How Long Can Spacer Bars – Filled with Desiccant – Be Exposed to Ambient Air?

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Keywords
1 = Insulating Glass Unit 2 = Spacer Bar 3 = Corner Key 4 = Desiccant

Abstract

The water ingress into spacer bars filled with desiccant and stored in ambient air has been experimentally determined. The influence of the following parameters has been investigated: profile type, temperature/humidity of the ambient air, desiccant type and type of frame construction. It is shown in which cases the storage of filled spacer bar frames may lead to critical losses of the water adsorption capacity of the desiccant.

Introduction

Often, during the manufacture of Insulating Glass Units (IG-Units) spacer bar frames pre-filled with desiccants are stored at the manufacturing plant for several hours, sometimes over night or over the weekend, before the IG-Unit is finally assembled.

During storage, however, water vapour from the ambient air diffuses into the frame and reduces the moisture adsorption capacity of the desiccant. Consequently, the theoretical lifetime of the finished IG-Unit is reduced.

In order to evaluate the influence of the storage time of spacer bar frames on the activity loss of the desiccant, the impact of the following parameters on the water uptake of filled spacer bars has been investigated:

- Type of profile (profiles with different perforations: "slow" and "fast" profile)
- Storage conditions (air humidity and temperature)
- Type of desiccant (different molecular sieves)
- Type of frame construction (bent corners, corner keys, profile junctions)

Experimental

Profile Test

The water ingress into spacer bars has been investigated by cutting the spacer bars into pieces of approx. 40 cm length, filling these spacer bar specimens with active desiccant (molecular sieve: zeolite type 3A) and sealing the ends of the spacer bars tightly with polyisobutylene (abbr. "butyle"). The spacer bars were stored in a climate chamber at exactly defined ambient temperature and humidity.

The time dependence of the water ingress into the spacer bar was determined by weighing the spacer bar immediately after sealing and then again in defined time intervals during storage in the climate chamber. In most cases, the atmosphere in the climate chamber was maintained at 25°C and 50%RH (standard conditions). The water uptake was observed for at least 24 hours.

In all tests at least 5 spacer bars of the same type have been investigated, i.e. all curves shown in the following Profile Test graphs represent the averages of at least 5 spacer bar or frame specimens.

Results

Influence of the type of profile

Typical water uptake curves obtained by the above described Profile Test (different profile types and different profile manufacturers) are shown in Figure 1a. The legend of Figure 1a indicates the width of the spacer bar and the spacer bar desiccant filling amount in grams per meter.

Figure 1a illustrates the large differences in the transmission rates of water for commercially offered profiles, i.e. the variety in the perforations of the available profiles. The water uptake of the "fastest" investigated profile A is 25 times higher than that of the "slowest" profile G.

To evaluate the loss of water uptake capacity of the filled profiles during storage, the water ingress must be related to the available desiccant mass (Figure 1b).

Example for the impact on the activity of the desiccant:
Figure 1b shows that Profile J picks up nearly 6%wt. water within twelve hours. Assuming that the typical water adsorption capacity of the fresh desiccant (3A type zeolite) is 18%wt., twelve hour storage of the filled profile means, that the water adsorption capacity of Profile J and consequently also the lifetime of the finished Insulating Glass Unit is reduced by approx. 1/3. This example drastically illustrates, that when filled profiles (frames) are being stored during the manufacturing process, it is necessary to know the water ingress into the profile (frame) to avoid critical losses of lifetime for the finished IGU. The "Profile Test" permits this influence to be evaluated quantitatively.

For the following tests 3 profiles with 15 mm profile width but significantly different water vapour transmission rates and/or desiccant filling masses have been selected:

Profile B (fast water ingress): 60g desiccant/m; 3,2%wt. water uptake in 24 hours

Profile E (slow water ingress): 60g desiccant/m; 0,6%wt. water uptake in 24hours

Profile G (slow water ingress): 36 g desiccant/m; 0,3%wt. water uptake in 24hours

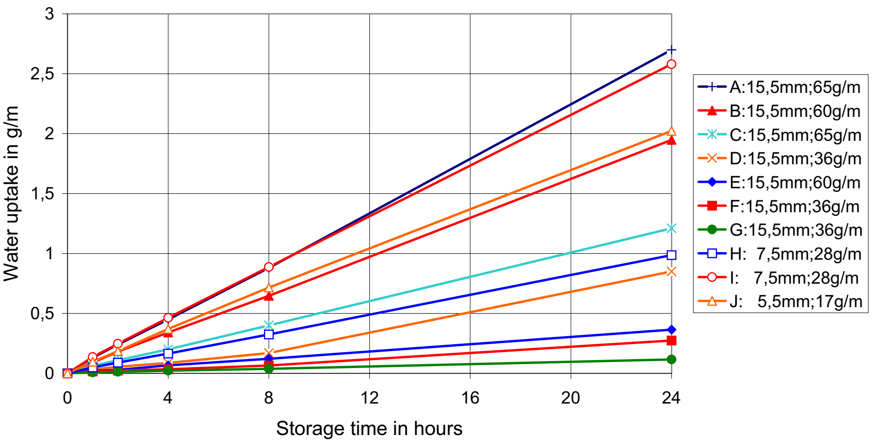

Fig 1a
Profile Test at 25°C, 50%RH – Various profiles

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Influence of the humidity and temperature of the ambient air

It is known that the normal diffusion of water vapour molecules into the filled profiles depends on the total area of the openings of the profile, the water vapour concentration in the air and the diffusion coefficient D of water vapour in air. The latter parameter depends on the temperature in the following manner: $D \sim T^{1,75}$, where the temperature of the air T is given in °K.

Knowing the water transmission rate a_0 into the profile at standard conditions (25°C, 50%RH = 298°K,15,8mbar water vapour partial pressure) from our Profile Test, the water transmission rate a_x at other temperatures (T_x) and relative humidities can be easily calculated according to:

$$a_x = a_0 (p_x \times T_x^{1,75}) / (p_0 \times T_0^{1,75})$$

a – water transmission rate at x°C, x%RH
a_0 – water transmission rate at standard conditions
p_x – water vapour partial pressure at x°C, x%RH
p_0 – water vapour partial pressure at 25°C,50%RH
T_x – temperature x in °K
T_0 – standard temperature (298°K)

Example:

Measurement: Water uptake/24h at 25°C, 50% RH for profile B: 3,2 %wt.

Calculation: Water uptake/24h at 50°C, 25% RH for profile B: 7,15 %wt.

From Figure 2 can be seen that the measured water ingress at 50°C, 25%RH is in good agreement with the calculated value.

Example for the impact on the activity of the desiccant:

When Profile J (see Figure 2) is stored for 12 hours at 25°C and 75%RH instead at 25°C and 50%RH the water ingress into this profile would be equal to 9 %wt. corresponding to approx. 50% loss of the initial water adsorption capacity of the fresh desiccant.

Influence of the desiccant

Different desiccants may exhibit different water uptake velocities and uptake capacities. Figure 3 shows the water uptake kinetics for two different commercially available 3A type molecular sieves (zeolite 1 and 2) when arranged in a 5 cm high zeolite layer (i.e. outside the profiles).

The graph shows that even molecular sieves of the same type may exhibit different water uptake velocities as well as different water capacities.

In contrast to this in Figure 4 the water uptake curves of the same molecular sieves (zeolites 1 and 2 when accommodated in profiles, are given. It is seen, that the water uptake curves of zeolites 1 and 2 in both profiles are almost identical, although - outside the profiles - the water uptake velocity of zeolite 1 is considerably faster. This means that in the profile the water uptake velocity is essentially determined by the diffusion of the water molecules through the holes of the perforation and not by the water uptake velocity of the desiccant.

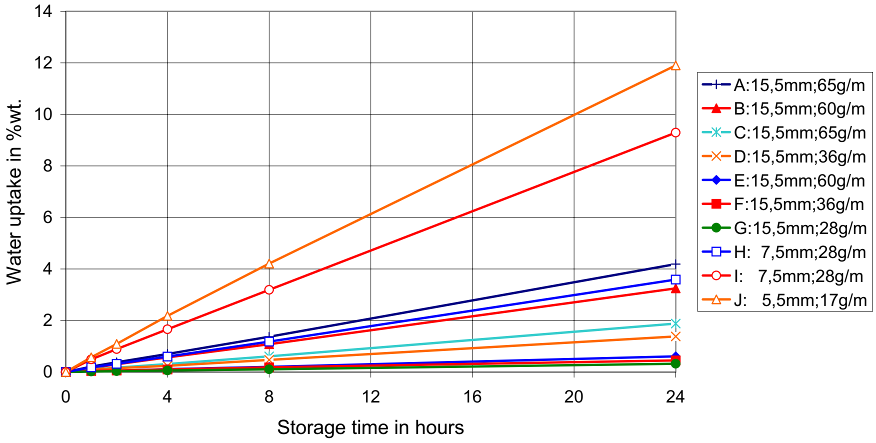

Fig 1b

Profile Test at 25°C, 50%RH – various profiles

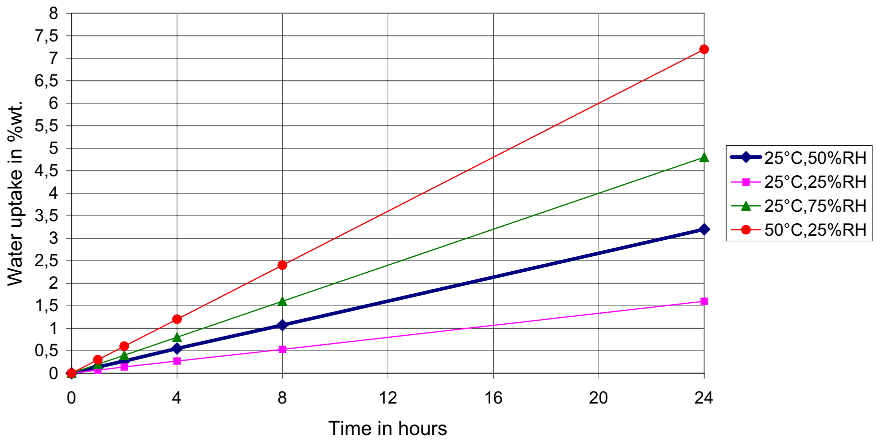

Fig 2

Profile Test at different humidities and temperatures

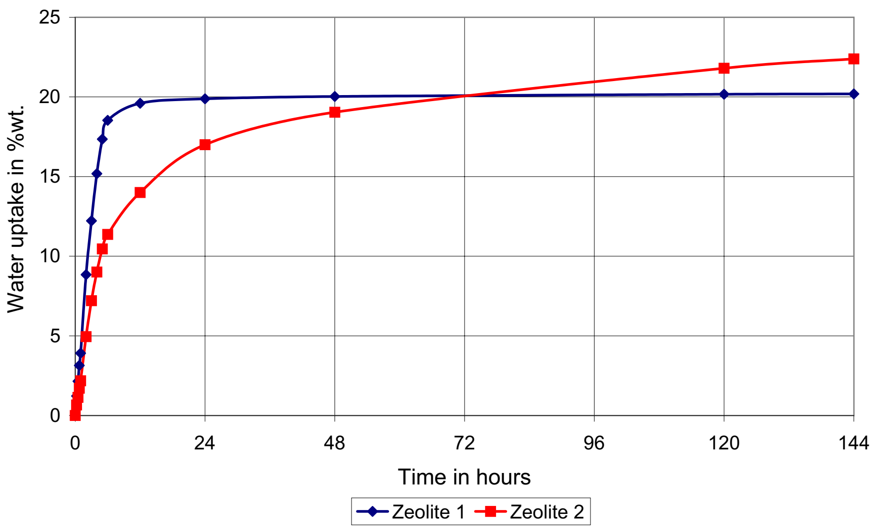

Fig 3

Water uptake of different molecular sieves at 25°C, 50%RH

Influence of corner keys and profile junctions

In Figure 5 - for profile B and E - the water uptake of a 40 cm long spacer bar filled with molecular sieve and sealed on both ends with butyle is compared with the same spacer bar cut in the middle into two parts, filled with fresh molecular sieve and then connected again by a corner key.

Comparing the water uptakes for profiles with and without corner keys it can be seen that the influence of the corner key is relatively small. Similar results have been found when the spacer bars were connected by profile junctions. This means, that the investigated corner keys and profile junctions sufficiently tightly closed the spacer bar against the surrounding atmosphere.

It is interesting to note, that only in the case of the "slow" profile (profile E) the presence of the corner key increases the water transmission rate of the profile as expected, whereas in the case of the "fast" profile (profile B) the corner key fictitiously improves the sealing of the profile. This inverse behaviour may be explained by a "shielding effect" of the corner keys in the case of profiles with a large number of perforation openings per profile length. In our case the 2,5 cm long sides of the corner keys closed about 15% of the perforation holes thus decreasing the water ingress. It is obvious that in this case the water transmission rate is dependent on the length of the spacer bar specimens used in the test.

To exclude this effect the succeeding tests have been carried out only with "slow" profiles. Special care has been taken that in the following experiments no perforation hole was closed by the corner keys.

To study the water transmission rate for bended profiles during storage, we have asked an insulating glass producer to manufacture two types of frames with the same frame size (300mm x 300mm) and profile type (Profile G):

1. Frames with bent corners manufactured by means of a bending automat
2. Frames with 4 corner keys manually manufactured

Figure 6 shows how these frames performed in our Profile Test.

As expected, the bent frames show less water ingress during storage than the frames manufactured manually with corner keys. Please note, that the differences between both water uptake curves can not be related to the corner keys alone, since the bent frames have also one weak point in respect to water ingress: the profile junction.

To determine the influence of the corner keys on the water ingress quantitatively, we tested the water ingress into two spacer bar pieces connected with a corner key and also closed on both ends with corner keys. Such a "spacer angle" (see Figure 7) should show the same water ingress as a complete frame when the water uptake is measured in g/m.

Figure 8 shows that indeed the measured water transmission rate for this spacer angle related to the profile length is very close to that measured for the complete frame (compare Figure 6 and Figure 8).

Additionally, in Figure 8 the water transmission rate of the very same spacer angle after butyle has been injected into the 3 corner keys is represented. The graph shows that hereby the water ingress into Profile G is reduced by about 0,1 g/(m x day). The

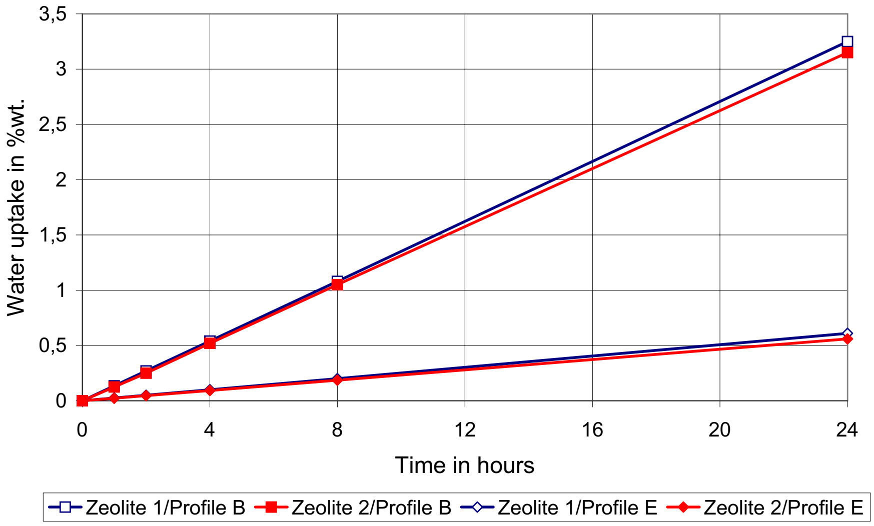

Fig 4

Profile Test at 25°C, 50%RH – Different molecular sieves

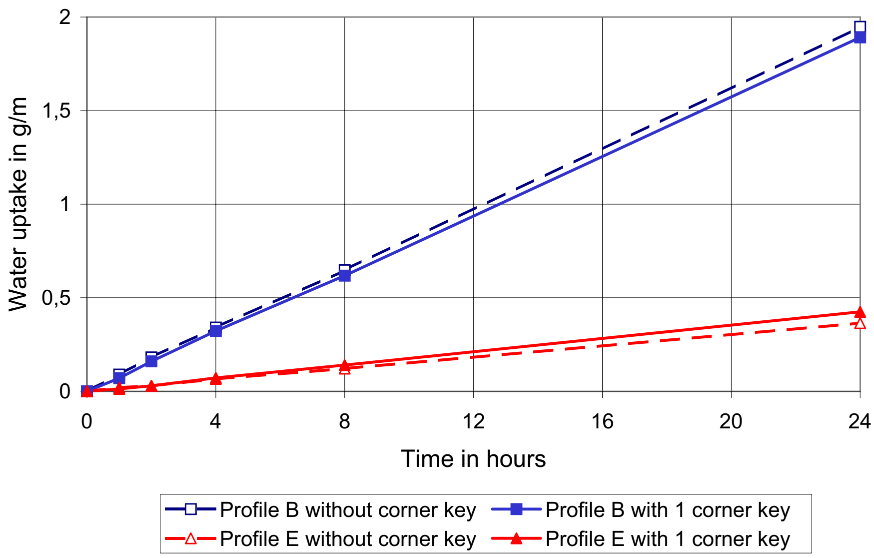

Fig 5

Profile Test at 25°C, 50%RH – spacer bars without corner keys versus spacer bars with one corner key

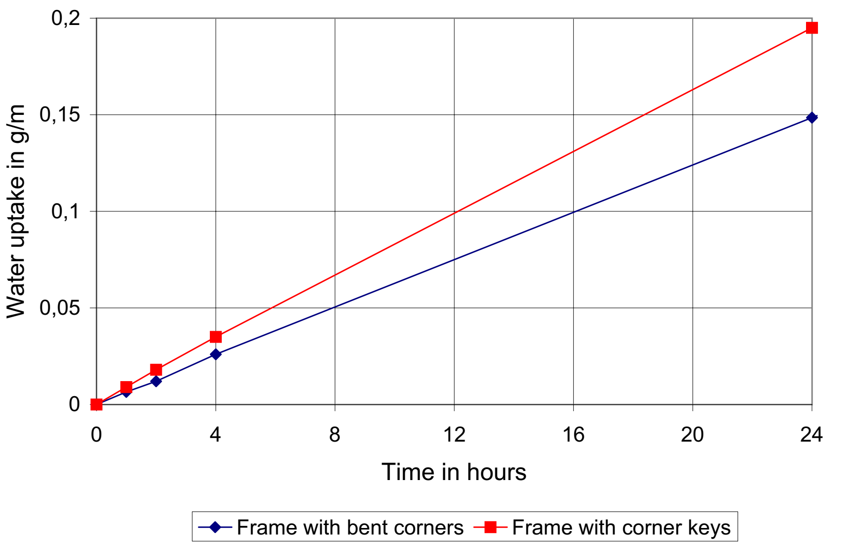

Fig 6

Profile Test at 25°C, 50%RH – frame with bent corners versus frame with corner keys

same difference was found for profile E. This value is also in good agreement with 0,05g/(m x day) found for a spacer angle with one corner key and both ends sealed with butyle (compare Test 5). From this follows that for a complete frame (4 corner keys) the water ingress via the 4 corner keys amounts to approx. 0,2 g/day.

Example for the impact on the activity of the desiccant:

0,2 g/day water ingress via 4 corner key corresponds to approx. 0,3 %wt. water uptake by the desiccant in Profile E or 1,2 %wt. water uptake in Profile J. This corresponds to a loss of less than 2% of the initial water adsorption capacity of Profile E. Even in the case of Profile J – provided that the results for the 15,5 mm corner keys can be transferred to the 7,5 mm corner keys – the loss of the activity would be less than 7%.

It is important to note, that the impact of corner keys on the activity of the desiccant during storage investigated in this paper is different from the impact of corner keys on the activity of desiccants in the finished IG-Unit: During the storage of filled spacer bars (or frames) for some hours or days the water ingress via the corner keys competes with the water ingress through the holes of the profile perforation.

In the finished IG-Unit the water ingress via corner keys competes with the water ingress via the primary sealing of the IGU (usually butyle). In this case the water ingress via corner keys without butyle injection may be very significant [1].

Fig 7

"Frame" with 4 corner keys and "spacer angle" with 3 corner keys as used in Profile Tests for Figures 6 and 8

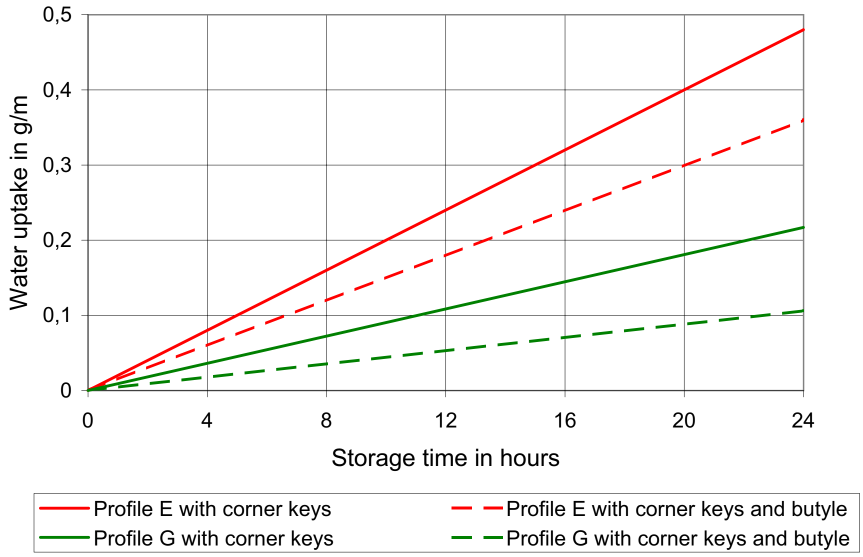

Fig 8

Profile Test at 25°C, 50%RH – Profiles with corner keys with and without butyle injection

Conclusions

The major findings of this study are:

1. The influence of the storage of filled spacer bars in ambient air on the activity of the desiccant can be experimentally determined by means of a "Profile Test" at standard conditions (25°C, 50% RH). For other temperatures and relative humidities the activity loss of the desiccant may be calculated with sufficient accuracy.
2. Spacer bars with many and/or large perforation holes ("fast" spacer bars) show high water adsorption capacity losses during storage when the desiccant filling amounts are small. Such spacer bars should not be stored.
3. The influence of the type of desiccant on the activity loss during storage of filled profiles is normally negligible.
4. The absolute water ingress via corner keys or profile junctions into filled profiles is small. The investigated complete spacer bar frames showed approx. 0,2 g/day water ingress via the corner keys at standard conditions.
5. Bent frames exhibit less water ingress during storage than frames with corner keys. By careful injection of polyisobutelene into the corner keys, however, the water ingress via corner keys may be completely eliminated.

Acknowledgements

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References

[1] Brook, H.: Glaswelt 10 (1991), p.84-92