Performance Data and Comparisons

The performance characteristics of Cardinal's LoĒ® products are shown on the attached "Insulating Glass Performance Comparison" charts. The following products and combination of products are compared:

- IG units with nominal 3 mm and 6 mm glass substrates;
- IG units with clear, green, gray, and bronze non-coated glass substrates;
- IG units with LoĒ²-272®, LoĒ²-270®, LoĒ³-366®, and LoĒ²-240® on the #2 glass surface;
- IG units with LoĒ-180® on the #2 or #3 glass surfaces;
- IG units with green, gray, or bronze outdoor glass substrates with LoĒ-180®, LoĒ²-272®, LoĒ²-270®, LoĒ³-366®, LoĒ²-240® or LoĒ-180® on the #3 Indoor glass surface;
- IG units with LoĒ²-272®, LoĒ²-270®, LoĒ³-366®, LoĒ²-240® or LoĒ-180® on the #2 glass surface with LoĒ-i89 on the #4 glass surface.

Although the Winter U-factors are not affected when Cardinal's LoĒ® 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 LoĒ® 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 LoĒ® coated products on (surface #3) indoors.

Cardinal also does not recommend solar control LoE® coatings (LoĒ²-272®, LoĒ²-270®, LoĒ³-366®, and LoĒ²-240®) 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 LoĒ® coating recommended for use on the #3 surface of a dual pane IG unit with a clear outdoor lite is LoĒ-180®.

Cardinal Double-Pane Insulating Glass Performance Data

3 mm / 13.0 mm airspace / 3 mm

Exterior Glass	Interior Glass	Visible Light			SC	SHGC	Center of Glass U-Value (BTU/hr/ft²/°F)		Comfort Indoor Glass Temperature (°F)		UV Trans.	Tdw ISO/CIE
		Trans	Reflectance Out	Reflectance In			Air	Argon	Winter	Summer		
Clear	Clear	82%	15%	15%	0.89	0.78	0.48	0.46	45	90	58%	75%
LoÉ-180® (#2)	Clear	79%	15%	15%	0.74	0.64	0.31	0.26	55	87	29%	63%
LoÉ²-272® (#2)	Clear	72%	11%	12%	0.47	0.41	0.30	0.25	56	84	16%	55%
LoÉ²-270® (#2)	Clear	70%	12%	13%	0.42	0.37	0.29	0.25	56	83	14%	53%
LoÉ³-366® (#2)	Clear	65%	11%	12%	0.31	0.27	0.29	0.24	56	83	5%	43%
LoÉ²-240® (#2)	Clear	40%	14%	10%	0.29	0.25	0.30	0.26	55	86	16%	35%
Clear	LoÉ-180® (#3)	79%	15%	15%	0.79	0.69	0.31	0.26	55	94	29%	63%
LoÉ-180® (#2)	LoÉ-i89® (#4)	77%	15%	14%	0.72	0.62	0.24	0.21	46	105	27%	61%
LoÉ²-272® (#2)	LoÉ-i89® (#4)	70%	11%	11%	0.47	0.41	0.23	0.20	47	94	16%	53%
LoÉ²-270® (#2)	LoÉ-i89® (#4)	69%	12%	12%	0.41	0.36	0.23	0.20	47	93	14%	51%
LoÉ³-366® (#2)	LoÉ-i89® (#4)	63%	11%	11%	0.31	0.27	0.23	0.20	48	90	5%	41%
LoÉ²-240® (#2)	LoÉ-i89® (#4)	39%	14%	10%	0.28	0.24	0.24	0.21	47	95	15%	34%
Green	Clear	75%	13%	14%	0.69	0.60	0.48	0.45	45	99	34%	63%
Green	LoÉ-180® (#3)	71%	13%	15%	0.57	0.50	0.31	0.26	55	92	16%	53%
Green	LoÉ²-272® (#3)	66%	10%	10%	0.48	0.42	0.30	0.25	56	97	11%	48%
Green	LoÉ²-270® (#3)	64%	11%	12%	0.45	0.39	0.29	0.24	56	97	10%	46%
Green	LoÉ³-366® (#3)	59%	10%	10%	0.40	0.35	0.29	0.24	56	100	3%	38%
Green	LoÉ²-240® (#3)	37%	9%	14%	0.48	0.42	0.30	0.26	55	117	10%	30%
Gray	Clear	57%	9%	13%	0.70	0.60	0.48	0.45	45	95	32%	50%
Gray	LoÉ-180® (#3)	53%	9%	14%	0.56	0.49	0.31	0.26	55	93	17%	42%
Gray	LoÉ²-272® (#3)	50%	8%	9%	0.43	0.38	0.30	0.25	56	96	10%	38%
Gray	LoÉ²-270® (#3)	48%	8%	11%	0.40	0.35	0.29	0.25	56	97	9%	37%
Gray	LoÉ³-366® (#3)	45%	8%	10%	0.34	0.29	0.29	0.24	56	99	3%	30%
Gray	LoÉ²-240® (#3)	28%	7%	14%	0.44	0.38	0.30	0.26	55	116	9%	24%
Bronze	Clear	61%	10%	13%	0.72	0.62	0.48	0.45	45	94	31%	51%
Bronze	LoÉ-180® (#3)	59%	10%	14%	0.61	0.53	0.31	0.26	55	93	17%	44%
Bronze	LoÉ²-272® (#3)	54%	8%	10%	0.45	0.39	0.30	0.25	56	96	10%	39%
Bronze	LoÉ²-270® (#3)	52%	9%	11%	0.42	0.36	0.29	0.25	56	97	9%	37%
Bronze	LoÉ³-366® (#3)	48%	8%	10%	0.35	0.31	0.29	0.24	56	99	3%	30%
Bronze	LoÉ²-240® (#3)	30%	8%	14%	0.46	0.40	0.30	0.26	55	117	9%	25%

Notes:

(1) Data was calculated using Window 6.3 computer program with NFRC 100-2010 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) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
(5) 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			SC	SHGC	Center of Glass U-Value (BTU/hr/ft²/°F)		Comfort Indoor Glass Temperature (°F)		UV Trans.	Tdw ISO/CIE
		Trans	Reflectance Out	Reflectance In			Air	Argon	Winter	Summer		
Clear	Clear	80%	15%	15%	0.83	0.72	0.47	0.45	45	96	48%	70%
LoÉ-180® (#2)	Clear	77%	15%	14%	0.69	0.60	0.30	0.26	55	92	24%	60%
LoÉ²-272® (#2)	Clear	70%	11%	11%	0.45	0.40	0.29	0.25	56	87	14%	53%
LoÉ²-270® (#2)	Clear	68%	12%	12%	0.41	0.36	0.29	0.25	56	86	13%	50%
LoÉ³-366® (#2)	Clear	63%	11%	11%	0.31	0.27	0.29	0.24	56	85	4%	41%
LoÉ²-240® (#2)	Clear	37%	13%	10%	0.28	0.24	0.30	0.25	56	88	13%	32%
Clear	LoÉ-180® (#3)	77%	14%	15%	0.73	0.64	0.30	0.26	55	98	24%	60%
LoÉ-180® (#2)	LoÉ-i89® (#4)	75%	15%	13%	0.67	0.58	0.24	0.21	47	112	23%	58%
LoÉ²-272® (#2)	LoÉ-i89® (#4)	68%	10%	11%	0.45	0.39	0.23	0.20	47	99	14%	51%
LoÉ²-270® (#2)	LoÉ-i89® (#4)	66%	12%	12%	0.40	0.35	0.23	0.20	47	97	12%	49%
LoÉ³-366® (#2)	LoÉ-i89® (#4)	61%	10%	11%	0.30	0.26	0.23	0.20	48	93	4%	40%
LoÉ²-240® (#2)	LoÉ-i89® (#4)	37%	13%	9%	0.27	0.23	0.24	0.20	47	98	13%	31%
Green	Clear	68%	12%	14%	0.57	0.49	0.47	0.45	45	99	22%	54%
Green	LoÉ-180® (#3)	63%	11%	14%	0.44	0.38	0.30	0.26	55	93	10%	45%
Green	LoÉ²-272® (#3)	60%	9%	10%	0.42	0.36	0.29	0.25	56	97	8%	43%
Green	LoÉ²-270® (#3)	58%	10%	11%	0.40	0.35	0.29	0.25	56	97	7%	41%
Green	LoÉ³-366® (#3)	54%	9%	10%	0.36	0.32	0.28	0.24	56	100	2%	34%
Green	LoÉ²-240® (#3)	32%	8%	13%	0.41	0.36	0.30	0.25	56	114	6%	26%
Gray	Clear	42%	7%	12%	0.56	0.48	0.47	0.45	45	101	20%	37%
Gray	LoÉ-180® (#3)	38%	7%	13%	0.43	0.37	0.30	0.26	55	95	11%	31%
Gray	LoÉ²-272® (#3)	36%	6%	9%	0.35	0.30	0.29	0.25	56	96	7%	28%
Gray	LoÉ²-270® (#3)	35%	6%	10%	0.32	0.28	0.29	0.25	56	96	6%	27%
Gray	LoÉ³-366® (#3)	33%	6%	9%	0.28	0.24	0.29	0.24	56	97	2%	22%
Gray	LoÉ²-240® (#3)	19%	6%	13%	0.35	0.30	0.30	0.25	56	110	6%	17%
Bronze	Clear	48%	8%	13%	0.58	0.50	0.47	0.45	45	100	19%	37%
Bronze	LoÉ-180® (#3)	46%	8%	14%	0.49	0.42	0.30	0.26	55	96	11%	33%
Bronze	LoÉ²-272® (#3)	42%	7%	9%	0.37	0.32	0.29	0.25	56	97	6%	29%
Bronze	LoÉ²-270® (#3)	41%	7%	10%	0.34	0.30	0.29	0.25	56	97	6%	28%
Bronze	LoÉ³-366® (#3)	38%	7%	9%	0.30	0.26	0.29	0.24	56	98	2%	23%
Bronze	LoÉ²-240® (#3)	22%	6%	13%	0.37	0.32	0.30	0.25	56	112	5%	18%

Notes:

(1) Data was calculated using Window 6.3 computer program with NFRC 100-2010 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) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
(5) UV Damage Weighted Transmittance (Tdw) 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			SC	SHGC	Center of Glass U-Value (BTU/hr/ft²/°F)		Comfort Indoor Glass Temperature (°F)		UV Trans	Tdw ISO/CIE
			Trans	Reflectance Out	Reflectance In			Air	Argon	Winter	Summer		
LoĒ-180® (#2)	Clear	LoĒ-180® (#5)	70%	20%	20%	0.64	0.56	0.19	0.15	61	94	13%	50%
LoĒ²-272® (#2)	Clear	LoĒ²-272® (#5)	57%	13%	13%	0.40	0.35	0.18	0.14	62	93	5%	40%
LoĒ²-270® (#2)	Clear	LoĒ²-270® (#5)	55%	15%	15%	0.36	0.31	0.18	0.14	62	93	4%	37%
LoĒ³-366® (#2)	Clear	LoĒ³-366® (#5)	47%	13%	13%	0.27	0.24	0.18	0.14	62	91	<1%	27%
LoĒ³-366® (#2)	Clear	LoĒ-180® (#5)	57%	14%	18%	0.28	0.25	0.19	0.14	61	83	2%	36%
LoĒ-180® (#2)	LoĒ-180® (#4)	LoĒ-i89® (#6)	68%	21%	19%	0.61	0.53	0.16	0.13	54	111	13%	49%
LoĒ²-272® (#2)	LoĒ-180® (#4)	LoĒ-i89® (#6)	62%	15%	16%	0.41	0.36	0.16	0.13	54	97	8%	43%
LoĒ³-366® (#2)	LoĒ-180® (#4)	LoĒ-i89® (#6)	56%	14%	16%	0.27	0.24	0.16	0.13	55	90	2%	35%

Notes:

(1) Data was calculated using Window 6.3 computer program with NFRC 100-2010 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) The UV Transmittance is determined as an average for wavelengths 310 -380 nm.
(5) UV Damage Weighted Transmittance (Tdw) is the weighted average for wavelengths 300 - 700 nm (based on CIE 89/3).

The following sputtered and pyrolytic low-E coated products are grouped according to their construction make-ups for comparisons of optical and thermal performances. Performance values for the products listed below were calculated using the Lawrence Berkeley Window 6.3 Computer Program, and are listed in the "Low-E Insulating Glass Performance Comparison Table" on the following page.

Sputtered – Triple Silver Layer Products:

- Cardinal LoĒ³-366®
- PPG Solarban® 70 XL
- Guardian ClimaGuard™ 62/27

Sputtered – Double Silver Layer Products:

- Cardinal LoĒ²-272®
- Cardinal LoĒ²-270®
- PPG Solarban® 60
- Viracon E1-2M
- Guardian ClimaGuard™ 71/38
- Guardian ClimaGuard™ 70/36
- Guardian ClimaGuard™ 63/31
- AGC Comfort Ti-AC™
- AGC Comfort Ti-R™

Sputtered – Double Silver Layer Sun Coatings:

- Cardinal LoĒ²-240®
- Viracon VE 1-48
- Pilkington N.A. Solar E™
- Guardian ClimaGuard™ 55/27

Sputtered – Single Silver Layer Products:

- Cardinal LoĒ-180™
- PPG Sungate® 100
- Viracon E1-85
- Guardian ClimaGuard™ 75/68
- Guardian ClimaGuard™ 80/70
- AGC Comfort Ti-PS™

Passive Design Coatings:

- Cardinal LoĒ-180™
- Cardinal LoĒ-i89™
- AGC Comfort Ti-PS™
- AGC Comfort E2™
- Pilkington N.A. Energy Advantage™
- PPG Sungate® 500
- PPG Sungate® 600

Although there are other Low-E products in the industry, the attached listing includes the most commonly used. If further performance information is required on these or other Low Emissivity Products, please contact Cardinal Technical Services.

Low-E Insulating Glass Performance Comparison Table

Exterior Glass	Interior Glass	Visible Light			SHGC	LSG	Center of Glass U-Value (BTU/hr/ft²/°F)		Comfort Indoor Glass Temperature (°F)		UV Trans	Tdw ISO/CIE
		Trans	Reflectance Out	Reflectance In			Air	Argon	Winter	Summer		
Clear	Clear	82%	15%	15%	0.78	1.05	0.48	0.46	45	90	58%	75%
Low-E Sputtered Products - Triple Silver Layer												
Cardinal LoE³-366® (#2)	Clear	65%	11%	12%	0.27	2.41	0.29	0.24	56	83	5%	43%
PPG SolarBan® 70XL (#2)	Clear	64%	12%	13%	0.27	2.37	0.29	0.24	56	83	6%	43%
Guardian ClimaGuard™ 62/27 (#2)	Clear	62%	13%	13%	0.27	2.30	0.29	0.24	56	82	5%	40%
Low-E Sputtered Products - Double Silver Layer												
Cardinal LoE²-272® (#2)	Clear	72%	11%	12%	0.41	1.76	0.30	0.25	56	84	16%	55%
Cardinal LoE²-270® (#2)	Clear	70%	12%	13%	0.37	1.89	0.30	0.25	56	83	14%	53%
PPG SolarBan® 60 (#2)	Clear	72%	11%	13%	0.39	1.85	0.29	0.25	56	84	21%	56%
Viracon E1-2M (#2) [6mm only]	Clear	71%	11%	12%	0.38	1.87	0.29	0.25	56	86	10%	51%
Guardian ClimaGuard™ 71/38 (#2)	Clear	71%	10%	11%	0.39	1.82	0.29	0.25	56	84	24%	56%
Guardian ClimaGuard™ 70/36 (#2)	Clear	70%	11%	13%	0.36	1.94	0.30	0.25	56	83	30%	57%
Guardian ClimaGuard™ 63/31 (#2)	Clear	63%	12%	15%	0.31	2.03	0.29	0.25	56	83	23%	50%
AGC Comfort TI-AC™ (#2)	Clear	62%	29%	23%	0.40	1.55	0.30	0.25	56	83	30%	51%
AGC Comfort TI-R™ (#2)	Clear	71%	21%	19%	0.47	1.51	0.29	0.25	56	84	30%	57%
Low-E Sputtered Products - Double Silver Layer Sun Coatings												
Cardinal LoE²-240® (#2)	Clear	40%	14%	10%	0.25	1.60	0.30	0.26	55	86	16%	35%
Viracon VE 1-48 (#2) [6mm only]	Clear	47%	17%	11%	0.37	1.27	0.31	0.27	55	90	20%	42%
Pilkington Solar E™ (#2)	Clear	55%	11%	16%	0.46	1.20	0.34	0.30	53	90	38%	51%
Guardian ClimaGuard™ 55/27 (#2)	Clear	55%	12%	17%	0.27	2.04	0.29	0.24	56	84	18%	41%
Low-E Sputtered Products - Single Silver Layer												
Cardinal LoE-180® (#2)	Clear	79%	15%	15%	0.64	1.23	0.31	0.26	55	87	29%	63%
PPG Sungate® 100 (#2)	Clear	79%	12%	13%	0.57	1.39	0.31	0.26	55	86	35%	65%
Viracon E1-85 (#2) [6mm only]	Clear	76%	12%	13%	0.54	1.41	0.31	0.27	55	91	27%	61%
Guardian ClimaGuard™ 75/68 (#2)	Clear	76%	13%	15%	0.63	1.21	0.32	0.28	54	88	45%	66%
Guardian ClimaGuard™ 80/70 (#2)	Clear	81%	13%	13%	0.66	1.23	0.32	0.27	55	87	41%	69%
AGC Comfort TI-PS™ (#2)	Clear	78%	12%	12%	0.55	1.42	0.30	0.26	55	85	44%	67%
Passive Design Coatings												
Clear	Cardinal LoE-180® (#3)	79%	15%	15%	0.69	1.14	0.31	0.26	55	94	29%	63%
Clear	Cardinal LoE-i89® (#3)	80%	15%	14%	0.75	1.07	0.33	0.29	54	98	55%	72%
Clear	AGC Comfort TI-PS™ (#3)	78%	12%	12%	0.61	1.28	0.30	0.26	55	96	44%	67%
Clear	AGC Comfort E2 (#3)	76%	16%	14%	0.73	1.04	0.35	0.31	53	101	44%	64%
Clear	Pilk. Energy Adv.™ (#3)	77%	17%	17%	0.74	1.04	0.34	0.30	53	96	51%	68%
Clear	PPG Sungate® 500 (#3)	76%	18%	17%	0.72	1.06	0.35	0.31	52	99	48%	66%
Clear	PPG Sungate® 600 (#3)	74%	17%	16%	0.72	1.03	0.33	0.29	54	106	44%	63%

Notes:

(1) Data was calculated using Window 6.3 computer program with NFRC 100-2010 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).