Static Electric Pinholing Through Polyethylene Pipe

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INTRODUCTION

Static electricity pinholing occurs when dust or dirt particles are present in the gas stream and a high volume of flow exists through a restriction.

Prime examples are: broken lines, flow control through a squeeze off zone, close proximity of tube turns, saddle fittings near a break, etc. These circumstances create a sufficient static charge to build on the inside of the pipe, which can exceed the dielectric strength of the plastic pipe. When this occurs, the discharge can cause a pinhole through the pipe wall.

Thus far, our investigation indicates that prevention is the best solution in preventing electrostatic pinhole damage:

- Keep pipe end caps in place at all times before fusion takes place.
- Pig pipe sections, as needed.
- Purge new piping systems with a reusable steel purging fitting.
- Purge existing dead ends before tying on a new piping system.
- Vacuum new piping systems to eliminate the need to purge.

In August of 1984, our first field failure by a static electric discharge was brought to our attention. A contractor crew installing a 1¼ inch medium-density polyethylene line was in the process of filling and purging a new piping system. Controlling the flow of natural gas was done through a squeeze-off unit. It was during this process that a cracking or popping sound was heard in the vicinity of the squeeze-off or flow-control area. Inspection of the section of pipe revealed a small leak on the edge of the squeeze cheek area. A brittle squeeze failure was first diagnosed, which was later dismissed.

Closer examination of the failure revealed some small black dots (pinholes) that were leaking. Not fully understanding what had happened, our soaping of squeeze-off areas was emphasized. Field personnel were asked to look consciously for this pinholing leak. These efforts resulted in six pinholing squeeze-off failures reported in a two-week period, all of which were determined to be caused by static pinhole discharge. See Figures 1, 2, 3, and 4.

Only three known static pinholing discharges had been reported throughout the gas industry at this time. Evidence again had shown that a static charge had developed on the inside wall of the plastic pipe in sufficient voltage to cause a pinhole discharge. During this time frame, samples of pinhole discharge were sent to our pipe manufacturers for evaluation and verification. The results and information received are

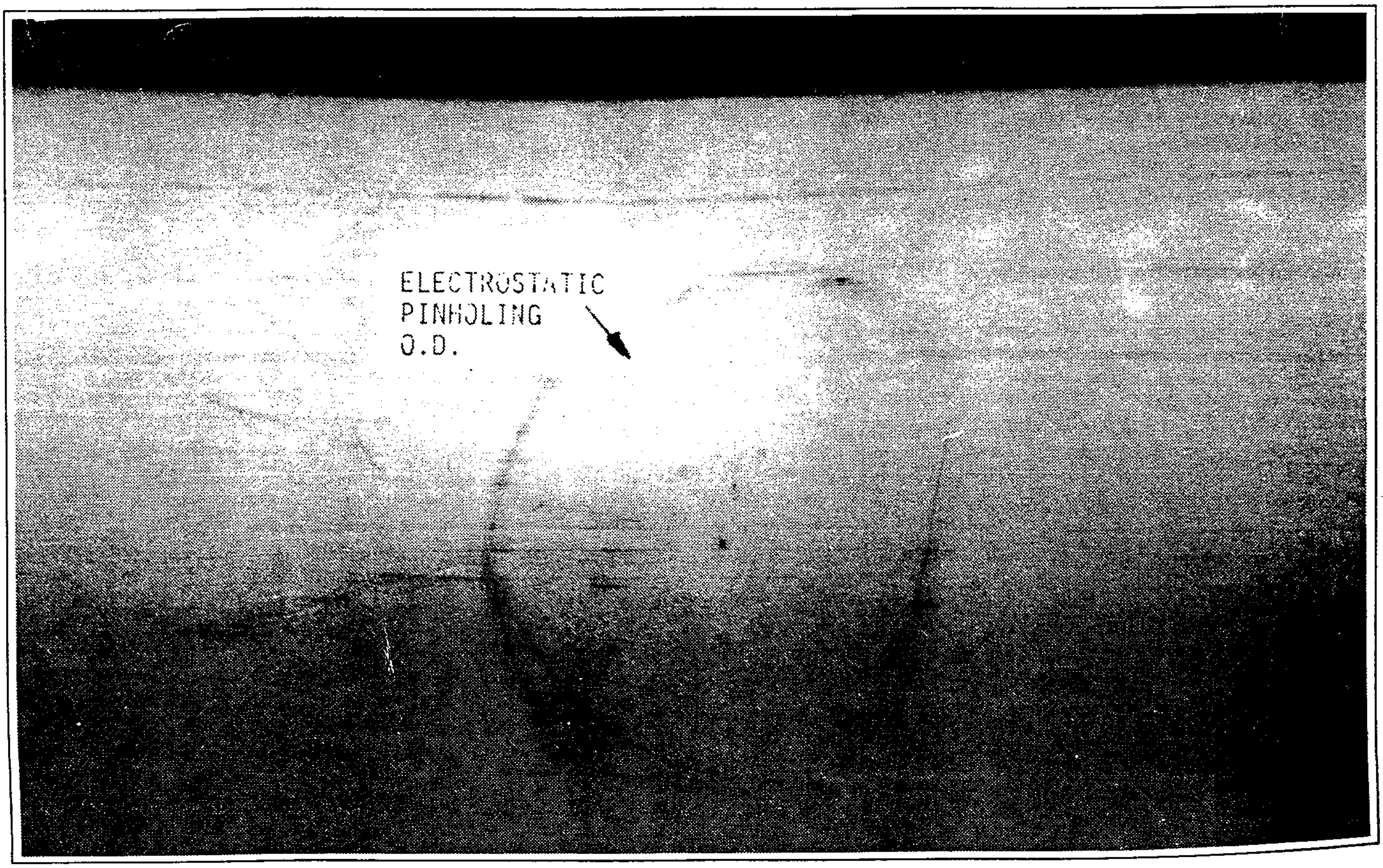


Figure 1. This 2″ I.P.S. electrostatic pinhole occurred when purging a new piping system.

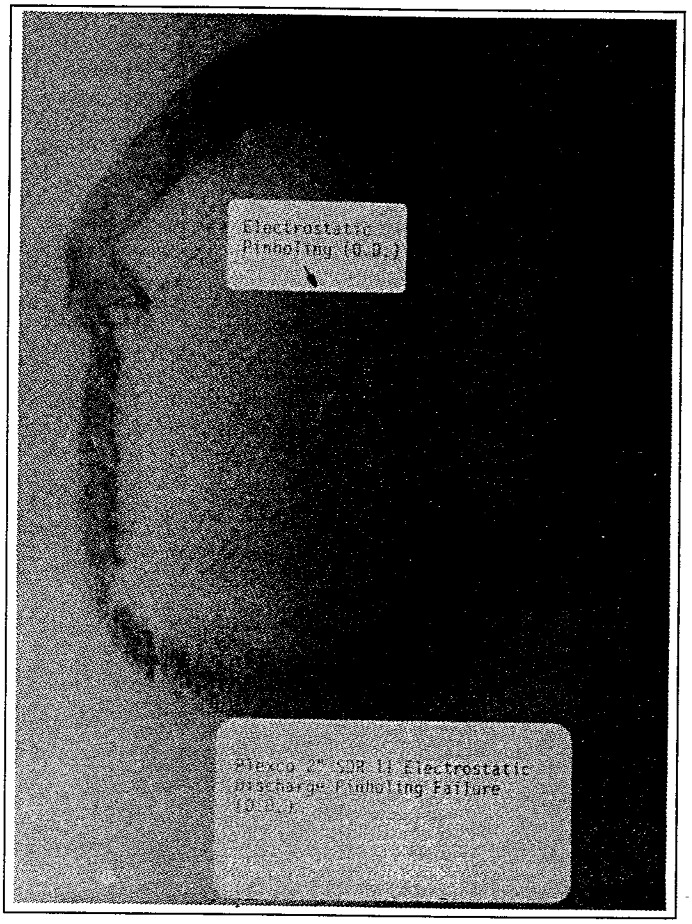


Figure 2. This 2″ electrostatic pinhole occurred while filling a new piping system with natural gas.

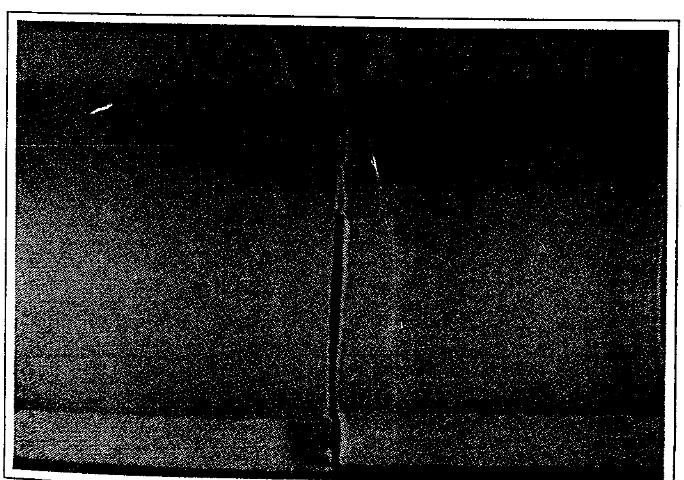


Figure 3. This 1¼″ I.P.S. electrostatic pinhole failure occurred during a squeeze off and purging operation. This sample would be similar to the failure analysis report given to Mountain Fuel by the Dupont Company.

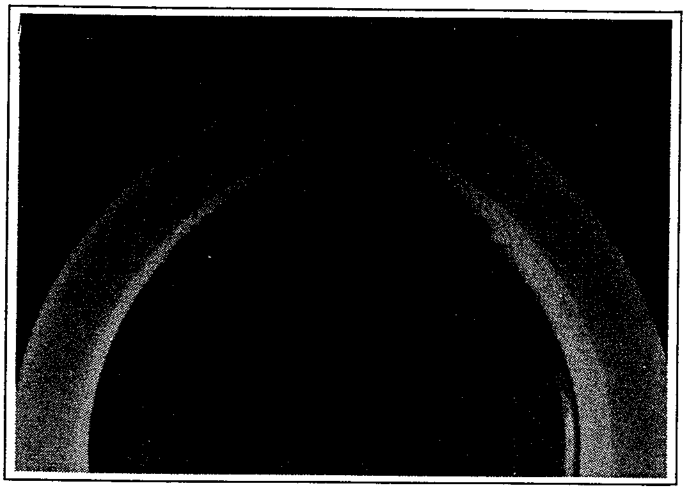


Figure 4. This 2″ I.P.S. electrostatic pinhole failure occurred during the filling of a new main extension with natural gas.

presented in Figure 5. To date 38 such failures have been received and reported. Only two failures were reported in 1988.

The static discharges have happened in various ways. The majority of occurrences have taken place when a squeeze-off unit was being used to control the flow of gas. Purging or filling of new piping systems accounted for approximately 90 percent of our failures. Discharges have occurred in a variety of sizes and manufacturers of pipe – ½-inch C.T.S. through 4-inch I.P.S. pipe with S.D.R. ranges of 10.0 to 11.5.

Other pinhole discharges have occurred in multi saddles when a third party has broken a service line. The restriction in the multi saddle was enough to cause a sufficient charge to build up, which discharged directly through the multi-saddle fitting. We have had similar occurrences in a ¾-inch inline tee. Some third party damages have also resulted in the same pinholing.

One of the more rare reported occurrences happened when a two-inch plastic line was broken with a double ell arrangement not far from the line break. With the high volume flow, dirt particles present, and a flow restriction with the double ell configuration, enough static electricity built up to exit through one of the ells.

In our early stages of investigation and testing, some equipment that produced a static charge under controlled conditions was constructed and used. It consisted of a hopper that was full of fine sand, a series of valves that connected the hopper to a line that had a high flow of gas, and a discharge that vented the gas flow to the atmosphere. Squeeze-offs were made along the length of pipe during this rapid-flow situation. Throttling through the squeeze units was also performed. These two procedures produced many discharges but not consistently enough to predict when they would occur.

An example of this occurred while we were setting up for a demonstration for our company management supervisors. A test run in which static discharges occurred frequently was performed. When it came time to demonstrate the static discharge assembly, a cloud moved over the test area. No static charges could be produced at all. This led to thinking that humidity might be a significant factor. This thought continued until we received a 4-inch static discharge field failure a few weeks later that occurred during a rain storm. Since that time we have had reported discharges in every type of weather condition. So the only predictable thing about a static discharge is that it is unpredictable.

Additional testing was performed by use of a closed loop and a blower from a vacuum to generate the needed static build up. Static pinholes were created and evaluations were done in hopes of again finding a solution.

Utilizing this closed loop, an attempt was made to record a static discharge on video tape. A discharge focal point was set up to record this effort, but we could not get a discharge recorded at that time – all static activity simply stopped. While changing the configuration of the test loop, a hacksaw was used to cut into the pipe. As the hacksaw

FAILURE ANALYSIS FOR MOUNTAIN FUEL SUPPLY COMPANY
PINHOLE LEAKS IN 1 1/4" SDR 10 ALDYL PIPE

<u>BACKGROUND</u>

Mountain Fuel Supply submitted to DuPont an 8" long sample of 1 1/4" SDR 10 ALDYL "A" pipe, lot number T0308U24, for failure analysis. The pipe was installed in 1984 and operated at a pressure of 45 psig. After being squeezed-off, the pipe leaked through serveral pinholes (black spots) on the O.D. of the pipe.

<u>ANALYSIS</u>

The first step in determining the cause of this failure was to analyze physical properties of the pipe. Normally, melt index and density checks are performed to assure that the pipe is within specification. In this case, the melt index was 1.12 g/10 min. and the density was 0.942 g/cc. The specifications for ALDYL "A" polyethylene pipe are melt index .9 - 1.5 g/10 min. and density 0.940 - 0.948 g/cc. From these tests we can conclude that the pipe was in specification.

There have been three failures reported to DuPont that have been classified as electrostatic discharge pinholing failures. These failures have been photographed and studied very thoroughly. The physical characteristics of this failure were compared to past electrostatic discharge pinholing failures and serveral similarities were found. For example, two occurred during the squeeze-off O.D. and I.D. of the pipe. Since this failure has all the characteristics of past electrostatic discharge pinholing failures, it is believed that is is also an electrostatic discharge failure.

<u>DISCUSSION</u>

Normally there are no problems with electrostatic discharge when squeezing-off ALDYL pipe. There have only been three cases reported in the 20 years we have been manufacturing ALDYL pipe.

The pinhole leaks occur when an electrostatic voltage develops inside the pipe which exceeds the dielectric strength of the pipe. Polyethylene pipe has a dielectric strength of 4.06 x 10 V/in. Since 1 1/4" SDR 10 ALDYL "A" pipe has a wall thickness of .166 inches, it would take 67,400 volts before discharging would occur. In Medium Density Polyethylene Gas Piping Systems electrostatic voltages, under unusual circumstances, have been measured as high as 70,000 volts. Therefore, under certain conditions, electrostatic discharge can occur in polyethylene pipe which create pinhole leaks.

It is important to recognize that electrostatic discharging will only occur under certain conditions. During squeeze-off, the flow restriction drastically coupled with particles in the gas stream are what generate the excessive electrostatic voltage on the bore of the pipe. Only under these conditions will the electrostatic voltage exceed the dielectric strength of the pipe and result in a discharge through the pipe wall to the grounded squeeze-off tool.

<u>CONCLUSIONS</u>

Based on our analysis we can conclude that:

1 1/4" SDR 10 ALDYL "A" pipe (lot #T0308U24) was within specification.

Failure of this pipe specimen during squeeze-off was due to electrostatic discharge through the pipe wall as evidenced by the black spots on the I.D. and O.D. of the pipe and by the abraded inside surface.

Electrostatic voltage greater than 67,400 volts must have been generated inside the pipe due to very high gas velocity (flow restriction during squeeze-off) and a high level of particles.

Installation guidelines for Mountain Fuel Supply to consider for prevention of future electrostatic discharge failures during squeeze-off are:

Eliminate/reduce particles in the gas stream.

Isolate (do not ground) the squeeze-off tool.

Figure 5. Manufacturer's analysis of pinhole damage.

reached the inside of the pipe wall, a spark and cracking sound of a discharge was heard. This type of static discharge was recorded on video tape—see Figure 6. After experiencing this discharge, several more cuts were made in the pipe at various intervals. Small discharges were found in virtually every hacksaw cut. Some cuts were within three inches of another cut. The conclusion of this test is that a static charge that develops on the inside of the pipe does not dissipate very rapidly. We have been able to determine that a static charge can remain on the pipe wall for as many as twelve hours.

To this date, through our limited testing, no permanent solution has been found to control internal static discharge. Prevention then became our best solution. Here is a list of procedures that can help to prevent a static pinhole discharge.

Protective shipping end caps should remain on the pipe at all times that the pipe is not actually being worked on. Receiving inspection should ensure that the end caps are in place. The only time the end caps should be removed is when fusion is going to take place. This will help ensure that construction dust and dirt does not collect in the plastic piping system. See Figure 7.

Pigging pipe sections or lengths should be required when end caps are missing or in any other case when it is deemed necessary in the judgment of the crew foreman or company inspector. See Figure 8.

When purging new piping systems, a reusable steel (riser type) purge fitting properly grounded could be used to dissipate any charges that may develop during this process. Flow control of the purging operation could also be accomplished with this fitting.

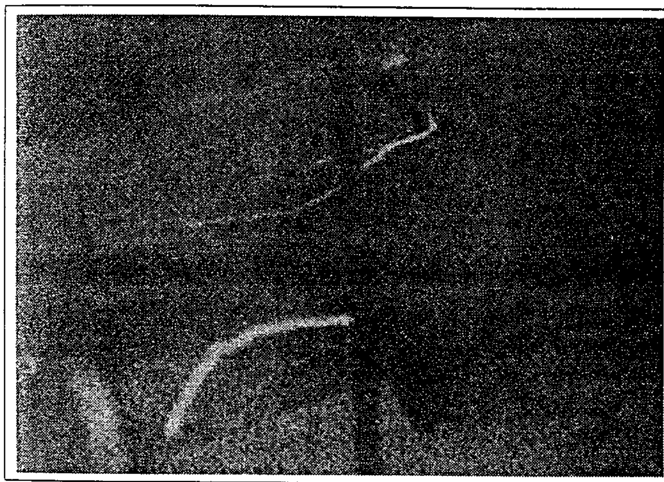


Figure 6. This static spark occurred while in the process of cutting into the pipe with a hacksaw. A static charge had been given to this test system approximately 15 minutes earlier.

Figure 7. End caps in place until fusion is to begin.

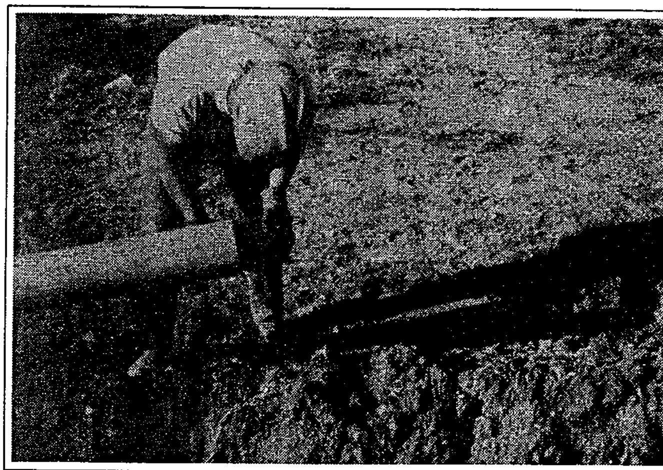


Figure 8. Pig the pipe whenever end caps are missing or doubt as to cleanliness exists.

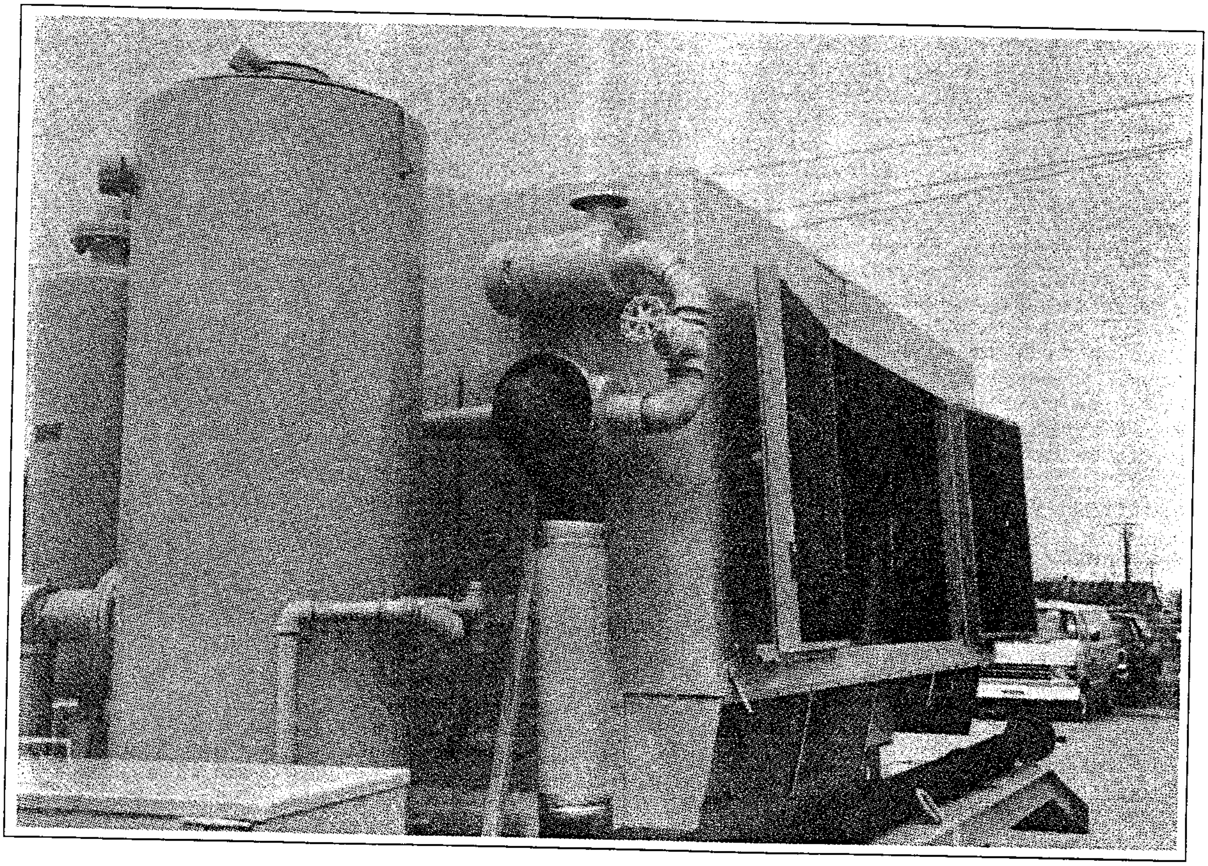
Purging dust particles from existing dead ends should take place before the new piping system is connected. This would help eliminate any dust particles from entering the new piping system, thus reducing the chances of a static pinhole discharge. The steel reusable purge fitting could be used to accomplish this procedure. See Figure 9.

Use of the vacuum method eliminates the need to purge new piping systems. This in turn reduces the chances of a static discharge from occurring. The objective of the vacuum system is to remove as much air from the piping systems as possible. When this vacuum set point is achieved, natural gas would then be released into the piping system filling the vacuum. This process not only reduces the chance of a static discharge, it also replaces the costly need for purging each dead end and the associated waste of natural gas. This vacuum process can be accomplished in two ways.

1. Use a vacuum pumping engine assembly capable of removing the desired amount of air for a given elevation. See Figure 10.
2. Use a series of air injections with an air compressor to create a venturi type vacuum, which would produce the same results. See Figure 11.

In conclusion, static electric pinholing is a part of working with the polyethylene piping system. The problems it has created to this point are not very serious. But we should not choose to ignore the potential

Figure 9. Use a steel reusable purge fitting to purge dust particles from existing dead ends before connecting new pipe.



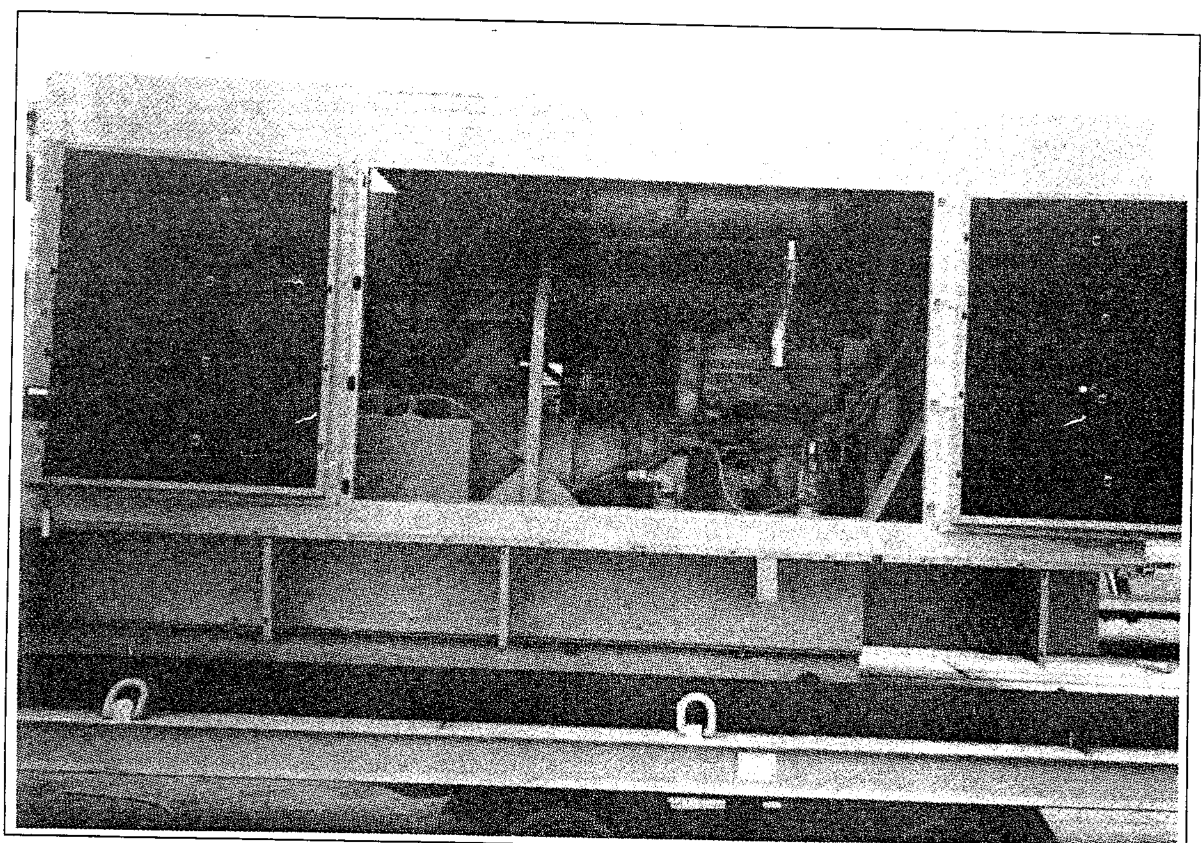


Figure 10. The Sullair rotary screw vacuum system. It will pull 8 to 3 millimeters HG. ABS at sea level.

problem simply because it hasn't happened within our own company, nor should we ignore the possibility that it has happened in our own company. When static pinholing occurs, long-term performance of our plastic systems may be affected. We know that a hole in the pipe is created and a small leak results from the electric pinholing discharge. If the pipe then is put into service without the fault's being detected, the systems have been compromised. Additionally, a potential source of ignition from the static pinholing spark is a reality. When we have to react to unusual problems, it consumes considerable time and resources, so prevention is always the preferred step. Our reaction to static electric pinholing should not be different.

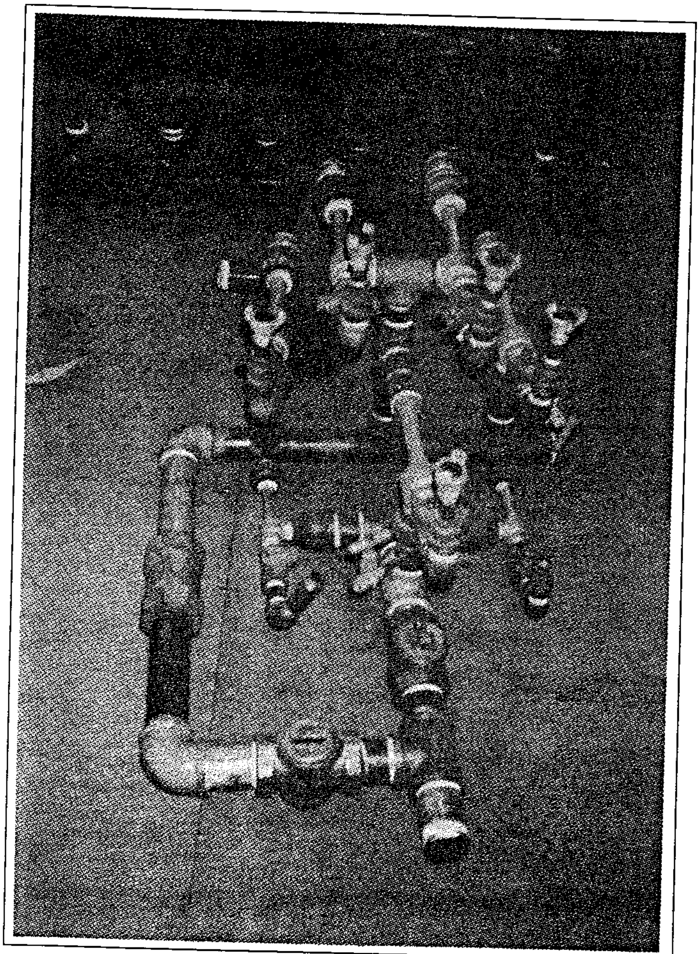


Figure 11. Use of a series of air injections to create a venturi type of vacuum.