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Glazing rebates and beads for sealed glazing units

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Glazing rebates and beads for sealed glazing units

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1. Introduction

The manufacturers of sealed glazing units (also known as insulating glazing, thermoglass, etc.) usually require that bead glazing shall be used when their units are installed. They very rarely accept ordinary face glazing, unless the units are very small. In their brochures the manufactures give advice on how the rebates are to be dimensioned in order to give the necessary clearances and thicknesses of glazing compound between unit and rebate and between unit and bead. The intention is to have the units installed and kept in place without being subjected to mechanical strains that may damage the glass or the edge seal of the units. At the same time the installation shall be watertight. Frequently the glazing is also intended to give the edge seal of the units an additional protection against water. This is especially true for units where the tightness of the edge seal is based on a glued or cemented bond.

From a theoretical point of view, the brochures should give proper directions about the dimensioning of the glazing rebates. In practice, this has unfortunately proved not to hold true, as the rebates frequently have been too small. This is especially true for the period up to the beginning of 1961. With a critical examination of the instructions from that period, it will also be seen at once that sufficient attention has not been paid to the tolerances on the glazing units and the surrounds. For units with a soldered metal spacer between the panes it was required at that time that the metallic coating on the glass should theoretically lie flush with the edge of the rebate, while the requirement made for units with an external metal protecting channel was only a theoretical covering of about one millimeter. The result was in practice that the metal edge seal of the units could easily be able to project over the edge of the rebate.

Since 1960 the Norwegian Building Research Institute has recommended a covering of the metal edge seal of the units of at least 2 mm for units with soldered metal spacer and at least 4 mm for units with

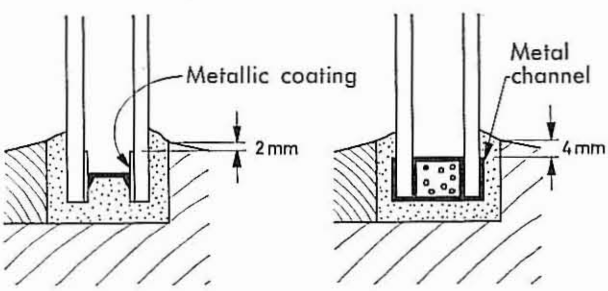

Fig. 1. Recommended covering at least 2 mm for units with soldered spacer between the panes and at least 4 mm for units with external metal protecting channel.

an external metal protecting channel, see *Figure 1.* The various glass manufacturers have gradually followed up on the same lines, and the situation is now considerably improved. Inadequate rebates do, however, still occur in such a number that the Norwegian Building Research Institute has found it appropriate to take the problems up in all its aspects. One of the main points has been to establish the necessary clearances and dimensions of the rebate, taking into consideration all normal tolerances on the sealed glazing units and the frames and casements into which they are going to be mounted, together with movements between unit and rebate resulting from variations in temperature and moisture content of materials. The greatest part of this work has been carried out by the author, inspired by preliminary studies in the Dóor and Window Technical Committee of the Norwegian Standards Association, as well as personal discussions with Ing. *Letourneur,* Compagnie de Saint-Gobain. Certain sections, however, are based on what came out in discussions in a working group with representatives of the National Associaton of Glaziers in Norway and the Norwegian Building Research Institute.

2. Terminology

The expressions rebate width, rebate depth and rebate height are in Norway used mixed together and in different meaning by the different glass manufacturers, glaziers and others who have something to do with glazing units and connected problems. In the original Norwegian version of this paper the designations were chosen in agreement with the Norwegian Standards NS 755 and NS 798 M. In the English version the terminology will be in accordance with British Standard Code of Practice C.P. 152:1960. The most important dimensions are given in *Figure 2.*

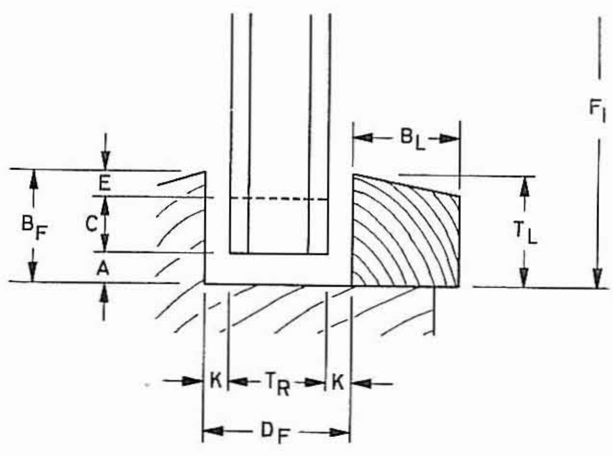

Fig. 2. Designations utilised.

- A = edge clearance
- B_F = rebate depth
- B_L = width of glazing bead
- C = width of the edge seal of the unit (external metal channel, internal metal coating or similar)
- D_F = unit glazing gap width
- E = recommended covering of the edge seal
- F_h = tight size height
- F_b = tight size width
- F = greatest dimension of tight size height or width
- K = face clearance or width of lateral glazing compound
- T_L = depth of glazing bead
- T_R = thickness of sealed glazing unit (measured on the glass)

Further the following designations will be used for tolerances and movements:

t_{Gp} = plus tolerance on glass size width or height
t_{Gm} = minus tolerance on glass size width or height
t_{Fp} = plus tolerance on tight size width or height
t_{Fm} = minus tolerance on tight size width or height
t_R = tolerance (±) on the thickness of the sealed glazing unit
t_B = tolerance (±) on the rebate depth
t_D = tolerance (±) on the unit glazing gap width
k = contraction of the surrounds in relation to the unit by changing temperature and moisture content of materials, determined in relation to a normal condition
e = expansion of the surrounds in relation to the unit by changing temperature and moisture content of materials, determined in relation to the same normal condition as for k.

Both k and e are calculated per metre of tight size (per linear metre along the rebates).

3. Tolerances on sealed glazing units

The manufacturers of sealed glazing units usually give certain tolerances on the size and total thickness of the units. In *Tables 1 and 2* the available data for nine types of unit on the Norwegian market are recorded. It should be noted that the thickness tolerances for some types of unit are only approximate as these will be different for units of sheet glass and plate glass and also will vary somewhat with the size of the unit.

The tolerances on the size of sealed glazing units can as a principle be of three different kinds, namely dimensional tolerance, out of square and edge deviation, as shown in *Figure 3.* With modern cutting equipment and methods the edge deviation can, however, be ignored in practice. Only dimensional tolerance and out of square are then remaining. The out of square that has to be taken into account can be so great that the upper corners of a unit are coming 4 mm out of place when one edge is adjusted horizontally. If such a unit was installed in a rectangular opening on setting blocks of equal thickness, then the edge clearance would be reduced by about 2 mm at two points, as shown in *Figure 4a.* By using setting blocks of different thickness the situation can be somewhat improved,

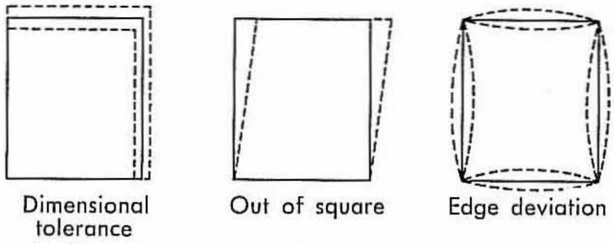

Fig. 3. Tolerances in the plane.

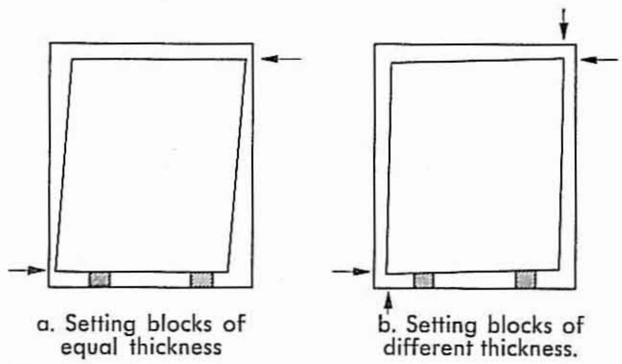

Fig. 4. Unit out of square installed in a rectangular opening. Reduced clearances as shown by arrows.

Table 1. Tolerances in millimeters on the size of sealed glazing units.

Type of unit	Glass thickness			
	3 mm	4 mm	5—6 mm	over 6 mm
Aluco	±1.5	±1.5	±1.5	±1.5
Aterphone	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5
Cudo	±1.5	±1.5	±2.0	
Duoterm	±2.5	±2.5		
Gado	±1.5	±1.5		
Multipane	±1.0	ab. ±1.0	ab. ±1.5	ab. ±1.5
Polyglass	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5
Schalker Isolierglas	±1.6	+3.0 —1.6	+3.0 —1.6	+3.0 —1.6
Thermopane	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5	+2.5 —1.5

Table 2. Tolerances in millimetres on the total thickness of sealed glazing units.

Type of unit	Glass thickness			
	3 mm	4 mm	5–6 mm	over 6 mm
Aluco	±1	±1	±1	±1
Aerphone	±0.5	±0.5	±0.5	±0.5
Cudo	±1.0	±1.0	±1.0	
Duoterm	±0.75	±0.75		
Gado	insignificant	insignificant		
Multipane	±0.5	±0.5	±0.5	±0.5
Polyglass	±0.5	±0.5	±0.5	±0.5
Schalker Isolierglas	ab. ±1.0	ab. ±1.0	ab. $^{+1.0}_{-1.5}$	ab. $^{+1.0}_{-1.5}$
Thermopane	ab. ±1.0	ab. ±1.0	ab. $^{+0.5}_{-2.0}$	ab. $^{+0.5}_{-2.5}$

as shown in *Figure 4b*. There will, however, always remain a certain reduction of the edge clearance at four points. This reduction will depend on the relationship between the width and the height of the unit, and can in the most unfavourable case amount to as much as about 1 mm.

It does not appear quite clearly in the brochures whether both dimensional tolerance and out of square have been included in the tolerances on the size of the units given in Table 1. It is quite possible that it may be a little different in this respect. But in any case it seems to be realistic to calculate with a total tolerance on the size of sealed glazing units of $^{+3}_{-2}$ mm when trying to include the various types in Table 1 in a common specification. This tolerance should then include the dimensional tolerance as well as the part of the out of square that cannot be compensated by using setting blocks of different thickness.

The thickness tolerances on sealed glazing units are, as can be seen from Table 2, exceedingly different for different types of unit. If in this case a common denominator should be found which includes the tolerances for the various types of unit, it would have to be $t_R = ^{+1.0}_{-2.5}$ mm. For the real thickness tolerance unit against rebate there is one more factor that may have to be taken into account: The unit may be out of flat. Single flat glass panes themselves can be considered as absolutely flat, and the same applies to sealed units as assembled in the factory. When being installed on the building site it happens very often, however, that the units are out of flat because the boxes with the units or the units themselves have been unevenly supported. This is especially pronounced for units where the edge seal is made of soft metals as for instance lead, or other soft plastic-elastic materials. But even units with profiles of rigid metals such as iron or aluminium in the edge seal are not free from this defect. The distortion can be corrected again, however, either by letting the units stand for a time with a suitable support, or by pushing the units carefully back in the rebate, if necessary step by step. The thickness tolerance that has to be taken into account should then be covered by the common denominator of $^{+1.0}_{-2.5}$ mm.

4. Tolerances on glazing rebates

When the tolerances on tight size width and height are going to be discussed, attention must be paid to dimensional tolerance as well as out of square and edge deviation, as seen in Figure 3.

The dimensional tolerance has so far been very variable and has in certain cases been found to amount to as much as ±10 mm. Factories with modern equipment, however, seem to have the dimensional tolerance under control, and it does not appear unrealistic to calculate with a dimensional tolerance as small as ±0.5 mm.

The out of square that has to be taken into account can amount to 2 mm. Larger out of square may certainly be supposed to occur in some cases, but can be assumed to be adjusted downwards during the installation of the window. For a rectangular glazing unit installed in a casement out of square, the situation will be the same as for a glazing unit out of square installed in a rectangular casement, that is to say that the situation can be improved by using setting blocks of different thickness. For a casement with an out of square defect of 2 mm, the clearance between unit and rebate will then only be reduced by at most about 0.5 mm.

The edge deviation is usually the factor that is of prime importance for the tolerances on tight size width and height. For opening windows the edge deviations are usually caused by the fact that the casements are distorted, partly on account of their own weight and partly as a result of the weight of the sealed glazing units. On horizontally pivoting windows, for instance, the bottom casement member will usually be deflected down in the middle, the top casement member up in the middle and the two side casement members inwards in the middle. In large fixed windows the window frames will usually have so light profiles that they must be affixed and adjusted quite carefully if the edge deviations shall not become too great. It is most critical with the top frame member, which is inclined to hang down in the middle and with the bottom frame member which can acquire the strangest deformations as a result of the weight of the glazing unit if not supported at the right places. But even the side frame members must be fixed correctly if the edge deviations shall be under control.

In practice it has to be taken into account that the edge deviations can amount to ±1 mm for opening windows with tight size width or height of 1.5 m and ±1.5 mm for large fixed windows. The variation with window size will then be about as shown in *Figure 5.*

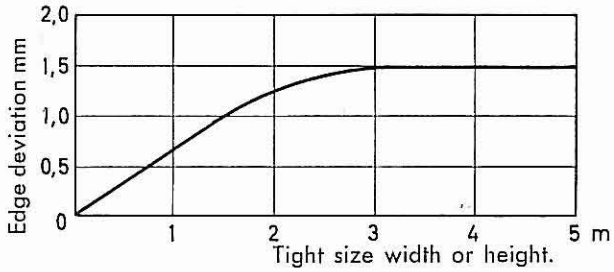

Fig. 5. Edge deviation as a function of window size.

The influence of the edge deviations on the tolerances on tight size width and height will be twice as much as that given in Figure 5, because two opposite frame or casement members can be deflected against one another or away from each other exactly to the same amount.

Altogether one has to take into account that the tolerances on tight size width or height will be made up by a dimensional tolerance of ±0.5 mm, a tolerance due to out of square of —0.5 mm, together with a tolerance due to edge deviations which can go up to ±3.0 mm. In the most unfavourable case these factors combine and give a total tolerance of $^{+3.5}_{-4.0}$ mm. When the coincidence factor is taken into account, however, it appears more realistic to place the maximum total tolerance at $^{+2.5}_{-3.0}$ mm, with a dependence on window size as shown in *Figure 6.*

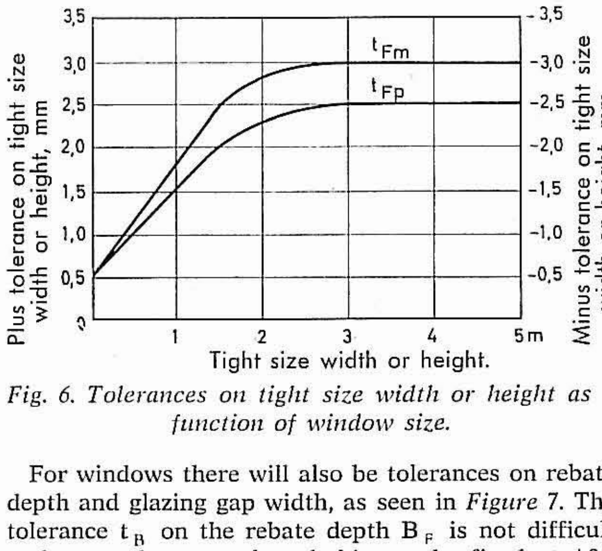

Fig. 6. Tolerances on tight size width or height as a function of window size.

For windows there will also be tolerances on rebate depth and glazing gap width, as seen in *Figure 7.* The tolerance t_B on the rebate depth B_F is not difficult to keep under control, and this can be fixed at ±0.5 mm for wooden windows, ±1.0 mm for iron windows with rolled profiles and ≈ 0 for aluminium windows and steel windows with extruded profiles. For the

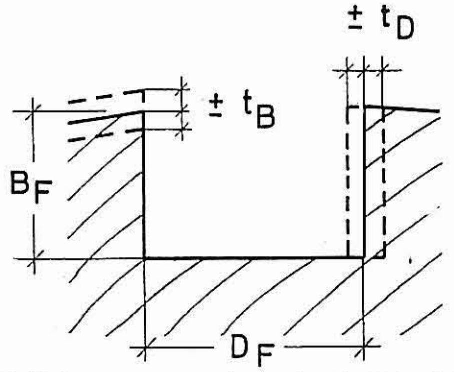

Fig 7. Tolerances on rebate depth and glazing gap width.

glazing gap width D_F it should, from a theoretical point of view, not be required to calculate with any tolerances for rebates with adjustable fixing of beads. In practice, however, the casement can be distorted or warped, as seen in *Figure 8,* and these distortions

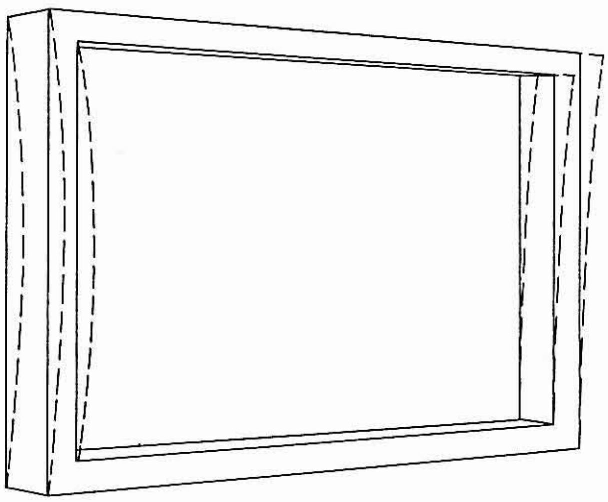

Fig. 8. Distortion in the space.

will reduce the face clearance at certain points, as seen in *Figure 9.* The result is the same as with a

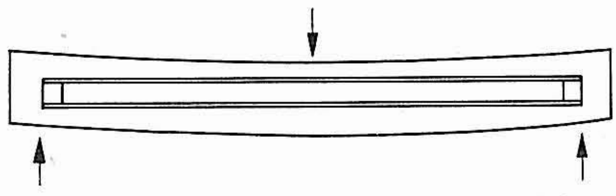

Fig. 9 Cross-section of bottom rebate viewed from above. Reduced face clearances as shown by arrows, resulting from distortion.

genuine tolerance on the glazing gap width and these distortions must, therefore, be calculated in the tolerances on glazing gap width and face clearance. For wooden windows it can be assumed that the distortion can amount to ±1 mm for tight size 1.5 m, increasing to ±1.5 mm for tight size over 3 m. This is the same dependence on size as in Figure 5. In the most unfavourable case the tolerance t_D on the glazing gap width D_F will be twice as much and thus amount to ±3.0 mm for very large wooden windows. For metal windows the distortions will scarcely be so great as for wooden windows. On the other hand many metal windows have non-adjustable screwed beads or studs, where the tolerance in the placing of the fixing points will be about ±1 mm. In practice, the tolerance on the glazing gap width will thus be of the same order as for wooden windows.

5. *Thermal movements*

The various materials in sealed glazing units and casement or frame have different coefficients of thermal expansion. This means that the units will move in relation to the rebate with changing temperature, something which for one thing will cause the clearances to be altered. These movements must then be taken into account when the nominal clearances and rebate dimensions are established.

The coefficients of thermal expansion for the actual materials are as follows:

glass	$8 \cdot 10^{-6}$ °C^{-1}
wood (in the longitudinal direction of the fibers)	$5 \cdot 10^{-6}$ «
iron	$12 \cdot 10^{-6}$ °C^{-1}
aluminium	$24 \cdot 10^{-6}$ «

Aluminium and iron will thus expand in relation to glass with rising temperature and contract with sinking temperature. For wood against glass the relationship will be the opposite.

What temperatures that have to be taken into account can be a matter of discussion. In general, the production of windows and sealed glazing units will be carried out at temperatures between +15 and +25° C, and the nominal dimensions will be set out at these temperatures. In practice, it must be assumed that the outside air temperature will go down to —25°C, giving the outer glass and the outer parts of the casement a temperature of about —15°C. Correspondingly, the temperature on sunny days in the summer can go up to +60°C. This gives a total temperature variation of about 75°C, divided on about 40°C temperature increase and about 35°C temperature decrease in relation to the reference state. The resulting relative movements will be as follows:

contraction (k)	aluminium-glass	wintertime	0.56	mm per m tight size
»	iron-glass	»	0.14	» » » » »
»	wood-glass	summertime	0.10	» » » » »
expansion (e)	aluminium-glass	»	0.64	» » » » »
»	iron-glass	»	0.16	» » » » »
»	wood-glass	wintertime	0.12	» » » » »

6. *Moisture movements in wood*

Wood will alter its dimensions with alterations in the humidity. Increased moisture content causes the wood to swell, and diminishing moisture content causes it to shrink. According to available information for Norwegian fir, a variation of 1 % by weight in the moisture content will give the following figures for the shrinkage and swelling:

Longitudinally to the grain	$\alpha_l = 0.01$ %
Radially » » »	$\alpha_r = 0.13$ %
Tangentially » » »	$\alpha_t = 0.25$ %

To what extent the moisture content in wooden windows varies with the time of the year is, strictly speaking, a problem about which very little is known, and the conditions can obviously be very different. Normally, it can be assumed that the wood on the inside of the windows will dry out from about 15 % to about 11 % moisture content in the course of the heating season, if not frequently soaked by condensation. On the outside there will be an increase in the moisture content in the same period of time by reason of high relative humidity in the air, autumn rain and melting snow. For well preserved wood the increase in moisture content can roughly be taken to be from about 15 % to about 20 %, for badly preserved wood right up to about 30 %. In the summer the moisture content in the wood will be reduced again to about 15 %, and on the sunny sides of a building the exterior wood may in a dry summer well get a further drying out down towards about 10 % moisture content. The variations inside and outside during the year, do, however, go in the opposite direction. The variations in the interior of the casement, that are decisive for the alterations in the tight size width and height, will then be considerably less. Now it cannot be accepted, for reasons which are to be treated more in detail later on, that the wood is badly preserved. What has to be taken into account here is, therefore, normally well preserved wood for which can be roughly estimated a variation in the moisture content in the interior of the casement of about 3 % by weight. The most interesting thing, however, is the alteration in moisture content in relation to the moisture content during the production of the windows, since these alterations determine the deviations from the nominal tight size dimensions. With the numerical values given above, these alterations can be calculated to about 2 % drying out in the summer time and 1 % moistening in the winter time. A drying out of 2 % in the summer time means a contraction wood-glass of 0.2 mm per linear metre along the rebates. Together with the contraction with rising temperature in the summer time, this will give a total contraction wood-glass in the summer time of 0.3 mm per m tight size. The corresponding expansion in the winter time will amount to 0.2 mm per m tight size.

For pressure-impregnated wood without surface treatment the moisture content will vary approximately as for untreated wood. The moisture movements will then be considerably larger than what is quoted above for well preserved wood.

7. *Edge clearances*

Sealed glazing units are usually placed on two setting blocks with thickness corresponding to the nominal edge clearance A_{nom}. From a theoretical point of view the setting blocks should be placed one fifth of the width of the unit in from each corner in order to give minimum stresses in the glass. The positioning is, however, not critical, and for the sake of simplicity the setting blocks are usually placed at the quarter points, one quarter of the width of the unit in from the corners.

Edge deviations will result in an actual clearance under the unit somewhat less than the nominal. Depending upon whether it is a question of deflection up or down, there will be two different cases, as seen in

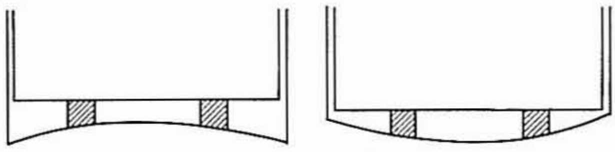

Fig. 10. Reduction of the edge clearance under the unit as a result of deformation of the bottom member.

Figure 10. The edge deviation can, according to Figure 5, amount to maximum 1.5 mm. Assuming the deflection as a sine curve, it will be found that the edge clearance in the middle will be reduced by 0.44 mm by the deflection upwards in Figure 10a, and by 1.06 mm at the corners by the deflection downwards in *Figure 10b.* Usually the glaziers can, however, foresee deflections of this type and adjust the setting blocks towards the corners so that the real reduction of the clearance remains well under 0.5 mm. This is so little that it does not need to be taken into consideration, and the necessary clearance under the unit can then be fixed equal to the minimum clearance A_{min} so that

$$A_{n\ bottom} = A_{min} \qquad (1)$$

The size of the minimum clearance will be discussed later on under the present heading.

The nominal clearance along the two vertical side edges of the unit must be so large that the real clearance will never be less than the minimum clearance when the tolerances on the glass size and tight size as well as the movement (contraction) between the surrounds and the glass are taken into consideration. In practice, both tolerances and movements can

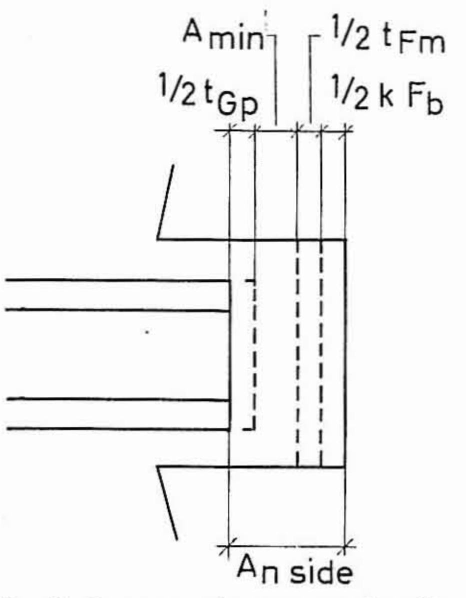

Fig. 11. Necessary clearance at the sides.

be assumed to be distributed with one half on each of the side edges. The necessary edge clearance on the sides will then according to *Figure 11* be

$$A_{n\ side} = A_{min} + \tfrac{1}{2}\, t_{Gp} - \tfrac{1}{2}\, t_{Fm} + \tfrac{1}{2}\, k\, F_b \qquad (2)$$

here A_{min} = minimum clearance
t_{Gp} = plus tolerance glass size width
t_{Fm} = minus tolerance tight size width
k = contraction of the surrounds in relation to the unit
F_b = tight size width

The minus sign in front of t_{Fm} arises from the fact that the minus tolerance on the tight size width is negative.

For the clearance at the top of the unit it will be found in a similar manner

$$A_{n\ top} = A_{min} + t_{Gp} - t_{Fm} + k\, F_h \qquad (3)$$

Here it is assumed that the unit will remain firm at the bottom so that the top has to take the tolerances on both glass size and tight size as well as the total movement between surrounds and glass.

From (1), (2) and (3) it is seen that the requirements for the edge clearance will be different for bottom, side and top. In practice, it will scarcely be possible to operate with different clearances on the different edges. It is necessary to try to combine the requirements in a common nominal edge clearance. The first simplification that can be introduced is to give up distinguishing between tight size width F_b and tight size height F_h in (2) and (3), and use instead a common tight size dimension F as the greatest of width and height. Furthermore, it will in practice be possible to divide the tolerances in the vertical direction equally on top and bottom by adjusting the thickness of the setting blocks. The movements in the vertical direction will, however, always have to be taken up at the top. The requirements are by this changed to:

$$A_{n\ bottom} = A_{min} + \tfrac{1}{2}\, t_{Gp} - \tfrac{1}{2}\, t_{Fm} \qquad (1a)$$

$$A_{n\ side} = A_{min} + \tfrac{1}{2}\, t_{Gp} - \tfrac{1}{2}\, t_{Fm} + \tfrac{1}{2}\, k\, F \qquad (2a)$$

$$A_{n\ top} = A_{min} + \tfrac{1}{2}\, t_{Gp} - \tfrac{1}{2}\, t_{Fm} + k\, F \qquad (3a)$$

The difference between (1a), (2a) and (3a) lies simply in the term constituting the movements. It further appears that

$$A_{n\ bottom} + A_{n\ top} = 2\, A_{n\ side} \qquad (4)$$

It is therefore possible to manage with a common nominal clearance

$$\boxed{A_{nom} = A_{min} + \tfrac{1}{2}\, t_{Gp} - \tfrac{1}{2}\, t_{Fm} + \tfrac{1}{2}\, k\, F} \qquad (5)$$

provided that during installation the clearance at the top is adjusted to be somewhat larger than the clearance at the bottom, corresponding to the term kF in (3a). How much this amounts to in practice will be dealt with later on.

Of the dimensions which enter into (5), t_{Gp}, t_{Fm} and k have been determined earlier, and only A_{min} remains before A_{nom} can be calculated numerically. The minimum clearance is often taken as identical with the nominal clearance. This is, however, erroneous. The nominal clearance is, in fact, determined just to give a certain play for the tolerances on glass size and tight size as well as the movements between unit and surrounds. The absolute minimum clearance A_{min} in (5) is actually determined by two other conditions. The unit must under no circumstances be in contact with the rebate, and it must also be possible to install the unit in the rebate without unreasonable difficulties. For windows in normal design the first requirement is fulfilled by a minimum clearance of 1 mm. Small units may also be easily installed by such a clearance. For larger and heavier units, however, the minimum clearance must be increased, for the largest units preferably up to 3 mm. Otherwise these units can easily touch the rebate during the installation. The dependence of the minimum clearance on the size

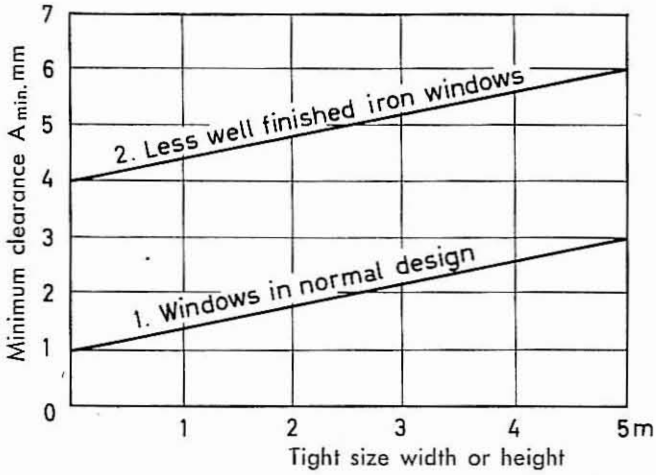

Fig. 12. Minimum clearance as a function of window size.

of the unit will be about as graph line 1 in *Figure 12.* In less well finished iron windows there will often be weld seams, for instance in the corners, and all minimum clearances must then be increased by 3 mm as shown by graph line 2 in Figure 12.

The nominal clearance can now be calculated by substituting numerical values in (5). The minimum clearance A_{min} can be taken from Figure 12 and the tolerance t_{Fm} from Figure 6. The remaining sizes are

$t_{Gp} = +3$ mm
k = 0.3 mm per m tight size for wooden windows
k = 0.56 mm per m tight size for aluminium windows
k = 0.14 mm per m tight size for iron windows

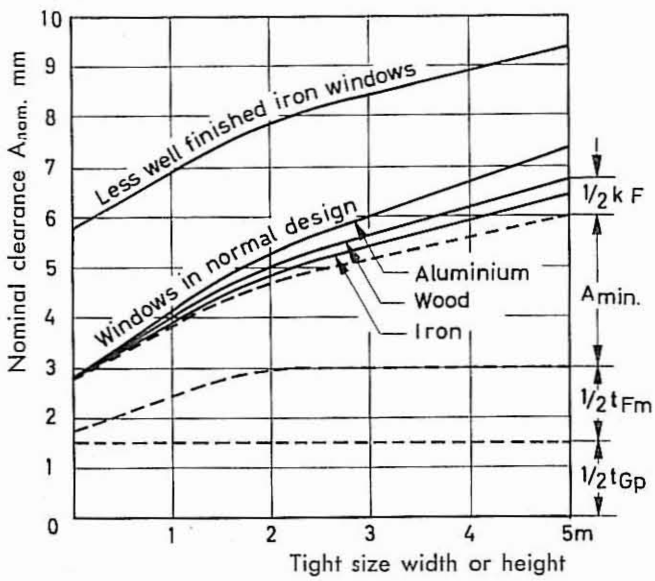

Fig. 13. Nominal clearance as a function of window size.

The result appears as *Figure 13.* For wooden windows it is shown how the nominal edge clearance is made up of the four terms in (5). The graph lines for wooden, iron and aluminium windows in normal design fall so close that there is no great practical difference, while the graph line for less well finished iron windows is very much on its own. This is due to the requirement of 3 mm additional minimum clearance.

It has scarcely any purpose to utilise the graph lines in Figure 13 to determine the nominal edge clearance in every single case. It would be better to try to classify the windows into a limited number of classes. The following division seems to be natural:

Class 1. Windows with maximum tight size dimension about 1.5 m. This group will then comprise all opening windows as well as fixed windows of moderate size.

Class 2. Windows with maximum tight size dimension between 1.5 and 3 m.

Class 3. Windows with maximum tight size dimension between 3 and 5 m.

For these classes the nominal clearances given in *Table 3* should be suitable.

Table 3. Nominal edge clearances in millimetres.

	Class 1	Class 2	Class 3
Wood, iron and aluminium windows in normal design	5	6	7
Less well finished iron windows	7	8	9

For windows in normal design, these clearances are about 1 mm larger than what has been actual practice in Europe up to the present. In this connection it is worth noting that American practice is always prescribing a nominal clearance of ¼".

The thickness of the setting blocks should, theoretically, be equal to the nominal clearance less one half of the movement at the top of the glazing unit, corresponding to the term ½ k F in (5). From Figure 13 it will be seen that for wooden windows and iron windows this term will be so small that is does not need to be taken into consideration. The same applies to aluminium windows with tight size height less than about 2 m. For these windows it should then in practice be sufficient quite simply to adjust the edge clearance at the bottom and the top to approximately the same size. For aluminium windows with tight size height greater than 2 m, however, the clearance at the top of the unit should be adjusted 2 mm larger than the clearance at the bottom.

In practice, it might be necessary to adjust the thickness of the setting blocks downwards to the minimum clearance A_{min}. This means that it would be necessary to have a large number of different setting blocks with thicknesses ranging from 1 mm to 9 mm, and anything like this is quite unthinkable in practice. The simplest solution is probably to use one standard setting block thickness of e.g. 5 mm, and 1 mm thick adjusting blocks in order to obtain greater clearance at the bottom. When, occasionally, it might be necessary to use thinner setting blocks than 5 mm, this could simply be done by putting together a suitable number of 1 mm blocks.

8. Rebate depth

The necessary rebate depth will, like the edge clearance, be slightly different for bottom, side and top. For the bottom rebate the requirement, as will appear from Figure 2, is quite simply:

$$B_{F\,bottom} = A_{nom} + C + E \qquad (6)$$

here $B_{F\,bottom}$ = necessary rebate depth at the bottom of the unit

A_{nom} = nominal edge clearance

C = width of the edge seal of the unit

E = recommended covering of the edge seal

For the rebate at the sides of the unit the rebate depth must, on the other hand, be so large that the recommended covering E really is obtained, even when the unit has the greatest minus tolerance, the tight size the greatest plus tolerance, the rebate depth the largest minus tolerance, and the surrounds have expanded as much as possible in relation to the glass. The requirement, see *Figure 14*, will then be the following:

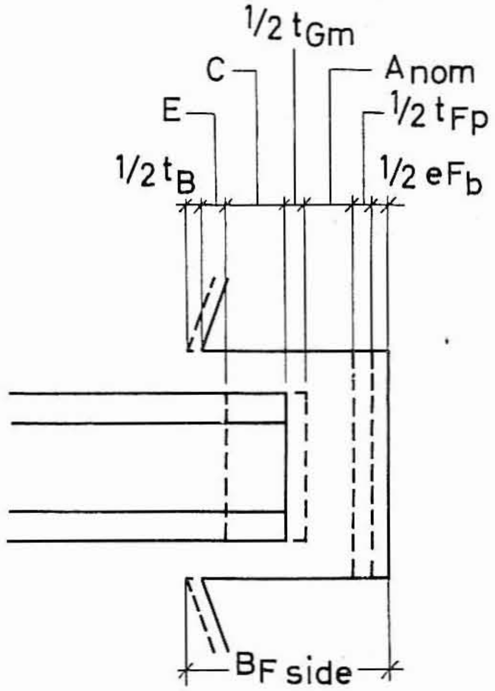

Fig. 14. Necessary rebate depth at the sides.

$$B_{F\,side} = A_{nom} + \tfrac{1}{2} t_{Fp} - \tfrac{1}{2} t_{Gm} + \tfrac{1}{2} t_B + \tfrac{1}{2} e_{Fb} + C + E \qquad (7)$$

here $B_{F\,side}$ = necessary rebate depth on the sides of the unit

t_{Fp} = plus tolerance on tight size width

t_{Gm} = minus tolerance on glass size width

t_B = tolerance on rebate depth

e = expansion of the surrounds in relation to the unit

F_b = tight size width

For the rebate depth at the top of the unit it will be found in a similar way:

$$B_{F\,top} = A_{nom} + t_{Fp} - t_{Gm} + t_B + eF_h + C + E \qquad (8)$$

Here, too, it would be appropriate to avoid distinguishing between tight size width and height, and use a common tight size dimension F as the greatest of the two. By dividing the tolerances in the vertical direction on the top and bottom rebate by adjusting the thickness of the setting blocks, it will be found, in the same way as for the edge clearance, that the following rebate depth will be sufficient:

$$B_{F\,nom} = A_{nom} + \tfrac{1}{2} t_{Fp} - \tfrac{1}{2} t_{Gm} + \tfrac{1}{2} t_B + \tfrac{1}{2} eF + C + E \qquad (9)$$

To be quite correct the term e F should have been used instead of ½ e F in order to get full covering at the top of the unit in the most unfavourable case. But since the top of the unit is the least exposed place, it must be considered as quite acceptable to give up some of the covering in certain extreme cases.

Of the sizes as contained in (9) the A_{nom} is obtained from Figure 13 or Table 3, and t_{F_p} from Figure 6. Of the remaining dimensions the following are known:

t_{Gm} = — 2 mm

t_B =
- ± 0.5 mm for wooden windows
- ± 1.0 mm for iron windows with rolled profiles. Approx. 0 mm for aluminium windows and steel windows with extruded profiles

e =
- 0.2 mm pr m tight size for wooden windows
- 0.16 mm pr m tight size for iron windows
- 0.64 mm pr m tight size for aluminium windows

It remains to determine the sizes C and E.

In accordance with the experience of the Norwegian Building Research Institute, the covering E should be at least 4 mm for units with an external metal channel, and at least 2 mm for units without external metal channel. These recommendations are based on several considerations. First of all, the edge effects arising from the edge seal must be reduced, in order to reduce the possibilities of condensation and ice formation along the edges of the units. Furthermore, it is important for glued types of unit with an external metal channel to get a proper covering with glazing compound so that the water does not reach the edge seal. Finally, it is usually considered preferable, from an aesthetic point of view, that the edge seal is shown as little as possible.

The width of the edge seal for the present types on the Norwegian market is given in *Table 4.* The data provided are based on information from the different manufacturers, partly corrected in accordance with measurements carried out by the Norwegian Building Research Institute. The reason why Aluco is contained twice in the table is that for these units an aluminium

Table 4. Width of the edge seal and recommended covering for the types of unit on the Norwegian market.

	Type of unit	Width of the edge seal C mm	Recommended covering E mm	C + E mm
Units with external metal channel	Aluco (external)	6 — 9	4	10—13
	Aterphone	10	4	14
	Cudo	6 —10	4	10—14
	Duoterm	10	4	14
	Multipane	10	4	14
	Polyglass	10	4	14
Units without external metal channel	Aluco (internal)	12	2	14
	Gado	12	2	14
	Schalker Isolierglas	8 —12	2	10—14
	Thermopane	8 —12	2	10—14

profile is used which penetrates quite deeply in between the glass panes, but gives a somewhat smaller external metal edge. In the table the recommended covering E is also recorded, as well as the total width of the edge seal and the recommended covering C + E. It will be seen that C + E = 14 mm will cover all actual types, and this will be utilised in the calculations.

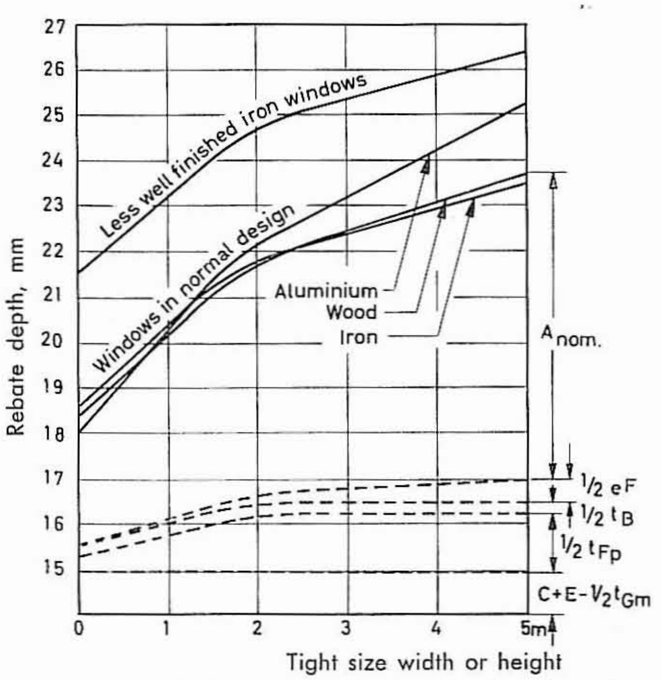

Fig. 15. Nominal rebate depth as a function of window size. Edge clearance according to figure 13.

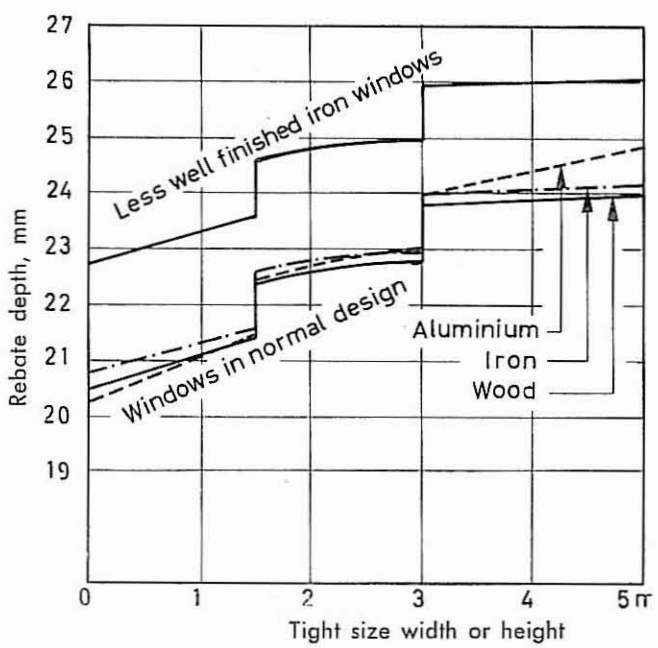

Fig. 16. Nominal rebate depth as a function of window size. Edge clearance according to table 3.

The rebate depths obtained when inserting the actual numerical values in (9) appear from *Figures 15 and 16.* In Figure 15 the edge clearance has been taken in accordance with the graph lines in Figure 13, while in Figure 16 it has been calculated with edge clearances according to Table 3. When comparing Figures 15 and 16 and utilising the later division into classes according to unit sizes with clearances according to Table 3, it will be found that the nominal rebate depths given in Table 5 should be suitable. The rebate depths which so far have been specified by the manufacturers have lain between 14 mm for small units and 20 mm for very large units. As will be seen from Table 5, the rebate depths arrived at here are considerably greater.

The rebate depth may also be considered from another point of view, the covering of the distance pieces. Usually the distance pieces used are 10 mm high and are placed flush with the edge of the unit as shown in *Figure 17.* Recommended minimum covering is 5 mm. This means that the total height of distance piece and covering will amount to 15 mm, whilst in the calculation of nominal rebate depth it was calculated witt a total width of edge seal and covering of 14 mm. Flat distance pieces can, however, easily be forced 1 mm down into the rebate so that the requirements will agree. For U-shaped distance pieces the internal height must either be reduced to 9 mm, or it will be necessary to dispense with the covering. Also from this point of view the rebate depths in Table 5 should be acceptable.

Table 5. Nominal rebate depths in millimetres.

Type of window	Size of unit		
	Class 1	Class 2	Class 3
Wooden windows and iron windows in normal design	21	23	24
Aluminium windows in normal design	21	23	25
Less well finished iron windows	24	25	26

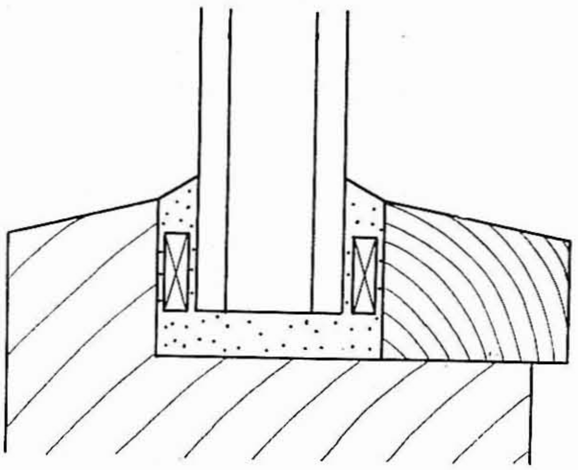

Fig. 17. Placing and covering of distance pieces.

9. Face clearance and suitable glazing sealants

So far there have been specified nominal face clearances and widths of lateral glazing compound from 2 mm to 6 mm dependent on the size of the unit. These figures are based on practical experience over a comparatively short period of time. Strictly speaking, the claims to minimum face clearance will be variable according to the type of glazing sealant that is to be used. There will always be certain movements between unit and rebate, and the degree of movement which the glazing compound can take will differ very considerably for the various types of glazing sealants.

The most important movement appears to be in the longitudinal direction of the rebate, as the unit width and height as well as the tight size width and height will change with changing temperatures, for wood also with varying moisture content. The top of the unit will acquire a movement corresponding to the sum of the previously calculated expansions and contractions (e + k), whilst each of the vertical edges will take one half part of these movements. *Figure 18*

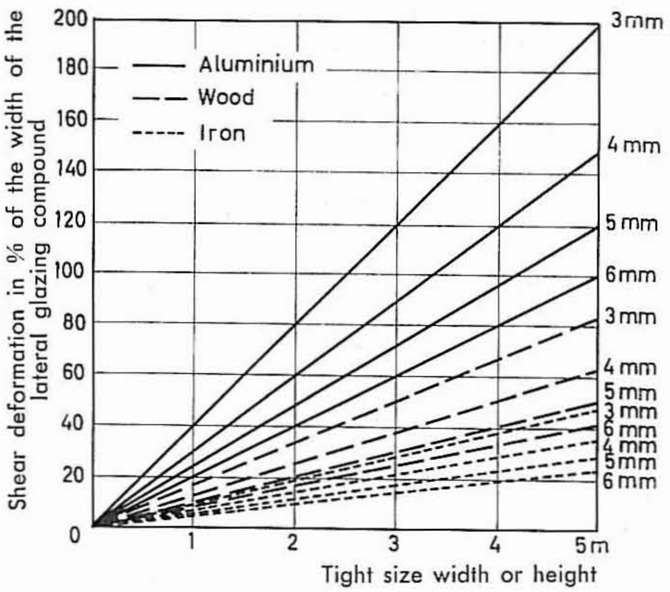

Fig. 18. Shear deformation of the lateral glazing compound at the top of the unit by various width of the lateral glazing compound and window materials.

Table 6. Maximum permissible deformations for various types of glazing sealant in aged condition.

Type of glazing sealant	Deformation in % of the width of glazing compound	
	tension and compression	shear
Plastic glazing compounds (Termokitt etc.)	2 %	10 %
Two-component plastic glazing compounds (oil-based)	2 %	10 %
Plastic oil-based joint sealants. (mastics)	10 %	40 %
Tough plastic joint sealants (mainly butyl rubber based)	25 %	75 %
Elastic joint sealants (mainly polysulphide based)	50 %	150 %

shows the shear deformations to which the lateral glazing compound at the top of the unit will be subjected by various heights of unit, widths of lateral glazing compound and window materials. At the vertical edges of the unit the movements will be only one half of this.

Figure 18 shows that the shear deformations may be very great, even for moderate unit sizes. On the other hand, it is not realistic to assume that the available glazing sealants in aged condition can deal with larger deformations than those given in *Table 6.* A comparison of Figure 18 and Table 6 shows clearly that certain types of glazing sealant should not be used at all, unless the size of the unit is small and the width of lateral glazing compound great. To increase the width of the glazing compound beyond 6 mm, however, has little purpose because in practice it will entail great difficulties. The minimum width of glazing compound and suitable types of glazing sealants must, therefore, be chosen within the possibilities presented in Figure 18 and Table 6.

With the previous division of the sealed glazing units into three classes according to the size, it should be suitable to employ widths of lateral glazing compound and types of glazing sealant as given in *Table 7.* When working out this table no attempt has been made to find the absolutely minimum widths of lateral glazing compound. Particular stress has instead been laid on getting the same width of glazing compound for windows of different materials but with the same unit size. At the bottom of the table some combinations of widths of lateral glazing compound and appropriate types of glazing sealant have been listed which fall outside the main part of the table.

Table 7 shows that in most cases better types of glazing sealant should be used than what has been the case up to the present. Special attention should be paid to the fact that the ordinary plastic glazing compounds (Termokitt, etc.) come out entirely of the main part of the table. Only for small and moderate sizes (class 1) iron windows and large width of lateral glazing compound can the plastic glazing compounds be regarded as acceptable in the long run. Many will perhaps make objections and say that it cannot be correct to doom the plastic glazing compounds like that, and that practical experience is not at all so bad. This is, however, a point of view which is greatly open to question. The experience of the Norwegian Building

Table 7. Widths of lateral glazing compound and suitable types of glazing sealant.

Size of unit	Minimum width of lateral glazing compound mm	Nominal width of lateral glazing compound mm	Window material	Suitable types of glazing sealant
Class 1	3	4	Wood	Plastic oil-based joint sealants Tough plastic joint sealants Elastic joint sealants
			Aluminium	Tough plastic joint sealants Elastic joint sealants
			Iron	Plastic oil-based joint sealants Tough plastic joint sealants Elastic joint sealants
Class 2	3.5	5	Wood	Plastic oil-based joint sealants Tough plastic joint sealants Elastic joint sealants
			Aluminium	Elastic joint sealants
			Iron	Plastic oil-based joint sealants Tough plastic joint sealants Elastic joint sealants
Class 3	4.5	6	Wood	Tough plastic joint sealants Elastic joint sealants
			Aluminium	Elastic joint sealants
			Iron	Plastic oil-based joint sealants Tough plastic joint sealants Elastic joint sealants
Class 1	4.5	5.5	Aluminium	Plastic oil-based joint sealants
	5	6	Iron	Plastic glazing compounds Two-component plastic glazing compounds
Class 2	5	6.5	Aluminium	Tough plastic joint sealants
Class 3	6	7.5	Wood	Plastic oil-based joint sealants

Research Institute is in any case that the plastic glazing compounds in a lot of cases have lost adhesion to the glass or rebate and bead after a few years. Some of these failures are attributed to bad pretreatment of the rebates or glazing on wet surfaces, but a number of cases remain which have so far not been explained. It is also worth noting that the glaziers, with their wide experience with plastic glazing compounds, quite categorically state that the glazing will not remain tight in the long run, and that for this reason outside bead glazing should be used. It must, however, be mentioned here that a number of plastic glazing compounds have in recent times been considerably improved so that they have developed towards the plastic oil-based joint sealants. One single manufacturer claims for one of his products that it can take a movement of 15 % of the joint width. Further improvements in this field can certainly be expected.

It should also be noted that the main part of Table 7 only comprises glazing sealants in gun consistency. The new and improved types of plastic glazing compounds will also have such a consistency that they may preferably be applied by gun. In other words, there will have to be a complete change in the glazing practice.

The nominal width of the lateral glazing compound is determined by the requirement for minimum width of lateral glazing compound together with the tolerance t_D on the glazing gap width D_F :

$$K_{nom} = K_{min} + \tfrac{1}{2} t_D \qquad (10)$$

The tolerance on the glazing gap width is discussed under heading 4. Half the tolerance on the glazing gap width is set at 1, 1.5 and 1.5 mm for class 1, 2 and 3, respectively. The nominal widths of lateral glazing compound hereby obtained are listed in Table 7.

The lateral glazing compound will also be subjected to tensile and compression movements cross-wise to the rebate. The magnitude of these movements will depend for one thing on the total glazing gap width and the width of the lateral glazing compound. Check calculations show, however, that the combinations of widths of lateral glazing compound and types of glazing sealant as given in Table 7 are quite all right also when regarded from this point of view.

10. Glazing gap width

The unit glazing gap width will be equal to the sum of the thickness of the sealed glazing unit, the nominal width of the lateral glazing compound on both sides of the unit, and the largest plus tolerance on the thickness of the unit.

$$D_{F\,nom} = T_{R\,nom} + 2\,K_{nom} + t_{Rp} \qquad (11)$$

in which $D_{F\,nom}$ = nominal glazing gap width
$T_{R\,nom}$ = nominal thickness of the unit
K_{nom} = nominal face clearance
t_{Rp} = plus tolerance on the thickness of the unit

The nominal width of the lateral glazing compound can be taken from Table 7, while t_{Rp} according to heading 3 can be taken at 1 mm. In order to determine the glazing gap width, it will then only be necessary to know the nominal thickness of the unit. This has, however, up to the present, been very different for different types of unit. Air spaces from 4 to 15 mm have been encountered and glass thicknesses from 2 to 12 mm. The development does now seem to be moving towards an air space of 12 to 15 mm, and the thicknesses as given in *Table 8* will then be obtained for sealed double-glazing units.

Table 8. Thickness of sealed double-glazing units.

Size of unit	Glass thickness mm	Air space mm	Thickness of unit mm
Class 1	3—4	12—15	18—23
Class 2	4—6	12—15	20—27
Class 3	6—12	12—15	24—39

For class 1 it should be possible to take 20 mm as standard nominal thickness and take up deviations by adjusting the beads. This gives a nominal glazing gap width of 20 + 2 · 4 + 1 = 29 mm. For classes 2 and 3, on the other hand, it seems impossible to fix any standard unit thickness, without risking that too large tolerances have to be adjusted by the beads. For these classes the glazing gap width should then be determined in every individual case when the total thickness of the unit is known. For units consisting of 3 or more sheets of glass, the necessary glazing gap width will be correspondingly greater.

11. Filling of the edge clearance with glazing compound

The question as to whether it is necessary to fill the clearance along the edges of the unit with glazing compound has been much discussed. European practice so far has been that the clearance shall be filled completely so that the unit is floating in a bed of glazing compound. American practice, on the other hand, has prescribed that the space under the unit shall be filled with glazing compound, while an air space shall be left on both sides and at the top.

Several factors have to be taken into consideration when judging the need for filling up with glazing compound along the edges. The first is what will happen with this compound when the unit moves in relation to the rebate with changing temperatures and moisture content of materials. At the top of the unit there will be a movement corresponding to the sum of the earlier calculated expansions and contractions, and on each of the sides about half of these. If the filling with glazing compound is perfect and the compound itself incompressible, the result will be an extrusion of the glazing compound as shown in *Figure 19*.

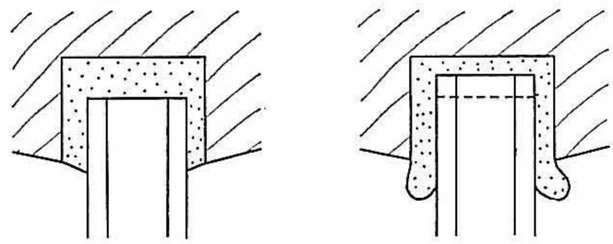

Fig. 19. Extrusion of glazing compound as a result of movement between unit and rebate.

In the most serious case, the edge seal of the unit may be damaged. The magnitude of the movements that can be expected at the top of the units is shown

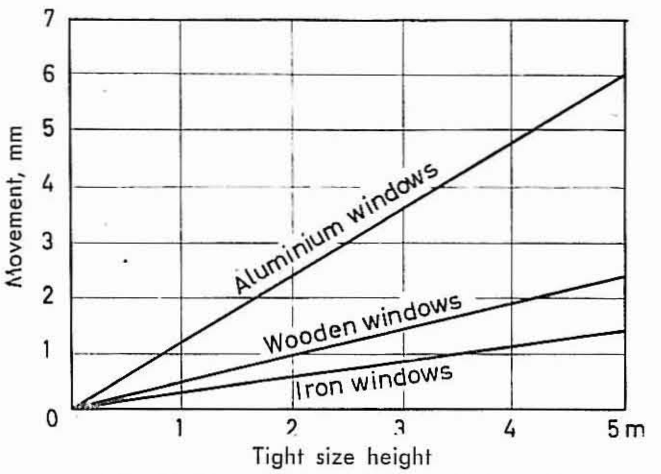

Fig. 20. Movement at the top of the units.

in *Figure 20.* The thickness of the unit is usually considerably larger than the total width of the lateral glazing compound on both sides of the unit. For units of class 1 there will, according to the previous heading, be a unit thickness of about 20 mm with a total width of lateral glazing compound of about 8 mm. This means that the extruding movement in the lateral glazing compound will be about 2.5 times greater than the movement of the unit. For units of classes 2 and 3 both unit thickness and width of lateral glazing compound will be greater, but the relation should be more or less the same, approximately 2.5. For units with three or more sheets of glass, however, the situation will be made correspondingly worse. Assuming a multiplication factor of 2.5 and a permissible extrusion of the lateral glazing compound of 1 mm, the maximum permitted tight size height with filling of glazing compound along the edges is found to be 0.8 m for wooden windows, 0.3 m for aluminium windows and 1.3 m for iron windows. The maximum permitted tight size width will be twice as much. It is thus quite simply found that it would not be considered advisable to fill along the edges at the top and the sides unless the windows are very small. At the bottom of the units it should nevertheless be possible to fill up with glazing compound as this is the most stable point of the units.

Many will perhaps object to the previous calculations, referring to the fact that extrusions as shown in Figure 19 do not occur in practice to the extent which the calculations would suggest. The lack of correlation is, however, due to a series of other circumstances. In practice, it will in fact be impossible to get the edge clearance filled completely, especially with the knife grade glazing compounds which are most utilised at present. There will always be a certain amount of cavities in the glazing compound, and when the glazing compound is subjected to pressure, the air spaces will be compressed or the air driven out, while the lateral glazing compound remains nearly unchanged. With wooden windows the priming has also in most cases been entirely inadequate, so that the rebates have absorbed oil and made the glazing compound porous and compressible. Finally, it must also be taken into consideration that oil from the glazing compound may have been forced into the wood. It is not impossible that some of the oil bleedings which have occurred in practice, may be due to the fact that the oil quite simply has been squeezed out of the glazing compound in this way.

Each and all of the factors mentioned above cooperate so that the lateral glazing compound is not extruded. The edge glazing compound will, on the other hand, be compressed to a layer which is easily losing adhesion to the rebate as well as the unit, as seen in *Figure 21.* In a number of cases of leakage damage which the Norwegian Building Research Institute has had the opportunity to inspect, the conditions have been just those shown in Figure 21.

The next thing which must be considered is what may happen if glazing compound is not filled up along the edges of the unit, and water should come into the rebate so that the bottom of the unit would be standing in water. The water may have come in by direct leakage, or by condensation of water vapour diffusing into the rebate from the inside. By wooden windows the bottom member would quickly start to rot and by metal windows the window and the metal in the edge seal of the unit might constitute a galvanic element, with detrimental results both for the window and the edge seal. Furthermore, the water itself would be able to damage the edge seal of the unit, especially if it should freeze to ice. If the edge filling is discarded, care should be taken to drain and ventilate the rebate to the open air. In any case the space under the unit should be filled with glazing compound. This filling gives an additional protection against leakages and, moreover, especially by wide windows, against standing water that cannot easily run off. The draining should be at both the bottom corners of the window, and preferably as slits which are not so easily filled with glazing compound.

One more factor must be taken into consideration if the edge filling is discarded. If a closed air space along the edges is made, the air will be able to expand and extrude the lateral glazing compound. This problem is, however, completely eliminated when provision is made for drainage and ventilation as mentioned above. On the other hand, it should be remembered that the ventilation in unfavourable cases can result in a cooling down of the edge of the unit and the internal part of the casement, especially by metal windows. The weep-holes must, therefore, be placed with great care.

The conclusion must be that glazing compound should be filled along the edge of the unit only at the bottom and not at the sides and the top. At the same time, care should be taken to drain and ventilate the air space to the open air, preferably by slits at the side of both the lower corners.

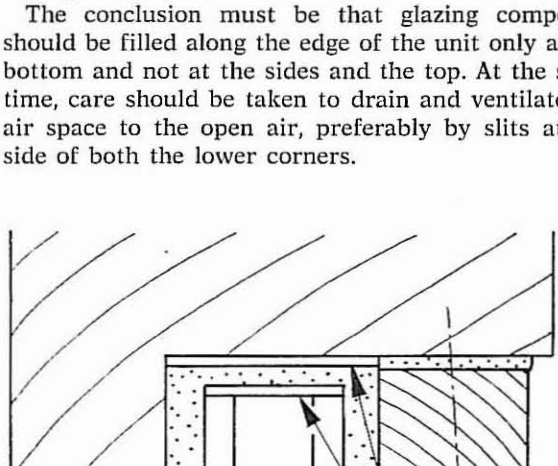

Fig. 21. Example showing how the edge glazing compound is losing adhesion to unit and rebate.

12. Glazing beads

The main purpose of the glazing beads is to keep the unit in place in the rebate, and this is achieved with quite slender beads. The same requirement to the covering of the edge seal of the unit must be put on the glazing bead side as on the rebate side. The depth of the glazing bead T_L must then be equal to the rebate depth B_F . Also from an aesthetical point of view this is usually considered to be an advantage.

The width of the glazing bead B_L must be large enough to give the bead sufficient rigidity. Wooden beads should, however, not uncritically be made very wide. The width of wooden beads, and especially external bottom beads, will vary considerably as a result of changing moisture content, and these variations of width will subject the lateral glazing compound to very large tension and compression deformations. Even for a well preserved bottom bead of wood the annual variations in moisture content can be set to about 10 % by weight. If the glazing beads are not quartersawed, it must be calculated with shrinkage and swelling tangentially to the grain, $\alpha_t = 0.25$ % per % of variation in moisture content. The resulting change in the width of the bead will be 2.5 %. Assuming that the bead is 20 mm wide and secured in the middle of the width, it will for widths of lateral glazing compound of 3 to 5 mm be found that the movement in the lateral glazing compound will be from 8 to 5 % of the width. This is considerably more than the plastic glazing compounds (termokitt) can be expected to take in aged condition, and also close to the limit of what the plastic oil-based joint sealants can manage. By wooden beads wider than 20 mm the conditions become even more unfavourable. Such wide wooden beads should not be fixed in the middle but 10—15 mm from the edge nearest to the glass.

If external wooden beads are not well preserved, the conditions will be, if possible, even worse. In such a case it must be taken into account that the moisture content can vary between 30 % by weight when soaked and 10 % by weight when sun dried, giving a total variation of 20 % by weight. With beads secured 10 mm from the edge nearest to the glass, this will give a movement in the width of the lateral glazing compound of 17 to 10 %. This is more than what plastic oil-based joint sealants can take in the long run, especially when the adhesion to wood is weakened as a result of the wetting. In general, it must be expected that any glazing sealant, even the best, will lose adhesion to wood if the wood is repeatedly soaked. It is, thus, an absolute requirement that all wood, both external and internal (possible soaking by condensation) be preserved by regular painting, oiling or the like.

As regards the shape of the beads, the Norwegian Building Research Institute has so far recommended that wooden beads shall be sloped as little as possible. This was in order to ensure that the distance pieces in the lateral glazing compound should not come into compression when the beads were mounted. In order to allow the water to run off the bottom bead easily, this should be sloped as much as possible; a slope of about one to four appears to be a useful compromise. Also bottom beads of other materials than wood should be sloped so that the water will run off.

At the top and the sides the external beads should not project beyond the rebate but rather be slightly behind, as seen in Figure 21. The bottom bead, on the other hand, should project over the rebate and preferably have a drip-nose to prevent water from being driven in under the beads. Wooden beads should always be completely bedded in glazing compound, as seen in *Figure 22*. By metal beads it should be sealed under the beads in a similar way. The lateral glazing compound must always be chamfered so that water will not remain but run off easily.

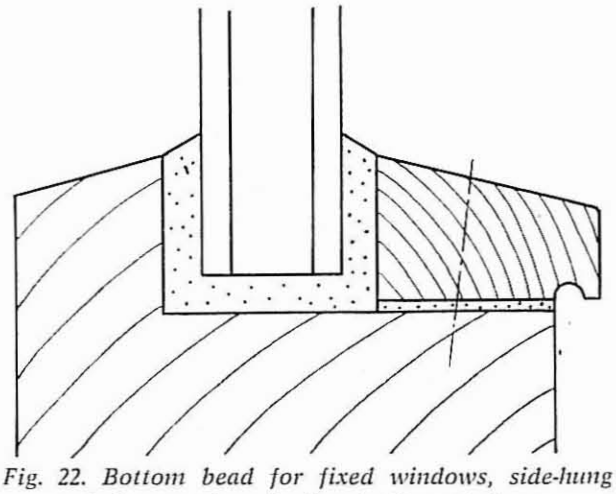

Fig. 22. Bottom bead for fixed windows, side-hung windows and vertically pivoting windows.

In principle, two different types of glazing beads are consequently obtained, one for bottom and another for side and top. The bottom bead in Figure 22 should be suitable for fixed windows, side-hung windows and vertically pivoting windows. By horizontally pivoting windows as well as top and bottom hung windows, however, a bead with a slope as small as one to four would lead to water standing over the bead and the lateral glazing compound if the window was left in the ventilating position during a rainfall. This would be very unfavourable both for bead and glazing. By these types of windows the external bottom bead should be sloped considerably more. The slope on wooden glazing beads, unfortunately, cannot just be increased without impending risk for the distance pieces and glazing unit to come into compression when the beads are mounted. A possible solution to this problem would seem to be a bead with a cross-section, as shown in *Figure 23*. This bead has a steep slope out from the glass and less slope further up to the edge and is fixed at the least sloped part. The dangerous point is in this way removed from the lateral glazing compound to the middle of the bead. By

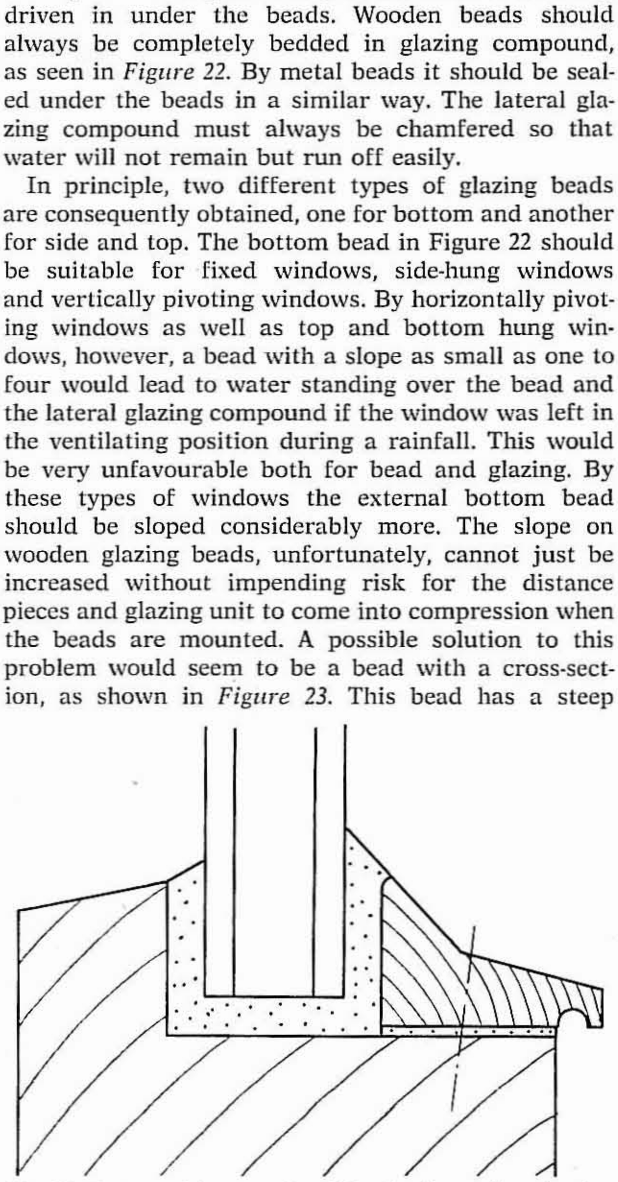

Fig. 23. Proposed bottom bead for horizontally pivoting windows as well as top- and bottom-hung windows.

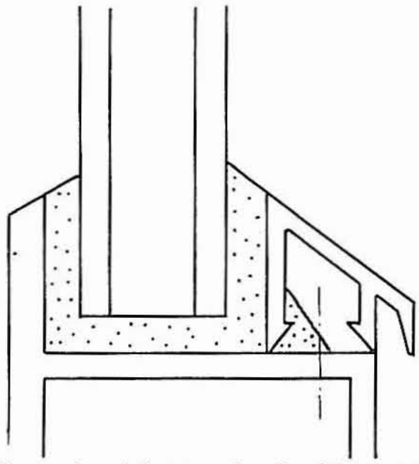

Fig. 24. Example of bottom bead with a steep slope for metal windows.

metal windows bottom glazing beads with steep slope can be made in different ways. An example is seen in *Figure 24.*

By metal windows the profiles must be so designed that neither the rebate nor the bead have projecting lips which can reduce the width of the lateral glazing compound. On the contrary, the surfaces of the profiles facing the glazing compound should be màde as flat as possible.

It is recommended that glazing beads shall not be mitred in the corners. The horizontal beads at the top and bottom should rather be made going through and the side beads coped at the top and bottom.

Practical experience suggests that wooden beads should not be fixed by screws but rather by nails. Screws will usually be hammered in and screwed only round the last turn. When screws are used, these should have flat heads. By round or lense-shaped heads the glazier's knife or similar tools may easily strike against the heads and disturb the smoothening of the glazing compound.

By internal beads it is all right with a cross-section as shown in Figure 21. The beads may also protrude beyond the edge on all sides. It should be pointed out, however, that internal beads put great requirements on the installation work if leakages are to be avoided. When internal beads are used, the bottom casement member must be given a sufficient slope outwards. By fixed windows, side-hung windows and vertically pivoting windows, it will do with a slope of about one to four. By horizontally pivoting as well as top and bottom hung windows, the slope should be increased to about one to one.

Glazing beads should always be made of the same material as the rest of the window. Otherwise they may open up in the corners, or get jammed and ride up; the latter has often been the case with teak beads on fir windows. Beads of oak should never be used as they nearly always will become heavily warped. Beads of fir should preferably be of pressure-impregnated material.

13. Installation direct into framework

The calculations under headings 7 and 8 refer to factory-made windows with comparatively narrow tolerances on the tight size dimensions. When installing sealed glazing units directly into framework, the tolerances on the tight size dimensions will be considerably greater, and the edge clearance as well as the rebate depth have to be increased correspondingly. Practical experience indicates that rebate depths of 25 to 30 mm are adequate. This is about 5 mm more than what is specified for wooden windows in Table 5. In practice, it is probably appropriate to increase the edge clearance as well as the rebate depth with 5 mm compared with the figures given in Tables 3 and 5.

14. Pre-treatment of rebates and after-treatment of lateral glazing compound

All the previous calculations presuppose that the rebates and beads in wooden windows are adequatèly pre-treated so that they do not absorb oil or other liquid constituents from the glazing compound. This is a point where there has so far been a great deal of sinning. Unfortunately, it is impossible to give any general advice on pre-treatment of rebates, as the requirements will differ greatly for the various types of glazing sealants. The problem is mentioned here in order to draw attention to the situation so that the glaziers can get into contact with the manufacturers of glazing sealants. The Norwegian Building Research Institute will try to take this matter up again later on.

After-treatment of glazing compound can also be actual in many cases. All oil-based glazing compounds should thus be coated with oil or paint according to the manufacturer's recommendations.

15. Conclusions

A large number of problems in connection with glazing rebates and beads for sealed glazing units have been treated under the previous headings. The results are given under each heading, and will not be repeated in detail here. Certain main points will, however, be summarized.

All clearances and rebate dimensions should be increased beyond what has so far been customary. This applies especially to the rebate depth.

It is recommended that better types of glazing sealant be used which in practice will mean a complete change to glazing sealants in gun consistency.

The glazing technique should be changed so that only the edge clearance under the unit be filled with glazing compound while an air space is left on both sides and at the top of the unit. This air space must be drained and ventilated.

Glazing beads and bottom casement members must be given such a shape that water will run off easily, even when the window is in a ventilating position.

The suggested solutions do in part deviate greatly from current practice. They should, however, give clear and comparatively simple directions, and lead to elimination of a large number of the existing problems.

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