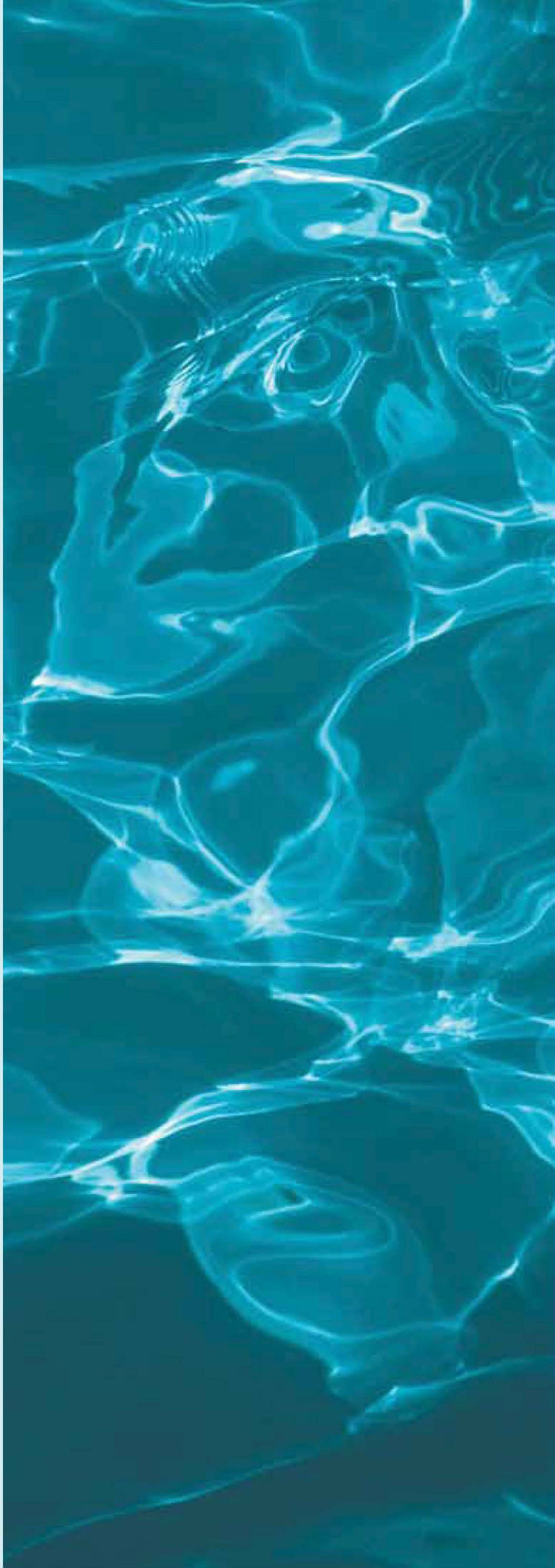
THE CHLORINE INSTITUTE

Pamphlet 60

Chlorine Pipelines

Edition 8



A LEGACY OF 1924 since SAFETY STEWARDSHIP

September 2019

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1. INTRODUCTION

1.1 SCOPE

This pamphlet provides recommendations on the design, construction, operation and maintenance of carbon steel pipelines that transport chlorine liquid or gas. The recommendations are applicable to pipelines that terminate outside the chlorine shipper's property, or cross property not owned by the shipper or receiver of the chlorine.

The recommendations contained in this pamphlet are to be considered in light of the following:

The Chlorine Institute (the Institute or CI) recommends operators of chlorine pipelines utilize Parts 191, 192 and 195 of Title 49 of the U.S. Code of Federal Regulations (49 CFR) as a minimum standard for design, inspection and testing of both liquid and gas pipelines where relevant. It is recognized that Part 195 does not cover liquid chlorine and that the reporting requirements of the regulation do not apply to liquid chlorine pipelines.

- Chlorine pipelines that do not cross state boundaries may be subject to regulations that are more stringent than those required by DOT or by recommendations in this pamphlet.

- For pipelines entirely within a plant, refer to CI Pamphlet 6 (*11.1*).

It is recognized that pipelines built prior to the publication of this edition of this pamphlet may be operating successfully without adhering to all recommendations contained herein. Operators of such facilities should evaluate discrepancies and validate that they do not pose disproportionate risks to safe operation or the environment. Continued operation without adhering to all aspects of this pamphlet is generally acceptable provided:

(1) Previous, successful, long-term operation, coupled with periodic hazard evaluations, show that risks to safe operation and the environment are sufficiently low;

(2) The system does not violate applicable codes or regulations; and

(3) Consideration is given to modifying the system to meet recommendations contained in this edition of the pamphlet when redesign or replacement projects are planned.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute exists to support the chlor-alkali industry in advancing safe, secure, environmentally compatible, and sustainable production, distribution, and use of its mission chemicals[1].

Institute members are committed to adopting CI's safety and stewardship initiatives, including CI pamphlets, checklists, and incident sharing, that will assist members in achieving measurable improvement. For more information on the Institute's stewardship program, visit CI's website at www.chlorineinstitute.org.

1.3 DEFINITIONS AND ACRONYMS

In this pamphlet, the following meanings apply, unless otherwise noted:

ANSI	American National Standards Institute, Inc.
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASME Code	ASME Boiler and Pressure Vessel Code (*Section VIII - Rules for Construction of Pressure Vessels; Section IX – Welding, Brazing, and Fusing Qualifications, and ASME B31.3 - Chemical Plant and Petroleum Refinery Piping*)
CAER	Community Awareness and Emergency Response
CFR	Code of Federal Regulations (U.S.)
chlorine	dry chlorine (either gas or liquid)
CI	The Chlorine Institute
control device	A chlorine storage or absorption system
DHS	Department of Homeland Security (U.S.)
DOT	Department of Transportation (U.S.)
dry air or nitrogen	air or nitrogen dried to a dew point of -40°F (-40°C) or below measured at the operating pressure
EPA	Environmental Protection Agency (U.S.)

[1] CI's mission chemicals: chlorine, sodium and potassium hydroxides, sodium hypochlorite, the distribution of vinyl chloride monomer (VCM), and the distribution and use of hydrogen chloride.

Institute	The Chlorine Institute
kPa	Kilopascal(s)
LEPC	Local Emergency Planning Committee
NCl_3	nitrogen trichloride
NDT	non-destructive testing
OSHA	Occupational Safety and Health Administration, U.S. Department of Labor
PHMSA	Pipeline and Hazardous Materials Safety Administration, DOT
PTFE	polytetrafluoroethylene
psig	pound per square inch gauge
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SMYS	specified minimum yield stress

1.4 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The Institute and its members, jointly and severally, make no guarantee and assume no liability in connection with any of this information. Moreover, it should not be assumed that every acceptable procedure is included or that special circumstances may not warrant modified or additional procedure. The user should be aware that changing technology or regulations may require a change in the recommendations herein. Appropriate steps should not be confused with federal, state, provincial, municipal or insurance requirements, or with national safety codes.

1.5 APPROVAL

The Institute's Transportation Issue Team approved Edition 8 of this pamphlet on September 17, 2019.

1.6 REVISIONS

Suggestions for revision should be directed to the Secretary of the Institute.

1.6.1 Significant Revisions in Current Edition

Significant revisions in Edition 8 of this pamphlet include:

- Additions and updates to guidance on pipeline design (Section 3);
- Additional explanation of why to avoid double-walled piping (Section 3);
- Caution on avoiding corrosion under insulation (Section 3);

- Revisions to inspection guidance (Section 7);
- Additional security guidance (Section 8); and
- Minor revisions throughout.

1.7 REPRODUCTION

2. GENERAL

2.1 BASIC CONSIDERATIONS

For general considerations in chlorine handling, refer to CI Pamphlet 1 (*11.1*).

2.2 GAS AND LIQUID PHASE CHANGES

Chlorine pipelines are operated in either the liquid or vapor phase. Suitable steps must be taken in design and operation to ensure adequate control of the process temperature and pressure. The chlorine phase diagram (CI Pamphlet 100 (*11.1*)) defines the temperature and pressure combinations needed to maintain the desired state. It is essential that a study of operating conditions be thoroughly carried out, because unusual equipment design and pressure ratings may be required to address the potential for vaporizing or condensing in the pipeline.

Phase changes are generally most difficult to handle during start-up. The introduction of liquid chlorine into a pipeline can cause flashing from the liquid to the gas phase at the leading edge of the liquid. A pressure drop in the pipeline can also cause such a phase change to occur. This phase change can cause "vapor locks" in the line if the gas is not purged. The presence of chlorine vapors in a liquid pipeline can cause flow restrictions.

Chlorine vapor introduced into a pipeline may expand, cool, and partially condense. When this happens, sudden pressure swings may occur in the line pressure. An effective way to prevent this is to provide a source of heat for the pipeline. A phase change can also be caused by pipeline cooling due to ambient conditions. For pipelines exposed to ambient conditions lower than the saturation temperature, regulated heat tracing and/or insulation should be considered. Changes in elevation and ambient conditions can also cause a phase change.

Pressure reduction points, such as pressure control or regulating valves, are the most likely locations for phase changes in a pipeline. In gas pipelines the refrigeration effect of expanding chlorine gas may cause a portion of the gas to condense into the liquid phase. A pressure drop can cause the liquid to vaporize in liquid pipelines.

2.3 DESIGN CONSIDERATIONS

Suitable consideration of the consequences of a leak and suitable means of minimizing or handling leaks must be undertaken in the early stages of design. Liquid chlorine pipelines generally have a larger chlorine inventory than gas pipelines therefore liquid pipeline leaks have the potential to be more severe.

2.4 ROUTING

When choosing a route for a pipeline, special consideration must be given to populated and environmentally sensitive areas. Consideration should also be given to potential pipeline damage due to adjacent pipelines, soil conditions, traffic, vandalism, commercial operations and other conditions along the route. These considerations are especially important when the pipeline traverses ground not under direct control of either the producer or the consumer. To comply with the U.S. Department of Transportation (DOT) regulations, a class location study may be required (49 CFR 192.5 (*11.2.1*)).

2.5 FEDERAL, STATE AND LOCAL REGULATIONS

DOT regulations generally provide the minimum standard in all states. However, additional federal, state or local regulations may apply. Regulations may be imposed by such agencies as the U.S. Coast Guard, the U.S. Environmental Protection Agency (EPA), Department of Homeland Security (DHS), or other national state, or local agencies with jurisdiction. It is the operator's responsibility to determine whether such additional regulations apply and to comply with any superseding regulation.

2.5.1 Transportation of Gas by Pipeline

The DOT regulations in 49 CFR (*11.2*) governing the transportation of hazardous gases (including chlorine gas) by pipeline are outlined below:

- Part 190 - "Pipeline Safety Program and Rulemaking Procedures."
- Part 191 - "Transportation of Natural and other Gas by Pipeline: Annual Reports, Incident Reports and Safety-Related Condition Reports."
- Part 192 - "Transportation of Natural and other Gas by Pipeline: Minimum Federal Safety Standards."

2.5.2 Transportation of Liquid by Pipeline

49 CFR Part 195 regulates the transportation of hazardous liquids by pipeline. Although liquid chlorine is not on the 49 CFR Part 195 list of hazardous liquids, many of the recommendations herein have been written in accord with these regulations.

3. DESIGN

3.1 GENERAL DESIGN CONSIDERATIONS

The minimum specifications for materials used in chlorine service can be found in CI Pamphlet 6 (*11.1*). Additionally, piping materials conforming to the American Petroleum Institute (API) Specification (5L (API SPEC 5L) may be considered for chlorine pipelines (*11.5.2*). API pipelines are more ductile than process piping materials indicated in CI Pamphlet 6. Design specifications need to be determined based on the potential range of operating conditions of the pipeline system including start-ups, abnormal operating conditions, shutdowns, and system evacuation. In selecting materials careful consideration should be given to the minimum temperature to which any part of the system may be subjected. Additional cold service Charpy testing per the American Society of Mechanical Engineers (ASME) Code may be required if API SPEC 5L piping is used. It should be noted that the boiling point of chlorine at atmospheric pressure is -30°F (-34°C). This is the temperature a pipeline may be subjected to when a liquid chlorine pipeline is vented to atmospheric pressure. For the vapor pressure curve of chlorine, see CI Pamphlet 1 (*11.1*).

The maximum recommended temperature to which any section of a carbon steel pipeline will be subjected should not exceed 300°F (149°C).

The designer should review and consider applicable federal regulations such as 49 CFR Part 195 (*11.2.1*).

3.2 INSTALLATION AND CONSTRUCTION

3.2.1 General

Pipelines may be installed above or below ground. The entire system should be evaluated to determine the preferred method.

- It is easier to monitor an aboveground system, but overall safety considerations may indicate an underground pipeline is preferred. Underground piping should be buried at a level below the normal frost line and not less than that required by regulation. Federal regulations require a pipeline to be buried to a depth of 2 or 3 feet. Consideration should be given to burying the line deeper to prevent accidental impact and allow for warning indicators to be buried above the pipeline.

- Special attention should be given to protecting the pipe from corrosion, especially at points where buried lines enter and leave the ground. Thick walls should be considered on chlorine pipelines to allow for corrosion and provide mechanical strength. Use of thick-walled pipe allows the pipeline to be used beyond the normal life of plant process piping.

- Provision must be made to evacuate the line to a safe location. This includes a controlled device at one or both ends of the pipeline.

- Where necessary to cross right-of-ways, roadway, highway or waterway, the pipeline must be designed with sufficient protections such as height above grade to preclude vehicular damage or be installed belowground. When crossing navigable waterways the pipeline should be buried well below the bottom so the line cannot be impacted by passing vessels or dredging activities.

- Underground piping can suffer third party damage due to poor excavation techniques. The design should consider means to reduce potential to sustain any damage to the pipeline. Design techniques that have been used successfully include increased depth of cover, increasing wall thickness, and concrete coating of the pipe.

- Vents and drains outside the supplier's or customer's property should be avoided if possible. Vents, drains, or other small protrusions from main lines that must be installed should be protected from potential damage.

- Consideration should be given to underground line marking tapes to notify excavators of the existence of an underground line and/or sacrificial fiber-optic alarm cable installed above the pipeline.

- Double-walled pipe should not be used, except where required by regulations for situations such as casings under roads, etc. In cases where double-walled pipe is used, steps should be taken to prevent moisture accumulation in the annular space. It is not recommended in other situations due to concerns in the annular space about liquid chlorine thermal expansion, difficulty of inspection, and potential nitrogen trichloride (NCl_3) accumulation.

- All pipelines should be well-supported and anchors should be capable of withstanding hydraulic forces that can result from starting and stopping flow.

- For gas pipelines, leak detection systems are required by 49 CFR Part 192. Consideration should be given to installing an automated leak detection system on liquid pipelines. This could be something as simple as measuring mass flow on each end of the line or a leak detection system which employs both pressure analysis and mass balance to verify the line is not leaking.

3.2.2 Welding

The welding of steel pipelines must be performed in accordance with written welding procedures that have been qualified under Section IX of the ASME Code (*11.4.2*) or Section VI of API 1104 (*11.5.3*). Welders must be certified for each procedure.

3.2.3 Heat Treatment

If required by ASME B31.3, welds must be preheated and/or stress relieved (*11.4.7*).

3.2.4 Inspection and Test of Welds

Visual inspection of all welds is required. Nondestructive testing procedures must be used in accordance with ASME B31.3 (*11.4.7*). This procedure includes radiography, dye penetrant, or other test methods recognized by ASME.

All butt welds are to be 100% radiographed. A combination of radiography and/or dye penetrant testing procedures should be used for all welds depending on the weld configuration. The weld area and pipe should be thoroughly cleaned after dye penetrant testing.

Radiographic techniques will identify many types of weld defects but are not fully effective for all weld configurations. Dye penetrant testing will sometimes locate weld defects not identified by radiographic techniques.

3.3 INSULATION AND LINE PROTECTION

3.3.1 Aboveground Piping – Insulation/Heat Tracing

The necessity to keep the line contents at the intended phase is the primary consideration in determining the need to insulate a system. Insulated pipes should have an appropriate exterior painting system similar to an uninsulated pipe. A reflective outer jacketing should be considered when covering insulated piping. This would reduce heat transfer with ambient sources. Recommended insulation is polyurethane foam or foam glass block protected by an adequate outer fire-resistant weather barrier. Polyisocyanurate insulation is also known to be used successfully in the chlor-alkali industry. Precautions to prevent corrosion under insulation can be found in CI Pamphlet 6 (*11.1*). Further guidance can be found in API Recommended Practice 583, *Corrosion Under Insulation and Fireproofing* (*11.5.1*).

Any heat tracing installation should be designed such that the surface temperature of the pipe shall not exceed 300°F (149°C), see CI Pamphlet 1 (*11.1*).

3.3.2 Aboveground Piping - Fire / Heat Protection

Where the risks for elevated temperatures exist, including fire or any other undesirable heat source (e.g. hot vent streams, adjacent steam lines or combustible materials), the chlorine line should be protected. The designer may consider physical isolation from other pipes in the pipe rack, erection of a fire-resistant barrier between the lines, or insulation of the chlorine line. Insulation in this case should be fire resistant material such as foam glass with a fire-resistant barrier on the outside.

3.3.3 Buried Lines - External Protection

All new buried pipelines, as well as repairs to existing lines, must be coated and wrapped. All buried pipelines must be evaluated to determine the need and adequacy of cathodic protection. Any changes to conditions along the route may require modifications to the external protection of the pipeline.

3.4 THERMAL PIPE EXPANSION

Provision must be made for thermal pipe expansion in the system. It is recommended that aboveground pipelines be designed utilizing flexibility analysis. If drains or vents are present, their volume should be included when designing for expansion.

3.5 LIQUID EXPANSION IN LIQUID PIPELINES

Liquid chlorine has a very high coefficient of thermal expansion. If liquid chlorine is trapped between two valves, the pressure of the blocked-in section will increase as the line temperature increases. The pressure can rise beyond the pressure rating of the line with only a small increase in temperature, with the potential to cause a leak or line failure.

An expansion chamber is connected to a pipeline to allow room for expansion of the liquid. An expansion chamber should be installed on top of the pipeline and be filled with dry air or an inert gas. The gas in the expansion chamber is compressed as the pressure in the line increases and protects the line from experiencing the extremely high pressure that can be caused by liquid-full hydraulic expansion.

Institute Drawing 136, which is included in CI Pamphlet 6, shows two suggested alternatives for expansion chamber installation (*11.1*). The expansion chamber should be designed so it can be isolated and cleared. Expansion chamber installation should include pressure indication to warn when the rupture disc has allowed flow into the chamber.

When expansion chambers are designed to meet the ASME Code Section VIII, a pressure relief device may be required. However, ASME UG-140 (formerly known as Code Case 2211) allows the user to provide overpressure protection via system design in lieu of a pressure relief device (*11.4.1*). Therefore, if the expansion chamber is designed to withstand a pressure greater than the maximum system pressure, a pressure relief device may not be required on the expansion chamber.

The expansion chamber should have a volume of at least 20% of the pipeline section being protected based on thermal expansion of liquid chlorine between 0°F (-18°C) and 140°F (60°C).

3.6 VALVE LOCATION

Regulations sometimes require the use of valves at locations along a pipeline to minimize the consequences from accidental discharge. In balancing this against environmental concerns for fugitive emissions, which can occur at each valve location, and the possibility of blocking in a section of line that is liquid full, it is the Institute's recommendation that valves be located at both ends of a pipeline (inside supplier's and customer's locations).

If offsite isolation valves are required, they should be located and protected to prevent access by unauthorized persons. Preferably, isolation valves should be located within an industrial site.

Isolation valves may be closed manually, remotely and/or automatically when a leak is detected. For automated remotely activated valves, valve position should be monitored.

Remotely operated valves require an energy source to close and should be equipped for manual as well as automatic operation. These may be used in either liquid or vapor pipelines.

Precautions should be taken to avoid liquid hammer in the event of a too rapid closure of the valve. This can be accomplished by controlling the rate of valve closure or by installing a buffer vessel.

3.7 VENT AND DRAIN BRANCHES

The use of vent and drain branches in a chlorine pipeline should be limited to the minimum number necessary for operation. Branches increase the risk of a leak and are difficult to insulate, allowing a location for corrosion to initiate. Branches added to test and prepare the line for service should be minimized or removed afterwards.

Vents and drains should be located inside the supplier's or customer's plant site.

3.8 MECHANICAL CLEANING

The designer needs to review the requirements associated with mechanical cleaning or inspection.

If a pigging system will be used for cleaning or if a smart pig will be used for inspections, the following features should be included at a minimum. Additional features may be required for use of pigs or smart pigs:

- Full port valves
- Radius of curvature must allow passage
- Pig catcher at one end and a launcher at the other
- Guide bars in piping tees

4. MARKING

4.1 LINE MARKERS

Underground pipelines should be provided with aboveground markers at public road crossings, at railroad crossings, and in sufficient number along the pipeline so that its location is accurately known to reduce the possibility of damage or interference. Aboveground pipelines should be provided with markers along sections of the pipeline that are in areas accessible to the public. For some pipelines, line marking may be required by 49 CFR Part 192 (*11.2.1*) and by state and local regulations. Additional line markings may be required.

4.2 LINE MARKER WORDING

The wording on the line marker should be "WARNING - LIQUEFIED CHLORINE UNDER PRESSURE" or "WARNING - CHLORINE GAS UNDER PRESSURE" and should include the name of the operator and telephone number where the operator can be reached at all times.

5. PREPARATION FOR USE

CI Pamphlet 6 includes details applicable for chlorine pipelines (*11.1*). Additional information specific to preparing chlorine pipelines for use is contained in this pamphlet.

5.1 PRESSURE TESTING

5.1.1 Chlorine Gas Piping

New, relocated, or replaced chlorine gas pipelines and modified sections of existing gas pipelines are to be pressure tested in accordance with 49 CFR Part 192 Subpart J (*11.2.1*) and CI Pamphlet 6 (*11.1*) until all leaks have been located and eliminated. To increase the rated pressure of a chlorine pipeline, it must comply with 49 CFR Part 192 Subpart K (*11.2.1*).

Chlorine gas piping intended to operate at a hoop stress of 30% or more of the specified minimum yield stress (SMYS) must meet the requirements of 49 CFR Part 192 Subpart J. This includes a hydrostatic test for a minimum of eight continuous hours at 1.25 times the maximum pressure to which the system may be subjected.

Less stringent testing conditions may apply depending on the pipeline DOT location class, intended operating pressure, the extent of the piping installation and the scope of modifications made to existing pipelines.

Air or inert gas may be used as a test medium. The operation of a chlorine gas piping system, tested in this manner, may be limited to lower stress conditions. Care should be taken to limit personnel exposure while conducting tests with these media. Refer to CI Pamphlet 6 for more information on pipeline pressure testing.

Following hydrostatic testing, it is essential that chlorine pipeline systems be thoroughly dried prior to service.

5.1.2 Liquid Chlorine Piping

Although 49 CFR Part 195 does not apply to liquid chlorine pipelines, it is recommended that testing be done as specified above for chlorine gas piping (*11.2.1*).

5.2 CLEANING

The preferred method for removal of dirt, weld spatter, chlorine, etc. from a chlorine pipeline is with a pig, which is forced through the pipeline by dry air or nitrogen pressure. CI Pamphlet 6 explains several chlorine piping system cleaning methods (*11.1*).

The aqueous and abrasive cleaning methods are most commonly used on large pipelines. The solvent cleaning method is not normally used for cleaning pipelines because of the need to address the environmental and industrial hygiene risks associated with most solvents. If moisture is introduced into a pipeline, all moisture-absorbing gaskets and valve packing must be replaced. Consideration should be given to removing valves prior to introducing moisture.

5.3 DRYING

Refer to CI Pamphlet 6 for details regarding proper drying of a chlorine line after it has been exposed to moisture (liquid or atmospheric) and for details on the special attention needed to ensure that valves do not contain water (*11.1*).

5.4 TESTING FOR LEAKS

Refer to CI Pamphlet 6 for details on testing chlorine piping for leaks (*11.1*).

6. OPERATION AND MAINTENANCE GUIDELINES

6.1 GENERAL

The pipeline operator must have procedures for the operation and maintenance of chlorine pipelines. For new pipelines, the procedures must be prepared before the start of pipeline operation. Various regulations require proof of personnel being trained on the procedures.

The procedures must encompass startup, shutdown, abnormal process operations, normal operation, maintenance and inspection procedures, and address procedures to be used in case of emergencies.

The procedures must be reviewed and updated once per calendar year or at a period not exceeding 15 months and kept at locations where operations and maintenance activities are conducted (49 CFR 192.605 (*11.2.1*) and 29 CFR Part 1910 (*11.3.1*)).

6.2 OPERATION GUIDELINES

6.2.1 Before placing a pipeline in service review Section 5 and ensure the following:

a. Clean the line and ensure it is free of oil and grease. Chlorine will react vigorously with hydrocarbon-based lubricants.

b. Dry the line with oil-free, dry air or nitrogen.

c. When starting a liquid chlorine line, precautions should be taken to minimize flashing when chlorine is initially introduced. Failure to do this may subject the line to temperatures below the design limitations.

6.2.2 During Operation

a. The line should be maintained at conditions that ensure the proper state, gas or liquid, at all times.

b. Only dry chlorine should be introduced into steel pipelines.

c. Operating data should be obtained and continuously evaluated to assure the integrity of the system. Applicable regulatory requirements must be met.

6.2.3 Removing Pipelines from Liquid Chlorine Service

a. Slowly reduce flow rate while maintaining system pressure.

b. If line is not to be emptied, the system must be able to handle thermal expansion of trapped liquid. System pressure must be maintained to prevent evaporation of liquid in the pipeline.

c. If line is to be emptied, close isolation valves. Use dry air or inert gas to purge to the appropriate control device. After liquid is purged proceed to “Removing Pipelines from Gaseous Chlorine Service.”

6.2.4 Removing Pipelines from Gaseous Chlorine Service

a. If line is not to be emptied, maintain at low enough pressure to prevent condensing chlorine in pipelines.

b. If line is to be emptied, isolate the pipeline. After evacuation, use dry air or inert gas to purge to the control device. Isolate the purge system when complete.

6.3 MAINTENANCE GUIDELINES AND PRECAUTIONS

6.3.1 Welding

Do not attempt to repair chlorine piping or equipment by burning or welding until all chlorine and traces of chlorine-associated residues have been purged from the system. Burning or welding can cause steel to react rapidly with chlorine and even burst into flame. Hot work of any kind must not be performed on an in-service chlorine pipeline. Following hot work, lines should be cooled prior to introduction of chlorine. Refer to Section 3.2 for welding guidelines. Chlorine lines should not be used to attach grounding leads for other welding operations while containing chlorine. Doing so may cause a hot spot at the point of attachment that could lead to a chlorine-iron fire.

6.3.2 Moisture

Every effort should be made to prevent the introduction of moisture into a dry chlorine piping system. Pipelines not in service should be sealed, dried, and padded. Wet chlorine is very corrosive to steel piping.

6.3.3 Lubricants and Seals

All materials used as lubricants, greases, packings, seals and gaskets (CI Pamphlet 95 (*11.1*)) must be non-reactive with chlorine. Chlorine will react vigorously with hydrocarbon-based lubricants that are not fully halogenated. A list of lubricants and greases used successfully by CI members can be found in CI Pamphlet 164 Section 2.3 (*11.1*).

Fluorocarbon grease may be used as a gasket dope but care should be taken to ensure it will not degrade the gasket. Where thread dope is used, care must be taken to prevent the material from entering the piping system. Thread dopes may include polytetrafluoroethylene (PTFE) tape, PTFE paste, white lead paste, litharge and glycerin. Special chlorine compatible lubricants are used in the assembly of valves for chlorine service.

6.3.4 Protective Coatings

The integrity of protective coatings on pipelines must be preserved. Corrosion under insulation may damage chlorine piping, particularly if it is subjected to freeze-thaw cycles. Any damage to the coating should be promptly and completely repaired.

6.3.5 Valves

Each valve necessary for the safe operation of the system shall be inspected and operated in accordance with manufacturer's instructions and applicable regulations.

7. INSPECTION, TESTING, AND MONITORING

7.1 GENERAL

Due to the characteristics of chlorine, the guidelines listed below are in some cases more rigorous than those required by regulation. The owner/operator shall have written procedures for inspection and surveillance. All activity must be documented to verify adherence to procedures as required by regulation (CI Pamphlet 6 (*11.1*)).

7.2 CONTINUING SURVEILLANCE AND DAMAGE PREVENTION

There should be an on-going pipeline surveillance program. Information should be recorded and evaluated to determine the condition of the pipeline and to schedule needed repairs (49 CFR 192.613). Operators of gas pipelines must be aware of, and comply with, the rules for pipeline integrity as defined in 49 CFR Part 192 Subpart O (*11.2.1*).

For buried pipelines outside the physical confines of the operator's facility, a damage prevention program should be maintained. All operators of buried pipelines must comply with requirements to participate in a one-call network to provide notification of excavation when required by state or federal law (49 CFR 192.614). Public education may be required (49 CFR 192.616) (*11.2.1*).

7.2.1 Weekly Patrol

The pipeline and pipeline right-of-way should be surveyed visually each week. The survey should be by pedestrian patrol, vehicular patrol, or aircraft patrol as best suited by the routing of the line. The inspector should look for leaks, vegetation kills, or impending excavation or construction that could damage the line.

7.2.2 Monthly Inspection

The above-ground portion of the pipeline should be inspected for leaks, damage, or serious external corrosion each month. For the below ground portion of the pipeline walk, drive or fly the entire right-of-way inspecting surface conditions and report any possible leakage. During the right-of-way inspection observe for signs of activity (excavations, heavy equipment, etc.) that could compromise the pipeline covering and protection. Follow-up accordingly to ensure proper protection of the pipeline. If applicable, the cathodic protection voltage should be checked at points that represent the voltage over the entire length of the line.

7.2.3 Bi-Monthly Inspection

The cathodic protection rectifiers, reverse current switches, and interference bonds should be inspected and preventive maintenance performed every two months (not exceeding 10 weeks). Coating or insulation deterioration should be repaired as necessary. Any required maintenance should be performed (49 CFR 192.465 (*11.2.1*)).

7.2.4 Valve Inspection

Valves necessary for the safe operation of the system should be inspected and partially operated at intervals not exceeding 7.5 months (49 CFR 195.420 (*11.2.1*)).

7.2.5 Mechanical Integrity Inspection

The preferred method for inspection and evaluation of chlorine pipelines is to utilize “smart pig” technology. This technology provides wall thickness and detection of pits, cracks, and other defects around the full circumference of the pipe for the entire length of the pipeline.

The smart pig evaluation shall be conducted on a maximum interval of seven years (more frequently, as required, taking into consideration pipeline design criteria, historical information, potential for internal or external corrosion, ongoing adequacy of cathodic protection equipment, stress locations such as railroads/roads, river crossing, etc.).

All new pipelines constructed must be designed to allow for the use of smart pig technology for inspections.

For existing pipelines where the design does not allow for the use of smart pigs (e.g. sharp radius elbows, non-full port valves, etc.) the below inspection methods can be utilized.

Above-Ground Sections of Pipeline

The owner should use the same direct assessment inspection method(s) that is used to inspect and monitor in-plant chlorine process piping. Inspection frequency criteria should follow the same criteria as used for determining in-plant chlorine process piping inspection frequency except for pipelines, the inspection frequency should not exceed five years.

Underground Sections of Pipeline

Assessment of underground pipelines is more difficult than aboveground pipelines because excavation is required to expose the outer surface of the pipeline for non-destructive testing (NDT). With excavation in mind each pipeline should have an inspection plan developed showing the locations for NDT evaluations to be performed during each inspection. Multiple inspection points along the entire length of the pipeline are recommended. Depending on the pipeline routing only the beginning and end of the pipeline may be able to be inspected due to right-of-ways and land ownership.

Air-to-Ground Pipeline Interface

An external visual inspection of the air-to-ground interface of pipelines shall be conducted every five years verifying that the interface wrap is in good condition. It is not necessary to remove the wrap to conduct this inspection.

A detailed inspection should be conducted every 15 years. This entails excavating the pipe to a minimum of two feet at the air-to-ground interface or until the coating/wrapping appears to be in acceptable condition. Following the removal of the wrap, detailed visual inspection and an appropriate NDT inspection shall be conducted. The base coating shall be repaired as needed, which may require blasting and re-coating of the entire area followed by application of proper paint/coating per owner specifications. A sufficient amount of time for the coating repairs to cure shall be allowed prior to applying tape wrap system.

7.2.6 Navigable Water Crossing

Liquid pipelines crossing a navigable waterway should be inspected at an interval not exceeding five years to determine the condition of the crossing.

Gas pipelines must be inspected according to 49 CFR 195.412 (*11.2.1*).

7.2.7 Continuous Overline Cathodic Protection Survey

For underground lines with cathodic protection applied, a continuous overline cathodic protection survey should be conducted once every five years to determine the level of uniformity of cathodic protection.

7.3 MONITORING OF EXPANSION BOTTLES

With each inspection of the pipeline, the expansion bottles and rupture discs shall be inspected for proper condition. Refer to Institute Drawing 136 which is included in CI Pamphlet 6 (*11.1*).

8. EMERGENCY PLANNING

8.1 EMERGENCY CONTROL PLAN

Each pipeline operator will have written procedures to minimize the hazards resulting from a chlorine pipeline emergency. Reference CI Pamphlet 64 as a guide to establishing an emergency control plan (*11.1*). For gas pipelines, this may be required by 49 CFR 192 (*11.2.1*) and by federal, state and/or local regulations.

Pipeline operators must comply with requirements to participate in a "One-Call Network." The emergency control plan must enable the operator to reach all areas affected by any pipeline emergency. The pipeline operator should establish a continuing education program on emergency procedures to enable operators, customers, the public and appropriate organizations (police, fire) to recognize a pipeline emergency.

8.2 SARA AND TITLE III

The Superfund Amendments and Reauthorization Act (SARA), which includes the Emergency Planning and Community Right-to-Know Act (Title III) should be reviewed to ensure that pipelines comply with applicable requirements of these regulations.

8.3 CAER SYSTEM

A Community Awareness and Emergency Response (CAER) system should be established at each plant location in cooperation with the Local Emergency Planning Committee (LEPC) in that area for the purpose of alerting the public to a potential release of chemicals. This system should provide for notification of all individuals within the predicted area of exposure to allow those persons to evacuate or to prepare to stay indoors until the danger has passed.

8.4 SECURITY

Needs for security should be developed with local, state and federal agencies.

For new installations, consideration should be given to installing an intrusion detection system with the pipeline. The intrusion detection system should provide the owner/operator indication of activity around the pipeline. Some intrusion systems (i.e. fiber optic cable) can also provide the location of the intrusion along the pipeline.

9. PERSONNEL QUALIFICATION

Each pipeline operator should have a written qualification program for individuals who perform operational, inspection and maintenance tasks on pipelines. This includes record keeping and emergency response training. For gas pipelines, this may be required by 49 CFR Part 192 (*11.2.1*) and by local, state, and/or federal regulations.

10. RECORDKEEPING AND ACCIDENT REPORTING

10.1 RECORDKEEPING

10.1.1 Design and Installation

Drawings, specifications, construction records, pressure test records, cathodic protection system details, maps, material verification, and modification records should be kept current by the owner/operator and on record for the life of the pipeline. These should be kept where operation and maintenance activities are being conducted. Reference the Occupational Safety and Health Administration (OSHA) requirements in 29 CFR 1910.119 (*11.3.1*).

10.1.2 Pipeline Operation

A manual of written procedures for operation of the pipeline must be prepared, made available and kept current by the owner/operator (49 CFR 192.605 (*11.2.1*)). For the operating life of the pipeline, training programs for the pipeline facility operating personnel should be maintained and updated, as necessary.

At least once each calendar year, but not exceeding a period of 15 months, the performance of operating personnel should be reviewed, and it should be verified that operating supervisors maintain a thorough knowledge of their responsibilities. A record of operating history must be maintained per applicable regulations. An emergency control plan with written procedures should be established as detailed in Section 8.

10.1.3 Pipeline Maintenance

A manual of written procedures for maintenance of the pipeline must be prepared, made available and kept current. For the life of the pipeline, the owner shall maintain records of inspections, tests, investigations, repairs and modifications to the pipeline. These records should also include information on line patrols, leak surveys, actual leaks and instances of maintenance line breaks.

10.2 REPORTING REQUIREMENTS

10.2.1 Gas Pipeline Facilities

Reporting is required by the DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) regulations for incidents which result in a release from the pipeline, death, or personal injury requiring inpatient hospitalization or incur certain damages.

a. An immediate telephone report to the National Response Center at 1-800-424-8802 (call 202-267-2675 in Washington, D.C.) for certain incidents as specified in 49 CFR 191.4.

b. A written report must be submitted to Office of Pipeline Safety utilizing the DOT Form PHMSA F 7100.1 as soon as practicable but not more than 30 days after detection of the incident.

c. An annual report is required by the Office of Pipeline Safety for each transmission pipeline on DOT Form PHMSA F 7100.1-1. It must be submitted by March 15 for the preceding calendar year.

Current regulations require pipeline operator reporting of safety-related conditions found on inspection of existing gas pipelines. Refer to 49 CFR Part 191 for such reporting conditions and the filing of such reports (*11.2.1*).

10.2.2 Liquid Pipeline Facilities

There are no requirements to make reports to PHMSA for pipelines handling liquid chlorine. However, in the case of a leak, reporting may be required to other federal agencies. While not required by PHMSA, it is recommended to make an immediate telephone report to the National Response Center at 1-800-424-8802 (call 202-267-2675 in Washington, D.C.) per 49 CFR Part 191.

10.2.3 State and Local Authorities

The pipeline operator should be aware of state and local reporting requirements. It is the operator's responsibility to fulfill those requirements for health, safety, environmental and operating regulations.

11. REFERENCES

11.1 CHLORINE INSTITUTE PUBLICATIONS

The following publications are specifically referenced in CI Pamphlet 60. The latest editions of CI publications may be obtained at www.chlorineinstitute.org.

Pamphlet #	Title
1	*Chlorine Basics*, ed. 8; Pamphlet 1; The Chlorine Institute: Arlington, VA, **2014**.
6	*Piping Systems for Dry Chlorine*, ed. 16; Pamphlet 6; The Chlorine Institute: Arlington, VA, **2013**.
64	*Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities*, ed. 7; Pamphlet 64; The Chlorine Institute: Arlington, VA, **2014**.
95	*Gaskets for Chlorine Service*, ed. 5 Rev. 2; Pamphlet 95; The Chlorine Institute: Arlington, VA, **2017**.
100	*Dry Chlorine: Behaviors of Moisture in Chlorine and Analytical Issues*, ed. 5; Pamphlet 100; The Chlorine Institute: Arlington, VA, **2018**.
164	*Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials*, ed. 3; Pamphlet 164; The Chlorine Institute: Arlington, VA, **2017**.

11.2 DOT REGULATIONS

11.2.1 *Code of Federal Regulations*. Title 49. Chapter 1. Parts 190-192 & 195. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

11.3 OSHA REGULATIONS

11.3.1 *Code of Federal Regulations*. Title 29. Part 1910. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

11.4 ASME STANDARDS

11.4.1 *Rules for Construction of Pressure Vessels, Section VIII, Division I*, ASME Boiler and Pressure Vessel Code; ANSI/ASME BPVC-VIII-I; The American Society of Mechanical Engineers: New York, NY, **2017**.

11.4.2 *Welding, Brazing, and Fusing Qualifications, Section IX*, ASME Boiler and Pressure Vessel Code; ASME BPVC-IX, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2019**.

11.4.3 *Pipe Flanges and Flanged Fittings*, ASME B16.5, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2017**.

11.4.4 *Factory-Made Wrought Steel Buttwelding Fittings*, ASME B16.9, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2018**.

11.4.5 *Square and Hex Bolts and Screws (Inch Series)*, ASME B18.2.1, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2012**.

11.4.6 *Square and Hex Nuts (Inch Series)*, ASME B18.2.2, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2015**.

11.4.7 *Process Piping*; ASME B31.3; an ANSI standard, The American Society of Mechanical Engineers: New York, NY, **2016**.

11.4.8 *Welded and Seamless Wrought Steel Pipe*, ASME B36.10, an ANSI standard; The American Society of Mechanical Engineers: New York, NY, **2018**.

11.5 AMERICAN PETROLEUM INSTITUTE PUBLICATIONS

11.5.1 *Corrosion under Insulation and Fireproofing***,** ed. 1, API Recommended Practice RP 583; American Petroleum Institute: Washington, DC, **2014**

11.5.2 *Line Pipe*, ed. 46, API Specification 5L; American Petroleum Institute: Washington, DC, **2018**.

11.5.3 *Welding of Pipelines and Related Facilities***,** ed. 21, API Standard 1104; American Petroleum Institute: Washington, DC, **2013.**

For further assistance and information on items referenced, contact:

American Chemistry Council (ACC)
700 2nd St., NE
Washington, DC 20002
Phone: 202-249-7000
Fax: 202-249-6100
www.AmericanChemistry.com

American National Standards Institute (ANSI)
1819 L Street, NW, 6th Floor
Washington, DC 20036
Phone: 202-293-8020
Fax: 202-293-9287
www.ansi.org

American Petroleum Institute (API)
1220 L Street, NW
Washington, DC 20005-4070
Phone: 202-682-8000
Order Desk: 800-854-7179
www.api.org

American Society of Mechanical Engineers (ASME)
3 Park Avenue
New York, NY 10016
Phone: 800-843-2763
www.asme.org

American Society of Testing Materials (ASTM)
100 Barr Harbor Drive
P.O. Box C700
West Conshohocken, PA 19428
Phone: 610-832-9500
Fax: 610-832-9555
www.astm.org

Canadian General Standards Board
Place du Portage III, 6B1
11 Laurier Street
Gatineau, Quebec
Phone: 800-655-2472
or 819-956-0425
Fax: 819-956-5644
www.tpsg.pwgsc.gc.ca/cgsb

The Chlorine Institute (CI)

1300 Wilson Boulevard, Suite 525

Arlington, VA 22209

Phone: 703-894-4140

www.chlorineinstitute.org

Canadian Government Publishing (PWGSC)

Ottawa, Ontario K1A OS5 (CANADA)

Phone: 800-635-7943

or 613-941-5995

Fax: 281-228-6300

www.nace.org

Canadian Transport Emergency Centre (CANUTEC)

330 Sparks Street

Office 1415

Ottawa, Ontario K1A ON5 (CANADA)

Phone: 613-992-4624

Fax: 613-954-5101

www.tc.gc.ca/canutec

National Association of Corrosion Engineers (NACE) International

15835 Park Ten Place

Houston, TX 77084

Phone: 281-228-6200

Toll Free: 800-797-6223

Fax: 281-228-6300

www.nace.org

Chemical Transportation Emergency Center (CHEMTREC)

2900 Fairview Park Dr.

Falls Church, VA 22042

Phone: 800-262-8200 or 703-741-5500

Fax: 703-741-6037

www.chemtrec.org

National Tank Truck Carriers, Inc.

950 North Glebe Road, Suite 520

Arlington, VA 22203-4183

Phone: 703-838-1960

Fax: 703-684-5753

http://www.tanktruck.org/

Superintendent of Documents

Government Printing Office

732 North Capitol Street, NW

Washington, DC 20401

Sales: 202-512-1800

https://www.gpo.gov/

Transport Canada

Ottawa, Ontario K1A 0N5 (CANADA)

Phone: 613-990-2309

Fax: 613-954-4731

www.tc.gc.ca

APPENDIX A -- PAMPHLET 60 CHECKLIST

This checklist is designed to emphasize major topics for someone who has already read and understood the pamphlet. Taking recommendations from this list without understanding related topics can lead to inappropriate conclusions.

Place a check mark (✓) in the appropriate box below:

Yes	No	N/A		
❒	❒	❒	1. Is the scope of the pamphlet understood?	{1.1}
❒	❒	❒	2. Are the liquid/vapor phase operating conditions fully understood?	{2.1}
❒	❒	❒	3. Has the routing been thoroughly reviewed to minimize exposure?	{2.2}
❒	❒	❒	4. Has the system been reviewed per federal, state and local regulations?	{2.3}
❒	❒	❒	5. Has proper consideration been given to prevent corrosion?	{3.2}
❒	❒	❒	6. Has thermal expansion of the pipeline been considered?	{3.4}
❒	❒	❒	7. Has thermal expansion of the liquid chlorine been considered?	{3.5}
❒	❒	❒	8. Does the design address periodic cleaning, hydrostatic testing and drying?	{5}
❒	❒	❒	9. Are operation and maintenance procedures in place?	{6}
❒	❒	❒	10. Have operators been trained on the procedures?	{6}
❒	❒	❒	11. Are procedures in place to monitor the pipeline during operation?	{7}
❒	❒	❒	12. Are emergency procedures in place?	{8}
❒	❒	❒	13. Has intrusion prevention and detection been considered for the pipeline design to prevent damage due to activity in proximity to the pipeline?	{8.4}
❒	❒	❒	14. Are procedures in place for proper record keeping?	{10}

REMINDER:

Users of this checklist should document exceptions

to the recommendations contained in this pamphlet.

1300 Wilson Boulevard « Suite 525 « Arlington, VA 22209
Telephone: (703) 894-4140
Email: pubs@CL2.com « Website: www.chlorineinstitute.org
Technical inquiries: techsvc@cl2.com