6.3 Piping Items and Valves

Introduction

The information presented in this section is a general composite of best practices and current information about piping and piping components, considerations, materials, selection of piping system components and welding. It describes the consideration for evaluation of specifications for pipe, fittings, and components suitable for dry phosgene piping systems.

The information provided in this section should not be considered as a directive or as an industry standard that readers must adopt or follow. Instead, the information is intended to provide helpful ideas and guidance that users may wish to consider in a general sense (See Section 1.1 *Preface and Legal Notice*). Also included is a reference list of useful resources.

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6.3 Piping Items & Valves

6.3.1 General

<u>In reviewing the following section, readers should note the following:</u>

- This section applies to systems that contain 100% dry phosgene. For purposes of this text, the term “dry phosgene” means -40° F dew point with the absence of contaminants. This section does not address mixed phosgene streams or wet phosgene.

- The “piping system” is defined as piping and piping components up to and including the first block valve prior to connecting to instrumentation, equipment, and other non-piping systems (e.g., cylinders, etc.).

- The piping components within this section are based on minimum design pressure of 150 psig. Other sources are available for information on other design conditions (e.g., ASME B31.3 and B16.5).[1]

- For identification and a point of reference, piping design, fabrication, installation and testing follow ASME B31.3.[1]

Precautions

This section describes general industry best practices that have been used previously. Each company must evaluate its own piping and valve requirements, and materials based on the specific facts and circumstances associated with its operations.

Consider the following with regard to the following activities:

- Thoroughly purging all piping of phosgene prior to any welding. Dry phosgene can support combustion of carbon steel and other metals, and may pose a safety risk to personnel performing the welding.

- Protecting piping (and valves and instruments) from over pressurization due to thermal expansion when liquid phosgene can be trapped between closed valves. Also give consideration for increased pressure due to expansion of trapped liquid phosgene in the cavities of ball valves and plug valves when they are in the closed position.

- Protecting dry phosgene systems from the intrusion of moisture.

Moisture can react with phosgene and cause severe corrosion and failure.

- Thoroughly cleaning, drying, and removing all oils, greases and other materials from dry phosgene systems that could react with phosgene to cause fire, corrosion, pressure increase or harmful deposits.

- Inspecting all phosgene piping systems at regular intervals for signs of leakage, internal or external corrosion, and insulation failure. Note that because piping supports can also be subject to corrosion and can create opportunity for other system integrity problems, including piping supports within the inspection plan can help to reduce risk.

- Where stainless steel materials are employed, inspections and testing may include an assessment of stress corrosion cracking caused by exposure to chlorides. Atmospheric exposure from the outside, as well as process exposure from the inside can cause stress corrosion cracking.

- Considering fugitive emission issues when designing piping systems for phosgene.

- Protecting liquid phosgene piping from liquid hammer damage. Phosgene liquid has a high density that can result in large hydraulic shock forces.

Materials

This section provides information on the components of piping systems. In general, carbon steel or alloy steel materials have been used for handling dry phosgene.

- Temperatures below -20°F (-29°C) may be encountered in phosgene systems and some steels may become brittle. ASTM A333 carbon steel and alloy steel materials suitable for the low temperatures have been used previously. The selection of specific grades of these materials reflects consideration of factors including the expected lowest temperature.

- Welded and flanged joints have been used for all sizes.

- Minimize flange use to reduce fugitive emissions.

- Piping systems for phosgene service can be constructed of seamless fittings and pipe. Or, if they have weld seams, then the seams are 100% radiograph tested.

Selection

During the selection of piping system components, refer to other sections of the Guidelines that may be relevant. When making design decisions, consider such items as variable operating conditions, including start-ups, upsets shutdowns and system evacuation.

The use of threaded joints in piping systems can create increased potential for leaks, and the fittings are necessarily thinner because of the requirement to taper the joints for threading. As a result, threaded fittings tend to be generally avoided, if possible but where threaded connections cannot be avoided, the use of a chemically compatible thread sealant can help reduce some risks of leakage. Another practice is to employ fluoropolymer-based thread sealants in phosgene service.

Welding

Specific details covering all situations for welding are beyond the scope of this section. However, it is important that the welding of pipe be performed by qualified individuals with up-to-date experience in the specific metallurgy. Procedures and welder qualifications are available (e.g., ASME BPV-IX and ASME B31.3, Chapter VIII).[1] Care must be taken to ensure appropriate actions on items such as the use of proper welding procedures, correct filler metal, and adequate pre- or post-heat treatment.

Evaluate adoption of a Non-Destructive Testing program where welded systems are contemplated. Examination guidelines such as ASME B31.3[1] are available although additional measures may also be considered.

6.3.2 Pipe & Piping Components

This subsection provides information that companies may consider as they evaluate specifications for pipe, fittings, and components suitable for dry phosgene piping systems. The following materials have been used previously for the service conditions shown. It is important to note, however, that like other sections of the Guidelines, the following information does not exclude utilization of potential non-listed approaches appropriate for a particular use.

Depending on particular circumstances, companies may wish or need to use other materials.

Table 2-1 Socket-Welded Construction (See Note 5)
Examples of components that have been used previously; alternatives may be necessary depending on circumstances.

Component	Nominal Pipe Size (NPS)	-20^{O}F and Greater	-50^{O}F and Greater
Pipe/Nipple	Through 1 ½”	ASTM A106, Grade B, Sch 80 Carbon Steel, Seamless, ASME B36.10.	ASTM A333, Grade 6, Sch 80 Carbon Steel, Seamless, ASME B36.10.
Fittings	Through 1 ½”	ASTM A105, Class 3000, Forged Steel, Socket Weld, ASME B16.11.	ASTM A350, Grade LF2, Class 3000, Forged Steel, Socket Weld, ASME B16.11.
Flanges	Through 1 ½”	ASTM A105, Class 150/Class 300, Forged Steel, Raised Face, Socket Weld, ASME B16.5.	ASTM 350, Grade LF2, Class 150/Class 300, Forged Steel, Raised Face, Socket Weld, ASME B16.5.
Unions, Flanged	Through 1 ½”	Flanges beneficial	Flanges beneficial
Unions, Hammer	Through 1 ½”	Flanges beneficial	Flanges beneficial
Branch Connections	Through 1 ½”	Fittings per Table 2-1, Socket Welded Tees, Reducing Tees, Tees with Swaged Nipples or Socket Welding olets. Socket Weld Inserts may be undesirable.	Fittings per Table 2-1, Socket Welded Tees, Reducing Tees, Tees with Swaged Nipples or Socket Welding olets. Socket Weld Inserts may be undesirable.
Bolts	All Sizes	ASTM A193, Grade B7, Alloy Steel Quenched & Tempered, Alloy Steel Stud Bolts & Cap Screws, ANSI B18.2.1/IFI 136. (See Notes 2 & 3).	ASTM A320, Grade L7, Alloy Steel Stud Bolts & Cap Screws, ANSI B18.2.1/IFI 136. (See Notes 1, 2 & 3).
Nuts	All Sizes	ASTM A194, Grade 2H, Carbon Steel Heavy Hex Nuts, ANSI B18.2.2. (See Note 2).	ASTM A194, Grade 4, Alloy Steel Heavy Hex Nuts, ANSI B18.2.2 (Charpy Test @ -150^{O}F/-101^{O}C). (See
Gasket	All Sizes	Spiral Wound with PTFE Fillers, Restructured PTFE with Barium Sulphate Filler, Glass-Filled PTFE, Flexible Graphite with Tanged Insert,	Spiral Wound with PTFE Fillers, Restructured PTFE with Barium Sulphate Filler, Glass-Filled PTFE, Flexible Graphite with Tanged Insert,

Table 2-1 Socket-Welded Construction (See Note 5) Examples of components that have been used previously; alternatives may be necessary depending on circumstances.			
Component	**Nominal Pipe Size (NPS)**	**-20°F and Greater**	**-50°F and Greater**
		Perforated Metal Fully Encapsulated with PTFE, Graphite Faced Corrugated or Profile. (See Note 4).	Perforated Metal Fully Encapsulated with PTFE, Graphite Faced Corrugated or Profile. (See Note 4).

Note 1 ASTM A193[2] Grade B7M bolts and ASTM A194[2] Grade 2HM nuts have been substituted for temperature applications to -50°F.

Note 2 Threads were in accordance with ANSI B1.1.[1] Bolts had a Class 2A fit and nuts had a Class 2B fit.

Note 3 Stud bolts or machined bolts were useful on in-line piping components that did not have tapped threads. Cap screws have been used for tapped piping components and instrumentation.

Note 4 Asbestos gaskets have been used in lieu of gaskets shown. Only individuals thoroughly familiar with the material and proper handling procedures and techniques should be allowed to work with asbestos.

Note 5 Butt-weld construction used for temperatures below -50°F.

Table 2-2 Butt-Welded Construction Examples of components that have been used previously; alternatives may be necessary depending on circumstances.				
Component	**Nominal Pipe Size (NPS)**	**-20°F and Greater**	**-50°F and Greater**	**-150°F and Greater**
Pipe/Nipple	Through 1 ½”	ASTM A106, Grade B, Sch 80 Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 6, Sch 80 Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 3, Sch 80 Alloy Steel, Seamless, ASME B36.10
Pipe	2” through 4”	ASTM A106, Grade B or A53, Sch 40 Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 6, Sch 40 Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 3, Sch 40 Alloy Steel, Seamless, ASME B36.10
Pipe	6” through 12”	ASTM A106, Grade B or A53, Std. Wt. Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 6, Std. Wt. Carbon Steel, Seamless, ASME B36.10	ASTM A333, Grade 3, Std Wt. Alloy Steel, Seamless, ASME B36.10
Fittings,	Through 12”	ASTM A234,	ASTM A420,	ASTM A420,

Table 2-2 Butt-Welded Construction Examples of components that have been used previously; alternatives may be necessary depending on circumstances.				
Component	**Nominal Pipe Size (NPS)**	**-20^{o}F and Greater**	**-50^{o}F and Greater**	**-150^{o}F and Greater**
Wrought		Grade WPB, Carbon Steel, Seamless (bore to match pipe), ASME B16.9	Grade WPL6, Carbon Steel, Seamless (bore to match pipe), ASME B16.9.	Grade WPL Alloy Steel, Seamless (bore to match pipe), ASME B16.9.
Fittings, Forged	Through 12"	ASTM A105, Forged Steel (bore to match pipe). (See Note 4).	ASTM A350, Grade LF2, Forged Steel (bore to match pipe). (See Note 4).	AST<A350, Grade LF3. Forged Alloy Steel (bore to match pipe). (See Note 4).
Flanges	Through 12"	ASTM A105, Class 150/Class 300, Carbon Steel, Raised Face, Weld Neck (bore to match pipe), ASME B16.5. (See Note 5).	ASTM A350, Grade LF2, Class 150/Class 300, Carbon Steel, Raised Face, Weld Neck (bore to match pipe), ASME B16.5. (See Note 5).	ASTM A350, Grade LF3, Class 150/Class 300, Alloy Steel, Raised Face, Weld Neck (bore to match pipe), ASME B16.5.
Branch Connections	Through 12"	Fittings per Table 2-2. Tees for size on size, tees or reducing tees for header sizes 2" & less & stub ins, reducing tees or welding olets for all other components. (See Note 6).	Fittings per Table 2-2. Tees for size on size, tees or reducing tees for header sizes 2" & less & stub ins, reducing tees or welding olets for all other components. (See Note 6).	Fittings per Table 2-2. Tees for size on size, tees or reducing tees for header sizes 2" & less & stub ins, reducing tees or welding olets for all other components. (See Note 6).
Bolts	All Sizes	ASTM A193, Grade B7, Alloy Steel, Quenched & Tempered Stud Bolts & Cap Screws, ANSI B18.2.1/IFI 136. (See Note 1)	ASTM A320, Grade L7, Alloy Steel Stud Bolts & Cap Screws, ANSI B18.2.1/IFI 136. (See Notes 1, 2 & 3).	ASTM A320, Grade L7, Alloy Steel Stud Bolts & Cap Screws, ANSI B18.2.1/IFI 136. (See Notes 1 & 3).

Nuts	All Sizes	ASTM A194, Grade 2H, Carbon Steel, Heavy Hex Nuts, ANSI B18.2.2. (See Note 1).	ASTM A194, Grade 4, Alloy Steel, Heavy Hex Nuts to be Charpy Tested @ -150^{O}F/-101^{O}C, ANSI B18.2.2. (See	ASTM A194, Grade 4, Alloy Steel, Heavy Hex Nuts to be Charpy Tested @ -150^{O}F/-101^{O}C, ANSI B18.2.2.
Gaskets	All Sizes	Spiral Wound with PTFE Fillers,	Spiral Wound with PTFE Fillers,	Spiral Wound with PTFE Fillers,

Table 2-2 Butt-Welded Construction Examples of components that have been used previously; alternatives may be necessary depending on circumstances.				
Component	**Nominal Pipe Size (NPS)**	**-20°F and Greater**	**-50°F and Greater**	**-150°F and Greater**
		Glass-Filled PTFE, Restructured PTFE with Barium Sulphate Filler, Flexible Graphite with Tanged Insert, Perforated Metal Fully Encapsulated with PTFE, Graphite Faced Corrugated or Profile. (See Note 7).	Glass-Filled PTFE, Restructured PTFE with Barium Sulphate Filler, Flexible Graphite with Tanged Insert, Perforated Metal Fully Encapsulated with PTFE, Graphite Faced Corrugated or Profile. (See Note 7).	Glass-Filled PTFE, Restructured PTFE with Barium Sulphate Filler, Flexible Graphite with Tanged Insert, Perforated Metal Fully Encapsulated with PTFE, Graphite Faced Corrugated or Profile. (See Note 7).

Note 1 Threads were in accordance with ANSI B1.1.[1] Bolts had a Class 2A fit and nuts had a Class 2B fit.

Note 2 ASTM A193[2] Grade B7M bolts and ASTM A194 Grade 2HM nuts have been substituted for temperature applications down to 50ºF.

Note 3 Stud bolts or machined bolts were useful for in-line piping components that do not have tapped threads. Cap screws have been used for tapped piping components and instrumentation.

Note 4 The reference varies depending on the forged fitting used.

Note 5 Weld neck flanges may be useful. Slip-on flanges have been used where required for alignment and fit-up purposes.

Note 6 Consider full penetration welds for branch connection in accordance with ASME B31.3, paragraph 328.5.4(C) and (E).[1]

Note 7 Asbestos gaskets have been used in lieu of gaskets shown. Work with asbestos only if thoroughly familiar with the material and proper handling procedures and techniques.

6.3.3 Valves

There are important considerations for valving for phosgene service by all persons associated with the application including the manufacturer, supplier, installer, operator, and maintainer. Companies evaluate whether the valve is sufficiently developed and designed to meet the specific engineering needs associated with phosgene service rather than more routine or other types of valves available. An understanding of the following sub-sections by all persons involved can help facilitate successful valve applications. ASME B16.34 is an available source regarding the construction, design, assembly and testing of valves.[1]

The following guidelines outline various types of valves in service at the time of the text's development. The text also include potential criteria that may be considered during the selection of valve features, valve section tables, materials of construction tables, valve testing guidelines and cleaning and packaging guidelines. Companies can consider the following general information as a part of their determination of the appropriate valve for their individual needs. Depending on specific circumstances, alternative or additional criteria may need to be considered during the selection process. Note that these guidelines are not intended to exclude the use of valve types and materials, which have completed sufficient testing, that are not mentioned and may be appropriate.

Types of Valves
Valves commonly employed in dry phosgene service are the globe, ball, plug and butterfly types. Each valve is available in several basic body patterns, employing different design features often suited to a particular service and/or specific application.

General Considerations and Criteria for Valve Selection
When specifying valves for phosgene applications, consider factors such as those described below:

Stem Seal

When dealing with applications that have frequent or large temperature fluctuations, the specifier should consider alternative methods of stem sealing such as bellows seal or live-loaded packing to help prevent a leak through the stem seal. Evaluate whether the injectable sealants are compatible for the service and service conditions.

Bellows

Design the bellows valve to provide long service life and sufficient flexibility for the intended use. By way of a general example, some companies look to a guideline where the bellows is designed to operate for a minimum of 10,000 cycles, and at the maximum allowable working pressure of the valve within the temperature range of that valve. Note: Bellows seal designs are inherently difficult to clear of phosgene, and if inadequately addressed, can pose a potential risk to personnel during disassembly.

Globe Valves

Globe valves can offer several important safety features, including tight shut-off in both directions (bi-directional seating) without trapping liquid inside cavities, multi-turn operation that helps prevents quick (and sometimes accidental) opening and closing, and a positive means to verify valve position (open or closed).

One example of a configuration that has been used previously includes a blow-out proof stem, a bolted bonnet employing four (4) or more bolts and a gland with outside screw and yoke (OS&Y) for external packing gland adjustment. Both metal-to-metal seating employing hard-facing and soft-seating such as polytetrafluoroethylene (PTFE) have been used in service. Where PTFE is called for in the materials of construction, consider non-reconstituted PTFE to help ensure reduced porosity and permeation through the polymer.

Pay particular attention to the design of the stuffing box since even minute stem leakage will cause corrosion of the valve stem by means of phosgene reacting with humid air. For this reason, a bellows seal, improved stem material or an improved steam sealing design has been used for extended service life.

Ball Valves

Ball valves can provide tight shut-off, have a minimum resistance to flow when fully open and are in many cases easier to operate than plug valves of equal size. Some persons maintain that the quarter-turn stem movement lends itself to an inherently more reliable stem seal design. Ball valves of unibody design may be especially useful. Evaluate incorporating a blow-out proof stem design with a means to externally adjust the stem seal.

When designing a ball valve, take steps so that excess pressure will relieve spontaneously in the direction of higher line pressure. Excess pressure may result from expansion of liquid phosgene trapped in the ball and body cavity when the valve is closed. One previously used method of providing pressure relief is a hole in the ball. As alternative options are available, methods of relieving pressure can be specified based on user's experience and circumstances.

If the relieving method is directional (bored hole or passage), consider supplying the valve body with positive indication of the direction of pressure tightness. If it is possible to reverse this direction through improper reassembly of parts, consider securely attaching a tag (often stainless steel) with precautions to the valve.

Plug Valves

Plug valves have been used for phosgene service. A potential drawback associated with plug valves can be that higher torque is required to operate the valve. Like the ball valve, this valve can provide tight shut-off, and with the quarter-turn stem movement the valve can be a reliable stem seal design. The stem design can help mitigate against blow-outs. Plug valves may need to be provided with a means to externally adjust the stem seal.

Plug valves often have a reduced bore similar to the ball valve and are also likely to trap liquid phosgene when closed. Therefore, consider providing the plug and body cavities with a relief hole vented toward the direction of higher pressure.

If the relieving method is directional (bored hole), consider supplying the valve body with positive indication of the direction of pressure tightness. If it is possible to reverse this direction through improper reassembly of parts, consider securely attaching a tag, for example a stainless steel tag, with precautions to the valve.

Soft-Seated " High-Performance" Butterfly Valves

Soft-seated, high-performance butterfly valves have been used in phosgene applications, particularly in the larger pipe sizes. These valves are distinguished from fully-lined butterfly valves primarily through their ASME/ANSI-rated pressure capacity.

Generally, soft-seated, high-performance butterfly valves can use standard adjustable packing, a wetted shaft/disc arrangement and a one-piece, soft-lip seal.

A soft-seated butterfly valve can provide tight shut-off, and, with the quarter-turn stem movement.

Rising Stem Ball Valves

These valves combine the high seating pressure of a globe valve with the ability to achieve full port flow characteristics of ball valves. It is possible that it may not trap liquid when shut off. The falling action of the stem acts through a cam device to turn the ball from the open to closed position. When the ball reaches the closed position, the final action of the stem/cam forces the ball against the seat. Rising action of the stem reverses the action.

Check Valves

Check valves may be useful in phosgene service in applications such as pump headers, where a small amount of reverse flow is acceptable. Check valves are less useful for total isolation or total elimination of reverse flow. In these cases, automatically operated control valves with appropriate instrumentation may be beneficial.

Valve Preparation - Identification Guidelines

Valves outlined in this section for phosgene service address the considerations listed below:

Valve Testing

Valve testing in accordance with ASME B16.34.[1] Alternative test methods may be specified by the user.

Cleaning & Packaging
Valves are specially cleaned, dried and prepared for use in phosgene service, including the use of special phosgene compatible lubricants for valve assembly. Valve complications can be reduced if the valves are packaged in a manner that prevents moisture from entering the ends once preparation is complete.

Use care to protect the integrity of the packaged valves until they are placed in service.

Clean and package in accordance with the user's specifications. Additional information on cleaning and packaging is available (e.g., The Chlorine Institute Pamphlet #6, latest edition).

6.3.4 Other Components

Other components such as instrument items, relief devices, decontamination hoses, temporary items, cylinders and expansion chambers are described in their respective sections.

Expansion Joints
It is important to consider whether phosgene piping systems have sufficient flexibility to prevent failure of the piping system due to thermal expansion or contraction. When flexibility cannot be introduced into the system through pipe routing, bellows expansion joints have been employed to absorb the differential expansion while containing the system pressure, while slip-joints could increase opportunity for leakage.

Bellows expansion joints are engineered products and use appropriate considerations and evaluate before purchase and use. If using expansion joints, consider referring to available material such as ASME B31.3 - Appendix X for additional information relevant to metal expansion joints. Non-metallic expansion joints can be designed and specified with the assistance of the manufacturers.

Hoses
It is not often that either metallic or non-metallic hoses are used in permanent piping systems, and their use in permanent piping connections can enhance the opportunity for leakage. When hoses are required for temporary connections, such as filling and emptying, cylinders and deinventoring equipment, give due consideration to the design, fabrication, testing and certification of all the components. CGA E-9 Standard for Flexible, PTFE-lined Pigtails for Compressed Gas Service (2010), British Standard BS6501 Flexible Metallic Hose Assemblies and the Chlorine Institute Pamphlet No.6 are available sources for additional information regarding the hoses. To help maintain the safe usage of hoses and/or flexible connectors in a phosgene service, consider emphasizing a strong mechanical integrity program, for example include appropriate inspection/replacement schedule of these components.

Where hoses are used with a PTFE liner for connections to rigid piping or cylinders, the hoses are typically used in well ventilated areas due to the potential permeability of the fluoropolymer liner. The permeability may lead to small accumulations of corrosive products within or around the structure of the hose. Tight-fitting banding or sleeves may trap the corrosive acid hydrolysis products within and around the surface of the outer braid. Carefully evaluate the design, use and maintenance of hoses in phosgene transfer that are constructed of permeable cores and materials subject to chlorides corrosion such as outer wire braid, reinforcement, end fittings and connectors.

6.3.5 Piping Layout and Design

Good piping layout can enhance safety, reduce maintenance costs and provide an efficient operation.

General Layout Considerations
Avoid trapping liquid phosgene between valves and to provide expansion chambers or pressure relief. Consider the following:

- Arranging and supporting piping to permit removal of process equipment and components.

- Installing phosgene lines next to steam lines, acid lines, etc. can increase risk of corrosion. Protect phosgene piping from risks of excessive heat or fire.

- Consider limiting the use of vent and drain connections in a phosgene pipeline to the minimum strictly necessary for removal of dirt, liquid or gas. However, consider if all sections that can be blocked in have sufficient connections for clearing the phosgene.

- Consider providing for linear thermal expansion by routing or pipe loops. ASME B31.3 is an available source for information on pipe stress analysis to select routing, loops and supports.

- Piping design can incorporate a means to minimize the possibility of liquid hammer. Phosgene liquid has a high density that can result in large hydraulic shock forces.

- Consider blinding all dead-ended valves/openings.

- Layout of both process equipment and piping and if potential safety benefits resulting from minimizing the length and diameter of piping in phosgene service and reducing phosgene inventory.

Clearances
Road and walkway clearances can be set to minimize the potential for impact damages. Barriers or guardrails may be useful. Railroad and roadway clearances may be regulated by federal, state, provincial or local laws. If phosgene piping must pass through a wall or bulkhead, the maintenance of proper side clearances is important.

Some companies have instituted operational procedures and policies relating to the use of motorized mobile equipment near or around phosgene containing equipment to reduce the potential for exposure to mechanical impact.

Supports
Companies use supports to prevent pipe sagging. It may be necessary to avoid hanging other piping from phosgene lines and conversely, to avoid hanging phosgene lines from other piping. Piping has been supported with hangers, pipe shoes or other items that do not allow metal to wear or corrode. If located in an area where seismic activity can be significant, local codes may require special design considerations.

Routing
Companies may wish to route phosgene piping for the shortest distance practical with consideration given to flexibility, line expansion and good engineering practice. Piping can be designed to avoid pocketing.

Valving

- Locate valves and controls in areas with adequate accessibility.
- Consider locating block valves as close to equipment as possible, also in branch lines at the main header and, where practical, to allow lines to drain away from the valves.
- Minimizing the use of valving can reduce some potential risks.

Tracing

Condensation can occur in gas lines when the temperature drops below the pressure-temperature equilibrium. To help prevent this action, the lines can be traced. Installation of tracing can be such so as to minimize corrosion or decomposition of the piping system.

Electric tracing has been a useful tracing method.. Consider monitoring the condition of the electric tracing system to ensure localized hotspots do not develop in the event of a wiring or control system failure.

Insulation

A key function of insulation is to provide a sufficient moisture barrier to prevent corrosion under the insulation. Engineered access methods, which do not compromise the system moisture barrier, have been used to accommodate thickness testing or external inspection.

Miscellaneous Considerations

- Connectors can be used in lieu of flange joints.
- Reduce confusion by readily identifying phosgene lines.
- Consider keeping the use of flange joints to a minimum.
- Select elastomers, which have been used in piping components, based on factors including relevant service and service conditions.

6.3.6 Preparation for Use

Cleaning

Because phosgene can react with foreign materials, clean all portions of new phosgene systems before use. Remove all residues because phosgene also reacts with water. Clean any equipment received in an oily condition and thoroughly dry before use.

There are various cleaning techniques available, but the appropriate technique for a particular situation will depend on factors such as the nature of the system and the type of contamination. For any technique employed, consider establishing a written procedure to help prevent potential errors. Closely monitor each step of the cleaning procedure. The procedure may include criteria for written acceptance of the effectiveness of the cleaning. Additional information on procedure development, such as the Compressed Gas Association's (CGA's) Pamphlet G-4.1, *Cleaning Equipment for Oxygen Service*, is available.

Refer to applicable federal, state and local regulations when setting your cleaning procedures. The manufacturers of the cleaning product and the equipment to be cleaned can provide useful information.

Three examples of common methods used to clean phosgene systems are described below. Sometimes, a combination of methods can be most useful in a given situation. Because cleaning solutions can collect in joint areas, these locations merit scrutiny. Consideration should be given to valve removal prior to cleaning operations or hydrostatic tests and gasket replacement after cleaning.

Aqueous Cleaning

Aqueous methods are frequently used for both new construction and plant maintenance, particularly for equipment already exposed to phosgene service. Examples include detergents, surfactants, coalescing agents, and inorganic solutions. To remove residue, thorough flushing with water is an option. Steam is often used to purge the pipe and raise the temperature to aid in drying. Care must be taken to address whether the system is thoroughly dried. Gaskets exposed to water during cleaning operations could trap moisture and cause corrosion to the sealing surfaces of piping or vessels. Gaskets may need to be replaced prior to placing the line in service. This also applies to gaskets that may be within vessel internals (e.g., tray gaskets).

Abrasive Cleaning

This method is used primarily on large piping sections for new construction. Types of abrasives include sand, steel shot, garnet, etc. The isolation of valves, instruments and process equipment can help prevent potential damage. It is important that all blasting residue is removed from pipe sections prior to installation. Check whether the system is thoroughly dried.

Solvent Cleaning
Solvents are most often used for cleaning individual components (e.g., valves, relief valves and instruments), especially parts that can be cleaned in commercial vapor degreasing equipment. For large phosgene systems, this method may be used due to the need for addressing environmental and industrial hygiene risks. While many solvents are excellent cleaning agents, they could pose significant risks due to toxicity, flammability or reactivity with phosgene. In selecting a solvent for use, consider factors such as whether the solvent:

- is available as a liquid in convenient containers;
- is compatible with materials of construction;
- is non-reactive with phosgene;
- is considered nonflammable;
- has relatively low vapor pressure;
- has a low toxicity rating; and
- is capable of removing the contamination.

Although most solvents may not meet all the above criteria, the user can prioritize these criteria and other potential criteria to select the best solvent for the application.

6.3.7 Leak Testing

Develop leak-testing procedures tailored to a company's own particular needs and circumstances. Additional information on leak testing, such as ASME B31.3, is available. Under ASME B31.3, Chapter VIII, phosgene is classified as a category "M" fluid. The ASME publication provides standards concerning radiographic examination for circumferential field welds and shop weld joints. (See ASME B31.3 for further information). While socket welded fittings are listed in Table 2-1, they cannot be radiographically tested for mechanical integrity. Some companies perform dye-penetrant testing for socket weld fittings. The use of butt-welded construction can allow for full weld penetration and radiographic mechanical integrity inspection.

6.3.8 Drying

It is important to consider whether the phosgene piping systems are adequately dried before being placed in service. Even if water has not been purposely introduced into the system for hydrostatic testing or cleaning, moisture may enter the system from the atmosphere or other sources. Where steam has been used for cleaning, companies can introduce nitrogen or dry air directly after the steaming. Heating the purge gas can aid considerably in the drying process. Base the temperature on the equipment and insulation type. Companies can start the purge gas flow at high volume rates to sweep the moisture out of the piping system, then reduce the rate. For example, ensure the system is dried until all the vent gas streams leaving have an appropriate dew point. Refer to the manufacturer for the appropriate dew point. This figure would be measured at normal system operating pressure or reasonably close to the entering purge gas dew point. Reducing the purge rates to a minimum, allow adequate time for the purge gas to reach equilibrium when the dew point is taken. Dew point measurements can be taken from different locations of the piping and equipment system being dried.

Direct drying using ambient-temperature dry air or nitrogen purge may take an extended period of time. This time can be decreased by the use of a pressure cycling technique. Commercial system dehydrators are available and normally dry piping and equipment by circulating or purging with large volumes of heated nitrogen.

Vacuum dehydration can also be considered after the majority of phased water has been purged from the system. This may be useful following the steam heating / nitrogen purge step, and can also be used for leak checking the system.

Valves

Consider valve removal for disassembly and drying if water has entered the piping system. Most valves, regardless of style, have pockets where water can be trapped, especially if the valve is fully open. It can be important that valves left in the piping system are fixed in the half-open position when the system is being dried. To help ensure that water or moisture is not trapped in a cavity, a check can be run on valves removed temporarily from the system during the drying operation. These valves are thoroughly dried prior to replacement in the piping system if they are not dried with the rest of the system. Make personnel responsible for drying the system familiar with valve construction and aware of places where water or moisture can be trapped.

6.3.9 Preventative Inspection & Maintenance

Preventative Maintenance
As part of an over-all preventative maintenance program, companies may consider checking the following items:

- Flange bolt condition and tightness
- Valve packing leaks
- Valve bonnet leaks
- Valve operation
- Threaded joints
- Insulation condition
- Tubing connections
- Paint condition
- Condition of supports
- External corrosion

Repainting on a regular basis can help maximize pipe life and minimize leaks by reducing external corrosion. Timing for this activity is determined by individual site conditions.

Periodic Inspections
Inspecting phosgene-piping systems on a regular basis can reduce potential risks. Methods include those such as visual inspections, ultrasonic thickness checks and non-destructive radiography checks. In many situations, the visual inspection is an most important inspection that can be done with other methods used to supplement. Documenting the results of all inspections helps provide for a thorough and consistent maintenance program.

Visual
Part of a visual inspection may encompass a leak check of all flanges, valves and other fittings and attachments. Particular areas of concern may include but are not limited to: items such as pipe supports, areas with paint or insulation damage, and weld areas, which can corrode more quickly. W here insulation is damaged, consider further inspection. Pitting or wall loss are also items to look for in a visual inspection.

Non-Destructive Testing
Non-destructive testing methods measure pipe wall thickness, pit depths and internal and external erosion/corrosion. These methods include ultrasonic thickness measurements and radiographic measurements.

Routine testing can indicate corrosion rates typical for the system so that the timing of major reports can be estimated. Consider checking areas of high fluid velocity more frequently due to possible internal erosion.

Radiographic techniques are available to check pipe wall thickness through insulation. This approach permits checking piping systems without breaking the vapor barrier of the insulation. If test methods are used which require the removal of insulation, then consider whether the insulation vapor barrier integrity has been properly restored.

Inspection, Repair, Alterations & Re-Rating
Information on periodic inspection, repairs, alterations and re-rating of piping components, such as API 570 and API 574, is available for companies to consider.

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Contacts

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https://www.asme.org/

United Engineering Center
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