

# Performance Data and Comparisons

The performance characteristics of Cardinal's LoE® products are shown on the attached insulating glass performance charts. The following products and combination of products are compared:

- IG units with nominal 3mm and 6mm glass substrates;
- IG units with clear, green, gray, and bronze non-coated glass substrates;
- IG units with LoE<sup>2</sup>-272®, LoE<sup>2</sup>-270®, LoE<sup>2</sup>-240®, LoE<sup>3</sup>-366®, and LoE<sup>3</sup>-340™ on the #2 glass surface;
- IG units with LoE-180® on the #2 or #3 glass surfaces;
- IG units with green, gray, or bronze outdoor glass substrates with LoE-180®, LoE<sup>2</sup>-272®, LoE<sup>2</sup>-270®, LoE<sup>2</sup>-240®, LoE<sup>3</sup>-366®, LoE<sup>3</sup>-340™ or LoE-180® on the #3 Indoor glass surface;
- IG units with LoE<sup>2</sup>-272®, LoE<sup>2</sup>-270®, LoE<sup>2</sup>-240®, LoE<sup>3</sup>-366®, LoE<sup>3</sup>-340™ or LoE-180® on the #2 glass surface with LoE-i89® on the #4 glass surface.

Although the Winter U-factors are not affected when Cardinal's LoE® coatings are used on the #2 or #3 glass surface, the Shading Coefficient and Solar Heat Gain Coefficient will be higher when the coatings are on the #3 glass surface compared to the #2 glass surface.

Cardinal does not recommend the use of LoE® coatings on tinted substrates; therefore, there is no performance data listed for these combinations. However, Cardinal will supply IG units with a tinted lite outdoors and clear LoE® coated products on (surface #3) indoors.

Cardinal also does not recommend solar control LoE® coatings (LoE<sup>2</sup>-272®, LoE<sup>2</sup>-270®, LoE<sup>2</sup>-240®, LoE<sup>3</sup>-366®, and LoE<sup>3</sup>-340™) be used on the #3 surface of a dual pane IG unit with a clear outdoor lite. The potential for having inside glass breakage from thermally-induced stress is increased. These coatings are designed as second surface coatings in a dual pane IG unit. The only LoE® coatings recommended for use on the #3 surface of a dual pane IG unit with a clear outdoor lite is LoE-180® and LoE-i89®.

## Cardinal Double-Pane Insulating Glass Performance Data

3 mm / 13.0 mm airspace / 3 mm

Exterior Glass	Interior Glass	Visible Light			SHGC	Center of Glass U-Value (BTU/hr/ft <sup>2</sup> /°F)		Comfort Indoor Glass Temperature (°F)		UV Trans.	Tdw ISO/CIE
		Trans	Reflectance			Air	Argon	Winter	Summer		
			Out	In							
Clear	Clear	82%	15%	15%	0.78	0.48	0.46	45	90	58%	75%
LoE <sup>-180</sup> ® (#2)	Clear	79%	15%	15%	0.64	0.31	0.26	55	87	29%	63%
LoE <sup>2-272</sup> ® (#2)	Clear	72%	11%	12%	0.41	0.30	0.25	56	84	16%	55%
LoE <sup>2-270</sup> ® (#2)	Clear	70%	12%	13%	0.37	0.29	0.25	56	83	14%	53%
LoE <sup>2-240</sup> ® (#2)	Clear	40%	14%	11%	0.25	0.30	0.26	55	86	16%	35%
LoE <sup>3-366</sup> ® (#2)	Clear	65%	11%	12%	0.27	0.29	0.24	56	83	5%	43%
LoE <sup>3-340</sup> ™ (#2)	Clear	39%	13%	16%	0.18	0.29	0.25	56	83	2%	27%
Clear	LoE <sup>-180</sup> ® (#3)	79%	15%	15%	0.69	0.31	0.26	55	94	29%	63%
LoE <sup>-180</sup> ® (#2)	LoE <sup>-i89</sup> ® (#4)	77%	15%	14%	0.62	0.24	0.21	46	105	27%	61%
LoE <sup>2-272</sup> ® (#2)	LoE <sup>-i89</sup> ® (#4)	70%	11%	11%	0.41	0.23	0.20	47	94	16%	53%
LoE <sup>2-270</sup> ® (#2)	LoE <sup>-i89</sup> ® (#4)	69%	12%	12%	0.36	0.23	0.20	47	93	14%	51%
LoE <sup>2-240</sup> ® (#2)	LoE <sup>-i89</sup> ® (#4)	39%	14%	10%	0.24	0.24	0.21	47	95	15%	34%
LoE <sup>3-366</sup> ® (#2)	LoE <sup>-i89</sup> ® (#4)	63%	11%	11%	0.27	0.23	0.20	48	90	5%	41%
LoE <sup>3-340</sup> ™ (#2)	LoE <sup>-i89</sup> ® (#4)	38%	13%	15%	0.17	0.23	0.20	47	91	2%	26%
Green	Clear	75%	14%	15%	0.60	0.48	0.46	45	94	36%	64%
Green	LoE <sup>-180</sup> ® (#3)	73%	13%	15%	0.52	0.31	0.26	55	92	19%	55%
Green	LoE <sup>2-272</sup> ® (#3)	66%	11%	11%	0.42	0.30	0.25	56	97	11%	49%
Green	LoE <sup>2-270</sup> ® (#3)	64%	12%	12%	0.39	0.30	0.25	56	97	10%	47%
Green	LoE <sup>2-240</sup> ® (#3)	37%	10%	14%	0.42	0.30	0.26	55	117	11%	31%
Green	LoE <sup>3-366</sup> ® (#3)	59%	11%	11%	0.35	0.29	0.24	56	100	3%	38%
Green	LoE <sup>3-340</sup> ™ (#3)	36%	14%	13%	0.36	0.29	0.25	56	114	1%	25%
Gray	Clear	55%	9%	14%	0.58	0.48	0.46	45	95	32%	49%
Gray	LoE <sup>-180</sup> ® (#3)	53%	9%	14%	0.49	0.31	0.26	55	93	17%	42%
Gray	LoE <sup>2-272</sup> ® (#3)	48%	8%	10%	0.37	0.30	0.25	56	96	10%	37%
Gray	LoE <sup>2-270</sup> ® (#3)	47%	8%	11%	0.34	0.30	0.25	56	96	9%	36%
Gray	LoE <sup>2-240</sup> ® (#3)	27%	7%	14%	0.37	0.30	0.26	55	115	9%	24%
Gray	LoE <sup>3-366</sup> ® (#3)	43%	7%	10%	0.29	0.29	0.24	56	98	3%	29%
Gray	LoE <sup>3-340</sup> ™ (#3)	26%	10%	13%	0.31	0.29	0.25	56	111	1%	18%
Bronze	Clear	61%	10%	14%	0.63	0.48	0.46	45	94	33%	51%
Bronze	LoE <sup>-180</sup> ® (#3)	59%	10%	14%	0.53	0.31	0.26	55	93	17%	44%
Bronze	LoE <sup>2-272</sup> ® (#3)	53%	9%	10%	0.39	0.30	0.25	56	96	10%	39%
Bronze	LoE <sup>2-270</sup> ® (#3)	52%	9%	11%	0.36	0.30	0.25	56	97	9%	37%
Bronze	LoE <sup>2-240</sup> ® (#3)	30%	8%	14%	0.40	0.30	0.26	55	117	9%	25%
Bronze	LoE <sup>3-366</sup> ® (#3)	48%	9%	10%	0.31	0.29	0.24	56	99	3%	30%
Bronze	LoE <sup>3-340</sup> ™ (#3)	29%	11%	13%	0.33	0.29	0.25	56	113	1%	19%

Notes:

- (1) Data was calculated using LBNL Window computer program with NFRC environmental conditions.
- (2) Calculations based on 13 mm (1/2") airspace, 3 mm (1/8") glass, and 90% Argon gas fill level.
- (3) Comfort Indoor Glass Temperatures are for the center portion of the glass.
- (4) Shading Coefficient (SC) can be calculated by dividing SHGC by 0.87.
- (5) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
- (6) UV Damage Weighted Transmittance (Tdw) is the weighted average for wavelengths 300 - 700 nm (based on CIE 89/3).

## Cardinal Double-Pane Insulating Glass Performance Data

6 mm / 13.0 mm airspace / 6 mm

Exterior Glass	Interior Glass	Visible Light			SHGC	Center of Glass U-Value (BTU/hr/ft <sup>2</sup> /°F)		Comfort Indoor Glass Temperature (°F)		UV Trans.	T <sub>dw</sub> ISO/CIE
		Trans	Reflectance			Air	Argon	Winter	Summer		
			Out	In							
Clear	Clear	80%	15%	15%	0.72	0.47	0.45	45	96	48%	70%
LoE-180® (#2)	Clear	77%	15%	14%	0.60	0.30	0.26	55	92	24%	60%
LoE <sup>2</sup> -272® (#2)	Clear	70%	11%	11%	0.40	0.29	0.25	56	87	14%	53%
LoE <sup>2</sup> -270® (#2)	Clear	68%	12%	12%	0.36	0.29	0.25	56	86	13%	50%
LoE <sup>2</sup> -240® (#2)	Clear	37%	13%	10%	0.24	0.30	0.25	56	88	13%	32%
LoE <sup>3</sup> -366® (#2)	Clear	63%	11%	11%	0.27	0.29	0.24	56	85	4%	41%
LoE <sup>3</sup> -340™ (#2)	Clear	38%	13%	15%	0.18	0.29	0.24	56	85	2%	26%
Clear	LoE-180® (#3)	77%	14%	15%	0.64	0.30	0.26	55	98	24%	60%
LoE-180® (#2)	LoE-i89® (#4)	75%	15%	13%	0.58	0.24	0.21	47	112	23%	58%
LoE <sup>2</sup> -272® (#2)	LoE-i89® (#4)	68%	10%	11%	0.39	0.23	0.20	47	99	14%	51%
LoE <sup>2</sup> -270® (#2)	LoE-i89® (#4)	66%	12%	12%	0.35	0.23	0.20	47	97	12%	49%
LoE <sup>2</sup> -240® (#2)	LoE-i89® (#4)	37%	13%	9%	0.23	0.24	0.20	47	98	13%	31%
LoE <sup>3</sup> -366® (#2)	LoE-i89® (#4)	61%	10%	11%	0.26	0.23	0.20	48	93	4%	40%
LoE <sup>3</sup> -340™ (#2)	LoE-i89® (#4)	37%	13%	14%	0.17	0.23	0.20	48	93	2%	25%
Green	Clear	69%	12%	14%	0.50	0.47	0.45	45	98	25%	56%
Green	LoE-180® (#3)	67%	12%	15%	0.42	0.30	0.26	55	94	13%	49%
Green	LoE <sup>2</sup> -272® (#3)	61%	10%	10%	0.37	0.29	0.25	56	97	8%	44%
Green	LoE <sup>2</sup> -270® (#3)	59%	11%	12%	0.35	0.29	0.25	56	97	7%	42%
Green	LoE <sup>2</sup> -240® (#3)	33%	9%	13%	0.36	0.30	0.25	56	114	7%	26%
Green	LoE <sup>3</sup> -366® (#3)	55%	10%	10%	0.32	0.29	0.24	56	99	2%	35%
Green	LoE <sup>3</sup> -340™ (#3)	33%	13%	13%	0.32	0.29	0.24	56	110	1%	22%
Gray	Clear	40%	7%	13%	0.46	0.47	0.45	45	101	20%	36%
Gray	LoE-180® (#3)	38%	7%	13%	0.37	0.30	0.26	55	95	10%	31%
Gray	LoE <sup>2</sup> -272® (#3)	35%	6%	9%	0.29	0.29	0.25	56	96	7%	27%
Gray	LoE <sup>2</sup> -270® (#3)	34%	7%	11%	0.27	0.29	0.25	56	96	6%	26%
Gray	LoE <sup>2</sup> -240® (#3)	19%	6%	13%	0.29	0.30	0.25	56	109	6%	17%
Gray	LoE <sup>3</sup> -366® (#3)	31%	6%	10%	0.23	0.29	0.24	56	97	2%	21%
Gray	LoE <sup>3</sup> -340™ (#3)	19%	7%	13%	0.24	0.29	0.24	56	106	<1%	13%
Bronze	Clear	48%	8%	13%	0.51	0.47	0.45	45	100	21%	38%
Bronze	LoE-180® (#3)	46%	8%	14%	0.43	0.30	0.26	55	96	11%	33%
Bronze	LoE <sup>2</sup> -272® (#3)	42%	7%	9%	0.32	0.29	0.25	56	97	7%	29%
Bronze	LoE <sup>2</sup> -270® (#3)	40%	7%	11%	0.30	0.29	0.25	56	97	6%	28%
Bronze	LoE <sup>2</sup> -240® (#3)	22%	7%	13%	0.33	0.30	0.25	56	112	6%	18%
Bronze	LoE <sup>3</sup> -366® (#3)	37%	7%	10%	0.26	0.29	0.24	56	98	2%	23%
Bronze	LoE <sup>3</sup> -340™ (#3)	22%	9%	13%	0.27	0.29	0.24	56	109	<1%	15%

Notes:

- (1) Data was calculated using LBNL Window computer program with NFRC environmental conditions.
- (2) Calculations based on 13 mm (1/2") airspace, 6 mm (1/4") glass, and 90% Argon gas fill level.
- (3) Comfort Indoor Glass Temperatures are for the center portion of the glass.
- (4) Shading Coefficient (SC) can be calculated by dividing SHGC by 0.87.
- (5) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
- (6) UV Damage Weighted Transmittance (T<sub>dw</sub>) is the weighted average for wavelengths 300 - 700 nm (based on CIE 89/3).

## Cardinal Triple-Pane Insulating Glass Performance Data

3 mm / 9.8 mm airspace / 3mm / 9.8 mm airspace / 3 mm

Exterior Glass	Center Glass	Interior Glass	Visible Light			SHGC	Center of Glass U-Value (BTU/hr/ft <sup>2</sup> /°F)		Comfort Indoor Glass Temperature (°F)		UV Trans	T <sub>dw</sub> ISO/CIE
			Trans	Reflectance Out	Reflectance In		Air	Argon	Winter	Summer		
LoE-180® (#2)	Clear	LoE-180® (#5)	70%	20%	20%	0.56	0.19	0.15	61	94	13%	50%
LoE <sup>2</sup> -272® (#2)	Clear	LoE <sup>2</sup> -272® (#5)	57%	13%	13%	0.35	0.18	0.14	62	93	5%	40%
LoE <sup>2</sup> -270® (#2)	Clear	LoE <sup>2</sup> -270® (#5)	55%	15%	15%	0.31	0.18	0.14	62	93	4%	37%
LoE <sup>3</sup> -366® (#2)	Clear	LoE <sup>3</sup> -366® (#5)	47%	13%	13%	0.24	0.18	0.14	62	91	<1%	27%
LoE <sup>3</sup> -366® (#2)	Clear	LoE-180® (#5)	57%	14%	18%	0.25	0.19	0.14	61	83	2%	36%
LoE-180® (#2)	LoE-180® (#4)	LoE-i89® (#6)	68%	21%	19%	0.53	0.16	0.13	54	111	13%	49%
LoE <sup>2</sup> -272® (#2)	LoE-180® (#4)	LoE-i89® (#6)	62%	15%	16%	0.36	0.16	0.13	54	97	8%	43%
LoE <sup>3</sup> -366® (#2)	LoE-180® (#4)	LoE-i89® (#6)	56%	14%	16%	0.24	0.16	0.13	55	90	2%	35%

Notes:

- (1) Data was calculated using LBNL Window computer program with NFRC environmental conditions.
- (2) Calculations based on 9.8 mm (3/8") airspace, 3.0 mm (1/8") glass, and 90% Argon gas fill level.
- (3) Comfort Indoor Glass Temperatures are for the center portion of the glass.
- (4) Shading Coefficient (SC) can be calculated by dividing SHGC by 0.87.
- (5) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
- (6) UV Damage Weighted Transmittance (T<sub>dw</sub>) is the weighted average for wavelengths 300 - 700 nm (based on CIE 89/3).

The following low emissivity (low-E) coated glass products are grouped according to their construction make-ups for comparisons of optical and thermal performances. This table includes the most commonly used low-E coatings in the market place. If further performance information is required on these or other low-E glass products, please contact Cardinal Technology Center.

**Performance Comparison of Low-E Insulating Glass Products**

Exterior Glass	Interior Glass	Visible Light			SHGC	LSG	Center of Glass U-Value (BTU/hr/ft <sup>2</sup> /°F)		Comfort		UV Trans	Tdw ISO/CIE
		Trans	Reflectance				Air	Argon	Indoor Glass Temperature (°F)			
			Out	In					Winter	Summer		
<b>Clear Insulating Glass</b>												
Clear	Clear	82%	15%	15%	0.78	1.05	0.48	0.46	45	90	58%	75%
<b>Solar Control Low-E Glass Coatings (Low SHGC)</b>												
Cardinal LoE <sup>2</sup> -240 <sup>®</sup> (#2)	Clear	40%	14%	11%	0.25	1.60	0.30	0.26	55	86	16%	35%
Cardinal LoE <sup>3</sup> -366 <sup>®</sup> (#2)	Clear	65%	11%	12%	0.27	2.41	0.29	0.24	56	83	5%	43%
Cardinal LoE <sup>3</sup> -340 <sup>™</sup> (#2)	Clear	39%	13%	16%	0.18	2.17	0.29	0.25	56	83	2%	27%
PPG SolarBan <sup>®</sup> 70XL (#2)	Clear	64%	12%	13%	0.27	2.37	0.29	0.24	56	83	6%	43%
AGC Comfort Select 28 (#2)	Clear	63%	14%	16%	0.28	2.25	0.29	0.24	56	82	17%	48%
Viracon VNE 1-63 (#2) [6mm only]	Clear [6mm]	63%	10%	11%	0.28	2.25	0.29	0.25	56	85	5%	42%
Guard. ClimaGuard <sup>™</sup> 62/27 (#2)	Clear	62%	13%	13%	0.27	2.30	0.29	0.24	56	82	5%	40%
<b>Low-E Glass Coatings</b>												
Cardinal LoE <sup>2</sup> -272 <sup>®</sup> (#2)	Clear	72%	11%	12%	0.41	1.76	0.30	0.25	56	84	16%	55%
Cardinal LoE <sup>2</sup> -270 <sup>®</sup> (#2)	Clear	70%	12%	13%	0.37	1.89	0.30	0.25	56	83	14%	53%
PPG SolarBan <sup>®</sup> 60 (#2)	Clear	72%	11%	13%	0.39	1.85	0.29	0.25	56	84	21%	56%
Viracon VE1-2M (#2) [6mm only]	Clear [6mm]	71%	11%	12%	0.38	1.87	0.29	0.25	56	86	10%	51%
Guard. ClimaGuard <sup>™</sup> 70/36 (#2)	Clear	70%	11%	12%	0.38	1.84	0.30	0.25	56	83	24%	37%
AGC Comfort Select 40 <sup>™</sup> (#2)	Clear	73%	12%	13%	0.39	1.87	0.30	0.25	56	83	19%	56%
<b>Passive Design Low-E Glass Coatings (High SHGC)</b>												
Clear	Cardinal LoE-180 <sup>®</sup> (#3)	79%	15%	15%	0.69	1.14	0.31	0.26	55	94	29%	63%
Clear	Cardinal LoE-i89 <sup>®</sup> (#3)	80%	15%	14%	0.75	1.07	0.33	0.29	54	98	55%	72%
Clear	AGC Comfort Select 73 (#3)	74%	18%	17%	0.73	1.01	0.33	0.29	54	101	43%	64%
Clear	Pilkington Energy Adv. <sup>™</sup> (#3)	77%	17%	17%	0.74	1.04	0.34	0.30	53	96	51%	68%
Clear	PPG Sungate <sup>®</sup> 400 (#3)	79%	14%	14%	0.69	1.14	0.32	0.28	54	97	32%	64%
Clear	Guard. ClimaGuard <sup>™</sup> 80/70 (#3)	81%	13%	13%	0.70	1.16	0.32	0.27	55	93	41%	69%

Notes:

- (1) Data was calculated using LBNL Window computer program with NFRC environmental conditions.
- (2) Calculations based on 13 mm (1/2") airspace, 3 mm (1/8") glass, and 90% Argon gas fill level.
- (3) Comfort Indoor Glass Temperatures are for the center portion of the glass.
- (4) Shading Coefficient (SC) can be calculated by dividing SHGC by 0.87.
- (5) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
- (6) UV Damage Weighted Transmittance (Tdw) is the weighted average for wavelengths 300 - 700 nm (based on CIE 89/3).

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