



THE CHLORINE INSTITUTE

Pamphlet 95

*Gaskets for Chlorine
Service*

Edition 5, Revision 1



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1. INTRODUCTION

1.1 SCOPE

This pamphlet is intended to provide manufacturers, packagers, and consumers of chlorine with practical information that can be used to improve safety and environmental performance by helping to prevent failures and minimize fugitive emissions from gasketed connections in dry and wet chlorine service. The pamphlet provides guidance for gasket material selection and gasket installation.

This pamphlet lists gaskets that have found user acceptance in chlorine service. Gaskets are added to the pamphlet only during routine pamphlet revisions. The Task Group charged with reviewing the pamphlet will decide whether to include additional gaskets based on experience and recommendations from member companies. Member companies utilizing new gaskets and sharing results will enable other members to become aware of gaskets that may provide improved service and reliability. This is consistent with the Institute's goal of continuous improvement.

The Chlorine Institute **does not** approve, rate, certify or endorse any gasket. The information on gaskets and gasket materials contained in this pamphlet reflects information obtained from member companies in their use and/or evaluation of the gasket or gasket material.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute (CI) exists to support the chlor-alkali industry and serve the public by fostering continuous improvements to safety and the protection of human health and the environment connected with the production, distribution and use of chlorine, sodium and potassium hydroxides, and sodium hypochlorite; and the distribution and use of hydrogen chloride. This support extends to giving continued attention to the security of chlorine handling operations.

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

1.3 DEFINITIONS AND ACRONYMS

Unless otherwise stated, the following meanings apply:

chemical lead	lead with 2% to 4% antimony
dry chlorine	chlorine is considered dry if it meets the criteria established in Chlorine Institute Pamphlet 100 (4.1)
Institute	The Chlorine Institute
lead	lead (not alloyed)

packaging plant	a chemical plant that repackages chlorine
producing plant	a chemical plant that manufactures chlorine
PTFE	polytetrafluoroethylene
psig	pounds per square inch gauge
SBR	styrene-butadiene rubber
EPDM	Ethylene propylene diene monomer
wet chlorine	Chlorine that does not meet the definition of 'dry' will be considered 'wet'. See CI Pamphlet 100 (4.1) for complete definition and technical summary of 'dry' chlorine.

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 be taken to insure that the information is current when used. These suggestions should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.5 APPROVAL

The Institute's Health, Environment, Safety and Security Issue Team approved Edition 5, Revision 1 of this pamphlet on May 24, 2016.

1.6 REVISIONS

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

1.6.1 Significant Revisions in Current Edition

This pamphlet was revised to update the gasket tables, provide an expanded Definitions and Acronyms section, clarify certain guidance including adherence to manufacturers' recommendations and the use of auxiliary materials such as lubricants or anti-seize compounds, and update the references section. The lists of gaskets that have been used successfully at member companies are still included in the pamphlet. Revision 1 of this edition added Table 3.5, Gasket Materials That Have Found User Acceptance with Chlorine Tank Cars.

1.7 REPRODUCTION

The contents for this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. **GASKET SELECTION, INSTALLATION AND PERSONNEL TRAINING**

2.1 CHEMICAL RESISTANCE

Chlorine is a highly aggressive oxidizer that reacts with many metals and organic compounds. Chemical compatibility and resistance to chlorine are key criteria in the selection of a chlorine gasket material. Service conditions, including contact with dry or wet chlorine, must be taken into account when assessing chemical resistance. For thermal considerations please see Table 3.1.

2.2 PHYSICAL PROPERTIES

Because all gasket materials are porous, a compressive load sufficient to reduce this porosity must be applied. If the initial load is insufficient or if there is a loss of gasket compression, porosity allows the system pressure to push the contained fluid into or around the gasket, leading to gasket degradation, leakage, or blow-out. Material factors such as gasket creep and bolt relaxation, and most importantly, installation practices or flange make-up can affect gasket compression. When choosing a gasket material, compressibility, recovery, creep relaxation, sealability, tensile strength, and stress required to seal should be considered.

2.3 INSTALLATION AND MAINTENANCE

Proper gasket installation and maintenance is a critical component of a leak-free chlorine system. The installation must create the proper compressive force to provide sufficient friction between the gasket and the flange, and provide sufficient compression to reduce the gasket material porosity to provide the proper seal. It is imperative that personnel be trained to install gaskets correctly.

When installing a gasket, the recommended procedures of the manufacturer, equipment supplier, and/or end-user should be followed. These procedures typically include the following:

- Inspect the gasket to verify that it is the correct size, material, and type for the intended service, and that it is clean and undamaged.
- Inspect the flanges to verify that they are properly aligned, clean, and undamaged.
- Examine bolts or studs, nuts, and washers for defects such as burrs or cracks, and rust. Clean and /or replace as needed.
- Avoid applying release agents such as anti-seize products, pipe dope, lubricants or grease to the gasket or flange faces. These release agents can attack some gaskets and can contribute to gasket blowout by filling the grooves on the face of the flanges and lowering the coefficient of friction

between the gasket and the flange faces. Also, the oils and greases in some of these products may react violently with chlorine.

- If using lubricants and/or coatings on nut threads and facings, and bolts to reduce friction between the flange fasteners and to create a consistent and correct bolt load ensure that the lubricants and/or coatings are chlorine compatible
- Tighten the bolts to the gasket and/or flange manufacturer's specifications. Most manufacturers recommend a cross bolt pattern in multiple steps of increasing torque, until the final torque requirements are achieved, followed by a final circular pass. To prevent damage it is important not to overtorque. This is particularly important in wet chlorine service when non-metallic piping is used.
- External factors including vibration, temperature cycling and pressure spikes can cause the loss of compressive load. If recommended by the gasket manufacturer, retorque the bolts per proper procedure after letting the gasket set and after the gasket has been in service for a short period of time.

2.4 TRAINING

Training of the personnel who install gaskets is a critical component of a leak-free chlorine system operation. Good procedures and a well-trained crew will enhance the integrity of the chlorine piping system.

3. **CHLORINE GASKET SELECTION**

3.1 DRY CHLORINE SERVICE

The gaskets listed in Table 3.2 and Table 3.3 have found user acceptance in dry chlorine service for the service class indicated (where applicable).

The use of gaskets on packaging equipment (i.e. outlet cap and yoke adapter) is considered a unique application by the packaging industry. These gaskets are typically in service for a much shorter time and at less severe temperatures and pressure conditions than gaskets used elsewhere in the chlorine industry. Table 3.3 contains information regarding packaging gaskets.

Contact gasket manufacturers for more detailed information including composition, testing, and service category details.

Gaskets used in fixed chlorine piping systems for a more severe service should be considered as acceptable for a less severe service, using the following criteria:

- Class II gaskets will be suitable for Class I service
- Class III gaskets will be suitable for Class I and Class II service
- Class IV service will be suitable for Class I service
- Class V service will be suitable for Class I, Class II and Class IV service

- Class VI service will be suitable for Class I, Class II, Class III, Class IV and Class V service

Table 3.1 Service Classes

I	Gas only vacuum to 150 psig (1034 kPa) and -20°F to 300°F (-29°C to 149°C)
II	Gas only vacuum to 150 psig (1034 kPa) and -50°F to 300°F (-46°C to 149°C)
III	Gas only vacuum to 150 psig (1034 kPa) and -150°F to 300°F (-101°C to 149°C)
IV	Gas or liquid vacuum to 300 psig (2068 kPa) and -20°F to 300°F (-29°C to 149°C)
V	Gas or liquid vacuum to 300 psig (2068 kPa) and -50°F to 300°F (-46°C to 149°C)
VI	Gas or liquid vacuum to 300 psig (2068 kPa) and -150°F to 300°F (-101°C to 149°C)

3.2 WET CHLORINE SERVICE

Table 3.4 is a listing of gasket materials that have found user acceptance in wet chlorine service. Specific gasket descriptions are given in lieu of manufacturers' brand names.

3.3 METHOD FOR THE INCLUSION OF CHLORINE GASKETS IN THIS PAMPHLET

Gaskets will be added to the tables during routine pamphlet revisions; currently a five year cycle. The Task Group that reviews the pamphlet will verify that new gaskets added to the tables were used and found acceptable by a member company.

To have a gasket added to the table, submit a notice to the Secretary of the Institute. The notice should include contact information from the gasket manufacturer and the member company that used the gasket.

The following information will typically be requested from the gasket manufacturer and/or member company for verification that the gasket was used successfully by the member company (see Appendix A for a suggested format):

- Name of member company where gasket was in service
- Gasket manufacturer and style/model number for dry service. For wet service a specific gasket description should be included
- Service conditions (temperature and pressure ranges, etc.) and Class if applicable
- Statement about gasket performance in the above service
- Quantity and duration of gaskets in service

3.4 USE OF GASKETS NOT INCLUDED IN TABLES

When considering the use of a gasket for chlorine service that is not included in the tables of this pamphlet the gasket should be thoroughly evaluated for compatibility with chlorine. Installing a gasket that is not compatible with chlorine could lead to a serious incident. Gaskets are typically added to this pamphlet only during the routine revision cycle (currently five years). Gaskets which have found user acceptance since the previous revision will not appear in the current edition. Contact the gasket manufacturer for detailed information.

Table 3.2 Gasket Materials That Have Found User Acceptance in Dry Chlorine Service

		Service Class						Comments
		I	II	III	IV	V	VI	
								Field test results can be obtained from the gasket manufacturer.
1	Asbestos, compressed (Fed. Spec. HH-P 46E)	A	A	A*	A	A	A*	May be restricted in some jurisdictions. Used successfully for service conditions down to -100°F (-73°C)
2	Chemical lead (2-4% antimony)	A	A	NI	A	A	X	Tongue & Groove Joints (confined on all four sides)
3	Spiral wound Monel/PTFE	A	NI	NI	A	NI	NI	
4	Virgin PTFE (unfilled & unexpanded)	A	A	NI	A	A	NI	Tongue & Groove Joints (confined on all four sides)
5	Lead	A	NI	NI	A	NI	X	Tongue & Groove Joints (confined on all four sides)
6	Garlock Gylon® 3510	A	A	A*	A	A	A*	Barium sulfate filled PTFE; "Off-White Color" *Tested for service conditions between 100°F (38°C) and -90°F (-68°C). Gasket Mfr.: Garlock Sealing Technologies, Inc.
7	Durlon® 9000	A	A*	NI	A	A*	NI	Silicate Filled PTFE; "Blue Color" Tested for service conditions between 250°F (121°C) and -40°F (-40°C). Gasket Mfr.: GRI/Triangle Fluid Controls Ltd

Table 3.2 Gasket Materials That Have Found User Acceptance in Dry Chlorine Service

		Service Class						Comments
		I	II	III	IV	V	VI	
								Field test results can be obtained from the gasket manufacturer.
8	Gore GR® Sheet Gasketing	A	NI	NI	A	NI	NI	Expanded PTFE tested for service conditions between 100°F (38°C) and 0°F (-18°C). Gasket Mfr.: W.L. Gore and Associates, Inc.
9	Inertex® SQ-S	A	A	NI	A	A	NI	Expanded PTFE. Tested for service conditions between 60°F (16°C) and -50°F (-46°C). Gasket Mfr.: Inertech, Inc./YMT.
10	Garlock Graphonic®	A	NI	NI	A	NI	NI	Graphite with Hastelloy C276 insert. Tested for service conditions between 300°F (149°C) and 0°F (-18°C). Gasket Mfr.: Garlock Sealing Technologies, Inc.
11	TEXOLON®	A	NI	NI	A	NI	NI	PTFE with 304 stainless steel insert. Tested for service conditions between 270°F (132°C) and 20°F (-7°C). Gasket Mfr.: Plastomer Products, Inc.
12	Flexitallic Sigma® 500	A	NI	NI	A	NI	NI	Glass-Filled PTFE; "Blue color". Tested for service conditions between 45°F (7°C) and 20°F (-7°C). Gasket Mfr.: Flexitallic L.P.
13	Gore-Tex® TriGuard™	A	A*	NI	A	A*	NI	Expanded PTFE. Tested for service conditions between 40°F (4°C) and -45°F (-43°C). Gasket Mfr.: W.L. Gore and Associates, Inc. Gasket has been replaced by Gore Universal Pipe Gasket (Style 800).
14	Task-Line®	A	NI	NI	A	NI	NI	PTFE with 304 stainless steel insert. Tested for service conditions between 222°F (106°C) and 0°F (-18°C). Gasket Mfr.: PureFlex.

Table 3.2 Gasket Materials That Have Found User Acceptance in Dry Chlorine Service

		Service Class						Comments
		I	II	III	IV	V	VI	
								Field test results can be obtained from the gasket manufacturer.
15	Flexitallic Sigma 533	A	A	NI	A	A	NI	Barium sulfate filled PTFE; "Off-White color". Tested for service conditions between 20°F (-7°C) and 72°F (22°C). Gasket Mfr.: Flexitallic L.P.
16	Gore Universal Pipe Gasket (Style 800)	A	A	A*	A	A	A*	Tested for service conditions between -90°F (-68°C) and 284°F (140°C). Gasket Mfr.: W.L. Gore and Associates, Inc.
17	Teadit Tealon TF1590	A	A	NI	A	A	NI	Tested for service conditions between -50°F (-46°C) and 131°F (55°C). Gasket Mfr.: Teadit.
18	Teadit Tealon TF1580	A	A	A	A	A	A	Tested for service conditions between -99°F (-73°C) and 255°F (124°C). Gasket Mfr.: Teadit.
19	Garlock® Gylon® 3591	A	NI	NI	A	NI	NI	Barium sulfate/Glass sphere filled PTFE. Tested for service conditions between 30°F (-1°C) and 70°F (21°C)
20	Teadit TF 1510	A	NI	NI	A	NI	NI	Glass microsphere filled PTFE. Tested for service conditions between 15°F (-9°C) and 45°F (7°C) in liquid and 50°F (10°C) to ambient in dry gas.

A = Gaskets used or tested successfully within this service class

A* = See comments for additional restrictions or information

NI = No information exists for the use of the gasket in this service

X = Gasket not recommended in this service class

Table 3.3 Chlorine Cylinder and Ton Container Valve Connection Gaskets That Have Found User Acceptance in Chlorine Service

1	Asbestos, compressed, (Fed. Spec. HH-P 46E)	May be restricted in some jurisdictions
2	Lead with 0 - 4% antimony	
3	GORE-TEX® TriGuard™	Expanded PTFE. Gasket has been replaced by Gore Universal Pipe Gasket (Style 800)
4	Gore Universal Pipe Gasket (Style 800)	Expanded PTFE

Table 3.4 Gasket Materials That Have Found User Acceptance in Wet Chlorine Service (1)

- 1 **Expanded PTFE gasket** sheet made from 100% Virgin PTFE without fillers and without pigmentation. A lowered density product less than 1.2 s.g. than skived or filled PTFE sheet, has a multi-directional fibrillated structure that resists cold-flow and creep relaxation.
- 2 **Microcellular PTFE gasket** sheet made from 100% Virgin PTFE without fillers and without pigmentation. A lower density product than skived or filled PTFE Sheet made with a manufacturing process that creates resistance to cold-flow and creep relaxation.
- 3 **Filled PTFE gasket** sheet, reinforced with glass beads or barium sulfate fillers to reduce creep and cold-flow characteristics.
- 4 **Ethylene Propylene Diene Monomer (EPDM) high polymer content** (elastomer), peroxide cured, soft (approx. 62 Durometer) for use at lower pressured applications. (Generally used in wet chlorine service on thermoplastic or fiberglass reinforced plastic flanges as well as on flat faced metal flanges).
- 5 **Ethylene Propylene Diene Monomer (EPDM) gasket fully or partially encapsulated with PTFE for added chemical resistance.** Generally used in wet chlorine service on thermoplastic or fiberglass reinforced plastic flanges as well as on flat faced metal flanges.
- 6 **Fluoroelastomer**, soft (approximately 60 Durometer Suggest 60 - 75) gasket sheet for use at lower pressure applications (up to approximately 100 psig for $\frac{1}{16}$ inch and 75 psig for $\frac{1}{8}$ inch thick gaskets). Generally used in wet chlorine service on thermoplastic or fiberglass reinforced plastic flanges as well as on flat faced metal flanges.
- 7 **SBR (Styrene-butadiene rubber)** has seen reduced use over the years as due to improvements in other gasket elastomeric materials.
- 8 **Virgin PTFE**, (unfilled and unexpanded), a high resistance to wet and dry chlorine but is susceptible to cold flow and creep. Chlorine permeability through the gasket is relatively high. Filled, microcellular or expanded PTFE is generally a better gasket material choice.

(1) Grade 2 titanium can be attacked at stagnant flow areas around gaskets, especially at low pH conditions (<2.5). Porous materials, such as virgin PTFE can also cause titanium flange failures.

Table 3.5 Gasket Materials That Have Found User Acceptance With Chlorine Tank Cars

Gasket Manufacturer	Garlock	Gasket Resources Inc./Triangle Fluid Controls
Gasket Model Number	Garlock 3510	Durlon® 9000
Gasket Material	PTFE w/ barium sulfate filler	silicate glass filled w/ PTFE
Typical Operating Temperature Range	-40°F to 200°F	-40°F to 200°F
Maximum Recommended Temperature Range	-450°F to 500°F	-350°F to 520°F

4. REFERENCES

4.1 CHLORINE INSTITUTE PUBLICATIONS

The following publications are specifically referenced in CI Pamphlet 95. The latest editions of CI publications may be obtained at <http://www.chlorineinstitute.org>.

<u>Pamphlet #</u>	<u>Title</u>
6	<i>Piping Systems for Dry Chlorine</i> , ed. 16; Pamphlet 6; The Chlorine Institute: Arlington, VA, 2013 .
100	<i>Dry Chlorine: Behaviors of Moisture in Chlorine and Analytical Issues</i> , ed. 4, Pamphlet 100, The Chlorine Institute: Arlington, VA, 2011 .

4.2 MISCELLANEOUS

Gasket Installation Procedures, Booklet by the Fluid Sealing Association and the European Sealing Association: Wayne, PA, **2001**.

APPENDIX A – GASKET INCLUSION REQUEST FORM

Typical information to be submitted to the Secretary of the Institute for inclusion in Chlorine Institute Pamphlet 95:

- Member Company: _____
- Member Company Contact: _____
- Submittal Date: _____

Gasket

- Gasket Manufacturer: _____
- Gasket Manufacturer Contact: _____
- Gasket Model Number: _____
- Gasket Material (as descriptive as possible): _____
- Number of Gaskets Installed: _____
- Duration of Service (provide dates – minimum of 6 months): _____

Service Conditions (check one service only:)

- Chlorine Cylinder
 Ton Container
 Wet chlorine gas
 Chlorine Tank Car
 Chlorine Cargo Tank
 Dry chlorine (check one of following service classes only):
- Gas above -20°F (CI Pamphlet 6, Class I)
 - Gas above -50°F (CI Pamphlet 6, Class I or II)
 - Gas above -150°F (CI Pamphlet 6, Class I, II or III)
 - Gas or liquid above -20°F (CI Pamphlet 6, Class I or IV)
 - Gas or liquid above -50°F (CI Pamphlet 6, Class I, II, IV or V)
 - Gas or liquid above -150°F (CI Pamphlet 6, Class I, II, III, IV, V or VI)

Operating Conditions

Temperature Range*: Min _____ Max _____
 Pressure Range*: Min _____ Max _____

*Only complete if Wet or Dry Chlorine Service

Describe the performance of the gasket (leaks, need to retorque, ease of installation, ease of removal, etc.)

APPENDIX B – PAMPHLET 95 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		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1. Were the gasket manufacturer's recommended procedures followed when the gasket was installed?	{2}
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2. Are the personnel responsible for installing the gasket properly trained?	{2}
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3. Are the gaskets used in chlorine service listed in the gasket tables?	{3}
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4. For gaskets used in dry chlorine service, is information from the manufacturer and Table 3.1 being considered?	{3}
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5. Do gaskets being used in wet chlorine service meet the criteria found in Table 3.4?	{3}
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6. If you are using a gasket in commercial service and would like to add it to Table 3.1, have you submitted a notice to CI?	{3}

REMINDER:

Users of this checklist should document exceptions to the recommendations contained in this pamphlet.



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