# Fundamental Concepts for the Design, Manufacture & Testing of Ig Units for Warm Climates

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## Abstract

Glass selection for IG Units for use in warm climates requires a different approach to the testing regimes currently available. Environmental issues like high temperature, solar and UV radiation has a significant influence on the type of glass and sealant required for the IG Unit. A modified test regime based on the 'Fit for purpose' concept will be offered for discussion.

## Historical Development

T. D. Stetson in 1865 was awarded a US patent for his idea of hermetically edge sealing two plates of glass.

There are essentially three types of IG Units, based on the type of edge seal, one in which the edge seal is made of glass, another has the glass edges soldered together and the third has the edges inorganically sealed. This type of IG Unit has been developed effectively since the early 1950's.

Present day IG Units use two different sealants, the primary seal generally consisting of a hot melt Butyl or a Poly Iso Butylene. This seal is the barrier to moisture permeation and the seal is generally plastic and does not cure. The secondary seal performs a structural function of holding the two panes of glass together. It has to provide good tensile and shear strength to the glass edge and the spacer. It must be compatible with all other glazing sealants to maintain long term performance of the IG Unit.

## International Standards

Significant laboratory and field studies have been undertaken on the performance of IG Units. These studies have validated the expected longevity of the units in the field. It has to a large extent validated the established test regimes currently in place. Researchers in the established IG Unit markets of the world have carried out most of this work.

A brief review of the existing International standards clearly shows the absence of an IG Unit standard suitable for a warm climate. Countries with a cold climate prepared all the existing standards. This fact is reflected in the test criteria. None of the existing standards have any tests that expose the IG unit to high temperatures. In addition there is no provision for any UV radiation in any of the established IG Unit test regimes.

The use of IG Units in the southern states of the US is now growing significantly. In addition IG Units are gaining popularity in most Arid and tropical regions of the world. Soon there will be a need for some modifications to be made in the testing regimes for IG Units.

## Design Criteria

The design of IG Units for use in warm climates does not require any significant changes in the fundamental principles used for conventional IG Unit systems. Some of the additional factors that must be remembered are the environmental conditions under which the units are to be manufactured, the type of sealants to be used for the primary and secondary seals and the environmental conditions to which the units will be exposed.

Temperature fluctuations produce pressure differentials in insulating glass panes which induces a strong mechanical stress on the edge seal, especially in the case of small units. Furthermore, the difference in thermal expansions lead to the development of shearing and peeling


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forces in the edge seal. High temperatures accelerate most physical and chemical processes, such as aging of the sealant and water vapour diffusion through the edge seal.

Two component sealants are effected by temperature. For instance, with polysulphide sealants an increase in the environmental temperature of 5° C will reduce the work life of the sealant by half.

The application of structural silicone to the IG unit at elevated temperatures can cause out gassing in the silicone. This in turn will significantly effect the cohesive strength of the structural silicone.

The advent of structural glazing has exposed the edge of the IG Unit. Consequently, in warm climates the UV radiation can become a problem. Fortunately, structural silicone is relatively inert when exposed to UV radiation. The need for UV protection is still important even for IG units that are glazed in conventional frames due to the potential for internal reflections of UV radiation.

The operating environmental temperature will also impact on the selection of the type of sealant that needs to be used. It is not uncommon for installed IG Units to be exposed to environmental temperatures in excess of 50° C with a possible glass temperature of at least 80° C dependant on the type of glass used in the IG Unit composition.

For structural glazing applications the influence of the operating temperature range will have a significant influence on the calculated tolerances that need to be provided for the performance of the curtain wall. In addition high environmental operating temperatures relative to the temperature at which the IG Unit was manufactured will also cause bowing of the glass. This could be aesthetically unacceptable to the client.

The performance of the sealants used for the fabrication of the units must consider their capacity to perform under conditions of extreme heat and UV radiation. Given an environment where the ambient air temperature can reach 50° C then the frames and the glass (solar control ie. heat absorbing or reflective) could well exceed 80° C at which temperature the sealants performance could deteriorate and result in unit failures.

The use of setting blocks, location blocks etc. are also important factors that will influence the performance of the IG unit in warm climates. They could soften and thus effect the load transfer between glass and supporting frame. This will be especially true if the IG Unit does not have the bottom edges perfectly uniform relative to the setting blocks.

The manufacturing environment in warm climates is generally not conducive to the assembly of IG Units. Warm and tropical climates generally suffer high levels of humidity. Consequently it will be essential that the manufacturing facility have dehumidifying equipment set up to minimise the impact of humidity. Failing this the units will experience significant bow due to moisture absorption, in service.

## Current Test Regimes

The primary focus of all existing test methods relates to the durability & weatherability of sealants and measure of internal moisture content. The value of undertaking accelerated aging tests in small samples has been disputed, it is generally acknowledged that these tests normally constitute the most important part of the basis for a quick evaluation of new types of units.

Recent studies have indicated that the dew point method has become less useful, as modern desiccants require to have approximately 80% saturation before the dew point will rise above 50° C. The dew point method is unable to resolve dew formation temperatures below about –50° C.

Recent CEN investigations have showed that low temperatures did not fail seals. Only sustained high humidity was considered the main driving force of moisture into the sealed units, rather than high humidity cycling. There are no strength requirements or criteria in any of the existing test regimes. The use of structural silicone, for IG Units required in the construction of Unitised Curtain Wall facades must be tested for its adhesive and cohesive strength. IG Unit durability testing has evolved from the early 50's when the Canadians introduced the first test regime, into a plethora of different national standards and methods. The same glass, sealants and spacer systems are available worldwide.

## Recommended Test Regime for Warm Climates

This test regime is based on the various existing standards, with some additions to cater for the expected higher humidity, temperatures and UV radiation that exists in warm climates around the world.

*Weathering test:*

During the heating phase the test samples should also be subject to continuous UV radiation.

Place 4 test specimens in the laboratory weathering apparatus, so that the edges of the unit are not protected and one surface of each specimen is exposed to the normal laboratory environment (23 ± 2 °C) and the other surface to the weathering cycle conditions. Take care to




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ensure that no additional stress is induced in the units by the fastening method. The weathering program shall consist of 320 consecutive cycles. There shall be forced circulation of air through the apparatus and over the surface of the units, as follows:

Heating Phase: Period – 90 minutes. Raise the temperature of the weathering chamber to 85± 5 C within 60 minutes and maintain this temperature for the remainder of this phase.

Natural cooling Phase: This phase is programmed for 90 minutes. 60 minutes after commencement of this phase spray water over the surface of the units for 5 minutes. The water temperature should be 24 ±3˚C.

Forced Cooling Phase: This phase should last for 90 minutes. From the beginning of this phase the temperature should be reduced to – 10° C± 2° C within 60 minutes. And maintained at this temperature for the rest of this phase. This completes the typical weathering cycle.

Inspection: On the completion of the first 50 cycles, the specimens shall be removed from the cabinet and the Dew Point measured. All cracked units shall be replaced. If there is any condensation observed then the unit must be considered to have failed.

*High humidity testing:*

For this test 4 samples are placed in a high humidity cabinet, after determining the dew point, for 224 consecutive cycles of exposure. The samples are then exposed to air flow of not less than 95 percent relative humidity. Water is then sprayed continuously between the cabinet walls and a baffle and the temperature of the cycle must be maintained between 25 and 55 degrees centigrade.

Heating phase: this face should last 440 minutes. At the beginning of this phase the temperature in the cabinet is slowly raised to 90 degrees within 90 minutes and this temperature is maintained for the remaining of the phase.

Forced cooling phase: this phase is programmed to last 40 minutes. During this time the temperature is lowered to 25°C within thirty minutes and maintained at that temperature for the rest of the phase.

After 50 cycles of high humidity exposure the specimen units must be checked. Any cracked panels to be replaced and the cycle continued.

On completion of the 224 cycles the specimen units are removed from the cabinet and condition for a week at normal laboratory environment. Then the dewpoint measured.

Any condensation or frost formation will render the units and the test as having failed.

*Joint strength*

This test is designed to measure the strength of the joint (adhesive/cohesive strength of secondary sealant) by cutting out a 50 mm wide X 50 mm deep coupon from the control and exposed samples. That is, the coupon will consist of two pieces of glass with the spacer and the sealants as originally fabricated. A tensile load is then applied to the coupon to determine the tensile stress of the joint. Prepare one specimen coupon from each of the exposed IG units.

Using an Instron or any other Universal tensile testing machine and using a loading rate of 50 mm/minute pull the glass coupon apart. From the failure load and the cross-sectional area of the secondary sealant calculate the failure stresses.

Compare these results with the tensile strength obtained from the control sample.

For structurally glazed units it is important that the measured joint strength is compatible with the theoretical joint strength based on the silicone bite required for the particular application relative to the design loads.

Record any reduction in the joint strength between the exposed and the control samples. Any variation exceeding 20% between the control and the exposed samples will constitute a failure.

## Conclusions

After a development phase of more than 50 years, insulating glass units have reached a standard which ensures an average service life of 30 to 35 years. This has been validated for IG Units built and used in cold climates.

The major prerequisite for the service life of IG Units is that the edge seals continue to function perfectly during this time.

The impact of high temperatures that occur in warm climates can be significant in the performance of the IG Unit. High temperatures will induce stresses in the sealants. It is important that the sealants can accommodate these stresses. Unless the test regime accounts for these high temperatures, it will be virtually impossible to predict the unit's performance.

A further factor is the temperature difference between, where the IG Units are originally manufactured and where they will be used. The larger the difference the greater the risk of failure in the units.

The development of unitised structural glazing has in effect worsened the situation. This is especially true for the primary seal.

The industry has now become relatively automated with the availability of specialised manufacturing equipment. When these units are used for structural applications, it is possible that


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the design criteria could require a larger bite. The manufacturer must be made aware of this requirement.

The IG Unit sealants will be subject to significant stresses through the high temperatures available in warm climates. This will automatically impose additional stresses in the secondary sealant, especially if a standard joint is used in the construction of the IG Unit for structural applications.

None of the existing test regimes cater for the peak operating temperatures to which the units will be exposed.

It is strongly recommended that the industry consider the need for a test regime to be set up for the manufacture and use of IG Units in warm climate regions. The original development of IG Units was for use in cold climates. The industry has recognised the benefits of IG Unit construction in warm climates. We need to determine whether or not the current test paradigms are suitable for the new emerging market for IG Units.