Photopic HEA®
Product Specification #6102009

1.0 Description

This specification defines the product requirements for MAC Thin Films Inc. HEA® (High Efficiency Anti-reflection) coating.

2.0 Reference Documents

The following documents form a part of this specification to the extent specified herein:

MIL-C-675C	Coating of Glass Optical Elements (Antireflection)
MIL-C-14806A	Coating, Reflection Reducing for Instrument Cover Glasses and Lighting Wedges.

3.0 Performance & Operating Characteristics

3.1 Photopic Brightness

The Photopic Brightness, when measured at 10 degrees angle of incidence shall be ≤ 0.2%

Brightness (reflected luminance) is a term used for the value of average reflectance weighted by the human eye response and is a measure of the level of sensation a person perceives because of reflection of light from an object.

Brightness is calculated as follows:

$$\text{Brightness} = \frac{\Sigma\,(S\,(\lambda)\,V\,(\lambda)\,R\,(\lambda))}{\Sigma\,(S\,(\lambda)\,V\,(\lambda))}$$

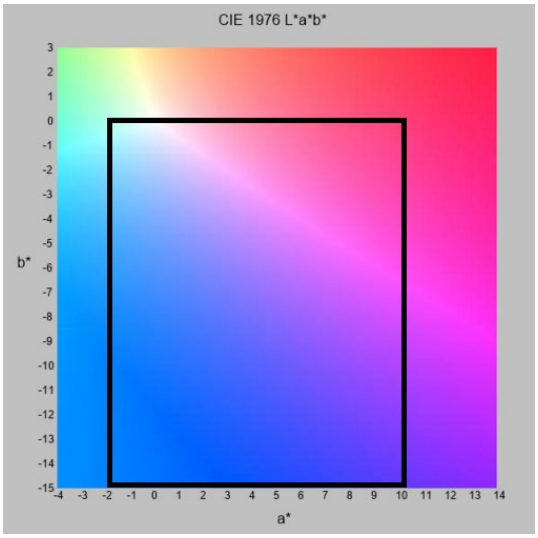
Where S is an equal energy light source, V is the Photopic eye response curve and R is reflectance of the coated surface.

Photopic HEA®
Product Specification #6102009

3.2 Color:

The reflected color of the HEA® coated surface when measured at 10° incidence shall fall within the following color limits as defined by CIE 1976 L*a*b* color space using a 2 deg observer and illuminant D65.

3.3 Color Coordinates: a* = -2 to +10 / b* = -15 to 0



3.4 Transmittance (Y): (Clear soda lime float glass only)

Glass Thickness (mm)	Photopic Transmission	
	Single Sided HEA	Double Sided HEA
≤ 1.1	94.0	96.9
1.2 - 2.2	93.5	96.4
2.3 - 2.8	93.0	95.9
3.0-3.2	92.7	95.6
4.0	92.2	95.1
5.0	91.6	94.5
6.0	91.0	93.9

3.5 Transmitted Color: (Clear soda lime float glass only)

Transmitted b* will be below 1.25 for a single sided coating and 2.75 for double sided coating.

3.6 Coating Environmental and Durability Requirements:

3.6.1 Adhesion:

The coating shall show no evidence of damage after "snap tape" test by which Scotch brand #610 cellulose tape is pressed firmly against the coated surface and removed quickly with a snap of the wrist as referenced in paragraph 4.5.12 of MIL-C-675C.

3.6.2 Abrasion Resistance:

The coating shall show no damage after a 20 cycle (40 stroke) eraser abrasion resistance test and meet the requirements referenced in paragraph 4.5.10 of MIL-C-675C for sleeking at the area of abrasion.

3.6.3 Humidity Resistance:

The coating shall be subjected to continuous exposure for 24 hours in an atmosphere of 120 degrees F. ± 4 degrees and 98% ±2% relative humidity without evidence of deterioration as referenced in paragraph 4.5.8 of MIL-C-675C.

3.6.4 Solubility:

The coating shall show no evidence of deterioration after being immersed for 24 hours in water containing six ounces of Sodium Chloride per gallon as referenced in paragraph 4.5.7 of MIL-C-675C.

3.6.5 Temperature Resistance*

The coating shall show no evidence of deterioration after being exposed to an ambient temperature of -65 degrees F. and +160 degrees F. for a period of four hours at each specified temperature as referenced in paragraph 3.11.3 of MIL-C-14806A.

* Compliance will be certified with each shipment, not tested.

Photopic HEA®
Product Specification #6102009

4.0 Surface Quality

Unless otherwise specified by MAC Thin Films, the following workmanship standards will be used.

4.1 Inspection Conditions and Area: The parts will be inspected by transmission and reflection at an approximate distance of 457mm (18") against a flat black background using fluorescent lighting adjusted to 85+/- 20 foot-candles. Inspection time to be no more than 30 seconds for 812.8mm x 1288mm (32" x 50.7") stock sheets and proportionally less for smaller sheets.

4.2 Transmission Inspection: Inspect the parts in front of the flat black background at a normal angle and inspect the glass by transmission.

4.3 Reflection Inspection: Inspect the parts at approximately a 45° angle in front of the flat black background and use the overhead fluorescent lights to inspect by reflection.

4.4 Surface Quality Inspection Criteria:

DEFECT TYPE	INSPECTION CRITERIA	
LINEAR DEFECTS **SCRATCHES, LINT**	**SIZE (Width)**	**STANDARD**
	> 0.08mm (> 0.003")	REJECT (SEE USABLE AREA *S*5.0)
	≥ 0.038mm to ≤ 0.08mm (0.0015" - 0.003")	≤ 25.4mm (1") single length (SEE USABLE AREA *S*5.0)
	< 0.038mm (< 0.0015")	DISREGARD
CIRCULAR DEFECTS **SPATTER, BUBBLES, SEEDS, DIGS**	**SIZE (mean ∅) $\frac{L+W}{2}$**	**STANDARD**
	> 0.5mm (> 0.020")	REJECT (SEE USABLE AREA *S*5.0)
	≥ 0.25mm to ≤ 0.5mm (0.010" - 0.020")	3 per 102mm (4") ∅ circle (SEE USABLE AREA *S*5.0)
	< 0.25mm (< 0.010")	DISREGARD

4.5 Stain: (such as color variations, non-removable haze, smears, or surface irregularities)

The Surface shall be free from distinct and objectionable color variation or stain. Heavy or distinct stains visible under transmission inspection are not allowed. Light stains visible only under reflection inspection conditions are acceptable. Stains that do not exceed the circular or linear defect criteria are allowed.

4.6 Edge Chips

Intrusion of edge chips shall not be greater than 3.2mm (0.125”). Depth of edge chips shall not be greater than ½ the glass thickness. Accumulated length shall not be greater than 12.7mm (0.5”) over any 254mm (10”) length and the maximum length of a single chip shall be less than 12.7mm (0.5”).

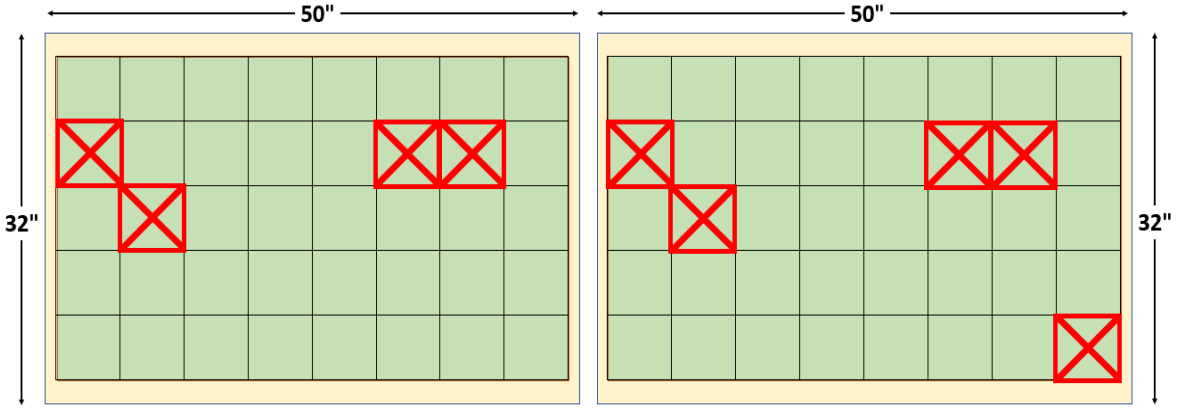
4.7 Fractures: (visible to the unaided eye) None allowed

5.0 Stock Sheet Usable Area

5.1 Individual sheets will yield a minimum of 90% useable area using the following criteria:

STOCK SHEET SIZE	USABLE AREA	GRID SIZE
812.8mm x 1288mm (32" x 50.7")	711mm x 1237mm (28" x 48.7")	142.2mm x 152.4mm (5.6" x 6")
812.8mm x 1270mm (32" x 50")	711mm x 1219mm (28" x 48”)	142.2mm x 152.4mm (5.6" x 6")
635mm x 812.8mm (25" x 32")	584mm x 711mm (23" x 28")	146.1mm x 142.2mm (5.75" x 5.6")
406.4mm x 635mm (16" x 25")	356mm x 584mm (14" x 23")	116.8mm x116.8mm (4.6" x 4.6")

5.2 For 90% useable area, an 812.8mm x 1288mm or 812.8mm x 1270mm (32” x 50.7 or 32" x 50”) sheet is divided up into forty 142.2mm x 152.4mm (5.6” x 6.0”) grids. A passing sheet is allowed 4 reject grids. The 5th reject grid will fail the sheet.



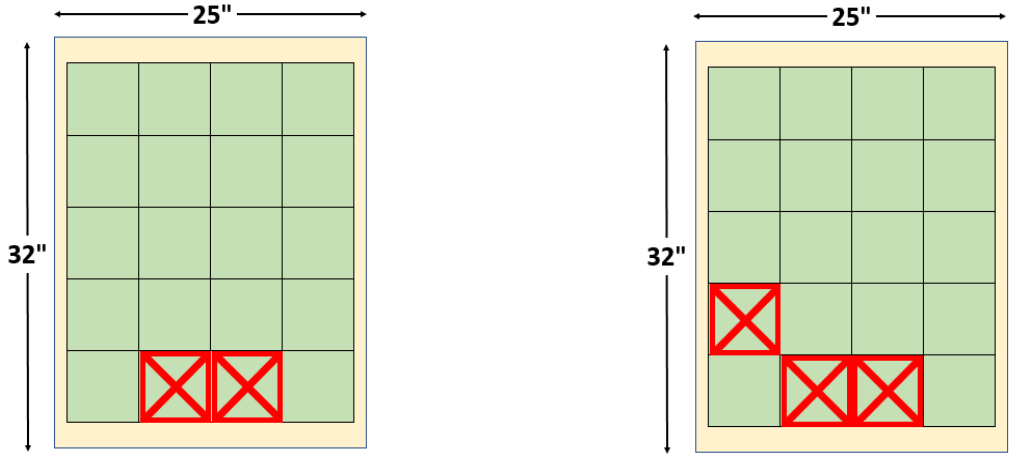
For 90% useable on a 32" x 50": 4 grid areas may be defective and the sheet will PASS

Indicates a failed grid

For 90% useable on a 32" x 50": If 5 grid areas are defective, the sheet will FAIL

Indicates a failed grid

5.3 For 90% useable area, a 635mm x 812.8mm (25” x 32”) sheet is divided up into twenty 142.2mm x 146mm (5.6” x 5.75”) grids. A passing sheet is allowed 2 reject grids. The 3rd reject grid will fail the sheet.



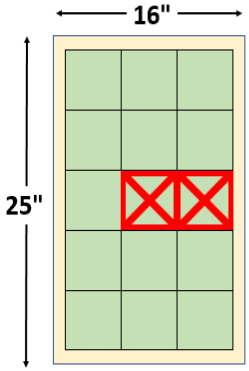
For 90% useable on a 25" x 32": 2 grid areas may be defective and the sheet will PASS

Indicates a failed grid

For 90% useable on a 25" x 32": If 3 grid areas are defective, the sheet will FAIL

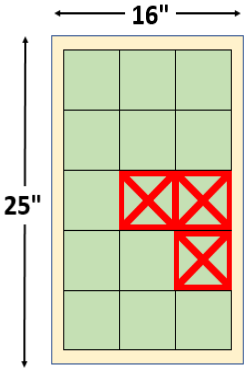
Indicates a failed grid

5.4 For 90% useable area, a 406.4mm x 635mm (16” x 25”) sheet is divided up into fifteen 116.8mm x 116.8mm (4.6” x 4.6”) grids. A passing sheet is allowed 2 reject grids. The 3rd reject grid will fail the sheet.



For 90% useable on a 16" x 25": 2 grid areas may be defective and the sheet will PASS

Indicates a failed grid



For 90% useable on a 16" x 25": If 3 grid areas are defective, the sheet will FAIL

Indicates a failed grid

6.0 Quality Assurance Provisions & Data Package

Each part is certified to meet the requirements of this specification. A “Certificate of Compliance” will be provided with each shipment of coated product. Representative scans of photopic brightness and color will be provided with each shipment.

7.0 Preparation for Delivery

Finished parts shall be clean and packaged in a manner to ensure protection against breakage or damage during reasonable handling and transportation. Additional requirements for packaging may be specified in the MAC Thin Films quotation or Sales Order Acknowledgement.

Photopic HEA®
Product Specification #6102009

8.0 Definitions

- MAC: Multi-layer Automatic Coater
- HEA®: High Efficiency Antireflection

9.0 Notes

Customer Cleaning of Coated Surfaces

- HEA® coatings are impervious to dust and dirt in normal environments. Dusting with a dry, soft, clean cloth is typically sufficient. Heavier contaminates may be removed with the following:
  - Detergent and water
  - Joy
  - Sparkle Glass Cleaner
  - Alconox
  - Liquinox Window Cleaner
  - Windex
  - Glass X

10.0 Safety Information

All materials used in the construction of this product comply with RoHS rules as given in Directive 2002/95/EC

11.0 Processing and Storage Recommendations

MAC Thin Films coated sheets may be shipped with a protective tape on the coated surface that provides safe transport for coated optics during transit and protection during fabrication. When processing these products with this protective tape still on, we recommend the following:

- Glass needs to be at least at room temperature (>20°C) prior to cutting.
- Crates need to be held at >20°C for at least one (1) week prior to processing to allow the large mass of glass to stabilize to room temperature.

Notes: If glass is processed below or above room temperature, adhesion of the protective tape may vary greatly. Certain chemicals, solvents or liquids that contact the protective film may also cause undesirable adhesion/delamination.