

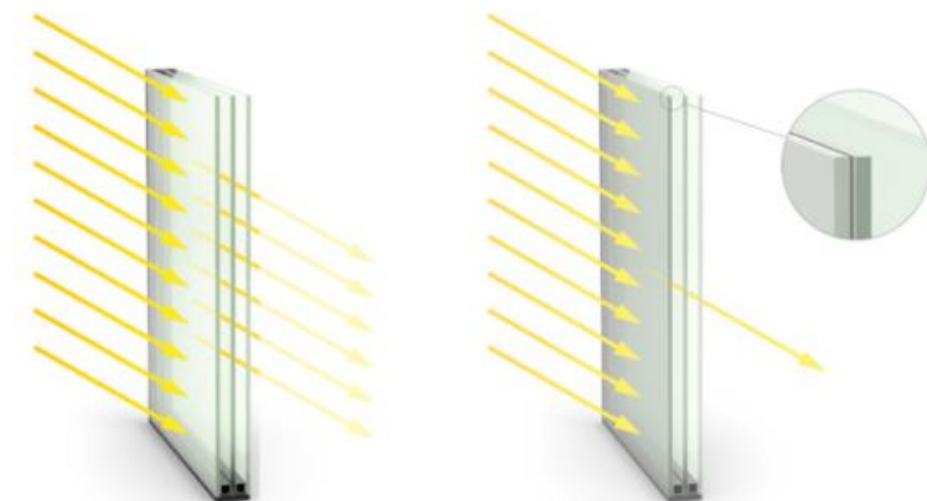
## ChromoGenics Dynamic Glass, Technical Specification



### OVERVIEW

ChromoGenics Dynamic Glass is a facade glass with dynamic light- and solar-control properties, which improves indoor comfort and contributes to better energy efficiency in buildings, while always having access to daylight and clear views. Its low climate and energy footprint facilitate fulfillment of climate goals, energy goals and building certifications. The dynamic state is controlled automatically, and completely continuously, to give the building the best possible indoor comfort and energy efficiency, regardless of weather and climate. The dynamic transition is smooth and comfortable, energy-efficiently and without moving parts, which results in an imperceptible, energy-efficient and reliable solar-control solution. In addition, ChromoGenics Dynamic Glass design freedom make it easy to adapt shape and function to the conditions and requirements for the building or project.

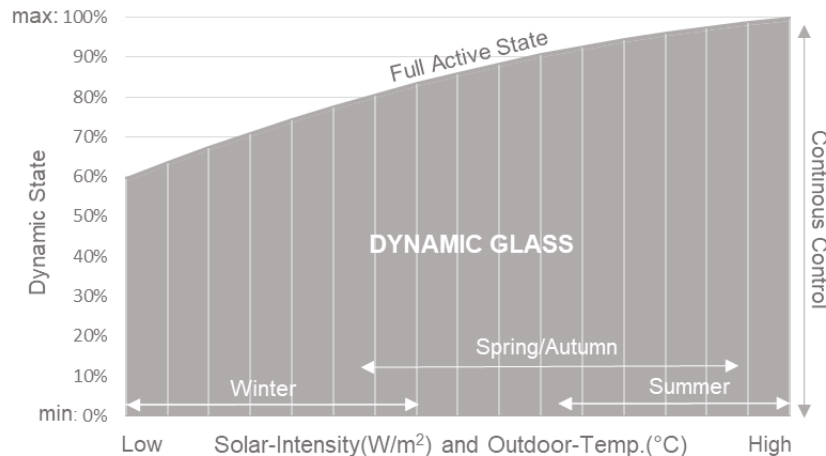
### CHROMOGENICS DYNAMIC GLASS



*With dynamics that always provide excellent visual and thermal comfort; and energy properties.*

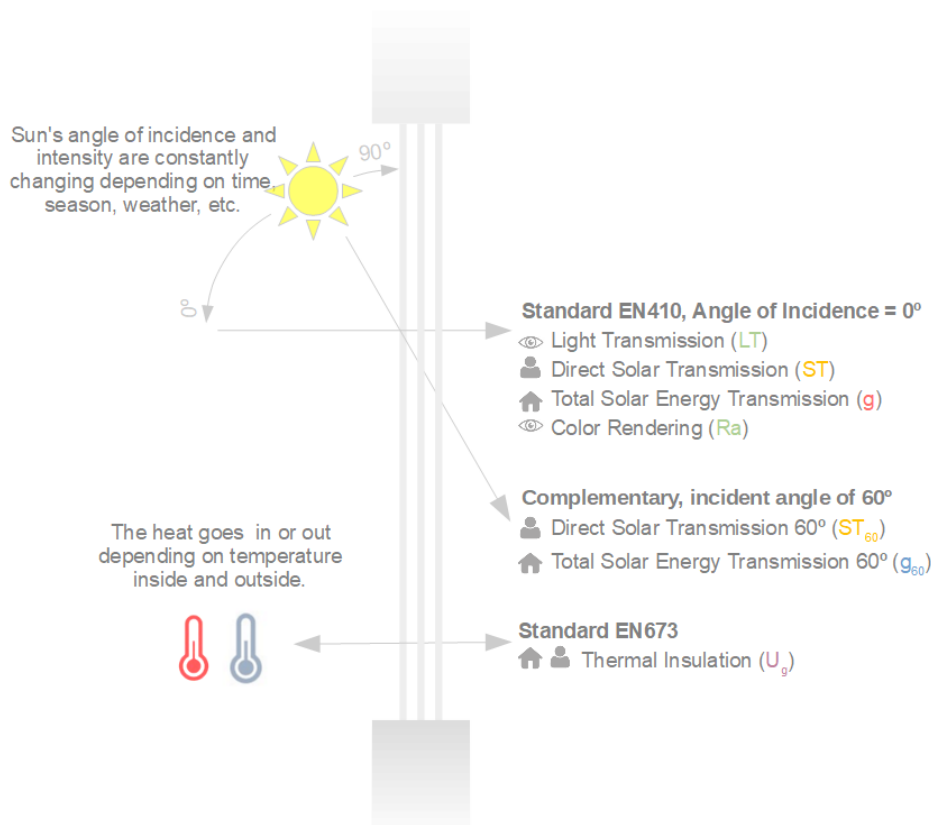
## DYNAMIC PROPERTIES

With ChromoGenics Dynamic Glass unique dynamic properties, it is flexible and easy to control the indoor climate in the building. In full active state, the glass automatically adjusts itself to the best state, seen in season and weather, to optimize the indoor climate with respect to solar-heat and daylight inlet. In inactive state, the solar-heat and daylight inlet is maximized. The dynamic state can also be controlled completely continuously between fully active and inactive state for times or periods when more solar-heat and daylight are desired. The dynamic transition is roughly a 20 minutes smooth and comfortable process, depending on the solar intensity and outdoor temperature, but where significant effect is occurring within a few minutes. In addition, the transition is energy-efficiently, in average  $<0.05\text{W/m}^2$ , and in rest/hold average  $<0.000001\text{W/m}^2$ .






## ESTIMATING COMFORT AND ENERGY

In order to estimate a façade glass' actual comfort and energy performance, one should also take in to account its angular properties, since the solar angle of incidence rarely, or never, falls onto the glass at the standard angle ( $0^\circ$ ).



Performance of glass according to the standard- (0 °) and the 60° angle complement each other extremely well since the standard gives the performance of view, daylight for sunny or cloudy weather, and values in 60° provides the performance of thermal comfort and energy for sunny weather.

Property	Parameter	Desired Performance	Dynamic 75 3G	Dynamic 65 3G
<b>Visual Comfort</b> 	Light Transmission (LT max-min)	High (↑) to increase view and daylight	61-33%	56-14%
	Color Rendering (Ra max-min)	High (↑) to increase the quality of the daylight	94-90	93-86
<b>Thermal Comfort</b> 	Direct Solar Transmission (ST min)	Low (↓) to reduce thermal discomfort from the sun early spring, late autumn <sup>1</sup>	21%	7%
	Direct Solar Transmission 60° (ST <sub>60</sub> min)	Low (↓) to reduce thermal discomfort from the sun's hot seasons.	10%	4%
	Thermal Insulation (U <sub>g</sub> )	Low (↓) to reduce thermal discomfort at cold seasons	0.6W/m <sup>2</sup>	0.6W/m <sup>2</sup>
<b>Energy</b> 	Total Solar-Energy Transmission (g max)	High (↑) to save heating-energy in cold seasons	40%	36%
	Total Solar-Energy Transmission 60° (g <sub>60</sub> min)	Low (↓) to save cold energy hot seasons	14%	6%
	Thermal Insulation (U <sub>g</sub> )	Low (↓) to both save heating-energy cold seasons and cooling-energy hot seasons	0.6W/m <sup>2</sup>	0.6W/m <sup>2</sup>

<sup>1</sup>In the cases where there is high solar intensity and low solar angle, which can occur, for example, short periods early spring, late autumn.

## CLIMATE DATA

Regardless of the building's location, the glass' angular properties are always important to better reflect the glass's true performance.

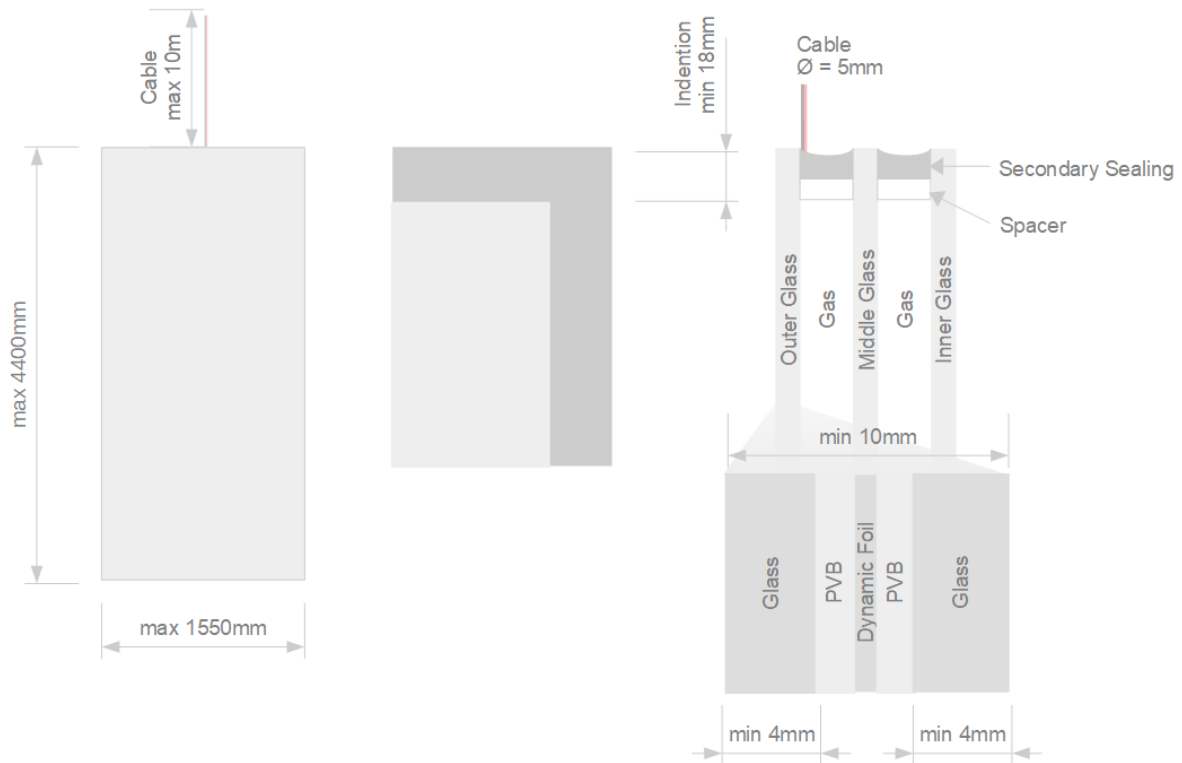
Location		Spring	Summer	Autumn	Winter
Kiruna, Narvik, Rovaniemi	Suns Angle of incidence <sup>1</sup>	>23°	>45°	>22°	>1°
	Solar Intensity <sup>2</sup>	<767 W/m <sup>2</sup>	<598 W/m <sup>2</sup>	<725 W/m <sup>2</sup>	<445 W/m <sup>2</sup>
	Outdoor Temperature <sup>3</sup>	-5°C	15°C	6°C	-9°C
Stockholm, Oslo, Helsinki	Suns Angle of incidence <sup>1</sup>	>31°	>54°	>30°	>7°
	Solar Intensity <sup>2</sup>	<678 W/m <sup>2</sup>	<493 W/m <sup>2</sup>	<656 W/m <sup>2</sup>	<370 W/m <sup>2</sup>
	Outdoor Temperature <sup>3</sup>	2°C	20°C	9°C	-1°C
London, Berlin, Paris	Suns Angle of incidence <sup>1</sup>	>39°	>62°	>38°	>15°
	Solar Intensity <sup>2</sup>	<600 W/m <sup>2</sup>	<385 W/m <sup>2</sup>	<614 W/m <sup>2</sup>	<567 W/m <sup>2</sup>
	Outdoor Temperature <sup>3</sup>	9°C	21°C	17°C	8°C
Rome, Madrid, Athens	Suns Angle of incidence <sup>1</sup>	>49°	>71°	>48°	>25°
	Solar Intensity <sup>2</sup>	<543 W/m <sup>2</sup>	<256 W/m <sup>2</sup>	<530 W/m <sup>2</sup>	662 W/m <sup>2</sup>
	Outdoor Temperature <sup>3</sup>	14°C	28°C	25°C	13°C

<sup>1</sup> Angle of incidence south-façade, mid-day (12:00) when the solar intensity is at its highest.

<sup>2</sup> Maximal Sun-intensity south-façade, mid-day (12:00) on a facade glass, i.e. corrected direct-normal value for the angle of incidence.

<sup>3</sup> Mean temperature for first mentioned location.

## DIMENSION & CONFIGURATIONS



	Dynamic Standard	+Clear	+Anti-Condensation	+Insulation	+Safety +Silence	+Security	+Fire	Paragon	+Other Options
Width x Height (mm)	1550x4400	1550x4400	1550x4400	1550x4400	1550x4400	1550x4400	1500x3000	1550x4400	
Cable <sup>1</sup>	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	max 10m (Ø = 5mm)	+>10m <sup>2</sup>
Indentation <sup>3</sup>	18mm	18mm	18mm	18mm	18mm	18mm	18mm	18mm	+>18mm possible <sup>3</sup>
Outer Glass <sup>3</sup>	10mm Dynamic	10mm Dynamic +Iron-free	10mm Dynamic +Coating	10mm Dynamic	10mm Dynamic	10mm Dynamic	10mm Dynamic	10mm Dynamic +Iron-free +Coating	+>10mm <sup>4</sup> +Pyrolytic (hard) Coating
Middle Glass <sup>3</sup>	4mm LowE	4mm LowE +Iron-free	4mm LowE	4mm LowE	4mm LowE	4mm LowE	4mm LowE	4mm LowE +Iron-free	+>4mm <sup>4</sup> +Tempered
Inner Glass <sup>3</sup>	4mm LowE	4mm LowE +Iron-free	4mm LowE	4mm LowE	+44.2 LowE	+44.4 LowE	+11mm Fire Glass	4mm LowE +Iron-free	+>4mm <sup>4</sup> +Tempered +Laminated
Gas	95% Argon	95% Argon	95% Argon	95% +Krypton	95% Argon	95% Argon	95% Argon	95% +Krypton	+Krypton
Spacer	16mm Warm Edge Black	16mm Warm Edge Black	16mm Warm Edge Black	14mm Warm Edge Black	16mm Warm Edge Black	16mm Warm Edge	16mm Steel	16mm Warm Edge Black	+6-20mm <sup>5</sup> , other type and color possible <sup>6</sup>
Secondary Sealing	Silicon	Silicon	Silicon	Silicon	Silicon	Silicon	Silicon	Silicon	

<sup>1</sup> Comes with 0.5m cable, extended up to 10m.

<sup>2</sup> Can be 15m if cable doesn't cross high-current or communication cable, 20m if one uses twisted-pair cable and doesn't cross high-current or communication cable. At twisted-pair cable, cable diameter becomes larger.

<sup>3</sup> Size & loads can affect the requirements for the thickness and indentation of the glass (spacer + secondary seal).

<sup>4</sup> May affect glass performance such as LT, g, Ra, etc.

<sup>5</sup> May affect glass performance as Ug.

<sup>6</sup> Steel, Aluminum, etc, and color according to the desired RAL and NCS color. Can affect glass performance as Uw (total glass insulation value)

## DETAILED SPECIFICATION

Below are some examples of possible solutions with ChromoGenics Dynamic Glass. Any special needs or questions, please contact ChromoGenics.

ChromoGenics Dynamic 75																													
Features: Always excellent access to daylight and view, good solar control and excellent thermal insulation																													
Suggested applications: Facade or Skylight glass with high demand on daylight, comfort and solar control.																													
Glass Configuration	Light Transmission (%)		Light Reflection, outside (%)		Ra-index		Direct Solar Transmission (%)		Direct Solar Transmission, 60° angle (%)		Total Solar-Energy Transmission (%)		Total Solar-Energy Transmission, 60° angle (%)		Thermal Insulation, center of glass (W/m <sup>2</sup> ·K)		Sound Reduction (dB)			Safety, inside		Protection		Fire Protection		Thickness (mm)		Weight (kg/m <sup>2</sup> )	
	LT max	LT min	LR max	LR min	Ra max	Ra min	ST max	ST min	ST60 max	ST60 min	g max	g min	g60 max	g60 min	U <sub>g</sub>	R <sub>w</sub>	R <sub>w</sub> +C	R <sub>w</sub> +Ctr	1(B)1	P2A	E	EW	EI						
<b>Dynamic 75 GL</b>	<b>73</b>	<b>39</b>	<b>11</b>	<b>8</b>	<b>95</b>	<b>92</b>	<b>56</b>	<b>28</b>	<b>47</b>	<b>22</b>	<b>64</b>	<b>43</b>	<b>55</b>	<b>37</b>	<b>5,29</b>	<b>35</b>	<b>34</b>	<b>33</b>	<b>1(B)1</b>	<b>P2A</b>				<b>10</b>	<b>21</b>				
+ Clear	75	40	11	8	94	93	62	31	53	26	68	45	59	40	5,28	35	34	33	1(B)1	P2A				10	21				
+ Anti-Condensation	71	38	12	9	95	92	53	26	47	22	62	41	55	37	5,29	35	34	33	1(B)1	P2A				10	21				
<b>Dynamic 75 2G</b>	<b>67</b>	<b>36</b>	<b>14</b>	<b>9</b>	<b>94</b>	<b>91</b>	<b>41</b>	<b>21</b>	<b>30</b>	<b>14</b>	<b>46</b>	<b>25</b>	<b>35</b>	<b>18</b>	<b>1,12</b>	<b>38</b>	<b>36</b>	<b>33</b>	<b>1(C)21</b>	<b>P2A</b>				<b>30</b>	<b>31</b>				
+ Clear	67	36	13	8	94	93	44	22	34	16	49	27	40	20	1,13	38	36	33	1(C)21	P2A				30	31				
+ Anti-Condensation	65	35	15	10	94	92	40	20	30	15	45	24	35	19	1,12	38	36	33	1(C)21	P2A				30	31				
+ Insulation	67	36	14	9	94	91	41	21	34	16	46	25	39	20	1,01	38	36	33	1(C)21	P2A				24	31				
+ Safety	65	35	14	9	94	90	38	19	28	13	45	25	35	18	1,14	40	39	36	1(B)1	P2A				34	42				
+ Security	65	35	13	9	94	90	39	19	28	13	46	25	36	19	1,09	41	40	35	1(B)1	P4A				34	42				
+ Silence	65	35	14	9	94	90	38	19	28	13	45	25	35	18	1,14	43	42	37	1(B)1	P2A				34	42				
+ Fire	65	35	16	9	94	90	42	21	33	15	52	31	43	25	2,37				1(B)1	P2A	30	30	20	37					
<b>Dynamic 75 3G</b>	<b>61</b>	<b>33</b>	<b>16</b>	<b>9</b>	<b>94</b>	<b>90</b>	<b>34</b>	<b>17</b>	<b>30</b>	<b>10</b>	<b>40</b>	<b>21</b>	<b>36</b>	<b>14</b>	<b>0,58</b>	<b>39</b>	<b>37</b>	<b>33</b>	<b>1(C)21</b>	<b>P2A</b>				<b>50</b>	<b>41</b>				
+ Clear	64	34	15	9	94	92	40	20	29	14	48	25	36	19	0,59	39	37	33	1(C)21	P2A				50	41				
+ Anti-Condensation	60	32	17	11	94	90	33	17	22	11	39	21	28	14	0,58	39	37	33	1(C)21	P2A				50	41				
+ Insulation	61	33	16	9	94	90	34	17	30	10	40	21	36	14	0,49	38	37	35	1(C)21	P2A				42	41				
+ Safety	60	32	16	9	93	89	32	16	20	9	39	21	28	14	0,58	41	40	35	1(B)1	P2A				54	52				
+ Security	59	32	16	9	93	89	32	16	20	10	40	21	28	14	0,57	41	40	35	1(B)1	P4A				55	53				
+ Silence	60	32	16	9	93	89	32	16	20	9	39	21	28	14	0,58	48	46	42	1(B)1	P2A				54	52				
+ Fire	59	32	18	10	94	89	34	17	23	11	42	23	31	16	0,87				1(B)1	P2A	30	30	20	57	0				
<b>Dynamic 75 4G</b>	<b>56</b>	<b>30</b>	<b>18</b>	<b>10</b>	<b>93</b>	<b>89</b>	<b>29</b>	<b>15</b>	<b>16</b>	<b>8</b>	<b>36</b>	<b>19</b>	<b>23</b>	<b>12</b>	<b>0,40</b>				<b>1(C)21</b>	<b>P2A</b>				<b>70</b>	<b>51</b>				
+ Clear	59	32	17	10	94	92	35	17	23	11	43	22	32	16	0,41				1(C)21	P2A				70	51				
+ Anti-Condensation	55	29	19	11	93	89	28	14	16	8	35	18	23	12	0,40				1(C)21	P2A				70	51				
+ Insulation	56	30	18	10	93	89	29	15	16	8	36	19	23	12	0,31				1(C)21	P2A				64	51				
+ Safety	55	29	18	10	92	88	27	14	14	7	35	19	22	12	0,40				1(B)1	P2A				74	62				
+ Security	54	29	17	10	92	88	28	14	15	7	36	19	23	12	0,40				1(B)1	P4A				75	63				
+ Silence	55	29	18	10	92	88	27	14	14	7	35	19	22	12	0,40				1(B)1	P2A				74	62				
+ Fire	54	29	19	10	93	88	29	15	17	8	37	20	25	13	0,51				1(B)1	P2A	30	30	20	77					
<b>Paragon 75 4G</b>	<b>57</b>	<b>30</b>	<b>18</b>	<b>11</b>	<b>93</b>	<b>91</b>	<b>33</b>	<b>16</b>	<b>23</b>	<b>11</b>	<b>41</b>	<b>20</b>	<b>31</b>	<b>15</b>	<b>0,32</b>				<b>1(C)21</b>	<b>P2A</b>				<b>64</b>	<b>51</b>				

Possible to combine the different solutions, as well as choose other glass types for higher safety and security classes.

<sup>1</sup> With tempered/toughened interior glass, otherwise no security

ChromoGenics Dynamic 65																													
Features: Always good access to daylight and view, excellent solar control and thermal insulation																													
Suggested applications: Facade or Skylights with high demand on daylight, comfort and solar control.																													
Glass Configuration	Light Transmission (%)		Light Reflection, outside (%)		Ra-index		Direct Solar Transmission (%)		Direct Solar Transmission, 60° angle (%)		Total Solar-Energy Transmission (%)		Total Solar-Energy Transmission, 60° angle (%)		Thermal Insulation, center of glass (W/m <sup>2</sup> K)		Sound Reduction (dB)			Safety, inside		Protection		Fire Protection		Thickness (mm)		Weight (kg/m <sup>2</sup> )	
	LT max	LT min	LR max	LR min	Ra max	Ra min	ST max	ST min	ST <sub>60</sub> max	ST <sub>60</sub> min	g max	g min	g <sub>60</sub> max	g <sub>60</sub> min	U <sub>g</sub>	R <sub>w</sub>	R <sub>w</sub> +C	R <sub>w</sub> +Ctr			E	EW	EI						
<b>Dynamic 65 GL</b>	66	17	11	7	93	88	51	12	42	7	60	31	52	26	5,29	35	34	33	1(B)1	P2A				10	21				
+ Clear	68	17	12	7	93	89	57	13	47	8	64	32	56	27	5,28	35	34	33	1(B)1	P2A				10	21				
+ Anti-Condensation	65	16	13	9	93	88	49	11	40	7	58	30	50	25	5,29	35	34	33	1(B)1	P2A				10	21				
<b>Dynamic 65 2G</b>	61	15	13	7	93	87	37	8	27	5	42	13	32	9	1,12	38	36	33	1(C)2 <sup>1</sup>	P2A				30	31				
+ Clear	63	16	13	7	93	89	44	10	31	5	49	14	38	10	1,13	38	36	33	1(C)2 <sup>1</sup>	P2A				30	31				
+ Anti-Condensation	59	15	15	9	93	87	36	8	26	5	41	12	31	8	1,12	38	36	33	1(C)2 <sup>1</sup>	P2A				30	31				
+ Insulation	61	15	13	7	93	87	37	8	27	5	42	13	32	9	1,01	38	36	33	1(C)2 <sup>1</sup>	P2A				24	31				
+ Safety	59	15	14	7	93	86	34	8	25	4	41	13	31	9	1,14	40	39	36	1(B)1	P2A				34	42				
+ Security	59	15	13	7	93	86	35	8	25	4	42	13	32	9	1,09	40	39	36	1(B)1	P4A				35	43				
+ Silence	59	15	14	7	93	86	34	8	25	4	41	13	31	9	1,14	43	42	37	1(B)1	P2A				34	42				
+ Fire	59	15	15	7	93	86	38	9	30	5	49	19	40	15	2,37				1(B)1	P2A	30	30	20	37					
<b>Dynamic 65 3G</b>	56	14	15	7	93	86	31	7	20	3	36	10	25	6	0,58	39	37	33	1(C)2 <sup>1</sup>	P2A				50	41				
+ Clear	58	15	15	7	93	88	37	8	23	4	44	11	30	7	0,59	39	37	33	1(C)2 <sup>1</sup>	P2A				50	41				
+ Anti-Condensation	54	14	18	9	93	86	30	7	19	3	35	10	25	6	0,58	39	37	33	1(C)2 <sup>1</sup>	P2A				50	41				
+ Insulation	56	14	15	7	93	86	31	7	20	3	36	10	25	6	0,49	38	37	35	1(C)2 <sup>1</sup>	P2A				42	41				
+ Safety	54	14	15	7	93	85	29	7	18	3	36	10	25	6	0,58	41	40	35	1(B)1	P2A				54	52				
+ Security	54	14	15	7	93	85	29	7	18	3	36	10	25	6	0,57	41	40	35	1(B)1	P4A				55	53				
+ Silence	54	14	15	7	93	85	29	7	18	3	36	10	25	6	0,58	48	46	42	1(B)1	P2A				54	52				
+ Fire	54	14	17	7	93	85	30	7	20	4	39	11	29	8	0,87				1(B)1	P2A	30	30	20	57	0				
<b>Dynamic 65 4G</b>	51	13	17	7	93	85	26	6	15	3	32	9	21	5	0,40				1(C)2 <sup>1</sup>	P2A				70	51				
+ Clear	53	13	16	7	92	88	31	7	18	3	39	10	26	6	0,41				1(C)2 <sup>1</sup>	P2A				70	51				
+ Anti-Condensation	50	13	18	9	92	88	25	6	14	3	32	8	21	5	0,40				1(C)2 <sup>1</sup>	P2A				70	51				
+ Insulation	51	13	17	7	93	85	26	6	15	3	32	8	21	5	0,31				1(C)2 <sup>1</sup>	P2A				64	51				
+ Safety	50	13	17	7	92	84	25	6	14	2	32	9	21	5	0,40				1(B)1	P2A				74	62				
+ Security	49	13	17	7	92	84	25	6	14	3	32	9	21	5	0,40				1(B)1	P4A				75	63				
+ Silence	50	13	17	7	92	84	25	6	14	2	32	9	21	5	0,40				1(B)1	P2A				74	62				
+ Fire	50	13	18	8	92	84	26	6	15	3	34	9	23	6	0,51				1(B)1	P2A	30	30	20	77					
<b>Paragon 65 4G</b>	50	13	18	9	93	86	26	6	15	3	33	8	21	5	0,31				1(C)2 <sup>1</sup>	P2A				64	51				

Possible to combine the different solutions, as well as choose other glass types for higher safety and security classes.

<sup>1</sup> With tempered/toughened interior glass, otherwise no security

## DESIGNING WITH INSULATION

Insulation is an important design factor for glass, and with ChromoGenics Dynamic Glass it is easy to find the right configuration according to insulation and thickness requirements, see table below.

Gas Filling	Dynamic Standard 2-Glass		Dynamic Standard 3-Glass		Dynamic Standard 4-Glass	
	Thickness (mm)	Ug-value (W/m <sup>2</sup> K)	Thickness (mm)	Ug-value (W/m <sup>2</sup> K)	Thickness (mm)	Ug-value (W/m <sup>2</sup> K)
6mm Argon	20	1,93	30	1,19	40	0,86
8mm Argon	22	1,62	34	0,96	46	0,69
10mm Argon	24	1,41	38	0,82	52	0,58
12mm Argon	26	1,25	42	0,71	58	0,50
14mm Argon	28	1,13	46	0,64	64	0,44
16mm Argon	30	1,12	50	0,58	70	0,40
18mm Argon	32	1,13	54	0,54	76	0,37
20mm Argon	34	1,14	58	0,55	82	0,35
6mm Krypton	20	1,36	30	0,78	40	0,55
8mm Krypton	22	1,12	34	0,63	46	0,44
10mm Krypton	24	1,01	38	0,54	52	0,37
12mm Krypton	26	1,03	42	0,49	58	0,33
14mm Krypton	28	1,05	46	0,50	52	0,31

*Insulating glass use LowE 1.1 coating(s) as middle and inner glass*

*Argon = 95% Argon, 5% Air*

*Krypton = 95% Krypton, 5% Air*



## MEASUREMENTS AND CALCULATIONS

### Standard angle, 0° angle of incidence

Light transmission (LT), Light Reflection (LR), Ra-index, Direct Solar Transmission (ST) and g-value/SHGC (g) according to EN410 is measured according to standard procedure and calculated with LBNL Optics 6.0 & Windows 7.1.1. Measurements have been carried out by glass producers or by the Ångström Laboratory in Uppsala, calculations of ChromoGenics.

### Complementary angle, 60 ° angle of incidence

Direct Solar Transmission at 60 ° angle (ST60), the g-value/SHGC at 60 ° angle (g60) is measured at angle and calculated according to EN410 with LBNL Optics 6.0 & Windows 7.1.1. Measurements have been carried out by the Ångström Laboratory in Uppsala, calculations of ChromoGenics.

### Other

U<sub>g</sub> for vertical facade glass (90 °) value according to EN673 calculated with LBNL Windows 7.1.1

Sound Reduction according to EN717-1

Safety according to EN12600

Security according to EN356

Dynamic properties are measured and calculated by ChromoGenics.

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For questions, please contact ChromoGenics