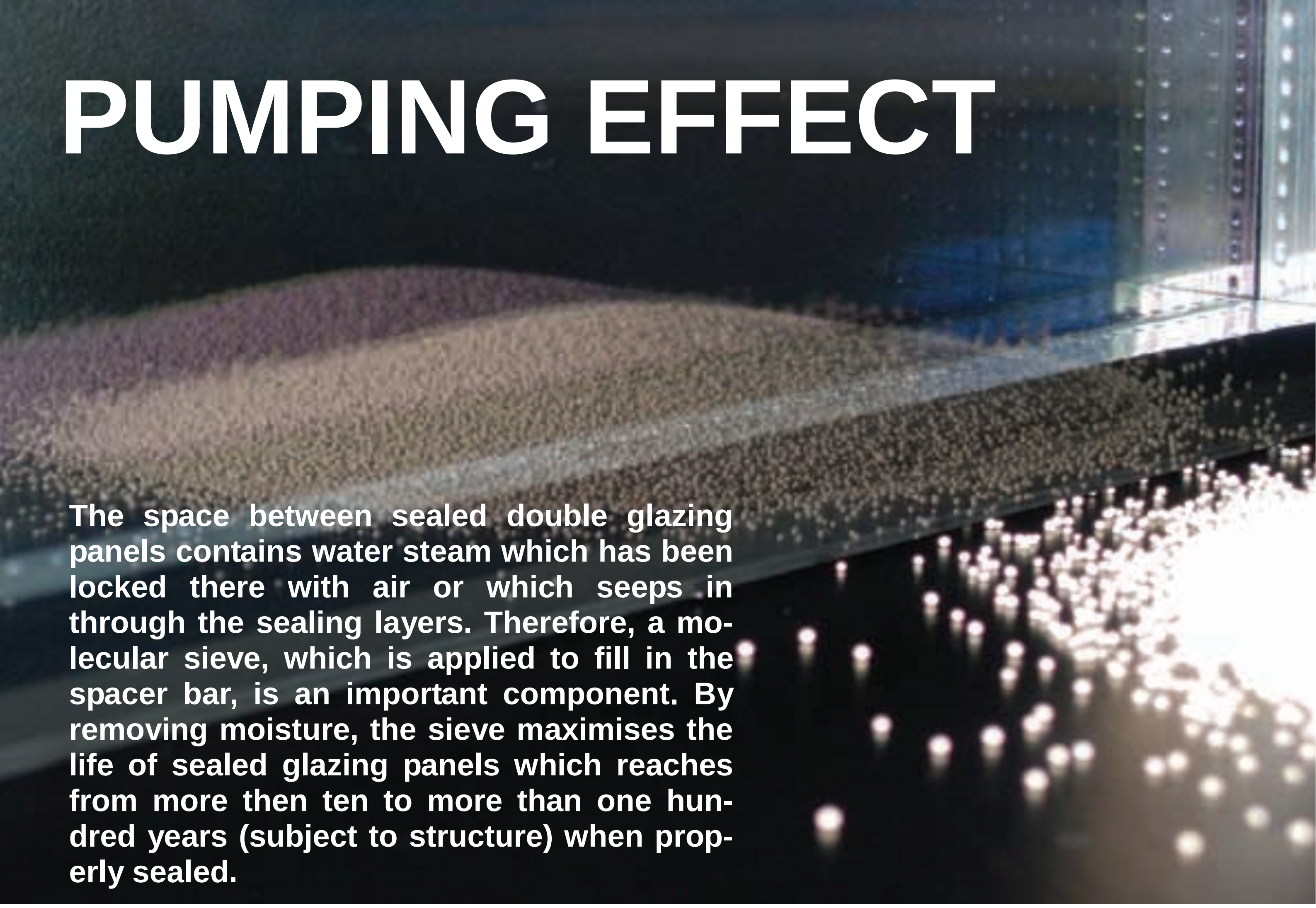


# PUMPING EFFECT

**The space between sealed double glazing panels contains water steam which has been locked there with air or which seeps in through the sealing layers. Therefore, a molecular sieve, which is applied to fill in the spacer bar, is an important component. By removing moisture, the sieve maximises the life of sealed glazing panels which reaches from more then ten to more than one hundred years (subject to structure) when properly sealed.**

**Adsorptive properties of zeolite**

As a moisture adsorbent, a molecular sieve binds water molecules on pore surface. The process of water steam adsorption is quick thanks to a strongly porous structure of sieve granules. The openings that provide *access to that structure are known as windows*. Through those openings, gas molecules reach channels in the structure of the molecular sieve (e.g. zeolite) which are referred to as pores.

After passing through the window, gas molecules occupy adsorbent pores, but the duration of their stay in the pores is determined by the physical properties of those molecules and the molecular sieve as well as ambient conditions.

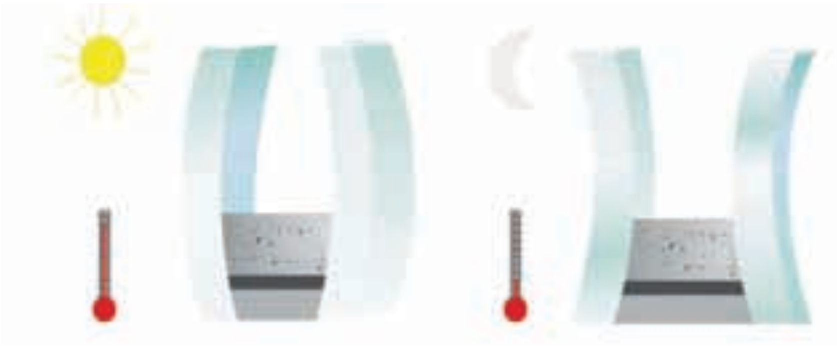
A layer - usually with the thickness of several atoms - comprising the adsorbed gas molecules is formed in the surface layer of the adsorbent. The lower the temperature, the thicker that layer (a greater quantity of gas is absorbed from the space between sealed panels).

**Absorption** (physical) - process in which a gas substance permeates a liquid or solid substance or in which a liquid substance permeates a solid substance.

**Adsorption** - adhesion of liquid or gas molecules to a solid surface.

**Zeolite "attracts" water steam**

Zeolite most readily adsorbs water because - *similarly to water - it is a polar material* (i.e. bi-polar, whose particles have a + and a -).



*Change in gas volume between sealed panes subject to ambient temperature.*

The mutual attraction force is so strong that the separation of the pair requires either *very high temperature or very low pressure*. Since only water has polar molecules among the various gases present between the sealed panes, water has absolute priority - the strongest affinity to pore surface. According to research, even a 4% content of water in the sieve practically eliminates the absorption of other gases from sealed panes.

The adsorbent does not "attract" nitrogen, oxygen or argon particles because they are electrically neutral. The atoms of those gases have already devoted all of their electrons to build mutual relations in the particle.

**Zeolite "with custom-sized windows**

The average size of "windows" in the most popularly applied molecular sieves is around 3Å (i.e. 3 ten billionth parts of a meter). A water molecule will freely flow through the "window". Nitrogen, argon and oxygen molecules will find it difficult to “fit in” the window.

Adsorbents with pore diameter of 4Å were popular at a time when the space between double glazing panes was filled only with air. The 4Å sieve is characterised by higher activity (i.e. it absorbs water steam more quickly) and greater adsorptive capacity. The air between sealed glazing panes had a moisture content identical to a production hall. It had to be quickly removed to prevent water steam condensation when the temperature dropped, e.g. during transport in winter.

**Dimensions of particles (Å) of various gas types applied in double glazing units:**

| | |
|---|---|
| Water steam $H_2O$ | 2.65 |
| Carbon dioxide $CO_2$ | 3.30 |
| Argon $Ar_2$ | 3.40 |
| Oxygen $O_2$ | 3.46 |
| Krypton $Kr^2$ | 3.60 |
| Nitrogen $N_2$ | 3.64 |
| Sulphur Hexafluoride $SF_6$ | 5.50 |

Today, when most double glazing panes are filled with noble gas (e.g. argon), and where at least one panel is covered with a low-emissivity layer, new methods had to be devised to reduce the sieve's absorption of gases other than water steam. The "pane pumping" effect is especially visible in panes characterised by high reflexivity due to a glazing layer that also reflects visible rays.

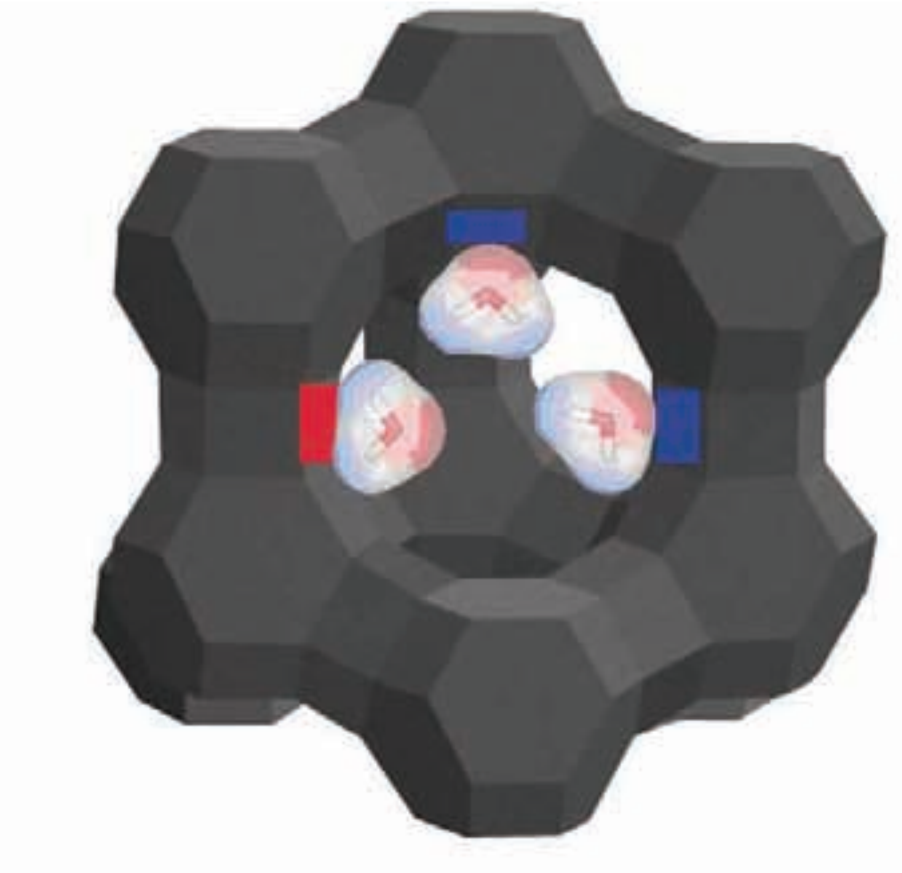
**It should also be considered whether it is the adsorbent that has a major impact on the "pane pumping" effect.**

**Adsorbent's impact on "pumping" effect**

The question whether the moisture adsorbent could be responsible for the pumping effect in sealed glazing panes has recently stirred high emotions.

The answer is yes, but, if so, to what extent and when?

Let's say we are expanding the "window" to 4Å. This will create relatively free access for nitrogen, oxygen and argon to the adsorbent. If the adsorbent is very active, it will hold vast quantities of gas in its pores.



*Section of zeolite chain - diagram illustrating the "attraction" of water as a polar molecule.*

If temperature between sealed panes is increased to, for example, 70ºC, the adsorbent could release the adsorbed gas. This is a way of testing the adsorptive/desorptive characteristics of a given sieve.

To investigate the co-relations between sieve absorptivity and "window breathing", let us use the example of a sealed double glazing pane measuring 1 x 1 m with a 16 mm spacer frame. The quantity of added adsorbent is around 120 g, and gas volume between the panes is 16 l.

If the poorest-quality 4Å adsorbent with very high gas adsorptive capacity (600 ml gas/250 g sieve) is used, the gas volume between sealed panes could be expected to increase by 288 ml under disadvantageous conditions.

120 g x 600 ml./250 g - 288 ml

The above equals to 0.288 l/16 l, i.e. 1.8% increment in gas volume between sealed panes.

If a 3Å sieve is applied, for which gas absorptivity is maximum 50 ml gas/250 g sieve, gas increment between sealed panes will reach 24 ml.

120 g x 50 ml/250 g = 24 ml

The above accounts for 0.15% of gas volume between sealed panes.

**Impact of gas compression and decompression caused by temperature change on the "pane pumping" effect.**

To compare, based on thermodynamic gas laws, e.g. Charles's law (on the assumption of an isobaric process - when pressure is constant, gas volume is directly proportional to its temperature[*]), it is easy to calculate that when gas is heated in the test pane by 20ºC, gas volume will increase by 1091 ml, which accounts for 6.82% of pane volume.

$V1/T1=V2/T2$; therefore $V2=V1 \times T2/T1$

$V1=0.016\ m^3$

$T1=(20^{\circ}C + 273.15)=193.15\ K$

$T2=(40^{\circ}C = 273.15)=313.15\ K$

$V2=0.016 \times 313.15 / 293.15=0.017091\ m^3$, i.e. 1.091 l

It can, therefore, be assumed that the natural environment poses a much more serious threat for sealed panels than the poorest-quality sieve.

In our opinion, the so called pane breathing effect is a normal phenomenon that occurs in properly sealed double glazing units.

All renowned adsorbent suppliers are aware of the fact that it is much safer to apply 3Å adsorbent in double glazed units.

It is up to our Readers to decide whether expensive sieves pose a noteworthy alternative.

**Wojciech Przybylski**

[*] This assumption is correct at low pane rigidity which is determined by the dimensions of the glass pane: rigidity decreases as pane surface increases and pane thickness decreases.

**Molecular sieve consumption in Poland in 2005**