TRITIUM GAS TRANSFER PUMP DEVELOPMENT

by

C. L. Sharpe

E. I. du Pont de Nemours and Company
Savannah River Plant
Aiken, South Carolina 29808

A paper presented at the
46th DAMSUL Committee Meeting in
Oak Ridge, Tennessee on
June 5-6, 1985, and for inclusion in the proceedings
of the meeting

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C. L. Sharpe
E. I. du Pont de Nemours and Company
Savannah River Plant
Aiken, South Carolina 29808

ABSTRACT

Non-lubricated, hermetically sealed pumps for tritium service have been selected to replace Sprengel pumps in the existing Tritium Facility. These pumps will be the primary gas-transfer pumps in the planned Replacement Tritium Facility. The selected pumps are Metal Bellows Corporation's bellows pumps and Normetex scroll pumps. Pumping range for a Normetex/Metal Bellows system is from 0.01 torr suction to 2300 torr discharge. Performance characteristics of both pumps are presented.

INTRODUCTION

Sprengel falling mercury drop pumps (Figure 1) are the primary gas-transfer pumps in the existing Tritium Facility. Pumping range is from 0.01 torr to 1600 torr and pumping speeds are 2 to 8 liters/minute. These pumps are no longer made, the pumps on hand have become a maintenance problem, parts are scarce and/or expensive to make, and the mercury working fluid is both a personnel hazard and a major contaminant in the process system. New non-lubricated, hermetically sealed pumps are needed to replace the Sprengel pumps and for installation in a proposed new Tritium Facility.

The Equipment Engineering Department at the Savannah River Plant (SRP) started looking for alternate pumps as far back as 1963. Higher pumping speed was the original objective. In 1977, replacement of Sprengel pumps became the objective, and in 1984, the needs in a new facility were added.

A general statement of the pump requirements is:

- 0.01 torr suction to 2300 torr discharge
- 35 to 70 liters/minute
- All metal (or tritium compatible) materials
- Double containment (in existing facility)
- Ease of leak detection
- Flow control (in some applications)
- Mercury free

* The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy
Four pumps have offered enough promise for evaluation testing. Of these, two have been successful and two have not. The pumps tested were:

- **Metal Bellows** - successful; but ultimate suction pressure is about 30 torr, which is acceptable for some applications. The Metal Bellows is also suitable for forepumping the Normetex pump.

- **Kinney Liquid Ring** - adapted from water working liquid to mercury. No acceptable shaft seal could be found. Mercury-free requirement was not met either.

- **A.D. Little Scroll Pump** - stainless steel scrolls, magnetic drive. Almost acceptable for lower pressures, but internal contact occurred as temperature increased from compression and from the magnetic drive. Development was discontinued in favor of other options.

- **Normetex Scroll Pump** - stainless steel scrolls, bellows sealed. This pump has been in service, primarily in Europe, for several years. Works efficiently below 250 torr discharge and, therefore, requires a forepump.

**TEST DETAILS**

Normetex and Metal Bellows pumps are shown in Figures 2 and 3 (photographs) and Figures 4, 5, and 6 (sketches).

Metal Bellows pumps are available in several configurations such as 35 L/min, 70 L/min, and one or two heads (heads may be staged). The Model reported on here is an MB601, with 70 L/min heads, and two heads in series.

The Metal Bellows pump has a constant compression ratio until the suction pressure is so low that the check valves cease to function. Thus, the suction pressure is dependent on the discharge pressure above a suction pressure of 20 to 30 torr. This is shown in Figure 7. Pumping speed is shown on the composite figure (Figure 8).

The Normetex pump is a 9 cfm (nominal) Model 15. This pump uses two nested spirals - one is fixed, the other moves in an orbital, not rotating, motion. In this motion, gas is trapped and compressed between the spirals. The discharge occurs at the center of the spirals. The key to successful operation of such a pump is building and maintaining close clearance - about 0.001 inch - between the scrolls. Any contact will cause seizure, but larger clearances result in excessive internal leakage.

Internal leakage limits pump performance at both pressure extremes - high and low. Thus, the pump is limited to producing about $1 \times 10^{-5}$ torr suction regardless of how low the discharge may be. In our system, with 30 torr as the lowest discharge pressure, the suction pressure is about 0.001 torr. When the discharge pressure exceeds 250 torr, the internal leakage becomes turbulent with the result that the pumps are able to produce a differential pressure of only about 300 torr. These characteristics are shown in Figure 9 and 10. Figure 9 shows the Normetex suction pressure as a function of its discharge pressure. Figure 10 is the same data rearranged to show
the differential pressure produced by the Normetex pump as a function of discharge pressure. Notice that the differential approaches a limit of 300 torr. Pumping speed for the Normetex/Metal Bellows system is shown in the individual data points in Figure 8. (The solid line is Normetex data for a system using a rubber diaphragm forepump.)

The Normetex pump is sealed by a bellows around the central, fixed, support shaft. It does not have double containment of the process fluid. Static seals are "Helicoflex" metal O-rings.

CONCLUSIONS

Two pumps have been evaluated which meet the pumping requirements for both projected and existing tritium facilities. Pumping speeds exceed those of the most commonly used existing pumps. Both types of pumps - Metal Bellows and Normetex - are now being tested in actual tritium service. EED will continue to look for other pumps to meet the requirements for tritium service at SRP. The principal motivation for the continued effort is to avoid having only a single source. The pumps identified are believed to be satisfactory.
FIGURE 1. Sprengel Pump
FIGURE 2. Normetex Pump
FIGURE 3. Normetex Metal Bellows System
FIGURE 4. Metal Bellows Double Containment Pump Head
FIGURE 5. Normetex Side View
FIGURE 6. Normetex End View
FIGURE 7. Metal Bellows -- MB 601
FIGURE 8. Pumping Speeds
FIGURE 9. Normetex 9 cfm
FIGURE 10. Normetex 9 cfm