American Glovebox Society
ENCLOSURE
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Aerial View of TA-55
Courtesy of Devin Gray

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The Gloves We Use and Why at the World's Premier Nuclear Facility

Part 2: Let's Talk Gloves

By: José Rodriguez, LANL

Figure 1 – Aerial View of TA-55 - Courtesy of Devin Gray

The World's Premier Nuclear Facility

Welcome back! As the title of this series states, I am discussing the gloves at the World's Premier Nuclear Facility also known as the Plutonium Facility. The World's Premier Nuclear Facility is located at Technical Area (TA) 55 (TA-55) at the Los Alamos National Laboratory (LANL). The Plutonium Facility began operations in 1978 specializing in processing various plutonium-containing materials, researching other special nuclear material, advancing nuclear energy concepts, and nuclear stockpile stewardship. The Plutonium Facility was built to replace the older DP Site Radioactive Materials Processing Facility at LANL's TA-21 and its design incorporated lessons learned from the fires at Rocky Flats in the 1960s. There are approximately 7,500 gloves on approximately 450 gloveboxes in the Plutonium Facility. Some of the gloveboxes came from the old DP Site and range from 40 to 60 years old.

So, what kind of gloves do we use at the World's Premier Nuclear Facility? Well that depends on who you ask…so I asked them.

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Methodology

Figure 2 – Richard P. Feynman Courtesy of the LANL Archives

When preparing my presentation for the 2016 AGS Conference, I decided to talk to as many glovebox technicians as possible in order to get the expert's take on the gloves they use and why. Full disclosure, as stated in Part 1 of this series, I am a qualified Glovebox Cognizant System Engineer. I have spent no time as a glovebox worker, and I am not an expert. I'll also be the first to admit that I don't mind a good conversation especially where I'm being taught something new.

Therefore, I set out categorizing the groups at the Plutonium Facility based on the work they did. Next, I identified glovebox technicians who are revered by their peers as expert glovebox workers. I didn't, however, limit myself to just the experts because I wanted to include the less experienced glovebox worker's take. Lastly, I asked if they would like to change anything about their glovebox gloves with their responses resulting in similar desires which are discussed last.

Groups at the World's Premier Nuclear Facility

I categorized those I interviewed into two distinct categories: programmatic and support. Support groups are just that, groups that support programmatic personnel at successfully completing their mission and include the TA-55 Warehousing Group and Engineering Services. Programmatic groups are those performing work in gloveboxes fulfilling a specific mission. Those groups include: Actinide Analytical Chemistry, Nuclear Materials Science, Manufacturing & Surveillance, Actinide Process Chemistry, Material Disposition, Heat Source Technologies, Radiation Protection, and Programmatic Maintenance.

Engineering Services: Glovebox Glove Subject Matter Expert

Since I work in Engineering Services, I figured I'd start close to my group. During our interviews, I learned that: Chlorosulphonated polyethylene (CSM) a.k.a. Hypalon® is the most common material, polyurethane/CSM blended (layered) gloves are good, thinner gloves equate to higher dexterity, and material composition determines mechanical properties (puncture and cut resistance). Gloves are changed at "Plutonium Facility specific" intervals. "PF specific" intervals are defined as five-years after installation for working level gloves and ten-years after the glove manufacture date for non-working level gloves; this also includes a glove inspection every two-years.

Below is a table showing the gloves that could be installed in or procured for use in the Plutonium Facility.

Model Number	Description	Also Known As	Corresponding Thickness
8Y15XX	CSM 15 mil. Thickness	15 mil unleaded	0.015
8Y30XX	CSM 30 mil. Thickness	30 mil unleaded	0.03
8YLY30XX	CSM 30 mil. Thickness, Lead-Loaded Glove	30 mil leaded	0.03
8UY12XX	Polyurethane/CSM 12 mil. Thickness		0.012
8UY20XX	Polyurethane/CSM 20 mil. Thickness	20 mil blended	0.02
8B30XX	Butyl 30 mil. Thickness		0.03
8BT25XX	Butasol 25 mil. Thickness		0.025
8N20XX	Nitrile 20 mil. Thickness		0.02
8USY4DAXX	Polyurethane-nonhaz Shielding-CSM, 4X attenuation, 35 mil. Thickness		0.035
8USY5DAXX	Polyurethane-nonhaz Shielding-CSM, 5X attenuation, 45 mil. Thickness		0.045
8YLY65XX	CSM 65 mil. Thickness Lead Loaded Glove	65 mil leaded, Americium Glove	0.065

Table 1: Gloves at the World's Premier Nuclear Facility

TA-55 Warehouse

Description	Handedness	*Gloves Issued, Pairs (Individual)	*Gloves Ordered, Pairs (Individual)
CSM 15 mil. Thickness	Rights/Lefts	715.5	957
	Ambis	352	362
CSM 30 mil. Thickness	Rights/Lefts	1,355.5	1,780
	Ambis	520	447
CSM 30 mil. Thickness, Lead-Loaded Glove	Rights/Lefts	1,894	2,544
CSM 30 mil. Thickness, Lead-Loaded Glove, for Big Hands (10" hand size)	Rights/Lefts	15	24
Polyurethane/CSM 20 mil. Thickness	Rights/Lefts	878.5	768
*Polyurethane-nonhaz Shielding-CSM, 4X attenuation, 35 mil. Thickness	Rights/Lefts	497	496
CSM 65 mil. Thickness Lead Loaded Glove	Rights/Lefts	5	42
Totals		6,232.5 (12,465)	7,420 (14,840)

* These gloves are no longer in use

Table 2: Gloves Issued and Ordered for the Plutonium Facility from January 2010 to June 2016 * These gloves are no longer in use.

The TA-55 Warehouse provided me with bulk usage information which is presented in the following table. The TA-55 Warehouse Team Leader echoed the Glovebox Glove SME's desire to get the polyurethane/CSM blended gloves back in stock.

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Actinide Analytical Chemistry

The Actinide Analytical Chemistry group are experts in chemical and radiochemical analysis often requiring high levels of dexterity. They tend to deal with small material quantities in processes including plutonium assay, mass spectrometry analysis, elemental analysis by X-ray fluorescence, and nuclear forensics. Traditionally, this group used CSM 15 mil unleaded or PU/CSM 20 mil blended gloves but a recent transition to CSM 30 mil leaded occurred on one glovebox due to high extremity exposure. They traditionally used left/right pairs but an influx of personnel from another facility has brought with them a shift to ambidextrous gloves. They are easy-going on their gloves which are changed at "PF specific" intervals; however, cross-contamination is a concern since they deal with miniscule quantities and want high levels of accuracy, so there may be campaigns to change out all gloves outside of this interval.

Figure 3 – DTO Glovebox – Courtesy of Paul Contreras

Nuclear Materials Science

The Nuclear Materials Science group are experts in actinide material science including destructive analysis, non-destructive analysis (NDA), and characterization of new and aged nuclear materials. This group covers such a broad range of processes, so I spoke with glovebox technicians from two different teams with differing needs from their glovebox gloves.

Dynamic Testing Operations

Dynamic Testing Operations (DTO) takes place in a couple very different gloveboxes. In their crowded and very large (~750 ft^3) glovebox (partially shown in Figure 3), CSM 30 mil unleaded ambidextrous gloves are used which provides protection from potential sharps while working with their very large equipment. Additionally, the use of the ambidextrous gloves allows the glovebox technicians to work between defined workstations that would otherwise require the technician to use a right-handed glove for their left hand and vice-versa which would not work. In their much smaller glovebox, they use CSM 15 mil left/right pairs, with CSM 15 mil ambidextrous gloves in strategic locations, because the small samples they work with require high levels of dexterity. Gloves in both gloveboxes are changed at the "PF specific" intervals; however, ancillary equipment/items may introduced via a glove change.

Material Properties and Characterization

Material properties and characterization activities take place in many different gloveboxes with varying types and sizes of equipment. The predominant gloves used are the CSM 30 mil unleaded left/right pair with ambidextrous gloves in strategic locations. The CSM 30 mil unleaded will definitely be found on the most active workstations because they are radiation and puncture resistant. Overall, the technicians feel the CSM 30 mil unleaded glove is good all-around and doesn't overly favor any single mechanical glove property. High use gloves are changed every two-years; otherwise, "PF specific" intervals are utilized. An observation from an operator is the inconsistent fit, "Some gloves fit well whereas others don't fit quite as good."

Manufacturing & Surveillance

The manufacturing process includes casting, welding, and assembly. Utilizing small scale induction furnaces, casting is the process by which alpha-phase plutonium-239 is turned into a bulk case product with desired material properties. Surveillance plays an important role in the current weapons complex. The majority of gloves used by this group are CSM 30 mil unleaded with CSM 30 mil leaded gloves being used in casting operations. Left/right pairs are normally used with some ambidextrous gloves sprinkled in. Gloves are changed at the "PF specific" intervals with no processes requiring more frequent glove changes. Nonetheless, gloves may be changed more frequently as necessary if compromised.

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Figure 4 – Casting Pour – Courtesy of Bill Peach

Figure 5 – Casting Furnace – Courtesy of Bill Peach

Actinide Process Chemistry

The Actinide Process Chemistry processes actinide compounds in aqueous chemistry or pyrochemistry. These processes are some of the harshest in the facility where nitric acid, hydrochloric acid, or chlorine gas might be found.

Aqueous Chemistry

There are two distinct aqueous chemistry process that differ based on the type of acid used. Both acids, hydrochloric and nitric, contribute to a very harsh environment that makes the gloves feel very tacky or gummy where blisters may develop on the gloves.

In hydrochloric acid operations, CSM 30 mil leaded gloves in left/right pairs (ambidextrous gloves are unavailable) are used with high use gloves changed annually with other gloves changed at the "PF specific" intervals. CSM 65 mil leaded gloves are used for Americium processing to minimize operator dose.

In nitric acid operations, CSM 30 mil leaded gloves in left/right pairs are used, "no exceptions!" Steam is also present in these processes which adds to the harshness of the environment and presents a unique aspect to these operations. Gloves are changed every six-months to one-year. An observation of one operator is that the gloves tend to be too big, but she's "adjusted."

Pyrochemistry

Figure 6 – Electrorefining (ER) Ring – Courtesy of Matt Jackson

Pyrochemistry technicians use CSM 30 mil leaded gloves in left/right pairs throughout their processes. The pyrochemistry technicians like the CSM 30 mil leaded gloves because "they can take a beating from anything we throw at them including a lot of heat." Residual heat can linger in these gloves for some time which can be difficult as well. Furnace working gloves are changed one-to-two times per year with other gloves being changed every couple of years. The pyrochemistry technicians have "mitts" for hands and prefer the "big handed" gloves. They don't like the CSM 15 mil gloves because they feel that they are better protected with other gloves.

Material Disposition

The Material Disposition group supports the national objectives of nuclear deterrence, nuclear disarmament, and fissile material disposition through processes including metal oxidation, oxide characterization, and oxide packaging. In metal oxidation, CSM 30 mil unleaded gloves are used with an operator preferring the 30-inch (rather than the 32-inch) long gloves (no longer stocked in the warehouse). In uranium operations, both CSM 30 mil unleaded gloves and PU/CSM 20 mil blended gloves are used. Both metal oxidation and uranium operations use mostly left/right pairs with ambidextrous gloves in strategic locations and gloves are changed at "PF specific" intervals.

Heat Source Technologies

Figure 7 – Glowing Pu-238 RTG – Courtesy of Diane Spengler

The Heat Source Technologies group supports the national interests pertaining to plutonium-238 as it relates to heat source and generator development, production, dismantlement, and recycling. Processes include aqueous processing, fuel fabrication, hot processing, encapsulation, surveillance, and assemble. This group works very closely with NASA supplying them with radioisotope thermoelectric generators (RTGs, shown in Figure 7)

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for missions to Mars and deep space. Contributions are shown in Figures 8 and 9. CSM 30 mil leaded gloves are used exclusively in plutonium-238 gloveboxes because they are good against degradation, exhibit excellent thermal loading, have high integrity, last a "long time," and provide some shielding against gamma radiation. Gloves are changed as often as once every 3 weeks in gloveboxes where powder operations occur with other gloves being changed annually. Even though the lead doesn't provide an appreciable amount of shielding, this is the only type of glove used because the orange color from the lead layer "shines" through when the first layer of CSM has been compromised while still protecting the worker.

Figure 8 – Curiosity looking back at its tracks (and RTG) – Courtesy of the Jet Propulsion Laboratory

Figure 9 – Pluto in True Color – Courtesy of the Jet Propulsion Laboratory

Radiation Protection

Radiation Protection (RP) radiological control technicians (RCTs) provided a unique perspective since they don't deal with the glovebox gloves on a regular basis. RCTs perform regular glove surveys looking for alpha contamination and a swipe survey for removable contamination. The RCTs (combined ~50 years' experience) also said the CSM 65 mil leaded gloves are very hard and difficult to work in. Programmatic personnel are responsible for looking at the glove expiration date written on the glove; a radiological work permit (RWP) is required if the glove has not been inspected within a given time. The RCTs have also noticed ebbs and flows during their careers from CSM 30 mil leaded to CSM 30 mil unleaded back to CSM 30 mil leaded. They suspect this was due to both breach and dose concerns. They also feel the CSM 30 mil unleaded gloves are good gloves that can take a pretty good beating.

Programmatic Maintenance

The Programmatic Maintenance personnel I interviewed are experienced glovebox technicians who have transitioned over to performing glovebox maintenance and are knowledgeable with operations in the Plutonium Facility. Most of their time was spent working in CSM 30 mil leaded and CSM 30 mil unleaded gloves with a preference toward the 32-inch long gloves. They also feel the CSM 30 mil unleaded gloves are good gloves if dose is not a concern. In a dry plutonium-239 environment, CSM is a very good and durable glove; however, once chemicals are introduced (hydrochloric or nitric acid) glove durability and longevity is greatly reduced. A CSM 30 mil leaded glove that was over 20-years old was recently changed on a non-plutonium-238 glovebox and was still in good/usable condition; he has also changed gloves that were of similar age on other gloveboxes. Plutonium-238 is a completely different animal and is worse than the combined chemical/plutonium-239 environment. Plutonium-238 wreaks havoc on everything including gloves, gaskets, process equipment, glovebox shells, and outlets; it destroys everything.

The CSM 65 mil leaded gloves are terrible to work in because they offer very poor dexterity and the glovebox operator might as well have oven mitts on. These gloves are very tough on the fingers and wrists and they make glove changes very difficult.

For maintenance purposes, they like the PU/CSM 20 mil blended gloves but lately they have been using a lot of CSM 30 mil unleaded ambidextrous gloves. Ultimately, the glove used will be based on dose concerns.

Challenges to Others

During my interviews I took the opportunity to ask if there was anything they would like from a glovebox glove. The majority of those interviewed had two desires: a brightly colored indicator layer provided it didn't hamper dexterity and reorder the PU/CSM blended gloves. Those with experience in the CSM 65 mil leaded glove wanted to know if there was anything available, such as undergloves, which could be used in its place. Additionally, our TA-55 Warehouse Team leader and Glovebox Glove SME wanted to know how other sites deal with glove shelf life.

Summary

The World's Premier Nuclear Facility has over 7,500 gloves on approximately 450 gloveboxes. The consensus from glovebox technicians is that the CSM 30 mil unleaded gloves are good overall gloves that can generally take a beating. The CSM 30 mil leaded gloves are also good gloves but they require some getting used to. The CSM 15 mil unleaded and PU/CSM 20 mil blended gloves are the gloves used for high dexterity tasks where the extremity dose concern is minimal. The CSM 65 mil leaded gloves are terrible to work in but are necessary in some processes.

Thanks to...

…all those glovebox technicians that put up with the engineer asking them questions. Also thanks to those who provided me with photos for my AGS Conference presentation and those utilized in this article series. ❖


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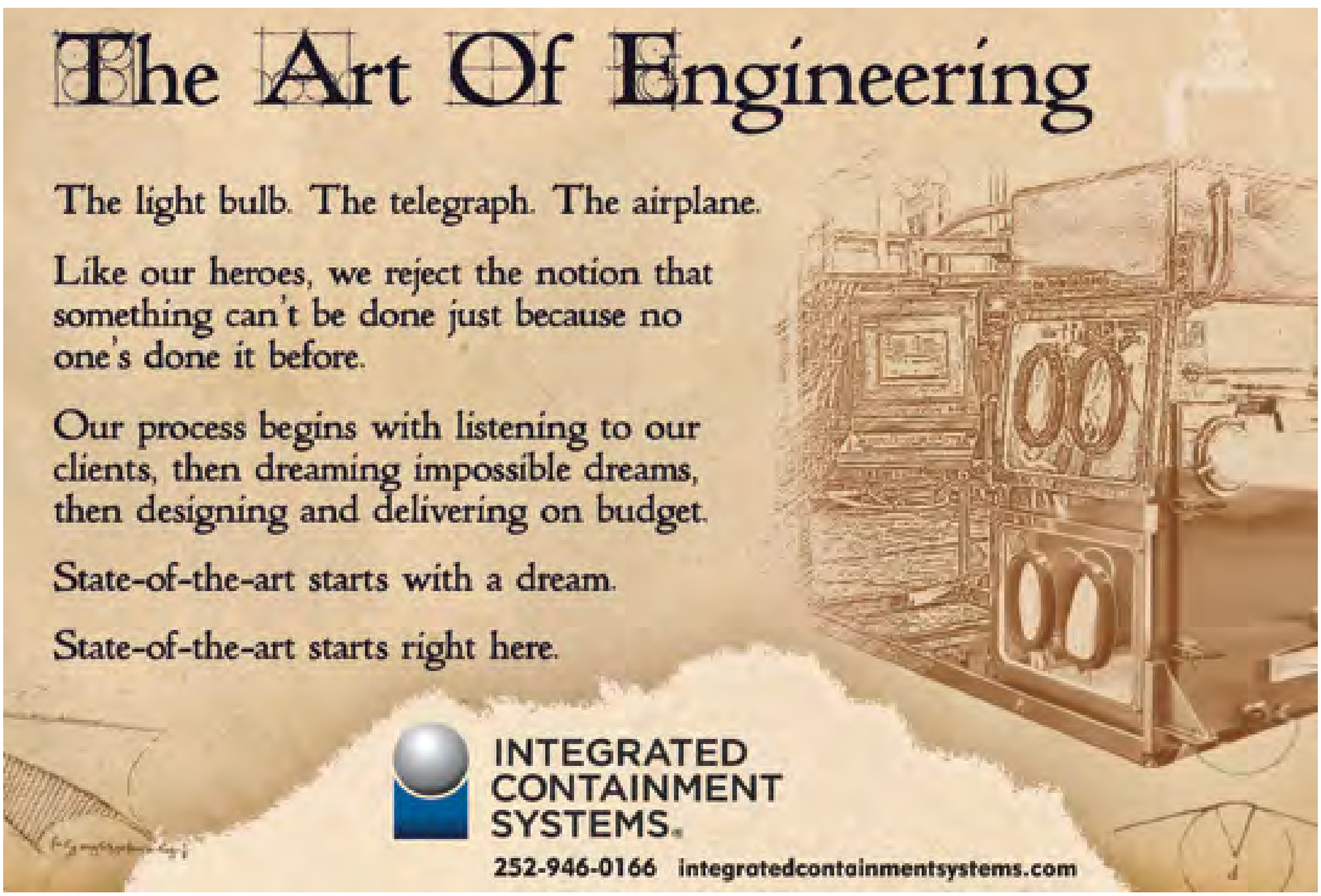
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Flow Visualization Methods for Field Test Verification of CFD Analysis of an Open Gloveport

By: Philip Strons and James L. Bailey PhD, both from ANL

Anemometer readings alone cannot provide a complete picture of air flow patterns at an open gloveport. Having a means to visualize air flow for field tests in general provides greater insight by indicating direction in addition to the magnitude of the air flow velocities in the region of interest. Furthermore, flow visualization is essential for Computational Fluid Dynamics (CFD) verification, where important modeling assumptions play a significant role in analyzing the chaotic nature of low-velocity air flow. A good example is shown Figure 1, where an unexpected vortex pattern occurred during a field test that could not have been measured relying only on anemometer readings. Observing and measuring the patterns of the smoke flowing into the gloveport allowed the CFD model to be appropriately updated to match the actual flow velocities in both magnitude and direction.

In recent work, as part of the Nuclear Safety Research & Development program of the DOE Office of Nuclear Safety, field test methods were developed to verify CFD analyses of ventilation safety systems in actual nuclear facilities. Much of this work focused on the scenario of an open gloveport on a glovebox. Here, we present the results of our flow visualization development while working within a modest budget. The initial methods are lower in cost and produce more qualitative results, and as methods and techniques become more sophisticated, we arrived at a quantitative method suitable for CFD verification.

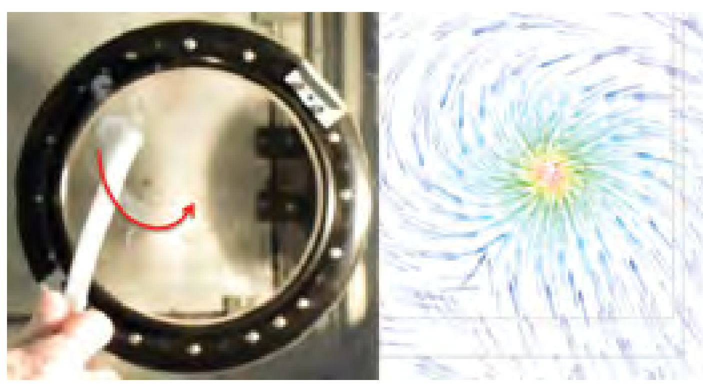

Figure 1 (right) – Unexpected flow patterns made visible with smoke during a field test. After examining conditions surrounding the glovebox, identifying thermal loads, and updating CFD model, the calculated flow patterns match what was observed in the field.

Qualitative Flow Visualization

Initial work in developing flow visualization techniques resulted in what might be best described as qualitative methods. We began by using low-cost options for smoke and photography. Sources of smoke included standard ventilation smoke tubes commonly used in industrial hygiene and smoke from aerosol spray cans often used for smoke effects in live theatre. The ventilation smoke tubes outperformed the aerosol spray cans and provided some flexibility by allowing individual puffs for studying velocity or a continuous stream for observing streamlines. Careful use of the manual squeeze bulb from the smoke tube kit could produce either the single puffs or continuous streams. The tubes could also produce streams of smoke by attaching them to a low flow pump.

Experiments with laser illumination of smoke were attempted with a class 2 laser with 1 mW of power. The laser better defines a plane, making direct comparison to CFD results easier, and the choice of a class 2 laser was based both on cost and safety. In our early results, air flow patterns are clear to the naked eye and record well on video. This is useful for qualitative results, but to obtain measureable, quantitative results, requires a much brighter laser for high quality still shots taken at a high frame rate. Our experience was that most class 2 laser images were not visible when using still photography.

Quantitative Flow Visualization

Since our goal was to verify CFD results, we needed methods that could produce measurable data. Prior tests had been conducted with a DSLR camera. A typical DSLR camera is 3 frames per second at best. For photographing clear, still images of smoke, it was determined that a higher frame rate of 20 frames per second was needed. This frame rate is based on the fact that an average face velocity of 125 feet per minute, is equivalent to 25 inches per second (63.5 cm per second). Photographing at the higher rate meant that our puffs of smoke would only move an inch or two between frames. A mirrorless camera was found that

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could achieve the necessary higher frame rates. With high frame rate photography, using a flash for illumination became impractical, and a bright 1500 Watt halogen work lamp was obtained to provide constant, bright light for the high shutter speeds.

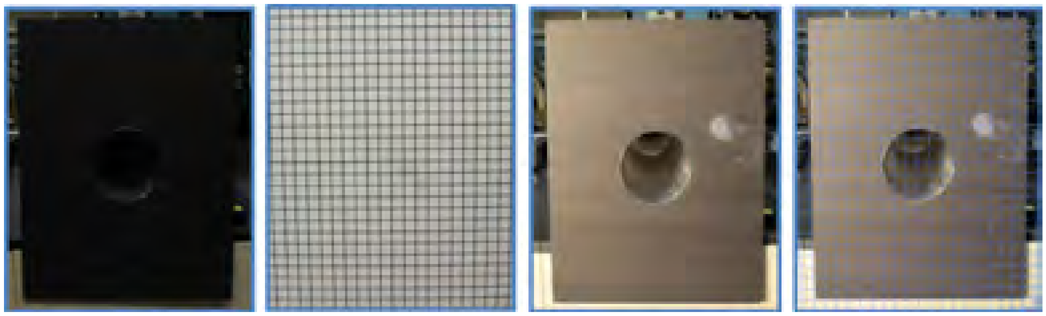

Figure 4 (above) – From left to right, the benchtop setup under normal lighting conditions, the poster grid photographed to establish focus and to be saved for overlaying on more photo picture images, photographed smoke at high shutter speed with bright illumination, the final result produced with phot editing software to place the grid over the image.

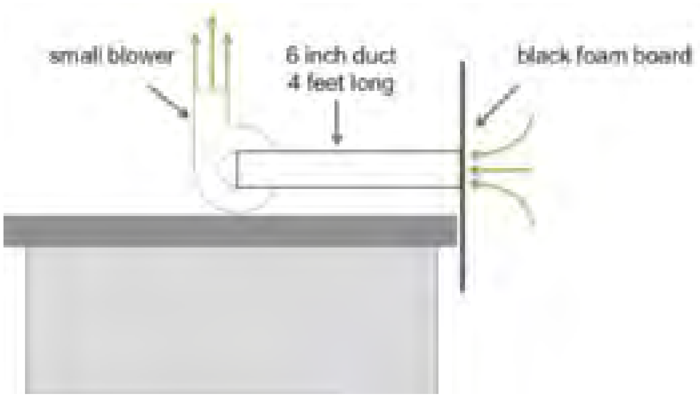

Figure – 2 Illustration of benchtop setup used to experiment with different visualization techniques, as well as rehearsing prior to testing in a controlled area.

To put the new camera and halogen lighting to the test, a benchtop setup was assembled to mimic an open gloveport (see Figure 2). The gloveport mockup included a piece of black foam board mounted to a 4 foot long section of 6 inch diameter duct. A small DC powered blower acted as the exhaust. This setup allowed us to dial in the best camera settings for aperture, shutter speed, and ISO compatible with the high frame rate. The results can be seen in Figure 3, where three images of one puff of smoke are taken at approximately 50 milliseconds apart.

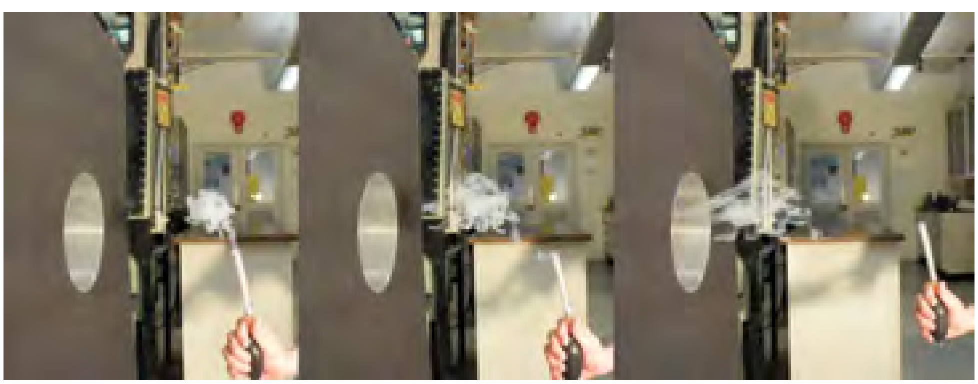

Figure 3 Use of ventilation smoke tubes. Single puff of smoke photographed at 20 frames per second with constantly illuminated with a 1500 Watt halogen lamp.

Having established the necessary techniques to photograph puffs of smoke moving at 25 inches per second, our next step involved developing a means to calculate, or at least reasonably estimate, flow velocity from the images. A poster board grid of one inch squares was photographed prior to photographing the smoke. Photographing the grid was useful for proper focusing of the camera, and the image was then later used with photo editing software to overlay on photos to provide a scale reference and approximate velocity. An example of this process is shown in Figure 4. Note that the black foam board only appears gray in the third and fourth images due to the bright lighting.

Perhaps the best way to compare actual flow conditions to CFD results is through particle image velocimetry (PIV). PIV captures data in a well-defined 2-D plane that is easily matched to a plane in a CFD model, and the PIV software provides velocity vectors similar to the post-processor of the CFD software. However, PIV normally requires an extremely bright pulsed laser, high performance optics, and controlled conditions to be effective. At a cost in the hundreds of thousands of dollars, this was, of course, well beyond the limits of our budget. An attempt at PIV was made with a less expensive 500 mW laser. Using a class 3b laser in a radiological area required considerable safety planning and review, yet the improvement in the images obtained compared to the 1500 W work lights was remarkable.

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Flow Visualization Methods for Field Test Verification of CFD Analysis of an Open Gloveport

Figure 5 From left to right, streamline results from the CFD model, photograph from field test using 500 mW laser to illuminate smoke, and the combination of the two with the addition of a grid. Near the gloveport, the patterns in the photographed smoke match the CFD streamlines well.

Observable patterns in the illuminated smoke match well with calculated streamlines near the open gloveport. True PIV was not possible with the equipment used because the software could not identify individual particles, but velocity unit vectors could still be applied to the images. Additional comparison further from the port (Figure 6), where velocities are slower, yielded differences in flow velocity direction due to our introduction of smoke.

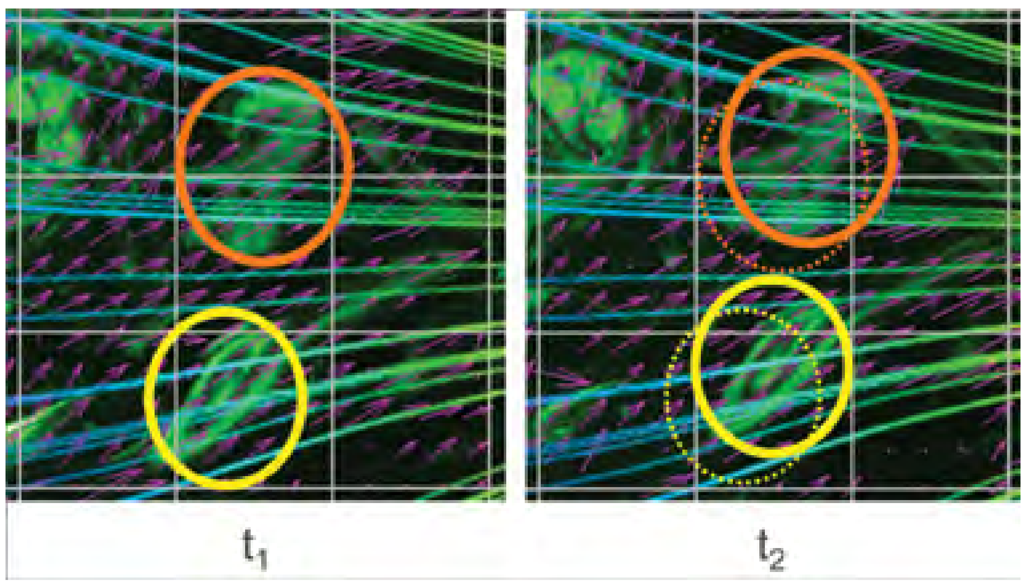

Figure 6 – Comparisons of two consecutive frames analyzed with PIV software. The 500 mW laser was not bright enough for the camera to capture individual particles. Simple velocity vectors, shown in purple, which show direction without magnitude, are overlaid on the images by the PIV software. Additionally, the CFD streamlines and a grid have been added using photo editing software. By examining the large swirl features, circled in yellow or orange, it can be seen that the velocity unit vectors accurately capture the direction of movement.

Summary

Flow visualization is a valuable tool for verifying proper containment in an open gloveport scenario. It provides a more complete picture of the air flow patterns external to the glovebox. Many conditions external to a glovebox, such as a downdraft from a nearby supply vent, have the potential to disrupt proper flow into an open gloveport. Although quantitative methods are necessary for verification of CFD models, even the qualitative methods presented here make a good complement to anemometer measurements of face velocity. ❖

By: John T. Newman, PE

Manufacturing Tolerences for Gloveboxes

In this issue I would like to talk a little bit about manufacturing tolerances. What is a tolerance? A tolerance is an allowable deviation for a dimension or a specification as used in manufacturing. It is an established boundary for an acceptable build. Or, in other words, an allowed variation in a dimension of a part that will allow the part to properly function, as long as the variation is not exceeded. The concept seems simple, but in practice it can be complicated when you have many parts that fit together and function together.

Why have tolerances at all? Can't we just make all things to the exact dimensions? Well, that could work, if it were possible. You see, we happen to live in a very imperfect world with many variables, some easily controllable, others very difficult to control. Many of these variables can have a dramatic effect on manufacturing processes. The tighter or smaller the dimensional boundary, the more difficult manufacturing can become, which then has a direct relation to the cost. So then logically, if items were designed with larger or looser tolerances, the manufacturing could be less difficult or less expensive.

I have spent most of my life working in the world of manufacturing of which most of that has been the for the glovebox industry. But, early in my career, back in the mid 80's, I got the opportunity to work as an actual manufacturing engineer. The company was a high volume, high precision machine shop that specialized in manufacturing armament hardware for the department of defense. One of the main products that we manufactured was wing assemblies for the AIM-9 Sidewinder Missile. It was here, where I really got to experience the effect that dimensional tolerances can have on manufacturing processes.

The sidewinder missile was designed in the early 1950's, entered service in 1956, and variations of this design still remain in service today. Many have been manufactured over the years, especially during the Korean and Vietnam wars. When I started working there, we were producing around 500 wings per month. The company had a large array of CNC machining centers, tooling, fixtures, and inspection gages that had been developed and used over the years of manufacturing these wings.

The wing design had some very tight dimensional tolerances, but they were reasonable and achievable. The ultimate test for a finished wing was to fit on a functional gage, designed to emulate mounting to the actual missile body. There were other dimensional and functional requirements that had to be met, but mounting on the gage was the most important. If it fit on the gage, then it would fit on the missile.

Then one day, along came a new procurement contract that included a new set of drawings. The missile design authority had re-dimensioned many of the wing components, changing plus/minus dimensional tolerances into true position tolerances per ASME Y14.5 Geometric Dimensioning and Tolerancing. This resulted in approximately 25% of the tolerance that was allowed in the previous design and was a game changer for us.

After many process and tooling upgrades, we discovered that we could not meet those new tolerance requirements. In our minds, they had created an un-manufacturable wing. It was like machining a rubber band. The base wing frame was forged aluminum and from start to finish we machined off about half of the weight. Wing frames would change overnight by just setting in the rack. We tried everything we could think of. We even considered a voodoo priestess. Production ground to a halt and at the end of the month, not a single part could be shipped. Months went by, and as you can imagine, businesses don't fare well when the product does not ship.

To make a long story short, the company went out of business, and luckily, I got out before that. I left to go back to the good old glovebox business. I really don't know if the design authority eventually changed the design back to some looser tolerances, or someone smarter than us figured out how to make them, but as far as I know, they are still being manufactured somewhere.

You know, the irony of the whole thing is, that our company had been successfully manufacturing those wings for years. They had always fit on that functional gage, on the missile, and I assume, managed to blow something up. Through all our attempts, we actually made the best wing that we had ever built. Even though those wings fit that functional gage better than ever, the tolerances specified on the drawings were not met, so we could not ship anything. The whole situation was pretty sad.

Lately, I've seeing similar things happening in our glovebox industry. Drawings and specifications are coming out on the street for build with some very tight dimensional tolerances. Whether they are truly necessary, I don't know. But, I do know that every dimensional tolerance specified on a drawing will have a direct affect on the manufacturing cost. Real problems can occur when these tolerances exceed the capability of the part, as I believe was the case with the sidewinder wing frame.

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Each part must be analyzed to determine the tolerance capability and how accurately it can be produced. For example, it is not possible to hold much dimensional accuracy on a piece of folded paper. When you fold it, the angle of the fold would be constantly variable because the paper bends easily and flops all over. How could you even measure that? Specifying an angular dimensional tolerance for this would exceed the capability of the part.

How flat would the surface of the paper be if it was held extended in your hand? It would be all over the place, and if there was a breeze blowing, forget it. A flatness requirement would also exceed the capability of the part. But, what if it was critical to have a flat piece of paper for the application? Stiffeners and laminations could be added, but would that really be practicable? Of course not, it would make more sense to revise the requirements to match the capability of the piece of paper or use a different material that would better match the requirements. You would have to think, that would be less costly to do instead.

Sheet metal behaves exactly like that piece of paper. It is quite amazing how much metal will move with a surprisingly small force or a change in temperature. Place a dial indicator on the edge of a piece of 7 gage (0.188″ thick) stainless steel sheet extended out 10 to 12″, as you could see in a typical glovebox shell, and you will find that you can move it 0.020″ to 0.030″ just by pushing with your hand. And if you were to put a little heat on one side of it, it would curl up like a banana. Again, a tight flatness tolerance could easily exceed the capability of this material.

Gloveboxes are typically manufactured from sheet metal. We have been manufacturing with sheet metal for a long time and have a pretty good idea how accurate parts can be made. Particularly with gloveboxes, as the established achievable tolerances are printed in the AGS Guideline G001 and Standard G006. These values were very carefully thought out and are a very good representation of what a professional sheet metal shop can routinely achieve with the standard tools at their disposal. When these guides are followed, the capability of the material will not be exceeded and the costs for manufacturing a glovebox will be reasonable.

In our industry, the most critical function is to make things seal, as we are all about making a securely contained space. The parts that mate together and seal, usually require a sealing surface, which must be smooth and flat. The degree of this requirement is completely based on the design of the seal. Different types of seals will dictate different smoothness and flatness requirements. Lately, window and flange sealing surfaces have been a high priority.

First of all, there is no reason to be afraid of a glass window on a glovebox. We have been successfully doing this for many years, and have developed window designs that work very well with reasonable manufacturing tolerances. The clamp style glass window design has been used on gloveboxes for a very long time. Why? Because it works and can be used successfully on gloveboxes built from sheet metal using standard sheet metal tools. The seal surface can be formed and polished by a skilled craftsman without the use of any machining or milling processes and when the window is assembled the glass will not break.

These designs and the manufacturing tolerances required for them to work properly are defined for everyone to use in the AGS documents. If a window breaks, then the glovebox is most likely out of tolerance from the AGS dimensions. Tighter tolerances are not required, all that really needs to happen, is to follow the AGS guide. You need to trust me on this, by tightening up the manufacturing tolerances tighter than those specified in the guideline, the window will certainly work, but the difference will be, your glovebox will cost much more.

Connecting flanges for gloveboxes is the other concern. If properly designed, they too can be formed and bolted together without any tight tolerance machining or milling operations. The secret is to make the flanges thin so when bolted together with a flat gasket the flanges will move and bend, conforming to each other to make a seal. When the flanges are thick, they cannot flex and conform to each other. Then the thick flanges will require machining to make them flat and parallel enough to seal. This will cost more to achieve the same thing.

The other thing that you have to realize is that manufacturing and quality assurance people take things very literally. They don't have the luxury of deciding whether a tolerance is required. Their job is to manufacture and inspect the parts, exactly as specified on those drawings. It is up to the engineer / designer to make those decisions. If you wish to keep the manufacturing cost low for your glovebox, or any manufactured product, then you need to apply appropriate tolerances that will fit the part capability and the standard manufacturing techniques for the fabricator.

But at the end of the day, isn't it more important that the component functions as intended and not necessarily how accurate it is manufactured? I believe that is always the desired result. So why not think that way when you are generating your drawings and specifications? With that in mind, would it not be a better idea to just state that in your specifications, instead of trying to define everything? Specify a leak rate requirement and perhaps a positive/negative pressure proof test over time to prove that the window will not break or the flange will seal and let the manufacturer worry about how flat to make the sealing surfaces.

There are many other ways to solve a problem, other than just specifying a tight tolerance. You see, costs will grow exponentially as the tolerances get tighter and in the end, your glovebox may not work any better at all, it will just cost more. ❖

ISO-KF Vacuum Flange Connections

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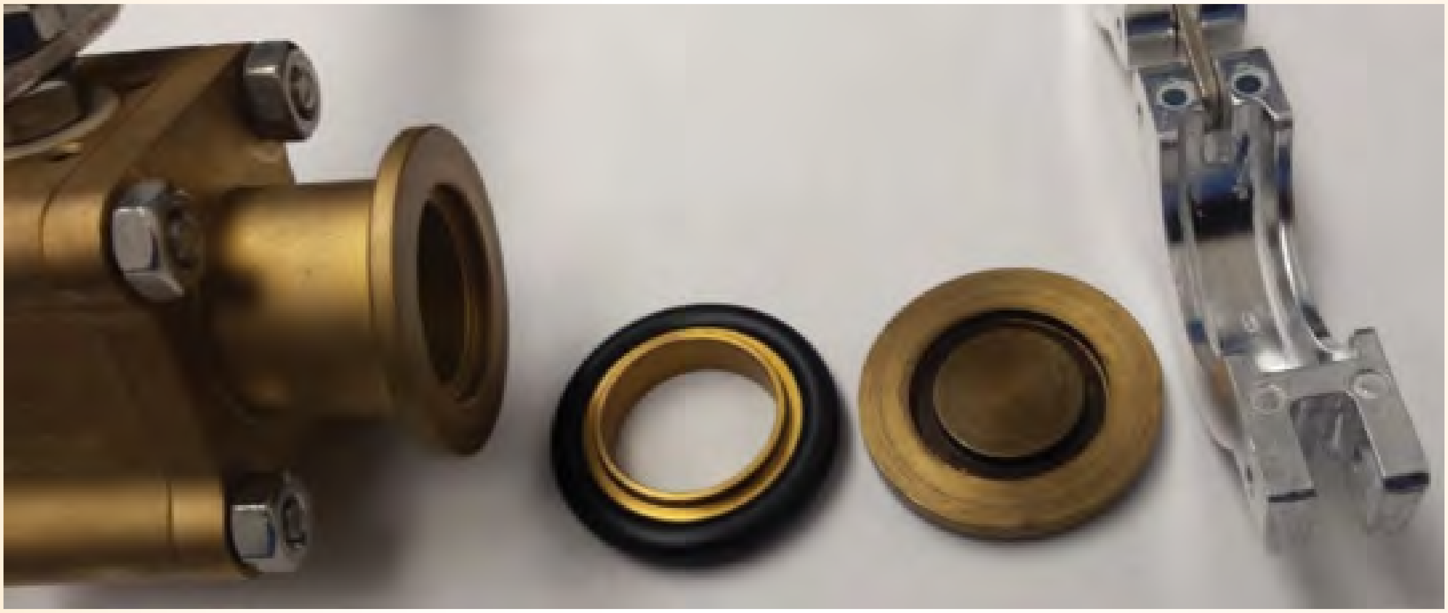

Figure 1

ISO-KF vacuum flange connections can be found in glovebox applications on vacuum pumps, recirculation lines, and other low pressure connections. The integrity of the connection relies on an O-ring clamped between two flange faces. A metal centering ring is used to align the joint correctly as the joint is clamped together, see Figure 1. Care should be taken when assembling vacuum flange joints in order to avoid damage to the O-ring seal and the metal centering ring. Figure 2 shows a damaged ISO-KF O-ring and centering ring due to poor alignment and assembly practices. Consider these tips for avoiding ISO-KF vacuum flange installation issues.

- If you plan to store the O-ring for extended durations, consider purchasing and storing the O-rings separate from the centering rings. Store the O-ring in the un-stretched condition in a properly sealed package to avoid premature cracking of the O-ring while in storage.
- Be sure that the ISO-KF flange sealing surfaces are clean and free of debris and scratches before installing the O-ring and centering ring.
- Apply a thin film of vacuum grease on the O-ring prior to installation. The thin film lubricates the O-ring to prevent friction damage during installation and aids in obtaining a good seal.
- Be sure the flanges are aligned correctly when installing the centering ring and O-ring. Difficulty closing or tightening the clamp can be a sign of poor alignment.
- Viton® O-rings have been successfully used for most general purpose glovebox applications. The Idaho National Laboratory has experienced degradation of Buna-N O-rings in glovebox applications as shared on OPEXshare Lessons Learned website, https://opexshare.doe.gov/lesson.cfm/2016/7/15/5983/Buna-N-O-ring-Degradation-due-to-Environmental-Conditions.As always, consider your application specific requirements when choosing an O-ring material. ❖

Figure 2


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