NATIONAL GLASS ASSOCIATION with GANA

Glass Technical Paper **XXXX (year)**

Guidelines for Use of Capillary Tubes

Introduction

The use of capillary tubes in IGUs has long been established as a means to accommodate changes in elevation of an IGU from the point of IGU manufacture to the point of installation. Such elevation changes create pressure differentials between the IGU glazing space and the exterior environment that, unless alleviated, can cause glass deflection, excessive edge sealant stress, and/or glass breakage. These pressure changes can be exacerbated by internal heating of the IGU due to the radiant effects of the sun. Capillary tubes act as mechanisms for relieving this pressure differential over a short period of time.

Breather tubes are an alternative to capillary tubes, serving a similar function but having much larger diameters. While breather tubes utilize the same mechanism for pressure equalization between the IGU interior and the ambient exterior air, the larger diameter has the potential to allow a rapid gas exchange that may introduce excessive moisture into the IGU. This has the potential for reducing the life of the IGU. For this rea- son, use of breather tubes is not recommended for use in insulating glass and is not addressed in this document.

While the benefits of using capillary tubes are straightforward, several factors should be considered when determining whether to use them, including:

1. Magnitude of elevation change to require use
2. Insulating Glass Unit (IGU) pressurization due to temperature difference
3. Use with insulating gases
4. IGU sizes and aspect ratios
5. Glass thickness, type and coatings
6. IGU cavity width
7. Short term (in transit) vs. long term (installed) elevation and/or temperature changes
8. Types of edge seal construction
9. Multiple-cavity IGU's (triples, quads, etc.)
10. Proper IGU design and fabrication for use of capillary tubes

This document discusses considerations for the use of capillary tubes and provides direction for proper design according to application and explores advantages and disadvantages of their use in insulating glass. Contact the fabricator for specific guidelines. Fabricator guidelines supersede any instructions contained within this document.

1.0 Terminology

1.1 Breather Tubes: Tube(s) inserted in an IGU to control unit internal pressure during shipping. They generally have a 3 mm (0.125 in) inside diameter and are made of either aluminum, copper, polyethylene, or other materials. These tubes must be closed at the job site or IGU failure could result. They permit rapid pressure equalization of the IGU airspace.

1.2 Capillary Tubes: Tube(s) inserted in an IGU to control unit internal pressure during shipping and / or during in-service use. They are typically either 0.53 mm (0.021 in) I.D. stainless steel tubes 300 mm long (12 in) long or a0.81 mm (0.032 in) inside diameter I.D. aluminum tubes. They allow gradual pressure equalization within the IGU airspace. Depending on application, capillary tubes may or may not need to be closed at the job site. Contact fabricator for guidance.

2.0 General Information and Considerations

Capillary Tube Function

Many theories and misconceptions have emerged on how capillary tubes work. Theories such as "an open capillary tube has a small enough diameter to only allow air to diffuse and not a water molecule" are not accurate. The diameter of the capillary tube is significantly larger than the diameter of a water molecule, being over a million times the size. Testing conducted by outside laboratories has shown moisture diffusion through the tube is a function of several factors, including, but not limited to, tube diameter, tube length, humidity level and pressure changes.

Moisture can be transported into the IGU by the pressure changes caused by daily and seasonal temperature changes ("breathing" of the IGU). In some IGU constructions (primarily smaller IGUs), this mode of transport can allow significant amounts of moisture into the airspace. Capillary tube IGUs are designed for the purpose of relieving pressure associated with high altitudes, typically mountainous areas with low humidity. It is preferred that capillary tubes are closed at the time of installation after pressure equalization has taken place (see Equalization Rate, below) as open capillary tubes may reduce the longevity of the IGU. Although this conservative approach is preferred, it is not uncommon, for a variety of reasons, for capillary tubes to be left open after installation.

Equalization Rate

The rate of equalization is dependent upon temperature, barometric pressure, altitude, IGU dimension, glass thickness, cavity width, and the type of insulating glass spacer. Typically, the majority of pressure equalization will occur within 48 hours. As the IGU pressure equalizes, the pressure difference becomes less, and, therefore, the rate of pressure equalization is reduced. IG fabricators should provide specific instructions regarding the length of time required for pressure equalization before sealing a capillary tube.

3.0 Capillary Tube Advantages and Disadvantages

3.1 <u>Advantages:</u>

3.1.1 Relieve pressure caused by elevation changes from point of manufacturing to job site that could cause glass breakage or severe visual distortion.

3.1.2 Reduce pressure changes caused by elevation differences during transport that may cause shipping related breakage.

3.1.3 Assist in equalizing unit pressure during some types of unit fabrication processes.

3.1.4 Minimize reflective distortion due to glass deflection caused by barometric pressure and/or temperature changes (when capillary tubes are left open).

3.1.5 Maintain thermal performance by maintaining the intended airspace width (when capillary tubes are left open).

3.1.6 Reduce the mechanical stress on glass and sealant during in-service use caused by glass deflection due to airspace pressure changes (when capillary tubes are left open).

3.1.7 Minimize aesthetic or functional concerns caused by glass contacting internal components, especially with narrow airspace IGUs (when capillary tubes are left open).

3.2 Disadvantages:

3.2.1 Add processing step during IGU fabrication and introduce additional workmanship considerations.

3.2.2 Allow escape of gas content through capillary tubes.

3.2.3 Difficulty in closing tubes in the field.

3.2.4 Inability to close tubes in window sash.

3.2.5 Introduce a path for some moisture to enter and exit the IGU (when capillary tubes are left open) which could reduce the life of the IGU.

3.2.6 Result in negative effects when used in conjunction with moisture-sensitive films and glass coatings.

4.0 Workmanship Considerations

4.1 The sealant must have good adhesion to the capillary tube.

4.2 The sealant must completely seal the area around the tube where it penetrates the IGU.

4.3 Inadvertently closing or plugging the tube during fabrication, shipping or installation negates its value.

4.4 Additional desiccant may be required to compensate for moisture entry into the IGU when capillary tubes are left open.

5.0 Manufacturing Considerations and Guidelines

5.1 IGU fabricator should consider variables such as IGU construction, installation altitude, unit size, airspace thickness, glass type and thickness, manufacturing versus installation altitude when capillary tubes should be used.

NOTE 1: Use of capillary tubes is not recommended with gas filled IGUs, as gas content will escape through the capillary tube, reducing the gas concentration.

5.2 The capillary tube can be inserted in a corner or through any leg except the bottom.

NOTE 2: For butyl sealant spacer systems, the capillary tube should be inserted as per the spacer or sealant fabricator's recommendations.

5.3 The capillary tube can be inserted in either desiccated side or non-desiccated sides. When using the desiccated side, it is important that the desiccant does not block the tube during insertion.

5.4 A sufficient length of the tube must extend beyond the IGU to allow for bending the tube in place without kinking and embedding the tube end in the perimeter sealant.

5.5 The area around the tube where it penetrates the seal must be completely sealed with the insulating glass perimeter sealant.

5.6 Typical capillary tube length is approximately 30 cm (12"). Use of shorter tubes may decrease IGU longevity.

5.7 Multiple glazing space IGUs (triples, quads, etc.): One capillary tube may be required for each cavity. Refer to TM-1300-13 Design Considerations for Multiple Cavity IG Units.

6.0 Storage and Handling

6.1 The fabricator's instructions for IGUs manufactured with capillary tubes should be followed, including, but not limited to: storage conditions, handling, and length of time to remain open. IGUs should not be stored in humid or moist environments, especially in contact with liquid water, or where physical damage to the tube may occur.

7.0 Glazing of IGU Utilizing a Capillary Tube

7.1 IGU with Tubes Remaining Open

7.1.1 IGUs should be glazed with the open end of the capillary tube pointing downward along the vertical dimension, and at least 2.5 cm (1 in.) off the bottom of the sash to prevent wicking of moisture into the tube.

7.1.2 Bending of the tube is only acceptable to accommodate vertical legs that are shorter than the tube. Care should be taken to avoid crimping or plugging the tube. In these instances, the tube should be inserted into the as-installed top leg of the IGU and bent around the corner so that the end of the tube is pointing down.

7.1.3 Shortening and twisting of the tube is not acceptable.

7.2 IGU with Tubes to be Closed

7.2.1 IGUs should be glazed in accordance with the IGU fabricator's recommendations.

7.2.2 Testing conducted by members of the IGMA Technical Services Committee and the Glazing Guidelines Working Group has shown capillary tubes can be closed by snipping the end of the tube with wire cutters or crimping the end of the tube with pliers and then adding a

sealant dab over the end of the tube. A few sealants that have been tested and may work well are extruded butyl sealants, polyisobutylene (PIB) and neutral cure silicone sealants. The IGU fabricator should provide snipping or crimping, and sealing techniques and requirements.

8.0 Design and Application Consideration for Environment Conditions

8.1 Altitude Changes and Duration

8.1.1 IGUs experiencing changes in altitude can fail from glass breakage, or pressure over loading of the edge seal. In addition, sliding doors and windows that employ sliding sash (vertical or horizontal sliders) may experience excessive deflection from the altitude changes that will result in the window not operating properly. Check with the IGU fabricator for recommendations regarding when capillary tubes should be used.

8.1.2 An IGU, from the point of fabrication to the final installed location, may undergo multiple elevation changes during transport. In cases such as shipment from US Midwestern States to the US or Canadian west coast through the US or Canadian Rocky Mountains there may be multiple elevation changes and, concurrently, short-term relative pressure changes between the IGU and ambient air. While these pressure intervals may be short in nature (several minutes to several hours) they may be quite extreme with elevation differences approaching 3,048 m (10,000 ft).

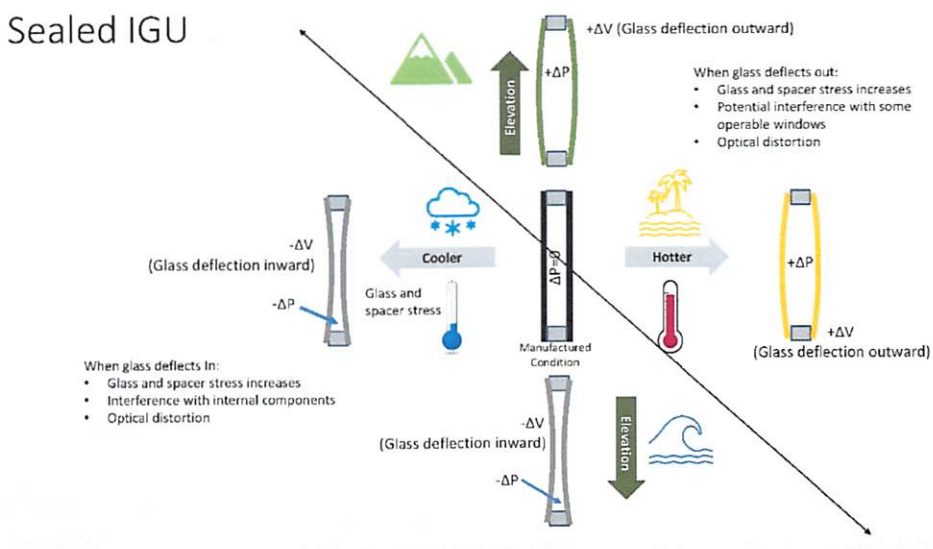
8.1.3 Depending upon the relative difference in elevation change and time duration between changes, capillary tubes may not be of sufficient diameter to enable a pressure equalizing response over these short periods of extreme pressure change. IGUs utilizing capillary tubes that experience such type of conditions should be treated as IGUs without capillary tubes and should be packaged to properly manage glass and edge seal stresses that will be experienced.

8.2 Sealing tubes over a wide range of temperatures and/or pressures may result in IGUs having varying degrees of flatness.

9.0 IGU Design Considerations

9.1 Gas Laws and IGU Behavior

A sealed IGU follows the Ideal Gas Law ($PV = nRT$) and Boyles Law ($P_1V_1 = P_2V_2$). See Figure 3 below:



9.2 Temperature

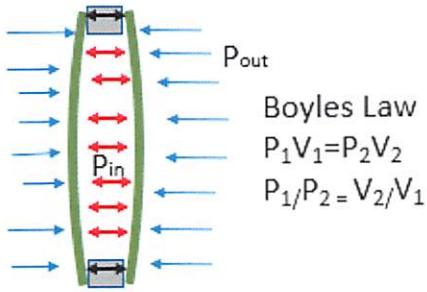
9.2.1 According to Ideal Gas Law:

- Increase in Temperature leads to an INCREASE in Pressure and/or Volume
- Decrease in Temperature leads to a DECREASE in Pressure and/or Volume

9.2.2 The relationship between Pressure and Volume is determined by the deflection of the glass in the IGU at a given temperature. In a sealed IGU, these variables may increase the internal pressure:

- Thicker glass
- Greater IGU cavity thickness (airspace)
- Increased aspect ratio

9.3 Pressure (elevation or other cause):



9.3.1 An increase in elevation of the IGU (transporting over the mountains) will REDUCE the external pressure on the IGU causing the glass to deflect outward increasing the internal volume and the decrease in internal pressure.

9.3.2 A decrease in elevation of the IGU (moving toward sea level) will INCREASE the external pressure on the IGU causing the glass to deflect inward decreasing the internal volume and an increase in internal pressure.

9.3.3 The relationship between the internal and external pressure of the unit is related to the deflection of the glass. The internal pressure is increased with:

- Thicker glass
- Greater IGU cavity thickness (airspace)
- Increased aspect ratio

9.4 Variables Affecting the Need for a Capillary Tube

- Glass area
    - Smaller areas result in higher pressure differentials
- Aspect ratio
    - Larger aspect ratios result in higher pressure differentials
- Glass thickness
    - Thicker glass results in higher pressure differentials.
- Spacer/cavity width
    - Wider IGU cavities result in higher pressure differentials.

9.4.1 Capillary tubes can be used to lessen the stress exerted on the IGU sealants and glass and can also be used to minimize the glass deflection the IGU may experience due to these conditions. A capillary tube creates a path for gas to flow into and out of the IGU resulting in an equalization of pressures between the inside and outside of the IGU over time.

9.4.2 The very small diameter of the capillary tube restricts the gas movement through the tube and affects the time it takes for the IGU to equalize. The time it takes for the internal pressure to equalize will be increased with:

- Larger internal volume of the airspace (either larger IGU or thicker IGU cavity width)
- Smaller differential between the internal and external pressures

9.4.3 In general, the conditions that drive higher pressure differentials, that would benefit from a capillary tube, are the same ones that drive a greater air exchange rate through the capillary tube. The air that is exchanged may allow moisture to enter the IGU as well. The IGU will pull air in as it cools down. Depending upon the environment in which this exchange takes place, this may shorten the life of the IGU. This effect is most severe in humid climates with large daily temperature differentials.

9.4.4 Multiple glazing space IGUs (triples, quads, etc.): One capillary tube may be required for each cavity. Refer to TM-1300-13 Design Considerations for Multiple Cavity IG Units.

10.0 References

10.1 TM-3000-90(04), IGMA North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use

10.2 NGA with GANA Glazing Manual

10.3 SIGMA, TB 1600-90; SG 2000-92

10.4 TM-1300-13 Design Considerations for Multiple Cavity IG Units

This Paper was developed by dedicated member volunteers and subject matter experts. This is the original version of this document. It was approved and published in 2023.