Double Glazed Units with Built-In Venetian Blinds - Failures Can Be Avoided

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Abstract

Double glazed units with built-in Venetian blinds are well suited to be used for adjustable solar protection. Using the blinds makes it possible to vary direct solar transmission between zero and the normal amount of transmission found in traditional double glazed units. Units with integral Venetian blinds have been used in Denmark for several years but some projects with failed units have brought the principle into disrepute.

The Danish Technological Institute has analysed these units and found different types of failure, all of which could have been avoided during manufacture. Mechanical failure and failures caused by release of chemical solvents were found. This article analyses the failures and proposes methods of avoiding them in the future.

Introduction – doubled glazed units with built-in Venetian blinds

During summer, large glass areas in building envelopes can cause overheating inside buildings. Reducing the temperature by cooling is extremely expensive and it is normally recommended to install a solar control system either outside or inside the building. Both solutions have advantages and disadvantages, however a third solution could be to install Venetian blinds in the cavities of the double glazed window units. In Denmark this type of unit has been used for several years and performs well as a solar control system.

The purpose of this article is not to discuss the advantages or disadvantages of double glazed units with built-in Venetian blinds. During recent years, a small number of units have unfortunately exhibited various types of failure. The majority of failures could have been avoided if theoretical analysis supplemented with testing had been carried out. No standard exists for double glazed units with integral Venetian blinds and the units have only been tested for sealant durability according to the existing Danish standard for traditional double glazed units.

Different types of failures

During the last five years, the Institute has received double glazed units with integral Venetian blinds exhibiting failures caused by chemical compounds or by mechanical failure of the blinds. Failures caused by chemical compounds are normally seen as a whitish contamination on the second glass surface, counted from the outermost glass surface and mostly on glazing oriented towards the sun. Examples of failure caused by mechanical problems with the blinds could be a broken string, a sliding gear motor or locked slats.

Contamination on glass

Organic compounds:
The appearance of a whitish contamination on the second glass surface, counted from the outermost glass surface, is the most frequently occurring failure in double glazed units with integral Venetian blinds. Different levels of pollution have been seen, ranging from barely visible to visible from a considerable distance. Figure 1 shows a double glazed unit with a clear whitish coating especially accentuated by the wear track from the ladder string.

The above-mentioned double glazed unit were Venetian blinds with aluminium slats. The whitish contamination could be wiped away with a dry cloth leaving a greasy surface. Chemical analysis showed that the whitish coating consisted of organic compounds and that these compounds could also be found on the surface of the aluminium slats.

To avoid this whitish contamination all components built in the cavity should be checked for any release of organic compounds. We have 20% of a special order had whitish contamination whereas the rest did not have this type of problem. All the units were produced at the same time and on the same manufacturing line. A fogging test carried out on new units produced on the same manufacturing line following the same system description did not reveal any contamination.

We were unable to find any deviation in the production of the double glazed units or blinds that could have caused failure in approximately 20 % of the units, whereas the remaining 80 % had no problems. One possible explanation is a variation in the paint used on the slats but we were not requested to investigate this part.

To prevent failure caused by release of organic compounds from the blinds, quality control should ensure that all blinds delivered have stable surfaces.

Figure 1

Whitish contamination on second glass surface caused by organic solvents

Figure 2

Whitish contamination on the second glass surface caused by corrosion of the surface

Corrosion of glass:

In one case it was not possible to wipe away the whitish contamination and it was impossible to remove it with solvents or acid. Chemical analyses showed that the whitish contamination was not of organic compounds but showed that there was a greater concentration of sodium ions than on normal glass surfaces. The contamination is shown in figure 2.

Examination of the 25 mm wide aluminium spacer from the unit showed one row of holes and that the holes were almost closed where they should

Figure 3.

Water absorption capacity of 3 different types of spacers

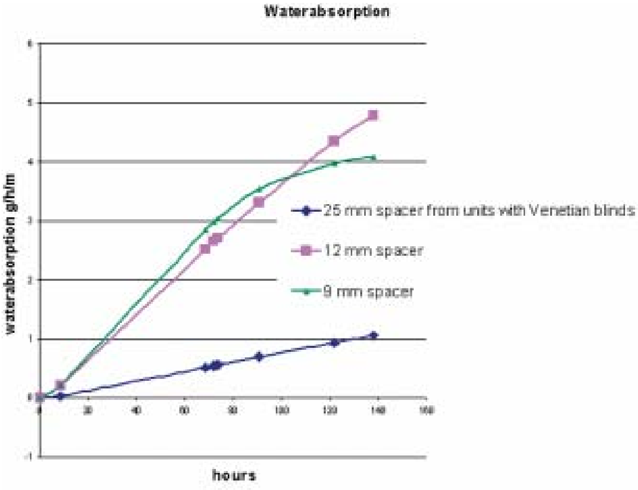

Figure 4.

Marks on the third glass surface caused by the ladder string

be opened. Compared with 9 and 12 mm spacers from traditional double glazed units we measured the capacity of the 25 mm spacer to absorb water from the air.

The spacers were filled with the same type of desiccant and were left freely exposed in laboratory air for 6 days. The results of the weighing of spacers are shown in figure 3. The capacity of the spacer from the unit with the Venetian blind had less than a quarter of the capacity of a normal spacer. The unit with the Venetian blind was produced during the winter and installed a few days after manufacture during a period of cold weather.

We assume that water has condensed on the second glass surface and that the Venetian blinds have been closed during periods of sunshine whereby the temperature in the cavity increased. High temperature and a thin layer of water results in rapid corrosion of the surface corresponding to what is normally seen in a "punctured" double glazed unit.

To avoid corrosion of the inner glass surface, it is important that the air in the cavity is dried quickly after manufacture, and therefore the holes in the spacer should be designed with the correct size. Especially critical are units filled with atmospheric air containing water vapour combined with a large cavity width.

Marks on glass surfaces:

In some units failure was due to marks from the ladder string of the blinds on the glass. Figure 4 shows a unit with marks on the third glass surface counted from the outermost glass pane. The marks are located just below the blind in its rolled-up position in front of each row of ladder string.

The marks could not be wiped away with a soft cloth but could be removed gently with a knife. The glass surface was a soft-coated low-e glass. Chemical analyses showed that the marks were of the same material as the ladder string and not a wear mark in the coating.

Marks on glass surfaces caused by stings can be avoided with acceptable tolerances between the glass and the blinds and by taking into account possible deflections in the glass caused by climatic changes. In the case of blinds, which can be rolled up with ladder strings, the double glazed units should have greater tolerances to prevent the strings from reaching the glass in a up-rolled position.

Mechanical problems with the blinds

Problems with the strings:

Units have exhibited simple mechanical failures such as broken strings or blinds slowly sliding down when the power supply has been switched off. Figure 5 shows a broken carrying string caused by wear from the sharp edge shown in figure 6. When a carrying string breaks, the blinds will hang lopsided, see figure 7.

Motor problems:

Some units have experienced problems preventing the blinds from slowly sliding down after switching off the power supply. Measurements of the gear-motor friction showed that the resistance was less than the weight of the slats. This is illustrated in figure 8.

Broken strings and motor problems can be avoided by removing all sharp edges and by carrying out functional tests (several thousand times) on test units. Automatically controlled blinds should be tested for being rolled up and down 20,000 times plus 20,000 tilt-and-turn operations. Manually controlled blinds should be tested for half this number. During tests the pressure in the cavity should be maintained to correspond to the minimum free distance between glass in winter.

Problems with locked slats:

During winter some blinds cannot be operated because of direct contact between glass panes and slats. Low temperature and high pressure causes a concave flexing of the glass, and units with tight tolerances may be vulnerable to contact between glass surfaces and slats, resulting in the slats locking.

Locked slats caused by contact between slats and glass can be avoided by controlling pressure in the cavity during manufacture. Based on temperature and pressure during production, the size of the unit, the dimensions of the glass, the expected pressure and temperature during normal lifetime, it is possible to calculate the deflection of the glass. In the same way the stresses in the glass can be

Figure 5

Broken carrying string

Figure 6

Carrying string with wear marks from sharp edges

Figure 7

Lopsided Venetian blinds

Figure 8

Blinds slowly sliding down after switching of the power supply

calculated and glass thickness specified.

Figure 9

Breakage of inner glass in units with Venetian blinds

Glass breakage

The purpose of units with Venetian blinds is to control and reduce the solar energy passing through the unit. This causes higher temperature in the cavity and together with the increased width of the cavity the pressure can increase so much that under some circumstances it can cause the glass to break, see figure 9. A less serious problem is deflection of the glass causing large distortions in reflection from the glass.

Glass breakage should be avoided by calculating bending stresses in the glass depending on climatic conditions during manufacture and expected climatic conditions during lifetime. Double glazed units with integral blinds will reach much higher temperature every day compared with normal double glazed units without blinds.

Higher temperature together with increased cavity width raises the stresses and deflections in the glass. Often thicker glass is used for the outer glass layer to reduce deflections. For smaller units this can cause breakage of the thin glass.

Summary

Double glazed units with built-in Venetian blinds should be designed with special attention to more extreme conditions than traditional double glazed units. There are no national standards for units with blinds in the cavity and using the standards for double glazed units such as the future European product standard for double glazed units prEN 1279 will not be sufficient for units with blinds.

The temperature in the cavity will reach much higher temperature than ordinary units, and combined with the necessity for a wider cavity the bending stresses in the glass of the panes will increase and eventually cause breakage. During winter deflections of the glass of the panes will be greater than in traditional units with the same dimensions because of the increased spacer width. If tolerances are too tight there is the risk of direct contact between glass and blinds leaving marks or locking the slats.

The introduction of thing new may cause contamination of the internal glass surfaces. It is essential to make sure there is no release of organic compounds from any surface.

If this advice is followed, it should be possible to design well-performing double glazed units with built-in Venetian blinds – and to avoid failures.