Fermilab

$\bar{p}$ NOTE # 439

Fermilab and Varian Titanium Sublimation Pump Comparison Test

E. Podschweit
December 1985

December 1985
E. Podschweit

FERMILAB AND VARIAN TITANIUM SUBLIMATION

PUMP COMPARISON TEST

A comparison test was done to observe the difference in performance between a titanium sublimation pump controller designed by Fermilab, which is presently being used, and a standard Varian controller. Tests were also done to determine if an increase in emission current in the Fermilab controller would significantly improve sublimation rate.

The Varian controller applies a continuous current to the filament. The current can be adjusted to give the desired sublimation rate. The suggested typical settings are between a minimum of 45 amps and a maximum of 50 amps which corresponds to a sublimation rate of between 0.01 gm/hr. and 0.09 gm./hr. When the Varian controller is turned on there is a slight current surge of about 5 or 6 amps above the desired setting the first 6 seconds in a new filament. This slight increase in current is due to the change in resistance in the filament as it heats up. As the titanium in the filament is used up, the current gradually decreases which decreases the sublimation.

The Fermilab controller uses an emission current control circuit to regulate the filament current. A collector tube with a diameter of 0.5 inches is installed where the middle filament would normally be in a standard filament holder. The emission control circuit consists of a feed back loop where the emission is sensed and the output is controlled to regulate the filament current. When the controller is turned on, a certain amount of time passes until the correct emission current is sensed. As the emission current setting is increased the amount of time to reach the desired emission current increases. During the time it takes to reach the correct emission current, the filament is operating at full power, typically, 62 amps with a new filament.

Comparison tests between the two controllers were done at various vacuum pressures to determine saturation times. Figure A shows the results of tests done at 1.0×10^{-9} TORR which is typical of the vacuum in the accumulator ring during the time that the sublimation pumps operate. The vacuum pressure rise is a result of the filament heating up when the sublimation pumps are first turned on. The ultimate vacuum pressure is the lowest vacuum pressure achieved before the titanium became saturated and no longer provided any pumping. The saturation time is the time from when the filament is turned off to when the vacuum pressure begins to worsen. The time from when the

filament was turned off to when the vacuum reached its initial pressure (the set leak rate) was also recorded. The current was measured both at the controller and at the filament with a clamp-on ammeter. It should be mentioned that the clamp-on ammeter did not show the true RMS reading in the case of the Fermilab controller because it does not put out a true sine wave. The peak current is the initial current before reaching the regulated emission current setting.

The results of the test shown in Figure A indicate that the Fermilab controller significantly spoils the vacuum when the filament is first turned on due to the larger current peak before the emission current is regulated. As a result the ultimate vacuum is not quite as good as the pressure achieved by the Varian controller which did not have as large an initial current peak. The same results, although not as dramatic, can be seen in Figure B where the leak rate was set at the higher pressure of 10×10^{-8} TORR. In Figure C no pressure rise was seen because the leak rate was set at a higher pressure than the outgassing rate of the filament. In Figure D the Varian controller was increased from 44 amps to 48 amps which was more in line with the manufacturer's suggested setting. The only significant improvement was seen in the saturation time.

The data in Figure E show the effect on the vacuum when the emission current setting in the Fermilab controller was increased from the normal 10 milliamps to 12 milliamps. The test was done at two different leak rates 1.0×10^{-8} TORR and 5.0×10^{-8} TORR. When the emission current was increased from 10 to 12 milliamps, the time it took for the feed back loop to regulate the current to the filament increased from 12 seconds to 15 seconds. During this time the filament is operating at a peak current of about 62 amps. There was no appreciable effect on the ultimate vacuum pressure.

The main concern with the Fermilab controller is the large current applied to the filament during the time it takes to reach the correct emission current setting. Initially, this large current spoils the vacuum because of the outgassing of the filament due to its heating up. Our test show that increasing the emission current setting from the normal 10 milliamps to 12 milliamps did not have a significant offset on the performance of the sublimation pump. Apparently, the increased amount of titanium that is sublimed when the current is increased to the filament is effect by the longer outgassing of the filament caused by the increase in time that the filament operates at full power until the correct emission current is sensed. If the controller could be modified to operate the filament at a reduced power during the time it takes to reach the correct emission current, the outgassing of the filament would be less and the subsequent spoiling of the vacuum would be less.

FIGURE A

Vacuum Pressure Rise	Ultimate Vacuum Pressure	Current (A) Controller	Current (A) Meter	Current (A) Peak	Saturation Time	Time To Reach Initial Pressure
Leak Rate: 1.0×10^{-9} Torr	Fermi Controller		10 mA Emission Current			
10^{-7}	6.6×10^{-10}	43.6	37.4	55	80 mins.	8 hrs
3×10^{-8}	6.4×10^{-10}	43.7	37	58	72 mins.	24 hrs
1.8×10^{-8}	6.1×10^{-10}	43.6	37.9	57	93 min.	26 hrs
	Varian Controller					
5.9×10^{-9}	3.7×10^{-10}		45	49.7	45 min.	45.5 hrs
2.5×10^{-9}	3.7×10^{-10}		43.4	47.8	~39 min.	24.5 hrs
2.2×10^{-9}	4.5×10^{-10}		45	49.4	~17.5 hrs	~71 hrs.

FIGURE B

Vacuum Pressure Rise	Ultimate Vacuum Pressure	Current (A) Controller Meter Peak	Saturation Time
LEAK RATE: 1.0×10^{-8} TORR	FERMI CONTROLLER	10 MA	EMISSION CURRENT
3.7×10^{-8}	2.5×10^{-9}	44.4	42 MINS.
3.3×10^{-8}	2.4×10^{-9}	44.4	31
2.8×10^{-8}	2.4×10^{-9}	44.4	23
2.4×10^{-8}	2.4×10^{-9}	44.3	31
2.3×10^{-8}	2.4×10^{-9}	44.3	28
2.0×10^{-8}	2.5×10^{-9}	44.3	30
1.9×10^{-8}	2.5×10^{-9}	44.2	28
2.3×10^{-8}	2.7×10^{-9}	44.2	16
1.7×10^{-8}	2.7×10^{-9}	44.1	15
1.5×10^{-8}	2.0×10^{-9}	44.1	25
	VARIAN CONTROLLER		
8.1×10^{-9}	3.3×10^{-9}	45	13 MINS.
6.1×10^{-9}	3.2×10^{-9}	45	13
5.4×10^{-9}	3.2×10^{-9}	45	16
4.9×10^{-9}	3.1×10^{-9}	45	16
4.3×10^{-9}	3.1×10^{-9}	45	15
4.2×10^{-9}	3.0×10^{-9}	45	11
4.0×10^{-9}	2.7×10^{-9}	45	10
3.8×10^{-9}	2.7×10^{-9}	45	11
4.7×10^{-9}	1.8×10^{-9}	45	25
2.9×10^{-9}	1.8×10^{-9}	45	15
2.7×10^{-9}	1.9×10^{-9}	44.5	13
2.8×10^{-9}	2.1×10^{-9}	45	19

FIGURE C.

Vacuum Pressure Rise	Ultimate Vacuum Pressure	Current (A) Controller Meter Reading		Saturation Time
Leak Rate: 5.0×10^{-7} torr	Fermi Controller		10 mA Emission Current	
No Rise	2.0×10^{-7}	44.1	37.6	~ 2 mins.
"	1.9×10^{-7}	44.1	37.4	2
"	1.8×10^{-7}	44.1	37.4	2.5
"	1.8×10^{-7}	43.9	37.9	3
"	1.8×10^{-7}	43.9		2
"	1.7×10^{-7}	43.9		3.5
"	1.7×10^{-7}	43.8	37.8	4
"	1.6×10^{-7}	43.8	37.8	4.5
"	1.6×10^{-7}	43.8	37.4	4
"	1.6×10^{-7}	43.8	37.6	4.5
	Varian Controller			
No Rise	1.7×10^{-7}	45		2.5 mins.
"	1.7×10^{-7}		45.5	3.5
"	1.6×10^{-7}		45.2	4
"	1.5×10^{-7}		44.8	2.5
"	1.4×10^{-7}		44.7	4
"	1.4×10^{-7}		44.6	5
	1.4×10^{-7}		44.4	5
	1.4×10^{-7}		44.4	5
	1.4×10^{-7}		44.7	5

FIGURE 1

Vacuum Pressure Rise	Ultimate Vacuum Pressure	Current (A) Controller	Meter	Peak	Saturation Time
Leak Rate: 8.0×10^{-7} Torr	Fermi Controller 10 mA Emission Current				
No Rise	3.0×10^{-7}	43.8	37.5	58	1.5 mins.
"	2.8×10^{-7}	43.8	37.6	58.5	2.5
"	2.8×10^{-7}	43.7	37.8	57	3
"	3.0×10^{-7}	43.7	37.4	57.2	2.5
"	2.8×10^{-7}	43.7	37.6	56	2.5
"	2.8×10^{-7}	43.6	37.8	56	3
"	2.7×10^{-7}	43.7	37.4	56	3
"	2.7×10^{-7}				3
"	2.7×10^{-7}	43.6	37.4		3
	Varian Controller				
No Rise	2.4×10^{-7}	43.7			3.5 mins.
"	2.3×10^{-7}	43.8		47.8	3.5
"	2.3×10^{-7}	43.5		47.2	4
"	2.3×10^{-7}	43.8		48.2	3.5
"	2.3×10^{-7}	43.8		48.3	4
"	2.3×10^{-7}	43.8		48.3	4
	2.3×10^{-7}	43.8		48.1	4
Increased Current To 48 Amps					
No Rise	2.2×10^{-7}		48.1	53	6 min.
"	2.2×10^{-7}		48.0		6 min
"	2.2×10^{-7}		47.7	52.5	6 min
"	2.2×10^{-7}		48.1		7.75 min.
"	2.2×10^{-7}		48.3		7 min
"	2.2×10^{-7}		48.2	53.3	7 min
"	2.2×10^{-7}		48.2	53.6	6.5 min
"	2.2×10^{-7}		48.0	53.1	7 min
"	2.2×10^{-7}		48.1	53.5	7 min

FIGURE E

Vacuum Pressure Rise	Ultimate Vacuum Pressure	Current (A) Controller Meter		Peak	Saturation Time	Time To Reach Initial Pressure
Leak Rate: 5.0×10^{-8} Torr	10 mA Emission	Current		(12 sec.)		
5.6×10^{-8} Torr	2.0×10^{-8} Torr	44.7	37.4	61.7	1.5 mins.	~3.75 hrs.
No Rise	2.0×10^{-8}	44.6	37.3	62.8	1.5 mins.	~2.0 hrs.
No Rise	1.9×10^{-8}	44.5	37.2	62.8	1.5 mins	~3.0 hrs
No Rise	1.9×10^{-8}	44.5	37.2	62	1.5 mins.	~3.5 hrs.
	12 mA Emission	Current		(15 sec.)		
No Rise	2.0×10^{-8}	43.9	37.8	63	2 mins	~2.25 hrs
7.7×10^{-8}	2.1×10^{-8}	43.9	37.7	62	1.5 mins.	~5.0 hrs
No Rise	2.0×10^{-8}	43.8	37.7	62	1.5 mins.	~2.5 hrs
Leak Rate: 1.0×10^{-8} Torr	10 mA Emission	Current				
1.9×10^{-8}	4.2×10^{-9}	44.8	37.7	62	7.5 mins.	~4.3 hrs.
6.2×10^{-8}	4.2×10^{-9}	44.8	37.4	62	9 mins.	~5.3 hrs.
4.7×10^{-8}	4.2×10^{-9}	44.7	37.4	61.5	8 mins.	~4.3 hrs
	12 mA Emission	Current				
2.6×10^{-8}	4.7×10^{-9}	44.2	37.9	62	7 mins	4.6 hrs.
2.9×10^{-8}	4.3×10^{-9}	44.1	38.4	61	7.5 mins.	4.1 hrs.
2.3×10^{-8}	4.0×10^{-9}	44.0	37.7	61	7.5 mins.	9.1 hrs.