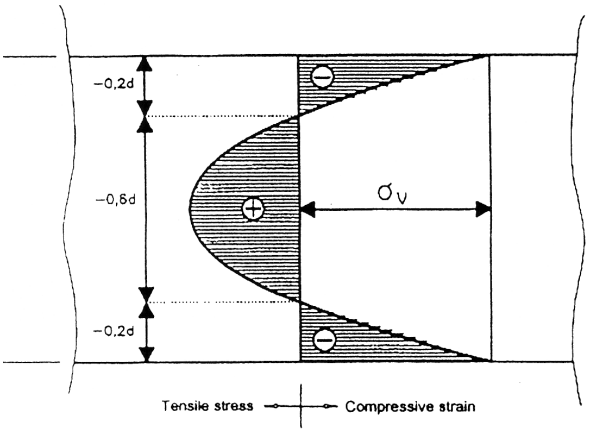
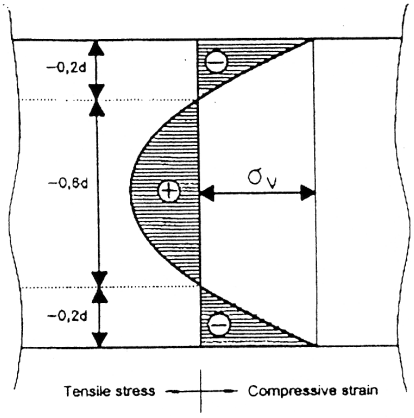
1. BI-HESTRAL - Heat strengthened or semi-tempered glass

1.1 Manufacture

BI-Hestral is a heat strengthened or semi-tempered glass. It offers considerable advantages in special applicational areas where it must fulfill special safety criteria. The origin of this glass is to be found in America. The manufacturing method is similar to the production process for tempered glass. The significant difference however is that after heating at the start of the forming area the glass panes are cooled much less abruptly in the air stream. The panes are brought into a tempering range which is between that of normal flat glass and tempered glass, but tends significantly more towards that of thermally fully-tempered glass. This can be shown schematically in the following sketches:



Fully tempered



Heat strengthened

After it has been damaged BI-Hestral displays a coarse fracture pattern which is comparable to normal plate glass in its crumb size.

1.2 Properties

By means of this heat strengthening the glass is provided with higher mechanical resistance to pressure and shock than a technically-cooled glass. The temperature resistance is also much higher than normal glass. In the following comparison of some of the technical data the most important differences between plate glass (float glass), heat strengthened glass based on float glass and tempered glass according to DIN 1249 „Flat glass in civil engineering“ Parts 10 and 12 "Tempered glass“.

Comparison of glass types

	Base glass is plate glass (float glass) according to DIN 1249 Parts 1 and 10		
	Normal glass, techn. cooled	Heat strengthened glass **BI-HESTRAL** according to EN 1863	Tempered glass according to DIN 1249 Parts 10 + 12
Ultimate bending strength	45 N/mm²	70 N/mm²	120 N/mm²
Bending strength (Calculated value taking a suitable safety correction value into account)	12 N/mm²	29 N/mm²	50 N/mm²
max. permitted temperature gradient (Temperature difference over pane surfaces)	40 K	100 K	150 K
Density	2,5	2,5	2,5
Cutting capability	yes	no	no
Fracture behaviour	some radial cracks from centre of break	some radial cracks from centre of break	break with small crumb structure

For resistance to impact and pressure the following rules of thumb can be given:

Normal glass
Factor 1
BI-HESTRAL Heat strengthened glass
Factor 2

Tempered glass
(fully-tempered)
Factor 3
In very many cases double the resistance against mechanical influences is fully sufficient.
The serious difference between heat strengthened glass and fully-tempered glass is the fracture appearance in the event of breakage. Whilst - as is generally known - fully tempered glass breaks up into many small crumbs, heat strengthened glass bursts out from the impact point with radial cracks. Since the fracture lines proceed radially to the edge of the glass only a few, individual broken pieces arise, which are retained in the framework support. Heat strengthened glass should therefore be retained within an all-round frame when used in monolithic applications.

No spontaneous fractures due to nickel-sulphide inclusions

One very important advantage of heat strengthened glass is that spontaneous fractures due to nickel-sulphide crystals cannot occur. The experts will know that in the glass mixture it is not completely possible to avoid invisible inclusions of nickel sulphide due to the firing process. These invisible foreign bodies have the unfortunate property of growing over time due to thermal influences and can cause tempered glass to spontaneously fracture after an unknown period of time. In the case of non-tempered glass (normal float glass) as well as for only moderately tempered heat strengthened glass slow deformation of these foreign bodies occurs, so that fractures cannot occur. On the other hand due to the high and constant temperature changes fully tempered glass - as a result of exceeding the permitted edge tension - must fracture outwards from the nickel-sulphide crystal. It is thus possible to dispense with the heat-soak test in the case of heat strengthened glass for façade applications and still be confident that no spontaneous fractures will occur due to nickel-sulphide inclusions.

1.3 Applications of monolithic heat strengthened glass

Heat strengthened glass can be used where the normal bending strength and temperature resistance of float glass is insufficient but where fully tempered glass is not required, for example for:

- Façade panels
- Sun protection skirting
- Solar collectors

In the case of façades it is important that monolithic heat strengthened glass is only used if a frame support is provided on all four sides.

2. BI-HESTRAL-VSG - Laminated glass, made from heat strengthened glass

2.1 Properties

An optimum glass for special applications is obtained by combining BI-HESTRAL glass panes into a laminate. This results in a type of glass which can withstand the most extreme thermal and mechanical conditions e.g, in the case of vandalism.

The following advantages can be added together:

- Glass with high bending strength
- High resistance to temperature differences over the whole surface of the pane of up to 100° C. This is sufficient for all the temperature gradients which arise in civil engineering, even with the most extreme locations and also for coloured glass.

Since the flatness of the glass suffers somewhat during all thermal tempering processes, it is sensible to select the thickness of the PVB film to be at least 0,76 mm. As well as avoiding the formation of bubbles during lamination a significant increase in strength is also achieved in this way.

Due the strength of the film in the event of a fracture (through excessive load or malicious damage) the necessary residual bearing capacity is achieved. In the most frequent cases only one pane is damaged and the function and bearing capacity of the pane combination is retained. If both panes are damaged the fracture pattern of the outer and inner panes are never congruent, which has the effect that the remaining laminated glass package has a residual strength, in other words the stability and function remain intact over a period of time. The fractured pieces adher to the film and remain stable in form so that no dangerous parts splinter off or fall down.

In the case of laminated glass panes where both panes are fully tempered there would be much less stability in such a situation. If both panes were smashed thousands of small joints would occur from the crumbling process - like a patchwork quilt - the whole element becomes unstable and collapses like a sack.

2.2 Applications

2.2.1. Overhead glazing

In the case of overhead glazing in buildings in which the general public can circulate BI-HESTRAL-VSG offers the greatest protection. It has about twice the resistance than laminated glass made from normal float glass, resists temperature influences from normal climatic

conditions and largely retains its inherent stability even when smashed, which is an important criterion especially in the case of point-supported glazing.
Heat strengthened glass can also be applied with a ceramic colour coating.

The following combinations should be selected for high-quality insulation glazing according to the current status of glass technology:

External pane:
Float glass or - only for areas subject to hail and snow loads - fully tempered glass in the corresponding thickness according to the structural requirements, made from transparent or coloured float glass, possibly with reflecting glass.

Gap between panes: 10 - 16 mm

Inner pane:

Laminated safety glass made from 2 x heat strengthened glass and polyvinylbutyral film (PVB), possibly with a precious metal coating for thermal and sun protection.

2.2.2. Partition walls and balustrade glazing

Additional applications are partition walls, balustrade glazing on free-standing steps etc. Heat strengthened laminated glass offers optimum reliability with respect to the loads which arise here. In the case of fully free-standing balustrade structures without a stable handrail this pane combination must be used since all other glass solutions involve a significant risk.

2.2.3 Other applications

- Glazing of viewing terraces from floor to ceiling
- Glazing of enclosures for beasts of prey or large aquaria
- Windows to terraces with risk of falling
- Window-glazing on high-speed vehicles
- Aircraft windows
- Glazed railings at locations where the general public is circulating
- Large surface-area lift glazing, without frames where appropriate.