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Factory-Sealed Double-Glazing Units

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Please note

The use of sealed double-glazing units has expanded greatly in recent years. As they may represent a major item in the cost of the building enclosure, and as they have certain potential limitations as well as advantages, an awareness of their physical characteristics is essential.

Sealed glazing units are sometimes referred to as "insulating glass," and may be specified because of some assumed thermal advantage over other double glass arrangements. This is a misconception. They are, in fact, inferior in some respects to conventional double windows. Their principal advantages, aside from simplification of design through the use of a single sash unit, are: reduction of the number of surfaces that require cleaning to two, and the elimination of condensation between the panes. Indeed, the prevention of such condensation is a principal requirement of satisfactory service.

Repeated wetting and drying of common soda lime glass results in scumming, that is, in leaching of the sodium salt so that it is left on the surface as a cloudy white film. If this occurs on inaccessible surfaces of sealed double glazing the units will ultimately have to be replaced. A dry air space and in effective seal are therefore essential requirements. A permanent hermetic seal is, however, very difficult to achieve and even more difficult to maintain under normal conditions of exposure. Few manufacturers have records of the long-term performance of their windows, and where this information is not available suitable laboratory tests will assist in the selection of appropriate units.

Description of Sealed Glazing Units

There are, in general, three types of construction used for hermetically sealed glazing units:

Type I - in which a spacer of lead is bonded to the glass by a special soldering technique;

Type II - which has an all-glass edge;

Type III - in which the panes are sealed by one or more organic sealants to an aluminum, steel or polyvinyl chloride spacer, usually hollow and containing a desiccant.

The edges of the units are covered by a metal or polyvinyl chloride channel, by adhesive tape or simply left bare. In some designs a single sealant provides both the seal and the structural strength to hold the unit together. In others a primary sealant is used for sealing, and a second sealant, or the edge channel or both are used to hold the unit together. The air in the space is dried by purging with dry air before sealing in Types I and II and by contact with the desiccant in Type III. The majority of sealants are polysulphide, butyl or other synthetic rubber base materials, with various additives to, provide the desired properties. Type I and III units usually have ½ or ¼-inch air spaces; although a few Type III units are made with 5/8-inch spaces. Type II usually has 3/16-inch air spaces.

Thermal Performance

Typical over-all heat transmission coefficients versus thickness for glass-enclosed air spaces are shown in Figure 1. The optimum thickness for minimum heat flow is about 5/8 inch; thicknesses of ¼ and 3/16 inch are significantly less effective.

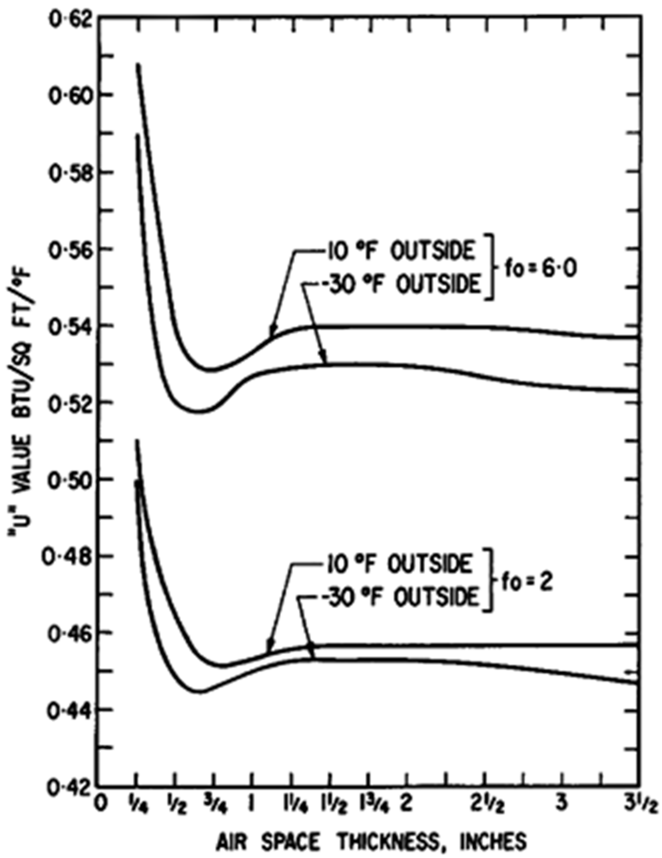

Figure 1. Over-all heat transmission coefficients for double glazing.

More important than the over-all coefficient for many applications is the minimum interior surface temperature that will occur in use; this determines the conditions under which condensation will occur (CBD's **1**, **4**, **42**). With sealed double glazing the spacers and edge surround constitute a path of much higher thermal conductance than that through the air space (regardless of spacer materials) owing to the limited thickness of the units. Interior surface temperatures are thus much lower at the edges than at the centre. This is illustrated in Figure 2 where two types of sealed units are compared with two sheets of glass with ¾-inch air space, all glazed in wood sash. The dew-point temperature lines indicate the extent of condensation at various relative humidities for the particular conditions shown in the figure. For example, at 30 per cent relative humidity condensation would occur on all surfaces with temperatures below 40.5°F, so that unit No. 3 would have condensation over its entire surface.

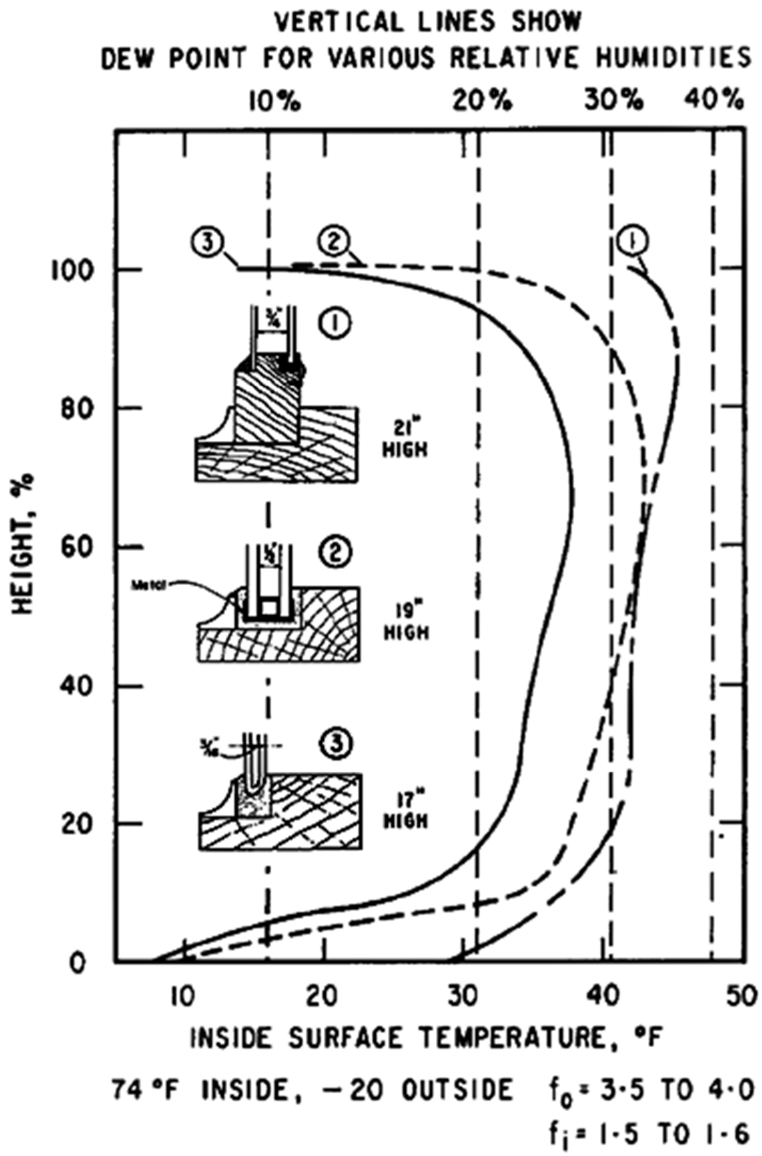

Figure 2. Surface temperatures on three types of double glazing.

Degree of Sealing Necessary

The moisture content of the air in the units can be expressed as its dew-point temperature; moisture transferred to the space is evident as a rise in dew-point. For climatic conditions prevailing in Canada the dew-point temperature should probably not exceed 0°F. There is some evidence that condensation on cooled glass surfaces exposed to the air space can be excessive at higher values. As some moisture gain can be anticipated in most designs, the initial dew-point temperature should be even lower. Values of -60°F can be readily achieved, and initial temperatures approaching this are desirable.

If no desiccant is used the amount of moisture gain that can be tolerated is extremely small and units must provide essentially perfect sealing. With units containing desiccant the tolerable moisture gain depends on the amount of desiccant and its initial moisture content. The dew-point temperature increases as the moisture content of the desiccant increases.

Moisture can be transferred to the air space by diffusion of water vapour through the sealing material, or, if seal leaks exist, by air flow resulting from the pumping action induced by temperature and barometric pressure changes. The vapour permeability coefficients of organic sealants in use vary widely. Calculations indicate that with spacers filled with desiccant there is little chance that moisture transfer by diffusion alone will cause failure within a five- year period, although in some instances it may lead to, failure well within the required service life.

If seal leaks occur the amount of moisture transferred by air flow due to pumping action will generally be in excess of that by diffusion; excessive dew-point temperatures are a probability within one to five years, even with spacers filled with desiccant, and premature failure is certain. Failure is quickly apparent if liquid water can be drawn in through a leak. Satisfactory performance can be realize, therefore, only if sealants have very low vapour permeability and if a hermetic seal is obtained initially and is maintained.

Factors Contributing to Failures

Temperature and barometric pressure fluctuations induce continuous cycling of pressure differences between the air space and the atmosphere. These differences may be quite large and cause the glass to deflect, thus producing stresses in the glass and tension or compression on the seal and spacer. They also tend to move the spacers in or out from the edges. Because both deflection and pressure differences increase with increasing thickness, air space thicknesses are usually limited to a maximum of about ½ inch.

Wind loads stress both the glass and the seal; although the magnitude of the resulting pressure differences, except perhaps at design wind conditions, is generally small compared to that caused by temperature and barometric changes. Gusty wind conditions can, however, produce many cycles of glass deflection and seal stress.

Temperature differences between components and unequal expansion coefficients produce seal stresses. A temperature difference of 40 F deg between the two panes of a 72-inch unit produces a difference of 0.013 inch in the dimensions of the panes. If the temperature of the whole unit is changed by 50 F deg the differential dimensional change between the glass and spacer will be about 0.008 inch for steel, 0.035 inch for aluminum and 0.086 to, 0.30 inch for polyvinyl chloride. Depending on the properties and relative strengths of the sealant and the spacer and on the arrangement of the various components, these dimensional changes can cause movement of the spacer relative to the glass, or stress in the glass, the spacer, and the sealant. Thus all components in the sealing system must be carefully integrated in both design and assembly in order to avoid glass breakage or excessive strain in the sealant. In addition, it is essential that the components, particularly organic sealants, do not lose their required properties as a result of deterioration with age.

Differential temperatures over the glass surface are a major factor contributing to breakage. When a window is suddenly exposed to solar radiation the glass temperature may rise very quickly over its central portion, particularly with heat-absorbing glass. The edge temperatures, on the other hand, may rise more slowly, partly because the edge is shaded from radiation and partly because of the relatively large heat capacity of the frame. These temperature differentials produce high tensile stresses in the glass near the edge and compressive stresses in the centre. Similar temperature differentials and corresponding stresses occur on the inner pane of sealed double units during the winter owing to the edge temperature gradients illustrated in Figure 2. These effects are accentuated by under-window heating units.

The strength of the glass is usually sufficient to withstand the stress produced by temperature differentials alone, but if the glass is already stressed from other causes, as in sealed double glazing, the added thermal stress may cause breakage. Stress concentrations at edge imperfections also increase the likelihood of breakage.

Correct installation practices are extremely important in the successful performance of sealed glazing units. Bedding compounds chemically incompatible with the sealing material can cause sealant deterioration; and if spaces between the glazing units and the sash are improperly drained damage to the seal can occur from water and frost action. Bedding materials must remain resilient in order to accommodate differential movement between the sash and the unit and avoid stresses due to building movements.

Evaluation Procedures

In view of the severe physical requirements imposed on sealed double glazing, and because the majority of manufacturers have only short term field experience, laboratory test procedures are useful for evaluating the efficacy of sealing systems. The complete unit, as well as the sealant, must be tested because performance will depend on all elements of the system and on assembly methods. Tests should subject units to the net effect of the stresses, moisture conditions and aging to be encountered over their service life and reduce the time required for failure.

Test procedures must invariably involve subjecting units to a very large number of cycles of stress in the presence of moisture. Short term tests of a few days are usually meaningless. Only a few manufacturers have adequate test facilities, however, and no standards have been developed within the industry. In Canada the Division of Building Research has been preparing appropriate methods and carrying out tests for manufacturers that require several months to complete. This work has confirmed the difficulty of devising adequate evaluation procedures.

Summary

It is important that the characteristics of sealed double-glazing units be fully recognized. Interior surface temperatures at the edges of such units are lower than those of many conventional double window arrangements, and the building humidities that can be carried without excessive condensation on these surfaces are correspondingly lower. They must be sealed initially with dry air between the panes, and in spite of the stresses imposed by service conditions must retain the seal over their required service life. Units can fail by either breakage or condensation and the scumming that results from excessive moisture gain.

On the other hand, sealed glazing units have advantages in the elimination of storm sash, reduction of surfaces that need cleaning to two, and prevention of condensation between panes. These may often outweigh the potential problems in their use.