08.00 Protection against condensation

Layers of air behind ventilated outer shells of exterior walls are not to be taken into account when determining the required thermal resistance. "Ventilated" is a term used to refer to multi-shell wall structures containing air chambers which connect to the outside air via openings. Such air gaps must extend over the entire width and height of a wall. A cross-section of min. 200 cm²/m is required for a wall with a rear ventilation function. From the standpoint of ventilation, no advantage results from substantially increasing the ventilation cross-section over 200 cm²/m.

Air gaps under 2 cm are ineffective in terms of ventilation. The bottom intake air opening and top discharge air opening may be smaller than the required ventilation cross-section inside the wall. However, the cross-section must be at least 50 cm². Some ventilation openings should be secured against vermin by means of perforated plates or strainers 4 to 8 mm in diameter.

Caution:
Perforated plates must have a free cross-section in the perforated portion. It must be possible to remove the perforated plates or strainers for cleaning since they fill with dust and dead vermin. The ventilation cross-section is then no longer guaranteed after a short time.

It is the duty of the designer to specify the layout and size of the ventilation openings on the basis of the building physics of individual buildings.

09.00 Fabricating instructions

The ability to fabricate FF2 and FF2 plus without difficulty ensures that cladding panels and vertical and horizontal junctions can be executed as part of an integrated system. Cutting and folding tools must be clean to avoid scratches.

It is advisable not to remove the protective film while processing the cladding panels and to perform fabricating only at a material temperature of ≥ 20 °C.

10.00 Storage

FF2 and FF2 plus prepainted aluminium semi-finished product should be stored on a clean, dry wooden base in such a manner as to exclude deformations due to the product's dead weight. The storeroom must be dry and well-ventilated. Packaging which has become moist during shipping must be removed immediately.

Condensation may form on semi-finished product which has cooled drastically during shipping or during storage in unheated storerooms and is then moved into heated storerooms or workshops. Condensation forms, for example, at a relative humidity of 60 % and a semi-finished product temperature of + 10 °C at a shop temperature of 17 °C.

This means that the semi-finished product temperature is decisive both for the formation of condensation on the product and for processing (particularly bending, flange folding, curving, etc.) It is always advisable to store the material to be processed until the material temperature reaches ≥ 20 °C.

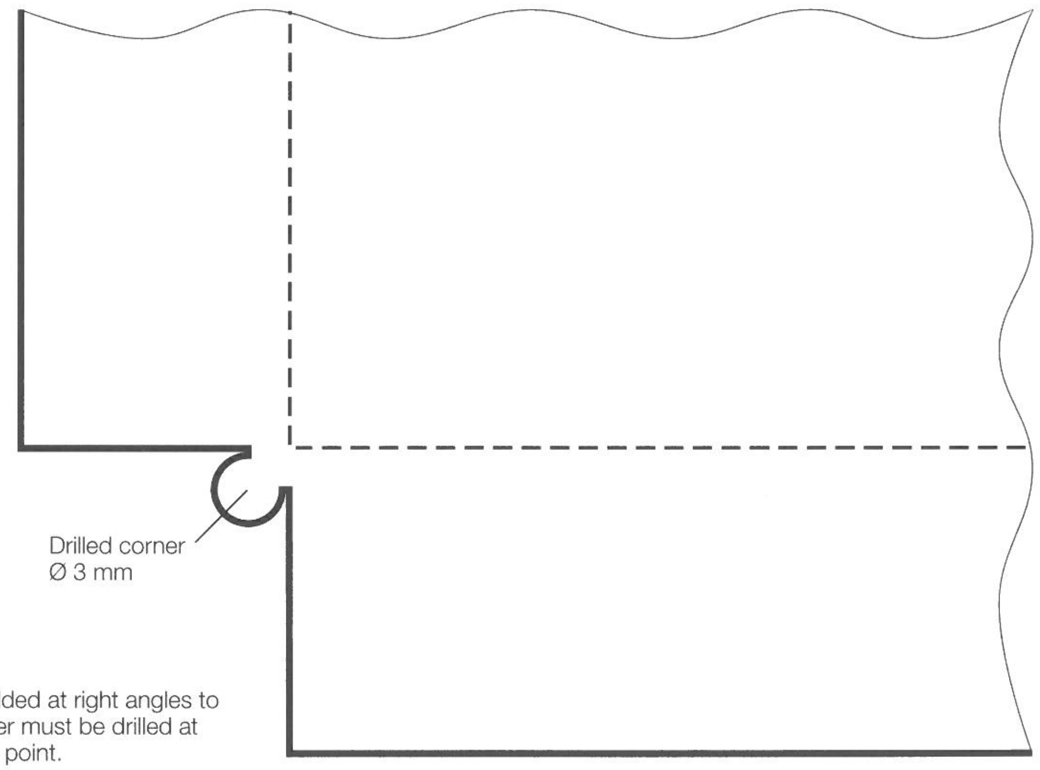
11.00 Flange folding and corner fabrication

11.01 Flange folding

To avoid notch stresses and resultant stress peaks, a hole must be drilled where a corner is to be formed by folding two adjacent flanges together at right angles to each other. The diameter of the hole depends on the thickness of the sheet or plate.

Hole diameter where flanges come together at right angles:
For a material thickness of 2.0 mm (ALCAN prepainted aluminium FF2): 3 mm

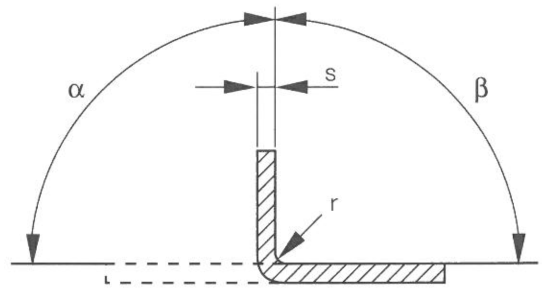
Determinig sheet sizes before bending



Flanges folded at right angles to one another must be drilled at the folding point.

Bending radius

Minimum permissible bending radius r for the material thickness s = 2.0 mm (ALCAN prepainted aluminium FF2): 5.0 mm



Material temperature ≥ 20 °C

s Material thickness
r Inside bending radius

α Bending angle
β Groove angle

Determining blank sheet sizes for 90 ° bent components

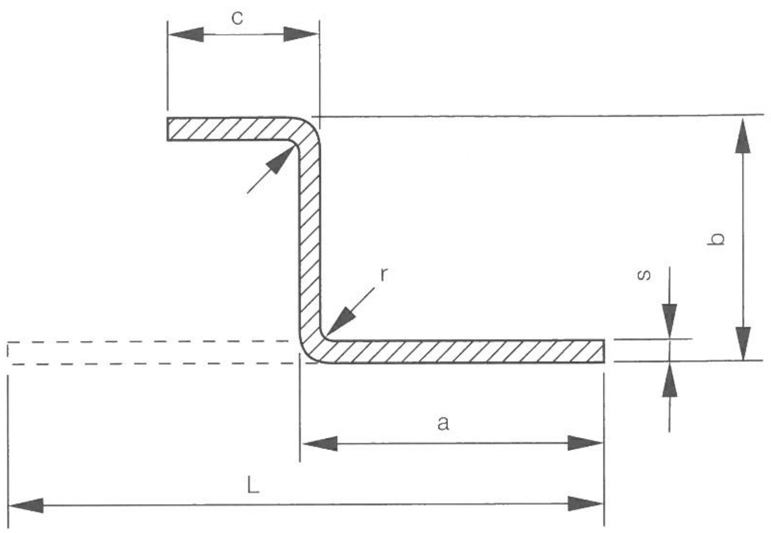
The following equation applies when determining the effective length of a bent component:

Effective length

$$L = a + b + c + \ldots - n \cdot v$$

L	Effective length¹)
a, b, c	Length of flanges
s	Material thickness
r	Bending radius
n	Number of bending points
v	Adjusted value

¹) The calculated effective lengths must be rounded up to full millimetres.



Adjusted value v for bending angle α = 90 ° for material thickness s = 2.0 mm (ALCAN prepainted aluminium FF2 and FF2 plus)	
Bending radius r in mm	Adjusted value v per bending point in mm
5.0	4.87

Example of determination of blank sheet size for 90 ° bent components of a facade panel of ALCAN prepainted aluminium FF2 or FF2 plus for facades

$a = \frac{634\ \text{mm}}{2} = \frac{(a_1 + a_2)}{2} = 317\ \text{mm}$

$b_1 = 32$ mm; $b_2 = 34$ mm

$c_1 = 32$ mm; $c_2 = 34$ mm

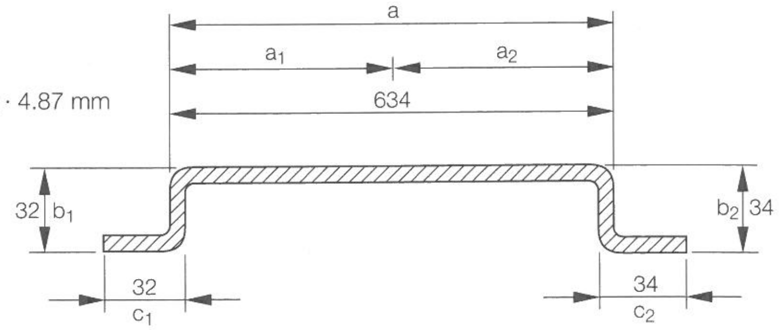
$r = 5.00$ mm

$v = 4.87$ mm (see table)

$L_1 = a_1 + b_1 + c_1 - n \cdot v$
$= 317$ mm + 32 mm + 32 mm − 2 · 4.87 mm
$= 381$ mm − 9.74 mm
$= 371.26$ mm

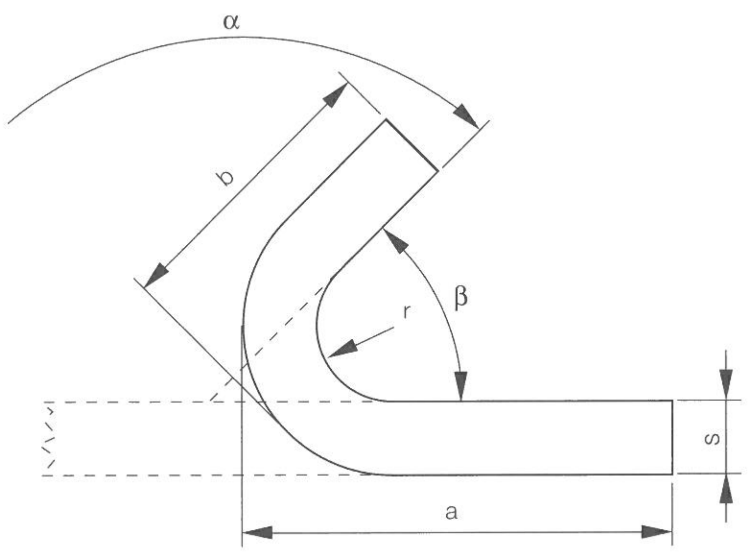
$L_2 = a_2 + b_2 + c_2 - n \cdot v$
$= 317$ mm + 34 mm + 34 mm − 2 · 4.87 mm
$= 385$ mm − 9.74 mm
$= 375.26$ mm

$L_1 = 371.26$ mm
$L_2 = 375.26$ mm
746.52 mm ≈ 747 mm



Since two different sides are used in the example of a panel, the distance "a" is cut in half. The example shows this calculation. At the end, both sides are added – 746.52 mm in our example – and rounded up to the full millimetre. Consequently, a total sized section 747 mm wide is required for this panel.

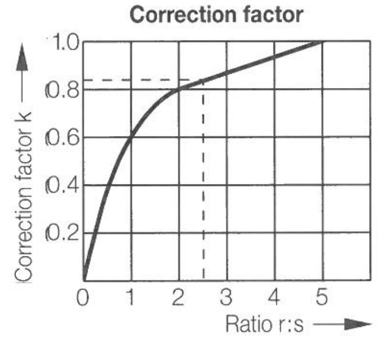
Determining the blank size for components with any desired bending angle



L	Effective length
a, b	Length of flange
v	Adjusted value
s	Material thickness
r	Bending radius
β	Groove angle
k	Correction factor

Material thickness s	Inside bending radius r	Ratio r:s	Correction factor k
2.0 mm	5.0 mm	2.5	0.85

Correction factor



Adjusting value v for β = 0° to 90°

$$v = 2\,(r + s) - \pi \cdot \left(\frac{180° - \beta}{180°}\right) \cdot \left(r + \frac{s}{2} \cdot k\right)$$

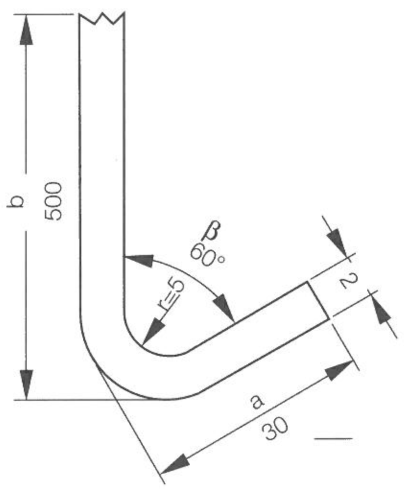
Adjusting value v for β > 90° to 165°

$$v = 2\,(r + s) \cdot \tan\left(\frac{180° - \beta}{2}\right) - \pi \cdot \left(\frac{180° - \beta}{180°}\right) \cdot \left(r + \frac{s}{2} \cdot k\right)$$

for β > 165° to 180 °; v ≈ 0 (negligibly small)

Effective length $L = a + b - v$

Determining the blank size for components with a bending angle of 0° to 90°



$L = a + b - v$

$\frac{r}{2} = 2{,}5$ (see table on p. 9)

Edged component with groove angle $\beta = 60°$
$k = 0.85$ (see table on p. 9)

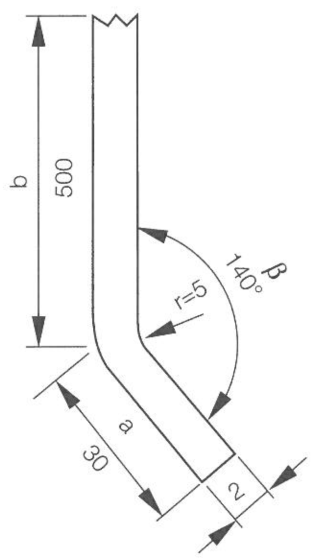
$$v = 2\,(r + s)\text{ mm} - \pi \cdot \left(\frac{180° - \beta}{180°}\right) \cdot \left(r + \frac{s}{2} \cdot k\right)$$

$$v = 2\,(5 + 2)\text{ mm} - \pi \cdot \left(\frac{180° - 60°}{180°}\right) \cdot \left(5 + \frac{2.0}{2} \cdot 0.85\right)\text{ mm}$$

$= 1.79$ mm

$L = a + b - v$
$= 30$ mm $+ 500$ mm $- 1.79$ mm
$= 528.2$ mm
$= 529$ mm effective length

Determining the blank size for components with a bending angle of > 90° to 165°



$\frac{r}{2} = 2.5$ (see table on p. 9)

Edged component with groove angle $\beta = 140°$

$k = 0.85$ (see table on p. 9)

$$v = 2\,(r + s) \cdot \tan\left(\frac{180° - \beta}{2}\right) - \pi \cdot \left(\frac{180° - \beta}{180°}\right) \cdot \left(r + \frac{s}{2} \cdot k\right)$$

$$= 2\,(5 + 2) \cdot \tan\left(\frac{180° - 140°}{2}\right) - \pi \cdot \left(\frac{180° - 140°}{180°}\right) \cdot \left(5 + \frac{2}{2} \cdot 0.85\right)$$

$= 1.47$ mm

$L = 30$ mm $+ 500$ mm $- 1.47$ mm

$= 528.53$ mm

$= 529$ mm effective length

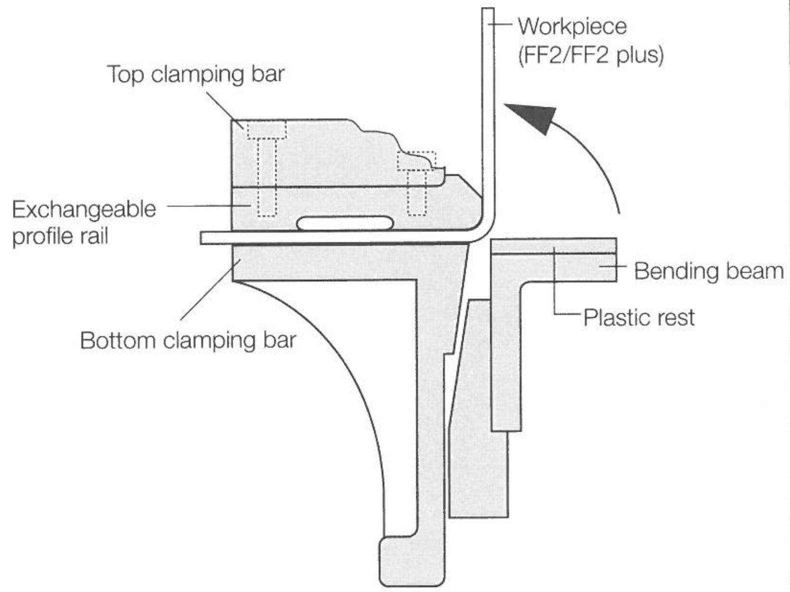
Folding

When folding with a machine, a rounded rail is used because of the required radii (r). If possible, the bent edge should be parallel to the direction the plate is rolled in.

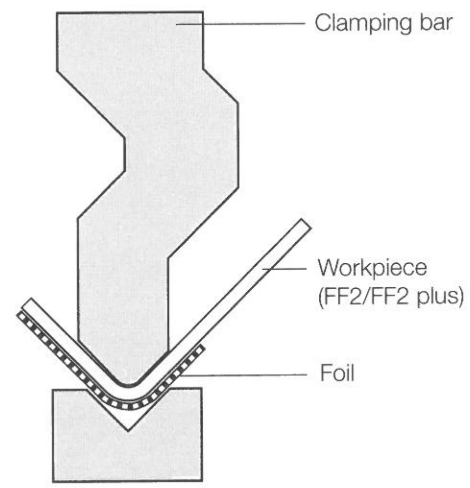
To be practical, bending lines are marked with a pencil. Marking them with a scratch awl may result in fracture. At folded edges, any burring has the effect of a notch (notch stresses). High-strength materials are particularly sensitive, so they are deburred prior to bending. It may be necessary to file the edges. The same applies for drilled holes (see figure on p. 7).

There are different types of machines for folding. There is the folding machine with adjustable top clamping bars and bending beams in which profile rails and cheek rails are exchangeable. The profile rail should have a rounded edge. Top clamping bar, profile rail and swivel angle of the bending beam must enable "overbending" to compensate for the resilience. Bending beam and folding rail are set after trial bendings on the basis of material thickness and the desired bend. To avoid surface damage, it is advisable to place plastic pads on the folding rails or to cover the plate/sheets with protective film (e.g. Vulkollan® D15 made by Bayer AG).

Folding machine

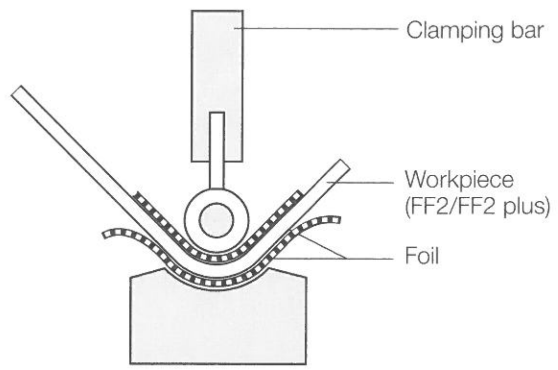


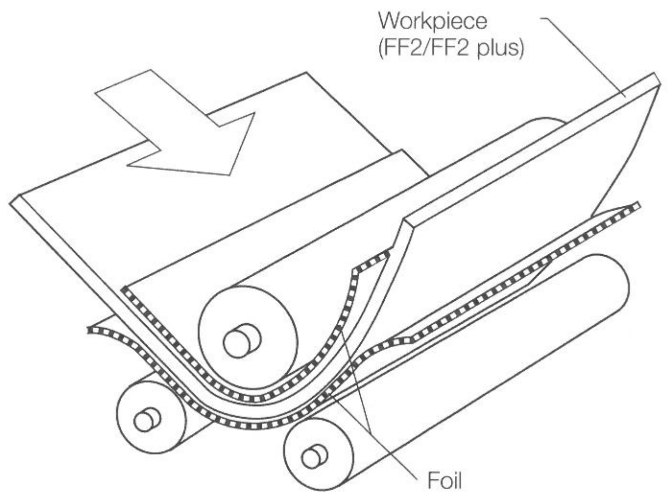
Bending press



11.02 Roller Curving

Care must be taken when curving coil coated prepainted aluminium on rolling machines to ensure that the rollers remain undamaged and clean. Suitable linings of plastic or the like (e.g. Vulkollan® D15 made by Bayer AG) must be used to protect the surface. Large bending radii are shaped with a 3-roller rounding machine.

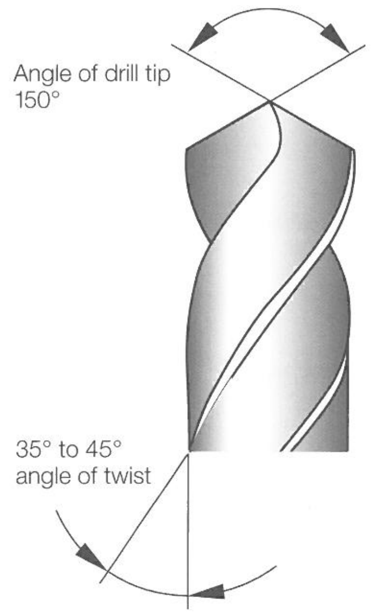




11.03 Drilling

Bits especially for aluminium are advisable when drilling in aluminium. Drill bits for aluminium differ from those for other metals in that they have a relatively large angle of twist, max. 45° compared to 25° for steel. A striking characteristic of aluminium bits is the enlarged space for chip discharge.

Drill bits with a centre tip have demonstrated their worth in the field because of their enhanced dimensional accuracy. When drilling large holes in thin sheets, e.g. > 5 x s (s = thickness of material), such as > 10 mm in prepainted aluminium, even well-ground bits produce eccentric holes. The reason: The drill tip no longer has any guide after penetrating the sheet. In such cases, the bit is ground so that the angle of the tip is about 150°. Consequently, the back of the cutting lip supports and guides the bit. Despite this "incorrect" drill bit grinding, the bit now drills round holes in aluminium sheets. Trial drillings are advisable.



12.00 Thermal expansion

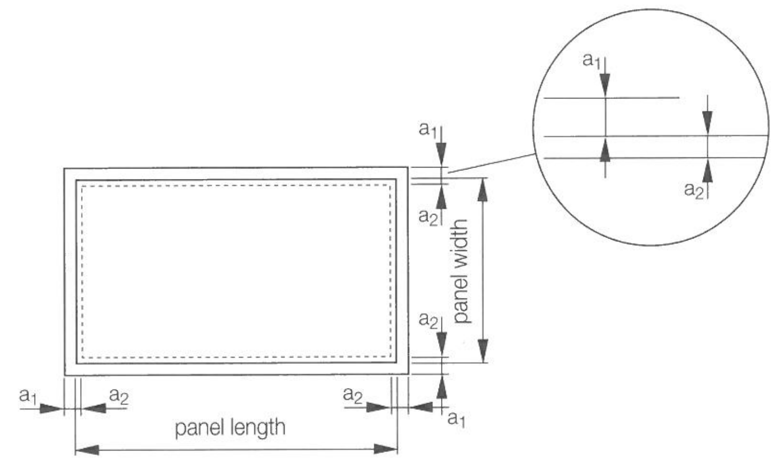
When temperatures fluctuate, aluminium objects expand and shrink in all directions. The coefficient of expansion of aluminium is 0.024 mm/m/°C.

When exterior wall cladding is subjected to rainfall, temperature differences must be taken into account which range from the temperature during assembly, generally +10 °C, and limit temperatures of −20 °C and +80 °C. In actual practice this results in an applicable temperature difference (Δt) of 70 °C.

When thermal expansion is hampered, the stresses developing in the component due to distortion may result in dents in the visible surface.

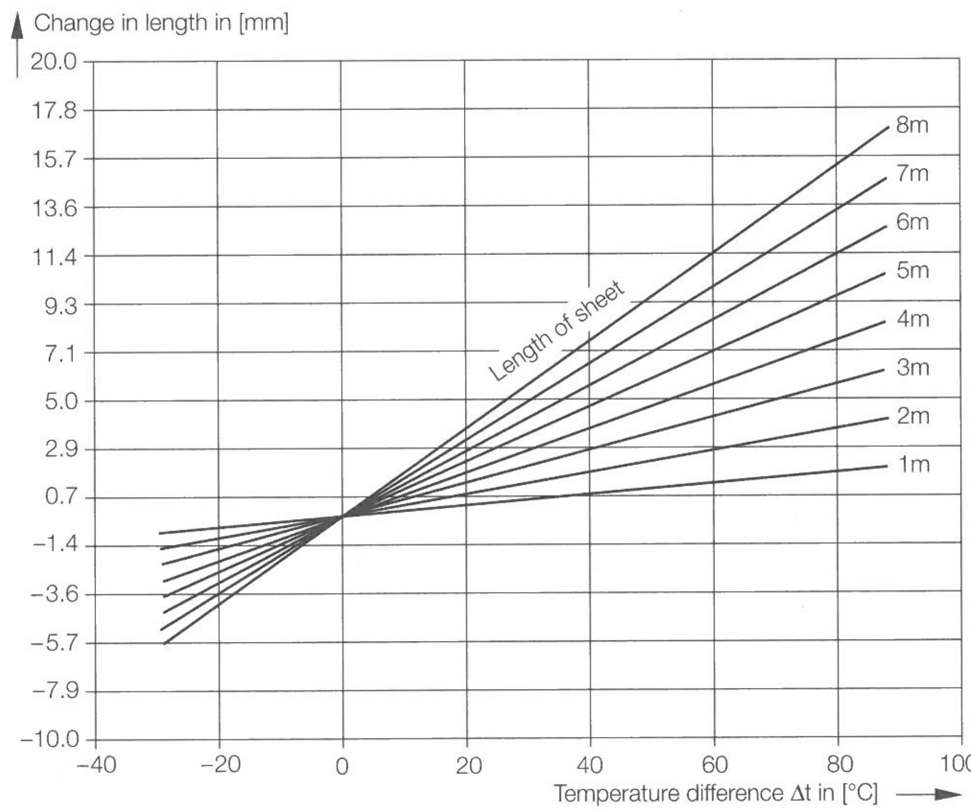
Contraction may result in fixing lugs being sheared off. The extremes of thermal movement in sheet length and width are illustrated below.

Thermal expansion of an aluminium sheet/panel



Assembly temperature: +10 °C
a_1 = Expansion in mm; a_2 = shortening in mm
Temperature difference Δt: Assembly temperature – material temperature (Δt)
Coefficient of expansion for aluminium = 0.024 mm/m/°C

Diagram of the longitudinal expansion of an aluminium sheet in mm



13.00 Fasteners/Connectors

Connect aluminium components only with fasteners which do not corrode in service.

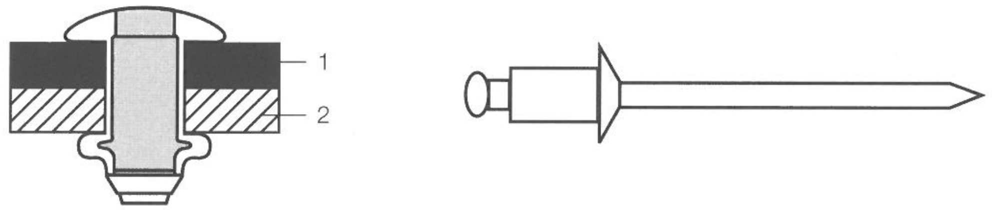
Sliding points

Where connections with no friction grip are involved (sliding points), the pressure is applied to the face of the hole, not the hole itself.

Fixed points

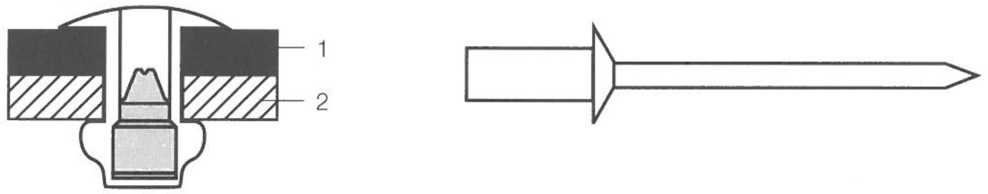
Connections with friction grip (fixed points) exert surface pressure and pressure to the face of the hole. No relative movement to the parts develops. Three types of rivets are possible as fasteners for facade structures: The blind rivet, the cup rivet and the Bulb-tite blind rivet.

Blind rivet



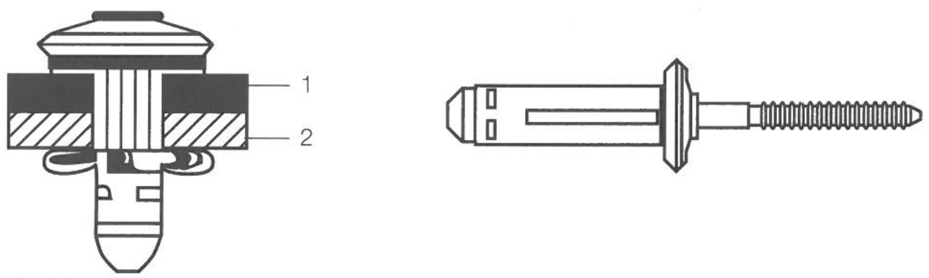
Aluminium blind rivet of various diameters and lengths

Cup rivet



Aluminium cup rivet of various diameters and lengths

Bulb-tite blind rivet

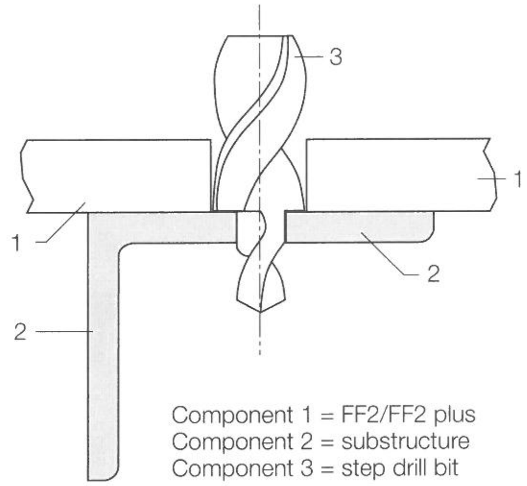


Bulb-tite blind rivet – a special aluminium rivet with Neoprene gasket (without pressure to face of hole if hole diameter is relatively large)

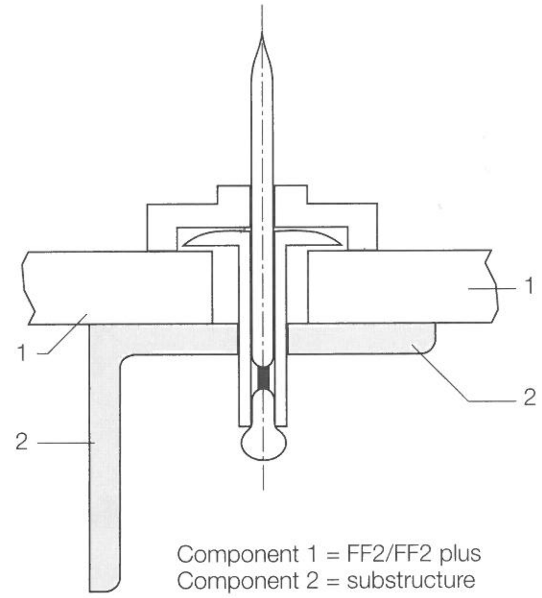
Component 1: FF2/FF2 plus
Component 2: Substructure

13.01 Creating a sliding point with blind or cup rivet

Expansion resulting from temperature can be compensated for by creating a sliding point. No stress develops in the aluminium component.



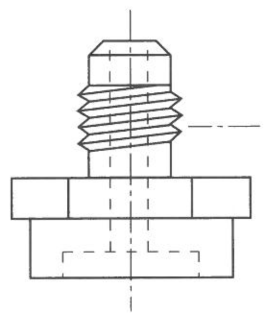
Component 1 = FF2/FF2 plus
Component 2 = substructure
Component 3 = step drill bit



Component 1 = FF2/FF2 plus
Component 2 = substructure

Blind rivets and processing tool form one system. For this reason, the tools recommended by the manufacturer for processing should be utilised. It is especially important that nozzle sizes should match rivet diameters.

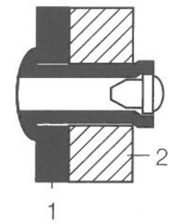
Where nozzles are too large, burrs from the rivet bush can be drawn into the nozzle or the drift is pulled all the way through the rivet bush.



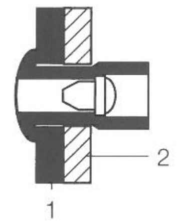
Special nozzle for riveting tongs as rivet gauge with specified tolerance of about 0.3 mm

A basic precondition for an expert rivet connection is the selection of the proper connection element and the correct choice of the material, geometric form, sealing disc (if necessary), clamping area and diameter for blind rivet and its bore.

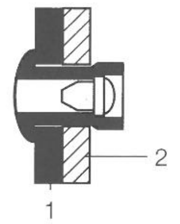
Above and beyond this, take care to avoid the following illustrated errors.



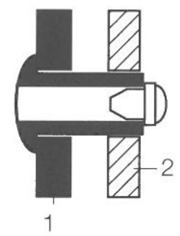
a) Clamping package too thick or clamping area too small (snaphead is not fully formed).



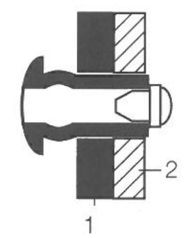
b) Clamping package too thin or clamping area of the rivet too small for the thickness of the component package.



c) Hole too small, therefore retaining ring contact too small.



d) Components are too far apart, therefore no snap-head formation is possible.



e) Blind-rivet snap head not brought into contact with component surface, thus no snaphead formation is possible.

Component 1 = FF2/FF2 plus
Component 2 = substructure

13.02 Using Bulb-tite blind rivets to form sliding and fixed points

The strength of a rivet fixing should be calculated. The results of a study of the fastening of the FF2 or FF2 plus panel with Bulb-tite blind rivets onto support profiles were as follows:

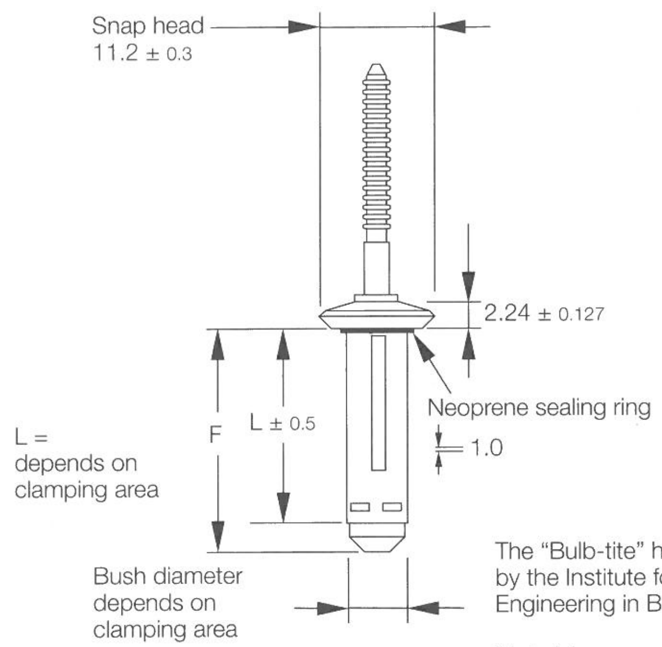
The diameter of the rivet hole for a sliding should remain limited to ≤ 7.00 mm in order to achieve regular formation of the bulbs during riveting. Necessary shifting due to thermal expansion between the riveted FF2 and FF2 plus panels and the support profile of V ≈ ± 1.0 mm is possible at the permissible shearing stress of perm. S = 0.5 kN per rivet.

The permissible stresses on type RV6604-6-4 and RV6604-6-6 Bulb-tite blind rivets are:

shearing:	perm. S = 0.50 kN	
traction:	perm. H = 0.34 kN	
at edge distances:	a ≤ 40 mm	
and	b ≥ 25 mm	
traction:	perm. H = 0.50 kN	
at edge distances:	a ≤ 25 mm	
and	b ≥ 25 mm	
Edge distances:	a = FF2 or FF2 plus panel	– component 1
	b = support profile	– component 2

Important: The lowest edge distance of the rivets from the edge of the FF2 or FF2 plus panels ≤ 25 mm.

Bulb-tite blind rivet (Bulb-tite®)

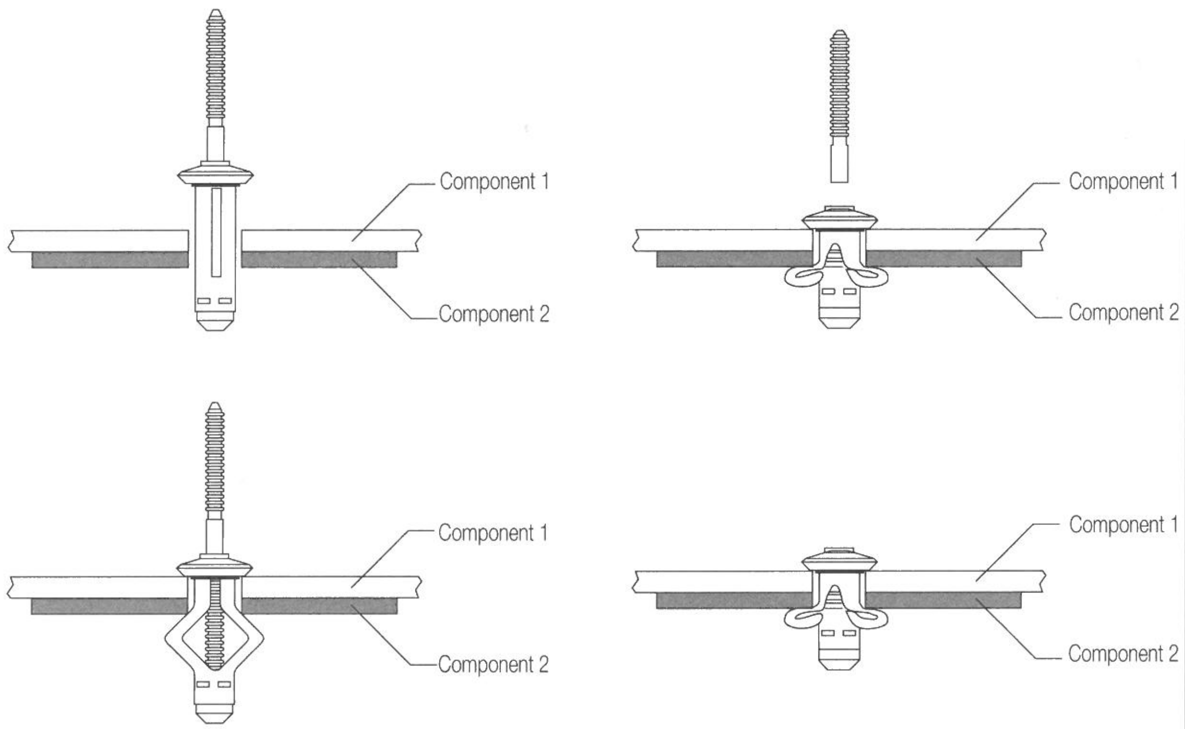


The "Bulb-tite" has been approved by the Institute for Structural Engineering in Berlin

Material:
Bush AlMg5
Drift Al Cu Mg1

Clamping area	Order number	L	$F_{max.}$
1.27 – 4.75 mm	RV6604-6-3W	17.45	22.15
1.57 – 6.35 mm	RV6604-6-4W	19.05	23.75
4.75 – 9.50 mm	RV6604-6-6W	22.23	26.92
7.92 – 12.70 mm	RV6604-6-8W	25.40	30.10
11.10 – 15.88 mm	RV6604-6-10W	28.58	33.27
14.30 – 19.05 mm	RV6604-6-12W	31.75	36.45

Mode of operation of the Bulb-tite blind rivet



A special nozzle is required for Bulb-tite blind rivets.

Component 1 = FF2/FF2 plus
Component 2 = substructure

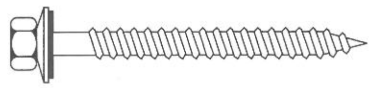
The hole diameter for a fixed point should correspond to the diameter of the relevant type of Bulb-tite blind rivet.

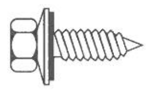
One of the characteristics of the Bulb-tite blind rivet is that the rivet is always drawn centrally into the bore hole such that it permits a 1 mm thermal expansion of component 1 even while making a sliding point.

13.03 Screws

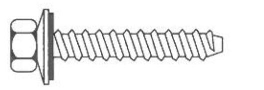
Where connections/fasteners with screws are concerned, the same technical prerequisites and conditions apply as with rivet connections, e.g., fixed point, sliding point. In selecting the material, care must be exercised to ensure that the connectors and/or fastening points do not corrode under the conditions of use for which they are intended.

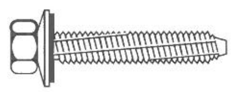
① ②
Wood and Parker screw made of aluminium or special steel with aluminium washer and vulcanised neoprene gaskets to fasten FF2 or FF2 plus panels to aluminium substructures and to connect aluminium panels to one another.

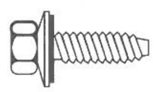
①


②


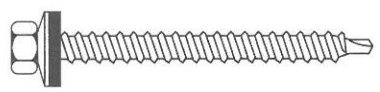
③ ④ ⑤
Self-tapping screw made of special steel with aluminium or special steel washer and vulcanised neoprene gasket to fasten FF2 or FF2 plus panels to steel and aluminium substructures.

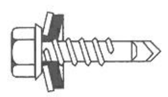
③


④


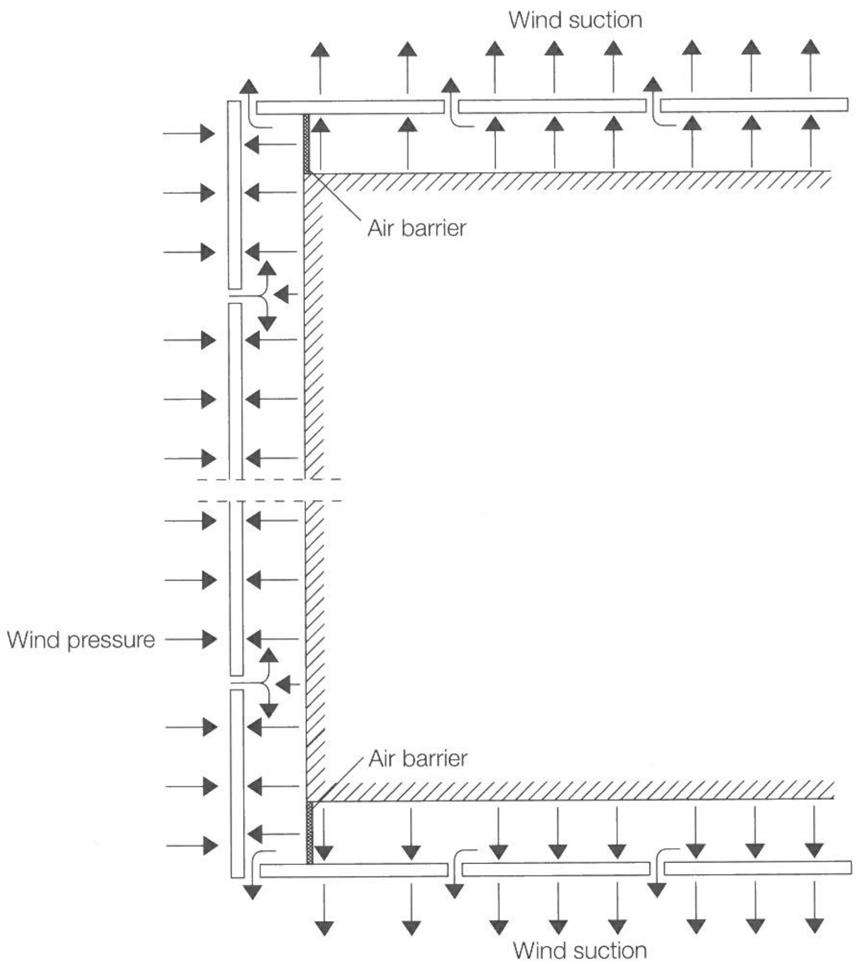
⑤


⑥ ⑦
Self-drilling screws made of aluminium and special steel to be used as above.

⑥


⑦


16.01 Air barrier



16.02 Wind screen

Heat losses resulting from heat exchange occur due to leaks through joints around windows, doors, etc., but particularly due to leaking seals of exterior components. These joints must therefore be sealed.

In the case of joints in the heat-transmitting facing surface of a building, care must be taken to ensure that these joints receive a long-lasting, airtight state-of-the-art seal. In particular, this applies to continuous joints between assembly units or between web members and the supporting framework.

The above-listed heat losses through joints are as per DIN 4108, "Thermal protection in building construction". The following regulations of the (German) energy-saving law, thermal protection code must be added:

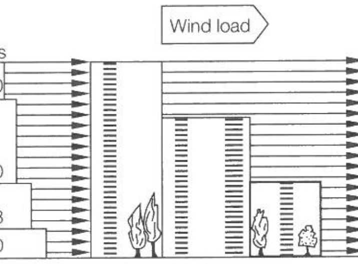
"Limiting the termal losses in case of leaks: The other joints in the heat-transmitting facing surface must receive long-lasting, state-of-the-art, airtight seals."

Roof and wall structures must have windtight exterior envelopes for the building. Since panels can never be windtight on the inside or outside due to their longitudinal and horizontal joints and the many junctions, it is imperative that special wind barriers be installed. This task can be performed with sheets that are open to diffusion on one side if they are installed over the entire area, without gaps, and tightly connected at all abutting and connecting points. If no adequately sealing wind barriers are present, this is a construction defect. The requirements of the (German) thermal protection code were not observed. An uncontrolled air flow through joints in the heat-exchanging roof and wall areas means elevated heat loss. Reference is made to a so-called "thermal bridge due to mass flow".

16.03 Static predimensioning

Wind loads per DIN 1055, Part 4 (8.86)
– Wind pressure and wind suction on exterior walls parallel to wind

Building height (m)	Wind velocity V ms/kmh	Metres	Wind load: in normal zone – Wind suction (kN/m²)	Wind load: in normal zone – Wind pressure (kN/m²)	Wind load: in edge zone[1] – Wind suction (kN/m²)	Wind load: in edge zone[1] – Wind pressure (kN/m²)
over 100	45.6 164.2	▽·100	−0.91	1.3	−2.6	1.3
over 20–100	42.0 151.2	▽·20	−0.77	1.1	−2.2	1.1
over 8–20	35.8 128.9	▽·8	−0.56	0.8	−1.6	0.8
from 0–8	28.8 103.7	▽·0	−0.35	0.5	−1.0	0.5



[1] In each case, the width of the edge zone is 2.0 m on both sides of the building corners.

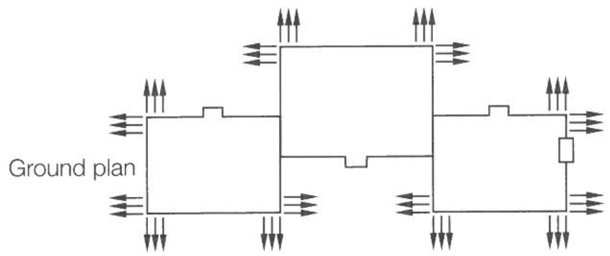
w = Pressure or suction of wind exerted on surface of structure

$w = q \cdot cp$ (kN/m²)

q = Dynamic pressure of the wind

$q = \frac{v}{1600}$ (kN/m²)

v = the wind velocity to be factored in a various elevations above the enclosed terrain



Per DIN 4113 the cladding elements are statically determinable components for which the stability under the stresses which develop can be verified through calculation. No general permit or permit under building law is necessary for the cladding elements made of ALCAN prepainted aluminium FF2 and FF2 plus.

16.04 Wind design loads per DIN 1055

Cladding elements are statically determinable components for which the stability under the stresses which develop can be verified through calculation.

In the load tables shown the specified values are maximum loads taking into consideration the permissible stress of the specific material. The deflection is not limited under DIN 4113 and was also not taken into account in the tables. In actual practice, however, the deflection should be limited to l/40 – l/50. Diaphragm structural conditions were used in the calculations for the load tables of the coffers.

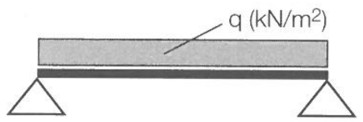
The calculations illustrated here are just approximate values for predimensioning facade elements. A static must be prepared for the property in any event.

Static comparison between the alloys AlMg3 H42 (FF2 and FF2 plus) and the alloy AlMg3 H22 mill finished (2.0 mm).

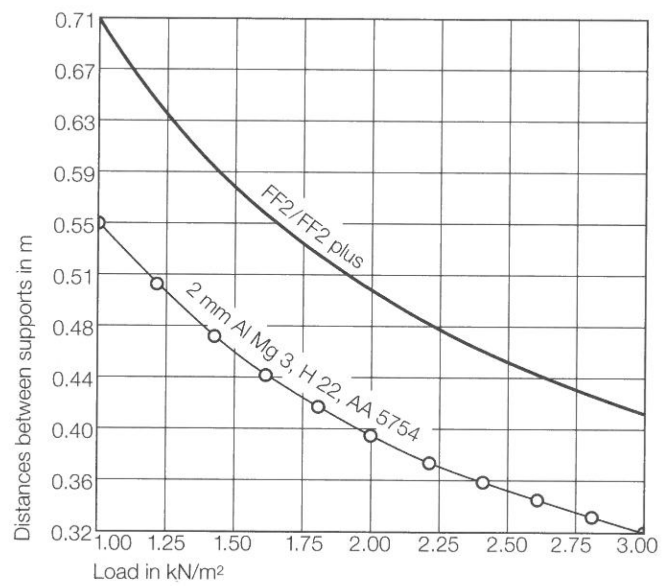
Permissible stress per DIN 4113:

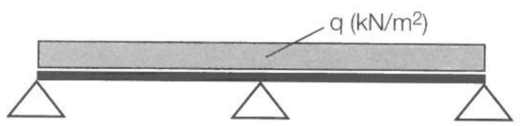
- for FF2: 97 N/mm²
- for AlMg3 H22: 76 N/mm²

Load tables based on the static comparison:

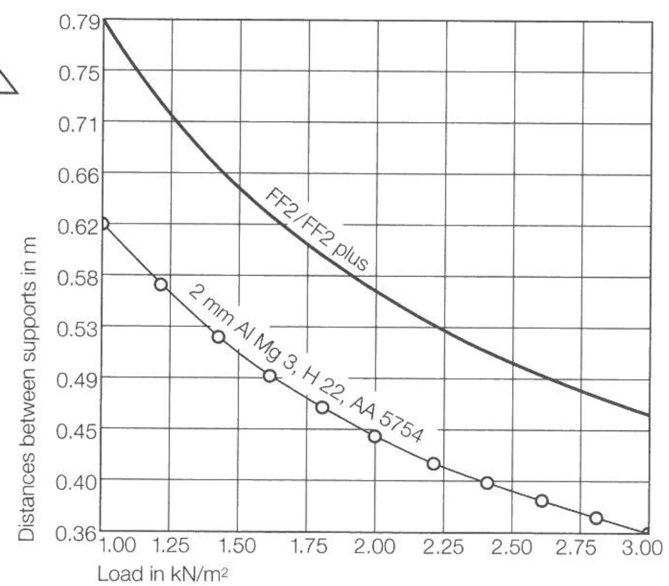


Single-span situations





Double-span situation



Static comparison between the alloys

AlMg3, AA 5754, H42, 2 mm (FF2 and FF2 plus)
AlMg3, AA 5754, H22, 2 mm
AlMg1, AA 5005, H14, 2 mm and 3 mm
Al99.5, AA 1050, H14, 2 mm