Condensation on Indoor Glass Surface

The minimization of condensation on the indoor glass surface is an important consideration in the selection of windows for residential applications, or glass and metal framing systems for commercial applications. Knowledge of the factors that influence the formation of condensation, combined with good design principles, and the selection of appropriate products can achieve the desired results.

An in-depth discussion of the pschrometric principles involved is beyond the scope of this document. The reader is encouraged to reference resources, such as the ASHRAE Handbook of Fundamentals, or other textbooks dealing with psychrometrics to gain the necessary understanding.

The purpose of this document is to offer a first level, simplified explanation of the cause of condensation and to offer a relative indication of the performance of selected Vitro (formerly PPG Industries) glass products with regard to the occurrence of condensation.

If the temperature of any object (e.g., grass, wood, cement, glass, etc.) falls below the dew point temperature of the surrounding air, condensation (liquid water) from the water vapor (gas) in the surrounding atmosphere begins to form on the surface. NFRC 500, "*Procedure for Determining Fenestration Product Condensation Resistance Values",* defines the Dew point temperature as: *temperature at which water vapor condenses to liquid water at a given relative humidity.*

Obviously, the goal for windows and commercial glazing systems is to select products that, under assumed design conditions, have thermal properties that maintain the indoor surface temperature above the dew point temperature. To assist design professionals to make the proper choices, the American Architectural Manufacturer Association developed the *Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.* The current version is available from AAMA as Publication No. 1503-98. More recently, the National Fenestration Rating Council developed and published *NFRC 500: Procedure for Determining Fenestration Product Condensation Resistance Values* (published in January, 2002). The NFRC also developed and published *NFRC Special Publication 500UG-2002* which is a user guide for NFRC 500.

Both the AAMA and NFRC procedures result in a relative rating number for windows and glazing systems.

The AAMA rating number is known as ***Condensation Resistance Factor (CRF)***; the NFRC rating number is known as ***Condensation Resistance (CR)***

In both cases the established rating number is a <u>relative rating</u> developed for a single set of specified design conditions.

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AAMA 1503 is a test method that measures the thermal characteristics of the glazing (windows, doors, glazed exterior wall sections) under steady-state conditions using a specified set of design conditions.

NFRC 500 is a procedure that includes both a test method and a simulation method. The test method is similar, but not exactly the same as for AAMA 1503. The simulation method is based on a 2-dimensional heat transfer simulation and must be performed with NFRC approved software tools.

Whether by test or simulation, the purpose is to establish a temperature profile, under the specified design conditions, across the indoor surface of both the glass and framing system. Finally, using calculation techniques given in both documents, either the CRF or CR is calculated.

> It is important to recognize that a meaningful rating number (either CFR or CR) is based on not one, but a number of measured or simulated temperatures at various locations on both the glass and glazing system.

The procedure for selecting the required data points is detailed in the referenced documents.

Glass installed in framing systems typically can have significant temperature variations across both dimensions. These variations are influenced by the framing system, air movement, and - in the case of insulating glass units - spacer material and design, sealant material and dimensions, and even changes in barometric pressure, which causes the air space gap to expand or contract. Therefore, a CFR or CR for the glass itself is meaningful only when generated for a specific framing system and, of course, only for the specified design conditions used to perform the test or simulation.

Condensation may occur even after rigorous attention is devoted to testing or simulation to select the proper products. Some of the causes of this unexpected condensation include:

- Outdoor conditions that are more severe than those specified for the simulation or test.
- Air leakage through the framing system.
- Indoor environmental conditions that are different than those specified for the simulation or test. For example: If the specified indoor relative humidity was 40%, but the actual relative humidity is higher, condensation may occur.
- Changes in the interior space such as:
  - ✓ Partitions, shades, obstacles, etc. that influence air movement across the glass surface.
  - ✓ Plants, aquariums, etc. that increase relative humidity, often only in the microclimate adjacent to the glass.

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While this document has focused on condensation on the indoor surface of glass, it should be recognized that condensation could also occur on the outdoor glass surface. This is more likely to occur with today's high performance low-e coated glasses. It does not constitute a problem with the glass, rather it is actually because the glass is doing what is intended – reducing heat loss. Please refer to Vitro's TD-102, "*Outdoor Condensation on Glass*" for further discussion.

Finally, as a good faith attempt to assist our customers and others to evaluate the relative performance of Vitro glass products in resisting the formation of condensation, we offer the graphs shown on the following pages. The graphs are not intended to be, nor should they be construed as anything more than a first level guide to help in the selection of candidate products to meet design requirements.

The final product selection must be subjected to the more rigorous procedures of either the AAMA or NFRC methodology, or other methodology that is acceptable to the design professional.

While the graphs are labeled, the following points are emphasized to ensure that the user clearly understands what is shown.

- ► The curve (in red) represents the relationship between the indoor glass surface temperature and the relative humidity at which condensation would be predicted to form.

- ► Three graphs are given and represent the following assumed design conditions:

Assumed Design Conditions			
	Graph #		
Design Condition	**1**	**2**	**3**
Outdoor Air Temperature (°F.)	-20	0	+20
Outdoor Air Velocity (mph)	15	15	15
Indoor Air Temperature (°F.)	70	70	70
Indoor Air Velocity (mph)	0	0	0

- ► The Vitro glass products shown on the graphs are located by predicted <u>center-of-glass</u> indoor glass surface temperature as generated by the LBL Window 4.1 computer program.

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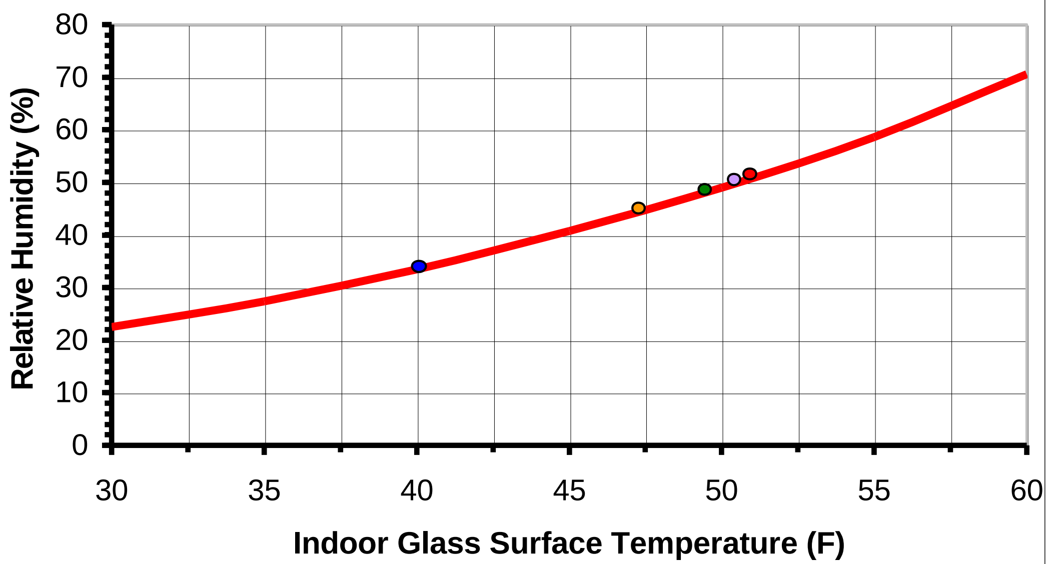
LEGEND FOR USE WITH GRAPHS Simulated Product: 1" Insulating Glass Unit with ¼" Glass for Both Lites and ½" Airspace - *Except as Noted*	
SYMBOL	**PRODUCT REPRESENTED**
● (blue)	Clear, all tints, Solarcool® coated glass
▲ (blue)	1/8" Clear, Tinted, or Solarcool Glass – Argon fill (Graph 2 only)
● (orange)	Sungate® 500 coating on the #2 or #3 surface
● (green)	Sungate 100 coating on the #2 or #3 surface
● (lavender)	Solarban® 60 coating on the #2 or #3 surface
▲ (lavender)	1/8" Clear Glass with Solarban 60 Coating on the #2 or #3 surface – Argon fill (Graph 2 only)
● (red)	Solarban 80 coating on the #2 or #3 surface

GRAPH #1 – *Outdoor Air Temperature @ -20°F.*



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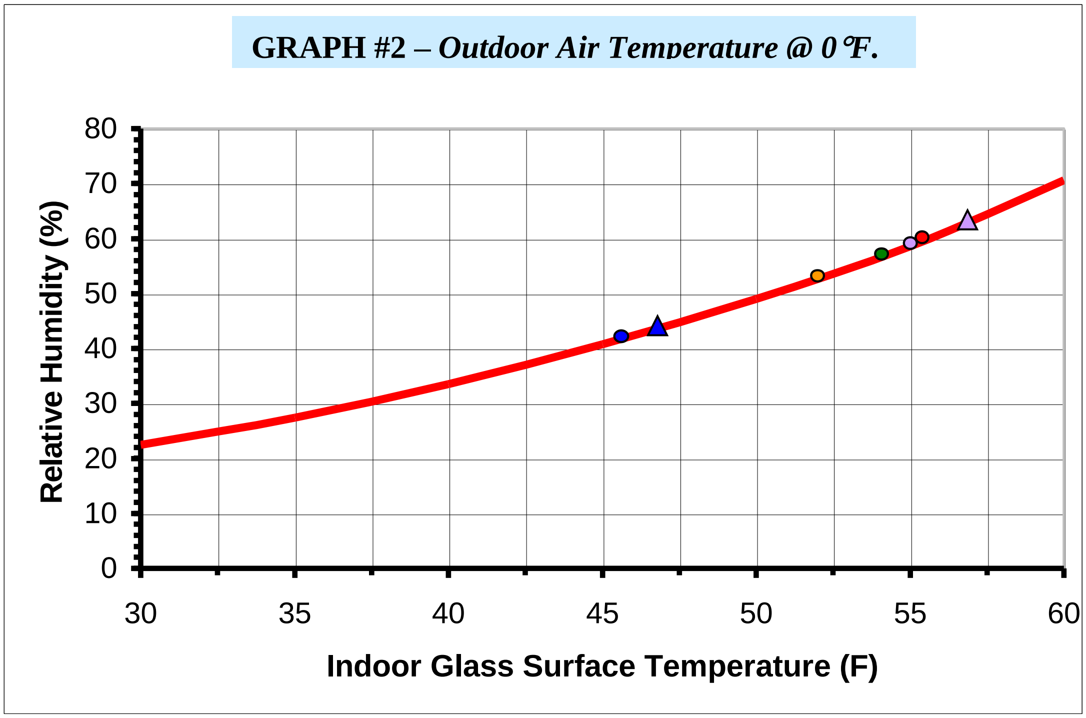

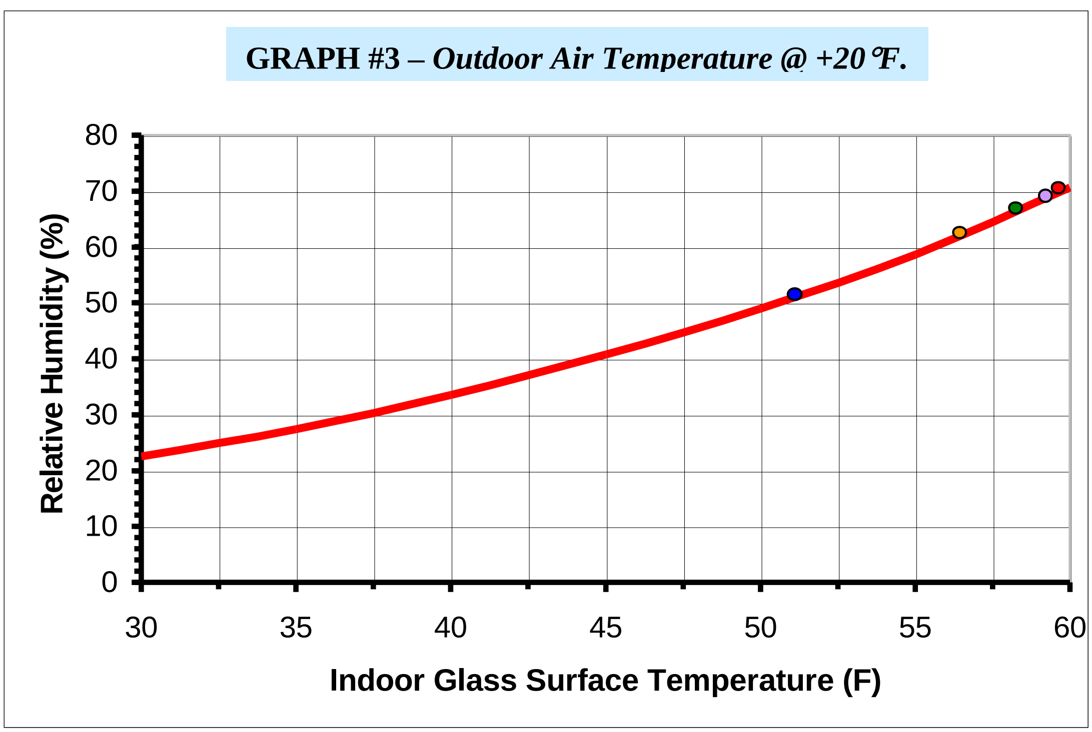

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HISTORY TABLE		
ITEM	DATE	DESCRIPTION
Original Publication	21 Mar 2003	TD-133
Revision 1	2016-10-04	Updated to Vitro logo and format