ISO-Altimeter

Gasdruck-Ausgleichssystem
für Mehrscheiben-Isolierglas

Pressure compensation system
for insulation glasses

Système pour la compensation
de la pression des vitrages isolants

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1. General Problem

Gas filled insulation glass has a closed and sealed space between the glasses. This space is normally filled with air or a special filling gas like Argon.

This space has to be absolutely leak-proof to retain its insulating quality, which highly depends on the gas-concentration inside the pane, and to prevent precipitation of humidity.

Insulation glass is subjected to various climatic conditions. It has to sustain stresses caused by these conditions.

Changing climatic conditions cause different forces , which influence insulation units.

These influencing factors are:

- Temperature changes
- Atmospheric pressure changes
- Altitude changes.

Especially for insulation glass, the following questions are of interest:

- Which force takes effect?
- What impact on the glass does it have?
- Which force can the glass compensate?
- Is it possible to compensate pressure during production process ?

2. Which force develops?

Forces develop from,

- atmospheric pressure changes due to altitude changes (altitude of production- vs. altitude where the unit is finally used)
- the gas extends in a different way when the temperature changes.
- atmospheric pressure changes due to climatic variations.

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2.1 Pressure changes caused by the height difference between place of production and place of installation (difference in atmospheric pressure) .

This kind of pressure is measured either in Pascal (hPa) or in milli bar (mbar).
For reasons of simplification hPa and mbar is equated here.

Standard pressure is defined as follows:

- 1013 mbar/hPa
- 20°C
- 0 m above sea level.

Atmospheric pressure decreases in higher altitude.

Example:

Installation altitude (m)	difference in pressure (mbar/hPa)
100	- 12
200	- 23
400	- 46
800	- 91
1200	- 134

2.2 Temperature change

The change of the gas pressure caused by temperature changes in a closed, inflexible space can reach enormous extensions.

Example:

Temperature (°C)	difference in pressure (mbar/hPa)
+20	0
+40	+ 69
0	- 69
- 10	- 104

2.3 Meteorological phenomenon (anticyclone/ depression)

Generally the following fluctuations can occur:

	hPa / mbar	difference in pressure (hPa / mbar)
Normal pressure	1013	0
Anticyclone	1050	37
Depression	950	- 63

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2.4 Other stresses

Apart from the stresses on the IG unit mentioned above, stresses caused by the wind play an important role as well. Depending on the position of the IG glass and the size of the building this stress can either express in pressure or suction. Our considerations are based on a vertical position of the glasses. If the IG unit is positioned overhead, additional stresses on the glass occur (e.g. roof windows).
The pressure of snow located on the glass should also not be neglected, as well as the thickness of the glass used, a.s.o.

2.5 Abstract view

Presumptions:

- The IG unit is supposed to be **absolutely stiff** (which is not the case) and extreme climatic conditions exist.
- Differences caused by a contrast of low/high
- Difference between production altitude and installation altitude >1000 m
- Temperature difference > 40℃

Under these conditions, enormous pressure would stress the glass, which would always lead to the breaking of the glass.

Example for real pressure conditions:

IG unit 1m x 1m	=	1 m²
Production altitude 0 m (1013 mbar) / 20℃		
Installation altitude 800 m	= -	91 mbar
depression -983 mbar	= -	30 mbar
Total difference	=	**- 121 mbar**

If you transfer the pressure into a force, stressing the whole surface of the glass, this pressure would equal a force of 1210 kg applied to the whole surface of the IG unit. Considering a sealing with a thickness of 5 mm, a force of 6,05 kg/cm² stresses the sealing. A sealing is not able to withstand such a pressure for a long time.

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3. Impacts in reality

3.1 The developing forces engross a larger or smaller capacity.

Due to its bending elasticity, the glass will

- deflect to the outside if -temperature rises
  -atmospheric pressure drops
  -altitude declines
- deflect to the inside if -temperature drops
  -atmospheric pressure rises
  -altitude inclines

Depending on the situation, the forces mentioned above, will either nullify or add to each other.

Examples:

In summer: Depression and sultry-warm weather increase the effect of deflection to the outside.
In winter: Anticyclone and coldness increase the effect of deflecting to the inside
In summer: A rise in temperature increases the effect of deflecting to the outside, anticyclone at the same time generates a force that works against this effect.

3.2 Bending stress / deformability

A big advantage of IG glasses lies in its elasticity and deformability. By deflecting to the inside or to the outside, the capacity of the unit is accommodated automatically. This feature reduces the impact of the forces mentioned earlier.

When calculating the bending stress, the construction of the IG unit has to be considered (inside and outside).
The position of the glass (vertical or overhead) also needs to be considered.
Deformation of insulating glass can be divided in 3 Categories:

- Small formats are stiff and deform little.
- Large formats are less stiff and therefore compensate pressure changes better.
- IGs with critical dimensions are stressed heavily. Critical dimensions lie between 25 cm and 80 cm side length.

Deformation of glass with a side length of about 35 cm is lowest, and therefore the tension at pressure load is highest.

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The longer the short edge, the more elastic the glass. The tension inside a glass with a length of 75 cm for example, is only half of the tension in a unit with a length of 35 cm and the tension in a 80 cm glass is only a third.

The permissible bending stress can be calculated. Heavy deflection has the disadvantage of suggesting a less smooth optical surface, which is unfavourable in façade construction.

3.3 The sealing

Tension in very small or very large IG units is smaller. They are more resistant against high stress or deform without breaking.
Glasses with critical edge lengths are normally between 0,25 and 0,8 m. The forces stressing the glass are normally shared between the sealing and the deformability. Stresses on the sealing have the following effects:

- In under pressure conditions the glass twists around the vertical axis. This movement is compensated by the sealing compound (primary and secondary).
- In overpressure conditions a twist of the sealing applies as well.

Conclusion:

In nature and real conditions, an IG unit is in steady movement. Stresses on the sealing are enormous. As a result of that questions of warranty and the ensured quality “insulating value” arise.

It is obvious that movements should be kept as little as possible. This is only possible if the influence of the factors described above is kept as little as possible and sealing is done with adequate care.

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4. Methods of pressure compensation

To work against the problems caused by different pressures, different methods are used at present:

Transport in open state

The most simple method is sealing the IG unit only at the place where it is installed. This, however, involves an extreme loss of gas.

Capillary attraction

A very thin tube or metal pipe leads outside the unit. This makes pressure compensation in the inside of the IG possible. The disadvantage of this method however is, that a time dependent gas-loss is inevitable, which effects the insulating quality, as the gas-concentration inside the unit decreases continuously. As this method is open to atmosphere, humidity could reach the space of the unit.

Pressure relieve valve

If pressure increases inside the glasses, these valves prevent the unit from bending to the outside by allowing the gas to flow out. With this method, however, it is not possible to prevent a bending to the inside. Furthermore this method reacts to the highest overpressure during transportation and not to the local annual average pressure, where the glass is finally installed.

Compensating reservoir

If the inside-pressure of the unit grows, gas flows from the IG unit into a reservoir. If the pressure is falling, the gas flows back again.
This method, however, is very complicated to put into practice.

The procedures mentioned above are more or less methods for transport safety.

In addition you also have to close the unit before you install it.

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5. Advantages of the Helantec ISO-Altimeter

The pressure compensation of all methods mentioned earlier, is solely based on current climatic conditions.

Pressure compensation using the Helantec method, is based on annual climatic average values at the place of installation.

The advantages are f.i.:

- An additional treatment of the insulation-glass unit at the place of installation is not necessary anymore.
- The forces at the seal between the panes are minimized, which makes the insulating unit more leak-proof and results in a higher durability of the IG unit.
- Apart from taking gas out of the IG unit, it is also possible to fill the insulating unit with gas. The type of gas used, is selectable.
- All pressure compensated units are documented. Therefore complete quality control is possible and the trace ability of the delivered quality is ensured.
- During production, general conditions and the altitude of the place of installation are already considered. This makes it possible to transport the insulation unit to the place of installation “pre-finished”.
- The surface appears more smooth (important for aesthetics).
- The possibility to dose in a very exact way offers a appropriate solution to the “critical dimension” problem.
- The high resolution of the compensation system offers an ideal field of application in facade engineering and for the installation of blinds.
- It is possible to respect the place of installation using the parameter “temperature”.

The Helantec method ensures not only transport safety (breaking) but also disburden the stress on the sealing. Furthermore contributes to a higher durability as well as to a higher quality.

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6. The Helantec pressure compensation system ISO-Altimeter

This system consists of

- ➔ pressure compensation system and input terminal
- ➔ probe for gas-filling or gas withdrawal.
- ➔ HELANTEC Software for the calculation of the pressure compensation necessary, and for the calculation of the static strength at production and transport.
- ➔ Documentation

6.1 Procedure

Order processing creates the order for pressure compensation using the HELANTEC software. This order contains:

- the calculation of the static stress on the insulating glass at the place of production and at the transport.
- checking whether pressure compensation is necessary or not.
- Altimeter settings
- documentation

The production department receives the production order and makes the following settings:

- order number
- altimeter number
- total Volume

6.2 HELANTEC Software

The HELANTEC Software considers:

- format
- pane construction (glass type, glass thickness, spacer, gas type)
- production conditions
- installation conditions
- transport conditions

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The following calculations are made and displayed:

- deflection
- tension and stress
- risk of breaking

All calculations are made considering standard conditions.

The pressure compensation system considers the conversion of production conditions into standard conditions.

6.3 Scope of delivery

Pressure compensation system

size	28 x 39 x 32 cm
weight	13 kg

including:
- probe
- connection tubes
- mains cable

Dongle protected calculation software

User manual

OPTIONS

- Data transfer via USB-Memory

  → from order processing to Altimeter set up

- connectibility to a LAN (in preparation)

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Attachment: Printout of a calculation made by the HELANTEC-Software

HELANTEC ISO-Altimeter

Order/IDENT-No.: 112

Settings:

Altimeter settings: **-611618** (-out, +in)
Gas: Argon 100%
Complete volume : 24000 ml

Stress:
✓ Production: OK
✓ Transport: OK

	Production	Installation	Installation - Production
Altitude above s.l.	0	600	600
Atmospheric pressure (s. l.)	1013	943	-70
Temperature (°C)	20	20	0

Geometry:
Rectangle, all sizes
Width (b): 1000 mm
Height (h): 1500 mm
Cavity: 16 mm

Structure: Insulating glass
Outer pane/top: Float
Thickness: 8 mm
Inner pane/bottom: Float
Thickness: 6 mm

Production - climate stress: **Standard temperature** **Standard difference of athmospheric pressure**

			Isochorous pressure	Pressure between glasses
Stress max:	25 K	-20 hPa	10,50 kN/m²	**0,46 kN/m²**
Stress min:	-15 K	40 hPa	-9,10 kN/m²	**-0,40 kN/m²**

Stress of glazing from production:

Total stress (kN/m²)	deflection(mm)	defl. perm		stress(N/mm²)	stress perm (N/mm²)	
-0,13	-0,33	7,00	OK	-0,99	18,00	OK
Insulating glass: outer pane->Proof production: Climate max						
0,13	0,77	7,00	OK	1,75	18,00	OK
Insulating glass: inner pane->Proof production: Climate max						
0,69	1,69	7,00	OK	5,14	18,00	OK
Insulating glass: outer pane->Proof production: Climate min						
-0,69	-4,02	7,00	OK	-9,13	18,00	OK
Insulating glass: inner pane->Proof production: Climate min						

Transport - climate stress: **Standard temperature difference** **Standard difference of athmospheric pressure**

			Isochorous pressure	Pressure between glasses
Stress max:	35 K	-20 hPa	13,90 kN/m²	**0,61 kN/m²**
Stress min:	-15 K	40 hPa	-9,10 kN/m²	**-0,40 kN/m²**

Transport - altitude:

	Production:	**Transport:**		
Stress max:	0 m	600 m	7,20 kN/m²	**0,31 kN/m²**
Stress min:	0 m	0 m	1,20 kN/m²	**0,05 kN/m²**

Stress of glazing from transport:

Total stress (kN/m²)	deflection(mm)	defl. perm		stress(N/mm²)	stress perm (N/mm²)	
-0,58	-1,42	7,00	OK	-4,30	18,00	OK
Insulating glass: outer pane->Proof transport: Climate max, Height max						
0,58	3,36	7,00	OK	7,65	18,00	OK
Insulating glass: inner pane->Proof transport: Climate max, Height max						
0,69	1,69	7,00	OK	5,14	18,00	OK
Insulating glass: outer pane->Proof transport: Climate min, Height min						
-0,69	-4,02	7,00	OK	-9,13	18,00	OK
Insulating glass: inner pane->Proof transport: Climate min, Height min						

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