A NEW GLOVE-BOX SYSTEM FOR A
HIGH-PRESSURE TRITIUM PUMP

S. W. WILSON, R. J. BORREE, D. I. CHAMBERS,
Y. CHANG, J. T. MERRILL, P. C. SOUERS, and R. K. WIGGINS
Lawrence Livermore National Laboratory
P.O. Box 808, L-358
Livermore, CA 94550
(415) 422-1986

ABSTRACT

A new glove-box system that was designed around a high-pressure tritium pump is described. The system incorporates new containment ideas such as "burpler" passive pressure controls, valves that can be turned from outside the box, inflatable door seals, ferro-fluidic motor-shaft seals, and rapid box-to-hood conversion during cryostaging. Currently under construction, the system will contain nine separate sections with automatic pressure-balancing and venting systems.

INTRODUCTION

A new glove-box system has been designed around a high-pressure tritium pump and will be built at Lawrence Livermore National Laboratory (LLNL). The new system will pump to 200 MPa (30 ksi) and provide protection for the environment, whereas our present 120-MPa (18-ksi) pump is in open hoods connected to the stack. The

new system, although it will pump with a conventional 70-MPa (10-ksi) mechanical compressor plus cryostaging, incorporates many new containment ideas of interest to the tritium community.

The glove-box system was designed around the pump, rather than vice versa as is usual. However, the expected cost of \$53,000/ft (along the perimeter of the system) is comparable to other construction in our tritium facility. The total cost is expected to be about \$4 million.

An artist's conception of the system is shown in Fig. 1. The layout allows two or three operators to handle the entire system from the internal open area. The process starts at the tritium-can input section and proceeds clockwise around the diagram. Starting its journey in cans at 1 atm pressure, the tritium proceeds into the low-pressure system, which provides gas at 0.48 MPa (70 psia) to the inlet of the high-pressure compressor. The compressor is a conventional mechanical diaphragm system with an

MASTER

Fig. 1. Artist's conception of the glove-box system built around the high-pressure tritium pump.

outlet pressure of 70 MPa (10 ksi) and a throughput of $12 \mu\text{m}^3/\text{s}$ (0.025 cfm). Bottles can be directly filled at this point or the gas can be run to the cryo-staging area for the final boost to 200 MPa (30 ksi). The high-pressure functions are controlled in the manifold section. The 25-m^3 abort volume is designed for the largest possible accident inside the system.

A major issue concerned the philosophy of valving. Our high-pressure operators stated that they did not wish to work through gloves. Funding was inadequate to allow remotely actuated valves, as are being used in the new high-pressure tritium facility at Los Alamos.² The solution was to design a system with all valves inside the box as usual, but with their shafts passing through the box walls directly to the handles outside. This approach maintains operator "feel" for the valve while placing the operators away from the tritium.

At this time, three of nine sections are being constructed and examples exist of all key components. Testing of the low- and high-pressure systems is due to be finished by August 1989 and July 1990, respectively. This system is designed to fit to a catalyst/molecular-sieve cleanup system, also reported at this conference.¹

SYSTEM OPERATION

The system is composed of nine sections: three true glove boxes, five convertible hood-to-box enclosures, and the 25-m^3 abort volume. When tritium is being handled, each section becomes a true box with an argon atmosphere at 0.1 MPa (1 atm). Each section has its own balance system, which adjusts the pressure upon receipt of information from a transducer. The balance system will automatically adjust the pressure to the nearest 25 Pa (0.2 torr) by opening either a vacuum or an argon line.

Provision has been made for the failure of the automatic system in any section. The sections are connected by four rupture discs and five "burplers." The rupture discs are 9-in.-diam aluminum films. If the pressure rises on one side by 1.3 kPa (0.18 psia) above the other side, the disc is driven onto a knife, which cuts it. If the pressure is in the opposite direction, the disc must be stressed to 3.4 kPa (0.5 psia) before rupture. The burpler (Fig. 2) is an open-ended U-shaped tube with small holes in the bottom, set inside a can filled with oil. The burpler will pass gas at 800 Pa (6 torr) overpressure and then slowly refill itself through the small holes. The burpler on the abort volume is the final line of defense for the entire system. If it opens at 6.2 kPa (0.9 psi overpressure), the gas inside is vented to the stack.

If, for example, a vacuum valve opens up accidentally in one section, the burpler or rupture disc leading to the next section will eventually activate. The pressure controller in the next section will pump in argon to compensate. In this case, all gas is non-

Fig. 2. "Burpler" passive pressure control.

radioactive, so that the clean-up system will automatically pass it through to the stack.

When a glove-box door is opened, that enclosure goes to hood operation. The balance system to that section is closed and the hood vent to the stack is opened. The vent adjusts so that an air flow of 0.63 linear m/s (125 ft/min) moves through the opening. When the door is closed, the enclosure is flushed with argon, the vent to the stack closes and the system returns to box operation. The argon flush may be for a preset time or to a preset oxygen level. If a tritium alarm sounds, the operator need only to close the door, and the system will revert to box operation but without the argon flush.

One of the more complicated hood-to-box operations is that of cryostaging. This is the process of boosting the pressure by use of lower temperatures, in this case, liquid argon at 87 K. The compressor can load gas into a bottle at 50 MPa (7.2 ksi) at the cold temperature. When the gas is brought to room temperature, the pressure rises by roughly the ratio of the absolute temperatures (ignoring the compressibilities), so that a final pressure of up to 200 MPa (30 kpsi) may be obtained.

In our present system, in a hood, it is easy to cool the cryostaging bottle with liquid nitrogen. However, we wish to use an inert argon atmosphere in our box system, and the liquid argon gives off vapor during the cooling

process, which must be handled. Most of it comes off when the bottle is first cooled, and this step will be carried out with the enclosure in the hood mode. When the bottle is chilled, the door will be closed and tritium will be added with the system in the box mode.

MECHANICAL FEATURES

Valves

The valves pass through the box walls to be turned from the outside, and considerable effort has gone into the design of this feature. A schematic of the low-pressure valve is shown in Fig. 3. The entire valve system is attached to the box wall by Viton O-rings. The shaft is sealed by double Viton O-rings followed by a metal bellows seal. If the bellows break, tritium will exit into the box through the relief hole. At the end of the shaft is a ceramic ball-stem tip. These valves, rated to 10 MPa (1500 psi), are supplied by Astava of Amsterdam, Holland.

The high-pressure valve (Fig. 4) is a rebuilt Autoclave Engineering product, rated to 400 MPa (60 ksi). Again, the valve is connected by an O-ring seal to the wall. There are two rotating shafts, one for the valve and one for compressing the valve packing. Both are sealed by double Viton O-rings to the next unit. The central shaft, of course, turns repeatedly to

open and close the valve. The outer shaft is turned only to tighten the vespel-teflon-glass packing that constitutes the main pressure seal along the stem. The adjustment of the packing is made from outside the box. In fact, the packing may be removed and changed without ever disconnecting the valve from the wall.

Inflatable Door Seals

The hood-to-box transition of two of the enclosures makes it essential to be able to quickly and definitely seal the door. To this end, inflatable door seals, shown schematically in Fig. 5, are used. Two grooves in the wall contain neoprene half-balloons attached to a gas-fill line. When the door is closed and locked, argon is pumped into the neoprene seals and the space between them is evacuated to 75 kPa (11 psia). Both of these functions are monitored, and the next step (the argon purge cycle) will not begin until the door seal is verified by the process controller.

Motor Shaft Seals

Because of the argon atmosphere, all motors will be placed outside and their shafts will be coupled through the box wall by ferro-fluidic seals. These seals are made of oils containing a colloidal suspension of a magnetic material like magnetite.³ If the wall around the motor shaft is magnetized, the colloid attaches itself

Fig. 3. Schematic of the low-pressure valve.

Fig. 4. Schematic of the high-pressure valve.

Fig. 5. Schematic of the inflatable door seals.

to both the wall and the shaft, thereby creating a seal. Because it is liquid, the seal remains intact even through the shaft is turning.

These motors are intended for the pumps, which are metal bellows and Normatex scroll pumps, in general use in the tritium community. Our present Sprengle pumps, which operate with a waterfall of tritium-contaminated mercury, will be retired.

ACKNOWLEDGMENTS

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

REFERENCES

1. R. J. SHERRY and L. C. MILLER, "Design of a Tritium Recovery System," this volume.
2. R. NOLEN, private communication, Los Alamos National Laboratory, Los Alamos, NM 87545, 1987.
3. K. RAJ and C. REISER, "Magnetic-Fluid Seals," Laser Focus (April 1979), pp. 56-63.