*PROCEEDINGS*

THE FIFTY-FOURTH ANNUAL

# SYMPOSIUM
## ON THE
# ART OF SCIENTIFIC GLASSBLOWING

# 2009

THE
AMERICAN SCIENTIFIC GLASSBLOWERS SOCIETY

# *Proceedings*

***The Fifty-fourth Annual***

# Symposium

**on the**

# Art of Scientific Glassblowing

Sponsored by
The American Scientific
Glassblowers Society

*Red Lion Hotel Vancouver at the Quay*
*Vancouver, Washington*
*June 3 – 6, 2009*

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# Papers

# Borosilicate Glass Tray and Tank Containers

**by**

**Doni Hatz***

## ABSTRACT

*Square and rectangular borosilicate glass containers require unique fabrication methods. Three different procedures will be described: square tube container, single plate low form rectangular tray, and small tank. The size of the container will determine which fabrication method works best for the project.*

My first intention was to demonstrate a couple of tanks that I had fabricated, but I thought it would be helpful to step back and to show a couple of other methods that I would consider first before making my final decision. From simple to complex, you can choose to mix some of the techniques, blending different aspects from each approach depending on the size of the container and your shop equipment capability.

Over the years I have been working in research and development and in academia, there would be requests for square or rectangular cells. As time passed, I was asked to make square low form trays and dishes which would be added to the mix of glassblowing. This is more like welding, especially when scaled up to larger containers that require a lot more time and care in setup.

The techniques to be discussed will include three different procedures:

**Method 1**: Square tube container—glass plate sealed to square tubing, trim body of tubing, fire polish top edge.

**Method 2**: Single plate low form tray—corners cut out, side walls slumped 90 degrees, corners sealed closed, trim top edge and fire polish top edge.

**Method 3**: Small tanks—individual plates fused together.

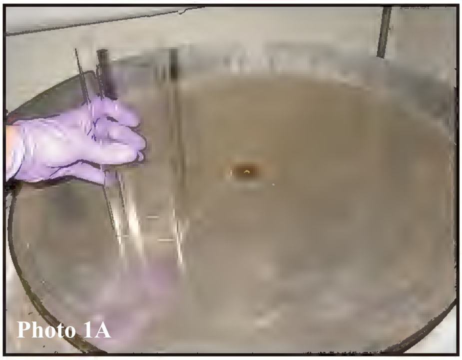
## METHOD 1

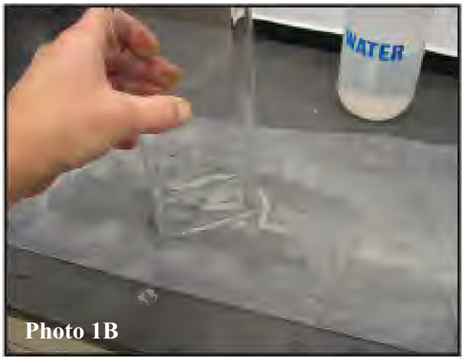
Containers fabricated with square and rectangular tubing are a simple method that has nice clean lines. Optical quality is usually clear enough for most visual and video observations.

When a request comes through the door for a square or rectangular container I always take advantage of square or rectangular tubing. The simplest, no fuss method that is always my first choice is to seal a plate on the bottom of a tube and you are done. Since I have not documented these cells fabricated in the past, I took advantage of a workshop demonstration by Mike Souza at the 52nd ASGS Symposium in Norfolk, Virginia. There are a couple of pictures of Mike supplemented with a few other pictures to help fill in gaps.

**Material**. Five inch square borosilicate tubing cut at an eight inch length and five inch square plate of 1/8 inch thickness. A motorized rotating turntable with two Carlisle CC blast burners are set up as cross fires to warm the tube and a National hand torch with a #4 piloted tip. Silicon Carbide grinding powders: 320 grit, 400 grit, 600 grit, 800 grit.

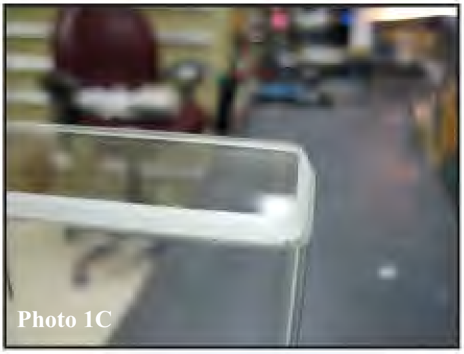
* The Procter & Gamble Company, Mason Business Center, 8700 Mason Montgomery Road, Mason, OH 45040. E-mail: hatzdj@pg.com.






**Preparation of tube.** Cut the square tubing to the desired height with a wet cut off saw, fire polish one end and oven anneal.

Check the other end of the tube for flatness with a glass plate, mark tube with a Sharpie to identify glass to be removed. If needed, grind the tube on the wet belt sander or flat lapping wheel (Photo 1A). Begin grinding the glass with the silicon carbide abrasive grit powders starting with a rough 320 grit powder. Sprinkle grinding powder on a glass or metal plate, sprinkle water and begin grinding the tube. Grind the glass until the surface is smooth with no scratches from the wet cut off saw (Photo 1B).



Mark one wall of the tubing with a Sharpie to identify the beginning point of rotation as the tube is ground down one quarter turn at a time. I prefer to grind in a figure 8 pattern but the W pattern is also good. Check for flatness with a scrap piece of plate glass. Wash and rinse off grinding powder, dry tube and dab a small amount of water on the edge. As water wicks across the ground surface, mark areas that do not contact the glass plate. Continue grinding until flat; proceed to 400 grit, 600 grit, and 800 grit until there is an ultra fine surface.* Be aware of cross contamination of grinding powders and keep the grinding plates clear of each other. It sounds like too much attention to detail but it is a critical requirement for the project. Acid clean the ground end of contaminants from the grinding powders with HF or ammonium bifluoride.

* **Grinding styles**: This is only a suggestion of a grinding method since there are other options depending on your shop setup. Ideal setup can be a lapping wheel with magnetic back diamond abrasive pad equivalent to medium (220 grit) to fine porosity (600 grit).

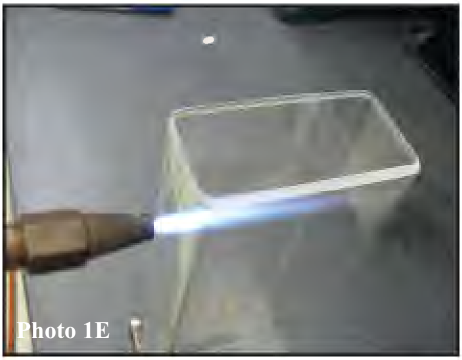


Photo 1E


Photo 1F

**Bottom glass plate.** Cut the plate to the same size of the tube; bevel the edge of the plate on the wet belt sander feathered all the way to the edge (no flat edges). Grind the plate slightly smaller than the outside diameter of the tube, about half the wall thickness of the tube. Wash and acid clean the ground edge (Photo 1C).

**Sealing the plate to the tube.** The tube is placed in the center of a slow rotating turntable heated slowly by two Carlisle CC blast burners set up in a cross fire alignment. A weight is placed on the plate to prevent it from slipping off center (Photo 1D). Most projects like this would be fabricated in the oven instead of using the turntable method.


Photo 1G

The tube is heated slowly with the large torches, gradually increasing the heat until it reaches working temperature above 600 degrees C (Celsius). Using the hand torch, fuse the edge of the plate to the tube at a tangent with the flame pointing in the direction of the edge to be sealed (Photo 1E). The glass will roll up catching the edges fusing them together (Photo 1F). Make sure there is not cleavage on the inside of the seal before moving on or it will crack, if not now then later or when sealing the other side of the tube. Seal a few inches of the glass then reheat the entire top area of the tube with the large torches. Allow the tube to anneal and remove the strain before continuing on with the seal. Once the seal is finished (Photo 1G), immediately flame anneal and place in preheated oven.

## METHOD 2

Glass tray or low form container: 6.5” W x 10.5” L x 1” height.

In this case, the customer needed a rectangular tray to fit 20 each 1” x 3” micro slides for their experiment.

Photo 2A

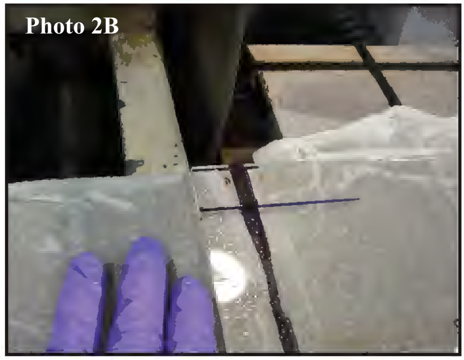


Photo 2B

**Materials.** Borosilicate plate glass 8.5” W x 12.5”L x 1/8” thickness, stainless steel (316) plate and bars to support the plate glass, graphite paper (two inch width).

**Two National hand torches.** One torch with a #4 piloted tip and the other torch with a three inch ribbon tip with two rows of holes. The necks of both torches are changed to 10 inch long necks to reach in the oven. The plastic fuel control knobs are changed to metal to prevent melting while working in the oven.

**Glass plate preparation.** A pattern is drawn to full scale, the corners are marked with a permanent Sharpie and dried (to keep lines visible while cutting in water) (Photo 2A). Remove the water splash guard on the diamond saw table; lay the glass plate on the table top with a paper towel underneath to prevent scratches on the surface of the glass. In addition, I wear a water proof apron and face shield and throw lots of water absorbing pads on the floor to soak up the water spray.

The corners of the plate are cut out with the wet diamond saw (Photo 2B).

Photo 2C

**Setup in the oven.** The glass plate is slumped over a stainless steel plate that is thick enough not to warp in the oven at 600 degrees C. A ¼” thick stainless steel plate is cut ¼” smaller than the inside diameter of the tray at 10.25” x 6.25”. Underneath the stainless steel plate are several ¾” stainless steel bars supporting the larger metal plate. The support blocks can be taller but this ensures that the glass plate side walls slump down to the finished height. Graphite paper is placed on top of the stainless steel plate to prevent the glass from sealing as well as warping on the metal surface. Position the glass plate on top of the graphite paper (Photo 2C).

The oven is heated slowly, about 1 1/2 to 2 hours ramp cycle (depending on wall thickness of glass; for 5 mm or more, more time is needed) with the temperature set at 600 degrees C. The temperature is increased slightly above the normal 565 degrees C annealing temperature to ensure that the glass is above the strain point but also to allow for heat loss once the oven door is opened. Care should be taken to heat the plate gradually because the metal is also absorbing heat at a different rate and can shock the glass and cause it to crack.

To fabricate glass in the oven, extra personal protective clothing is needed. I am wearing 18-inch Kevlar sleeves with glove-like hands with the fingers and thumb cut out: this protects the knuckles through the large high temperature gloves. I am wearing two lab coats, one over the Kevlar sleeves then another lab coat over the first coat; the multiple layers protect the skin because you can get burns through two layers of clothing. I also have two welder's hoods (one hood protects my neck and another is pulled over the top of my head), a couple of clear face shields (to change out the face shields quickly so I do not breathe fumes from the heated plastic), and a pair of high temperature gloves.

A handy torch holder should be set up next to the oven door for quick use; this is to hang up the torches quickly and safely since the gloves are so thick and it is difficult to adjust the flame of the torch. The tools should also be close to the oven: a graphite paddle, a graphite rod and a stainless steel rod (12 inch length, with a 90 bend on the end). If possible, get a helping hand and recruit an assistant to open and close the oven door or to help with handling torches and tools. A few minutes with a second person assisting can save time limiting heat loss in the oven.

To begin, all corners need to be fire polished where the two cuts meet. The raw edge has to be sealed or a crack can quickly spread into the middle of the plate (Photo 2D). It is not worth slumping down three sides then get to the last side and the corner develops a crack; the entire piece is now an ugly repair job and best scrapped for a new plate. (For this reason, have a couple of extra pieces of plate in stock.)

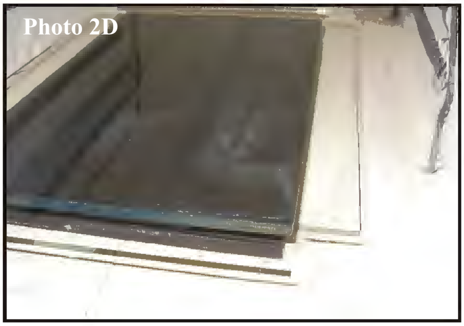


Photo 2D

Once the corners have been fire polished with the #4 tip hand torch, allow the glass to anneal about 15 minutes before moving on to the next step. Using the ribbon tip hand torch, heat the glass across the area to be slumped, quickly moving the torch back and forth. If needed, heat and adjust the glass in or outward with a stainless steel rod (with the 90 degree hook) in case the force of the flame pushes the glass inward (Photos 2E & 2F).

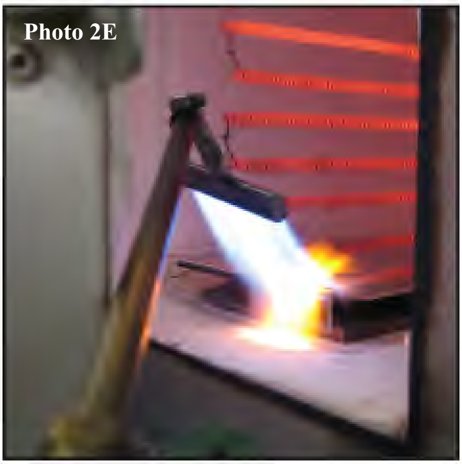


Photo 2E

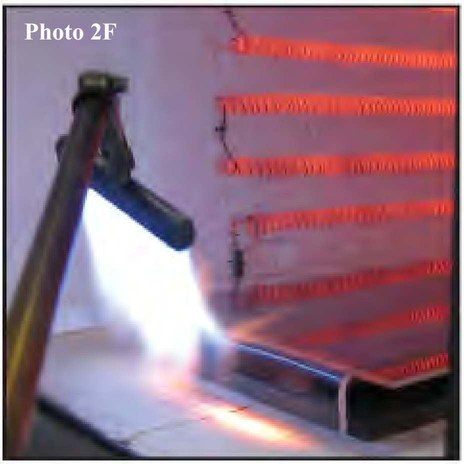
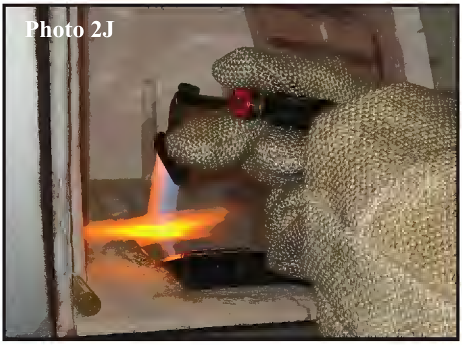


Photo 2F



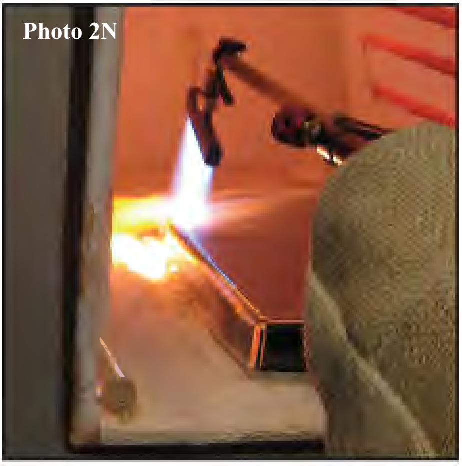




Anneal the glass, then move onto the next side wall (Photos 2G, 2H & 2I). Anneal the glass then continue to the third side wall (Photos 2J & 2K).

Adjust side wall with graphite paddle in case certain areas do not slump uniformly (Photos 2L, 2M & 2N).

Seal the two corners with a 2 mm rod (Photo 2Q), add extra glass to the end of the seal (since the glass thickens and reduces the height of the corner). It is easier to add glass now and grind back any excess instead of grinding down the entire top edge



evenly. Anneal the glass and let cool. Once it is cool enough to handle, turn the plate around and finish the last side wall and corners, and anneal.

Check the height of the tray with a marker across the entire edge and grind down uneven edges. Reheat in the oven and fire polish the top edge and anneal.

## METHOD 3

**Small tank.** Borosilicate plate glass 9" w x 19" L x 7" ht. x 5 mm wall thickness.

The next project is where a lot more work is needed in the setup of the glass plates as well as in more time needed to work in the oven. Since this container is larger, I had to move the project to the larger Wilt Bell Type oven. Through trial and error, too much heat was lost with the oven top open. Stainless steel heat shields were placed around the perimeter of the oven; they are taller than the final height of the open bell jar top so that they do not fall inward (Photo 3A).

A torch holder, made up of a sturdy ring stand and a long cross bar to hang up the torches, is set up immediately outside the oven door. A rack of basic tools include: striker, tweezers, 2 mm rod, graphite paddle, graphite rod. The two hand torches used in this project are a Carlisle CC 702 large flame hand torch and a National Hand torch with #4 piloted tip with 18 inch extended neck. Personal protective clothing consists of Kevlar sleeves, two lab coats, two welding hoods, two clear plastic face shields, and extra high temperature gloves. Definitely this time an assistant is recruited to open and close the oven lid.

This tank has a ½" lip that extends outward away from the top edge of the glass at a 90 degree angle. A large stainless steel base plate is placed in the oven (to keep vermiculite dust from being stirred up by the flame) and it is checked to make sure that it is level. Another stainless steel plate ½" thick is placed on top of that with the graphite paper – to


Photo 3B

Photo 3C

slump the glass to the exact ½" overhang. The oven is heated and set to the higher temperature of 600 degrees C and the glass is slumped (Photo 3B).

Once the four side walls are modified (with the lip), the glass is set up on the stainless plate and checked to be square (Photo 3C).

The corner edges are beveled with the wet belt sander (Photo 3D) to reduce the amount of glass in the seal then set up in the oven (Photo 3E).


Photo 3D


Photo 3E


Photo 3F

For quick reference of alignment, mark the tank inside dimensions on the stainless steel base plate with a Sharpie – to check things are square. Set up three side walls supported with stainless steel blocks heavy enough to support the glass on each side of the plate. A stainless steel bar cut to the inside dimension is supported on blocks in the middle about 4 inches up to keep the walls square (Photo 3F). (I have included pictures from a couple of other tanks for you to see the whole process.)

Begin fabricating the tank with the large torch and a bushy gas oxygen mix flame around the area to be sealed. The glass needs to be heated up to sealing temperature to avoid stress from the lower 600 degrees C temperature differential. Armed with the large torch in one hand and the small tip torch in the other hand, begin heating the plate (Photo 3G). The flame from the large torch warms the area to be sealed before the small flame fuses the


Photo 3G

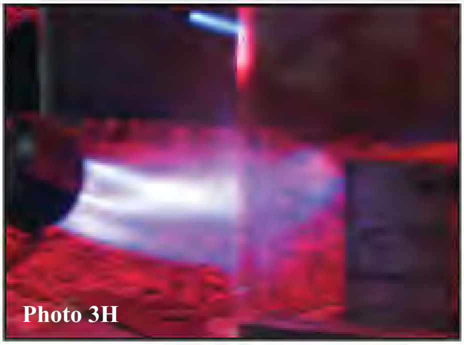


Photo 3H

glass (Photo 3H). Seal one corner at a time about 2 to 3 inches of the seal. Anneal glass about 15 minutes between seals. Open the oven just enough to get inside with the torch and 2 mm rod to prevent heat loss (Photo 3I). If you can reduce heat loss, you can seal up to 6 inches of glass, but it is risky.


Photo 3I

Continue working the glass until the two corners are sealed (Photo 3J). Let the oven anneal the glass and cool before adjusting the tank position to seal the next two corners (Photo 3K).


Photo 3J


Photo 3K

Check the height and grind edges flat with a slight beveled edge on tank (Photo 3L).

Set up the tank with inside supports and mark the bottom plate to be sealed (Photo 3M).

Bevel the edge of bottom plate (photo 3N). As you can see, there is a stainless steel plate supporting the glass to prevent warping. Seal the bottom plate in the same process as mentioned previously sealing 2 to 3 inches at a time (Photo 3P).


Photo 3L

Photo 3Q is of the finished tank (as you can see this was another tank without a lip but you get the idea).

Photo 3M

Photo 3N

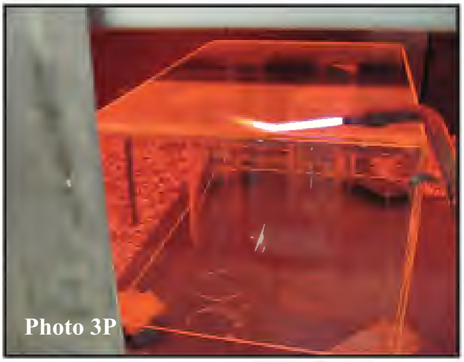


Photo 3P

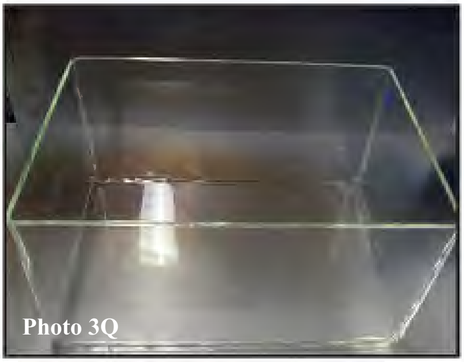


Photo 3Q

This is not production, so commercial shops will probably approach things differently. Thankfully a lot of those shops were extremely helpful in giving me the guidance and advice needed to get the job done. That is what the ASGS is all about: sharing information and technology for the greater good of the field of scientific glassblowing.

I would like to acknowledge some of my teachers; Rudy Schlott for optical window sealing that applied to method #1 and Adolf Günther who taught me single plate construction as well as tank construction. With their knowledge and insight and the help from my many assistants, I was able to get the job done.

# Characteristics of Quartz Glass: The Properties, Tools, and Techniques Used to Manipulate a Unique Material

**by**
**Patrick S. Bennett***

## ABSTRACT

*This article has been written to provide glassblowers, both novice and master alike, a broad understanding of a material many of us are familiar with but know little about. This includes information regarding the molecular structure of, preparation of, and approach to working fused quartz and fused silica type glasses.*

"Ideally, when a solid material is allowed to form slowly, its component molecules or ions have sufficient opportunity to rearrange into a symmetric structure. However, if they lose kinetic energy too rapidly, they will be trapped in less symmetric arrangements and the rigid material will not exhibit the crystallinity of more ordered solids. These disordered materials are known as *glasses*. A common example is window glass which is identical in chemical composition to quartz (from a basic point of view) except that window glass is formed from the rapid cooling of silicon dioxide, while quartz crystals are formed in nature from the same elements – slowly over millions of years."[1] While window glass from a glassblower's perspective is typically soda-lime glass, closer inspection of the makeup of glass is necessary to begin to comprehend why glasses, especially quartz act the way they do when being manipulated by the glass worker.

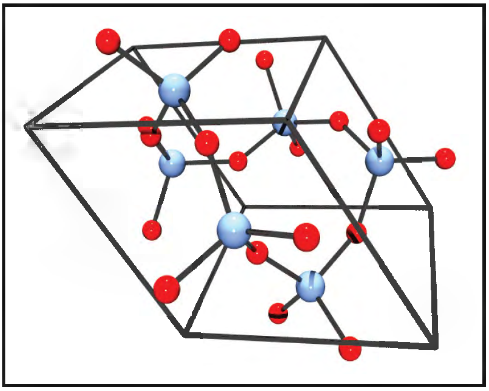


**Figure 1.** *Unit cell molecule, quartz*

Provided are diagrams of both crystalline quartz and amorphous, or glassy, quartz. Note how the unit cell molecule is composed of $SiO_4$ tetrahedrons which share oxygens and make a chemical formula of $SiO_2$ or silicon dioxide. When these unit cells are stacked into a lattice structure, they form a crystal which is exhibited by the crystalline quartz diagram provided. Conversely, the diagram of amorphous, or glassy, quartz shows how the bond angles, which were not allowed to form crystals, are arranged in

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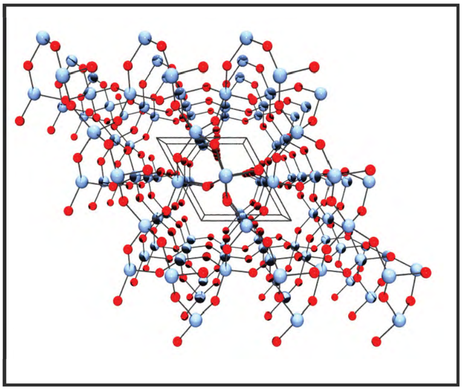
[1] D. W. Bennett, *Understanding Single Crystal X-Ray Crystallography* (New York: Wiley Publications, 2010): 3-4.



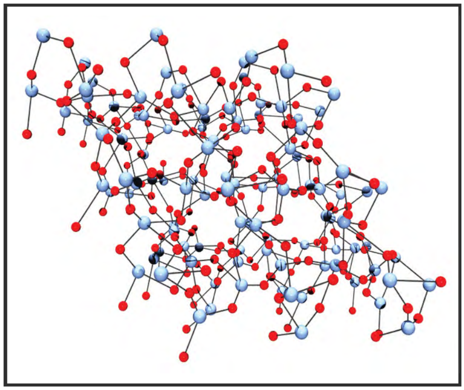
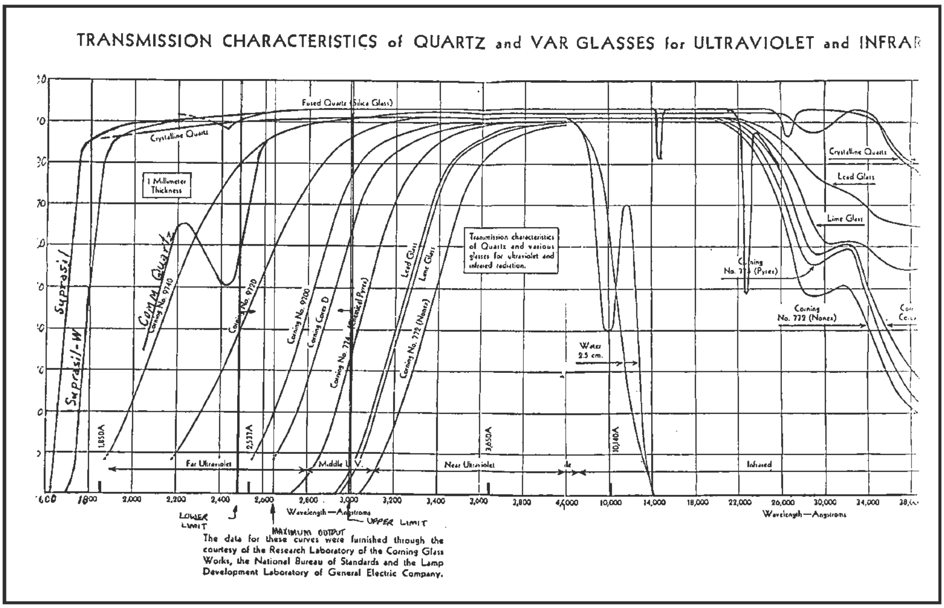


**Figure 2.** *Crystalline quartz* **Figure 3.** *Amorphous/glassy quartz*

a random order and truly change the appearance and properties of the material. Quartz glass because of its entirely silica ($SiO_2$) composition carries some very unique properties as opposed to other glasses.




One of these properties is the ability to allow light to pass through the material at further ends of the light spectra than other glasses as exhibited by the diagram provided. Furthermore, different types of quartz glass have different abilities to pass light. The two main types of quartz glass are fused quartz (CFQ) and fused silica. Fused silica is synthetically produced pure silica with a minimal amount of impurity to its composition. It is fused together and is an excellent material for light transmission. The following images show a comparison of how UV light is allowed to pass through both fused silica and fused quartz type glasses. Note how regular quartz will fluoresce slightly when exposed to UV, but the fused silica allows all of the UV to pass through and remains entirely transparent.

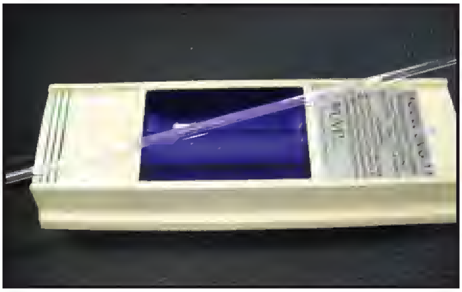


**Figure 4.** *Fused quartz under UV light*

**Figure 5.** *Fused silica under UV light*

Another unique property of quartz is its lack of viscosity, or its inability to flow. This can be explained by the fact that quartz molecules would like to be crystalline and they do not want to be separated or moved. Therefore, unlike borosilicate glasses, quartz glasses are much more coherent or less viscous: quartz does not want to "flow" when molten; it would rather stick together than move to other areas. As a result, to make quartz move or even out, some other form of physical manipulation is necessary in addition to heating. Some examples of this manipulation would be blowing, tooling, or an in-and-out motion to even out the wall weight.

One more shortcoming of quartz type glasses, compared to borosilicate, is its lack of tensile strength. When quartz is in its crystalline state, it cleaves very easily along planes in the crystal lattice. Fused quartz is actually very similar in nature to its crystalline form. However, it does not have these lattice planes and will cleave in whichever direction is weakest. With borosilicate glass, ingredients are added to the batching process that inhibit this and significantly raise the tensile strength.

**Figure 6.** *Broken cuvette exhibits lack of tensile strength in quartz*

**Figure 7.** *Water on hot quartz*

One of the most significant advantages of quartz glass compared to other types is its thermal resilience. Quartz glass has a very low COE (coefficient of thermal expansion). For the most part, when heated and cooled, it does not expand or contract much. This is true to the point that oftentimes quartz workers will take the glass after it has been worked and is still hot and submerge it in water, causing a drastic decline in temperature yet leaving very little strain.

Many other types of glasses, borosilicate included, would crack immediately upon being heated and exposed to room temperature water. Along with a lack of expansion and contraction, quartz also has a very high melting point, making it ideal for high temperature application. When salts are added to ice, they significantly lower the melting point. This can be said for any substance of pure composition, quartz included. When other ingredients, such as boron oxide found in borosilicate glass, are introduced to quartz they significantly reduce the melting point and other relative working temperatures. Because of this sort of "rule of impurity" in relation to temperature, quartz glass works at much higher temperatures than other glasses.

| Technical Properties | Soda Lime Glass | Borosilicate Glass | Fused Quartz | Fused Silica |
|---|---|---|---|---|
| Density (gm/cm³) | 2.49 | 2.23 | 2.203 | 2.201 |
| Tensile Strength (N/mm²) | 19-77 | 282 | 50 | 50 |
| Softening Temperature (C) | 713 | 821 | 1710-1660 | 1600 |
| Annealing Temperature (C) | 536 | 560 | 1220-1160 | 1100 |
| Strain Temperature (C) | 496 | 510 | 1125-1070 | 950 |
| COE ($X10^{-7}$ cm/cm/degC) | 90-108 | 33 | 5.5 | 5.5 |

**Table 1.** *Technical properties of different types of glass compared*

Because of these unique properties and characteristics held by quartz glass, certain precautions and approaches must be observed by the quartz worker. When working quartz, the glassblower must begin by using tools that are quartz-friendly. Along with the standard glassblowing tools, a glassblower will also introduce some other specific tools to quartz working. The first tool adjustment made by the quartz worker is a safety issue. Since quartz, while being worked, tends to transmit bright light, a welding shade 5 or higher pair of glasses needs to be worn to protect the eyes. To prevent finger prints from being placed onto the glass, a quartz worker will typically wear cotton gloves while working the glass. The standard brass torch tips also need to be replaced with stainless steel tips as the brass at that high of a temperature tends to burn off into the glass. In addition, because of the lack of viscosity in quartz, oftentimes specially shaped carbon tools will be implemented to allow for shaping of this glass. When the thickness of the quartz makes for difficulty in melting the glass, oftentimes the worker will replace the standard natural gas and oxygen mix torch fuel with a hydrogen-oxygen blend, which has a much higher temperature.

**Figure 8.** *Unique tools for quartz work*

Along with tools and supplies, a quartz worker must focus on their work environment. When quartz is heated to a high enough temperature, a vapor is produced. This vaporized silica is called bloom, and it contains microscopic particles of $SiO_2$ that, when entering your lungs, can be very dangerous. Since bloom has a tendency to settle around the glassblower, obvi-

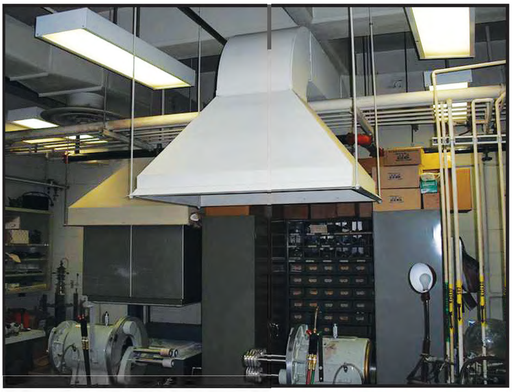


**Figure 9.** *Proper quartz shop ventilation*

ously concern should arise over inhalation of this silica. Silicosis is an occupational disease associated with people who work around small particles of silica. This ailment is a predecessor to many other more serious ailments such as tuberculosis, pneumonia, and lung cancer, just to name a few. Common occupations prone to silicosis include miners, sandblasters, and glassblowers. Because of the risk of silicosis and other disorders, proper ventilation is required to swiftly remove the silica from the glassblower's immediate breathing area.

Now that we have established proper tools and work environment, some techniques should be addressed that pertain specifically to quartz glass. One of the most important techniques to address is proper cleaning. The oil in your skin contains alkali, which is one of the few materials that easily degrades glass. When this material is heated on the surface of quartz, it can leave permanent fingerprints on the glass diminishing its optical integrity. Because of this, the surface needs to be pre-cleaned, kept clean, and re-cleaned to ensure that the final product is of the highest quality. A lot of the time, a good way to pre-clean the quartz is to soak the glass in a 10% hydrofluoric acid (HF) bath, followed by a distilled, deionized water rinse.

**Figure 10.** *Electronics grade hydrofluoric acid*


**Figure 11.** *Gleme foaming glass cleaner*

This is a questionable tactic when it comes to optical cells however, as HF removes a thin layer from the surface of the glass potentially skewing the optical transparency of the cell. So, if you are confident in the storage and handling of the glass, a misting of glass cleaner with a clean wipe will suffice. I prefer Gleme as a glass cleaner because it foams, lifting contaminates away from the glass surface, and leaves no residue.

Once the glass is clean, the quartz worker should wear cotton gloves and avoid anything that may contaminate the surface of the glass. After working the glass, oftentimes bloom will have settled on the glass around the area that was worked. Wiping the glass and then another HF bath will remove a good share of the bloom, if not all of it. If bloom remains, finding just the right temperature flame to melt the silica bloom back into the surface, while minimizing the distortion of the glass is imperative. Start with a low heat and slowly work higher to find the correct flame temperature.

**Figure 12.** *Bloom on quartz before removal*

**Figure 13.** *Quartz after removal of bloom*

Once a quartz worker takes into account how to keep their glass clean, they then must choose the appropriate seal to use for the application. While there are many different approaches to fusing two different pieces of quartz together, they all fall around two basic types of seals. First is the welded seal, where the glass is heated above its softening point and melted together. This method is similar to welding as oftentimes a piece of quartz rod is used to bridge a gap between two pieces of quartz glass. This method is used for most non-optical applications for quartz. The other seal option is the diffusion, or molecular seal. This seal is very time consuming and has a few different approaches.

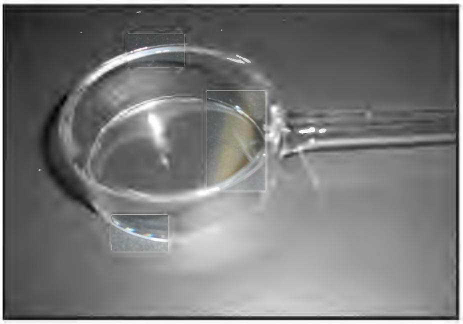


**Figure 14.** *Completed diffusion seal on a filter, with welded side arm*

The method that seems to be the most durable is the polish and heat method: the end of a piece of quartz glass is polished in steps down to an optical flat, and a lens or flat polished plate are adjoined to one another. The two pieces are held flush, either manually or via vacuum, and heated just enough to excite the molecules causing them to grow together on a molecular level. When working the seal, the quartz worker should pay attention to interference fringes, as illustrated here.

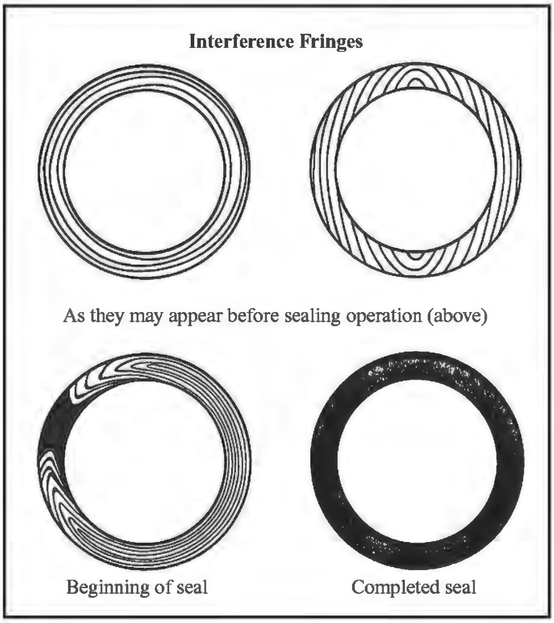



**Figure 15.** *Top view of optical flat plate glass, on the end of a polished piece of tubing*

The other option, or short cut, for this type of seal is the use of transfer tape. This tape is made of a borosilicate-type glass that will fuse the two pieces of glass together when heated in the kiln. The downside of the use of this transfer tape, is that once the fusion of glass has occurred, the glass can no longer be worked in the flame.

Quartz is a unique material for the glass worker to use. The learning curve for the material is really no different than that for borosilicate or soda lime glasses. With the right knowledge of the material, it is no harder to work than any other glass. It has its own set of difficulties in working it, whether it is the higher working temperature or the lack of tensile strength. However, it also has many attributes that simplify this work, such as the fact that the glass does not flow away from the working area easily. So really, it all comes down to the worker's knowledge of the material. Knowing your medium is the key to success!

# Inexpensive, Off-the-shelf Hybrid Microwave System

**by**
**R. T. Walters, P. Burket, and J. H. Scogin, IV**
**Presented by**
**William (Curt) Sexton***

## ABSTRACT

*A hybrid-heating microwave oven operating on a 120V system provides energy to heat small 10-gram samples to 1100ºC to release trapped helium. This paper will discuss the hows and why of this project conducted at the Savannah River National Laboratory.*

## BACKGROUND

Savannah River National Laboratory (SRNL) has developed a modern gas assay method for spent tritium storage beds for Sandia National Laboratory. Currently, helium from tritium decay remains trapped after delivery of the stored gas, so a complete characterization of the storage bed is not obtained from the delivered gases. A technique has been developed that releases the helium content from the spent bed material in a way that allows quantitative measurement with the same accuracy as that measured for other gas species. SRNL has successfully identified the right materials of construction and process configuration to heat small samples of spent palladium storage bed material in an inexpensive commercial "hybrid" microwave oven in a controlled manner to a high enough temperature to cause the desired effect of releasing the helium.[1] Researchers at SRNL produced a dry gas in the unit and measured the moles of gas produced to demonstrate the ability to quantify a non-condensable gas produced in the system. The decomposition of $CaCO_3$ to $CO_2$ was used to test the system without using tritium-contaminated samples. This proved to be quite acceptable since the measured number of moles of $CO_2$ matched the calculated number of moles based on stoichiometry to within 3%.

## SYSTEM CONFIGURATION

The choice of a heat source is limited because of the extreme temperature needed. The release of deep trapped $^3$He from aged palladium tritide requires greater than 1000°C. Conventional high heat sources include resistance, induction and microwave ovens. Resistance and induction ovens require sufficiently high current and voltage to reach the desired temperature. Using a 1000 watt kitchen microwave oven on house current and voltage, any temperature between room temperature and 1200°C can be selected and held making it a pseudo temperature programmed desorption instrument for large sample sizes. The concept of this hybrid microwave oven is described here.

The hybrid microwave unit for gas measurement consists of the microwave oven, the susceptor unit and insulation, the plasma shield, the cooling fin(s), the charge tube, and the gas manifold. A thermocouple, vacuum pump, pressure gauge, gas supply, and calibrated bomb tank are connected to the gas manifold. Flexible hoses between the manifold and the vacuum pump, pressure gauge, and calibrated bomb tank allow freedom of movement of the part of the manifold that holds the charge tube. Figure 1 shows a picture of

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[1] G. C. Abel, L. K. Matson, R. H. Steinmeyer, R. C. Bowman, Jr., B. M. Oliver, "Helium Release From Aged Palladium Tritide," *Physical Review B*, Vol. 41, No. 2 (1990-1): 1220-1223.

the prototype microwave oven with the charge tube inserted into the unit. A 7.4 inch tall charge tube reaches 2.25 inches into the susceptor encasement, which is 5 inches above the bottom of the microwave cavity. The charge tube is made of a 1" o.d. quartz tube and is sealed by an Ultra-Torr® fitting at the top.

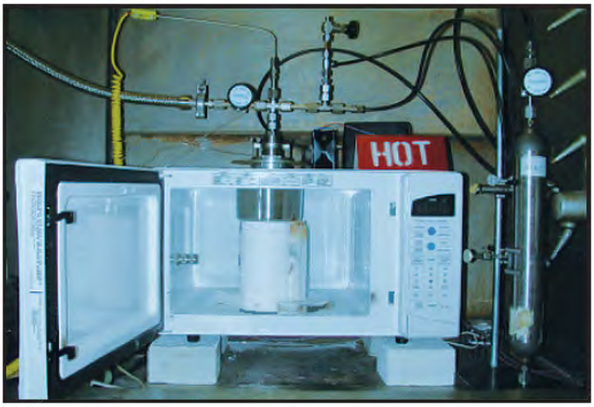



**Figure 1.** *Prototype microwave oven*

A thermocouple extends down through the center of the tube that has an alumina filter attached to it to shield the coupling at the top from the heat shine below. The single fin with fan keeps the temperature at the fitting below 50°C. If the fan fails, the coupling temperature reaches almost 80°C at an operating temperature of 1200°C in the charge tube. The maximum temperature for the O-ring in the Ultra-Torr® vacuum fitting is 204°C. Figure 2 shows the charge tube fully removed above the microwave oven. The microwave susceptor is 200 grams of granular SiC (silicon carbide) encased in a 6" tall annular quartz encasement around a 1" center hole where the charge tube slides in and out. The 2" o.d. quartz encasement is set in a 2" i.d. x 4" o.d. x 8" tall alumina insulation tube that has a 1" thick bottom to it.

**Figure 2.** *Charge tube with alumina foam filter*

Once the quartz encasement is inserted into the insulation tube, a 1" thick alumina insulation ring is placed on top of the quartz encasement and some alumina wool is stuffed above that to ensure no heat shine reaches the metal above. The 3" tall stainless steel plasma shield goes around the outside of the insulation and is positioned against the top of the microwave oven cavity. The bottom of the shield is about 3/8" below the top of the SiC in the susceptor unit. These pieces are shown in Figure 3.

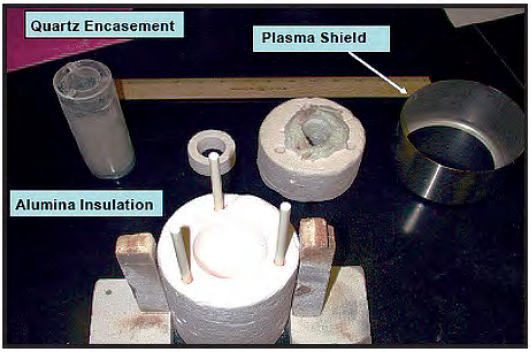



**Figure 3.** *Plasma shield and quartz encasement*

The plasma shield extends down from the top of the microwave cavity to about 1/4" below the top of the susceptor. The purpose of this shield is to reduce the direct impingement of microwaves into the charge tube to prevent plasma formation inside the charge tube at low pressures. A plasma causes uncontrolled rapid heating of the tube and its contents. Without the plasma shield, a plasma can form at pressures from 3 Torr up to 80 Torr. With the plasma shield, a plasma can only form at pressures less than 9 Torr. As a result, the heating process can be started with about 15 Torr of an inert gas.

## SYSTEM CONTROL

### A. Microwave Heating Control

The magnetron produces the microwaves in the oven. Control of the magnetron was accomplished by inserting an ON/OFF relay in the line going to the step up transformer prior to the magnetron. Automatic computer control of the relay was based on either the pyrometer temperature reading or the charge tube thermocouple temperature reading versus an operator set point. Manual computer control of the relay was based on a percent output specified by the operator. The cycle time is 32 seconds, so a 50% output would produce 16 seconds ON, then 16 seconds OFF, and so on. To operate the oven, the operator would still have to enter a time on the oven front panel and press the start button. All original safety interlocks on the oven remained in use, which includes the door interlock and the cavity over-temperature interlock. Both interlocks shut off the oven.

### B. Temperature Response

Using the magnetron control scheme described above, the temperature of the sample in the charge tube rapidly heats to process temperature and remains at temperature for the duration of the measurement. Figure 4 shows the pyrometer (IR2) reading for a process run, and the pressure increase in the charge tube for an initial pressure of 400 Torr.

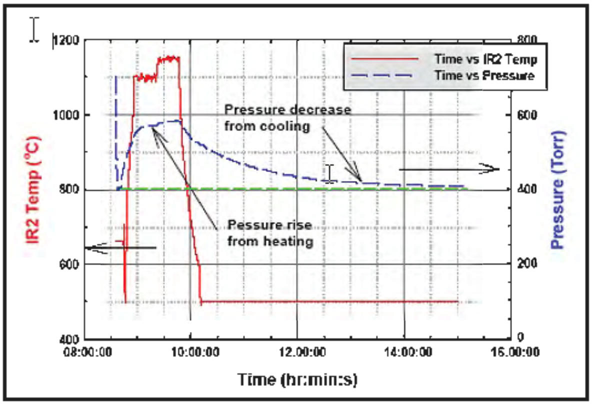



**Figure 4.** *Pressure rise due to gas heating*

The sample temperature rose to 1100°C, remained for about 30 minutes, and was increased to 1150°C for another 30 minutes. Power was turned off and the system cooled for about four hours. Notice the pyrometer does not begin to read until 600°C, necessitating the use of an internal thermocouple to measure the full range of temperatures of the sample. While the sample is at temperature, there is a good bit of radiant "shine" emanating in all directions. The alumina foam filter (Fig.2) attached to the internal thermocouple effectively blocks the shine and helps maintain the temperature

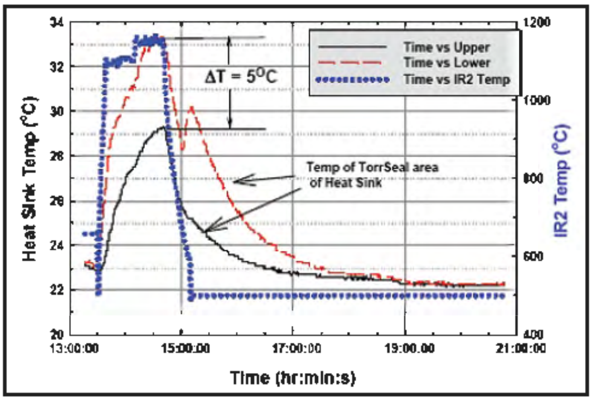



**Figure 5.** *Temperature range of O-ring area*

of the Ultra-Torr® O-ring connection to the quartz tube at or near ambient. Figure 5 shows the IR2 pyrometer reading during a process run again at 1100°C-1150°C along with the measured temperatures of the upper and lower parts of the O-ring connection. The heat sink and instrument fan help remove the heat, maintaining 29°C to 33°C at the O-ring. The temperature rise is rapid for these process runs.

The observed increase based on the pyrometer is about 80°C per minute from about 500°C to 1100°C. The temperature control using the ON/OFF power control of the magnetron is within ±5°C at 1100°C.

## MEASUREMENT OF A GAS

The quantitative measurement of a gas requires the knowledge of the total system volume, the charge volume, the hot volume, the initial cold temperature, the initial pressure, the final pressure, the final cold temperature, and the hot temperature. The total system volume and the hot volume are calibrated once and are constants throughout successive runs.

### A. Hot Volume Determination

During operation, part of the system is heated to about 1200°C with a temperature gradient to the temperature of the rest of the system, which is near ambient temperature. For purposes of determining moles of gas, the system will be described mathematically as having two distinct temperature zones, the hot volume $V_H$, and the cold volume, $V_C$ pressures less than 9 Torr. As a result, the heating process can be started with about 15 Torr of an inert gas.

Using the Ideal Gas Law,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \tag{1}$$

Eq. (1) can be divided into hot and cold volumes

$$m = \frac{P_1}{P_2} = \frac{\left(\frac{V_C}{T_O} + \frac{V_H}{T_O}\right)}{\left(\frac{V_C}{T_O} + \frac{V_H}{T_H}\right)} \tag{2}$$

where $V_C$ is the cold volume, $V_H$ is the hot volume, $T_O$ is the cold temperature, $T_H$ is the hot temperature, $P_1$ is the pressure when the charge tube is at the hot temperature, and $P_2$ is the pressure when the charge tube is at the cold temperature. Cold temperature is usually the room, or starting temperature. Solving for the hot volume,

$$V_H = \frac{V_T T_H (m-1)}{m(T_H - T_O)} \tag{3}$$

where ***m*** is the ratio of the system pressure at the hot temperature to the pressure at the cold temperature (Eq.2), and $V_T$ is the total volume, $V_C + V_H$. To determine the hot volume, a known $ZrO_2$ charge and an initial pressure of $N_2$ at room temperature was heated to 1200°C and obtained steady state pressure. This was repeated for several starting pressures. The data are in Table I.

| TABLE I. Hot Volume | |
|---|---|
| $P_1$ (Torr) | $V_H$ (mL) |
| 269 | 53.9 |
| 338 | 54.1 |
| 378 | 54.7 |
| 451 | 54.2 |
| 489 | 52.0 |
| 629 | 52.6 |
| 733 | 51.7 |
| **Average** | **53.3** |

Table I

**B. Gas Production Determination**

The decomposition of $CaCO_3$ to $CO_2$ was used to demonstrate that a gas can be produced in the system and quantitatively collected. A total of eight runs were performed for determining gas production. In each run, various amounts of $ZrO_2$ and $CaCO_3$ were charged to the tube. The system was evacuated and purged with $N_2$ three times. The charge volume was determined, and the system was charged with enough $N_2$ to raise the pressure to 15 Torr to prevent plasma from forming during initial heating. The system was heated to 1200°C and held there until the pressure came to steady state. Then the data were collected to determine the number of moles of $CO_2$ formed from the $CaCO_3$ both by chemical stoichiometry and by the ideal gas law and are in Table II.

**Table II. $CaCO_3$ Decomposition Data**

| # | $CaCO_3$ gms | $P_1$ Torr | $CO_2$ calc | $CO_2$ meas | % |
|---|---|---|---|---|---|
| 1 | 1.575 | 495.2 | 0.0158 | 0.0157 | -0.28 |
| 2 | 1.568 | 496.2 | 0.0157 | 0.0157 | -0.22 |
| 3 | 1.575 | 498.8 | 0.0158 | 0.0158 | 0.27 |
| 4 | 1.580 | 504.1 | 0.0158 | 0.0160 | 0.95 |
| 5 | 1.574 | 510.2 | 0.0157 | 0.0161 | 2.52 |
| 6 | 0.926 | 314.2 | 0.009 | 0.001 | 5.57 |
| 7 | 0.926 | 314.0 | 0.009 | 0.001 | 5.32 |
| 8 | 2.235 | 705.0 | 0.022 | 0.023 | 0.99 |

Table II

The error results were analyzed against final system pressure and volume of inert charge. Neglecting the data of runs 6 and 7 (final pressure around 300 Torr seemed to have an issue); the measured moles of $CO_2$ were accurate at worst to within about 3%. The data were independent of the volume of the charge.

# CONCLUSIONS

- The hybrid microwave system is capable of heating samples to greater than 1200°C.
- The quartz components can withstand 1200°C for at least several hours without any apparent change. (Quartz annealing temp: 1215°C; softening temp: 1683°C).
- The quartz components in the susceptor remain usable after 26 runs.
- The unit can be controlled to prevent plasma from occurring.
- The unit can control the temperature ± 25°C at 300°C and ± 5°C at 1200°C.
- The system can measure non-condensable gases to within less than 3% error when the final pressure is 490 to at least 700 Torr. **Note:** The O-ring was tested at the high pressure test lab and held pressure up to 50 psig at room temperature. The expectation is to

run the unit where the maximum expected pressure is below 1000 Torr.

- Because of the massive amount of insulation around the charge tube and susceptor, the oven cavity temperature becomes warm (about 50°C) but does not follow the temperature of the charge tube.

The system protocol described here is but one of many that can be programmed to use the hybrid-heating microwave oven. For example, intermediate temperature stops can be included to soak a sample at temperature before continuing to a higher temperature. Also, the sample gas released can be evaluated after the charge tube and sample return to ambient, removing the need to calculate a "hot volume." However, we have demonstrated that the division of the manifold into a hot section and a cold section does return reasonable results to within about 3% once the calibration curve has been obtained.

## ACKNOWLEDGEMENTS

RTW acknowledges William Curtis (Curt) Sexton of the Glass Development Laboratory at SRNL for supporting all of our quartz glass needs for this project.

I would personally like to thank Dr R. T. Walters, for allowing me to present this paper and for acknowledging me and my input in this project. Thanks to Kim Balbag for organizing this paper and getting it through our review process. Also, The Savannah River National Laboratory for their support.

*This document was prepared in conjunction with work accomplished under Contract No. DE-AC09- 96SR18500 with the U.S. Department of Energy.*

# The International Hot Glass Invitational Flame-off Competition in Las Vegas, Nevada

**by**

**Doni Hatz***

## ABSTRACT

*The Glass Craft & Bead Expo hosted the* International Hot Glass Invitational *flame-off team competition held in Las Vegas, Nevada, April 3-4, 2009. With the goal to provide the audience with the largest, most dramatic glass sculptures and vessels in a three hour time limit.*

The *International Hot Glass Invitational* (IHGI) was an epic event started by Tommy Licata of Las Vegas Management, the promoter of the Glass Craft & Bead Expo in Las Vegas. Dozens of glass working artists from around the world gathered in a 4,400 seat arena to compete in the most unique flame off competition. Twelve teams of world-famous artists raced against the clock to finish the best and most spectacular work of glass art they could create within a three-hour time frame at the South Point Casino. Unfortunately Tommy passed away several months before his dream was realized but he still wanted the show to go on. With the support of the Las Vegas Management and *Flow Magazine* with Glass Craft & Bead Expo, this show became a reality (Photo 1).


*Photo 1*

The IHGI competition was held in conjunction with the 15th Annual Glass Craft & Bead Expo in the Equestrian Center located next to the exhibition hall. Inside was the 30,000 sq. ft, 4,400 seat arena with four 72" flat screen monitors that faced all sides of the arena

*Photo 2*

* The Procter & Gamble Company, 8700 Mason Montgomery Road, Mason, OH 45040. E-mail:hatzdj@pg.com.

along with a bar that overlooked the floor. The Glass Craft & Bead Expo is rooted in the flat glass world of stained, fused and slumped glass; it has grown to host over 200 instructors, 2000 students and 9000 attendees at the 2008 show. A flame work show was a different aspect they had never offered before; it was a risk but also a big deal because it offered the opportunity to be part of something big, possibly an annual event (Photo 2).

When I was asked to participate in the competition I was hesitant since the timing to plan for this was less than a year and this sounded like a big thing (the time factor is probably why only one international team attended the competition). But no matter what, this was like being in the Iron Chef competition you see on the Food TV Network but instead with glass, it sounded impressive. I was one of the few women invited to be in the contest and figured if all else failed this would be a good opportunity for exposure. I asked my brother Tim Kornahrens from Portland, Oregon, to join me. We had worked together years before at The Studio in Corning, New York teaching a one-week intensive flame working class. I knew Julie Riggs, who incorporates figurative pieces in most of her work, from the Art Glass Invitational gatherings in Pennsylvania. Then Tim "Fuzwirm" Williams joined in, a friend of my brother and former co-worker at TRS Scientific.

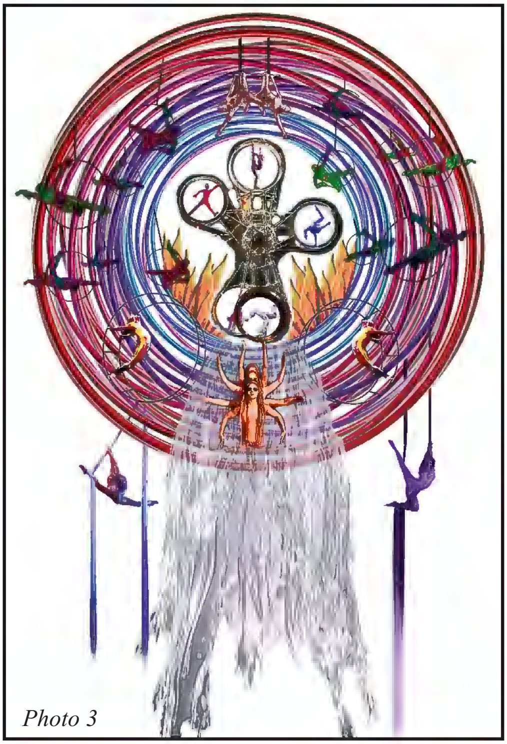


*Photo 3*

As my team began working together the challenge of 3000 miles between us was obvious but we connected through e-mail and phone calls back and forth. We considered the familiar themes of Fire and Ice, Fish in the Deep Sea, and flowers. Julie pulled it all together with a Las Vegas flash of circus and show girl entertainment in a Cirque du Soleil theme. She drew up a picture I called the "inspirational idea" of what we were trying to achieve. It had all the elements of fire and water, spinning wheels, circus trapeze performers in a circus tent of vibrant colors (Photo 3). With everyone spread out from the east to west coast we had to work from the same blueprint. I drew up one with each layer specific to the project for each person. I focused on the center, hamster wheel-looking contraption, Julie focused on the trapeze artists, Tim made the base manifold and tent structure, and Fuz the fire

*Photo 4*

and water features (Photo 4). Each aspect challenged us to look for faster ways to make our sections of the sculpture. Since we were able to make two pieces in advance for every one piece at the show we figured out our limits. Since everything looks so feasible on paper, there were a lot of things that would have been nice to add if we had had more time.

Tim and I made several different small scale pieces, talking daily on the phone, taking pictures of top view blueprints, e-mailing back and forth to finalize the design. We used our scientific glassblowing techniques making manifolds with standard laboratory ground glass joints and connectors to make the design work. Then we could assemble the sculpture easily at the show.

We included 19/22 ground glass joints on Glass Alchemy's new colored striped tubing for the main support with 14/20 ground glass joints on the water and fire manifolds. The spinning wheels are powered by motors with O-rings connected to the tubing that slowly turn the back and front piece at one revolution per minute. The wheels are actually 5 inch i.d. coils made with 8 mm o.d. medium wall tubing. The central stand is made with two 25 mm i.d. Chem-thread connectors sealed to a 55/50 outer ground glass joint on top and the bottom is a 55/50 inner joint sealed to a 60 mm i.d. Schott flange.

It was not until we arrived in Las Vegas to assemble the complete sculpture in my room at the South Point Casino that we could finally see it all together (Photo 5). It was so exciting to see our vision realized in three dimensional form. Now we had to copy it in the arena for the crowd and within the time limit.


*Photo 5*

Our good friend Barry Lafler, Past ASGS President and Wil Menzies of *Flow Magazine* were in charge of setting up the floor. They had the enormous task of setting everything up with a crew of volunteers to connect our fuel, torches, hand torches and ovens. Each team was assigned volunteers to tend to our needs, feeding us water and making sure the hardware and hoses were in check and safe, while keeping unauthorized people off the floor.

The competition was split up into two nights with six teams performing each evening from 6:30 pm to 9:30 pm. The Opening Ceremony began at 6:00 pm with full Las Vegas flare when Lewis Wilson came up on the stage dressed in a white tuxedo with a Las Vegas show girl dressed in a vibrant yellow feather outfit complete with large headdress full of beads, feathers and sequins (Photo 6). Lewis is a well-known glass artist in the industry and also a good friend to Tommy interacting with the Glass Craft & Bead Expos for many years. Lewis reminisced about how the show came to be with many conversations with Tommy, then there was a moment of silence in memory of Tommy (Photo 7).

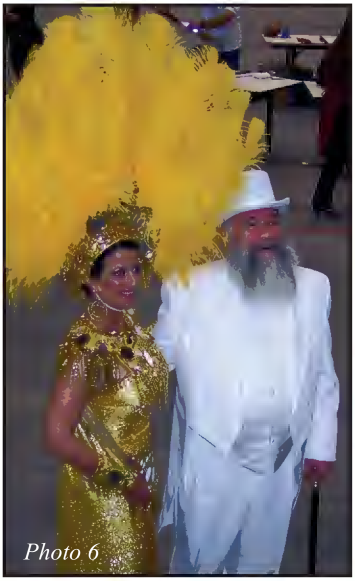


Photo 6


Photo 7

He continued with a 1932 song from Cab Callaway's' "Minnie the Moocher" (Ho-De-Ho) then finished off with eating fire, an old carnival trick he performed many years ago. We will not mention the smoke we saw rise off his moustache – did not see a thing.

A famous boxing announcer came on stage and yelled something like "Let's get ready to rumble" and the competition began. Jason Harris and Jenny Newtson took over the microphones for the rest of the show. They introduced each team and its members individually up on the stage before setting them free on to the floor and out to their tables and workstations to get busy. Jason and Jenny and camera crew roamed around the floor to capture the artists in action. Spotters around the floor threw up flags as markers when interesting techniques were being demonstrated drawing the attention of the camera crew to film the glassblowers.

As an added bonus of glassblowing extravaganza, a portable Hot Glass Furnace was set up at the opposite end of the stage in the arena. Friday night featured the Michael Angelo Menconi and George Kennard Team and Saturday night the Einar and Jaimes de la Torre team blowing glass with the blow pipe dipping into the furnace creating large pieces.

The Friday Night teams:

**#1 Eugene Glass School:** Dellene Peralta, Mark M. McCourt, Matt Dubois, Josh McDaniel created "Living in Eternal Peace." All members from Oregon created a Native American Indian touch eagle head with feather headdress with a rattle complementing the eagle sculpture. Dellene, one of the three women in the competition, was a key artist in making the eagle head the central point of the sculpture (Photos 8 & 9).

Photo 8

Photo 9

*Photo 10*

*Photo 11*

*Photo 12*

**#2 Pontilmotion:** Devin Somerville, Paul Stephan, Filip Vogelpohl, Mike Shelbo created "Birds of a Feather." They made a colorful sculpture of birds resting on a branch among flowers, cattails and leaves in a natural setting (Photo 10).

**#3 Lone Star:** Christian Luginger, Kevin Ivey, Micah Evans, Salt. The team members, most of whom were from Texas, created "Whole World in His Hands." The 23-inch diameter webbed globe used cobalt rod as the color of the ocean. The webbing also was a metaphor for networking and the connecting of people across continents as well as in life (Photo 11).

*Photo 13*

**#4 Frabel:** Hans Godo Frabel, Frankie Fox-Jones, Jack Roberts, Magnum Mangkang created "Water Lillies." This is one of Hans Godo Frabel's breathtaking Water Lillies, which he and his team first created for one of his large botanical garden exhibitions at the McKee Botanical Garden in Vero Beach, Florida (Photo 12).

**#5 Weinmayer:** Bernd Weinmayer, Sean Mueller, Ed Kirshner. The only international team from Austria created "Las Vegas Jellyfish." Although Bernd is from Germany, he makes his home in Austria. This plasma light sculpture of two large jellyfish was made with clear glass then back filled with a plasma gas mixture after annealing. The glass jellyfish had special characteristicswith a pleasantly weak light intensity. The gas created constant movement of the individual particles with flashes that looked like lightning and rotating fan-formations as well as small misty clouds (Photo 13).

**#6 Centrifugal Force:** David Sandidge, Eric Goldschmidt, Josh Bergsen, Lance Sanford. They created "Dragon's Nest," a three-level fountain look 36" high with each level representing a different theme of evolution: from hatchlings, to the bone yard and, on the upper level, Mother Dragon perched atop a giant dragon egg. I met Eric Goldschmidt teaching at The Studio in Corning and David Sandidge is one of the top glassblowers at Disney World (Photos 14, 15, & 16).

*Photo 14*

*Photo 15*

*Photo 16*

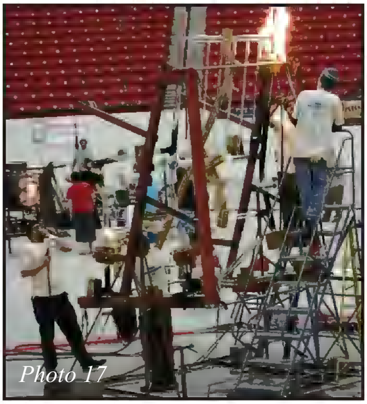


*Photo 17*

Saturday Night: The Teams:

**#7 Team Rockers:** Hamm Bruschland, Carlian Sage, Eli Copeland, Marcel Braun, created "Rocking Vegas," a larger-than-life, eight-foot tall rocking chair the exact dimensions of a child's rocking chair but scaled up. They used 3 inch heavy wall tubing and the most elaborate jig that tops any scientific glassblower's tool in their shop. Marcel designed and welded the holder for the tubing with metal and wood sections. In mid-fabrication, the entire structure is rotated upside down to seal the tubes in the appropriate sections. It was an amazing sight to see all four guys simultaneously working large hand torches until the fabrication was complete. Of course flame annealing was the only way to finish this sculpture. Unfortunately my team was working at the same time 40 feet away so I had to capture the fabrication on the live video feed, later on, on the computer (Photos 17 & 18).

Photo 18

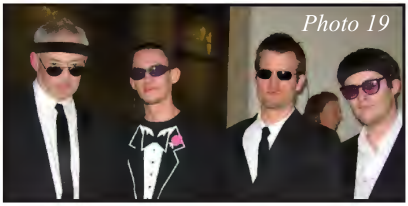


Photo 19

**#8 Men in Black:** Milon Townsend, Jacob Hyman, Justyn Schoenfeld, Eric Bailey. The four men dressed in black suits, or the illusion of suits to fit their team title, worked with borosilicate plate glass shaping it into waves with rods sealed together (Photo 19).

**#9 Northstar:** Clinton Roman, Darby Holm, Scott Deppe, Matthew "Banjo" Stroven. All were members from Oregon with Northstar Glass who generously sponsored them and the glass. Their sculpture was the first place winner as well as the people's choice award of the competition. They fabricated a spectacular scull and bone chandelier. It was inspired by a chandelier hanging in a Cistercian monastery in the small Czech village of Sedlec outside of Prague. They had the most unique method of capturing the hot glass furnace style glassblowing with a crucible pot in an oven. They dipped clear borosilicate glass tubing and rod into a new black glass with a unique fuming effect nicknamed "Deppe Darkness" and shaped them into the rib, spine and skull bones (Photos 20 & 21).

Photo 20

Photo 21

Photo 22

**#10 Onion Mountain:** Chaz Pyle, Nately Biskind, Eusheen Goines, and Eli Aller created a sculpture with two white birds on black branches. It held several flowers and spiraled gizmos all entirely of black and white combinations – very impressive montage work (Photo 22).

**#11 Scientific Splash:** Doni Hatz, Tim Kornahrens, Julie Riggs, Tim "Fuzwirm" Williams. My team created "Elements at Play." We dressed in our white and black lab coats for the scientific approach (Photo 23).

**Photo 23.** *(L-R) Fuz, Doni, Julie, Tim*

**Photo 24.** *Tim*

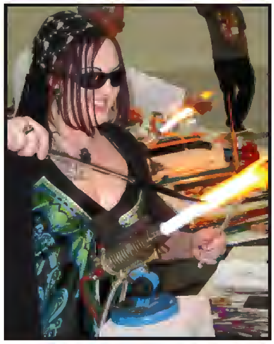


**Photo 25.** *Julie*

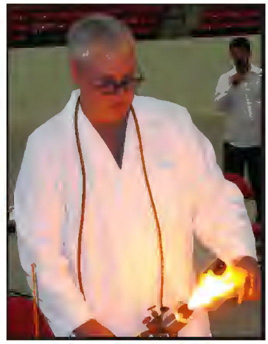


**Photo 26.** *Fuz*

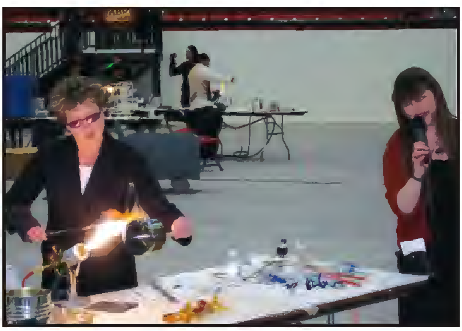
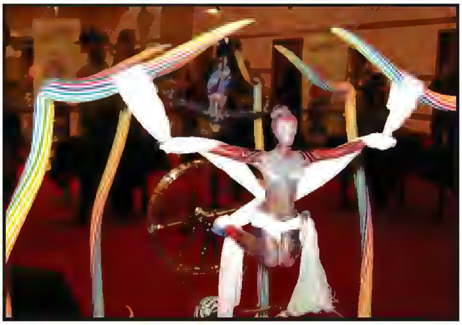


**Photo 27.** *Doni and Jenny Newtson*

**Photo 28.** *Big screen of coil wrap*

**Photo 29.** *Fuz and Doni*

**Photo 30.** *Doni and Julie*



Photos 31 & 32. *Close-up of trapeze figures*

Photo 32

**#12 Pitagora:** Bandhu Scott Dunham, Andrew J. Pollack, Cameron Reed, Dan McCarney created a "Kinetic Sculpture" with 6 mm rods aligned into tracks with marbles racing up, down, including a basket of dry ice, a soda bottle and mint candies creating a geyser effect. Bandhu is the author of several contemporary lampworking books as well as the maker of fun glass working steam engines and the kinetic sculptures that have captured his interest for several years (Photo 33).

Photo 33

Photo 34

Sunday Morning came quickly and we had to assemble our project for judging at 9 am. We scrambled around for a few ribbons and rubber bands just in time to plug in the motor for action. The sculptures were set up inside the Glass Craft Bead Expo exhibition hall. All the sculptures were incredibly beautiful. We knew that is was honor to be invited to participate in the competition and anything more was a bonus. We were quite privileged to win second place (Photo 34) behind Team Northstar's "Bone Chandelier," with Team Rocker's "Rocking Vegas" taking third place. Look for the article in *Flow Magazine* Summer Issue 2009 for more information about the competition. Also a DVD is available on the Glass Craft Bead Expo web site. This was an incredible experience working as a team stretching our imagination to make a collaborative piece when we had never worked together like this before. We were not afraid and knew we would give it our best shot with the hope that people would enjoy our sculpture "Elements at Play" which is a reflection of the motion of spinning wheels, flowing water, flames of fire and exotic trapeze figures.

Many thanks to our sponsors: Carlisle Machines, Inc. for use of their Carlisle CC Plus Blast burners, Glass Alchemy for the colored glass rods and new pre-striped colored glass tubing, Paragon Kilns for the ovens, Las Vegas Management and Glass Craft & Bead Expo.

# Quartz Burners and the Transition From Quartz Tubing to Metal Valving

**by**
**Marvin Molodow**[a]

## ABSTRACT

*A procedure for making a transition from quartz tubing to metal valves.*

This paper will describe a procedure for making a transition from quartz tubing to metal connectors to metal valves. Several types of connectors are available and can be used for this purpose. Swagelok makes a high vacuum O-ring connector called a Cajon Ultra-Torr® out of stainless steel or brass.

O-rings are the most desirable method to make this kind of transition. When using O-rings to make a tight seal between the quartz and metal connectors, I suggest using two O-rings. I place one O-ring at the inside under the top of the nut and one at the bottom where the metal insert compresses the bottom O-ring. The top O-ring is then compressed against the top of the metal insert making a tight seal.

Following are some of the quartz tube sizes that can be used for transitions: .250", 6 mm, .375", 10 mm, 8 mm, .5" and 12 mm. These tubing sizes are available from your quartz vendor or you can resize the tubing.

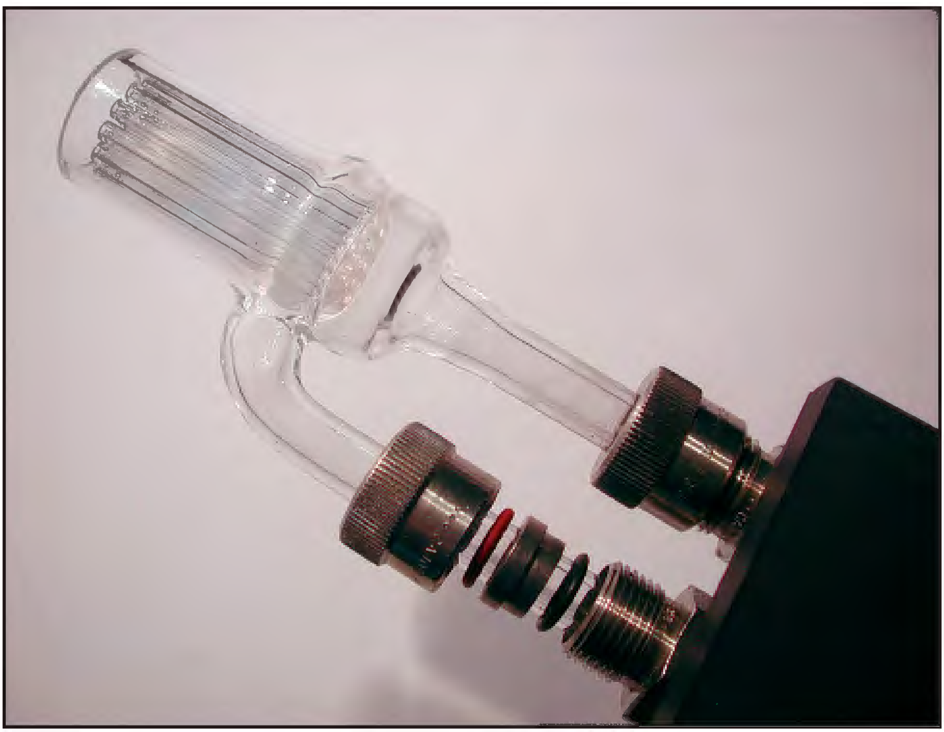


**Photo 1**

[a] Blue Flame Technology, 431 Kentucky Lane, McKinney, TX 75069. E-mail: bft@blueflametech.com.

There are several ways to resize the tubing. One way to enlarge it is by heating the quartz and passing a graphite mold through the quartz tubing. Or for a short piece, use a graphite paddle to bring it down to the desired size.

**Photo 2.** *Eight-jet quartz burner/mount*
*Smaller OR larger burners will adapt to this mount*

Another method to enlarge tubing is to use a graphite rod to bring the o.d. of the tube up to the required size. First, heat the tube, then insert the graphite rod into the inside of the tube to increase the o.d. of the tubing up to the dimension required. The graphite rod size depends on the i.d. of the tube: for example, if a 4 x 6 tube needs to be brought up to .250 o.d., you would use a 1/8 graphite with a point on the end. As you heat the glass or quartz, move the rod inside to raise the glass or quartz material to the desired o.d. **Do not let the graphite rod overheat, or it will stick to the quartz causing the quartz tube to deform or twist.**

If working heavy wall quartz, the material can be stretched to make the tubing smaller. If the tube ends up being too small, a 1/8 graphite rod can be used to tool up the o.d. to the correct size to fit the Ultra Torr connectors by whatever method is chosen.

When making quartz tubing the correct size for the metal transitions, I like to use a quartz burner of the type seen in Photo 1.

This torch has four valve connectors with a .375 Ultra-Torr® fitting. This is a surface mix torch that has a center fire of 7 Jets and an outer fire of 67 Jets. These types of burners have no metal being broadcast through the torch.

**Photo 3.** *Center & outside quartz burner/mount*
*Burner uses propane OR natural gas, ultra performance in a flame: glass working for the artisan*

The only way metal can be dispersed on the material being worked is if the gas lines and the cylinder have metal particles in them that pass through the flame onto the glass or quartz material. One method to stop this metal particulate from being flame deposited on the material is to use gas line filters.

# Safety and the Scientific Glass Shop
# Are You Donned with PPE?

**by**

**Art Ramirez**[a]

## ABSTRACT

*Personal safety practices should be a part of everyone's daily routine. Just as we all have to punch in and follow strict company policies in order to keep our jobs, we should all have our employers support our personal safety practices by providing us with the necessary PPE. You cannot be fired for demanding safety in the work place.*

This presentation will cover personal protective equipment that should be worn while performing specific tasks in a scientific glassblowing shop as well as other safety features that will decrease the rate of injuries associated with the hazards in your shop. There are three major hazards that are associated with everyday activities glassblowers face. Cuts, burns, and chemical exposure are the main hazards we encounter daily but I will also discuss some hazards that tend to be overlooked in just about every shop. Finally we will take a look at a JSA or Job Safety Analysis that will aid in evaluating potential safety hazards of a particular task before performing the job. I hope that this presentation will be helpful as a training tool for those individuals who do not have the experience of handling glassware on a daily basis and also for those who see safety in our shops as the number one personal requirement.

*Photo 1*

**Receiving packaged materials.**
The first task I will discuss is receiving new materials from a vendor. On average these materials are received intact but on occasion breakage will occur in transit despite the care taken by the vendor to avoid this. For this reason, a minimal PPE should be worn when opening boxes containing glassware. (Photo1)

*Photo 2*

**Glasses and lab coat.**
From start to finish there are several hazards of which we should be aware. First of all, you are opening a container which has been transported with hundreds of other packages of which you have no knowledge as to their contents. Cross contamination is a hazard to consider when opening your box.

**Cut resistant gloves Level 3.**
Opening the box itself poses a hazard. The box cutter can accidentally slip and cut your hand. Some vendors use staples to seal their boxes and these can cut or puncture the skin

[a] UOP, LLC A Honeywell Company, Research Building 3 Room 128, 25 E. Algonquin Rd. Des Plaines Il, 60017. E-mail: Arturo.Ramirez@uop.com.

easily. Remember, you are reaching into a package blindly not knowing if the material may have been damaged in shipping. (Photo 2)


Photo 3

**Minimal PPE.**

This is the personal protective equipment that I recommend using for this task. Safety glasses with side shields if available, cut resistant gloves level 3, as well as a lab coat or other protective garment that will not go home with you after work.

**Receiving packages with known hazards.**

When receiving packages containing glassware that we know will be broken such as repairs, we should pay close attention to the level of PPE that will be worn. (Photo 3)


Photo 4

**Glass in for repair.**

We are all aware that the majority of our work comes from repairs done on glass vessels from the lab. We also know that these repairs may be shipped from other locations and that their condition is unknown. Fishing blindly through packing material for that repair could cost you and the company more than you bargained for.

**Elevated PPE level 5.**

We know from experience that broken glass tends to be jagged and razor sharp. I like to employ the maximum level of protection when searching a box for my repairs. Notice the comfort grip added to these gloves which makes their use extremely ergonomic. To understand the levels of cut resistance go to http://ohsonline.com. (Photo 4)

**Minimal PPE.**

For the task of finding repairs in a sea of crinkles, a level 5 cut resistant glove serves best along with safety glasses and a smock. Latex gloves are also not a bad idea to use over the cut resistant glove to avoid contact with contaminants and to extend the life of your gloves.


Photo 5

**Excuses!!!!**

As a glassblower of almost 25 years, I understand that comfort and dexterity is very important to us. Ask yourself how much dexterity you will have when you sever a nerve in your rotating hand because putting on a cut resistant glove was too time consuming for that task that will only take two seconds to perform.

**Don't!!!**

How many times have we seen this? How many times have we done this ourselves? Some of you may have gotten lucky and avoided stitches, but I know of several people who did not get off so easily. (Photo 5)

**Do!!**
Use a minimal level 3 cut resistant glove while performing this task. The comfort grip glove allows you to hang on to the tube while scoring. It also protects you from that one in a million chance that this particular tube at this particular time under these particular conditions, temperature, and barometric pressure will break and you cut yourself. (Photo 6)

*Photo 6*

**Minimal PPE.**
This slide demonstrates the minimal PPE cut level 3 for scoring glass. It is very comfortable, form-fitting and the dexterity is incredible. Also shown are the safety glasses with side shields and lab coat.

**Cutting odd shapes on the wet saw.**
From time to time we all have had to cut a piece of glass that will not rest squarely on the table of our wet saw. We also have risked injuring ourselves not to mention breaking an expensive blade and having the piece yanked out of our hands as the piece catches the blade and sends shrapnel flying all over the place. Those of you with extensive experience know what I am talking about. This particular hazard is created out of the need to save time.

*Photo 7*

**Cutting the top off of a separatory funnel.**
I have seen this task performed free hand without the use of any PPE. (Photo 7)

**Free hand cutting.**
I understand that at some point we all must cut something free hand that is oddly shaped. By free hand I mean that the piece is not seated securely in a jig or the table of the saw. If you are going to do this, please take the time to protect yourself from the possibilities. The previous slide shows the minimal PPE but does not cover the what if's.

*Photo 8*

**What if?**
What if the piece catches the blade? There is no protection from the flying shards of razor sharp glass to protect this young lady from severe and potentially fatal injury. Although her eyes and hands are protected, there is still a lot of missing PPE. (Photo 7)

**Do!**
Protecting your hands and eyes is important but what about your arms? There are a lot of important veins and muscles that I am sure we would all like to keep intact. The coat you see here has leather sleeves that protect her from sharp objects. (Photo 8)


*Photo 9*

**Go for the jugular!**

Let us improve upon the rate of survival in a worse case scenario. This safety shield protects the worker from cuts to the neck and face. Notice the latex gloves used when water is present. This will extend the life of your gloves. This may seem like overkill to some, but in those rare moments, killing yourself is what you should avoid. (Photo 9)


*Photo 10A*

**Dispose of properly!**

When disposing of glassware, make sure that it fits in the waste container. (Photos 10A, 10B & 10C)


*Photo 10B*

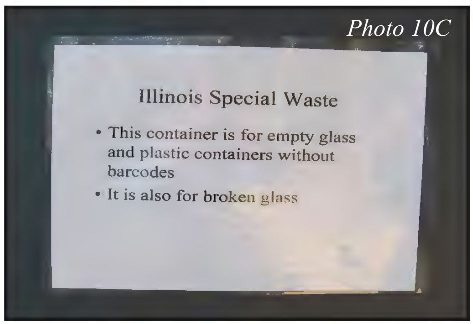


*Photo 10C*


*Photo 11*


*Photo 12*

We added safety goggles under the face shield because we were not quite sure where the pieces would fly. (Photo 11)

**Lapping wheel.**

When using the lapping wheel, your hands are always in the line of fire. Both sides of this glass ring have sharp edges. We employed the level 5 cut resistant gloves with latex over to keep our gloves free of slurry. (Photo 12)

**Level 5 Cut resistant stainless mesh.**

These gloves are considered a maximum level 5 protection. For liability purposes, the


Photo 13A


Photo 13B


Photo 14

gloves used for this presentation cannot be termed cut proof, only cut resistant. I like to use these when handling razor sharp edges on my glassware. (Photos 13A & 13B)

**I would like to do it myself!** Working in research and also having come in contact with many graduate students, I have always had the pleasure of passing on some shop hints to that ambitious student who would like to do it herself! (Photo 14)

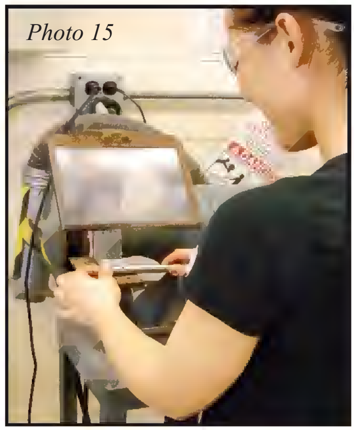


Photo 15

**Tool grinding could be hazardous to your health!** As glassblowers, we only hear about it, but my colleagues in the machine shop have seen it and it is ugly. The hazard associated with tool grinding is that you never know when the resin that keeps the wheel bonded together will overheat or have that imperfection that will cause it to explode. We use a grinding wheel for little else than sharpening our carbide tool for scoring glass and for that reason we need to pass on all this information about using it safely to those with less knowledge. (Photo 15)


Photo 16A


Photo 16B

**Safely and correctly!**
The same PPE is used here, that was used in free hand cutting on the wet saw, minus the purple latex gloves. In the event of wheel failure, the worker is protected and has a better chance of avoiding serious injury by donning her PPE. All safety features are in place and her technique is clean and precise. (Photos 16A & 16B)


*Photo 17*

**It will only take a second! Why risk it?**
All I needed was a slight chamfer on my tube but what I got were stitches that went from my thumb to my wrist and it only took a couple of seconds! (Photo 17)


*Photo 18*

**Better safe than sorry!**
Glass can give way at any time. When grinding, you are applying pressure to the piece so your hands and arms are in the line of fire. In the event something goes wrong, make sure you are protected. (Photo 18)

**Cutting corners on safety is NOT productive!**
We all understand the bottom line. Every company in every sector demands that we save money. After all, time is money, correct? WRONG! Keeping safety as the number one priority is money in the bank for both you and your employer. If you get hurt on the job there are medical bills that will need to be paid. You will need to be paid as well for your time off. After all investigations are completed, bills paid, restitutions made and wounds healed, it can cost a company upwards of $50,000 after everything is said and done. This may not include settling suits for injuries that are career-ending and let us not forget our new-found disability that no longer enables us to do the simple everyday things we take for granted like hold our own spoon. Insurance companies frown on payments for injuries that could be avoided if the proper safety procedures would have been followed. So, did you save your company any money by not taking the extra thirty seconds it takes to wear your PPE?

*Photo 19*

**Can't you tell it is HOT?**
Burns are a little more difficult hazard to avoid in a glass shop, but there are simple ways to lessen their frequency. As glassblowers, we know that hot glass looks just like cold glass. We are mindful of that tube we just polished and are aware of where we put it down. We never forget that first lesson. I have heard some say that they would rather get cut than get burned because the pain is less severe. I would rather do neither.


*Photo 20*


*Photo 21*


*Photo 22A*

*Photo 22B*

**Properly trained.**
This technician read the signs and has been trained on the potential hazards in the glass shop. Before retrieving her flask, she first puts on the proper PPE. (Photo 21)

**Working in the oven.**
Sometimes we have to fix a crack on a piece of glass inside the oven. The exposure to heat radiating from the oven is intense. A reflective face shield, gloves and sleeves is what I

**How do they know?**
We often have customers who come into the shop as we are working. I found that a simple sign is the best way to warn against the hazards around them. (Photo 19)

**Please read the signs!**
This technician may be unaware that this flask may still be HOT! Sometimes we are unavailable and customers will spot their work and assume the job is complete and it is okay to retrieve. (Photo 20)

*Photo 23A*


Photo 23B

employ for this job. The uniform is also fire retardant. A rolling chair that is low to the ground is a great asset! (Photos 22A & 22B)

**Big quartz gets HOT!**
When working on a big quartz job, this is my gear of choice. Reflective coat and gloves and my Miller welder's helmet do more than protect me from the heat while sealing on that large fitting. (Photos 23A & 23B)

**SPF 50?**
SURELY PROTECT your FACE! This Miller welder's helmet is designed to auto-darken when you strike an arc while welding. I adopted it for quartz work and found that it also darkens as soon as quartz gets up to working temperature. As the light lessens from the quartz, the face returns to normal and I can see without flipping up the helmet.


Photo 24A

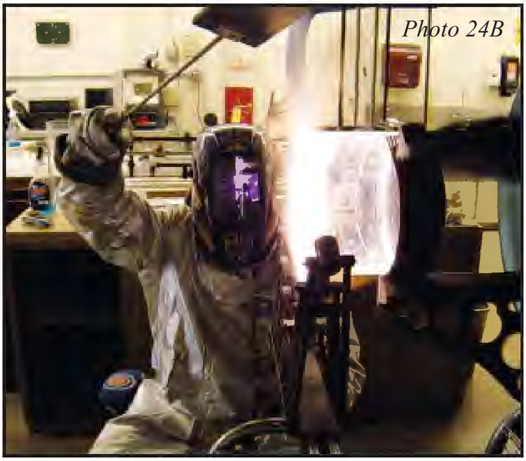


Photo 24B

Wear your PPE to avoid heat exposure. Make every attempt to identify the potential hazards that you may encounter on the job you are about to do. Keep in mind where you put down your hot work and inform anyone else who may come in contact with these hazards. BE SAFE! (Photos 24A & 24B)

**Chemical exposure.**
We should review the obvious. Apron, chemical resistant gloves, safety glasses, face shield, rubber boots and proper ventilation. Having an emergency plan in order is also important when working with chemicals. Know where your eye washes and safety showers are located and make sure they are working properly before you begin. Is your spill kit complete and is it adequate for the chemical you will be using? Have instructions on first aid available for the ERT that coincide with the chemical you may have been exposed to. Always have a second person present when working with any chemical that can overcome or prevent you from getting help such as HF.

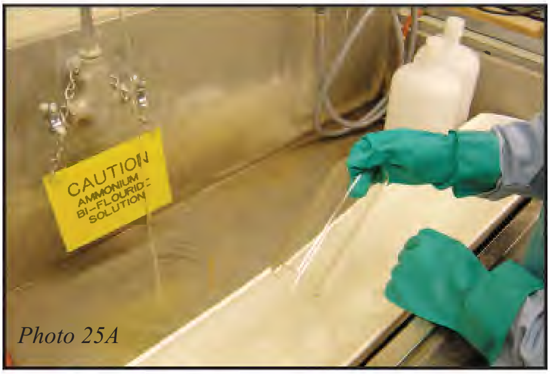


*Photo 25A*


*Photo 25B*


*Photo 25C*


*Photo 26*

**We all use it! Looks safe to me!**
We are always using some type of chemical for cleaning glassware; it simply comes with the territory. Whether it is HF or ammonium hydrogen-fluoride solutions, we expose ourselves daily. Here you see a cleaning task being performed and the PPE one would consider complete for doing this tasks. There is something missing. (Photos 25A, 25B, 25C)

**My cut resistant gloves are missing! It never "dawned" on me!**
Over twenty-four years of performing similar tasks such as washing glassware, it never

occurred to me that I was always at risk for injury even though I had on what I believed to be the proper PPE for washing glassware with a caustic solution. I was partially right. What I could have used before that quartz tube gave way under the slightest pressure from scrubbing were my cut resistant gloves. I wish they would have been level 5! The razor sharp tube pierced the nitrile glove that protected me from the caustic solution but was no barrier against the sharp edge of the tube. It was a bad end to an otherwise productive day and guess what, it did not save my company any money. But we did learn from it! (Photo 26)

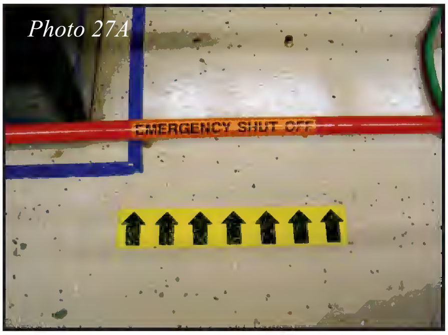


*Photo 27A*

*Photo 27B*

*Photo 27C*

*Photo 28A*

*Photo 28B*

*Photo 28C*

**Sign, sign, everywhere a sign!**

Everyone who walks into our shops risks injury. Signs on everything help the outsider identify hazards and safety features in your environment. If you are hurt and unresponsive during an emergency, anyone who walks into your shop can respond appropriately if they know where everything is. (Photos 27A, 27B & 27C)

**Emergency shut-offs labeled!**

(Photos 28A, 28B & 28C)


Photo 29A

Photo 29B

Photo 29C


Photo 30A


Photo 30B

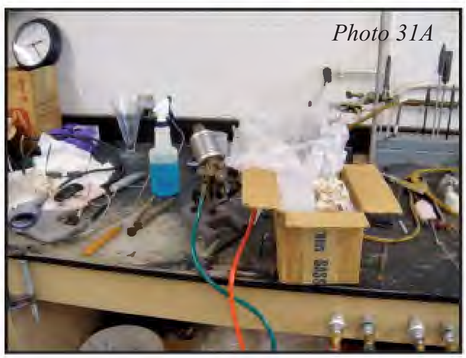


Photo 31A

Photo 31B

**Water and electricity do not mix!**
(Photos 29A, 29B & 29C)

**Shock proof.**
Identify shock hazards and correct them. Use GFCI outlets where water is present and wire your wet saw to water proof breaker boxes. (Photos 30A & 30B)

**Housekeeping and safety.**
Yes they do go together so clean up your act. It is difficult to be productive and nearly impossible to consider this a safe work station. (Photos 31A & 31B)

**Organize!**
Removing clutter and organizing is the safest way to manage your space. Anyone entering this space was at risk of tripping or having something fall on top of them. GET RID OF THAT JUNK!! (Photo 32)


*Photo 33*

*Photo 32*

**Trip hazards.**
Identification is an essential component to a safe work area. I offered this glassblower a hand at re-routing his lines by installing copper tubing up, over and down to his lathe. This eliminated the trip hazard. (Photo 33)

*Photo 34*

**JOB SAFETY ANALYSIS**

| | | |
|---|---|---|
| **JSA# TBD** | **Title: Use of a Ladder** | **Department: TBD** |
| **Issue Date: TBD** | **Prepared by:** Muskegon example - converted | **Approved by: TBD** |

| **Hazard Classifications:** *CB=Caught Between CI=Caught In CO=Caught On CW=Contact With CHEM=Chemical Exp. ELEC=Electrical ENV=Environmental ERGO=Ergonomics EXP=Exposure (thermal, other) Fall PROC=Process Hazard(fire, runaway) SB=Struck By SO=Strain-Overexertion OTH=Other, this is rare, explain | | | **PPE and protective equipment to consider (Be sure to check area PPE assessment and form):** hardhat, hearing protection, goggles, faceshield, chemical resistant gloves (which ones), cut resistant gloves, thermal insulated /cryogenic gloves, leather gloves, gauntlets, apron, protective clothing, respiratory protection (airhood, cartridge respirator, local ventilation), fall protection |
|---|---|---|---|
| **Basic Job Steps** | **Hazard Category*** | **Hazardous Conditions or Unsafe Practices** | **Safe Practices and Preventive Measures** |
| Determine correct ladder for the job | Fall | Using the wrong ladder can create unstable situation creating potential fall hazard. | Use the right tool for the job (Step Ladder verses Extension Ladder) |
| Inspect ladder | Fall | Defects with ladder can create unstable situation creating potential fall hazard. | Ladder should meet manufacturer's original specifications and be in good repair. If ladder is compromised such as cracked rail, broken rung, missing |
| Move ladder to desired location | SB | Ladder may strike and damage object while transporting it. | Ask a co-worker for assistance if in question. Inspect path for potential hazards and to make sure it's clear before moving ladder. |
| | SO | Potential muscle strain while carrying to location. | Ask a co-worker for assistance if in doubt. |
| Set up ladder | SB | Ladder may strike and damage object while positioning ladder. Object could fall and strike someone below. | Ask a co-worker for assistance if appropriate. Consider the need to barricade the work area. |
| | SO | Potential muscle strain while setting ladder in position | Ask a co-worker for assistance if in doubt. |
| | SO | Potential muscle strain while carrying to location | Ask a co-worker for assistance if in doubt. |
| | CI | Pinch hand/finger while opening or extending ladder | Be aware of hand placement and consider the use of gloves. |
| | | Potential for ladder to shift and causing | Make sure ladder feet are placed on stable |

**Maintenance.**

We all need to find the time to keep our areas clean. It is easier and safer to find what we are looking for if everything has its place and is put away once we are done. Make an effort to rid your shop of junk that has collected dust for years which you refuse to use because it looks cool. If you must keep it, clean it up and display it. If you find that you need it after you have trashed it, then build it. Remember you are the Glassblower!

**Job safety analysis.**

This next slide shows a simple JSA. We use a JSA to guide us through the potential hazards of any given task no matter how redundant that may seem. This JSA is on the use of a ladder. Does anyone else think that using a ladder is a no brainer? (Photo 34)

**Conclusion.**

It may seem redundant to those who have gone many years without a single incident but it only takes that one time to make us well aware that safety in the glass shop is a priority that we have to stop taking for granted. The daily hazards we face in the form of cuts, burns and chemical exposure seem like an extension of ourselves after many years. We overlook so much because we are surrounded by these dangers every day and for that reason we tend to experience a sort of tunnel vision. In my career, I have tagged along to the glass shops at universities and I have worked for small companies. After what I have seen over the years, I am surprised there are this many of us sitting here listening to this discussion. I hope my presentation will encourage everyone here to go back to their shops and improve at least one thing that will make their jobs a little safer.

Thank you and remember to wear your PPE!

Special thanks to: Steven Greene, Paulina Jakubczak, Mimoza Sylejmani, Liseth Carranza, Luis Rodriguez, Dennis Ramirez, and Shawn Ferber.

# Shop Talk: University of Wisconsin - Madison

**by**
**Tracy Owen Drier**[a]

## ABSTRACT

*This paper is a follow-on to the paper given by Curt Sexton at the 2007 Symposium in Portsmouth, Virginia, entitled "It works for Us." This paper will be a photographic meandering through the Glass Shop of the University of Wisconsin-Madison. It will highlight the layout and equipment used.*

## THE EXISTING CHEMISTRY DEPARTMENT GLASS SHOP

I started in UW-Madison Chemistry Department in October 2000. The glass shop had been empty for three months and students had access during that time. This shop was located on the street level and is shown in Figures 1, 2 and 3.

**Figure 1.** *Glass shop in 2000*

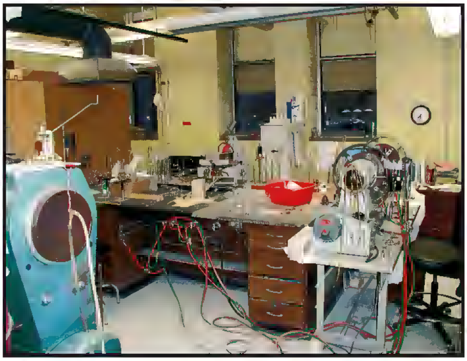


**Figure 2.** *Glass shop in 2000*

**Figure 3.** *Glass shop in 2000*

I figure that the time to ask for equipment is when you begin a new position. After accepting the position I made an appointment to tour the shop with the professor who was in charge of the glass shop. I created a word document with a check-box list of equipment that I *needed* to see that I brought for the tour. This included things like specific torches I was used to working with, ventilation over lathes, and ovens, as well as glass storage. First, he was impressed that I thought to bring a list. And second, he was able to use that list as justification to the finance committee for purchasing a new wet belt sander for me.

## THE NEW GLASS SHOP

When I arrived, they were in the process of building on a new addition to the chemistry building (now called the Shane Tower). As part of that project, they were renovating

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the two older sections of the building. The result was that the glass shop was being moved from its current location at street level up to the third floor. This had been in the works long before I arrived and I thank my predecessor, Charlie Patterson, for getting me this new space.

**Figure 4.** *New shop construction*

Figure 4 shows the demolition for the new shop.

Figure 5 shows the new shop as construction is progressing (looking West) and Figure 6 is looking East. The blue box on the counter of Figure 6 is a G-Tec gas booster, model GB-500.

**Figure 5.** *New shop construction looking West*

**Figure 6.** *New shop construction looking East*

The new space is ~1000 sq.ft.. It has good natural light with a full wall of south-facing windows. I was able to work with the architects on equipment placement. The blue painting tape on the floor outlines equipment footprints for the center island and lathes. All of the cabinet work was reused from the old shop.

Construction was completed and I moved into the new shop between Thanksgiving and Christmas 2001. Figure 7 is a photograph of the new glass shop. The center island top is Cem-Fil board which was custom ordered from Wale Apparatus. The top is made from four pieces with a total size of 12'x5' x 1.5" thick.

Figure 8 is the new shop looking towards the wet area of the shop.

**Figure 7.** *New third floor glass shop*

**Figure 8.** *New shop*

Figure 9 is a detail shot of the wet area. This includes a diamond band saw, ultrasonic cleaner, Wilt wet belt sander, a small sink, Pistorius 14” wet saw and a Buehler 12” flat lap. Above the belt sander are aluminum pegs bolted onto a board for holding the various diamond belts. Both the belt sander and cut-off saw have a fresh water feed. For both, there is an electric solenoid in-line for automatic water turn-on when the machine is turned on; this means you do not have to remember to shut off the water after every use.

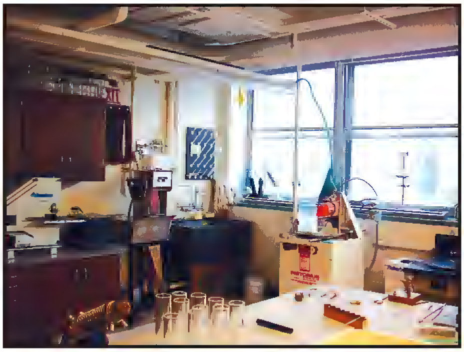

**Figure 9.** *Wet area detail*

The solenoid is ASCO brand Red Hat II, 2-way solenoid, series 8210 G002 for 1/2” pipe.

Figure 10 is looking towards the main entrance (there are two entrances). Underneath the bench is a manifold with shut off’s. The shop has a total of four manifolds - two for this work bench (one per side), plus one for each of the two lathes. The manifolds will be discussed in more detail shortly. I teach a one-semester class once a year during the spring semester (January-April). The center island holds a total of five student stations using hand torches plus my main work area (bench burner+ hand torch). There is a 5’ sink next to the entrance which is good for cleaning full lengths of tubing when necessary. The 5’ fume hood houses a mechanical pump for doing any vacuum silvering. This is also where I do vacuum leak checking of pieces.

**Figure 10.** *Shop photo looking towards main entrance*

**Figure 11.** *2-cylinder oxygen manifold*

Figure 11 shows the 2-cylinder oxygen manifold.

There is a large machine shop on site, but I also have a small space for simple metal/ plastic/wood working. See Figure 12.

**Figure 12.** *Small workbench area*

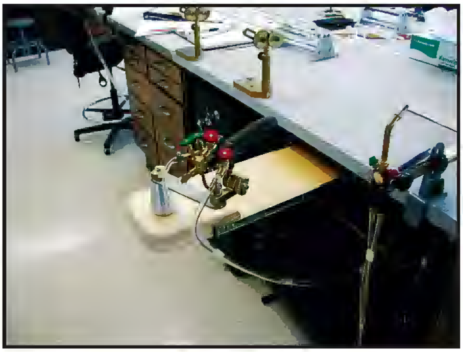

**Figure 13.** *Articulated torch slide – pulled out*

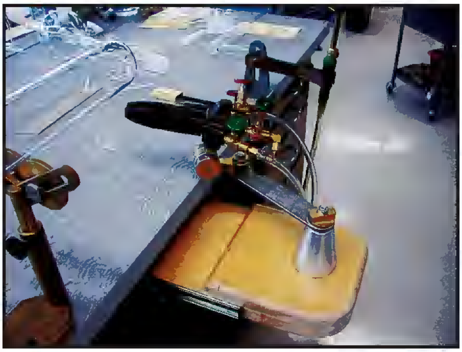

**Figure 14.** *Articulated torch slide – pushed in*

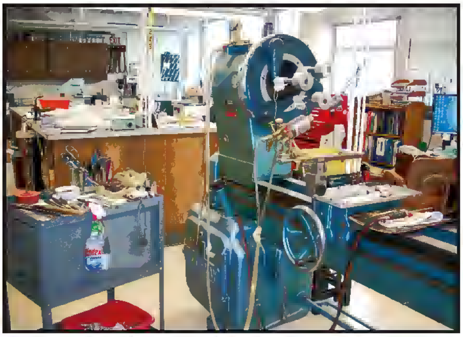

**Figure 15.** *Heathway lathe*

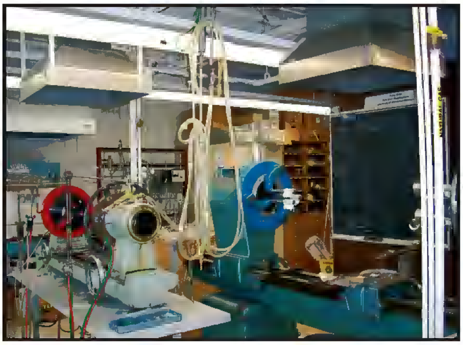

**Figure 16.** *Litton lathe*

**Figure 17.** *Wilt annealing ovens*

Figures 13 and 14 are shots of an articulated torch slide similar to what they use in the Eastern Michigan area (Dow Chemical, Wyse Glass, UM-Ann Arbor, Randy Hansen).

The glass tubing is worked off of two rollers and the slide is moved in with your hip.

Figure 15 is the 8-1/4" bore large Heathway lathe. There is a rolling tool cart. There is a gas saver with torch quick connects on the headstock. I generally use multiple hand torches when working on the lathe, but there is also an articulated arm for a Carlisle torch on the carriage assembly.

Figure 16 shows the smaller 4-1/2" lathe, Litton HSJ-U. There are canopy hoods over both lathes as well as the two Wilt ovens. There is also ventilation through the fume hood as well as a 4" diameter drop-down over bench area (no hood). The shop is designed as a standard chemistry laboratory and as such the air changeover is six times/hour (every ten minutes). The drop down piping for each of the manifolds has a shut-off safety valve for the gas line (yellow handled valve in upper right corner of photo).

Figure 17 shows the two Wilt annealing ovens: small MODEL 150 - 30" wide x18" deep x18" high and large MODEL 210 - 5' wide x18"deep x 20" high.

The small oven has a vacuum feed through.

The vacuum station is next to the small oven. Figure 18 shows the oil diffusion pump with cold trap. It has a Penning style vacuum gauge.

The tubing storage cabinet is shown in Figure 19. It is built for 4 foot lengths of tubing.

**Figure 19.** *Tubing storage*

Figure 20 illustrates the gas distribution manifold for the large lathe. There is one manifold near the headstock of each lathe. Each manifold has four each of gas/oxygen ports and two each of gas/air ports. All have quick disconnects and flashback arrestors, as well as their own shut-off valves for the drop down gas lines.


**Figure 21.** *High pressure natural gas piping*

**Figure 18.** *Vacuum pumping station*

**Figure 20.** *Gas distribution manifold*

### Gas line safety features

The G-Tec unit was disconnected after a couple of months. This particular model runs constantly and the compressor is too loud for the size of the room. G-Tec literature suggests that this model be put in a separate isolated room, but that was not an option in this case. Instead, we disconnected the booster and brought in high pressure

**Figure 22.** *Main gas shut-off valves, manual and electric solenoid*

**Figure 23.** *Solenoid On/Off button at door entrance*

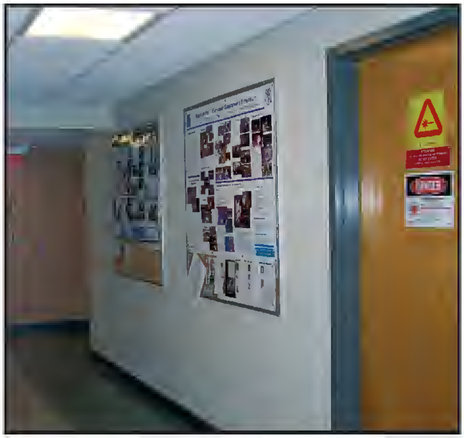

**Figure 24.** *Hallway outside of glass shop*

natural gas through 1-1/2" diameter black pipe from the street. It is the only high pressure gas (4 PSI) line in the building. It is well-marked throughout the building. See Figure 21.

Figure 22 shows the manual valve plus electric solenoid shut-off valves for the incoming gas line. The electric solenoid is activated by red *panic* buttons at either of the two exits (Figure 23). From the incoming natural gas into the shop to its exit out any torch nozzle, the gas travels through a total of five different valves.

There are three cork boards outside the glass shop for glass shop promotion. This includes articles, posters, section meeting demo photographs, and other items of interest. See Figure 24.

## ACKNOWLEDGEMENTS
I would like to thank the University of Wisconsin-Madison Chemistry Department for their continued support and encouragement.

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Steven M. Anderson
**“Liver Perfusion System”**
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Scott Bankroff & Mathew Puskar –
**“Thirteen Ways to Separate Glass From Itself”**
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Jack S. Korfhage & Ben Spalding
**“How the Scientific Glassblower Enhances the Ability of Researchers to Perform Experiments and Achieve New Technologies”**
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**“Burner Plumbing Solutions”**
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**“Constructing a Fritted Perforator for an Extraction Apparatus”**
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# 2009 Technical Workshops

Gary Dobos – *Savannah River National Laboratory*
**"Jacketed, One-Liter, Flat Bottom Reaction Vessel"**

Patrick DeFlorio – *Yankee Glassblower, Inc.*
**"Flaring 1 mm Tubing"**

Tracy Drier – *University of Wisconsin – Madison*
**"Sealing Frits in Small Length of Tubing"**

Joseph Gregar – *Argonne National Laboratory*
**"Quartz to Tungsten Seals"**

Doni Hatz – *Procter & Gamble Company*
**"Dispensing Erlenmeyer"**

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