

MMTO Conversion Technical Memorandum #96-3

Summary of Vacuum Tests at TIW
(7/24/95 — 8/4/95)

William Kindred

August 5, 1996

Summary of Vacuum Tests at TIW

(7/24/95 — 8/4/95)

The objectives of our tests were to determine that no external leaks existed at the sensitivity of our helium (He) leak detector and that the entire volume could be evacuated to a pressure (P) of 10^{-5} mmHg or less with a 32,000 l/s diffusion pump (dp) and cold trap. The following conditions were assumed:

- ◇ total volume of vacuum head and cell (V) _____ 5,000 ft³
- ◇ pumping speed of dp (S_{dp}) _____ 32,000 l/s [68,000 ft³/min]
- ◇ pumping speed of blower (S_b) _____ 300 ft³/min
- ◇ pumping speed of mechanical pump (S_{mp}) _____ 90 ft³/min
- ◇ blower crossover @ 20 mmHg
- ◇ foreline viscous conductance losses and manifold molecular losses are negligible.

A preliminary estimate of the pumpdown time was made using the relationship

$$t = c \left(\frac{V}{S} \right) \log \left(\frac{P_{initial}}{P_{final}} \right) \quad c = \text{constant.}$$

Assuming a net S_{mp} through the freewheeling blower of 45 ft³/min, t (640→20 mmHg) = 6.7 hour. Using S_b of 300 ft³/min for the mechanical pump/blower combination, t (20→2 mmHg) = 2.2 hour. On our first pumpdown we reached 20 mmHg in 6.3 hour. At 8.4 hour we bottomed out at 3.3×10^{-2} mmHg. Several sizable leaks in the volume up to the 32" poppet were found and sealed. Next, the valve was opened and several large pinholes in the manifold welds were plugged (leaks up to this point were sealed with aerosol resin or epoxy). A huge path was found in the onboard flange weld at approximately 5 o'clock (facing the near-horizon pointing vacuum head). Response time was very slow (normal system response <1 sec) indicating a circuitous path to the inside—not surprising given that this is a multi-pass weld. We ultimately determined that Votaw's cutting into the weld had exposed several pinholes. TIW rewelded sections of that quadrant to seal it.

With leaks sealed, the chamber pressure dropped overnight to 6.4μ ($1\mu = 10^{-3}$ mmHg) with a forepressure of 4.6μ . Closing the forevalve dropped forepressure to 2.0μ . With a He background of 4.6×10^{-8} atm-cc/sec, the structure was retested with no leaks found. At this point the dp was filled with oil and started. With the trap cold, dp operating pressure was 3.0×10^{-7} mmHg. After approximately 24 hours chamber pressure was 3.4×10^{-6} mmHg. We again tested the entire structure and found no leaks.

Since the mass spectrometer in our configuration does not sample all of the He entering a leak, calibration was necessary. One should be able to use the ratio of mechanical pumping speed for He to that of the leak detector (45 ft³/min) as an amplification factor but in the case of the former, speed is difficult to determine. With a precision metering valve we introduced a leak of

predetermined magnitude into the mirror cell and thus obtained directly a calibration factor of 4, i.e., throughput (Q_{actual}) = 4 ($Q_{indicated}$). With system noise at 0.2×10^{-8} atm-cc/sec, I conservatively estimated our minimum detectable leak to be 2×10^{-8} atm-cc/sec. A single such leak in our process (assuming an unrestricted 60,000 l/s cryopump) would, in itself, limit the obtainable pressure to 2.5×10^{-13} mmHg. Our gas load from external leaks will be negligible assuming we don't have any problems with our assembly techniques.

To further validate that conclusion, the rate of pressure rise in the valved-off volume was measured several times. Here we looked for a decreasing rate as evidence that the gas load is internal, i.e., outgassing and/or virtual leaks. Five successive measurements (units of μ /hr) yielded 0.46, 0.28, 0.18, 0.15 and 0.14. The last datum was taken starting from the system ultimate pressure of 3.4×10^{-6} mmHg.

In conclusion, we can state that no external leaks greater than 2×10^{-8} atm-cc/sec exist. This assures that outgassing will be the limiting factor in our system performance.

