COMPRESSED AIR SYSTEM DESIGN

A compressed air system made of thermoplastic piping is a simplified installation. The Air-Pro system by Asahi/America provides fast, safe installation with all the long-term corrosion resistance of plastics that are ideal for the air systems.

This section reviews the necessary items to consider when designing a compressed air system. The topics covered are:

- Materials of Construction
- Operating Parameters, Oils
- System Sizing
- Thermal Expansion
- Other Considerations
- Hanging
- Welding Methods

Materials of Construction

When designing a compressed air system, it is critical to use materials that are manufacturer recommended for the application. Only certain thermoplastics are approved for use in compressed air applications due to safety precautions that must be considered.

Thermoplastics, such as PVC, are not recommended for use in compressed air applications due to its highly crystalline structure. Under pressure, air will compress, generating a high potential energy. In the event of a failure, the release of the compressed air turns the potential energy into kinetic energy, which releases at high velocities as the air decompresses. Brittle materials can shatter and brake into fragments at the point failure. The plastic pieces that break off are dangerous to surrounding personnel, causing injury and possible death.

The use of Air-Pro for compressed air service is recommended by Asahi/America, Inc. The Air-Pro system was specifically designed for compressed air. The material's ductile nature makes it safe in the event of any possible failure. In a failure mode, the material will stretch and tear, without the fragmentation of any material. Air-Pro is similar to copper pipe when it breaks open due to failure in a frozen application. Air-Pro has been tested for impact failure at full pressure and full pressure at cold temperatures, displaying safe ductile properties under all conditions.

For compressed air systems, Air-Pro is recommended.

Operating Parameters, Oils

Because thermoplastic systems have varying ratings at different temperatures, it is important to design a system around all the parameters that will be subjected to it. As a first pass, verify the following operating parameters:

- Continuous operating temperature
- Continuous operating pressure
- Oil to be used in compressor

By knowing the above parameters, thermal plastic pipe systems can be selected. Compare the actual conditions to the allowable ratings of the material being selected for the job. It is important to predict elevated temperatures, as thermoplastics have reduced pressure ratings at higher temperatures. The Air-Pro system is rated at 230 psi at 68° F. Table D-3 lists correction factors for higher temperatures.

Table D-3. Air-Pro Pressure Rating Correction Factor

Temperature (° F)	Correction Factor
68	1.00
86	0.88
104	0.79
140	0.65

Multiply the standard rating of 230 psi by the correction factor that correlates with a system's expected operating temperature.

Valves should be verified separately in terms of temperature and pressure from a piping system, as certain styles and brands of valves have lower ratings than the pipe system.

Finally, in compressed air systems, oil is used in the compressor as a lubricant. Depending on the filter and drying system, it is common for the oil to get into the pipe system. With certain plastics, such as ABS, synthetic oils can break down the plastic or the glue and cause failures over time. For most mineral and synthetic compressor oils, Air-Pro is resistant to the effects of the oil. For an exact recommendation, contact Asahi/America's Engineering Department to verify your oil and application.

After verifying the standard operating conditions, it is necessary to examine other operations that might affect the piping. The following is a sample of items to investigate, prior to specifying a material.

- Will there be spikes in temperature or pressure?
- Is there a cleaning operation that the piping will be exposed to?
- If yes, what is the cleaning agent? What temperature will the cleaning be conducted at?
- Will the system be exposed to sunlight or other sources of UV?

Each of the above questions should be answered and the desired material should be checked for suitability based on the above factors, as well as any others that might be special to the system in question.

System Sizing

Designing pipe lines for compressed air or gas is considerably different from designing a non-compressible liquid system. Gases are compressible, so there are more variables to consider. Designs should take into account current and future demands to avoid unnecessarily large pressure drops as a system is expanded. Elevated pressure drops represent unrecoverable energy and financial losses.

One advantage in designing an Air-Pro system is its smooth internal bore and resistance to corrosion in moist environments, which means the material can be used for years with extraordinarily low maintenance and without increases in pressure drop common to metal systems. Condensate and moist environments cause most metal systems to scale, pit, and corrode, resulting in increased pressure drop. For Air-Pro piping, the roughness factor, C, of the pipe internals is approximately 150 to 165. This factor is inversely proportional to friction head losses. As C decreases, system friction increases. Since Air-Pro pipe is resistant to corrosion, the roughness factor will not decrease over time, thus the pressure drop will not increase. Conversely, a carbon steel system with an initial roughness factor of 120 will scale over time, causing an increase in friction, increased pressure drops, and greater demand on the air compressor unit.

Main Lines

Normal compressed air systems incorporate two types of pipe lines when designed correctly: the main (or the trunk) line and the branch lines. Main lines are used to carry the bulk of the compressed gas. Undersizing the main line can create large pressure drops and high velocities throughout the system. In general, systems should be oversized to allow for future expansion, as well as reduce demand on the compressor.

Oversizing the main line will be more of an initial capital expense, but can prove to be an advantage over time. In addition to reducing pressure drop, the extra volume in the trunk line acts as an added receiver, reducing compressor demand and allowing for future expansion. Small mains with high velocities can also cause problems with condensed water. High air velocities pick up the condensed water and spray it through the line. With a larger diameter, velocities are lowered, allowing water to collect on the bottom of the pipe while air flows over the top. A generally accepted value for velocity in the main line is 20 feet per second. It may also be preferable to arrange the mains in a loop to have the entire pipe act as a reservoir.

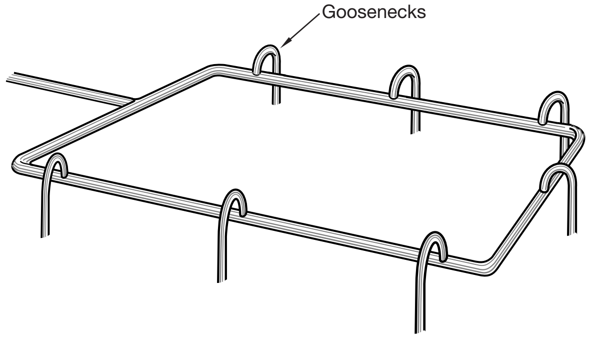

Figure D-42. Main compressed air loop with branches

To design the main line of a compressed gas system, Equation D-1 has been developed:

$$d = (0.00067\ L\ Q^{1.85}\ \Delta P)^{0.2} \qquad \text{(D-1)}$$

where:
- d = inside diameter (in)
- L = length of main line (ft)
- Q = standard volumetric flow rate (make-up air)
- P = output pressure from the compressor (psi)
- ΔP = allowable pressure drop (psi)

Equation D-1 relates the pipe's inside diameter (d) to the pressure drop. In order to use the equation, certain information must be known. First, the required air consumption must be predetermined. Based on required air consumption, a compressor can be chosen with an output pressure rating (P). The length of the main pipe line to be installed, and the number of fittings in the main line must also be known. For fittings, use Appendix A to determine the equivalent length of pipe per fitting style. The allowable pressure in the system has to be specified. Typically, a value of 4 psi or less is used as a general rule of thumb for compressed air systems.

To summarize, the following data should be specified:
- L = length of main line (ft)
- Q = standard volumetric flow rate (make-up air)
- P = output pressure from the compressor (psi)
- ΔP = allowable pressure drop (psi)

Branch Lines

Lines of 100 feet or less coming off the main line are referred to as branch lines. Since these lines are relatively short in length, and the water from condensation is separated in the main lines, branches are generally sized smaller and allow for higher velocities and pressure drops.

To prevent water from entering the branch line, gooseneck fittings are used to draw air from the top of the main line, leaving condensed water on the bottom of the main line.

Thermal Expansion

Based on your operating criteria, thermal expansion must be considered. For systems maintained at consistent temperatures, compensation for thermal effects may not be required. It is, however, important to review all aspects of the operating environment, such as:

- Is it outdoors where the pipe will be exposed to changing weather?
- Is the system spiked with a high temperature cleaning solution?
- Will the system run at a significantly higher temperature than the installation temperature?

The occurrence of any thermal change in a plastic system will cause the material to expand or contract.

Thermoplastic systems can be used in hot applications and applications where the temperature is cyclical. It just requires analysis of the thermal expansion effects. Section C discusses the steps of calculating thermal expansion, end loads, and expansion compensating devices. In most cases the use of expansions, offsets, and proper hanging techniques is all that is required to ensure a proper design.

Hot systems also reduce the rigidity of thermoplastic piping pipe, which, in turn, decreases the support spacing between pipe hangers. In smaller dimensions, using continuous supports made of some type of channel or split plastic pipe is recommended.

Finally, the use of hangers as guides and anchors becomes important. As the design procedures in Section C indicate, certain hangers should be used as guides to allow the pipe to move back and forth in-line, while other hangers should be anchoring locations used to direct the expansion into the compensating device. The anchors and hangers should be designed to withstand the thermal end load.

For calculation of allowed stresses and design of expansion compensation devices, refer to Section C, *Engineering Theory and Design Considerations.*

Other Considerations

UV Exposure

The Air-Pro system is not rated for direct UV exposure. In certain outdoor applications, wrapping the pipe for protection is recommended. There are a variety of methods to accomplish this wrapping. Consult with Asahi/America's Engineering Department for recommendations on Air-Pro in UV exposed applications.

Insulation

Insulation is a nice method of protecting a pipe system from UV exposure, as well as providing required insulation for the system or media being transported. A serious difference between plastic and metal is plastic's thermal properties. A metal pipe system will quickly take the temperature of the media being transported. A system carrying a media at 150° F will have an outer wall temperature close to or at 150° F. In contrast, thermoplastics have an inherent insulating property that maintains heat inside the pipe better than a metal system. The advantage is that a plastic pipe has better thermal properties, which translates into improved operating efficiencies and reduced insulation thickness.

Direct Connection to a Compressor

As with any material, Air-Pro has upper temperature and pressure rating limitations. For the majority of compressed air systems, Air-Pro is ideal and meets the requirements. One common concern with compressed air systems is the temperature of the air directly leaving the compressor. In many cases, this temperature is extremely high and can exceed the rating of Air-Pro. In these locations, it is not recommended to directly attach the Air-Pro system to the compressor. Instead, start the Air-Pro system after a cooler or dryer, where temperatures are lower. In between the compressor and the dryer/cooler, use metal piping to handle the higher temperatures. The length of metal pipe in these locations is generally very little and should have minimal effect on the air quality.

Hanging

Since plastic reacts differently than metal, varying hanger styles are required. The designer of a system should specify the exact hanger and location and not leave this portion up to the installer. Use Table D-4 for determining the hanging distance required on Air-Pro systems.

In smaller dimensions, it may be advantageous to use a continuous support for horizontal piping.

Table D-4. Maximum Hanging Distances for Air-Pro Systems

Pipe Size (inches)	Support Spacing (° F)	
	68° F	104° F
1/2	2.8	2.6
3/4	3.2	2.9
1	3.6	3.3
1 1/4	4.1	3.6
1 1/2	4.5	4.1
2	5.1	4.6
3	8.4	8.1

Welding Methods

The system designer should specify the equipment method to be used in any given project. The choice of particular equipment should be based on the following concerns:

- Installation location
- Size range
- System complexity

Socket fusion is ideal for small, simple, low cost systems. Socket fusion can be done quite easily with a hand-held welding plate and a few inserts. With just a limited amount of practice, an installer can make safe and reliable joints. For larger dimensions, up to a maximum of 4", bench style socket fusion equipment is available for keeping joints aligned.

For systems that have larger dimensions above 4", butt fusion is a logical choice. Welding can take place in a variety of climates and conditions. In addition, butt fusion offers the widest variety of welding equipment options. Tools are available for bench welding, trench welding, and welding in the rack, making it completely versatile for almost all applications. Refer to Section F, *Installation Practices,* for a tool selection guide.

Since Air-Pro is available as a socket system from 1/2" to 4", the only selection of equipment is between the hand-held tool or the larger bench style tool. However, if a system is mostly pipe with long straight runs, then the use of butt fusion can be considered. Using butt fusion on the pipe-to-pipe welds will reduce the amount of welds, as well as decrease the need for coupling fittings to connect the pipe. However, in these installations, two welding methods on the job site are required: butt fusion for the pipe and socket fusion for the fitting connections.

For a more detailed analysis of welding methods and equipment, refer to Section F, *Installation Practices*.