

Physical and Mechanical Properties of Typical Soda Lime Float Glass

Glass is a brittle material. It will act elastically until it fractures at ultimate load. That ultimate load will vary, depending upon the type and duration of the loads applied and the distribution, orientation and severity of the in homogeneties and micro-flaws that exist in the surface of the glass. Because of this nature, glass cannot be engineered in the same way as other building envelope materials that have a predictable, specific strength. In those cases, factors can be (and are) assigned to help assure that breakage does not occur at the selected design load.

Because the ultimate strength of glass does vary, its strength can best be described statistically. Architects and engineers who wish to specify a design factor for glass in buildings must choose the anticipated wind load, its duration and the probability of glass breakage (defined as x per 1000 lites of glass at the initial occurrence of the design load). The International Building Code (IBC) currently used in the United States references ASTM E1300, which commonly uses a conservative factor of 8 per 1000 for vertical glazing.

Glass manufacturers can provide the appropriate data for determining the expected performance of their products. However, it remains the responsibility of the design professional to review these performance criteria and determine if they are suitable for the intended application. The following is a summary of the average physical and mechanical properties of soda lime float glass produced in North America.

- Modulus of Elasticity (E) is the mathematical description of an object or substance's tendency to be de- formed elastically (i.e., non-permanently) when a force is applied to it. The elastic modulus of an object is defined as the slope of its stress-strain curve in the elastic deformation region.

Modulus of Elasticity for glass is $\sim 10.4 \times 10^6$ psi (71.7 GPa)

- Modulus of Rigidity (Shear) (G) is defined as the ratio of shear stress to the shear strain.

$\sim 4.3 \times 10^6$ psi (29.6 GPa)

- Poisson's Ratio (ν) is the ratio, when a sample object is stretched, of the contraction (perpendicular to the applied load), to the extension (in the direction of the applied load).

~ 0.22

- Coefficient of Linear Thermal Expansion (α) defines the change in the length of an object with a change in temperature. Specifically, it measures the fractional change in volume per degree change in temperature at a constant pressure.

$\sim 4.6 \times 10^{-6}$ strain per °F (8.3×10^{-6} strain per °C)

- Density (ρ) of a material is defined as its mass per unit volume
 $\sim 156 \text{ lb/ft}^3$ (2500 kg/m^3)
- Modulus of Rupture (MOR) (Flexure)^a is defined as a material's ability to resist deformation under load.

Glass Type	(mean)	(design: 8 in 1000) ^b
Annealed Glass	6,000 psi (41 MPa)	2,800 psi (19 MPa)
Heath Strengthened Glass	12,000 psi (83 MPa)	5,600 psi (39 MPa)
Fully Tempered Glass	24,000 psi (166 MPa)	11,200 psi (77 MPa)
note a - These are approximate values for short load durations (under 1 minute) for undamaged glass in four-sided support.		
note b - Probability of breakage - note that these values are for the surface of the glass (not the edge) and do not take into consideration area effects.		

- Hardness characterizes the scratch resistance of various minerals through the ability of a harder material to scratch a softer material

Knoop's Scale $\sim 470 - 605 \text{ kg/mm}^2$

- Specific heat capacity (C) a measurable physical quantity that characterizes the amount of heat that is required to change an object's temperature by a given amount.

$\sim 0.20 - 0.21 \text{ Btu/(lb x } ^\circ\text{F)}$ or $\sim 0.84 - 0.88 \text{ J/(kg x K)}$

- Thermal conductivity (k) is the rate at which heat flows through a material between points at different temperatures, measured in watts per meter per degree.

$\sim 0.52 - 0.57 \text{ Btu/(hr x ft x } ^\circ\text{F)}$ or $\sim 0.9 - 1.0 \text{ W m}^{-1} \text{ K}^{-1}$

- Mean Refractive Index describes the quantity that light is bent as it passes through a single substance at Sodium D Line: 1.5

- Chemical Composition:

Silicon dioxide (SiO ₂)	69 - 74%
Calcium oxide (CaO)	5 - 12%
Sodium oxide (Na ₂ O)	12 - 16%
Magnesium oxide (MgO)	0 - 6%
Aluminum oxide (Al ₂ O ₃)	0 - 3%

- Softening point - 1319 - 1345 °F (715 - 729 °C)
- Annealing point - 1011 - 1018 °F (544 - 548 °C)
- Strain point - 939 - 952 °F (504 - 511 °C)

- Hemispherical Emissivity at room temperature - ~ 0.84
- Reflection 4% from each surface
- Visible light absorption 1 - 2% for 1/8" (3 mm) glass
- Far infrared (~10 μm) transmission - 0
- Chemical Resistance - Excellent resistance to acids, other than HF. Poor resistance to alkalis.
- Electrical Resistivity - High

Design professionals should consult the *NGA with GANA Glazing Manual* and *Guide to Architectural Glass* for additional information on glass design and engineering, fabrication considerations, and application and glazing guidelines.

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