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AN UNCONVENTIONAL ULTRA-HIGH VACUUM FACILITY*

C. F. Barnett and J. A. Ray
Oak Ridge National Laboratory
Oak Ridge, Tennessee
U.S.A.

MASTER

In pursuing the problems of measuring atomic collision cross sections, the need arose for a vacuum vessel that would maintain a pressure of 10^{-10} torr in the interaction region. The system should also satisfy two additional requirements: 1) The walls should be sufficiently removed from the interaction region such that neutral particles released from particle impact on wall surfaces would produce a minimum effect on the pressure in the interaction region; 2) The vacuum system should be a subsidiary component designed to let the experiment proceed without spending full time in obtaining the low pressure required.

The first step in the design of the system was the selection of the type of pump to be used. To evaluate the pumps, a test was initiated in which two 6" diffusion pumps manufactured by two companies were compared under a variety of conditions. The pumps were blanked off and the ultimate pressure and visible oil back streaming were observed after 48 hours of operation. In Table I is a comparison of the performance of the two types of pumps with various baffle configurations.

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Test Conditions	<u>TABLE I</u>			
	<u>PUMP #1</u>		<u>PUMP #2</u>	
	Diffusion Pump Fluid	Ultimate Base Press. (Torr)	Diffusion Pump Fluid	Ultimate Base Press. (Torr)
Zeolite Traps Incl. in System	Convoil-20	5×10^{-10}	Dow 705	1×10^{-9}
Traps Removed - H ₂ O Cooling on Baffle	Dow 705	5.8×10^{-8}	Dow 705	1.3×10^{-9}
Traps Removed - Baffle Refrigerated (-35° to -40°C)	Dow 705	4.5×10^{-9}	Dow 705	1.2×10^{-9}

Liquid N₂ cooled traps were eliminated due to the attention required in maintaining N₂ levels or flow through the baffles. Table I indicates only small changes in pressure were obtained when elaborate baffles were used. Armed with the information from the tests, the decision was made to use the NRC 6" HK series pump with only water cooled optically thick baffles. The pump was also equipped with a water cooled cap above the upper jet.

The vacuum vessel shown schematically in Fig. 1 consisted of a stainless steel chamber two feet in diameter and eight feet long. The inside of the vessel was polished to approximately a sixteen micro-inch finish to assist in the cleanliness of the system. A liner inside the chamber was constructed of copper with copper tubing attached by a heli-arc process using a high-temperature solder. An inner copper container was suspended inside the liner and both regions could be outgassed by passing steam through the tubing or cooled by flowing water or liquid N₂. The diffusion

pumps and baffles were attached to the vessel directly with no intervening valves. All flanges were sealed by compression type aluminum wire gaskets made with 2S Al wire. Batch evaporation of Ti was accomplished by using the usual ORNL Ta filament wound with Ti wire and again all seals were either Al wire gaskets or flange welded ceramic bushings. Shown also on Fig. 1 are a set of Helmholtz coils to provide an axial magnetic field for steering of charged beams. Notice also that the vessel is compartmentalized. This was done so that with the use of beams of charged particles, differential pumping could be used to partially isolate the beam dumping region from the interaction region. Provisions have been made for inserting movable probes and beam scanners all through stainless steel bellows type arrangements. The fore vacuum was provided by Welch Duo-Seal #1398 pumps usually operating well below 10^{-3} torr under static conditions. A photograph of the system is shown in Fig. 2.

The procedure used in obtaining the required vacuum consisted in baking the unit by passing steam at 100°C through the liners for 24 hours. The steam was turned off and water was allowed to flow through the lines. Shortly thereafter, the pressure decreased to a constant value of 5×10^{-9} torr. Ti was evaporated onto the water cooled surfaces for a period of four hours after which the pressure stabilized at 5×10^{-10} torr as read by a Veeco RG-75 ionization gauge. Further Ti evaporation on liquid N_2 cooled surface produced no change in the observed pressure nor was any improvement noted when the liquid nitrogen cooled surface was thermally cycled.

A Veeco Residual Gas Analyzer was placed on the system to study the individual mass peak behavior when in the pressure range of 5×10^{-10} torr. In a typical scan before Ti evaporation, the predominate mass peaks were 28 and 18 and as shown in Fig. 3 on the top trace. After Ti evaporation on the water cooled liner the predominate mass peak was 28 which was reduced in amplitude and the usual hydrocarbon peaks in the mass 40 region disappeared. In the lower trace is a comparison when Ti was evaporated on surfaces at liquid N_2 temperatures which produced no further significant decrease in the remaining mass peaks. Under these conditions all of the hydrocarbon peaks vanished and also note in the lower traces the absence of masses in the 70-80 range, which was the expected mass fragment of the Si oil decomposition. To make observations more quantitative, the sum of the total partial pressures was determined and found to decrease by a factor of six when Ti was evaporated onto liquid N_2 cooled surfaces. From this decrease in pressure we have concluded that the pressure in the vessel was of the order of 10^{-11} torr.

This vacuum system has been operated for several months with no visible traces of oil backstreaming into the vessel. Crude tests, such as increasing the heater power have revealed no significant amounts of oil in the system. The vacuum obtainable is reliable, easy to obtain and is adequate to meet the requirements of the experimental program.

Cross Section of Ultra-High Vacuum Cross Beam System.

FIG 1

FIG 2

Photograph of Ultra-High Vacuum Cross
Beam System

Comparison of Mass Scans
Fig 3