Technical Bulletin

No. 001

Argon Gas Fill & Insulated Glass Units

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Argon Gas Fill – Ins & Outs

Argon gas is used within IGUs to improve thermal performance. As windows have a relatively low R-value to begin with, every improvement including low-e coatings, gas fills, and extra glazing layers are important. As we strive for more energy efficient buildings, enhancements such as using argon gas fill will become more commonplace. Based on a number of argon fill projects we have reviewed recently; the initial and ongoing argon fill in IGUs is variable.

Figure 1: Is the Argon gas fill that we specified actually present in these new windows?

The air we breathe is comprised of 78% nitrogen, 21% oxygen and 1% argon. Argon is commonly distilled from air during the production of liquid nitrogen and oxygen. Argon is non-toxic, non-reactive and has a thermal conductivity approximately 30% lower than air. On the periodic table argon falls into the class of Noble gasses including helium, neon, krypton, and xenon. Krypton and xenon are also used as gas fills to improve the performance of insulating glass units; however they are more expensive than argon.

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Insulating Glass Technology

One of the first questions asked is how much of a benefit is Argon gas fill within an insulating glass unit?

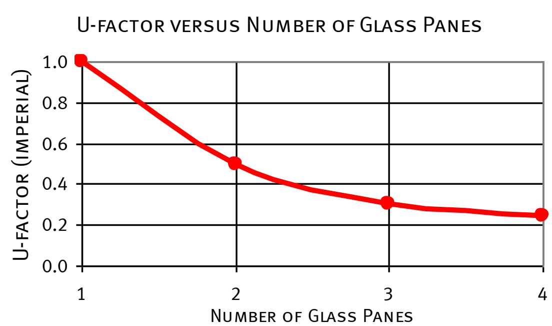

Figure 2: Glazing U-factor versus Number of Glass Panes

First consider a single pane of glass. The U-value (measure of heat flow) of this piece of glass is dependent only on the thermal conductivity of the glass and the surface air-films. The resulting U-value for a piece of ¼" glass is approximately 1.0 Btu/ft2·˚F·hr which is an R-value of 1.0 ft2·˚F·hr/Btu (herein referred to as imperial R-value which is equivalent to 1/U-value). Add a second layer of glass, separated by a ½" airspace, and the R-value would increase to approximately R-2. Add a third and fourth layer of glass (or suspended film) separated by airspaces and you end up with approximately R-4 and R-5 units (Figure

2). While this overall R-value is relatively low, what appear to be small improvements above these values can significantly impact the energy consumption in buildings, particularly in buildings with lots of windows (hint: think all new high-rises in the Lower Mainland).

Consider again the double glazed unit at R-2. To improve the performance, a low-emissivity (low-e) coating can be applied to one of the glass surfaces. Low-e coatings reduce radiant heat transfer across the airspace within the IGU. Low-e coatings also block selective wavelengths of sunlight from entering the building which reduces the Solar Heat Gain Coefficient (SHGC). These coatings are useful in managing summer time heat loads and fading and damage to interior finishes, flooring and furniture, while still maintaining sufficient levels of visible light, and light for indoor plants to thrive.

Taking the double glazed unit and adding a good low-e coating (emissivity of 0.04) to one interior glass surface, the R-value will increase from R-2 to R-3.3 (an improvement of 67%). The benefits of low-e coatings are obvious, and it appears that low-e coatings will be mandatory within most new windows in BC, where recent building code requirements have increased minimum overall window R-values to R-2.8 (U 0.36)- unattainable with clear double glazed units (Figure 3).

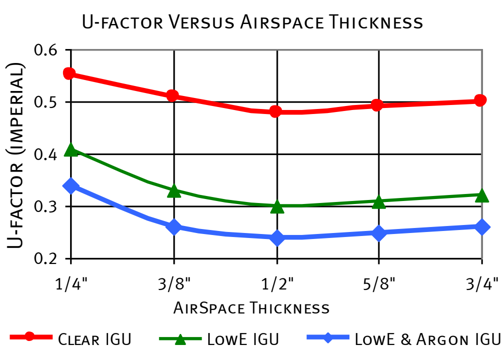

Figure 3: Glazing U-factor with Low-e and Argon Fill – Double Glazed Unit

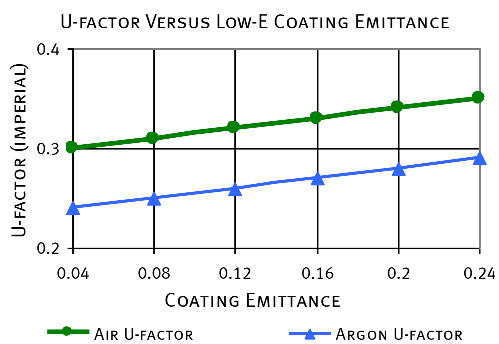

Figure 4: U-factor with Low-e Coating Emissivity

Low-e coatings can increase the R-value of double glazed unit by up to 67%.

Not all low-e coatings are created equal. Low-e technology has advanced to produce coatings with emissivity values as low as 0.022. By comparison, most natural earthen materials have an emissivity of 0.9 and shiny materials, like aluminum foil, have an emissivity around 0.2. Older and lower quality low-e coatings are not within the 0.02 to 0.04 range, but closer to 0.2, and have less of a thermal benefit. The relationship between low-e coating performance characteristics and U-value is linear, as shown in Figure 4. So it is always a good idea to ask the IGU fabricator, or use a program such as WINDOW or OPTICS to confirm the emissivity of the coating – the lower the better.

Argon gas is denser and therefore less conductive than air, and when sealed glass units are filled with argon gas, the convection within the airspace is significantly reduced, creating a better insulating unit. As shown in Figures 3 and 4, argon increases the R-value of the R-3.3 unit up to R-4.2 (a 25% improvement).

Argon fill can increase the R-value of a double glazed unit by up to 25%.

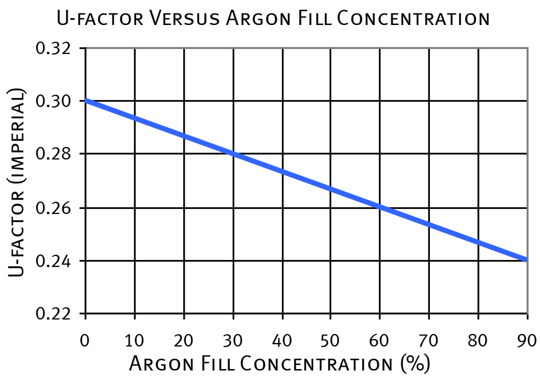

Figure 5: Glazing U-factor with Low-e and Argon Fill of Varying Concentrations.

The concentration of argon gas fill is important to this overall R-value, and the industry (IGMAC) accepted standard argon gas fill level is a minimum of 90%, out of the factory (the remaining 10% is air). As simplified in Figure 5, less argon equals less thermal improvement. Therefore, it is important to ensure that initial fill levels meet or exceed 90% (IGMAC guideline).

As windows are generally the poorest thermally performing element of the building enclosure, there is a strong drive to improve glazing performance to boost overall thermal efficiency. Currently selling at $1-2 per square foot for argon gas fill for a double glazed unit, short payback periods on the investment can be expected with rising energy costs.

Getting the Argon into the IGU

Getting the air out-of and argon into, a sealed glass unit may seem like a difficult task, but modern equipment including vacuum chambers or even simple hand-held filling methods have proven to be effective.

The simplest method involves drilling two holes into the glazing spacer bar and injecting compressed Argon gas into one end of the sealed unit and measuring the air coming out of the second hole until an argon concentration of 90% is achieved. The holes are then plugged and sealed. In some past cases these plugs have failed and the Argon gas has leaked out, or caused a failure in the perimeter seal of the IGU, so this method may not always be effective.

Figure 5: Glazing U-factor with Low-e and Argon Fill of Varying Concentrations.

The more modern method involves setting the primary seal of the unit within a vacuum chamber in the production line filled with at least 90% argon concentration (using a machine similar to that shown in Figure 6). Immediately following this, the secondary glazing seal is applied, trapping the argon within the glazed unit.

In the factory, for quality control during either method of filling, the argon concentration is checked with a special device (discussed in next section).

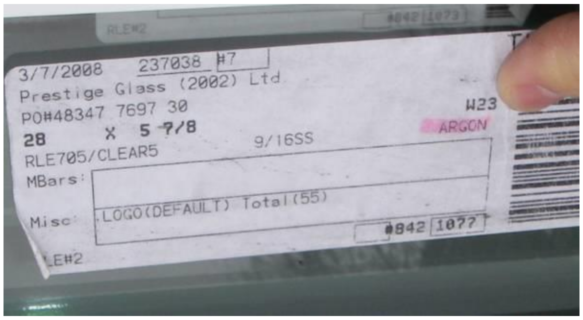

Figure 7: The glazing sticker says there is argon in the IGU - But is it really there?

Speculation that argon molecules leaking out of – or diffusing through – primary and secondary seals over-time are not well founded, at least when modern sealing technology is utilized. Research is showing that with current sealed unit technology argon gas or any other gas fill will remain within a sealed unit for life of the unit – hence the term "sealed". At most, argon may diffuse through some sealant materials at a rate of approximately 0.5% to 1% per year. At any greater rate it is likely that the primary or secondary seal is compromised, and the insulating glass unit will fail or has already failed.

Measuring Argon Fill in IGUs

One of our clients is replacing 30 year old single pane windows in two 1970s vintage exposed concrete high-rise buildings. The replacement program is intended to renew the appearance and performance of the two buildings, as well as enhance the energy efficiency. Overall, we will be improving the overall building R-value from R-1.4 to R-2.7 and increasing building air-tightness simply by replacing the old air-leaky windows. This is a big relative improvement (+93%), but further energy upgrades are still required to address the walls and other issues of this building. Note that most new high-rises in Vancouver have overall enclosure R-values from R-2 to R-6 at best, so R2.7 isn't all that bad relative to new construction projects.

In our specifications, we called for IGUs with low-e coating and argon gas fill to meet a minimum U-value of 0.24 (R-4.2). The window manufacturer sub-contracted the IGU production out to a large local glazing fabricator, who incidentally provides the majority of IGUs for other RDH rehabilitation products.

After production had started, the glazing fabricator noted having difficulties filling certain irregular sized IGUs. This raised the question of how do we assure that argon is present - without damaging the in-place glazing units.

Sparklike, a Finnish company owns the patent on, and produces a handheld device, which quickly and non-destructively measures the argon content within an insulating glass unit. The testing methodology is well established and accepted within the industry. The particular model we used was a GasGlass 1002 from Sparklike (Figure 8). A handheld model is also available.

Figure 8: Sparklike's GasGlass 1002 Analyzer

The principle behind the device is that a spark of electricity can be used to excite the argon atoms, which in turn emits light that is read by a spectrometer and converted to an argon concentration. Neon and fluorescent lights work on the same principle, where electricity causes the gas (neon or argon) to emit light.

The procedure for testing windows using the test unit is as follows:

1. Place the operating end of the analyzer on the surface of IGU opposite to the low-e coating. The low-e coating is used as a ground for the spark (and must be on the opposite side of the unit to work).
2. A button is depressed which emits a high voltage spark from the analyzer through the glass and across the airspace. If argon is present, the spark will arc and the atoms will emit light to the spectrometer.
3. The spectrometer measures the received spark light and an onboard computer interprets the information and calculates an argon percentage, which is displayed onscreen (Figure 9).

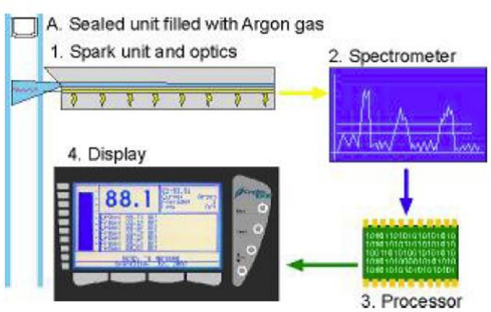

Figure 9: Argon Analyzer Process

Figure 10: Testing IGU units – prior to installation

The analyzer is accurate to within ±1% above 90% fill concentration, and ±2% between 80-90%. Below 80% the accuracy is ±5%, and below 50% concentration there is insufficient argon in the unit to create an arc across the airspace, and an error message will be returned. Visually observing the arc across the airspace provides indication of a good reading.

Our experience found that the readings from the analyzer were affected by backlight, and it was difficult to get accurate readings during sunny days. Testing is best performed on units indoors before they are installed, or at night when the units are in-situ. We also found that in units containing less than 60-70% argon fill – it was difficult to spark across the airspace. Error messages displayed by the machine indicated correct or invalid readings and errors etc.

Testing Results & Reality

As part of the testing protocol for the window replacement project, a total of 245 insulating glass units of various sizes were tested over 4 visits. Approximately 45,000 square feet of windows were supplied to the building over a period of 9 months. During this time IGUs were fabricated in batches, keeping with the progress of the window frame manufacturer.

Of the 245 units we tested, only 3 (1%) of the IGUs had argon fill concentrations above 90% (meeting IGMAC standard). A further 79 of 245 (32%) had concentrations between 75-90%, and 52 of 245 (21%) had concentrations between 50-75%. The remaining 111 of 245 (45%) had no measurable argon gas concentration or a concentration below 50%. A strong correlation was found between batch dates and the argon fill concentration. It appears that on certain dates the quality control was better than others. After we began testing in March, the fabricator improved quality control slightly. These results suggest that a manufacturing error instead of short-term argon loss from the units is occurring.

As follow-up, we tested more argon filled IGUs in two other buildings (under construction) which RDH is involved with. At the first project, IGUs are provided by the same fabricator as the previously mentioned rehabilitation project. Similar low argon concentrations and batch related deficiencies were found. None of the IGUs had argon fill concentrations above 90%, and 68% of the units tested had no measurable argon gas concentration (or less than 50%). At the second project, a different IGU fabricator provided the units. At this project, the majority of IGUs tested had argon fill concentrations above 90%, and met IGMA standards. We did however find batch related issues with a number of irregular sized units where Argon was missed.

Argon gas was not present or measurable within 45% of the units at one job and 68% at the other, both supplied by the same fabricator.

After the third project, it became apparent that testing of the argon fill within the factory is an essential quality control item. Some IGU fabricators, including both those tested; do intermittently check the argon fill concentration.

We still haven't received an acceptable explanation from the one IGU fabricator. The issue at this stage is that our clients may not always get what they pay for, and could end up with windows that are less thermally efficient than expected. We can now provide quality assurance of argon concentration as part of our field review services.

As a follow up, we have initiated a study with one client to measure the argon fill concentration of IGU units during fabrication and after several years in service. Measurements will be taken on the assembly line, when delivered to site, and several months to years after installation. This will provide insight that adequate provisions are being made at the factory and that the Argon is not leaking from the sealed units after installation.

Implications

So just what implications does this have for RDH? The preferable approach is to work with the IGU fabricators and develop solutions to resolve the quality control issues. The improvement that argon provides in IGUs is too significant to simply neglect. As we shift towards more energy efficient buildings, the use for argon gas fill will become increasingly popular and will become a standard request. We should be encouraging clients to select windows that will maximize their return on investment, and minimize life cycle costs. The use of argon fill is a low risk, relatively low cost investment with reasonable payback periods.

Future Bulletin Topics & Contact Information

Future bulletins will discuss the following topics:

→ Energy Consumption in High-Rise Residential Buildings – Impact of Enclosure Upgrades on Energy Efficiency

→ Window Materials Comparison – Life Cycle Costs and Energy Savings

→ Insulation of Spandrel Panels – Design for Thermal Efficiency and Durability

→ Splitting the Difference – A guide to dual insulated wall assemblies

→ Urethane Roof Membrane – Failures as the result of Osmosis

→ Air-leakage Testing and Airtightness of Multi-Unit Residential Buildings

→ Ventilated Attics - Avoiding Mould and Moisture Problems

→ Not-so-sealed glazing units – Understanding IGU performance and failure

→ Sealant and Material Compatibility Testing – In-house testing by James Bourget and others

For additional information on this and other topics, please visit our website, rdh.com, or contact us at contact@rdh.com.

Additional Resources

→ Further information on the Sparklike GasGlass Argon analyzer can be found at sparklike.com. While RDH does not currently own a device, we rent one as needed from INEX Spacer in Montreal, QC.

→ Chapter 31 of the ASHRAE 2005 Handbook of Fundamentals provides technical information and references for fenestration and glazing.

→ Thermal and Optical properties for insulated glass units from any manufacturer can be determined using LBNL's WINDOW program, similar to THERM. The impacts of low-e coatings and gas fills can be analyzed and compared using their regularly updated database of manufacturer properties.

→ Free download at: http://windows.lbl.gov/software/window/window.html