Course on Classification and Certification of Yacht

Lloyd's Register Rules and Regulations for the Classification of Special Service Craft

"GLASSES"

Simone Parizzi

Surveyor

Viareggio Office

THE RAW MATERIAL TO PRODUCE GLASS

The base material to obtain glass is the silica SiO_2. This material is present in nature under many forms in particular silicate, otherwise is extremely difficult extract it because combined with other elements. The only forms easily suitable to be overworked are the quartz and some varieties of sand which arrive to have to be constituted until 98% of quartz.

Due to the very strong chemical links it is extremely difficult to smelt the silica alone because the temperature required are close to 1700° C. To overcome this problem especially in the past when there are no refractory materials able to survive to this temperature some other elements were added to reduce the melting point. These elements are Na, Ca, Mg, K, Pb.

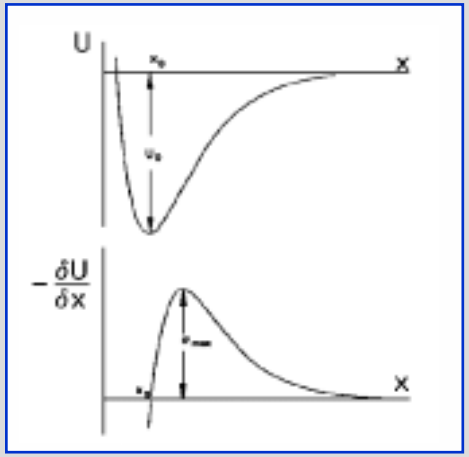
SiO_2 (Silica) + Na_2CO_3 (Soda or Natron) + CaO (Calce)

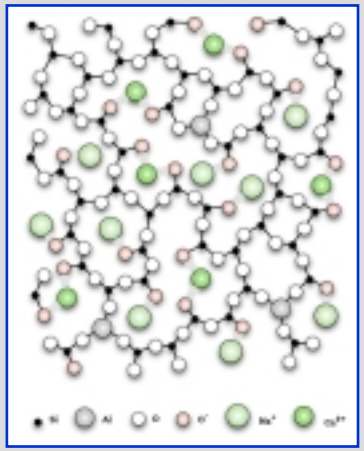
SiO_2 (Silica) + K_2CO_3 (Potassa) + CaO (Calce)

THEORETICHAL STRENGHT OF GLASS

The intrinsecally glass strenght is extreemely hight reaching values of 5 – 10 GPa.

In aboslute vacuum a pristine glass (=no inperfections) obtained by quartz (SiO_2) reaches a strenght of 14 000 MPa. This value is value is very close to the theoretical glass strenght which depend on the potential of atomic bonding.



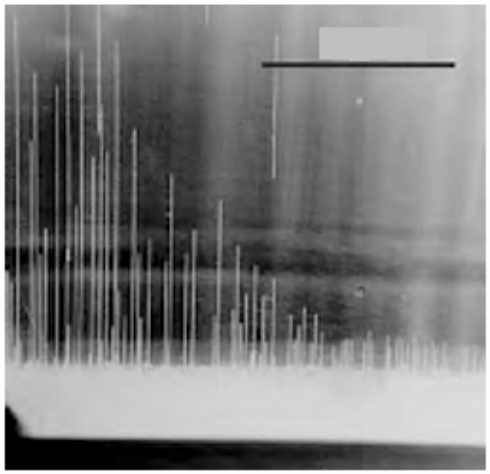


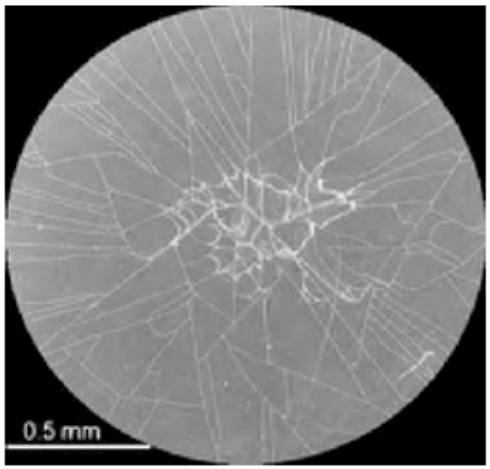
Despite the high theoretical strength, float glass actual strength currently manufactured is about 40 Mpa.

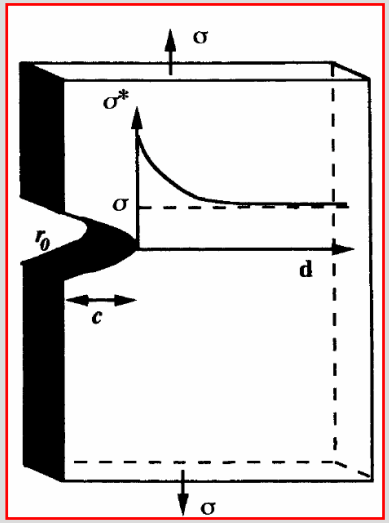
Reason: micro-cracks are located at the surface of glass producing stress concentration at the corner.

Glass Strengt ←→ cracks extension & radii

SAMPLE OF MICRO CRACK AND GRIFFITH THEORY







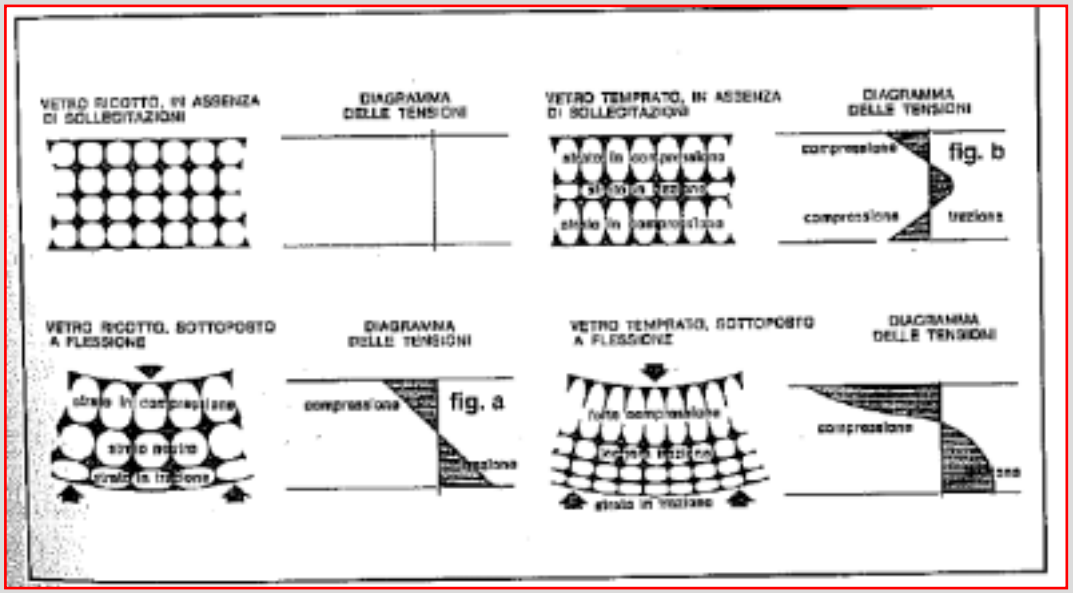
$$\sigma^{*}_{d=0} = \sigma \cdot 2 \cdot \sqrt{\frac{c}{r_0}}$$

TYPE OF GLASSES FOR INDUSTRIAL AND MARINE APPLICATION

- **Glass Pane (Cristallo):** flat piece of glass, edge worked, to size and shape ready glazing. May be monolithic or laminated (2 or more glass panes bonded), or made of other material.

- **Safety Glass**: Glass which, if fractured, gives fragments which are less liabel to cause severe cuts than fragments of ordinary glass.

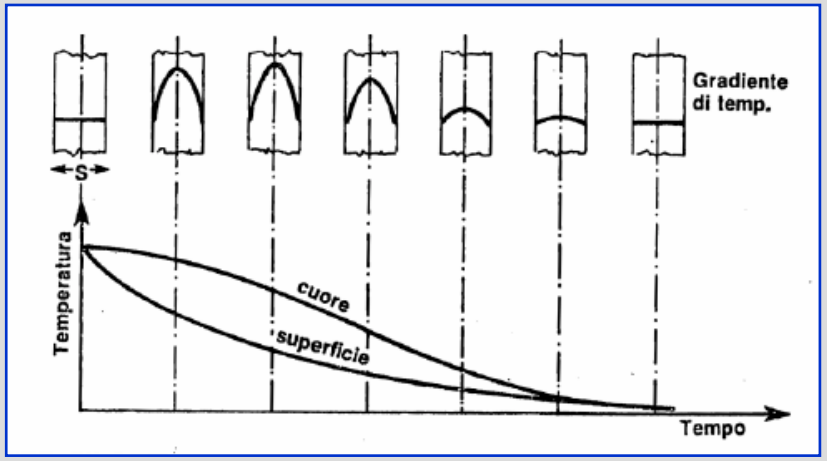
- **Toughened Safety Glass:** Glass which has been converted to safety glass by subjection to a process of heating and rapid cooling, so that if fractured, it disintegrates in small pieces and, in addition, increase its strength properties.
- **TSG is the glass generally required by the Rules and International Standards**

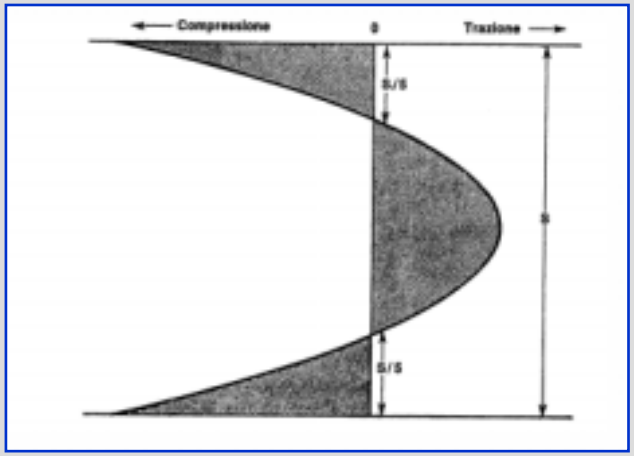


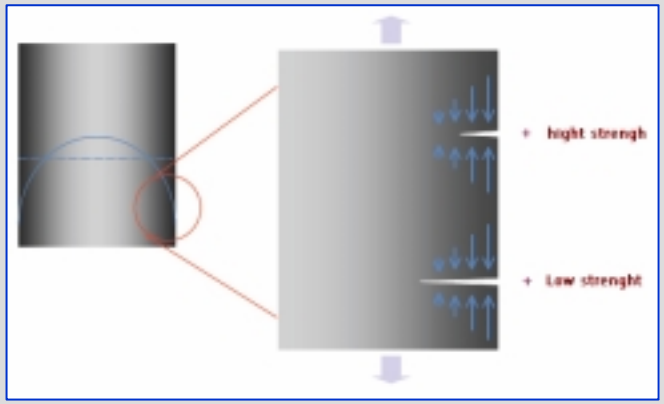
Thermal toughening

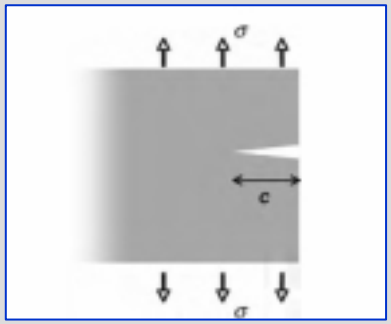
(industrially applied after 1930)

Rapid cooling of glass pane from a temperature > T_g









Different cooling rate between the outer surface and core produces a state of compression on the surfaces and tension in the core.

The state of compression on the surface acts in way to close the craks.

Toughened Safety Glass

With the production of stress field elastic energy is stowed in the material. When the glass is broken the energy is released, for this reason thermally toughned glass breaks in small non sharp pieces therefore they are **safety glasses.**

Other types of glasses breaks in big sharp fragments ➔ to be of safety type they are to be **laminated**.

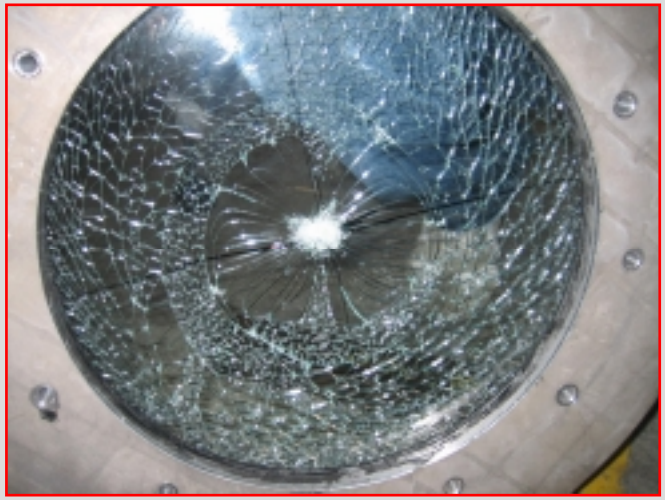
Require a minimum thickness to be treated of 4 mm

Strenght increases from 40 N/mm^2 to about 250 N/mm^2

Toughened Safety Glass

Thermally toughend glasses can not be cut (in conventional way), therefore production process is the following:

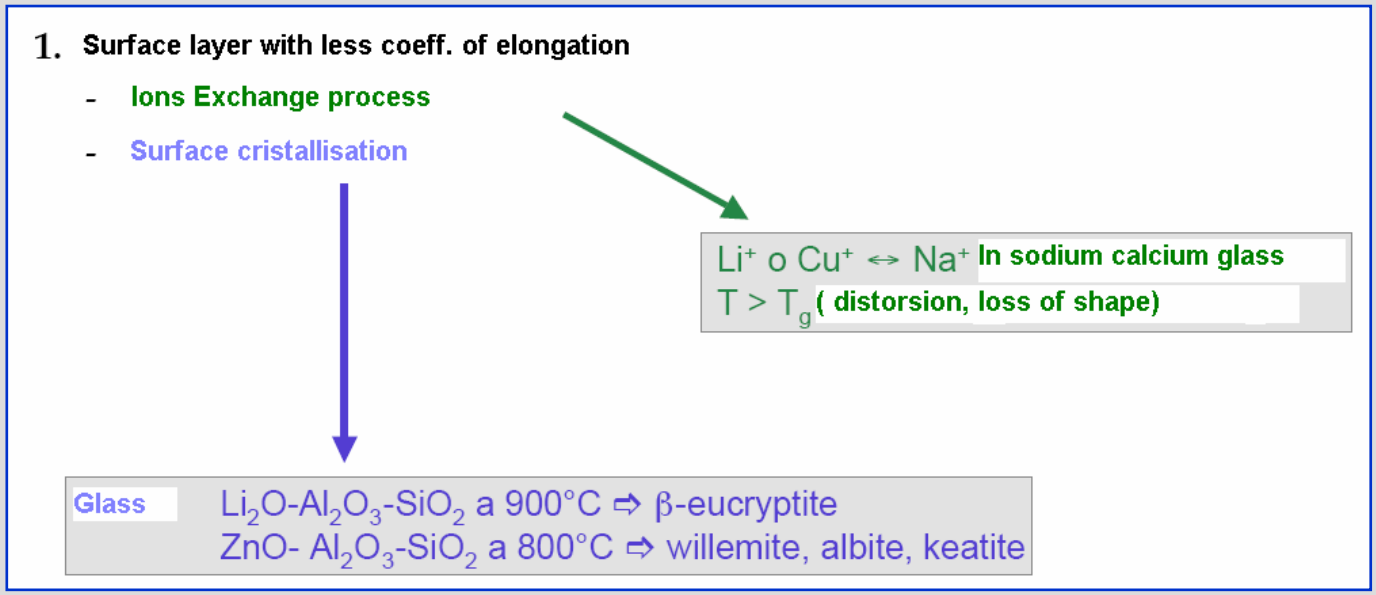
CUT → GRINDING → STAMP → THERMAL TREAT → TESTING



CHEMICAL STRENGTHENING PROCESS

It is a process of **diffusion** (thermally actived) that increases glass strenght <u>replacing some of the alkaline ions on the glass surface with other ions of greater size.</u>

<u>First method</u>: (Schottky process) a surface layer with a lesser α : a surface layer is created with a smaller coefficiend of eleongation α . This is obtained by ions excange at temprerature > Tg. (not used due to distorsion and surface cristallisation)

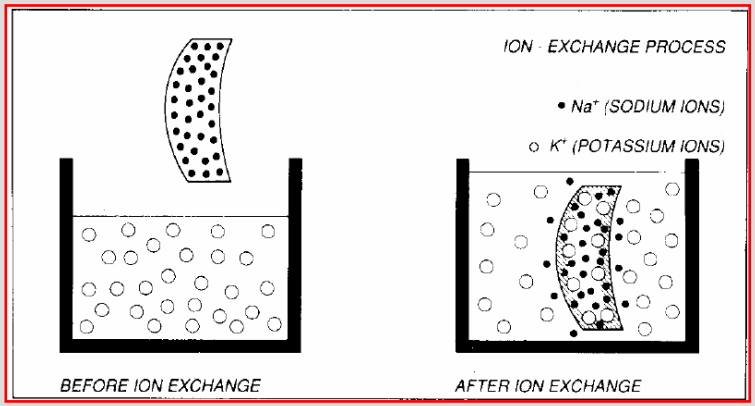


CHEMICAL STRENGTHENING PROCESS

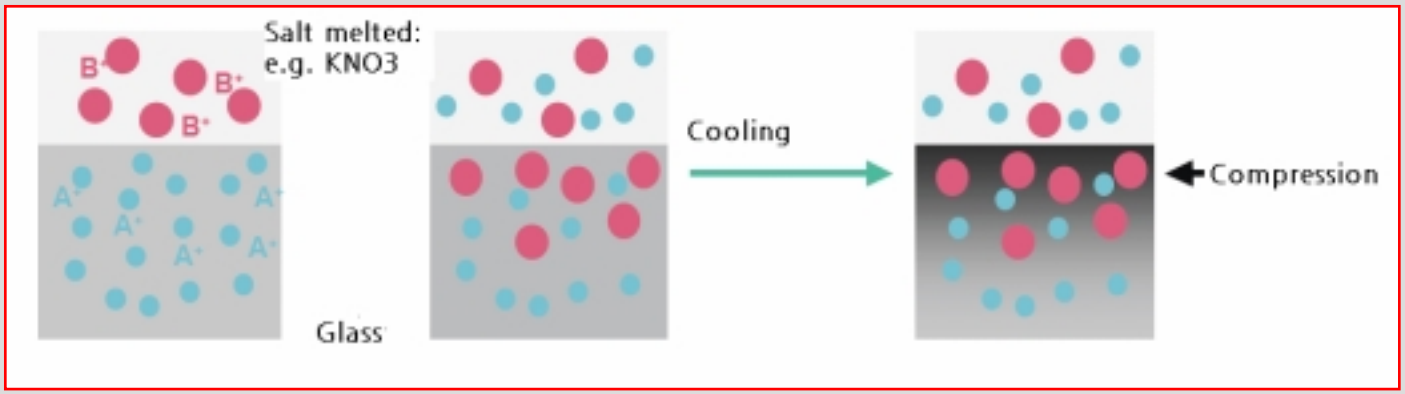
Second methond: surface strenghtening by ions exchange *(glass ceramics)* at temprature < Tg: Glasses in **annealed** condition are **immersed** in a potassium salt melted.

Parameters:

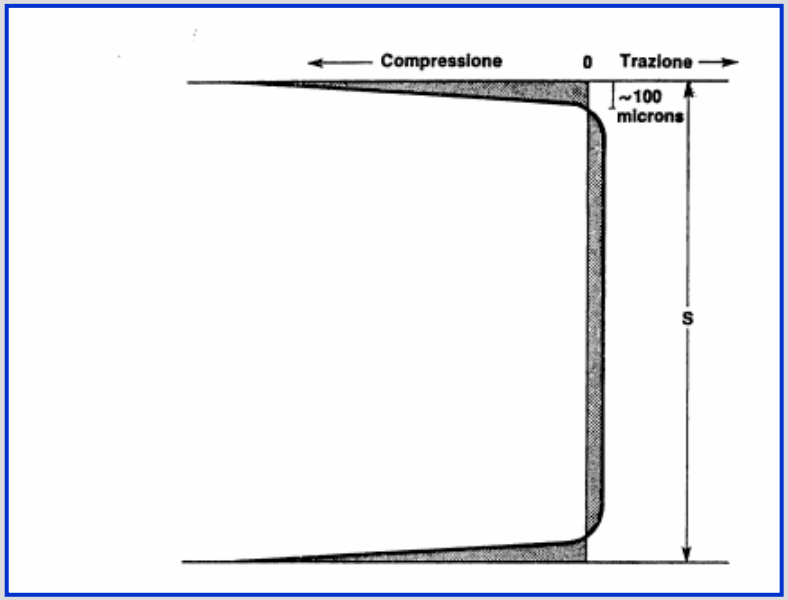
- **Temperature**
- **Time**
- **Concentration**

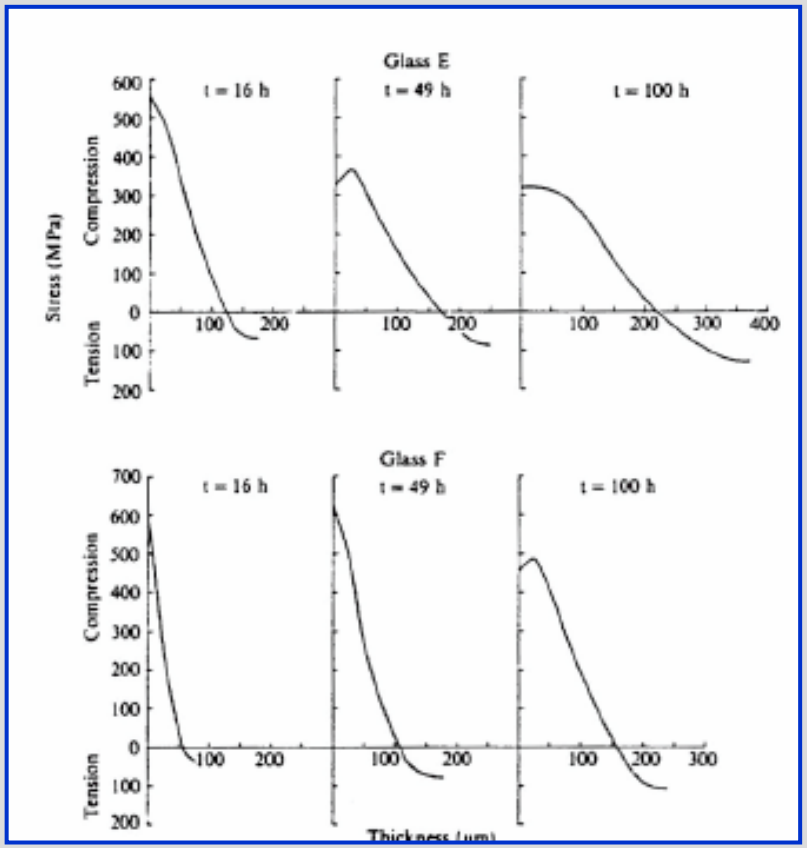


$$\overline{A}_{glass} + B_{salt} = \overline{B}_{glass} + A_{salt}$$



CHEMICAL STRENGTHENING GLASSES





More is the time and / or greater is the concentration of KNO_3 deeper is the penetration

More time ➔ less surface compression

Stress induced in the surface is much more higher that the termal treatment but the penetration is generally maximum 50 μm

A COMPARISON BETWEEN PROPRIERTIES OF DIFFERENT TYPES OF GLASSES

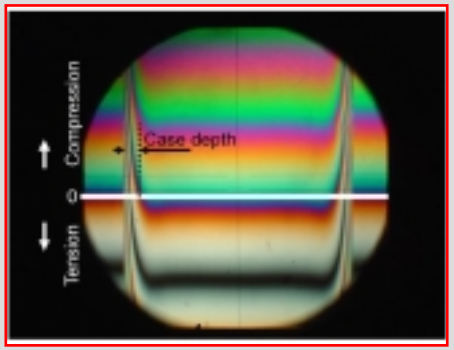
Tipo di Vetro	Ricotto	Indurito	Temprato termico	Temprato chimico
Spessore (mm)	da 2.3 a 19	da 2.3 a 8	da 3.2 a 19	da 0.7 a 19
Compressione superficiale [N/mq]	0	30/70	30/70	300/400
Spessore zona compressa	0	20% spessore del vetro	20% spessore del vetro	Fino a 100/120 micron
Resistenza alla flessione [N/mq]	30/40	50/100	120/200	250/600
Resistenza [°C]	30	40/100	110/180	Over 200
Frammentazione	Pezzi grandi taglienti	Pezi medi in Parte taglienti	Pezzi piccoli Non taglienti *	Pezzi grandi taglienti

Chemichally treated glass

1. Very high bending breaking strenght (300 – 600 N/mm^2) for applications where high performances are required.
2. Thin layers (min. 0.5 mm) can be treated.
3. The glass can have the most strange shape with hight curvature.
4. Easy to couple with PVB.
5. Impact strenght higher than thermal glasses.
6. Hight optical performances: no or very low ditorsions also curved shape.
7. No deformation or distorion.

BASIC PARAMETERS TO EVALAUTE THE QUALITY OF CHEMICHAL TREATMENT

- CD = depth of chemichal treatment process (mm) to be > 30 mm
- Sc = surface compression N/mm^2
- **σ c** = characteristic breaking strenght N/mm^2



The Glass ply Manufacturer must declare the above data and is responsible to guarantee the conformity of the production to the declared values.

Sc: compression on the surface may measured with double refraction methods and fotoelasticity, stress profiling or DSR.

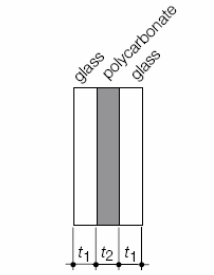
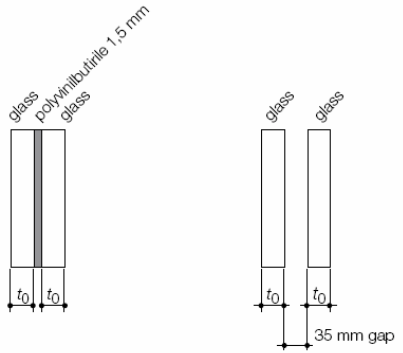
σ c: is derived on the basis of breacking full scale tests or four point bending stress (EN 1288-3) ***the two methods gives different results !!!*** Due to boundary effects.

CD = polarizing microscopy or stress profiling (also based on calibrated weight gain)

TYPES OF GLUE AND INTERLAYER

Polivinil-butirrale PVB
SGP Sentry Glass Pluss®
PC Policarbonate

Table 2.6.1 Acceptable arrangements of glazing in lieu of portable storm covers/deadlights

In lieu of portable storm covers	In lieu of deadlights or storm covers
 $t_1^2 + (0{,}77t_2)^2 + t_1^2 = (1{,}2t_0)^2$	
Symbols	
t_0 = minimum thickness of toughened glass as calculated in Pt 3, Ch 4,7.8.1.	