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BSY BEAM TUBE OIL TRAPPING TESTS

Introduction

Following the decision to use oil diffusion pumps to evacuate the beam switchyard, it was agreed that some measure of protection was needed to reduce the probability of organics reaching the accelerator from the switchyard end of the machine.

Test Set-up

As part of the differential pumping system, a standard 10 ft. section of disc-loaded waveguide was incorporated between the diffusion pump and the ion pump.

Figure 1 shows the test set-up. The idea was to simulate the anticipated pressure and gas thru-put conditions of the differential pumping system and measure the amount of oil or hydrocarbon fractions that traversed the waveguide when it was refrigerated and oil was purposely introduced at the diffusion pump end.

DC 705 Oil

The tests were conducted with Dow Corning 705 diffusion pump oil. Chemically, DC 705 is pentaphenyl trimethyl trisiloxane with a molecular weight of 546 and a specific gravity at 25°C of 1.095 g/cc. The vapor pressure of DC 705 follows the simple relation:

$$\log p = A - \frac{B}{T}$$

where

$$A = 12.31 \quad \text{and} \quad B = 6490$$

which gives a vapor pressure of $< 10^{-9}$ torr at 25°C and ~ 1 torr at 250°C. The diffusion pump and both effusion cells were loaded with DC 705 oil.

Mass Spectrometer

A CEC Type 21-613 residual gas analyzer was the principal tool employed to measure the partial pressures of the gases reaching the ion pumped end of the testing. The instrument was calibrated with nitrogen and found to have a sensitivity for this gas of 1×10^{-11} torr/div. On the basis of other work showing sensitivities for other gases not different by more than a factor of 2, we assumed a sensitivity of 1×10^{-11} torr/scale division for all gases commonly measured except hydrogen.

The mass spectrometer, connecting tubes and the chamber at the ion pump end were all held at temperatures of 80-100° C during the tests. This ensured that any oil entering this region would be at a high enough vapor pressure to be seen with the mass spectrometer.

Test Sequence

Complete mass spectra patterns were recorded intermittantly during all phases of the tests. Altogether over 100 patterns were obtained covering the mass range 2 to 400 during the following test sequence:

1. Ion pumping only
2. Diffusion plus ion pumping
3. Before and after baking system
4. Following refrigeration of pipe to -37°C
5. Following heating of side oil cell to > 200°C (v.p. ~ 80μ)
6. Following introduction of nitrogen through leak valve to simulate gas load toward ion pump end
7. Following heating of on-axis oil cell to 250°C (v.p. ~ 1 torr)
8. Following admission of viscous flow pressure waves sent down pipe by rapidly opening the nitrogen leak valve at the DP end
9. Following cut-off of refrigeration and return of pipe to room temperature
10. Following heating of pipe and ion pump end in effort to drive back hydrocarbons
11. Following re-refrigeration of pipe to -37°C

Results

Figure 2 shows the changes in heavy hydrocarbon pressure (all gases above mass 44) at the mass spectrometer as changes were made in the test conditions.

From the test results we can make some estimate of the steady state transmission rate of hydrocarbons through the "trap."

For purposes of worst-case analysis, let us assume a steady state transmission rate corresponding to a partial pressure, during the tests, of 10^{-10} torr.

$$Q = SP$$

S was measured for mass 58 at the spectrometer at 20 liters/sec.

$$20 \times 10^{-10} = 2 \times 10^{-9} \text{ t-l/sec}$$

Converting to molecules,

$$2 \times 10^{-9} \ \frac{\text{torr liter}}{\text{sec}} \times 3.3 \times 10^{19} \ \frac{\text{molecules}}{\text{torr liter}}$$

Transmission rate = 6.6×10^{10} molecules/sec.

From this transmission rate, we can estimate how long it might take to cover the internal parts of the accelerator with a monolayer of organic molecules.

$$\text{monolayer time} = \frac{\text{number of sites}}{\text{rate of arrival} \times \text{sticking fraction}}$$

From electron diffraction work we can assume monolayer coverage requires 2×10^{14} molecules/cm^2 for molecules of average mass 100.

The sticking probability for heavy organics is probably less than 0.5.

Therefore the time required to get a monolayer on 1 cm^2 would be:

$$\frac{2 \times 10^{14}}{6.6 \times 10^{10} \times .5} \sim 6000 \text{ seconds}$$

The internal area of the last ten foot section of the accelerator with related waveguide and vacuum plumbing is ~ 10^5 cm^2. Therefore, monolayer coverage of this part only would take 6×10^8 seconds or nearly 20 years.

Conclusions

1. It appears that a refrigerated disc-loaded waveguide section can act as an effective barrier and reduce to low values ($< 10^{11}$ molecules/sec) the number of heavy hydrocarbon molecules reaching the accelerator from the BSY and the end stations where oil pumps will be used.

The question of what radiation-resistant refrigeration fluid to use is being investigated by H. DeStaebler and J. O'Ryan.

2. Heating the "trap" in order to drive-back the accumulated oil and oil fractions did not appear promising.

3. We should probably provide an isolation valve at the ion pump end which could be closed when the refrigeration is cut off for any reason.

4. The waveguide should be sufficiently out-of-tune to prevent significant absorption of rf power from the beam.

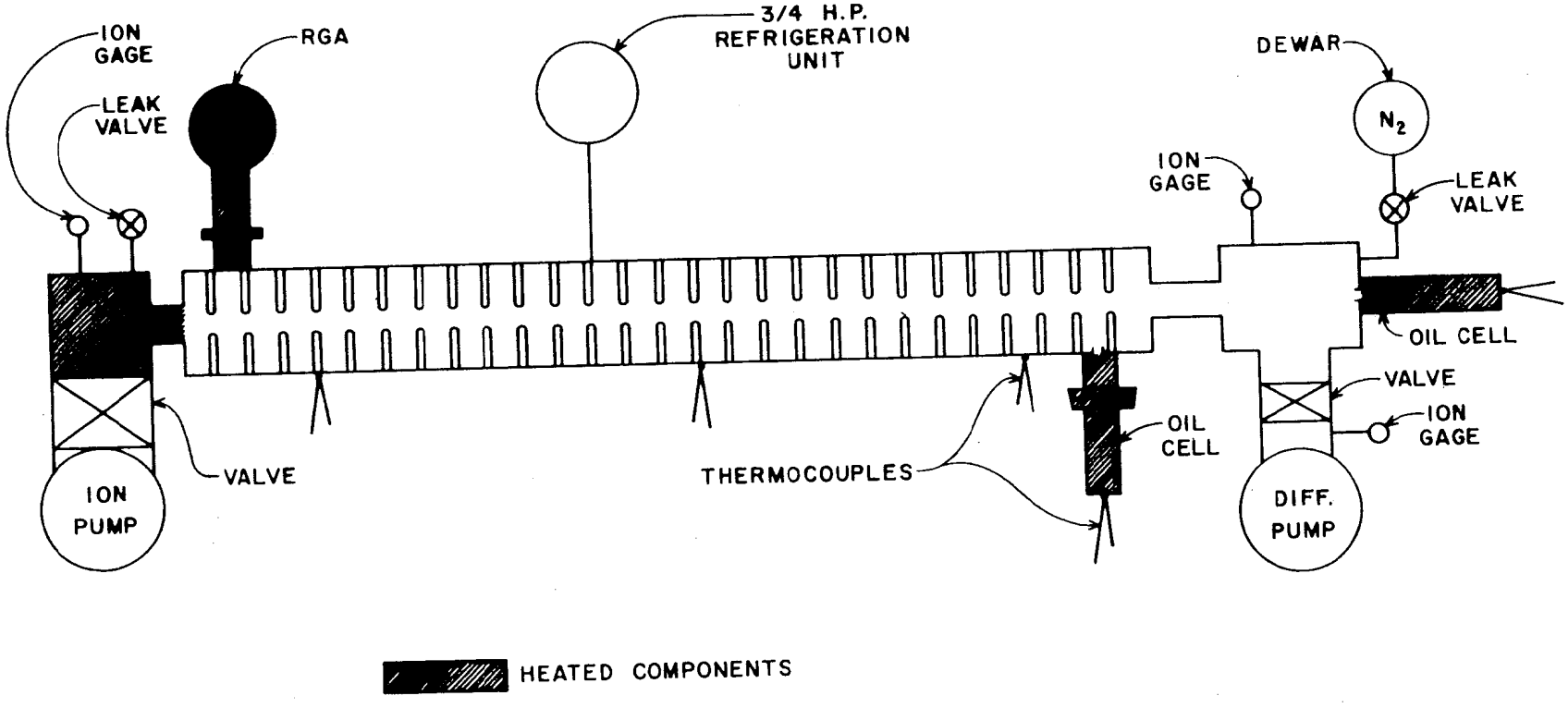

FIG. 1 - TEST SET-UP USING 10 FT. ACCELERATOR SECTION AS AN OIL BARRIER

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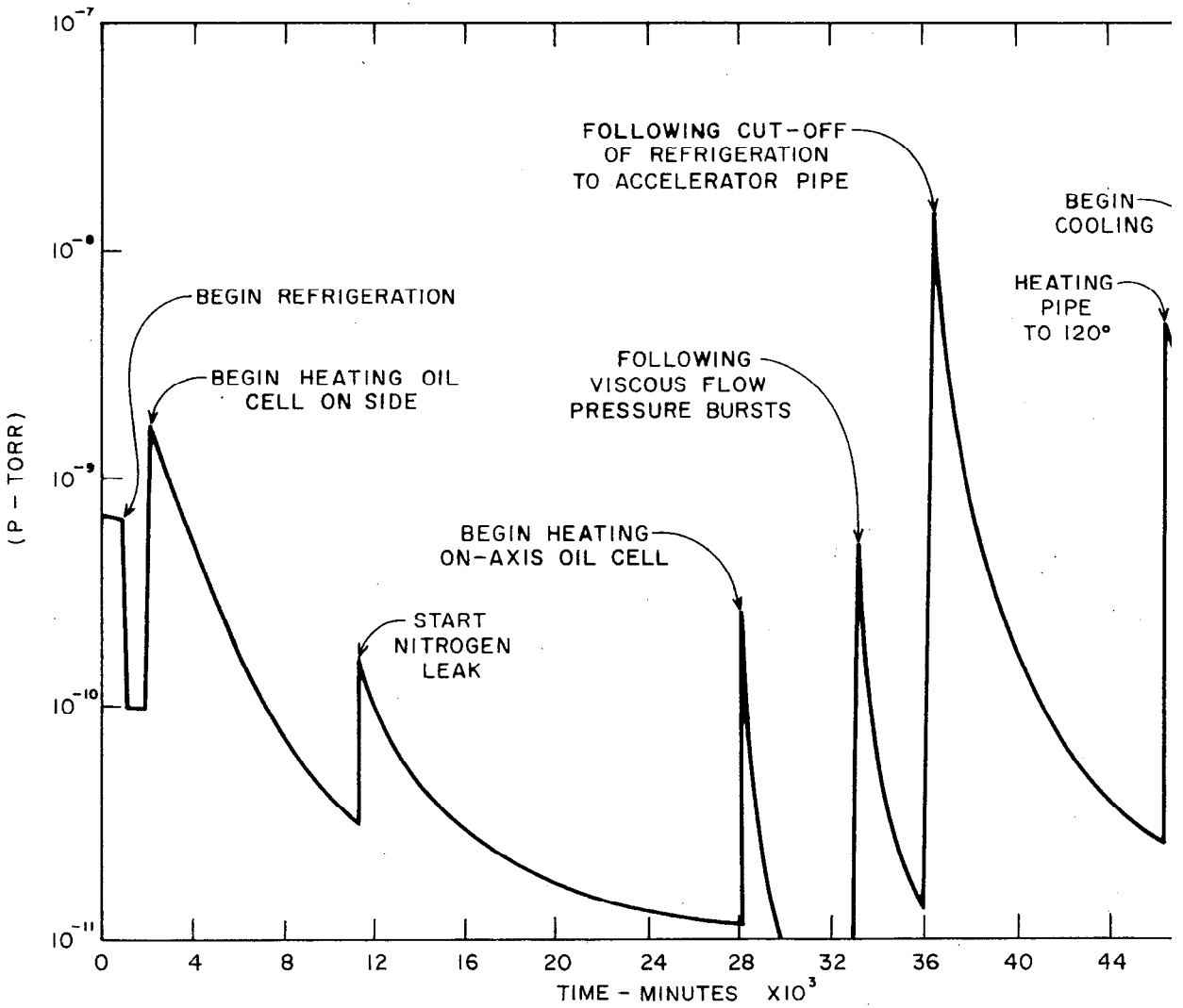

FIG. 2 - TOTAL HEAVY HYDROCARBON PRESSURE AT RGA DURING OIL TRAPPING TESTS