

Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 48 (1985)

Artikel: Windows and curtain walls in "high insulation technology"
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DOI: <https://doi.org/10.5169/seals-37455>

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Windows and Curtain Walls in «High Insulation Technology»

Fenêtres et façades rideau en «Haute Isolation Thermique»

«Hochisolationstechnologie» für Fenster und Fassaden

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SUMMARY

The main features of the «High Insulation Technology» (HIT) are presented. The extremely low values of the coefficient of heat transfer for windows completely change the comfort conditions as well as the energy management: high comfort with no heating and a very economic ventilation. Results of measurements in occupied rooms and some applications in buildings presently under construction are presented.

RÉSUMÉ

Les principes de la «Haute Isolation Thermique» pour fenêtres et façades sont présentés. Les valeurs très faibles du coefficient de transmission thermique pour les fenêtres influencent beaucoup le confort et le budget énergétique d'un bâtiment: haut confort sans aucun chauffage et avec une ventilation très économique. Des mesures dans des locaux occupés et des applications pratiques dans des bâtiments en construction sont présentées.

ZUSAMMENFASSUNG

Die Prinzipien der «Hochisolationstechnologie» (HIT) für Fenster und Fassaden werden vorgestellt. Die extrem tiefen Werte der Wärmedurchgangskoeffizienten für Fenster haben weitreichende Konsequenzen sowohl für den Komfort als auch für den Energiebedarf und die Haustechnik: hoher Komfort ohne Heizung und mit einer sehr ökonomischen Lüftung. Messungen in genutzten Räumen sowie konstruktive Anwendungen an im Bau befindlichen Gebäuden werden diskutiert.



1. "HIGH INSULATION TECHNOLOGY"(HIT)

In a joint development effort since 1978, the two companies Geilinger Ltd, Metal Works Division and Sulzer Bros Ltd, Heating and Air Conditioning Division have developed a new window technology. The work started from the following facts:

- the window area and its quality determine the maximum loads both for heating and for cooling except for the internal loads: the power amplitude,
- the low surface temperatures of common glazings require local comfort compensations to avoid draught, thus fixing the positions of the HVAC-installations
- the attainable range of humidity is restricted by the thermal bridges in common windows leading to condensation (1)

The aim was therefore,

- to eliminate all thermal bridges,
- to improve the U-value of the glazing to values much below $1 \text{ W/m}^2\text{K}$
- to improve the U-value of the frame to a level adequate to that of the glazing,
- to make a wide range of shading coefficients available.

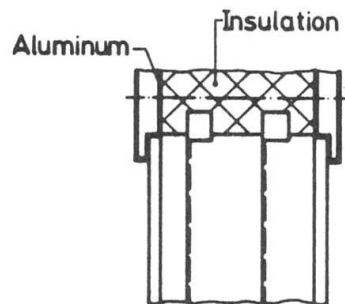
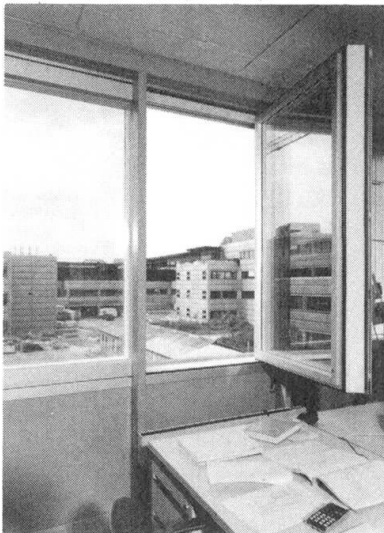


Fig 1 Schematic cross-section through HIT-window: frame (above), glazing (below)

Fig 2 View through HIT-window at Federal Institute of Technology, Lausanne (left)

The result is (figure 1 and 2):

- a glazing with U-values between 0.5 and $0.7 \text{ W/m}^2\text{K}$, shading coefficients from $.2$ to $.56$ and luminous transmittances from 0.3 to 0.63 ,
- a frame with a U-value of $1 \text{ W/m}^2\text{K}$
- the absence of all thermal bridges (figure 3)
- a window with a sound transmission of 44 to 45 dBA .

The glazing has a thickness of 100 mm and consists of two glass panes separated by an air gap of 90 mm . The air gap is divided by two suspended polyester films, which have a heat mirror coating. By variation of the type of coating (3 types) and including coated or tinted glass, a very wide range of shading coefficients can be attained.

The frame consists of aluminium parts separated by a thick (80 mm) insulating zone. The frame acts itself as sealing for the glazing and forms thus an

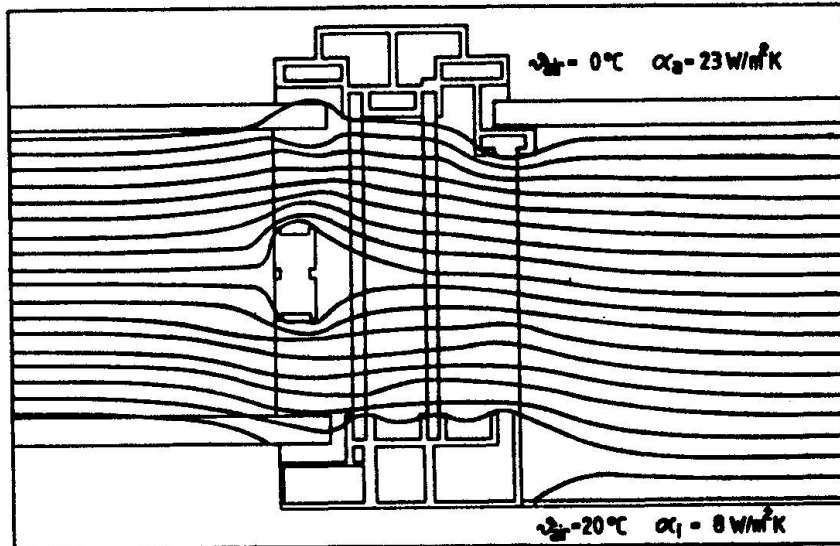


Fig 3 Temperature-distribution in HIT-frame and -glazing. Isotherms $\Delta T = 1^\circ\text{C}$. Left: glazing, middle: frame, right: curtain wall

integrated window unit without a separate sealing. The large air gap is vented to the outside to avoid pressure differences. This is done through a replaceable filter, yielding a high robustness and repairability.

Such windows have been tested at the test house LESO of the Swiss Federal Institute of Technology at Lausanne (2) for more than two years and even on the Jungfrauoch at 3500 m above sea level under the guidance of the Swiss Federal Institute for Material Testing with best results:

U-value measured: $0.68 \pm 0.06 \text{ W/m}^2\text{K}$ calculated: $0.65 \text{ W/m}^2\text{K}$

Loss factor of 22 m² facade with 9m² of glazing:

HIT : measured $14.9 \pm 2.5 \text{ W/K}$ calc: 13.7 W/K

Reference triple glazing: measured $36.6 \pm 6.0 \text{ W/K}$ calc: 35.4 W/K

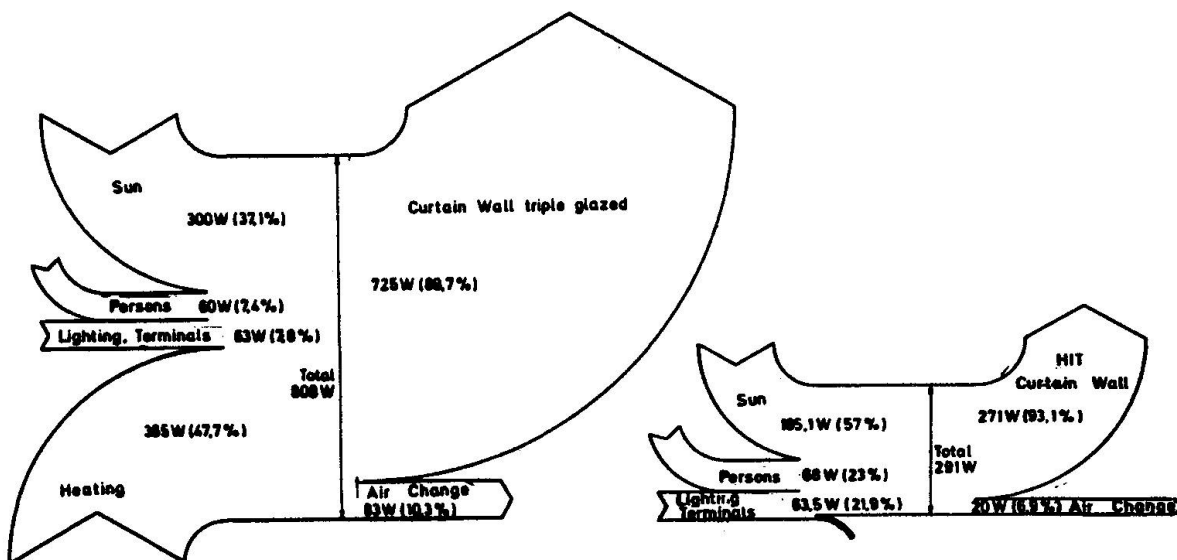


Fig 4 Mean power flux through curtain wall with triple glazing (left) and with HIT-window (right). Time: One week, $T_{ext} = 1.6^\circ\text{C}$, $I_s = 98 \text{ W/m}^2$



Figure 4 shows the measured energy flux diagram of the HIT and of the reference room for a representative mean winter week:

$$T_{ext} = 1.6^{\circ}\text{C} \text{ and } T_s = 98.5 \text{ W/m}^2.$$

There are three striking features:

- the total turnover of energy is very much reduced: 291 W compared to 808 W,
- the solar gain and the internal sources cover all losses: transmission and air leakage for HIT but by far not for the reference room,
- although the solar gain for HIT is in absolute values much smaller (165 W compared to 300 W) the relative portion is much bigger (57% compared to 37%) because of the very much reduced losses.

2. COMFORT

Figure 5 shows measured surface and air temperatures near the window without any heating. As expected, the surface temperature of the glazing remains for HIT very near to the mean air temperature even for low external air temperatures: $T_{ext} = -10^{\circ}\text{C}$, $\Delta T = 3^{\circ}\text{C}$. Discomfort due to asymmetric radiation loss is therefore eliminated independent of the size of the window and the distance to it.

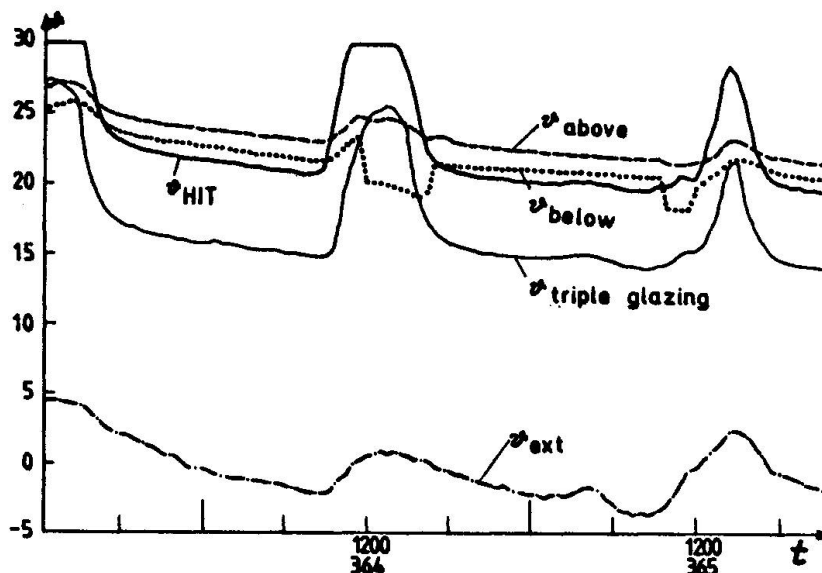


Fig 5 Surface temperatures on HIT- and triple glazing without heating, air temperatures above and below the window.

Extensive measurements of the flow pattern in the room and near the window surface have been made with low velocity anemometers(3).

In table 1, we present some measured values for HIT, triple and double insulating glazings and computed values for extreme conditions: $T_{ext} = -10^{\circ}\text{C}$, window height $h = 2\text{m}$.

In fact, the people working in the HIT rooms did not feel any discomfort even with no heaters below the window.

We have therefore put the heater in the worst position on the rear side of the rooms. But even then, no discomfort was felt. We thus conclude, that cold air draught is sufficiently reduced as to free the HVAC-equipment from local fixations.

Table 1. Measured and computed air velocities in boundary layer.

Glazing:		Measured for $\vartheta_i = 21^\circ\text{C}$ $\vartheta_{ext} = -2^\circ\text{C}$, $h = 1.6\text{m}$	Computed for $\vartheta_i = 20^\circ\text{C}$ $\vartheta_{ext} = -10^\circ\text{C}$, $h = 2\text{m}(4)$
HIT	$v = 12\text{ cm/s}$	$\Delta\vartheta = 2.4^\circ\text{C}$	$v_{max} = 24\text{ cm/s}$ $\Delta\vartheta = 3^\circ\text{C}$
Triple	$v = 16\text{ cm/s}$	$\Delta\vartheta = 5.5^\circ\text{C}$	$v_{max} = 40\text{ cm/s}$ $\Delta\vartheta = 8^\circ\text{C}$
Double	$v = 19\text{ cm/s}$	$\Delta\vartheta = 7.^\circ\text{C}$	$v_{max} = 48\text{ cm/s}$ $\Delta\vartheta = 11^\circ\text{C}$

3. CONSEQUENCES FOR THE HVAC-EQUIPMENT

During operating time, the internal sources: men, terminals, lighting and/or solar irradiation compensate for all transmission losses of HIT-equipped rooms even at design temperatures.

The measured time constant τ of such rooms:

$$\Delta\vartheta(t) = \Delta\vartheta(0) \cdot e^{-t/\tau}$$

τ : Time constant = C / L

C : Thermal storage capacity [MJ/K] L : Loss Factor [W/K]

turns out to be very big because of the small loss factor (measured at LESO: 23 days, calculated: 20 days(3)). Therefore the cooling process over night or week end is so slow, that no heating is required during the night: $\Delta\vartheta = 1^\circ\text{C}$ and even mostly not for the week end. Switching on the lights on monday morning suffices for an agreeable indoor climate.

For winter one has therefore no more need for heating, feeding fresh air at ambient temperature 20 to 22 C is sufficient.

In summer, the shading coefficient reduces the solar load and this can be further improved by external shades. In addition, the low U-value protects from the hot external air and the internal surface temperature is kept well below that of conventional sun protection glazings. The peak cooling power is therefore much reduced and mainly determined by the internal loads. Depending on climate and comfort requirements one may even eliminate active cooling and only work with free and night cooling.

The only remaining power need is therefore mainly that for preparing the fresh air. This fresh air is at least in winter freed from energy transportation (5). The only task is the maintaining of hygienic conditions. To reach that goal with the smallest possible amount of fresh air, a new ventilation method by stratification and displacement (6) has been developed together with the Norwegian Institute of Technology. This method allows to work with very low air change rates. It works best together with a building shell that produces only very small temperature differences as it is done by HIT-elements. Some preliminary measurements at the Norwegian Institute of Technology for HIT-conditions yielded very promising results. A complete report will be published later.



4. BUILDINGS IN "HIGH INSULATION TECHNOLOGY"(HIT)

A first building is now finished at Geneva, the "Tour Balexert". It has about 32'000 m³ volume and very large windows from the ceiling to the floor. There is no more heating near the window (Figure 6). The rooms are only supplied with fresh air at ambient temperature without any heating. Because of the lack of external shades, a somewhat higher air change rate has to be applied for cooling reasons, thus not exploiting the full potential of HIT. A further office building is under construction at Winterthur, where the above mentioned new ventilation technology is applied in some rooms for real-life test purposes.



Fig 6 Building "Tour Balexert" at Geneva. All windows and curtain wall in "High Insulation Technology". No heating, only ventilation at 20-22°C.

A wide variety of designs are now available: from curtain walls with or without casements (figure 7 and 8) to windows to be put into brick-block walls where the insulation zone is continued through the well insulating HIT-window (figure 9)

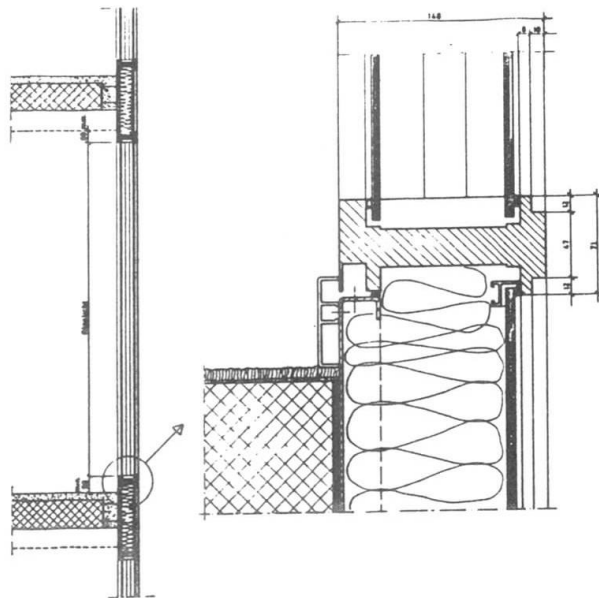


Fig 7 Example of a curtain wall with large HIT-windows.

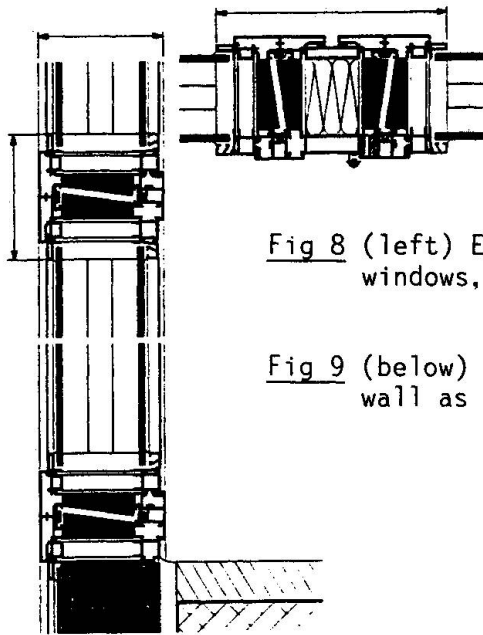
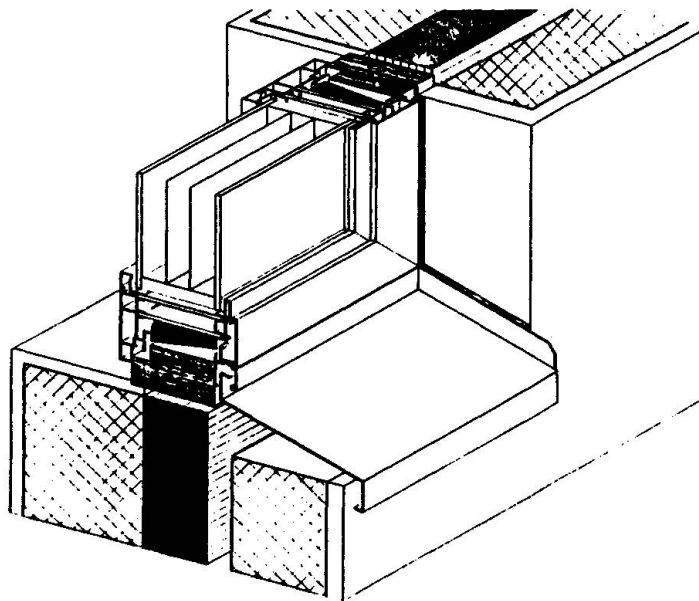


Fig 8 (left) Example for curtain wall with HIT-windows, casements.

Fig 9 (below) Example of HIT-window in brick-block wall as continuation of insulating zone.



5. CONCLUSIONS

The HIT-windows permit a HVAC-equipment focusing on the hygienic instead of the thermal requirements. Heating becomes unnecessary and cooling power is much reduced, sometimes even avoidable.

For the future, the "High Insulation Technology"(HIT) together with the ventilation by stratification and displacement promises a real step forward to a better comfort in winter as well as in summer with small air changes between



0.5 and 3 h⁻¹ (cooling). Some buildings of that type are now under construction.

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