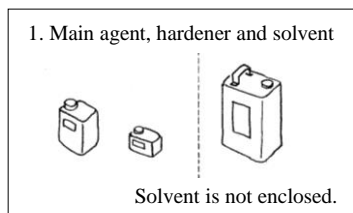
Bending work

Bend ALPOLIC panel and filling board together



Appendix 9: Touch-up coating method

It is one of the advantages of Lumiflon™ paint that the coated surface can be re-coated at room temperature. This manual refers to a typical touch-up (repair) coating method of ALPOLIC panels coated with Lumiflon™-based fluoropolymer paint. An air-cured type of Lumiflon™-based fluoropolymer paint, called “Bonflon #5000” is used as touch-up paint.

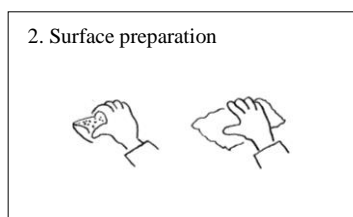


1. Touch-up paint (1 kg set) consists of:

Main agent: 0.93 kg

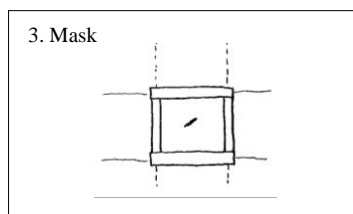
Hardener: 0.07 kg

Solvent is not enclosed in the package. If you need solvent to dilute and adjust the viscosity of the paint, procure it locally. Refer to the bottom note for suitable solvents.



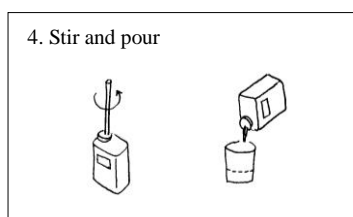
2. Wipe off dust and stains with a soft rag. Polish the relevant area with sandpaper #320-400 mildly. Remove oils and fats with IPA (isopropyl alcohol), ethyl alcohol or N-hexane diluted to 50% with water.

Note: Do not use solvents for surface preparation.



3. Cover the surrounding area, if necessary.

Note: Do not use PVC tapes. Gloss increase may occur.



4. Stir the main agent to homogenize the pigments. Pour an appropriate quantity of the main agent into a beaker.

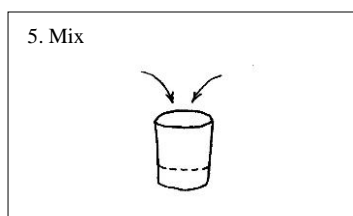
5. Add an appropriate quantity of hardener and solvent. Mix them well and maintain for 30 min before use. The mixing ratio is as follows:

Main agent: Hardener = 93 : 7 (=13 : 1)

Solvent: 20 - 40% to adjust the viscosity

6. Apply the paint with brush or spray. Approximately 1 hr. will be required for the surface to dry at 20 °C.

Note: Use the mixture within 6hrs (at 20 °C). Do not apply below 10 °C.



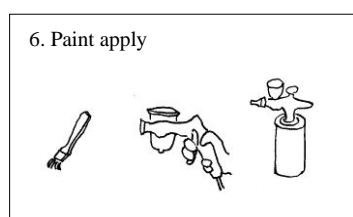
General Notes:

1. Re-coated surface shows a slightly different appearance, especially in metallic colors, due to the coating method difference.

2. Do not expose paint to direct sunshine for extended periods.

3. Store the paints away from direct flame and excessive heat. Keep airtight and away from moisture.

4. Suitable solvents: xylene, butyl acetate, MIBK (methyl iso-butyl ketone), and thinners for urethane/acrylic-urethane paints are suitable. As these are strong organic solvents that are inflammable and intoxicating, follow the manufacturer's instructions. Most commercially popular paint thinners are not suitable.

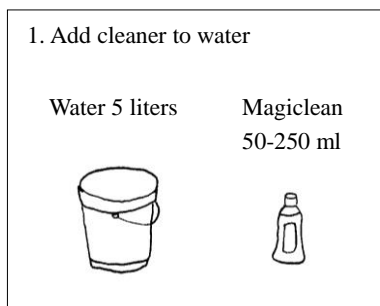


Appendix 10: Example of practical cleaning method

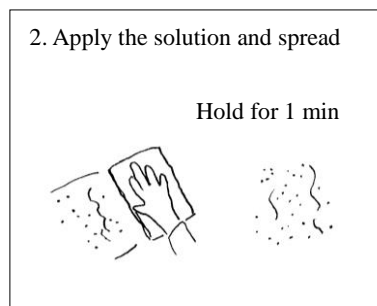
Cleaners and detergents are normally local products. A cleaner or a detergent widely available in one country may not be available in another country. This method is an example of practical cleaning method suitable for Lumiflon™-based fluoropolymer coating. The cleaner called “Magiclean” is a household cleaner from Kao Corp and widely available in East and Southeast Asian countries. “Sharpshooter” is a versatile cleaner from 3M and available worldwide.

1. Light surface soiling

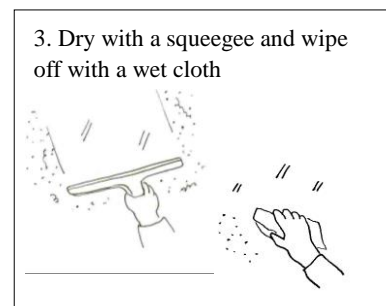
Firstly, try a water rinse using a soft sponge with modest pressure to remove the soiling (stain). If the soiling remains after drying, then use dilute Magiclean.



Dilute Magiclean to 1-5% (50-250ml Magiclean to 5 liters water). Magiclean is a household cleaner with pH 8 from Kao Corp.



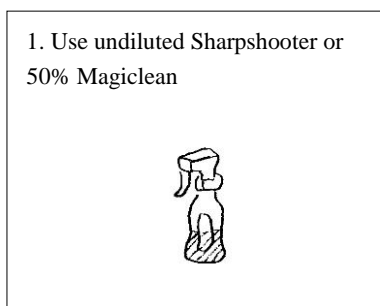
Spread the solution around ALPOLIC surface. Use soft towel or sponge. Wait for about 1 minute, the foam will be blackened.



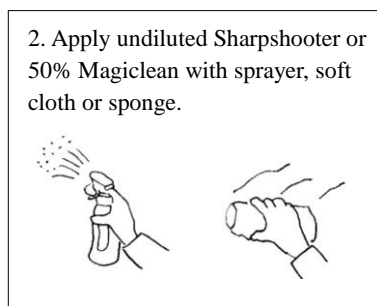
Dry with squeegee and finally wipe the surface with wet towel containing clean water.

2. Medium to heavy surface soiling

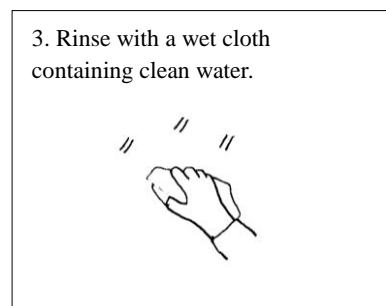
Use undiluted Sharpshooter or 50% Magiclean. As Sharpshooter is an alkali (pH12) and Magiclean is a weak alkali (pH8), we require a water rinse after using these cleaners. Also, eye protection is necessary to handle these solutions. Follow the manufacturer’s safety instructions.



Use undiluted Sharpshooter, or dilute Magiclean by 50% (100ml Magiclean to 100ml water).



Apply the solution on ALPOLIC with sprayer, towel, or sponge. Slight rubbing is required to remove heavy surface soiling. Use a soft towel.



Rinse with a wet cloth soaked in clean water.

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