

Purpose: This document details Cardinal's standard requirements for low iron glass to be supplied for use in solar modules.

Referenced Documents: ASTM 1036-06, ASTM C-1048, SAE J673

FLOAT

Characteristic	Specification	Tolerance
SiO ₂	72.7%	± 0.25
Al ₂ O ₃	0.6%	± 0.2
Fe ₂ O ₃	0.014%	± 0.005
CaO	8.75%	± 0.2
MgO	3.8%	± 0.2
Na ₂ O	13.8%	± 0.2
K ₂ O	0.16%	± 0.08
SO ₃	0.35%	± 0.15
TiO ₂	0.01%	± 0.01
Poisson's Ratio	0.24	
Modulus of Elasticity (Young's)	72.7 GPa / 10,550,000 psi	
Tensile Strength (Modulus of Rupture)	42.1 MPa / 6,100 psi	
Density at 21°C	2.499 g/cm ³	
Hardness	Moh's: 6 / Knoop: 475	
Expansion Coefficient 20-300°C	8.6*10 ⁻⁶ /°C	
Specific Heat at 25°C	0.167 cal/g°C	
Thermal Conductivity at 25°C	31.0 W/m ² -°C	
Softening Point	721°C	
Annealing Point	543°C	
Strain Point	500°C	
Refractive Index	1.516 - 1.520	
% Te 300-2500nm	at 3.2-3.9mm	≥ 90.3%
% Tl 380-780nm	at 3.2mm	≥ 90.0%
Surface Resistivity	10 ⁻⁶ to 10 ⁻⁸ Ω/□	
Dielectric Constant at 1MHz	5.7	
Tin Orientation	Tin side packed out	

GRINDING/TEMPERING

Characteristic	Specification / Description	Tolerance	Evaluation Method
Standard Width	Customer Requirement SPC Control Limits	± 1mm	Online measurement system, 60" caliper
Standard Length	Customer Requirement SPC Control Limits	± 1mm	Online measurement system, 60" caliper
Diagonal Difference	Target = 0mm SPC Control Limits	< 2mm	Online measurement system, 60" caliper
Dub Size	Target = 2.00mm SPC Control Limits	± 1mm	Online measurement system, optical loop
Thickness	Target = 3.175mm SPC Control Limits	± .1mm	Micrometer
Edge Quality	#2 Edge per SAE J673 Section 6.2		Visual and mirror
Temper	ASTM Standard	10,000 psi Minimum	GASP
Bow/Edge Kink	0-2mm Holding No Shedding allowed		Feeler gage on granite table
Distortion	± 200 mdpt		Online measurement system
Shell Chip	A circular indentation in the glass edge due to breakage of a small fragment	5mm x 5mm Maximum, no more than 3 per lite	100% human inspection
Corner Chip	A fragment out of an otherwise regular surface on the corner	< 3mm	100% human inspection
Edge Chip	A fragment out of an otherwise regular surface on the glass edge	< 1mm and NONE that show in the glass face	100% human inspection
V-Chip	A V-shaped chip indentation in the glass edge due to breakage of a small fragment	None	100% human inspection
Scratch	Damage on the glass surface in the form of a line caused by the relative movement of an object across and in contact with the glass surface / ASTM C1036-06 Q3	< 3"	100% human inspection / camera based inspection as guide
Shiner	A shiny strip along the edge of the lite that was missed during the grinding process	Per SAE J673 Section 6.2	100% human inspection
Seed or Point Blemish	An in-homogeneity in the form of a vitreous lump, knot, stone, dig, or air bubble	< 1mm	100% human inspection
Line Defects	Line defects (reams, roller marks, rubs) visible in frame plate	< 3" and light in appearance	100% human inspection / camera based inspection as guide

GRINDING / TEMPERING

Characteristic	Specification / Description		Tolerance	Evaluation Method
Particulates	Solid deposits on the glass surface that can be removed with non-contact methods such as high pressure air or water. Examples include paper, cardboard, or other packaging materials.		Permitted ONLY if removable via standard wash	100% human inspection / camera based inspection as guide
Surface Residue	Contaminants that can be removed by mechanical washing with or without water chemistry. Examples include smudges, fingerprints and streaks.		Permitted ONLY if removable via standard wash	
Tin Deposit	A small particle of metallic tin or oxide adhered to the surface of the glass		None	
Separator	Interleaver	150-300 mg/m ² UME		Scale
	Paper pack	Per customer		Visual
Tin Orientation	Tin side down online. Tin side packed out.			Online UV light
Packing of Lites	C60	2 vertical stacks per rack/ 400 lites total		Visual
	EC	1 horizontal stack per rack/ 270 lites total		
Glass Centering on Rack	Centered		± 1"	Tape measure
Labels	Two shipping labels per rack 2D barcode is standard			Visual
Certificate of Analysis	Cpk data of key characteristics			Cpk file generated through Infinity
Rack Return	C60	7 high (banded), 9 stacks = 63 racks per 53' trailer	Minimum	
	EC	400 per 53' trailer		

1. Process Capability
 - Values for **key material characteristics** will be identified and agreed upon between the customer and appropriate Cardinal personnel.
2. Product Traceability
 - Cardinal will maintain adequate batch traceability documentation for material utilized throughout the manufacturing process.
3. Packaging
 - Glass will be packaged with interleaver or paper pack, and securely packed in such a way to prevent scratches, damage, breakage, or any other condition that would prevent its use.
4. Labeling
 - Each rack will be labeled with the following information:
 - Part number
 - Quantity per rack
 - Manufacturing plant location
 - Date and Time of production
5. Revision Record
 - Any new revisions of this document will be listed on the revision table below and communicated to suppliers, manufacturing plants, and management and /or customer representatives relevant to this material specification **via email**. Current revision levels will also be reflected on the most recent Purchase Order following the revision change effective date.

Revision Table

Revision	Description of Change	Revision Date	Effective Date	Author