D-ZERO

VACUUM

SYSTEM

S. J. WINTERCORN

4/7/86

DØ Engineering Note
3740.000-EN-46

D-Zero Vacuum System

System Pumping Speed

The system pumping speed was calculated by taking the reciprocal of the sum of the reciprocal pump speed and the reciprocal line conductances. The conductances of the pipe were calculated from the following formulas taken from the **Varian vacuum manual**.

VACUUM FORMULAS

(i) Rate of air flowing through a long circular pipe. (The following rules are for air at 20°C and are accurate to within 10%.)

1. Viscous flow (high pressure) where the average pressure in microns multiplied by the pipe diameter in inches is greater than 200.

$$C = 0.52 \times \frac{D^4}{L} \frac{1}{P}$$

2. Transition range (intermediate pressure) where the average pressure in microns multiplied by the pipe diameter in inches is greater than 6 and less than 200.

$$C = 0.52 \times \frac{D^4}{L} \frac{1}{P} + 12.2 \times \frac{D^3}{L}$$

3. Molecular flow (low pressure) where the average pressure in microns multiplied by the pipe diameter in inches is less than 6.

$$C = 13.6 \times \frac{D^3}{L}$$

C = conductance in CFM

D = diameter in inches

L = length in feet

P = average pressure = $\frac{1}{2}(P_1 + P_2)$

The elbows of the system piping in the viscous region were represented by equivalent lengths of pipe using the following table (ref. 1), assuming 90 deg. elbows, standard radius.

L_e/D RATIOS FOR SCREWED FITTINGS, VALVES, ETC., TURBULENT FLOW ONLY*

Fitting	<i>L_e/D</i>	Fitting	<i>L_e/D</i>
45-deg elbows.....	15	Tee (used as elbow entering branch).....	90
90-deg elbows, standard radius.....	32	Couplings, unions.....	Negligible
90-deg elbows, medium radius.....	26	Gate valves, open.....	7 ^b
90-deg elbows, long sweep.....	20	Gate valves, one-fourth closed...	40 ^b
90-deg square elbows.....	60	Gate valves, one-half closed....	200 ^b
180-deg close return bends.....	75	Gate valves, three-fourths closed	800 ^b
180-deg medium-radius return bends.....	50	Globe valves, open.....	300 ^b
Tee (used as elbow, entering run).....	60	Angle valves, open.....	170 ^b

* Perry, ¹¹ p. 390.

^b Rough estimate; values depend on construction of valve.

Note: 1 l/s = 2.12 cfm

In the molecular region, the conductance of the elbows was calculated by the following formula (ref. 2);

$$78 \cdot D^{3/2} / r$$

This conductance was very large, so the elbows do not decrease the pumping speed drastically in the molecular region.

Pump Down Time

The pump down time depends on the instantaneous pumping speed, the size of the volume to be pumped, its dryness (absence from water), and its tightness. Assuming a tight and dry vessel of volume V_0 , the pressure at time t is approximately;

$$P(t) = P(0) \cdot e^{(-t/T_1)} + P(ULT.)$$

where $T_1 = V_0/S(\text{sys})$, $P(ULT.)$ is the pump blank off pressure, t is time, V_0 is the volume and $S(\text{sys})$ is the pumping speed from the pumping speed curves. The approximate volumes are 51000 liters (volume for central calorimeter (CC)) and 43000 liters (volume for end calorimeter (EC)) for the utility system and 8900 liters for (CC) and 8400 liters for (EC) for the insulation system. When the pressure gets down to about 100 microns, the outgassing rate controls the pump down time. The above equation can be used again when the outgassing is complete.

Utility Vacuum System

The utility vacuum system will be used to pump and purge the calorimeter cryostats. The surface area is large (approx. 7100 sq. meters for CC, EC is somewhat smaller) and will take much pumping to dry and outgas. When the utility vacuum system is not in use, it will be made available for

miscellaneous evacuation tasks associated with cleaning and charging the gas lines of the Central Detector, and other similar tasks. A series of valves will be provided along the length of the utility pipe run to serve the pumping needs on the assembly floor.

The proposed utility system consists of a two stage mechanical pump, 150 cfm (70.8 l/s) rough, 1600 cfm (755 l/s) blower (Stokes model 1721S), approximately 225' of 4" pipe to north EC, 217' to CC, 200' to south EC and any necessary valves and elbows. See fig. 1a for pumping speed curves. The utility vacuum pump has been increased in size so it may serve as a spare to the insulating vacuum rough pump. A crossover valve at the pumps (not shown) is required to effect this redundancy.

Insulation Vacuum System

The insulating vacuum system must keep the super-insulated cryostat insulating vacuum below 0.001 mm. Hg and preferably below 0.0001 mm. Hg, see fig. 1 (heat leak vs. pressure). It should be noted that although every effort will be made to make the insulating vacuum as tight as possible, the only temporary cure for internal leaks to the vacuum space is reliable pumping speed. The permanent cure for leaks that can't be pumped is mechanical repair. External leak repair is usually easy, internal repair is difficult, time consuming and to be avoided at, almost, all costs.

System One

This report compares two alternatives for the insulation vacuum system. The first system (see fig. 2a &c) has all 6" piping, a Stokes 1721S (150 cfm rough, 1600 cfm blower) two stage mechanical pump, a 400 l/s Sargent Welch turbo pump located outside of the end iron (fig. 2a) and one Varian M-4 800 l/s diffusion pump on the bottom of each cryostat. The pumping speed curve for north EC (worst case) is shown in fig. 1b.

Advantages

- greater pumping speed (800 l/s vs. 160 l/s)
- no moving parts in diffusion pumps
- 50, 75, 150 l/s without diffusion pumps
- flatter pumping speed curve

Disadvantages

- diffusion pumps not easily accessible
- possible backstreaming of oil with diffusion pumps
- possible electric interference of heater power lines

System Two

The second system has 6" pipe that reduces into 4" pipe after the rotary bayonets, a Stokes two stage mechanical pump like the first system and one Sargent Welch model 3120S turbo pump (160 l/s) on the bottom of each cryostat. The pumping speed curve for this system is shown in fig. 1e.

Advantages

- no backstreaming of oil

Disadvantages

- turbo pumps not easily accessible
- turbo pumps have moving parts and therefore cause vibration
- if turbo fails, only rough pump remains
- possible electric interference of motor power lines
- only 15 l/s pumping speed at 23 microns

Conclusions

It is not clear as of yet if vacuum pumps can be placed near the cryostats as they are shown in the figures of these two systems. The possibility of this is being looked into at this time.

References

1. McAdams, W., Heat Transmission. McGraw-Hill book co., 1954.
2. Barron, R. F., Cryogenic Systems, Second Edition. Oxford University Press, 1985.

HEAT LEAK vs. PRESSURE

Fig. 2

Fig. 1

RESIDUAL GAS PRESSURE, Torr

Utility Vacuum System

Fig. 1a

NORTH EC (1st System)

CENTRAL CALORIMETER

Fig. 1c

SOUTH EC

Fig. 2d

SECOND SYSTEM

Fig. 1e

D-ZERO
VACUUM SYSTEM
PUMPING SPEED
CONSIDERATIONS

Appendix - A

G. T. Mulholland

R.T. Krasa

May 9,1988

D0 Engineering Note 3740.000-EN-46A

Approved: G.T. Mulholland 5/18/88

Introduction

This report updates the original to reflect the pumping curves and basic vacuum system characteristics for the purchased components and installed piping of the D-Zero vacuum system. The system consists of two Edward's E2M275 two stage mechanical pumps, a Leybold-Heraeus WSU2000 Blower and three Varian 4" diffusion pumps (one for each cryostat). Individual pump and system pumping speed curves and a diagram of the system is included.

System Limitations

Pump operating ranges:

	Ultimate Vacuum		Backpressure
Edwards mechanical pump*	0.0003 torr	-	>1000 torr
Leybold-Heraeus Blower	0.0006 torr	-	≈760 torr
Varian diffusion pump	10^{-6} to 10^{-8} torr	-	0.550 torr

Note: The Leybold-Heraeus Blower incorporates an automatic bypass valve to eliminate the possibility of overheating due to backpressures. Therefore it is possible to operate the blower at all backpressures up to one atmosphere. That would normally not be possible until 10mmHg or below.

The only limitation of major consequence to the operation of the vacuum system is the diffusion pump can not be turned on until the mechanical pump/pumps and/or blower have reduced the pressure below 0.550 torr. Since the cryostats share a common vacuum line, all cryostat insulating vacuums must be rough pumped before any diffusion pump is turned on. If a cryostat was to develop large enough of a leak as to overwhelm the mechanical pumps and increase the pressure in the vacuum line to >0.550 torr, it would be necessary to valve out all of the diffusion pumps.

*Ballast closed, see pump speed curves.

A logical pump sequence would be:

1. Rough pump NEC
2. Rough pump CC
3. Rough pump SEC
4. Diffusion pump NEC
5. Diffusion pump CC
6. Diffusion pump SEC

Special Features:

Note in the schematic that the piping allows both E2M275 mechanical pumps to operate in parallel. Parallel operation doubles the pumping speed only at the higher pressures, but doubles the water pumping limit from 4lb./hr. to 8lb./hr..

The cross connection of the mechanical pumps allows using either pump as the spare for the other in the event of primary pump malfunction. The isolation valve allows the malfunctioning pump to be taken off line for repairs without affecting the forepump capability.

Pumping and purging is made convenient by providing a remote valve controlled 1" GN₂ purge line directly to the utility (P&P) manifold. Argon back fills can be made by the gas make up line, or by special connections from gas trailers.

Note: The turbomolecular pump previously considered is not required because of the reduction of the system pumping speed notch between the mechanical and diffusion pump curves. This is a direct result of large diameter piping and two, rather than one, stage mechanical pumps.

Pumping Speeds of Individual Pumps

Cryostat Inner Volume Pumpdown Speed

NEC Insulating Vacuum Pumping Speed

CC Insulating Vacuum Pumping Speed

SEC Insulating Vacuum Pumping Speed

Vacuum System
Instrumentation
& Interlocks
4/88, GTM

BLOWER

MECHANICAL PUMP

E2M175, E2M275

DIFFUSION PUMP

TECHNICAL DATA AIR SPEED AND THROUGHPUT !!

Speed curve based on standard AVS test procedures.

*Throughput as measured with 10 cfm backing pump.

!! Speed reduction due to cold cap. 646 L/s

1ST SYSTEM

FIG. 2a

2ND SYSTEM

FIG. 2b

INSULATION V. VACUUM SYSTEMS

STOKES MODEL 1721S

STOKES MODEL 1721S

Specifications *M-4 DIFFUSION PUMP*

M-4 Diffusion Pump

Maximum Speed: Air: 800 ℓ/s
 Helium: 1000 ℓ/s
 Operating Range: 1×10^{-3} to 5×10^{-9} Torr
 Maximum Forepressure: 6.5×10^{-1} Torr
 (no load)
 4.5×10^{-1} Torr (full load)
 Maximum Throughput: 1.5 Torr-liters/sec
 Fluid Charge: 250 cc
 Heat-up: 12 minutes
 Cool-down: 20 minutes
 Water: 0.15 gpm at 60°F to 85°F
 Heater Rating: 1190 watts
 (120/240/1/50/60) $\pm 5\%$
 Jet Assembly: Four-stage self-aligning aluminum with cold cap

Foreline Baffle: Stainless steel, half moon
 Water Connections: 1/8" FPT
 Body: Stainless steel
 Flanges: Mild steel
 Heater Skirt: Aluminum
 Net Weight: 27 pounds
 Shipping Weight: 45 pounds

334 Low-Profile Water-Cooled Baffle
 Nominal Conductance (Air): 900 ℓ/s
 Recommended Flow: 0.1 to 0.2 gpm

362-4 Cryotrap
 Nominal Conductance (Air): 1100 ℓ/s
 Reservoir Volume: 4.7 liters
 Liquid nitrogen required to fill and cool initially (approx): 7 liters
 Holding time for single liquid nitrogen charge (approx): 17 hours

1293S-4 Slide Valve
 Nominal Conductance (Air): 2450 ℓ/s
 Seal (nonscuff): O-ring (BunaN)

Speed curves based on standard AVS test procedures.

* Actual speed at foreline flange of diffusion pump.

ORDERING INFORMATION

Description	Model No.	Description	Model No.
M-4 Diffusion Pump		334 Low Profile Baffle	0334-F8286-304
Includes inlet O-ring and conduction-cooled cap		362-4 Cryotrap	0362-K2653-304
With 120 V heater	0187-F8265-301	1293S-4 Hand-Operated Slide Valve	1293-F1106-334
With 208 V heater	0187-F8265-306	1295S-4 Air-Operated Slide Valve	1295-F1315-334
With 240 V heater	0187-F8265-302		

HOW TO ORDER

Orders and requests for additional information should be addressed to the nearest Varian District Office or to Varian Associates, Lexington Vacuum Division, 121 Hartwell Ave., Lexington, Massachusetts 02173. Address European inquiries to nearest Varian District Office, to Varian GmbH, D-7000, Stuttgart-Vaihingen, Breitwiesenstrasse 9, West Germany, or to Varian SpA, Via Varian, 10040 Leini, Torino, Italy.

Specifications for StokesTM Series 1700 Mechanical Booster Pumps

The specifications on these pages, and the performance curves shown on the preceding page, cover the most popular standard models of our

Series 1700 Mechanical-Booster Vacuum Pumps. Our advisory service is available to help you custom-fit the right model for your application.

Specifications			HC and HCS Models provide for faster pumpdown capability.									
Model No.	1st Stage Blower Displacement Microvac [®] Pump		1736	1736-S	1721	1721-S	1722	1722-S	1722-HC	1722-HCS		
		cfm	612	850	1300	1600	1300	1600	1300	1600		
		m ³ /hr	1040	1444	2209	2719	2209	2718	2209	2718		
		cfm	150	150	150	150	300	300	600	600		
		m ³ /hr	255	255	255	255	510	510	1020	1020		
Normal Cut-in Pressure		Torr	25	10	15	10	25	15	75	60		
Pressure Limit for Continuous Operation		Torr	8	3	3	2	15	8	25	20		
Drive	1st Stage	hp	3	3	7½	10	7½	10	7½	10		
		kw	2.24	2.24	5.60	7.46	5.60	7.46	5.60	7.46		
	2nd Stage	hp	—	—	—	—	—	—	—	—		
		kw	—	—	—	—	—	—	—	—		
	Forepump	hp	7½	7½	7½	7½	10	10	two @ 10	two @ 10		
		kw	5.60	5.60	5.60	5.60	7.46	7.46	14.91 total	14.91 total		
Connections	Suction Flange	in.	6	6	8	8	8	8	8	8		
		mm	152	152	203	203	203	203	203	203		
	Discharge	in.	2 IPS	2 IPS	2 IPS	2 IPS	3 IPS	3 IPS	3 IPS (2)	3 IPS (2)		
		mm	—	—	—	—	—	—	—	—		
Water Requirements	1st Stage	gpm	Air Cooled									
		lpm	—	—	—	—	—	—	—	—		
	2nd Stage	gpm	—	—	—	—	—	—	—	—		
		lpm	—	—	—	—	—	—	—	—		
	Forepump	gpm	1½	1½	1	1	2	2	4	4		
lpm		5.68	5.68	3.785	3.785	7.57	7.57	15.14	15.14			
Oil Requirements	1st Stage	gal	1	1	.625	.625	.625	.625	.625	.625		
		liter	3.785	3.785	2.366	2.366	2.366	2.366	2.366	2.366		
	2nd Stage	gal	—	—	—	—	—	—	—	—		
		liter	—	—	—	—	—	—	—	—		
	Forepump	gal	3	3	3	3	12	12	24	24		
		liter	11.36	11.36	11.36	11.36	45.53	45.53	90.85	90.85		
Height	Overall	in.	47½	47½	49½	49½	56½	56½	56½	59½ ¹⁶		
		mm	1216	1216	1260	1260	1438	1438	1438	1513		
	To Inlet	in.	47½	47½	40¾	40¾	40¾	40¾	40¾	40¾		
		mm	1216	1216	1035	1035	1035	1035	1035	1035		
Length		in.	53½	53½	55½	55½	55½	55½	70	70		
		mm	1359	1359	1419	1419	1407	1407	1803	1778		
Width		in.	27¾	27¾	36¾ ¹⁶	36¾ ¹⁶	41¼	41¼	70½	70½		
		mm	705	705	919	919	1048	1048	1794	1794		
Weight	Net	lb	1775	1775	2700	2800	3500	3600	5300	5400		
		kg	805	805	1225	1270	1588	1633	2404	2450		

Electrical requirements: Full NEMA 12 controls supplied as standard on all models
460v/60Hz/3hp power with transformer and 115v control circuits are standard

Model 3106 The model 3106S is a double ended, horizontal turbo pump providing a speed of 400 l/s to an ultimate pressure in the 10^{-9} mbar range. This grease lubricated pump runs at only a few degrees above ambient temperature and requires coolant only for heavy gas load applications. This design of pump can easily handle deliberate or accidental exposures to atmosphere. The pump rotor is driven, via a gear, by an electric motor connected directly to a 208/230V, 50/60 Hz, 3 phase supply. The motor and gear are sealed

entirely within the vacuum system.

An alternative version, the 3106G, is available with an external belt drive for the pump rotor. This model is recommended where continuous high pressure operation is required. It is also recommended that the model 3106G be used with the 3132P refrigerator accessory.

The major application areas for the model 3106 are in sputtering systems, beam lines, thin film coating, semi-conductor production, etc.

Pump Dimensions

Dimensions in inches

Pumping Speed Curves

Model 3106D-01

The model 3106D-01 includes the 3106S turbo pump and the model 8851 direct drive forepump in a ready-to-run, mounted pumping package. The model 8851 forepump is fitted with an inlet isolation valve to protect the vacuum system in the event of power loss or similar failure.

INLET FLANGE 9" (228.6 mm) OD x 5.91 (150.1 mm) ID.
8 BOLT HOLES (0.69", 17.5 mm DIA.) EQUALLY
SPACED ON 7.5" (190.5 mm) DIA. BOLT CIRCLE.
O-RING (PARKER 2-258) 6.0" (152.4 mm) ID x
0.139" (3.5 mm) DIA.

M-4 DIFFUSION PUMP

O-RING (PARKER 2-258) 6.0" (152 mm) ID
x 0.139" (3.5 mm) DIA.

**334 LOW-PROFILE
WATER-COOLED BAFFLE**

**DIMENSIONS
INCHES
(MILLIMETERS)**

INLET FLANGE: 5.82" (148 mm) I.D. x 9.00" (229 mm) O.D. x
0.50" (13 mm) THICK (8) 0.75" (19 mm) SLOTS EQUISPACED
ON 7.50" (191 mm) B.C.

OUTLET FLANGE: 5.75" (146 mm) I.D. x
9.00 (229 mm) x .53" (14 mm) THK
(8) 5/8-11 TAP HOLES EQUISPACED ON
7.50" (191 mm) B.C.

362-4 CRYOTRAP

1293S-4 SLIDE VALVE

160 L/S TURBO PUMP

Model 3120 The model 3120 is a double ended, horizontal pump with three simultaneously useable inlets for convenience and ease of installation. The pump has grease lubrication requiring coolant only in heavy gas load applications.

The pump rotor is driven, via a gear, by an electric motor directly connected to a 3 phase power supply. This simple and rugged design provides a pump with 160 l/s pumping speed to the 10^{-7} mbar range. The motor and gear are

sealed entirely within the vacuum system.

An alternative version of this pump with an external belt drive system is available to special order. This model (3120G) is recommended when continuous operation at high pressures is required. The 3120G should also be used with the 3132P refrigerator accessory.

The major applications for the Model 3120 are in instrumentation, accelerators, vacuum deposition and thin films.

Pumping Speed Curves

Model 3120D-01 The model 3120D-01 pumping package includes the model 3120S turbo pump and the model 8821 direct drive forepump which is fitted with an isolation valve to protect the vacuum system in the event of power loss or similar failure.

Pump Dimensions

Dimensions in inches

D-Zero
Vacuum System
Pumping Speed
Calculations

Appendix - B

G. S. Ball

May 11, 1989

D0 Engineering Note 3740.000-EN-46B

Approved:

Introduction:

This report presents calculations performed in an effort to determine the pumping speed of the utility vacuum system leading to the cryostats. These calculations are based on both Edward's E2M275 pumps operating simultaneously in the pumping room with a pressure of 100.0 microns in the cryostat. At this pressure quite a bit of water may be desorbing from the modules and other surfaces, making pumping slow.

Assumptions:

The viscosity of air was assumed to be that of Nitrogen. Air was assumed to behave ideally for density calculations. The equations used are for viscous flow and are accurate for straight pipe to about 10% for flows where the product of the pipe diameter and the average pressure is greater than or equal to 500 micron-centimeters. The smallest flow diameter occurs in the two inch pipe (ID = 5.250 cm), and the pressure is 100.0 microns, resulting in a total of 525.0 micron-centimeters. Therefore, this condition is satisfied. The equivalent length ratios found on page one of the original report were used to determine equivalent pipe lengths. Since these equivalent lengths are those used in turbulent flow regimes, the calculations are good for "order of magnitude" approximations only.

Definitions of Variables:

C=pipe conductance
 D=pipe diameter
 L=total pipe length
 L_{eq}=equivalent pipe length
 L_o=actual pipe length

N=viscosity
 P=avg. pressure
 Q=pumping speed
 S=rated pump pumping speed

Properties of Air:

$$N_{N_2} = 1.747 \cdot 10^{-6} \text{ cp (at 290 K and 0.1 mm Hg)}$$

$$\text{let } N_{\text{air}} = N_{N_2}$$

$$N_{\text{air}} = 1.747 \cdot 10^{-6} \text{ cp (at 290 K and 0.1 mm Hg)}$$

Pipe Conductance, and Overall Pumping Speeds:

4" Pipe:

$$L_o = 222 \text{ ft.}$$

14 - elbows	100 ft.
3 - 45° elbow	16 ft.
1 - miter	22 ft.
<u>4 - tees</u>	<u>86 ft.</u>
	224 ft.

$$L_{eq} = 224 \text{ ft.}$$

$$L = L_o + L_{eq} = 446 \text{ ft.}$$

$$= 13600 \text{ cm}$$

$$\text{ID} = 4.260 \text{ in. (SCH 10)}$$

$$= 10.82 \text{ cm}$$

$$C = (\pi r^4 P_{avg}) / (8 N L) \quad (\text{ref. 1})$$

$$C_{\text{air}} = (3.00)(r^4/L)(P) \text{ [l/s]}$$

for:

$$N_{\text{air}} = 174.7 \cdot 10^{-6} \text{ poise}$$

r, L in cm

P in microns

$$C_{\text{air}} = (3.00)(856/13600)(100)$$

$$= 18.9 \text{ l/s}$$

2" Pipe:

ignore the 45° elbow and the gate valve

$$L_o = 24 \text{ ft.}$$

11 - elbows

39 ft.

2 - miter

21

3 - tees

32 ft.

92 ft.

$$L_{eq} = 92 \text{ ft.}$$

$$L = L_o + L_{eq} = 116 \text{ ft.}$$

$$= 3600 \text{ cm}$$

$$ID = 2.067 \text{ in (SCH 40)} = 5.250 \text{ cm}$$

$$C_{air} = (3.00)(47.5 / 3600)(100)$$

$$= 3.95 \text{ l/s}$$

Overall Conductance and Pumping Speed:

$$1/C_t = 1/C_1 + 1/C_2 + \dots \dots \dots \quad (\text{ref. 6})$$

$$1/C_t = 1/18.9 + 1/3.95$$

$$C_t = 3.26 \text{ l/s}$$

$$Q = (C \cdot S) / (C + S) \quad (\text{ref. 5})$$

$$S \text{ (for both pumps)} = 141 \text{ l/s}$$

$$Q = (3.26)(141) / (3.26 + 141)$$

$$= 3.18 \text{ l/s}$$

Conclusion:

The low pumping speeds predicted by these calculations are largely due to pipe effects. Under the current situation, using only one pump would not result in a significant change in the overall pumping speed. In order to increase the pumping speed the piping between the cryostat and the pump would have to be changed. Perhaps the simplest way to do this would be to use a utility pumping cart on the platform and pump the cryostats directly.

References

1. Dushman, Saul, Scientific Foundations of Vacuum Technique. (2 Ed.). John Wiley and Sons, 1962.
 2. Perry, Robert H., Chemical Engineer's Handbook (5th Ed.). Mc Graw Book Co., 1973. p. 3-210.
 3. Sonntag and Wylen, Fundamentals of Classical Thermodynamics. John Wiley and Sons, 1976. p. 645.
 4. O'Hanlon, John F., A User's Guide to Vacuum Technology. John Wiley and Sons. p. 356.
 5. Fitzpatrick, J. B., "CC Cryostat Vacuum Pumping Efficiency" D-Zero Engineering Note 3740.214-EN-117.
 6. Handbook Of Physics, Mc Graw Hill Book Co., 1958. pp. 5-78 - 5-82.
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FERMILAB ENGINEERING NOTE		SECTION	PROJECT	SERIAL-CATEGORY	PAGE
SUBJECT D-P 4" UTILITY VACUUM PLATFORM RW			NAME T. F. FARRER		
DATE 2 MAR 87			REVISION DATE

UNLESS NOTED ALL
 ELBOWS 90° LONG RAD.
 4" IPS SCH. 40

SIDEWALK TO 2" VLV VALVE

- 88'-4" PIPE (SCH 40)
- 8-90° L.R. ELBOWS
- 2-4" TEES
- 2-45° ELBOWS
- 1-90° MITER EL.
- 2" VLV VALVE

VALVE BOX

- 3'-2" PIPE
- 3-2" 90° L.R. ELBOWS
- 1-2" TEE (BRANCH TO BOX)

- ANNULAR SPACE PIPE
- 14'-2" PIPE (SCH 40)
 - 4 90° L.R. ELBOWS
 - 1-90° MITER

3'-2"-PIPE
3-2"-90°-LR. ELB.
1-TEE

29	1/2" LPT. HEAV PLUG	1
28	1/2" MS-25762	1
27	1/2" VALVE MOUNTING RING	1
26	1/2" VALVE MOUNTING RING	1
25	1/2" VALVE MOUNTING RING	2
24	1/2" VALVE MOUNTING RING	1
23	1/2" VALVE MOUNTING RING	1
22	1/2" VALVE MOUNTING RING	1
21	1/2" VALVE MOUNTING RING	1
20	1/2" VALVE MOUNTING RING	1
19	1/2" VALVE MOUNTING RING	1
18	1/2" VALVE MOUNTING RING	1
17	1/2" VALVE MOUNTING RING	1
16	1/2" VALVE MOUNTING RING	1
15	1/2" VALVE MOUNTING RING	1
14	1/2" VALVE MOUNTING RING	1
13	1/2" VALVE MOUNTING RING	1
12	1/2" VALVE MOUNTING RING	1
11	1/2" VALVE MOUNTING RING	1
10	1/2" VALVE MOUNTING RING	1
9	1/2" VALVE MOUNTING RING	1
8	1/2" VALVE MOUNTING RING	1
7	1/2" VALVE MOUNTING RING	1
6	1/2" VALVE MOUNTING RING	1
5	1/2" VALVE MOUNTING RING	1
4	1/2" VALVE MOUNTING RING	1
3	1/2" VALVE MOUNTING RING	1
2	1/2" VALVE MOUNTING RING	1
1	1/2" VALVE MOUNTING RING	1

REV	DESCRIPTION	DESIGN	DATE

SEE DETECTOR CO CRYOSTAT
4" UTILITY VACUUM SPACE

* FIELD FIT

* FIELD FIT

DESIGN SPECIFICATION		REVISIONS	
DATE	BY	DATE	BY
CHECKED		APPROVED	
USED ON		MATERIAL	
		304 SS.	
FERMI NATIONAL ACCELERATOR LABORATORY U.S. DEPARTMENT OF ENERGY			
DETECTOR CO CRYOSTAT 4" UTILITY VACUUM SPACE			
SCALE	FILMED	DRAWING NUMBER	REV
		3740.514-MB-229707	