Venting...

System Design for Pneumatic Fill!
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SAFE-Surge™ Technology
Poly Processing Company

Emergency Air Surge Protection
For
Polyethylene Storage Tanks
Assumptions:

- Proper design compensates for air surge
- Vent capacity $\geq$ ACFM at line purge
- Adequate venting mitigates fitting leaks and increases tank life
Critical Issue . . . ACFM!

- Tanker Discharge Hose Size
- Tank Inlet Pipe Size
- Tank Vent Size

Plan for 30 p.s.i. at line purge!
Helping Our Customers . . .

✓ Solve Problems
  • Venting design deficiencies for pneumatic filling

✓ Manage Risk
  • ACFM at line purge (AIR CUBIC FEET PER MINUTE)

✓ Enhance Your Profits
  • Continuous Operation
In-Use Customer Values

✓ Increased Safety Margin
✓ Increased Tank Life
✓ Peace of Mind
### Venting Requirements For Polyethylene Tanks

#### Pneumatic Fill

<table>
<thead>
<tr>
<th>Condition</th>
<th>Venting Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF - Vent length ≤ 3 feet</td>
<td>AND - Vent screen mesh size ≥ 1/4” or no screen used</td>
</tr>
<tr>
<td>IF - Vent length &gt; 3’ and ≤ 30’</td>
<td>AND - 3 or less 90° elbows with no other restrictions or reduction in pipe size</td>
</tr>
<tr>
<td>IF - Scrubber Application</td>
<td>Pipe from vent to scrubber CANNOT be reduced!</td>
</tr>
<tr>
<td> </td>
<td> </td>
</tr>
</tbody>
</table>

**For Emergency Pressure Relief Cover Required**
- Perforated dispersion pipe must be same diameter or larger, as vent. Sum of perforations ≥ cross sectional area of pipe
- Centerline of dispersion pipe not to be submersed > 6 inches

<table>
<thead>
<tr>
<th>Discharge Hose Size</th>
<th>Inlet/Fitting Size</th>
<th>Minimum Vent Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
<td>2”</td>
<td>4”</td>
</tr>
<tr>
<td>3”</td>
<td>2”</td>
<td>6”</td>
</tr>
<tr>
<td>3”</td>
<td>3”</td>
<td>6”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discharge Hose Size</th>
<th>Inlet/Fitting Size</th>
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</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
<td>2”</td>
<td>6”</td>
</tr>
<tr>
<td>3”</td>
<td>3”</td>
<td>8”</td>
</tr>
<tr>
<td>3”</td>
<td>3”</td>
<td>10”</td>
</tr>
</tbody>
</table>

**Discharge Hose Size**
- Inlet/Fitting Size
- Minimum Vent Size
Helping Our Customers . . .

✓ Solve Problems
• Proper design compensates for pneumatic filling

✓ Manage Risk
• Vent capacity ≥ ACFM at line purge

✓ Enhance Your Profits
• Continuous Operation
SAFE-Surge™ Technology

Emergency Air Surge Protection for Polyethylene Chemical Tanks

✓ Designed for Pneumatic-Fill
✓ Adequate ACFM Consideration (air cubic feet per minute)
✓ Increased Tank Life
✓ Increased Margin of Safety

Prepare for the Unexpected!

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Providing Solutions Through Innovation
www.polyprocessing.com

1-866-590-6845

Rev. 1/2006
Poly Processing Company commissioned an engineering consulting firm to determine the proper venting requirements necessary for polyethylene storage tanks. Two methods of filling were considered, 1) mechanical pumping and 2) compressed air (pneumatic) from tanker trucks.

Filling by Mechanical Pump
Using mechanical pumps to fill your tank is a low impact process and typically does not cause excessive pressure to be placed upon the tank.

- \( \leq 1000 \text{ gallons} \) – vent size should equal the size of the largest fill or discharge fitting
- \( > 1000 \text{ gallons} \) - vent size should exceed the largest fill or discharge fitting by one-inch.

Pneumatic Filling
The engineering study reviewed the pneumatic filling of a polyethylene storage tank for three common venting scenarios:

1. Short Vent (u-vent)
2. Long Vent (vented through the roof or into a common venting system)
3. Scrubber Vent (used where fume scrubbing is critical)

The following criteria were established for all three venting scenarios:

1. Maximum pressure used to unload tanker trailer was 30 psig.
2. Evaluate tanker hose impact; 1", 2" & 3".
3. Evaluate fill-line/fitting size impact; 1", 2" & 3".
4. Polyethylene tank internal pressure must not exceed 10" water column per ASTM D1998 section 1.1.3.

General Conclusions

1. Tanker trailer, once emptied of liquid, becomes large reservoir of compressed air at 30 psig.
2. Size of delivery hose from trailer to tank, 1 to 3 inches in diameter, impacts the volume of air delivered to the tank during line purge.
3. Size of fill line / fitting of the tank, 1 to 3 inches in diameter, impacts the volume of air delivered to the tank during line purge.
4. Vent size 2 inches larger than the fill assembly is sufficient to handle the delivery of the liquid product, but may not handle the volume of air released from the tanker trailer based on conclusions #2 and #3.

5. **Venting capacity must equal or exceed** Air Cubic Feet per Minute (ACFM) **coming from tanker truck for adequate margin of safety and increased tank life!**
Pneumatic Fill Scenario #1

**Short Vent**

- Vent length ≤ 3’
- Mesh size on bug screen ≥ ¼” or no screen
- Weighted hinged manway not required

<table>
<thead>
<tr>
<th>Hose</th>
<th>Inlet Pipe</th>
<th>Inlet Flow / ACFM</th>
<th>Min. Vent Size</th>
<th>Vent Flow / ACFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td>1”</td>
<td>1”</td>
<td>3”</td>
<td>600</td>
</tr>
<tr>
<td>B)</td>
<td>2”</td>
<td>1”</td>
<td>3”</td>
<td>600</td>
</tr>
<tr>
<td>C)</td>
<td>2”</td>
<td>2”</td>
<td>4”</td>
<td>1050</td>
</tr>
<tr>
<td>D)</td>
<td>3”</td>
<td>2”</td>
<td>6”</td>
<td>2500</td>
</tr>
<tr>
<td>E)</td>
<td>3”</td>
<td>3”</td>
<td>6”</td>
<td>2500</td>
</tr>
</tbody>
</table>

ACFM = air cubic feet per minute
Pneumatic Fill Scenario #2

**Long Vent**

- Vent length > 3’ and ≤ 30’
- Three or less 90° elbows and no other restrictions, i.e. smaller diameter pipe
- Weighted hinged manway not required

![Diagram of tank and vent system](image)

**Tank Vent Requirements**

<table>
<thead>
<tr>
<th>Hose</th>
<th>Inlet Pipe</th>
<th>Inlet Flow / ACFM</th>
<th>Min. Vent Size</th>
<th>Vent Flow / ACFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1”</td>
<td>180</td>
<td>4”</td>
<td>715</td>
</tr>
<tr>
<td>B</td>
<td>2”</td>
<td>190</td>
<td>4”</td>
<td>715</td>
</tr>
<tr>
<td>C</td>
<td>2”</td>
<td>910</td>
<td>6”</td>
<td>1870</td>
</tr>
<tr>
<td>D</td>
<td>3”</td>
<td>1120</td>
<td>6”</td>
<td>1870</td>
</tr>
<tr>
<td>E</td>
<td>3”</td>
<td>2250</td>
<td>8”</td>
<td>3450</td>
</tr>
</tbody>
</table>

*ACFM = air cubic feet per minute*
Pneumatic Fill Scenario #3

**Scrubber Vent**

- Piping from vent to scrubber **cannot** be reduced
- Perforated dispersion pipe must be same diameter, or larger, as vent
- Centerline of dispersion pipe not to be submersed > 6 inches
- Sum of perforations $\geq$ cross sectional area of pipe

**Tank Vent Requirements**

<table>
<thead>
<tr>
<th>Hose Size</th>
<th>Inlet Pipe Size</th>
<th>Inlet Flow ACFM</th>
<th>Min. Vent Size</th>
<th>Vent Flow ACFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1&quot;</td>
<td>180</td>
<td>4&quot;</td>
<td>330</td>
</tr>
<tr>
<td>B</td>
<td>2&quot;</td>
<td>190</td>
<td>4&quot;</td>
<td>330</td>
</tr>
<tr>
<td>C</td>
<td>2.5&quot;</td>
<td>910</td>
<td>6&quot;</td>
<td>970</td>
</tr>
<tr>
<td>D</td>
<td>3&quot;</td>
<td>1120</td>
<td>8&quot;</td>
<td>1780</td>
</tr>
<tr>
<td>E</td>
<td>3.5&quot;</td>
<td>2250</td>
<td>10&quot;</td>
<td>2935</td>
</tr>
</tbody>
</table>

**ACFM** = air cubic feet per minute
An investigation was made into tank venting requirements for a tank being filled from a tank truck. The following data represents the typical case and is the basis for all calculations:

Tank – HD polyethylene material capable of 10” water column (w.c.) internal pressure. Capacity of 6,600 gallons normal. Dimensions of 12’ dia. by 10’ high or 10’ dia. by 13’-5” high. Total capacity to full includes the dome and adds 675 gallons additional for a total of 7,275 gallons.

Truck – 2 axle trailer with a 5,500 gallon capacity.

Air unloading equipment consisting of – 1” air line to pressurize truck trailer thereby forcing the liquid HCL up a 3” eductor tube to a hose connection.

Fill hose – 2” hose from hose connection on truck trailer to the fill connection of the storage tank.

Tank Vent -- 6” diameter vent from the storage tank to a seal pot located at grade with 6” depth of water above the vent outlet (used to scrub HCL vapors from the venting air).

HCL acid -- Liquid being transferred from truck trailer to the storage tank.
Properties are:
   Specific gravity -- 1.19
   Viscosity -- 1.9 centipoise
   37% by weight HCL

Temperature -- 60 °F (Tables only list properties at this temperature, variation in viscosity and specific gravity are not likely to vary much within the actual range).
SECTION 1
FROM TANK TRUCK TO STORAGE TANK

30 PSIG IN TANK TRUCK
3" EJECTION PIPE 6' LONG
3" BALL VALVE
3" 90° ELL
30' OF 2" RUBBER HOSE
(3) 2" 90° ELLS
15' 2" PIPE TANK NOZZLE

SECTION 2
FROM STORAGE TANK TO SCRUBBER

6" TANK NOZZLE
(2) 6" 90° ELLS
20' 6" PVC PIPE
6" TEE, BRANCH FLOW
6" W.C. BACKPRESSURE
Methodology of the calculation is to determine the actual flow in cubic feet per minute through Section 1 of the system with liquid HCL and with air as the flowing medium in a 2” diameter hose and fill lines. The pressure in the storage tank for both HCL and air can be considered to be 10 inches of water column as this is the rated pressure for the tank. Pressure in the truck trailer is 30 psig determined by the setting on the relief valve. Normal operating procedure is to be a few psi below the maximum, but for calculation purposes it is necessary to use the maximum.

The cubic feet per minute determined in Section 1 is then the flow rate which must pass out of the storage tank vent without causing the pressure in the tank to “grow” beyond 10” w.c. There is a back pressure of 6” w.c. at the exit of the vent (seal pot) due to the height of the water. The total motive pressure for the vent is 10 inches w.c. minus 6” w.c. That delta pressure is only 4 inches w.c. (0.144 psi).

Results for the Section 1 calculations show that the following flow rates in cubic feet per minute are achieved from the truck to the storage tank with a motive force of 30 psi – 10” w.c. (0.361 psi) = 29.639 psi.

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Diameter</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCL</td>
<td>2”</td>
<td>28.8 cfm</td>
</tr>
<tr>
<td>Air</td>
<td>2”</td>
<td>920 cfm</td>
</tr>
</tbody>
</table>

Section 2 then must achieve vent flow rates equal to or better than those flow rates with a pressure differential of only 0.144 psi.

The calculated results for Section 2 flowing air and HCL vapor are as follows:

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Diameter</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapor</td>
<td>4”</td>
<td>382 cfm</td>
</tr>
<tr>
<td></td>
<td>6”</td>
<td>968.8 cfm</td>
</tr>
</tbody>
</table>

This shows that the 4” vent is more than adequate for air pressure driving liquid HCL through the fill line. As long as there is total assurance that the unloading valve at the truck is closed before the truck is totally emptied, there would not be any problem with over pressurizing the Storage Tank. Resistance to flow due to the viscosity of the liquid HCL is sufficient to prevent a rapid displacement of the air inside the storage tank.

If, however, the valve at the truck is not closed before air enters the fill line, there will be a very rapid increase of the flow rate into the Storage Tank. The truck will have become a very large air receiver filled with 30 psig air. This air will rush through the fill line into the Storage Tank at the rate shown above of 920 cfm. That air will start leaving the
Tank at 382 cfm (4” dia vent) or 969 cfm (6” dia. vent) at the Tank’s maximum pressure of 10 inches w.c. With the 4” vent, pressure will then continue to build until equilibrium of flow is achieved or until the Tank fails. Calculations were made with 1 psig in the tank which showed that air would enter the tank at 890 cfm and would vent out of the tank at 878 cfm. Equilibrium would be established at slightly over 1.0 psig in the Tank (by extrapolation). This is also roughly at the failure point of the tank. Clearly, a 4 inch vent is not adequate.

As an example of how quickly a tank failure could happen, let's look at the case of a truck being emptied with a 2” line and hose to the Storage Tank and a 4” vent line to the water seal (scrubber). We can assume that the truck completely unloaded the typical capacity of 5,500 gallons. The Tank has a total volume of 7,275 gallons counting the dome.

Tank air space = (7,275 gallons – 5,500 gallons) / 7.48 gal/cu.ft. = 237 cu.ft.

From the previous calculations we know that an average flow rate of around 900 cfm would be achieved as the tank went from a few inches of water column to 1.0 psig internal pressure. Flow out through the 4” vent will vary from around 200 cfm immediately after air starts flowing to 878 at 1 psig. Using 550 cfm as the average vent flow, we have the tank being filled with 1 psig air at a rate of 350 cfm (900 – 550) into a space of 237 cu. ft. total. This indicates that the tank would reach 1 psig in less than 1 minute after air starts flowing through the fill line. (This approach to determining time to reach pressure is greatly simplified and certainly not mathematically rigorous, but it is sufficient to see that it would be a very short time before tank failure could potentially occur.)

That time would be significantly shortened if the tank was more than 3/4 full, thus reducing the available air space. Also we know that if a 3" fill hose were used instead of a 2" hose, the time before failure would again be shortened.

Conclusion: Unless secondary safety devices are in place to protect the Storage Tank from an internal pressure above 10” w.c., it would not be prudent to use a vent smaller than 6" diameter when unloading a tank truck using 30 psig air as the motive force. The margin of error is so small to protect the tank with only 10” w.c. internal pressure rating that a safety relief device, such as a weighted hinged lid on the tank, is strongly recommended.
APPENDIX A

CALCULATIONS
FLUID DESCRIPTION

Asmpt: Incompressible
Fluid: Hydrochloric Acid Solution, 37.00 % Hydrochloric Acid
Temperature: 60.00 Fahrenheit
Density: 74.29 lb/cu ft
Specific Volume: 0.013 cu ft/lb
Specific Gravity: 1.190
Abs. Viscosity: 1.900 centipoise
Kin. Viscosity: 1.597 centistokes

HARDWARE DESCRIPTION

Number of Components: 11
Branch Inlet Diameter: 3.068 inches
Branch Outlet Diameter: 2.047 inches
Branch Elevation Change: 0.0 feet
Branch K Factor: 38.40

FLOW DESCRIPTION

Mass Flow Rate: 128,421.81 lb/hr
Volumetric Flow Rate: 28.81 cu ft/min = 215.52 US gal/min
Velocity: 3.35 ft/sec (fps)
Differential Pressure: 29.64 PSID
Head Loss: 52.21 feet
Head Loss: 26.937 PSID

The low displacement rate of 28.8 acfm indicates a 3" vent would be acceptable as long as only HCL is flowing.
FLOW DESCRIPTION - TABLE

Mass Flow Rate: 128,421.81 lb/hr
Volumetric Flow Rate: 28.81 cu ft/min = 215.52 US gal/min
Units as follows:
  Velocity: ft/sec (FPS)
  Head Loss: feet
  Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Out Vel</th>
<th>HL</th>
<th>DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>INLET</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance, 3&quot; proj</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe, NPS 3, sched 40, 8.00'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ball valve</td>
<td>9.35</td>
<td>9.35</td>
<td>0.07</td>
<td>0.036</td>
</tr>
<tr>
<td>Reducer, 3 X 2&quot; sud</td>
<td>9.35</td>
<td>20.61</td>
<td>1.80</td>
<td>3.632</td>
</tr>
<tr>
<td>Pipe, NPS 2, 30.00'</td>
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<td>22.01</td>
<td>25.00</td>
<td>12.896</td>
</tr>
<tr>
<td>Pipe, NPS 2, sched 40, 18.00'</td>
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<td>21.01</td>
<td>12.61</td>
<td>6.504</td>
</tr>
<tr>
<td>Ball valve</td>
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<td>21.01</td>
<td>0.39</td>
<td>0.202</td>
</tr>
<tr>
<td>[3] Elbow, 2&quot; 90 LR flg/BW</td>
<td>21.01</td>
<td>21.01</td>
<td>5.48</td>
<td>2.830</td>
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<tr>
<td>Exit, 2&quot; sharp-edged</td>
<td>21.01</td>
<td>21.01</td>
<td>6.86</td>
<td>3.539</td>
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<tr>
<td>OUTLET</td>
<td>21.01</td>
<td>52.21</td>
<td>29.639</td>
<td></td>
</tr>
</tbody>
</table>
Air Flowing

ONE-PAGE SUMMARY

File Name: POLY1-A

FLUID DESCRIPTION

Inlet Fluid Conditions
Spec. Heat Ratio (Cp/Cv): 1.400
Molecular Weight: 28.96
Specific Gravity: 1.000

Temperature: 80.00 Fahrenheit
Pressure: 30.00 PSIG = 44.70 PSIA
Density: 0.22 lb/cu ft
Specific Volume: 4.471 cu ft/lb

Abs. Viscosity: 0.018 centipoise
Kin. Viscosity: 5.080 centistokes

HARDWARE DESCRIPTION

Number of Components: 11
Branch Inlet Diameter: 3.068 inches
Branch Outlet Diameter: 2.047 inches

Branch Elevation Change: 0.0 feet
Branch K Factor: 37.04

FLOW DESCRIPTION

Mass Flow Rate: 5,675.26 lb/hr
Std Vol. Flow Rate: 1,239.224 SCFM
Inlet Vol. Flow Rate: 422.93 cu ft/min = 3,163.73 US gal/min
Inlet Velocity: 137.30 ft/sec (FPS)
Inlet Mach No.: 0.22
Outlet Vol. Flow Rate: 320.11 cu ft/min = 6,882.90 US gal/min
Outlet Velocity: 671.00 ft/sec (FPS)
Outlet Mach No.: 0.688

Differential Pressure: 29.64 PSID
FLOW DESCRIPTION - TABLE

Mass Flow Rate: 5,675.26 lb/hr  
Std Vol. Flow Rate: 1,239.224 SCFM
Units as follows:  
Volumetric Flow Rate: cu ft/min  
Velocity: ft/sec (FPS)  
Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Inl Vol</th>
<th>DP</th>
<th>Exp Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td>INLET</td>
<td>137.30</td>
<td>422.93</td>
<td>29.640</td>
<td></td>
</tr>
<tr>
<td>Entrance, 3&quot; proj</td>
<td>137.30</td>
<td>422.93</td>
<td>0.361</td>
<td>NA</td>
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<tr>
<td>Pipe, NPS 3, sched 40, 8.00'</td>
<td>138.10</td>
<td>425.39</td>
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</tr>
<tr>
<td>Ball valve</td>
<td>138.69</td>
<td>427.19</td>
<td>0.024</td>
<td>NA</td>
</tr>
<tr>
<td>Reducer, 3 X 2&quot; sud</td>
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<td>2.426</td>
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<td>540.88</td>
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<td>NA</td>
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<tr>
<td>Ball valve</td>
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<td>629.34</td>
<td>0.242</td>
<td>NA</td>
</tr>
<tr>
<td>Exit, 2&quot; sharp-edged</td>
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<td>709.82</td>
<td>6.594</td>
<td>NA</td>
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<tr>
<td>OUTLET</td>
<td>671.00</td>
<td>422.93</td>
<td></td>
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</tr>
</tbody>
</table>
ONE-PAGE SUMMARY

File Name: POLY1-A

FLUID DESCRIPTION

Inlet Fluid Conditions
Spec. Heat Ratio (Cp/Cv): 1.400
Molecular Weight: 28.96
Specific Gravity: 1.000

Temperature: 80.00 Fahrenheit
Pressure: 1,239.42 in water (68F) abs = 44.70 PSIA
Density: 0.22 lb/cu ft
Specific Volume: 4.471 cu ft/lb

Abs. Viscosity: 0.018 centipoise
Kin. Viscosity: 5.080 centistokes

HARDWARE DESCRIPTION

Number of Components: 11
Branch Inlet Diameter: 3.068 inches
Branch Outlet Diameter: 2.047 inches

Branch Elevation Change: 0.0 feet
Branch K Factor: 37.04

FLOW DESCRIPTION

Mass Flow Rate: 5,653.86 lb/hr
Std Vol. Flow Rate: 1,234.552 SCFM
Inlet Vol. Flow Rate: 421.33 cu ft/min = 3,151.80 US gal/min
Inlet Velocity: 136.78 ft/sec (FPS)
Inlet Mach No.: 0.120
Outlet Vol. Flow Rate: 669.73 cu ft/min = 6,655.71 US gal/min
Outlet Velocity: 648.85 ft/sec (FPS)
Outlet Mach No.: 0.662

Differential Pressure: 29.00 PSID
### FLOW DESCRIPTION - TABLE

**Mass Flow Rate:** 5,653.86 lb/hr  
**Std Vol. Flow Rate:** 1,234.552 SCFM  
**Units as follows:**  
- Volumetric Flow Rate: cu ft/min  
- Velocity: ft/sec (FPS)  
- Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Inl Vol</th>
<th>DP</th>
<th>Exp Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INLET</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance, 3&quot; proj</td>
<td>136.78</td>
<td>421.33</td>
<td>0.358</td>
<td>NA</td>
</tr>
<tr>
<td>Pipe, NPS 3, sched 40, 8.00'</td>
<td>137.57</td>
<td>423.76</td>
<td>0.260</td>
<td>NA</td>
</tr>
<tr>
<td>Ball valve</td>
<td>138.15</td>
<td>425.55</td>
<td>0.024</td>
<td>NA</td>
</tr>
<tr>
<td>Reducer, 3 X 2&quot; sud</td>
<td>138.21</td>
<td>425.71</td>
<td>2.407</td>
<td>NA</td>
</tr>
<tr>
<td>Pipe, NPS 2, 30.00'</td>
<td>338.54</td>
<td>443.15</td>
<td>9.846</td>
<td>NA</td>
</tr>
<tr>
<td>Pipe, NPS 2, sched 40, 18.00'</td>
<td>391.84</td>
<td>537.31</td>
<td>5.962</td>
<td>NA</td>
</tr>
<tr>
<td>Ball valve</td>
<td>454.49</td>
<td>623.22</td>
<td>0.238</td>
<td>NA</td>
</tr>
<tr>
<td>[3] Elbow, 2&quot; 90 LR flg/BW</td>
<td>457.50</td>
<td>627.35</td>
<td>3.646</td>
<td>NA</td>
</tr>
<tr>
<td>Exit, 2&quot; sharp-edged</td>
<td>510.56</td>
<td>700.11</td>
<td>6.258</td>
<td>NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OUTLET</strong></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>648.85</td>
<td>421.33</td>
<td>29.000</td>
<td></td>
</tr>
</tbody>
</table>
ONE-PAGE SUMMARY

File Name: POLY2-A

FLUID DESCRIPTION

Inlet Fluid Conditions
Spec. Heat Ratio (Cp/Cv): 1.400
Molecular Weight: 28.96
Specific Gravity: 1.000

Temperature: 60.00 Fahrenheit
Pressure: 417.52 in water (68°F) abs = 15.06 PSIA
Density: 0.08 lb/cu ft
Specific Volume: 12.787 cu ft/lb

Abs. Viscosity: 0.018 centipoise
Kin. Viscosity: 14.101 centistokes

HARDWARE DESCRIPTION

Number of Components: 5
Branch Inlet Diameter: 3.998 inches
Branch Outlet Diameter: 3.998 inches
Branch Elevation Change: 0.0 feet
Branch K Factor: 3.18

FLOW DESCRIPTION

Mass Flow Rate: 1,792.65 lb/hr
Std Vol. Flow Rate: 391.436 SCFM
Inlet Vol. Flow Rate: 382.06 cu ft/min = 2,858.01 US gal/min
Inlet Velocity: 73.04 ft/sec (FPS)
Inlet Mach No.: 0.065
Outlet Vol. Flow Rate: 384.69 cu ft/min = 2,877.72 US gal/min
Outlet Velocity: 73.54 ft/sec (FPS)
Outlet Mach No.: 0.066

Differential Pressure: 0.14 PSID

Flow from tank, 10" H2O

4" will not work
382 acfm is much less than
the 920 acfm into tank
**FLOW DESCRIPTION - TABLE**

Mass Flow Rate: 1,792.65 lb/hr  
Std Vol. Flow Rate: 391.436 SCFM  
Units as follows:  
Volumetric Flow Rate: cu ft/min  
Velocity: ft/sec (FPS)  
Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Inl Vol</th>
<th>DP</th>
<th>Exp Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INLET</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance, 4&quot; sharp-edged</td>
<td>73.04</td>
<td>382.06</td>
<td>0.023</td>
<td>NA</td>
</tr>
<tr>
<td>Pipe, NPS 4, sched 40, 24.00'</td>
<td>73.12</td>
<td>382.47</td>
<td>0.056</td>
<td>NA</td>
</tr>
<tr>
<td>[2] Elbow, 4&quot; 90 LR flg/BW</td>
<td>73.32</td>
<td>383.50</td>
<td>0.021</td>
<td>NA</td>
</tr>
<tr>
<td>Tee, 4&quot; Thru Branch</td>
<td>73.39</td>
<td>383.88</td>
<td>0.045</td>
<td>NA</td>
</tr>
</tbody>
</table>

| OUTLET                          |         |         |     |          |
|                                 | 73.54   | 382.06  | 0.144 |          |
FLUID DESCRIPTION

Inlet Fluid Conditions
Spec. Heat Ratio (Cp/Cv): 1.400
Molecular Weight: 28.96
Specific Gravity: 1.000

Temperature: 60.00 Fahrenheit
Pressure: 417.52 in water (68°F) abs = 15.06 PSIA
Density: 0.08 lb/cu ft
Specific Volume: 12.787 cu ft/lb

Abs. Viscosity: 0.018 centipoise
Kin. Viscosity: 14.101 centistokes

HARDWARE DESCRIPTION

Number of Components: 5
Branch Inlet Diameter: 6.031 inches
Branch Outlet Diameter: 6.031 inches
Branch Elevation Change: 0.0 feet
Branch K Factor: 2.56

FLOW DESCRIPTION

Mass Flow Rate: 4,545.59 lb/hr
Std Vol. Flow Rate: 992.556 SCFM
Inlet Vol. Flow Rate: 368.78 cu ft/min = 7,246.99 US gal/min
Inlet Velocity: 81.39 ft/sec (FPS)
Inlet Mach No.: 0.073
Outlet Vol. Flow Rate: 975.46 cu ft/min = 7,296.99 US gal/min
Outlet Velocity: 81.95 ft/sec (FPS)
Outlet Mach No.: 0.073

Differential Pressure: 0.14 PSID

4" H2O

6" will work
968.8 acfm is greater than 920.11 acf
Flow out of storage tank exceeds flow in
FLOW DESCRIPTION - TABLE

Mass Flow Rate: 4,545.59 lb/hr
Std Vol. Flow Rate: 992.556 SCFM
Units as follows:
  Volumetric Flow Rate: cu ft/min
  Velocity: ft/sec (FPS)
  Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Inl Vol</th>
<th>DP</th>
<th>Exp Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td>INLET</td>
<td>81.39</td>
<td>968.78</td>
<td>0.144</td>
<td></td>
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<tr>
<td>Entrance, 6&quot; sharp-edged</td>
<td>81.39</td>
<td>968.78</td>
<td>0.028</td>
<td>NA</td>
</tr>
<tr>
<td>Pipe, NPS 6, sched 40, 24.00'</td>
<td>81.50</td>
<td>970.07</td>
<td>0.042</td>
<td>NA</td>
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<tr>
<td>[2] Elbow, 6&quot; 90° LR flg/BW</td>
<td>81.66</td>
<td>972.01</td>
<td>0.024</td>
<td>NA</td>
</tr>
<tr>
<td>Tee, 6&quot; Thru Branch</td>
<td>81.75</td>
<td>973.10</td>
<td>0.051</td>
<td>NA</td>
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<tr>
<td>OUTLET</td>
<td>81.95</td>
<td>968.78</td>
<td>0.144</td>
<td></td>
</tr>
</tbody>
</table>
**ONE-PAGE SUMMARY**

File Name: POLY2-A

**FLUID DESCRIPTION**

Inlet Fluid Conditions
Spec. Heat Ratio (Cp/Cv): 1.400
Molecular Weight: 28.96
Specific Gravity: 1.000

Temperature: 60.00 Fahrenheit
Pressure: 435.25 in water (68F) abs = 15.70 PSIA
Density: 0.08 lb/cu ft
Specific Volume: 12.266 cu ft/lb

Abs. Viscosity: 0.018 centipoise
Kin. Viscosity: 13.527 centistokes

**HARDWARE DESCRIPTION**

Number of Components: 5
Branch Inlet Diameter: 3.998 inches
Branch Outlet Diameter: 3.998 inches

Branch Elevation Change: 0.0 feet
Branch K Factor: 3.03

**FLOW DESCRIPTION**

Mass Flow Rate: 4,292.73 lb/hr
Std Vol. Flow Rate: 937.341 SCFM
Inlet Vol. Flow Rate: 877.61 cu ft/min = 6,564.99 US gal/min
Inlet Velocity: 167.78 ft/sec (FPS)
Inlet Mach No.: 0.150
Outlet Vol. Flow Rate: 910.31 cu ft/min = 6,809.59 US gal/min
Outlet Velocity: 174.03 ft/sec (FPS)
Outlet Mach No.: 0.157

Differential Pressure: 0.78 PSID

---

**Diagram:**

- A diagram of a flow system with a tank labeled "Air" and a nozzle.
- A section of text indicating a flow rate comparison:
  - Flow from tank:
  - Calculated flow rate: 877.6
  - Measured flow rate: 889.7

---

"With 1 psig in tank and a 4" vent, the flow rate does not equal flow in."
FLOW DESCRIPTION - TABLE

Mass Flow Rate: 4,292.73 lb/hr
Std Vol. Flow Rate: 937.341 SCFM
Units as follows:
  Volumetric Flow Rate: cu ft/min
  Velocity: ft/sec (FPS)
  Differential Pressure: PSID

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Inl Vel</th>
<th>Inl Vol</th>
<th>DP</th>
<th>Exp Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td>INLET</td>
<td>167.78</td>
<td>877.61</td>
<td>0.784</td>
<td></td>
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<tr>
<td>Entrance, 4&quot; sharp-edged</td>
<td>167.78</td>
<td>877.61</td>
<td>0.127</td>
<td>NA</td>
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<tr>
<td>Pipe, NPS 4, sched 40, 24.00'</td>
<td>168.76</td>
<td>882.72</td>
<td>0.282</td>
<td>NA</td>
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<tr>
<td>[2] Elbow, 4&quot; 90 LR flg/BW</td>
<td>170.97</td>
<td>894.32</td>
<td>0.118</td>
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<tr>
<td>Tee, 4&quot; Thru Branch</td>
<td>171.93</td>
<td>899.30</td>
<td>0.256</td>
<td>NA</td>
</tr>
<tr>
<td>OUTLET</td>
<td>174.03</td>
<td>877.61</td>
<td>0.784</td>
<td></td>
</tr>
</tbody>
</table>
Engineering Study Assumptions

- Tank – Crosslinked PE capable of 10” water column internal pressure per ASTM D1998
- Tank Capacity – 6600 gallons nominal
- Delivery trailer – 2 axles w/ 5500 gal capacity
- Fill hoses – 2 and 3 inches
- Liquid properties
  - Specific Gravity 1.19
  - Viscosity – 1.9 centipoise
  - 37% by weight
- Temperature - 60°F
- Line purge < 15 seconds per purge
- Max trailer pressure rating – 30 psi