PLEXIGLAS® SHEET: Moisture Absorption

ACRYLIC SHEET

PLEXIGLAS® MOISTURE ABSORPTION

THERMAL AND HUMIDITY DIFFERENTIAL BOWING

Plexiglas® is a dimensionally stable thermoplastic material. With changes in humidity and temperature slight changes in dimensions may occur. The magnitude of these changes in dimensions can be determined by using the data in this bulletin and the data in Bulletin PL-74 "Thermal Properties of Plexiglas®."

The change in dimensions caused by a change in humidity does not occur instantaneously but requires several days to reach equilibrium. Climatic changes are rarely stable long enough for Plexiglas® to equilibrate at a given humidity. When changing from one equilibrium condition to another, if the humidity change is small (10 to 30 percent relative humidity differential), the major part of the small dimensional change will occur within 15 to 30 days. If the humidity change is large (>60 percent relative humidity differential), as long as 70 days may be required to reestablish dimensional equilibrium. For thick sheets, the time required to reach equilibrium is longer, for thin sheets, shorter.

Graphs 1 and 2 show the magnitude of dimensional changes in Plexiglas® G or 11 UVA and Plexiglas® 55 on going from equilibrium at one relative humidity to equilibrium at another relative humidity. Data are given for room temperature (77°F) and elevated temperature (122°F). The curves show that the dimensional change caused solely by changing humidity is greater, the higher the temperature.

If the different temperatures or humidities exist on opposite sides of a Plexiglas® panel, the surface next to the higher temperature or higher humidity will expand more than the other surface and the panel will bow. This bulletin tells how to calculate the extent of bowing of unrestrained panels due to temperature differentials and humidity differentials, alone or in combination. In service, Plexiglas® panels are seldom used in a completely unrestrained condition. The maximum bowing calculated from this bulletin will be reduced in service when the panel is properly restrained. Although edge restraint reduces the bowing, it also creates stress in the panel not present in unrestrained panels at equilibrium with environmental temperature and humidity. Bowed Plexiglas® panels cause distortion in image reflections. However, bowing does not materially affect visibility through the Plexiglas® panel.

TEMPERATURE DIFFERENTIAL BOWING

If an unrestrained Plexiglas® panel is mounted so that its two surfaces are exposed to different temperatures, it will bow. The direction of this bowing will be toward the higher temperature. The extent of bowing can be determined by following the method given in Example A (see Appendix).

HUMIDITY DIFFERENTIAL BOWING

Under normal atmospheric conditions Plexiglas® contains about 0.5 percent water. When subjected to high or low humidity, the water content changes, resulting in dimensional changes. When the two surfaces of an unrestrained Plexiglas® panel are exposed to different relative humidity, the dimensional change will cause the panel to bow in the direction of the more humid atmosphere. The extent of bowing can be determined by following the method given in Example B (see Appendix).

COMBINED EFFECTS OF TEMPERATURE AND HUMIDITY DIFFERENTIALS

In practice, Plexiglas® panels are usually exposed to temperature and humidity differentials simultaneously. Under these conditions, the resultant bowing is the algebraic sum of the effects of temperature and humidity differentials. If the differentials act in the same direction, the total bowing is equal to the sum of the two. If they act in opposite direction, the total bowing is the difference between them. The amount of bowing expected under such condition scan be determined by following the method given in Example C (see Appendix).

APPENDIX

EXAMPLE A TEMPERATURE DIFFERENTIAL BOWING

Problem:

How much bowing can be expected in an unrestrained 30" diameter 0.187" thick Plexiglas® G panel which has a surface temperature of +60°F on one side and +100°F on the other side?

Solution:

1. Determine the average coefficient of thermal expansion for Plexiglas® G and the +60°F and +100°F intercepts from Graph 1, Bulletin PL-74, "Thermal Properties of Plexiglas®." The average of these values is: 0.000039"/"/°F + 0.000046"/"/°F = 2 0.0000425"/"/°F

Note: Surface temperatures must be used in this calculation. In the case of an air-Plexiglas® air installation, the actual surface temperature is significantly different from the temperature of the surrounding air and must be measured or calculated (see Bulletin PL-74).

2. Multiply the average coefficient of thermal expansion by the difference in temperature at the two surfaces (100°F - 60OF = 40°F): 0.0000425"/"/°F X 40-F = 0.0017"/"

3. Using Graph 3, lay a straight edge between the 0.0017 mark on Scale C and the 0.18711 thickness on Scale T and it will intercept Scale R at 110". Then lay the straight edge from this point to the 30" mark (diameter of the panel in this example) on Scale D and continue the line to Scale H. The center deflection (bow) can be read from Scale H and is found to be 1.03".

EXAMPLE B

HUMIDITY DIFFERENTIAL BOWING

Problem

How much bowing can be expected in an unrestrained 30" diameter 0.18711 Plexiglas® G panel which is subjected to relative humidities of 25 percent on one surface and 75 percent on the other surface when the panel is maintained at 77°F?

Solution

1. Find the difference in the unit length by subtracting the low humidity intercept from the high humidity intercept on Graph 1: 0.0023"/" - 0.0004"/" = 0.0019"/"

2. Using Graph 3, lay a straight edge between the 0.0019 mark on Scale C and the 0.187" mark on Scale T intercepting Scale R at 100". Lay the straight edge from this point on Scale R to the 30" mark (diameter of the panel in this example) on Scale D and continue the line to Scale H. The center deflection (bow) is read from Scale H and found to be 1.15".

EXAMPLE C
COMBINED EFFECTS OF TEMPERATURE AND HUMIDITY DIFFERENTIALS
Problem:
How much bowing can be expected in an unrestrained 25" diameter 0.187" thick Plexiglas® G panel which has a surface temperature of 77°F and a relative humidity of 25 percent on one side and a surface temperature of 122°F and a relative humidity of 60 percent on the other side?

Solution:
1. Determine the average coefficient of thermal expansion for Plexiglas® G at 77°F and 122°F from the data in Bulletin PL-74 as in Example A. Note that the graph of coefficient of thermal expansion in PL-74 goes only to 100°F. However, the curve can be extrapolated to 122°F giving a value of 0.00005"/"/°F.
0.000042"/" + 0.00005"/" = 0.000046"/" 2

2. The temperature differential alone would cause a dimensional change of: 0.000046"/" X 45 = 0.0021"/"

3. From the curves, Graph 1, the dimensional change produced by the humidity differential is: 0.0026"/" - 0.0004"/" = 0.0022"/"

4. Since both the humidity and temperature differentials are causing the Plexiglas® to bow in the same direction in this example, the bowing may be calculated by adding the dimensional changes: 0.00211"/" + 0.0022"/" = 0.0043"/"

5. On Graph 3, lay a straight edge between the 0.0043"/" point on Scale C and the 0.187" thickness on Scale T and extend the line to Scale R. Scale R must be extended slightly to intersect the line thus drawn. Connect this point and the 25" diameter on Scale D and extend to Scale H reading a deflection (bow) of 1.8".

If the problem in Example C is revised so that one surface is at 77°F and 60 percent relative humidity while the other surface is at 122°F and 25 percent relative humidity, the differentials tend to cause bowing in opposite directions. In step 4 of the solution, above, the dimensional changes are subtracted from one another rather than added: 0.0022"/" - 0.0021"/" = 0.0001"/"

A dimensional change as small as this cannot be converted to a deflection using Graph 3, showing that the temperature and humidity differentials almost completely cancel one another in this example.

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