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TIPS FOR THE FABRICATION OF TEMPORARY TRITIUM EXPERIMENTS

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ABSTRACT

The Tritium System Test Assembly (TSTA) is a facility built for the demonstration of tritium handling systems necessary for tritium-burning fusion reactors. The facility has been in operation handling tritium for four years. The current inventory of tritium is approximately one hundred grams with DOE approval exists for a maximum inventory of two hundred grams. Not all experiments performed at TSTA require the operation of the main process loop. During the last four years, many small scale experiments have been performed to test the compatibility and operation of tritium processing components in small self-contained experimental packages. These packages are fabricated inside secondary containment gloveboxes and can be operated for hours or months with little monitoring. Construction of these packages need to be tritium compatible, inexpensive, easy to build, and versatile. This paper discusses some of the problems and remedies encountered during the building of temporary experiments.

DESIGN CONSIDERATIONS

Too often, temporary experiments are not given the time and consideration needed to fabricate a system that will give adequate versatility needed to produce adequate results. Experiments that are constructed for short durations are sometimes extended into long term runs. Experiments cannot be built to achieve infinite adaptability, but they can be designed to allow for more flexibility. The ultimate limiter that enters into every experiment is the cost.

Usually the most expensive part of a system is the instrumentation. Many pressure, temperature and flow transducers are needed in an ideal experiment. Since most experiments are not ideal, only the most needed parameters are monitored. While thermocouples can be placed anywhere in a system inexpensively during fabrication, other types of transduces need to have the ability to be placed in more than one location. This can be accomplished by the use of "SPOOL PIECES". The spool piece is a short piece of tubing that is the same length as the transducer and has the same end fittings. This allows the transducer to be removed from one location and placed in another. The displaced spool piece is inserted into the location where the transducer was removed. Capped tees placed at needed locations throughout the system provide flexible usage of pressure transducers.

COMPONENT LAYOUT

The layout of an experiment must allow for easy access, leakchecking, maintenance, and replacement of components. This can be accomplished in many ways, but each has its own draw backs.

Components can be assembled using just tubing and fittings without mounting. This allows for easy access and operation. Components are not mounted, so the systems can be visually traced easily while doing valve lineups and system checkouts. The disadvantage to this system is that it consumes space since it is usually built in only two dimensions. A system can take up the whole floor of a glovebox but wastes the upper 3/4 of the volume available. Another disadvantage is that the parts are not supported from moving side to side except by other components. Without support, valves are harder to operate and the tightening of components has the possibility to move and loosen other components.

Panel mounted systems allow for the support of components and the easy access to valves. This allows the builder to fabricate the experiment in three dimensions and allows for better usage of the glovebox area. The disadvantage to this construction is the accessibility. Fittings located behind the mounting panel are hard to tighten, remove, leakcheck, and see. Elaborate systems can not be easily traced out for checks unless laid out with this in mind.

Components mounted to braces that are mounted to the glovebox closely meet the advantages of the first two designs mentioned. The braces should be sturdy for support but not so large as to block operations. A good material is 2x1 inch "Modular Structural Channel". Modular Structural Channel is strong, inexpensive, and with the optional fittings is versatile. The ends of the channel can be C-clamped to lips in the box and made integral to the box.

Another variable to consider while fabricating a system is how components will be replaced if they fail or are changed. Are the components that are most likely to be replaced easily removed from the system and from the box? The number of components that can not fit through a glovebox ante chamber should be kept to a minimum. Similar consideration should be given to the ease of relocation of those transducers.

Instrumentation components, transducers, flowmeters, and flow controls usually have very small access ports for adjusting zero and span. The ports should be oriented to facilitate adjustment using the gloves.

The electrical connectors on these instruments are usually threaded to prevent disengagement of the connector. These connectors should be placed where they can be mated/demated with the box gloves on.

Thermocouples that are welded in place, instead of using a thermowell, should have at least one installed backup. A single thermocouple is often used for both measurement and control. These should be separate thermocouples. Also, a single welded thermocouple could fail and there is no easy way to replace it. Redundancy is very cost effective in this instance.

COMPONENT SELECTION

The mechanical and electrical components selected during the design phase of an experiment should, whenever possible, be "off the shelf" items. They are generally less expensive, have a faster delivery time, and a much faster repair turn around if necessary.

Mechanical and electrical connectors on the experiments should be shipped with the mating connectors to prevent a delay while waiting for a non-standard, mating connector to be delivered.

ANALYTICAL SAMPLES

The ability to take representative analytical samples while not depleting the system of gas is important during any experiment. This is especially true for tritium systems. Sample ports need to be placed throughout the system at all points where gas composition may be of interest. Special ports can be fabricated that will minimize the loss of gas from the system while allowing clean samples to be taken. These ports are constructed by assembling a valve to the side of a tee at each sample point. A flex hose with a valve and tee are installed on the end is used for the evacuation of interspace. When a sample is needed, the evacuation tee is placed on top of the sample port valve. A piece of filler metal such as tungsten rod, that is slightly smaller than the inside diameter of the tee and cut to a length that will fill the sample port stem, evacuation tee, and sample stem, is dropped into the tee. The sample port is installed on the open end of the evacuation tee. The metal rod will take up space in the interspace and decrease the amount of sample sent to the vacuum system.

To prevent perturbations in flow during the taking of a sample it may be advantageous to place a filter washer or other flow restriction between fittings to decrease surging of the gasses into the sample chamber.

During disconnection of a sample chamber, a plastic bottle with its bottom cut out and plastic tubing connected to its cap can be used to decrease the amount of sample released to the glove box if the other end of the plastic tubing is attached to the exhaust port of the glovebox.

LEAK CHECKING

Leak checking should be considered while building a system. It is very easy to bury a fitting so that it cannot be accessed after the glovebox window is back in place. All fittings should be accessible and have their leak checking ports facing the gloveports for easy access. One way to find tritium leaks in a large system is to tape a plastic hose to the middle of a plastic sheet and insert the other end of the hose to the effluent of the glovebox. The plastic can be placed over different portions of the system. When the glovebox level begins to drop, the leak area has been found. This type of leak finding is time consuming but is useful in the locating of small leaks.

DATA RECORDING

Local stand alone recorders are often useful in a temporary experiment. This eliminates the time consuming task of developing software to gather data and finding "extra" channels in the patch panel to access the computer. An RS-232 interface from the local recorder to a facility computer is a convenient means for archiving data and/or transferring to the Magnetic Fusion Energy (MFE) satellite link.

GLOVEBOX ELECTRICAL CONNECTORS

Experience indicates that temporary experiments often require additions or modifications after they are placed in a sealed glovebox. By using glovebox feedthrough connectors that are configured with sockets in the box and pins of the outside, instead of solder type connections the modifications can be made to the extension cables and connectors without the need for breaking the glovebox integrity. A good connector that is hermetically sealed to maintain blovebox integrity, is the "PAVE MATE 1" VS22-SS-150-41-20 QDB. This connector type confirms to MIL-C-26482 and can be obtained from PAVE Technology Co. If a tritium monitor chamber bias and signal or high voltage feedthrough is required the use of hermatically sealed BNC type connectors are recommended. The "KINGS" P/N 759-2 meets these requirements. Reference Kings Electronics Company, Inc. BNC series connectors.

BOX PENETRATIONS TO MECHANICAL LINES

A simple method of admitting different gasses to the glovebox is by the use of quick disconnects that seal at both ends. The tubing that is inside the box needs to have the ability to be pumped down before the next gas is admitted to the system.

A molecular sieve type 4A or 13X trap should be installed on the outlet of the system that goes to the evacuation system to prevent the migration of vacuum pump oil. It does not take very much vacuum pump oil to ruin an experiment. Traps can be easily made by filling a "KF" four inch extension with molecular sieve and packing it in place with glass wool. Weld fittings to "KF" end caps, install the caps on the end of the extension, and an easily refillable trap has been made.

If penetrations are installed on a glovebox that will be used at a later time, remember to cap them on the inside of the box only. This will allow something to be attached to the outside of the box without having to break into a contaminated system.

INSTRUMENTATION INTERFACING

The instrumentation for a temporary experiment should be carefully selected using several criteria. Instruments that are exposed to tritium in a glovebox, usually will remain in the glovebox until disposed of. Therefore the least expensive but adequate instrument should be chosen.

Instruments should have current calibration certificates prior to being installed in a contaminated atmosphere. It is nearly impossible and cost prohibitive to remove and calibrate contaminated instruments.

RACK AND PANELS

Ideally the instrumentation controls, readouts, and recorders should be equipped with EIA (Electronic Industries Association) 19 inch rack mount capabilities. For order and protection, it is desirable to rack mount the equipment. A standard electronic equipment rack, works very well for this purpose and also fits under a glove box to keep walkways clear. An assortment of blank aluminum panels with EIA 19 inch spacing, facilitates mounting meters, switches, lights. etc. and they fit the equipment racks.

ON-HANDS SPARES

Due to the many variables associated the temporary experiments and the time constraints usually placed on them, it is advisable to keep a supply of low cost, high usage, or long procurment time items. Some of the most common items are listed here:

a. Thermocouples, thermocouple extension wire, thermocouple connectors.
b. General voltmeters, and thermocouple meters (pyrometers).
c. Relays, mercury wetted and solid state types.
d. Autotransformers
e. Switches, fuses (various sizes), pilot lamps and lamp sockets.
f. Connectors for glovebox feedthroughs.

POWER REQUIREMENTS

Power requirements of experiments need to be considered during the design and specification phase. Some gloveboxes have no provisions for power internal to the box, some have only 115 Vac, others have both 115 Vac and 208 Vac single and three phase.

We have experienced the problem with foreign designed and built experiments not being compatible with the power we can supply. We can usually run the Japanese experiments of 100 Vac by using autotransformers to lower the voltage, but there is no cost effective way to supply 50 cycle power. Foreign experiments should be supplied with adapters to adapt their power cords to U.S. style power connectors.

Twist lock electrical plugs should be used inside all glove boxes. The locking action prevents the plug from being accidentally knocked or vibrated out of its socket.

Due to the low power limits of most electrical feed throughs, the current required for heaters need to be less than three amps. If the power requirement is larger than three amps, the power supply needs to be installed inside the glovebox. The heater can be controlled by installing a relay on the power supply and controlling the relay from outside the box. A schematic of a high amperage power supply controlled by a relay is illustrated in figure 1.

COOLING EXPERIMENTS

If excessive heat is generated by an experiment, a cooling system will be required. A good, inexpensive cooling unit is a small automatic transmission cooler (available at any auto parts dealer) and a 10 inch muffin fan. The fan can be mounted directly to the cooler and both pieces clamped anywhere in the box. The cooler can be supplied with cooling water.

OTHER OPERATING TIPS

Vibrations associated with pumps can cause problems. Use thread locking compound on set screws for T-handled valves to prevent them from vibrating loose. When using a bellows sealed valve where the valve handwheel can be removed completely during opening, open valves fully and then close them a fraction of a turn onto the spring to prevent the hand wheels from vibrating off and getting lost.

When checking if a valve is open or closed, always check it in the closed direction. This practice will prevent the accidental opening of a system or component.

CONCLUSION

When specifying the components and layout of an experiment, careful consideration should be made to insure that it is tritium compatible, easily maintainable, versatile, cost effective, and can be readily integrated into the glovebox where it will be operated.