



NaCl



THE CHLORINE INSTITUTE, INC.

Pamphlet 95

Gaskets for Chlorine Service

Edition 4



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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, Inc. (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

Unless otherwise stated, the following meanings apply:

chemical lead	lead with 2% to 4% antimony
dry chlorine	as defined in Pamphlet 100
Institute	The Chlorine Institute, Inc.
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
Viton®	a registered trademark of DuPont Performance Elastomers
wet chlorine	chlorine that does not meet the definition of dry defined in Pamphlet 100

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 4 of this pamphlet on October 7, 2008.

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 remove testing requirements and standard forms. The lists of gaskets that have been used successfully at member companies are still included in the pamphlet.

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.

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 or flange make-up practices 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, rust, and replace as needed.
- Avoid lubricating the gasket. Lubricants can attack some gaskets and can cause gaskets to blow out by reducing the friction between the gasket and the flanges.
- Use chlorine compatible lubricants on nut threads and facings, and bolts to reduce friction between the flange fasteners and to create a consistent and correct bolt load.
- Tighten the bolts to the gasket and/or flange manufacturer's specifications, taking care to use the recommended cross bolt pattern in multiple steps of increasing torque, until the final torque requirements are achieved. To prevent damage it is important not to over torque. This is particularly important in wet chlorine service when plastic 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, re-torque 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 EASE OF REMOVAL AND LUBRICATION

A gasket that requires very little or no scraping would be preferred over one that requires a laborious operation for removal. Consult the gasket manufacturer prior to using anti-seize, pipe dope or releasing agents. These lubricants 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 flange faces.

NOTE: Most oils and greases will react violently with chlorine. Extreme caution should be exercised to prevent contamination of inside surfaces.

2.5 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;
- 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
8	Gore-Tex GR	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.

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.
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	Tex-O-Lon	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.
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.
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.

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.
16	Gore™ Universal Pipe Gasket (Style 800)	A	NI	NI	A	NI	NI	Tested for service conditions between -20°F (-29°C) and 284°F (140°C). Gasket Mfr: W.L. Gore and Associates, Inc.
17	Teadit 1590	A	NI	NI	A	NI	NI	Tested for service conditions between 10°F (-12°C) and 90°F (32°C). Gasket Mfr: Teadit.
18	Teadit 1580	A	NI	NI	A	NI	NI	Tested for service conditions between 10°F (-12°C) and 90°F (32°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

Gasket Materials That Have Found User Acceptance in Chlorine Cylinder and Ton Containers

Gasket Name	Comments
1 Asbestos, compressed (Fed. Spec. HH-P 46E)	
2 Lead with 0 - 4% antimony	
3 GORE-TEX TriGuard	Expanded PTFE

Table 3-4. Gasket Materials That Have Found User Acceptance in Wet Chlorine Service (1, 2)

- 1 **Expanded PTFE gasket** sheet made from 100% Virgin PTFE without fillers and without pigmentation. A lowered density product (range of 0.6 s.g. to 1.2 s.g.) than skived or filled PTFE Sheet (approx. 2.1 s.g. or higher), 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 lowered 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. Displays good sealing ability in higher pressure applications yet does not require very high torque loads. Generally used on hard surface flanging as opposed to plastic flange faces.
- 4 **Ethylene propylene high polymer content (EPDM) elastomer**, peroxide cured, soft (approx. 62 Durometer) for use at lower pressured 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.
- 5 **EPDM gasket (as above), 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 **Viton A 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)** is a low cost elastomeric gasket that has been successfully used in wet chlorine service. In recent years, it has been largely replaced by more resistant EPDM or Viton gaskets. Generally used in wet chlorine service on thermoplastic or fiberglass reinforced plastic flanges as well as on flat faced metal flanges.
- 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) When using elastomeric gaskets in flat faced plastic flanges, it is recommended that a $\frac{1}{8}$ inch thick full face gasket be used.

(2) 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.

4. REFERENCES AND RELATED PUBLICATIONS

4.1 CHLORINE INSTITUTE PUBLICATIONS

4.1.1 *Piping Systems for Dry Chlorine*, ed. 15; Pamphlet 6; The Chlorine Institute: Arlington, VA, **2005**.

4.1.2 *Dry Chlorine: Definitions and Analytical Issues*, ed. 3; Pamphlet 100; The Chlorine Institute: Arlington, VA, **2002**.

4.2 MISCELLANEOUS

Gasket Installation Procedures, Booklet by the Fluid Sealing Association and the European Sealing Association: Wayne, NJ **2000**.

APPENDIX A**EXAMPLE FORM**

Typical Information to be submitted to the Secretary of the Institute for Inclusion in Chlorine Institute Pamphlet 95.

Gasket

- Manufacturer: _____
- Manufacturer Contact: _____
- Model Number: _____
- Material (as descriptive as possible): _____

Service Conditions

Wet chlorine gas

Dry chlorine (check one service only):

- Gas above -20°F (Pamphlet 6, Class I)
- Gas above -50°F (Pamphlet 6, Class I or II)
- Gas above -100°F (Pamphlet 6, Class I, II or III)
- Gas or liquid above -20°F (Pamphlet 6, Class I or IV)
- Gas or liquid above -50°F (Pamphlet 6, Class I, II, IV or V)
- Gas or liquid above -100°F (Pamphlet 6, Class I, II, III, IV, V or VI)

Chlorine Cylinder or Ton Container

Temperature: _____

Pressure: _____

Number of gaskets in service: _____

Duration of gaskets in service: _____

Member company using gaskets: _____

Member company contact: _____

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

APPENDIX B
CHECKLIST

This check list 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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