MUON CRYOSYSTEM DESIGN NOTE 18

SUBSYSTEM: ☐ CCM ☐ CVM ☒ Cryoplant

TITLE: Helium Piping Between Lab A and New Muon

AUTHOR: R. Sanders

DATE: April 8, 1986

OBJECTIVE OF NOTE

To describe the design of the warm helium piping between Lab A and New Muon building.

SYSTEM DESCRIPTION

The piping between Lab A and the New Muon Laboratory consists of the 3" and 8" underground pipelines whose route is shown in Fig. 1. The pipes go underground at the south wall of the lower level of the New Muon Lab and run at least five feet below grade. The pipes emerge above ground outdoors several feet west of Lab B which is all that this design note covers. Before going into Lab A there will be a ASA 150 lb filter and 6" Posi seal shut off valve off the 8" line. The 3" line will terminate at an ASA 300 lb filter and ball valve.

A copy of the specification for the installation of the pipes is attached in Appendix I. The pipes are schedule 10 S and 316 L stainless steel. The 3" line delivers helium at 60^{O}F to 120^{O}F and 275 psig from the compressors at Lab A to the cryogenic system at New Muon building. the 8" line returns the helium gas back to the Lab A compressors, typically at 60^{O}F and 1 psig.

The pressure rating of the pipe has been calculated according to ANSI B31.3 piping code as sown in Appendix II-A of Muon Design Note 10 with S = 16700 psi for the 316 L stainless steel. The pressure rating of the 8" and 3" pipe are 458 psig and 916 psig respectively. The flanges on the 3" line are ASA 300 lb which are rated at 720 psig. The ASA 150 lb flanges on the 8" line are rated for 275 psig.

The pressure rating of the 3" line is 350 psig at 60^{O}F to 120^{O}F and is protected by relief valves on the compressor at Lab A. It has been pressure tested to 385 psig. The 8" line has a pressure rating of 45 psig and is protected by relief valve SV-204-H at the New Muon building. It has been pressure tested to 50 psig. A copy of the pressure test procedure is in Appendix II.

For the weight loads on the pipe consider the 8" pipe buried 5' below grade which is the worse case. The earthen load on the pipe is read from Table 1 as 830 lb per linear foot. Table 2 shows that 2.8% of a wheel load will be transmitted to a linear foot of the pipe. A 20000 lb wheel load would then exert 560 lb per linear foot for a total load of 1390 lb per linear foot including soil load. This translates into an average compressive pressure of 14.5 psi exerted on the 8" pipe. This is less than the 125.8 psi external pressure rating of the 8" pipe which was calculated in Appendix II-C of Muon Design Note 10 for 304 SS. The 316 L SS pipe has the same pressure rating. The pipe system will not be affected by external weight loads or internal vacuum.

CLEANUP

During installation some mud had gotten into the 8" helium return line and had to be removed after the piping was buried. During December 1985, the pipe was cleaned out by forcing polyurethane foam "pipeline pigs" through it using compressed nitrogen. Catalog information for the pigs supplied by Sweco is in Appendix III. A "pig launcher" was constructed and attached to the flange on the south wall of the New Muon building which consisted of an elbow and a straight length of pipe. On the receiving end over by Lab A a special flange was made up with a connection for a fire hose that ran to a drainage ditch. Figure 5 shows a sketch of the equipment.

Initially the pipeline was filled from the New Muon building with 3000 gallons of clean water supplied by a Fermilab Fire Department pumper truck. Several trips were required. This did not completely fill the pipeline. The pig, a rough-coat model was stuffed into the pig launcher and the top flange bolted down. Pressure was applied by using boiloff N_2 from a LN_2 trailer. The trailer pressure varied from 20 to 50 psig and the pipeline pressure varied from 0-5 psig. The water coming out of the fire hose at Lab A was only discolored. No lumps of mud were observed in the discharge. The first flushing took over one hour. This was repeated three to four times using about 800 gallons of water each time. The water came out clear and clean near the end.

The next step was to dry out the pipe. Four plain foam pigs were sent through the line taking about 15 minutes for a passage. The last several came out damp like a sponge with no slugs of water. Continuing the procedure would have been a time consuming process so boiloff nitrogen was used to complete the drying. The fire hose near Lab A was removed, the fitting capped and the flange loosened to permit nitrogen to bleed out. The nitrogen completely dried out the line even sublimating the ice that had formed above ground inside the outdoors outlet. During the entire cleaning operations about 8000 liters of LN_2 were used.

The pipeline was then blind flanged at both ends and a vacuum pulled on it. After an over 24 hour period the vacuum was essentially unchanged and it was concluded that the pipe was dried out. This was confirmed by shooting a plain pig through which came out dry.

REVIEWED BY

R L Schmitt 4/15/86

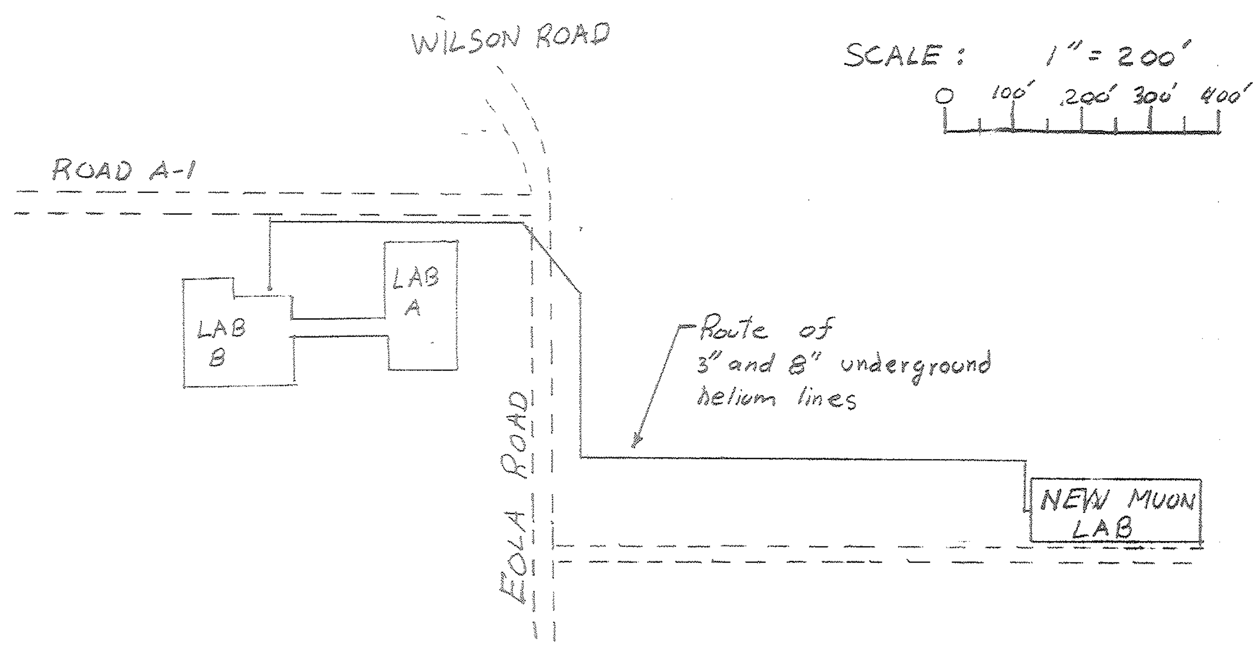


Figure 1. Pipeing Route. Extracted from Architectural Services Muon Laboratory Vicinity Plan and Drawing List, Drawing #8-2-76, C-2, Rev. 17.

Table 1. Dead load from earth cover on underground pipes.
Sabin Crocker Piping Handbook, 5th Edition, 21-31.

(Loads are shown in pounds per linear foot of pipe)

Depth of cover, ft	Nominal pipe diameter, in.																		
	3	4	6	8	10	12	15	18	21	24	27	30	33	36	39	42	48	54	60
2	145	180	240	290	340	390	450	500	560	610	700	750	820	875	940	1,000	1,140	1,280	1,380
3	220	270	370	460	550	630	750	860	950	1,040	1,120	1,200	1,300	1,400	1,480	1,580	1,740	1,970	2,080
4	300	370	520	650	780	920	1,080	1,230	1,400	1,520	1,630	1,750	1,850	2,000	2,100	2,220	2,500	2,730	2,980
5	380	470	660	830	1,000	1,160	1,420	1,610	1,810	2,010	2,200	2,340	2,500	2,630	2,800	2,950	3,250	3,600	3,820
6	460	570	800	1,000	1,200	1,430	1,710	2,000	2,230	2,500	2,700	2,950	3,180	3,350	3,500	3,650	4,030	4,420	4,700
7	540	670	950	1,180	1,420	1,700	2,050	2,400	2,700	3,050	3,300	3,570	3,900	4,100	4,300	4,440	4,900	5,450	5,780
8	620	780	1,080	1,370	1,620	1,960	2,400	2,780	3,200	3,550	3,900	4,200	4,500	4,800	5,050	5,300	5,900	6,430	6,880

These values apply to both rigid and flexible pipes buried in ditches or covered by embankment. They are based on maximum conditions of trench width and 120 lb/cu ft soil material, using the Marston formula, and should be used only as approximations. (See American Water Works Association Standard AWWA H1 for charts and tables based on full-scale tests for various conditions.)

Table 2. Percentage of wheel loads transmitted to underground pipes. Sabin Crocker Piping Handbook, 5th Edition, 21-32.

(Values show percentage of wheel load applied to one linear foot of pipe)

Depth of cover, ft	Nominal pipe diameter, in.																	
	3	4	6	8	10	12	15	18	21	24	27	30	33	36	39	42	48	54	60
1	15.2	18.6	25.6	30.0	34.6	40.0	45.2	49.6	52.8	54.4	56.0	57.2	58.0	58.8	59.6	59.7	60.0	60.3	60.6
2	7.0	8.5	11.4	14.0	16.6	19.2	23.0	26.4	30.0	31.2	33.6	35.6	37.4	39.0	40.0	40.9	42.6	43.6	44.6
3	3.5	4.0	5.8	7.2	8.6	10.4	12.8	15.0	17.2	18.6	20.4	22.2	23.6	25.0	25.8	26.0	26.6	28.0	29.4
4	2.0	2.4	3.4	4.2	5.0	6.2	7.8	9.2	10.6	11.6	13.0	14.4	15.8	17.0	17.6	17.7	18.0	19.7	21.4
5	1.4	1.8	2.4	2.8	3.4	4.2	5.2	6.2	7.2	7.8	8.8	9.8	10.6	11.6	12.2	12.4	12.7	14.0	15.3
6	0.9	1.2	1.6	2.0	2.2	2.8	3.6	4.2	5.0	5.6	6.2	7.0	7.6	8.4	8.6	8.8	9.3	10.7	12.0
7	0.3	0.5	1.0	1.4	1.6	2.0	2.6	3.2	3.8	4.2	4.6	5.2	5.8	6.4	6.5	6.6	6.7	7.7	8.7
8	0.2	0.4	0.8	1.0	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.6	5.0	5.1	5.3	6.0	6.7

The values include an impact factor of 2.0 and are based on "Underground Conduits—An Appraisal of Modern Research," M. G. Spangler, *ASCE Paper* 2337, 1947. The values apply to one vehicle with wheels at least 6 ft apart measured along the axle. The wheel load (as in the example) is ½ of the axle load. The wheel load may be on dual tires but is still considered one wheel. (See American Water Works Association Standard AWWA H1 for charts and tables based on full-scale tests for various conditions.)

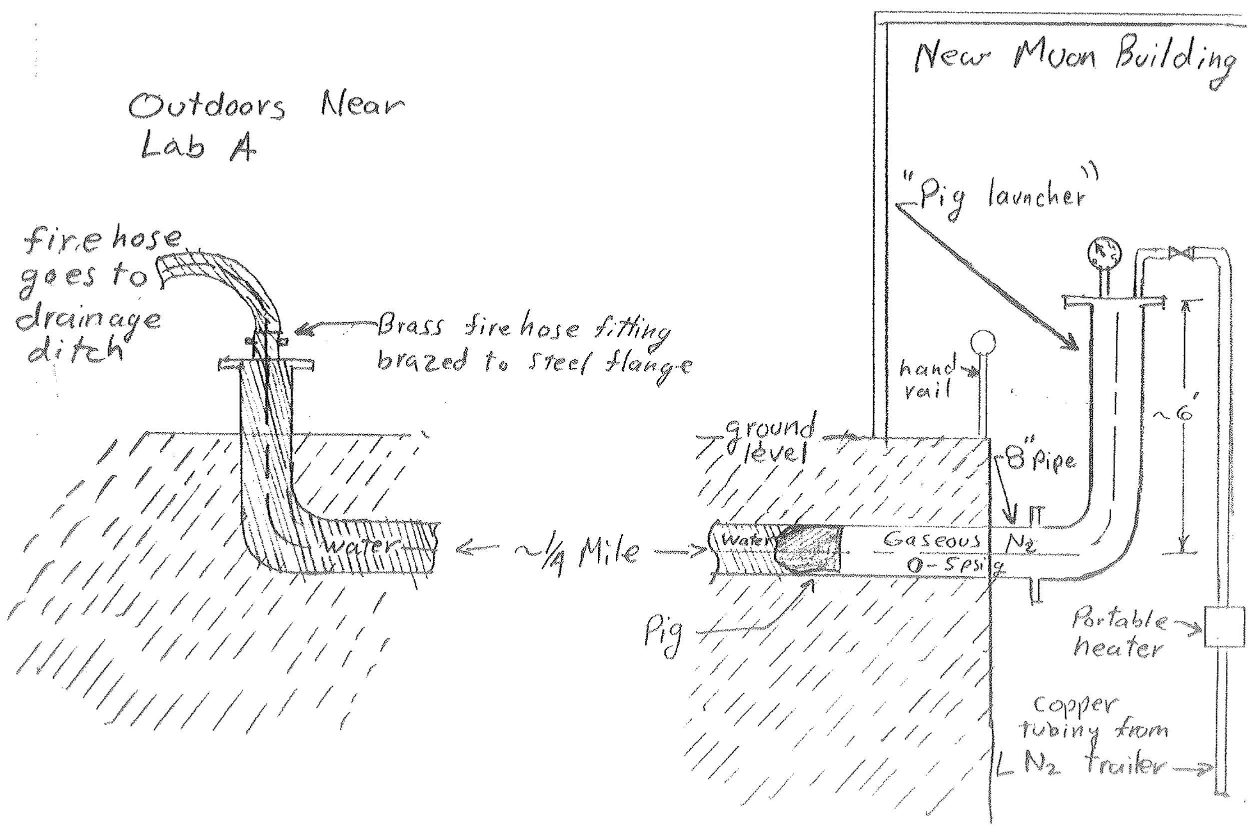


Figure 2. Equipment setup for pipe cleaning operations.

APPENDIX I

Specifications for Installation of Underground Piping

SECTION 2N

HELIUM DISTRIBUTION SYSTEM

PIPE FROM LAB B - MUON LAB

A. SCOPE

A. 01 INCLUDED: All labor, materials, transportation and equipment required for the completion of the Helium Distribution Piping System, exterior and below grade, as indicated.

A. 02 RELATED WORK SPECIFIED ELSEWHERE:

a. Section 2C, EXCAVATION AND BACKFILLING FOR UTILITIES.

b. Section 2D, SITE CONCRETE (Thrust Blocks).

c. Section 5D, MISCELLANEOUS METAL (Pipe Sleeves)

A. 03 RELATED WORK: Examine all Sections of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

B. CONDITIONS

B. 01 REFER to Section 1A, CONDITIONS, APPLICABLE STANDARDS AND MODIFICATIONS.

B. 02 IN ADDITION TO ALL OTHER STANDARDS that are applicable to the work of this Section as stated elsewhere in the Subcontract documents, the following standards and their specific subsections noted within this Section are hereby included and form a part of this specification.

a. American National Standards Institute (ANSI).

b. American Society for Testing Materials (ASTM).

C. MATERIALS

C. 01 MATERIAL REQUIREMENTS for the Helium Distribution System, exterior and underground, include but are not necessarily limited to the following:

a. Pipe:

1. Schedule 10S Type 316L welded seam, stainless steel per ASTM A-312, Grade TP 316L of sizes indicated on the drawings.

2. All piping shall be delivered to the job site with ends covered to exclude foreign material.

3. When the Subcontractor purchases straight lengths of pipe, he shall purchase this pipe to all the requirements of the ASTM Specification and the grade listed.

4. All pipe and fittings shall have ends beveled to $37.5^{\circ} \pm 2.5^{\circ}$ with a 3/64" $\pm$ 1/64" deep land per ANSI B16.9.

b. Fittings shall be of same material as pipe per paragraph C.01, a.1, with ends beveled per paragraph C.01, a.4, above, buttweld type per ASTM A403. Elbows shall be of long radius configuration.

c. Flanges shall be Class 300 for 3" pipe and Class 150 for 8" pipe forged Type 316L stainless steel, weldneck buttweld, raised face per ASTM A182, ANSI B16.5 with 316 stainless steel bolts and nuts per ASTM A193 and A194.

d. Gaskets shall be 1/16" thick asbestos composition such as Cranite or approved equivalent and coated with threaded lubricant before installation.

e. Joints at pipe to pipe and/or fittings shall be buttwelded.

C. 02 WELDING PROCEDURE FOR HELIUM DISTRIBUTION SYSTEM:

a. All welding shall be done in accordance with the procedure of the National Certified Pipe Welding Bureau, or other approved procedure conforming to the requirements of the ANSI B31.1 and ASME Boiler and Pressure Vessel Code Section IX for pressure piping. No welder shall be employed who has not fully qualified under the above codes and specified procedures.

b. Data sheets showing welding process and procedure for each class of work shall be submitted for approval.

c. Record forms of welder performance qualification tests for each welder employed shall be certified by independent third party laboratory for specific tasks, and submitted before starting of welding for each welding procedure.

d. Subcontractor shall assume all costs incidental to welder qualification tests.

e. Welding shall be Gas Tungsten Arc Welding (GTAW) for austenitic stainless steel utilizing 100% Argon shielding gas and gas backing.

f. Welds shall be visually inspected by the welder to insure freedom from weld discontinuities.

g. Welds shall be capable of compliance with the limitations on imperfections as specified in the Code for Visual Examination. Regardless of the class of inspection required, all accessible finished weld surfaces shall be visually examined for evidence of defects in accordance with Paragraph 3336.5 and Table 327.4.2 of ANSI B31.3.

h. Welds shall be considered acceptable in the absence of repetitive or injurious defects, which may be observable upon visual examination of pressure test per Paragraph f., above.

j. Butt end preparation and cleaning shall be done according to specification. Particular care shall be exercised in removing all foreign matter from inside the pipe before and after welding.

k. Where welding of joints has to be performed in the trench, clean cover (such as sheet metal) shall be placed between pipe and trench to ensure no contamination of dirt and other foreign materials to the pipe interior.

D. PREPARATION OF PIPE

D. 01 EACH individual pipe shall be cleaned inside with a clean rag over the entire length and blown clean and dry with compressed air. The pipe then shall be wiped inside over the entire length with a clean rag soaked in liquid freon for final cleaning.

D. 02 ALL PIPE shall be absolutely dry, clean, free of oily substance, or any other foreign matter before being installed.

D. 03 ALL PIPE shall be cleaned just prior to installation to avoid contamination.

E. PIPE ASSEMBLY AND INSTALLATION

E. 01 ORIENTATION AND SEQUENCE, route line, elevations and sizes of piping shall be as shown on the drawings. All pipe shall be kept clean inside by use of end caps and kept clear of debris and foreign matter at all times. The pipe shall be protected from damage prior to and during installation and backfilling of the excavation. Care shall be taken to avoid deformation and springing particularly where piping passes over or under other utilities.

E. 02 THE SUBCONTRACTOR shall have pumps available for dewatering the excavation throughout installation regardless of whether required due to precipitation or ground seepage.

E. 03 ALL PIPING shall be installed in the trench using normal procedure to install underground piping with the following exceptions:

a. Absolutely no chain, steel cables, or other sharp items may be used to lower the pipe in the trench. Use fabric slings.

b. Both ends must be taped closed while lowering piping in the trench.

c. Taped end on pipe shall be removed just prior to final alignment and welding; other end remains closed.

E. 04 DIPS under ditches and connections of elbows of pipes shall be fabricated above ground.

E. 05 IF WELDED JOINT must be placed under road, then welding shall be done above ground.

E. 06 THE TRENCH shall be left open at all welded joints to facilitate testing as described in Paragraph F.

E. 07 UNLESS OTHERWISE NOTED, specified, or approved, all pipe shall be joined by welding.

F. PRESSURE TEST

F. 01 BEFORE AN APPLICATION FOR FINAL ACCEPTANCE OF THE WORK will be considered, the pressure test specified to show proper execution of the work shall have been performed and completed in the presence of a Fermilab Field Engineer. Scheduling of testing procedures shall be pre-arranged with Fermilab.

a. All temporary piping, tapped flanges, compressors, nitrogen gas, gages, valves, and other pressure test equipment necessary to conduct leak tests shall be provided by the Subcontractor.

b. All tests shall be made before concealment of the work. Any leaks that may develop or imperfections that are detected shall be properly repaired or replaced (as determined by Fermilab) and the test shall be repeated until all work is proven sound and in perfect order.

c. Pressure medium shall be nitrogen gas.

d. Test pressure shall be 330 PSIG FOR HIGH PRESS, 3" LINE and shall be held at 330 PSIG for no less than 24 hours with no loss of pressure.

e. The nitrogen supply shall be disconnected during pressure test.

f. The Subcontractor shall supply to Fermilab a written report of the results of the tests showing the locations of identified leaks and method of repair.

g. Any repairs to be made to rectify any leakage in the piping shall be performed by the Subcontractor without any added cost to Fermilab.

h. In the event that leaks are found in the pipe itself other than at the joints welded by the Subcontractor, the section of pipe containing the leak shall be cut out and replaced. The cost of performing this work, including localizing the leak(s), shall be borne by the Subcontractor.

APPENDIX II

Procedure Used in Pressure Test

Fermilab

August 12, 1985

TO: DISTRIBUTION

FROM: R. L. SCHMITT

SUBJECT: PIPELINE TESTING

1. The two parallel pipelines between Lab A and the new Muon Lab have been pneumatically tested per ANSI B31.1. A record is attached.

2. The tested portion of each line is between the flange just inside the south wall of Muon Lab and the flange just above grade just west of Lab A.

RLS/bf

xc: R. Fast
H. Hart
J. Kilmer
B. Fowler
A. McInturff
R. P. Smith
R. Scherr

TEST DONE
8/8/85
R L Schmitt

Line Testing/Cleaning Procedure
R.L. Schmitt
July 3, 1985

1. Prior to the test evacuate the south half of Muon Lab and post a guard to prohibit entry.

2. Notify Lab A personnel when the pumper truck arrives. ✓ KILMER 2:30

3. Park the pumper truck beside road A. HOSE SHORTER THAN EXPECTED. PORTABLE H_2 DETECTOR USED PERIODICALLY IN THE AREA. NEARBY DOORS TO LAB A WERE CLOSED.

4. ~~Connect truck to 8" line~~.

5. Pressurize the line to about 10 psig. ✓

6. Bubble leak test the new weld joint in Muon Lab. ✓

7. Pressurize to 50 psig and hold for ten minutes. 7:55 – 8:05

8. Depressurize. ✓

9. Connect the truck to the 3" line. ✓

10. Pressurize to about 10 psig. ✓

11. Leak test the new weld joint. ✓

12. Pressurize to 100 psig and hold five minutes. 5:15 – 5:20

13. Pressurize to 200 psig and hold five minutes. 5:22 – 5:27

14. Pressurize to 300 psig and hold five minutes. 5:29 5:35

15. Pressurize to 385 psig and hold ten minutes. 5:37 5:47

16. Depressurize. ✓

17. Connect the return hose at Muon Lab end. ✓

18. Blow out line at full capacity until 42000 SCF is used. ✓

19. Reinstall blind flanges.

25000 SCF BLOWN THROUGH PIPES

APPENDIX III

Catalog Information for Pigs

SWEEGEE

FOAMED PLASTIC PIPELINE PIGS

SAFE

NO METAL PARTS

LIGHT WEIGHT

EASY TO HANDLE

ECO-NOMICAL

SWECO INC. P. O. BOX 15181 / 7320 TEXARKANA / HOUSTON, TEXAS 77020
PHONE 713/674-8484

FEATURES

1. No metal parts
2. Light weight
3. Economical
4. Efficient

OTHER FEATURES

This Pig called the "SWEEGEE" was primarily designed for removal of water and air from pipe lines after hydrostatic testing. It has since been proven in use to perform virtually all functions of the conventional flexible cup type Pig. The cost of a Sweegee of a given size is often less than the cost of replacing one cup on a conventional Pig of the same size. It can be considered an expendable item.

This Pig will easily pass through short radius 90 degree or even 180 degree turns with full surface contact. It will also pass through pipe lines of reduced diameters, gate valves, plug valves, check valves and other restrictions.

The Sweegees are cut in one piece from large buns of Polyurethane foam of the highest quality. The older method of molding the foam has been abandoned.

USES

For open end pigging, pig traps are not necessary as the light weight Pig will not be damaged by low pressure ejection into the atmosphere at the end of the line.

Due to the open cell construction of Sweegees, it has a high capacity to pick up and carry fluid or moisture from a line. These Pigs are compatible with crude oil, natural gas and their common by products. However, they will react with chlorinated hydrocarbons and some solvents of a certain group.

The Sweegee has proven to be highly successful in the removal of *paraffin* from pipe lines. In this application there are certain procedures which must be carefully followed. Information concerning these procedures will be furnished upon request.

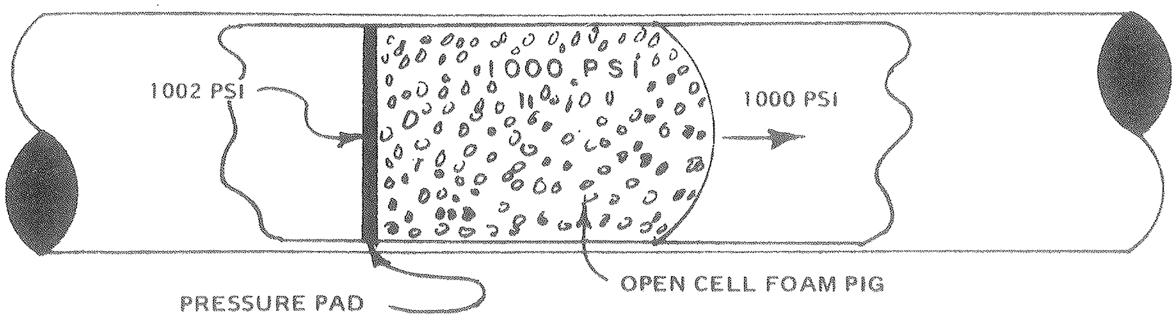
TYPES MANUFACTURED

There are three types of Sweegees being manufactured. First, and the most widely used is the PLAIN foam with a synthetic rubber pressure back. It is primarily used for drying out pipe lines, removal of rust, mill scale, and for cleaning inter-plant lines in refineries and chemical plants. It is also used extensively for Product Separation in these plants where the runs are relatively short.

The second type is the PLAIN foam type but with the nose section heavily coated with Estane. This coating material is a Polyurethane product developed by one of the major chemical companies. It is compatible with the Polyurethane foam used in Sweegees. It's most important feature is it's great resistance to wear and abrasion making it superior to any material available for this service.

The third type has a coated nose and lightly saturated body. It is especially effective when used in old pipe lines where rough interior surfaces and large quantities of rust and other debris are encountered. In addition to the regular sizes, this type is made in extra long lengths with one inch added to the diameter. This type is used for batch separation where the runs exceed one hundred miles. They also efficiently clean long runs of old pipe. The coated Pigs do not require the use of pressure backs.

SWECO FOAMED PLASTIC PIG (SWEEGEE)



Sweco Foamed Plastic Pigs are made by molding polyurethane into a homogenous open cell foamed mass. After heat curing, a pressure pad is attached to the back to prevent the pressure differential from migrating through the length of the pig.

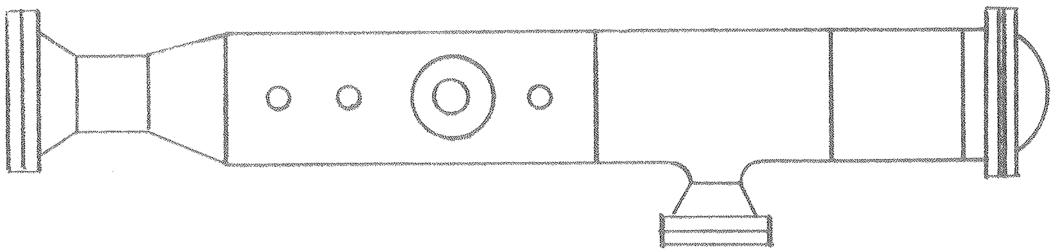
Due to the open cell structure of this pig, there is no tendency for it to collapse when subjected to high external pressures. A similarity would be natural gas in a limestone or sand structure.

The light weight of this pig (2–4 #/cu. ft., a 20" pig weighs only 15#) permits it to be propelled through a pipeline with a minimum of pressure drop, 1–2 PSI differential being the average.

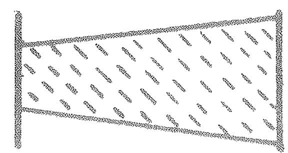
Illustrated above is a view showing the pig being propelled by gas through a pipeline pushing a head of water in front of the pig. You will note that the pig is not mashed and shorted by the head of water. This is due to the fact that the water permeates the sponge and the pressure immediately ahead of the pig is the same as the pressure inside of the pig. The pressure differential between the backside of the pressure pad and the inside of the pressure pad varies with the pig velocity. The length of the pig does grow shorter dur to the frictional forces between the pipe ID and the pig OD. of the pipe.

If the pig strikes a restriction in the line, it flows through the reduced opening much the same way as rubber flows in a rubber molding process.

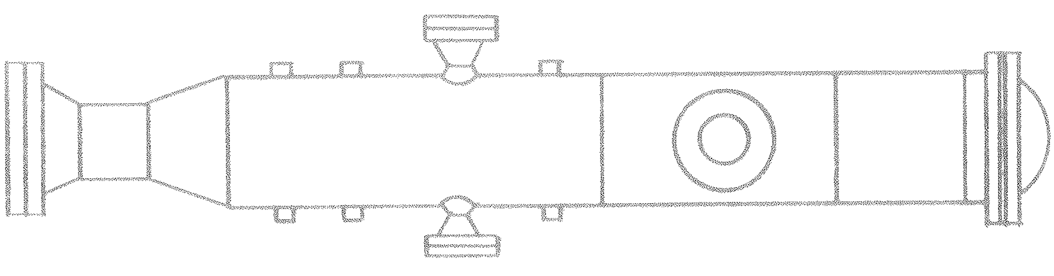
Due to the open cell construction, it has a high capacity to pick up and carry water or condensate from a line. The open cells will also pick up sand and rust not only on the surface, but throughout the body as the pig has a tendency to pulsate as it travels along the line striking the stringer beads at each joint of pipe.



PLAN VIEW



SWECO TYPE BASKET



ELEVATION

SCRAPER TRAP (RECEIVER/LAUNCH)