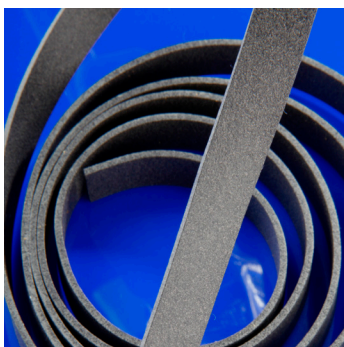
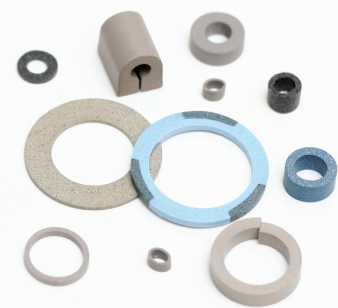


aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding



Extruded EMI Gaskets For Electronics Shielding Products & Custom Solutions Catalog



Customer Responsibility and Offer of Sale Statement

CUSTOMER RESPONSIBILITY



WARNING – USER RESPONSIBILITY

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker-Hannifin Corporation, its subsidiaries and authorized distributors provide product or system options for further investigation by users having technical expertise. The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the

application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalog and in any other materials provided from Parker or its subsidiaries or authorized distributors.

To the extent that Parker or its subsidiaries or authorized distributors provide component or system options based upon data or speci-

fications provided by the user, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the components or systems.

OFFER OF SALE

The items described in this document are hereby offered for sale by Parker Hannifin Corporation, its subsidiaries or its

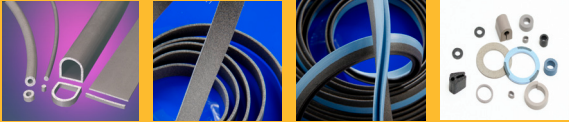
authorized distributors. This offer and its acceptance are governed by the provisions stated in the detailed "Offer of Sale" elsewhere in this

document or available at www.chomerics.com or www.parker.com.

U.S. Federal Supplier Code FSCM 18565

Extruded EMI Gaskets

Products & Custom Solutions Catalog



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Chomerics Capabilities Include:

EMI SHIELDING & COMPLIANCE

- Conductive elastomers – molded, extruded, and form-in-place (FIP)
- Conductive foam based gaskets – fabric-over-foam and z-axis foam
- Conductive compounds – adhesive, sealants and caulks
- RF and thermal/RF absorbing materials
- EMI shielding plastics and injection molding services
- Coatings – direct metallization and conductive paints
- Metal gaskets – springfingers, metal mesh and combination gaskets
- Foil laminates and conductive tapes
- EMI shielding vents – commercial and military honeycomb vents
- Shielded optical windows
- Cable shielding – ferrites and heat-shrink tubing, wire mesh tape, and zippered cable shielding
- Compliance and safety test services

THERMAL MANAGEMENT & CONTROL

- Thermally conductive gap filler pads
- Dispensed thermal gap fillers
- Silicone-free thermal pads
- Phase-change materials (PCM)
- Polymer solder hybrids (PSH)
- Dispensable thermal compounds
- Thermal grease and gels
- Insulator pads
- Thin flexible heat spreaders
- Custom integrated thermal/EMI assemblies

OPTICAL DISPLAY PRODUCTS

- EMI shielding filters
(conductive coating & wire mesh)
- Ant-reflective/contrast enhancement filters
- Plastic or glass laminations
- Hard coated lens protectors
- Touch screen lenses

About Parker Hannifin Corporation

Parker Hannifin is the world's leading diversified manufacturer of motion and control technologies and systems, providing precision-engineered solutions for a wide variety of commercial, mobile, industrial and aerospace markets. For more information, visit <http://www.parker.com>.

EMI Materials

INTRODUCTION

- Availability
- Design Flexibility
- Cost Effectiveness
- Proven Performance

...just four of the reasons why conductive elastomer gaskets are so often the right EMI shielding solution!

Once used mainly to shield critical defense and aerospace electronic systems, Parker Chomerics conductive elastomers have become the progressive choice for packaging designers of consumer, telecommunications, business, industrial equipment, automotive, medical devices and much more.

Conductive elastomers are reliable over the life of the equipment. The same gasket is both an EMI shield and an environmental seal. Elastomer gaskets resist compression set, accommodate low closure force, and help control airflow. They're available in corrosion-resistant and flame-resistant grades. Their aesthetic advantages are obvious.

Almost any elastomer profile can be extruded or custom-molded with modest tooling costs and short lead times for either prototypes or large orders. Parker Chomerics can take a customer-supplied design and deliver finished parts, typically within just a few weeks. Parker Chomerics offers hundreds of standard molded and extruded products. Molded products provide moisture/pressure sealing and EMI/EMP shielding when compressed properly in seals, flanges, bulkheads, and other assemblies. Extrusions provide similar benefits and are also readily lathe-cut into washers, spliced, bonded, kiss-cut,

or die-cut to reduce installation labor and to conserve material, resulting in a cost-effective alternative to other methods of EMI shielding and environmental sealing.

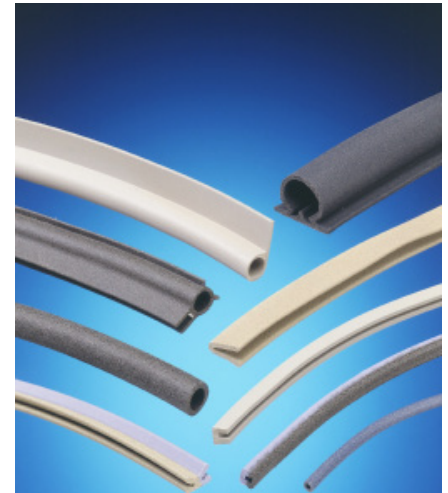
CHO-SEAL® CONDUCTIVE ELASTOMERS

Over the years, Parker Chomerics has developed and enhanced virtually every aspect of conductive elastomer materials technology, from the earliest silver and silver-plated copper filled silicones, to the latest and more cost-effective silver-plated aluminum and nickel-plated graphite composites. Today we offer the most comprehensive selection and highest quality products available.

Each conductive elastomer consists of a silicone, fluorosilicone, EPDM or fluorocarbon-fluorosilicone binder with a filler of pure silver, silver-plated copper, silver-plated aluminum, silver-plated nickel, silver-plated glass, nickel-plated graphite, nickel-plated aluminum or unplated graphite particles.

The development of these composites is the result of decades of research and testing, both in the laboratory and in the field. Our proprietary filler powder technology allows us to carefully control the composition, size, and morphology of the conductive particles. Their precise, uniform dispersion within the resinous binders produces materials with stable and consistent electrical and physical properties.

Parker Chomerics' conductive elastomers feature excellent resistance to compression set over a wide temperature range, resulting in years of continuous service. In addition to EMI shielding,



these materials can provide an environmental or pressure seal if required.

For those materials containing silver, both packaging and storage conditions should be similar to those for other silver-containing components, such as relays or switches. They should be stored in sheet plastic, such as polyester or polyethylene, and kept away from sulfur-containing materials, such as sulfur-cured neoprene, cardboard, etc. To remove dirt, clean the elastomer with water or alcohol containing mild soap (do not use aromatic or chlorinated solvents). Shelf life of these conductive elastomers without the presence of pressure sensitive adhesive (PSA) is indefinite.

The tables at the end of this brochure outline the properties and specification limits of Parker Chomerics' conductive elastomers. These materials are produced in a virtually unlimited variety of molded, die-cut and extruded shapes and sizes. Our Applications Engineering Department is very accessible, and ready to assist with material selection and gasket design. We welcome your inquiry.

MATERIAL SELECTION

The Parker Chomerics array of conductive elastomers offers true flexibility in selecting the appropriate material for a specific application on the basis of cost and level of attenuation required. Price varies directly with shielding performance.

For typical military/aerospace applications, we recommend that users of conductive elastomer gaskets specify that materials meet the requirements of MIL DTL- 83528 QPL sources. To avoid the risk of system EMI or environmental seal failure, any change in conductive elastomer seal supplier (including MIL DTL- 83528 QPL suppliers) should be preceded by thorough system qualification testing.

Fluid Resistance of Non-Silicone Based Elastomers

Certain specialty elastomers and fluorosilicone based materials, are offered specifically for their fluid resistance properties. Table 6 illustrates the qualitative assessment of fluid resistance towards various fluids for three non-silicone binders used for Parker Chomerics conductive elastomers.

Conductive Elastomer Applications

In general, certain types of Parker's conductive elastomers are specified more often for military/ aerospace applications or for commercial applications. However, there is a considerable overlap, and our Applications Engineering department will be pleased to assist you with your product selection.

ELASTOMER PRODUCT OFFERING (Sorted by filler family and by ascending shielding performance)

Military and Commercial Products

CHO-SEAL

1221 – Fluorosilicone, Molded Only
1224 - Molded Only
6502
6503 – Fluorosilicone
1298 – Fluorosilicone
1285
1287 – Fluorosilicone
1215
1217 – Fluorosilicone
1270 – Molded Only
1273
S6305
6330 – Molded Only
6370 – Extruded only
6371 – Molded only
6372 – Extruded Only
6308 – Extruded Only
L6303 – Fluorosilicone
1310 – Molded Only
1350
0860 – Extruded Only
0862 – Extruded Only
S6600 – Molded Only

Specialty Products

CHO-SEAL

1401
1239 - Molded Only
1212 – Molded Only
6435 – Molded Only
6307 – Molded Only
6452 – Extruded Only
V6433 – Molded Only

Corrosion Resistant Products

CHO-SEAL

6502
6503 – Fluorosilicone
1298 – Fluorosilicone
1285
1287 – Fluorosilicone

Refer to the following tables for specific material properties and material guidelines.

CONDUCTIVE ELASTOMER SELECTION GUIDE

The tables contained herein provide selection guidelines for Chomerics' most general-purpose EMI elastomer materials. With the exception of certain limitations noted under "Remarks", these materials are electrically stable over time and provide excellent moisture and pressure sealing. They are all medium-durometer materials and differ mainly in shielding performance and corrosion resistance. (Nickel-plated aluminum materials are significantly more corrosion-resistant than silver-plated copper, silver-plated aluminum, and silver-plated nickel filled materials against aluminum.)

Note on Gasket Deflection and Closure Force:

We do not recommend basing material selection primarily on hardness. Unlike unfilled elastomers, material hardness is not always an accurate indicator of deflection properties. The geometry of the gasket is generally the most important determinant of deflection under load.

For applications requiring large gasket deflection with minimum closure force, a hollow part geometry is recommended.

Please refer to the product specification data included within the next several pages for technical information regarding:

- Compression-Deflection
- Stress Relaxation
- Compression Set
- EMP Survivability
- Vibration Resistance
- Heat Aging
- Outgassing
- Volume Resistivity

TOP CORROSION RESISTANT MATERIALS

CHO-SEAL 6502 and 6503 gaskets with Ni/Al particles provide the material of choice for corrosion resistance against aluminum in harsh environments. These materials have lower transfer impedance at frequencies >10 MHz providing more than 100 dB of shielding effectiveness. After 2,000 hours, 125°C heat aging life testing, the shielding effectiveness is virtually unchanged. Ni/Al will lower the total cost of ownership by reducing or eliminating field service issues or maintenance schedules regardless of end use environment

UL 94 V-0 RATED MATERIALS

Chomerics introduced the first conductive elastomer with a UL 94 V-0 rating (UL file number 96ME 17043) with allowable thicknesses down to 0.014 inch (0.356 mm). Mated to aluminum, this fully extrudable material is a corrosion-resistant nickel-plated graphite filled silicone with shielding effectiveness equivalent to or greater than other commercial grade gaskets: 95 dB from 50 MHz to 10 GHz. CHO-SEAL 6370, 6371 and 0862 are UL 94 V-0 flammability rated materials. CHO-SEAL 6330 and 6372 are UL 94 V-1 rated.

For UL certifications, please visit www.ul.com

LIGHTNING STRIKE RESISTANCE

The survivability of any system to lightning strike is dependent on specific flange design. Lightning strike testing of CHO-SEAL 1298 gasket material has demonstrated survivability beyond 5 kA/in. Test data is available upon request. (Request Test Report TR-34A.)

FLUID RESISTANCE – HARSH ENVIRONMENTS

Table 6 lists a qualitative assessment of fluid resistance by material type. The customer is encouraged to evaluate specific materials to the requirements demanded by the application.

FLUID RESISTANCE – COMMON FLUIDS ON SILICONE

Table 5 illustrates the change in physical properties of CHO-SEAL S6305 after exposure to a variety of common fluids. The complete report is available from Chomerics upon request.

DUAL FUNCTIONALITY GASKETS, “Co-Extruded and Co-Molded”

Co-Extruded and Co-Molded gaskets (dual gaskets with both a conductive and a non-conductive element, cured in parallel) provide additional environmental sealing and corrosion protection. Seam vulcanization ensures the long term integrity and stability of the gasket.

Co-Extruded and Co-Molded gaskets permit the cost-effective use of existing flange designs, while offering attachment alternatives via the less expensive, non-conductive material. Compared to bonding and mounting separate gaskets or double-groove designs, Co-Extruded and Co-Molded gaskets offer design, cost and handling advantages.

Table 1: CHO-SEAL® ELASTOMERS FOR TYPICAL COMMERCIAL AND MILITARY APPLICATIONS
(M = Molded only, E = Extruded only, F = Fluorosilicone, EP=EPDM)

Material	Filler and Binder	Equipment Shielding Requirements (Typ.)	Remarks
CHO-SEAL 1224 ^(M)	Silver in silicone	> 120 dB	Highest shielding effectiveness and through conductivity performance; higher physical properties; excellent processing; also available in a fabric reinforced format.
CHO-SEAL 1221 ^(M)	Silver in fluorosilicone		
CHO-SEAL 6502	Nickel-plated aluminum in silicone	> 100 dB	Highest performance in harsh environments; excellent shielding; best choice for corrosion requirements against aluminum.
CHO-SEAL 6503	Nickel-plated aluminum in fluorosilicone		
CHO-SEAL 1298	Silver-plated aluminum in fluorosilicone	90 - 110 dB	High performance in harsh corrosive environments; material of choice for aircraft and marine military applications; good physical properties; molded, extruded and reinforced product forms.
CHO-SEAL 1285	Silver-plated aluminum in silicone	90 - 110 dB	Military grade gasket for corrosive environments; lightweight, 200°C max use temperature; good EMP resistance; molded, extruded and reinforced product forms.
CHO-SEAL 1287	Silver-plated aluminum in fluorosilicone		
CHO-SEAL 1215	Silver-plated copper in silicone	105 - 120 dB	Resists highest level of EMP induced current; military gasket of choice in non-corrosive environments; excellent processing for molding and extrusion.
CHO-SEAL 1217	Silver-plated copper in fluorosilicone		
CHO-SEAL 1273 CHO-SEAL 1270 ^(M)	Silver-plated copper in silicone	80 - 105 dB	Material of choice for high-end commercial applications; superior performance in non-corrosive environments; tear trim compression and injection molding. 1270, a low durometer hardness elastomer, is recommended for applications requiring low compression forces.
CHO-SEAL S6305, 6330 ^(M) , 6370 ^(E) , 6371 ^(M) , 6372 ^(E) , 6308 ^(E)	Nickel-plated graphite in silicone	100 dB	Good performance in moderately corrosive environments; material of choice for flange finishes needing "bite-through" for good electrical contact. Flame retardant 6370 ^(E) and 6371 ^(M) are UL 94 V-0 rated. 6330 and 6372 ^(E) are UL 94 V1 rated, 6308 ^(E) is designed for thin wall extrusions; 6330 ^(M) , a low durometer hardness elastomer, is designed for applications requiring low compression forces.
CHO-SEAL L6303	Nickel-plated graphite in fluorosilicone		
CHO-SEAL 1350	Silver-plated glass in silicone	80 - 105 dB	Standard material for high volume injection and compression molding and small extrusions; high performance in non-corrosive environments; used in grounding applications with little or no vibration.
CHO-SEAL 1310 ^(M)	Silver-plated glass in silicone	80 - 100 dB	Moderate performance in non-corrosive environments; no corrosion or fluid resistance; material of choice for small, delicate injection-molded parts or large dimension extrusions.
CHO-SEAL 0860 ^(E) , 0862 ^(E)	Carbon in silicone	30 - 80 dB	Low-end shielding and ESD protection; high tensile strength; no corrosion or fluid resistance. 0862 ^(E) is UL 94 V-0 rated.
CHO-SEAL S6600 ^(M)	Carbon in silicone	30 - 80 dB	Low-end shielding and ESD protection; high tensile strength; no corrosion or fluid resistance. Molded only.

Table 2: SPECIALTY ELASTOMERS

(M= Molded only, E = Extruded only, F = Fluorosilicone, EP=EPDM)

Material	Filler and Binder	Equipment Shielding Requirements (Typ.)	Remarks
CHO-SEAL 1401	Silver in reticulate silicone	80 -100 dB	High performance for non-corrosive environments; soft (45 Shore A) for low closure force where gasket geometry cannot be exploited; low tear strength; no fluid resistance.
CHO-SEAL 1239 ^(M)	Silver-plated copper in silicone with expanded copper reinforcement	110 dB	Material for waveguide choke, cover, and flange EMI shielding and pressure sealing; maximum heat transfer and minimum outgassing; hard (80 Shore A), high-strength material; available with raised lip around iris opening for high power/high pressure applications.
CHO-SEAL 1212 ^(M)	Silver-plated copper in silicone	120 dB	High strength, hard (80 Shore A) material for waveguide, choke, cover, and flanges with grooves for EMI and pressure sealing.
CHO-SEAL 6435 ^{(M) (EP)}	Silver-plated nickel in EPDM	95 dB	Material of choice for high shielding effectiveness where NBC fluid resistance is needed; good performance in corrosive environments.
CHO-SEAL 6307 ^{(M) (EP)} , 6452 ^{(E) (EP)}	Nickel-plated graphite in EPDM	> 90 dB	Good performance in moderately corrosive environments; excellent NBC fluid resistance; good physical properties.
CHO-SEAL V6433 ^(M)	Silver-plated nickel in fluorosilicone/ fluorocarbon	100 dB	Material of choice for extensive fluid resistance; no corrosion resistance.

		Table 3: Typical Elastomers-Galvanic Compatibility 168 Hour Exposure to Salt Spray / Salt Fog in Accordance with CHO-TM-100				
		Filler				
168 Hour Exposure		Nickel-Plated Aluminum*	Passivated Silver-Plated Aluminum	Silver-Plated Aluminum	Nickel-Plated Graphite	Silver-Plated Copper
Substrate						
Aluminum: 6061-T6 CR6 Finish		Excellent	Excellent	Excellent / Good	Fair	Poor
Aluminum: 6061-T6 CR3 Finish		Excellent	Excellent	Good	Fair	Poor
Aluminum: 6061-T6 Unplated		No Data	Good	Fair	Fair / Poor	Not Recommended
Stainless Steel: 304SS, 316SS		Excellent	Excellent	Excellent	Excellent	No Data
Electroless Nickel .002" thick		Good	Good	Good	Poor	No Data
Magnesium		Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended

*Tested via CHO-TM-101

		Table 4: Typical Elastomers-Galvanic Compatibility 504 Hour Exposure to Salt Spray / Salt Fog in Accordance with CHO-TM-100				
		Filler				
504 Hour Exposure		Nickel-Plated Aluminum*	Passivated Silver-Plated Aluminum	Silver-Plated Aluminum	Nickel-Plated Graphite	Silver-Plated Copper
Substrate						
Aluminum: 6061-T6 CR6 Finish		Excellent	Good	Fair	Poor	Not Recommended
Aluminum: 6061-T6 CR3 Finish		Good	Good	Fair	Poor	Not Recommended

*Tested via CHO-TM-101

Table 5: Exposure of CHO-SEAL® S6305 to Common Household Fluids				
Tensile/Elongation in accordance with ASTM D412				
Exposure Conditions: 70 hrs @ 22°C/50% RH		Pre-Exposure	Post-Exposure	% Change
Test 1				
ClearVue®	Tensile [psi]	200	178	-11%
	Elongation [%]	289	317	10%
Formula 409®	Tensile [psi]	200	197	-2%
	Elongation [%]	289	219	-24%
Windex®	Tensile [psi]	200	202	1%
	Elongation [%]	289	166	-43%
Test 2				
Carpet Cleaner	Tensile [psi]	203	207	2%
	Elongation [%]	414	443	7%
Coffee	Tensile [psi]	203	211	4%
	Elongation [%]	414	439	6%
Cola	Tensile [psi]	203	199	-2%
	Elongation [%]	414	433	5%
Hairspray	Tensile [psi]	203	207	2%
	Elongation [%]	414	326	-21%
Tire Cleaner	Tensile [psi]	203	175	-14%
	Elongation [%]	414	418	1%
Vinyl Protectant	Tensile [psi]	203	172	-15%
	Elongation [%]	414	433	5%
Tap Water	Tensile [psi]	203	199	-2%
	Elongation [%]	414	439	6%
Windshield Washer Solvent	Tensile [psi]	203	207	2%
	Elongation [%]	414	418	1%

Table 6: Typical Elastomer Fluid Resistance			
Exposure / Fluid Type	Elastomer Choice		
	Silicone	Fluorosilicone	EPDM
High Temp	Excellent	Good	Fair
Low Temp	Excellent	Excellent	Excellent
ASTM 1 Oil	Fair/Good	Good	Poor
Hydraulic Fluids (Phosphate Ester)	Poor	Poor	Poor
Hydrocarbon Fuels	Poor	Good	Excellent
Ozone, Weather	Good	Good	Good
STB (NBC Decontamination Fluid)	Poor	Fair/Good	Good
Dilute Acids	Fair	Good	Good

NOTE: Recommendations in application design and material selection are based upon available technical data and are offered as suggestions only. Customers should always test the seal material under actual operating conditions.

Extrusion Product Guide

Product Forms

STANDARD EXTRUSIONS – AN EXTENSIVE SELECTION

Our elastomer extrusions are hollow or solid strips in sizes ranging from 0.030 inch (0.76 mm) solid O cross section to a 4.00 inch (50.8 mm) wide flat ribbon. Existing tooling, available in hundreds of sizes, allows for immediate production of standard profiles:

- Solid O
- Hollow O
- Solid D
- Hollow D
- “Mushroom” D (patented)
- Solid Rectangle
- Hollow Rectangle
- Channel Strip
- Hollow P
- V Strip

Standard profiles are efficient for the majority of applications. Even problematic low closure force applications can be accommodated by lightweight, hollow gasketing.

There is generally no tooling charge for standard items. If needed, tooling of new dies for standard profiles is relatively inexpensive. Moreover, extrusions minimize material waste and do not require post-manufacture processing to remove flash. Subject only to packaging constraints, most extrusions are supplied on reels.

CUSTOM SHAPES IN ENDLESS VARIETY

Chomerics routinely produces elastomer extrusions in unusual sizes and intricate configurations to meet special needs. Explore the many specialized designs, for which tooling already exists. This showcase, beginning on page 33 of this guide, illustrates the variety and complexity that can be incorporated into extruded elastomers.

FINITE ELEMENTAL ANALYSIS – A POWERFUL DESIGN TOOL

Chomerics offers sophisticated FEA technology to prevent false starts, design delays and repetitive prototyping for unusual shielding requirements. Advanced computer simulation software is employed to predict gasket behavior, bypassing trial-and-error testing. FEA not only predicts how a design will behave, but allows it to be optimized. Complex algorithms provide critical information concerning: material selection, deformation, load-deflection, stress distribution, volume, void ratios, gland fill percent and more. The result is a technically superior solution achieved more rapidly and cost effectively than ever before.

MANUFACTURING LIMITATIONS

The extruded strips listed in this guide are generally available in all CHO-SEAL materials. However, the physical characteristics of certain materials make them unextrudable in very small sizes and with thin wall sections. General manufacturing limitations are listed in *Extrusion Profile Dimensional Guidelines, Table 8*.

KISS-CUT GROUNDING PADS ON TAPE

For manual “peel and stick” or robotic “pick and place” application, grounding pads are readily produced in quantities by kiss-cutting hollow D (or other) extrusions to their PSA release tape. Features such as holes or slots can be incorporated, and



Co-extrusions may also be cut. Continuous lengths are supplied on reels.

FULL-SERVICE FABRICATION

Often cost-competitive for both small and large volumes, conductive elastomer extrusions are readily fabricated for specific applications. These services are performed at the factory or by Chomerics’ skilled Authorized Fabricators throughout the world. Visit www.chomerics.com.

Cut-To-Length (CTL). Uniform parts are supplied ready for installation.

Standard Tolerances for cut parts, inch (mm)

- Less than 1.00 (25.4): ± 0.020 inch (0.51)
- Lengths of 1.0 to 30.0 (25.4 to 762): ± 0.062 (1.58)
- Greater than 30.0 (762): $\pm 0.2\%$ the nominal dimension

NOTE: Tighter tolerances are available upon request.

PRECISION WASHERS

Slicing solid and hollow O cross sections into disks or washers can save time and cost, with tolerances equivalent to molded parts. For extremely thin parts, less than 0.060 inch (1.52 mm), Chomerics experience and tooling leads the industry.



SPLICED GASKETS

For fabricated gaskets with a minimum inside diameter of 2 inches (51 mm), extruded strips can be spliced to form a continuous seal. Spliced gaskets offer cost savings over molded gaskets without sacrificing performance. In particular, spliced hollow extrusions yield lightweight, low closure force gaskets at considerable savings. For solid silicone extrusions, the splice is often as strong and as resilient as the gasket itself and avoids mold flash.

Gaskets spliced by Chomerics or our Authorized Fabricators feature a vulcanized joint, formed under heat and pressure, that ensures functionality and a more uniform joint compared with adhesive bonding.

Spliced gaskets with an inside diameter smaller than 2 inches (51 mm) are available for round, oval or “D” shaped profiles for a nominal set-up charge. Contact Chomerics’ Application Engineering Department for details.

FRAME ASSEMBLIES

Chomerics fabricates complete frame/gasket assemblies either in their entirety or using customer-supplied parts. These incorporate vulcanized joints and miters, and often more than one gasket material or profile. With experience ranging from handheld devices to floor-standing equipment, size is not a limitation.

BONDED GASKETS

Similar and dissimilar compositions and profiles can be bonded in parallel for special requirements. Capabilities include bonded-in compression stops, holes and other features.

SMALL, DIE-CUT GASKETS FROM FLAT EXTRUSIONS

Standard rectangular extrusions up to 4 inches (101.6 mm) wide can provide an economical means of producing die-cut gaskets for some applications.

PRESSURE-SENSITIVE ADHESIVE (PSA)

Chomerics’ extruded conductive elastomer EMI gaskets are available with non-conductive pressure-sensitive adhesive (PSA) tape for permanent attachment. Typical properties for this adhesive are shown in Table 7 below.

The acrylic pressure-sensitive adhesive does not appreciably affect the through-flange resistance of the EMI gasket because typically the PSA takes up only half the gasket footprint. The remainder of the gasket makes direct contact against both substrates.

Non-conductive PSA is preferred over conductive PSA because it exhibits higher peel strength than conductive PSA.

AVAILABLE WIDTHS OF PSA, INCH (MM)

- 0.050 (1.27)
- 0.090 (2.29)
- 0.125 (3.17) min. recommended
- 0.160 (4.06)
- 0.200 (5.08)
- 0.250 (6.35)
- 0.300 (7.62)
- 0.375 (9.53)
- 0.500 (12.70)

In general, pressure-sensitive adhesive requires a minimum of 0.125 inch (3.17 mm) flat mating surface. For this reason, Chomerics does not ordinarily supply PSA on solid or hollow O strips.

Table 7: Pressure-Sensitive Adhesive Typical Properties

Table 7: Pressure-Sensitive Adhesive Typical Properties	
Adhesive Description	Pressure-sensitive acrylic with poly release liner
Service Temperature Range	-20 to 150°F (-29 to 66°C); PSA will function for short periods of time at 200°F (93°C); ultimate high temperature limit is 250°F (121°C).
Shelf Life Conditions (from date of manufacture of elastomer with PSA)	1 year at 70°F (21°C)/50% RH Proper storage is important!
Application Temperature Range	40 to 150°F (4 to 66°C)
Initial Peel Strength on Aluminum *	6.0 lb/inch (1.05 N/mm)
Initial Peel Strength on Steel *	6.0 lb/inch (1.05 N/mm)
Heat Aged Peel Strength on Aluminum **	5.4 lb/inch (0.945 N/mm)
Heat Aged Peel Strength on Steel **	5.4 lb/inch (0.945 N/mm)
Humidity Peel Strength on Aluminum ***	6.0 lb/inch (1.05 N/mm)
Humidity Peel Strength on Steel ***	6.0 lb/inch (1.05 N/mm)
Product Composition (Ref)	Composite 8.0 mil
	Liner 3.0 mil
*Peel strength test data per ASTM D1000 (90° peel). **Heat aged 168 hrs. at 158°F (70°C). ***Humidity exposure of 168 hrs. at 95% RH and 158°F (70°C).	

Extrusion Product Guide

Surface Preparation of Metallic Substrates

SURFACE PREPARATION OF METALLIC SUBSTRATES

MATERIALS REQUIRED:

- 3M Scotch-Brite™ Pads or equivalent
- Rubber gloves
- Safety glasses
- Lint-free cotton wipes
- MEK, acetone or isopropyl alcohol (IPA)

Optimal performance of the pressure-sensitive adhesive requires that the substrates to which these gaskets must adhere are cleaned prior to application. Chomerics has developed specific, easy-to-follow procedures for preparing the following substrates:

- Phosphate-coated steel
- Conversion-coated aluminum
- Stainless and mild steel

It is essential to follow these cleaning instructions to ensure maximum adhesion of the PSA to metal substrates. Failure to comply with the appropriate cleaning process could result in poor adhesion. Proper safety precautions should be followed to protect the operator.

SURFACE PREPARATION OF CONVERSION-COATED ALUMINUM AND PHOSPHATE-COATED STEEL

1. Using a clean, lint-free applicator, moistened with MEK, acetone or IPA, wash the surface until all traces of contamination have been removed.
2. Clean the surface until the cotton applicator shows no discoloration.
3. If discoloration still exists, continue washing, changing the cotton applicator each time, until clean. Note: With

phosphate coatings, it is very hard to remove all discoloration from the surface so it is up to the operator to determine the cleanliness of the surface prior to bonding. Typically, cleaning the surface 3 times is required.

4. Allow the substrate to dry completely at room temperature. After the cleaning sequence is complete, do not touch the substrate with bare hands.
5. If the cleaned surfaces do not have the PSA applied within an 8 hour period, rewash using the above process.

SURFACE PREPARATION OF STAINLESS OR MILD STEEL

1. Using a 3M Scotch-Brite™ pad or equivalent, lightly abrade the steel surface.
2. Blow the dust residue off of the steel surface with oil-free filtered air.
3. Follow Steps 1 through 5 from the previous section to complete the surface preparation.

GASKET INSTALLATION PROCEDURE

1. Cut gasket material to specific lengths per drawing. If gasket is one piece, such as a four-corner spliced gasket, pre-fit the assembly to ensure fit and location.
2. Remove a portion of the gasket liner and position the gasket. Press firmly against the gasket to tack in place. Continue pressing along the entire length of gasket until it is positioned and aligned to the mating surface.
3. Using a rubber roller, apply moderate pressure to the entire gasket to ensure complete

contact between the PSA and substrate surface. It is important during the rolling procedure that the operator not apply excessive pressure to the gasket. Extreme pressure will cause the gasket to elongate and creep as it relaxes, which may cause poor bonding to the substrate surface.

NOTE: Typically 70% of the ultimate acrylic adhesive bond strength is achieved with initial application, and 80-90% is reached within 15 minutes. Ultimate adhesive strength is achieved within 36 hours; however the next manufacturing step can typically occur immediately following the initial application.

OPTIMUM APPLICATION TEMPERATURE

Temperatures below 50°F (10°C) can cause poor gasket adhesion to the substrate. The ideal gasket installation temperature is 72°F (22°C), ambient room temperature. All materials should be stored at this temperature when not in use. Hardware and gasket materials stored below 50°F (10°C) should be brought to room temperature before installing gasket.

MATERIALS CONTAINING SILVER

For those materials containing silver, both packaging and storage conditions should be similar to those for silver-containing components, such as relays and switches. They should be stored in sheet plastic, such as polyester or polyethylene, and kept away from sulfur-containing materials, such as sulfur-cured neoprene, cardboard, etc. To remove dirt, clean the elastomer with alcohol. Do not use aromatic or chlorinated solvents.

Scotch-Brite is a trademark of 3M.

ORDERING PROCEDURE

For standard or existing configurations, select the Chomerics part number from the tables that follow. The last four or five digits (represented by XXXX in the tables) designate the material type. In addition to the parts listed, all O strips up to 0.500 inch (12.7 mm) are considered standard. Not all combinations of OD and ID have part numbers assigned. Contact Chomerics for details.

For custom configurations, cut-to-length parts, spliced parts, etc., drawings or specifications must be provided. Part numbers will be assigned by Chomerics upon receipt. Custom configurations requiring MIL-DTL-83528 certification are generally denoted by a -40 suffix.

Pressure-sensitive adhesive may be ordered for any standard extrusion, other than O-strips, and many custom profiles, which have

at least a 0.125 inch (3.17 mm) flat mating surface. The standard part numbers listed must be modified to designate the PSA tape requirement per description below. Contact Chomerics for details.

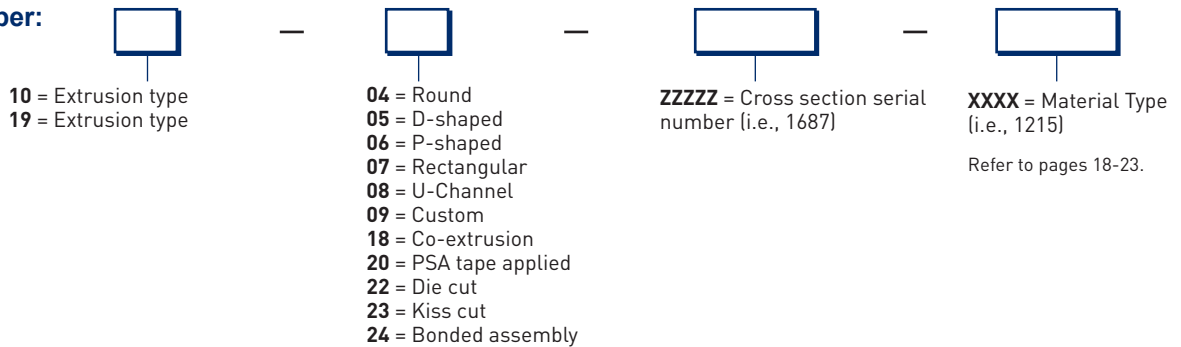
Orders must also specify quantity (feet or inches are preferred). Please note that minimum quantities may apply.

Our Applications Engineering Specialists provide shielding gasket approaches that reduce overall manufacturing costs.

Part Numbering for Extruded Products

Example: 10-04-1687-1215

Part Number:



Extrusion Product Guide

Dimensional Guidelines

Table 8: Dimensional Guidelines

Min. Radii:	SOLID D				HOLLOW D				HOLLOW RECTANGLE				CHANNEL					
	1.5 x W				2.0 x W				2.0 x W				1.5 x W					
	inch		mm		inch		mm		inch		mm		inch		mm			
Units:	H	W	H	W	WT	H	W	WT	H	W	ID	WT	W	WT	S	W	WT	S
1215	0.035	0.035	0.889	0.889	0.017	0.114	0.114	0.413	0.290	0.290	0.020	0.025	0.508	0.635	0.020	0.508	0.508	0.508
1217	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.032	0.508	0.813	0.020	0.508	0.813	0.508
1273	0.035	0.035	0.889	0.889	0.017	0.114	0.114	0.432	0.290	0.290	0.020	0.025	0.508	0.635	0.020	0.508	0.508	0.508
1285	0.040	0.040	1.016	1.016	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.032	0.508	0.813	0.020	0.508	0.812	0.508
1287	0.040	0.040	1.016	1.016	0.030	0.140	0.140	0.762	3.556	3.556	0.020	0.032	0.508	0.813	0.020	0.508	0.813	0.508
1298	0.040	0.040	1.016	1.016	0.030	0.140	0.140	0.762	3.556	3.556	0.020	0.032	0.508	0.813	0.020	0.508	0.813	0.508
1350	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.032	0.508	0.813	0.020	0.508	0.812	0.508
1401	0.062	0.062	1.575	1.575	0.045	0.170	0.170	1.143	4.318	4.318	0.020	0.045	0.508	1.143	0.045	0.508	1.143	0.508
L6303	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.032	0.508	0.813	0.020	0.508	0.812	0.508
S6305	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.025	0.508	0.635	0.025	0.508	0.635	0.508
6308	0.032	0.032	0.813	0.813	0.014	0.108	0.108	0.356	2.743	2.743	0.020	0.015	0.508	0.381	0.014	0.508	0.356	0.508
6315	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.025	0.508	0.635	0.025	0.508	0.635	0.508
6370	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.025	0.508	0.635	0.025	0.508	0.635	0.508
6372	0.035	0.035	0.889	0.889	0.025	0.130	0.130	0.635	3.302	3.302	0.020	0.025	0.508	0.635	0.025	0.508	0.635	0.508
6452	0.040	0.040	1.016	1.016	0.030	0.140	0.140	0.762	3.556	3.556	0.020	0.032	0.508	0.813	0.020	0.508	0.813	0.508
6502	0.032	0.032	0.813	0.813	0.014	0.108	0.108	0.356	2.743	2.743	0.020	0.015	0.508	0.381	0.015	0.508	0.381	0.508
6503	0.040	0.040	1.016	1.016	0.030	0.140	0.140	0.762	3.556	3.556	0.020	0.032	0.508	0.813	0.020	0.508	0.813	0.508
860/862	0.035	0.035	0.889	0.889	0.020	0.120	0.120	0.508	3.048	3.048	0.020	0.025	0.508	0.635	0.020	0.508	0.508	0.508

Consult Chomerics' Applications Engineering Department concerning material compatibility for smaller dimensions and custom extrusions.

Maximum dimensional restrictions apply. Please consult with a Chomerics Application Engineer.

Uniform wall thickness is ideal for manufacturability

*Typical Minimum Inside Corner Radii of Gasket

Legend:

ID - Inside Diameter

W - Width

WT - Wall Thickness

S - Slot Width

Table 8: Dimensional Guidelines, (Cont.)

EXTRUSION PROFILE MINIMUM DIMENSIONAL GUIDELINES Minimum dimensions suggested for manufacturing stability																
SOLID O			HOLLOW O			HOLLOW P			RECTANGULAR							
1.5 x DIA.			2.0 x OD			Varies			Varies							
Contact Applications Engineering			Contact Applications Engineering			Contact Applications Engineering			Contact Applications Engineering							
Units:	inch		inch		inch		inch		inch		inch					
	DIA.	DIA.	WT	ID	WT	ID	WT	ID	WT (min)	T	W (min)	T				
Min. Radii:*	mm		mm		mm		mm		mm		mm					
	DIA.	DIA.	WT	ID	WT	ID	WT	ID	WT (min)	T	W (min)	T				
1215	0.030	0.762	0.017	0.020	0.432	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
1217	0.035	0.889	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
1273	0.030	0.762	0.017	0.020	0.432	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
1285	0.040	1.016	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
1287	0.040	1.016	0.020	0.030	0.508	0.762	0.030	0.030	0.045	0.762	0.762	1.143	0.031	0.031	0.787	0.787
1298	0.040	1.016	0.020	0.030	0.508	0.762	0.030	0.030	0.045	0.762	0.762	1.143	0.031	0.031	0.787	0.787
1350	0.035	0.889	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
1401	0.062	1.575	0.045	0.020	1.143	0.508	0.045	0.045	0.045	1.143	1.143	1.143	0.031	0.045	0.787	1.143
L6303	0.035	0.889	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
S6305	0.030	0.762	0.025	0.020	0.635	0.508	0.025	0.030	0.045	0.635	0.762	1.143	0.031	0.031	0.787	0.787
6308*	0.030	0.762	0.014	0.020	0.356	0.508	N/A	N/A	N/A	N/A	N/A	N/A	0.031	0.031	0.787	0.787
6315	0.030	0.762	0.025	0.020	0.635	0.508	0.025	0.030	0.045	0.635	0.762	1.143	0.031	0.031	0.787	0.787
6370	0.030	0.762	0.025	0.020	0.635	0.508	0.025	0.030	0.045	0.635	0.762	1.143	0.031	0.031	0.787	0.787
6372	0.030	0.762	0.025	0.020	0.635	0.508	0.025	0.030	0.045	0.635	0.762	1.143	0.031	0.031	0.787	0.787
6452	0.040	1.016	0.020	0.030	0.508	0.762	0.030	0.030	0.045	0.762	0.762	1.143	0.031	0.031	0.787	0.787
6502	0.030	0.762	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787
6503	0.040	1.016	0.020	0.030	0.508	0.762	0.030	0.030	0.045	0.762	0.762	1.143	0.031	0.031	0.787	0.787
860/862	0.030	0.762	0.020	0.020	0.508	0.508	0.020	0.030	0.045	0.508	0.762	1.143	0.031	0.031	0.787	0.787

Consult Chomerics' Applications Engineering Department concerning material compatibility for smaller dimensions and custom extrusions.
 Maximum dimensional restrictions apply. Please consult with a Chomerics Application Engineer. Uniform wall thickness is ideal for manufacturability
 *Typical Minimum Inside Corner Radii of Gasket Legend: ID - Inside Diameter T - Thickness W - Width WT - Wall Thickness

Extrusion Product Guide

Materials Guidelines





Elastomer Binder Legend			
Silicone	Fluorosilicone	EPDM	Fluorocarbon/ Fluorosilicone
			

Table 7: Material Guidelines - Military and Commercial

		Test Procedure (Type of Test)	CHO-SEAL® 1221	CHO-SEAL® 1224	CHO-SEAL® 6502	CHO-SEAL® 6503	CHO-SEAL® 1298	CHO-SEAL® 1285
Physical	Molded (M) or Extruded (E)	--	M	M	M/E	M/E	M/E	M/E
	Conductive Filler	--	Ag	Ag	Ni/Al	Ni/Al	Passivated Ag/Al	Ag/Al
	Elastomer Binder	--	Fluorosilicone	Silicone	Silicone	Fluorosilicone	Fluorosilicone	Silicone
	Type (Ref. MIL-DTL-83528)	--	Type F	Type E	Not Applicable	Not Applicable	Type D	Type B
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	Not Applicable	Not Applicable	0.150	0.250	Not Applicable	Not Applicable
		MIL-DTL-83528 (Q/C)	0.002	0.002	Not Applicable	Not Applicable	0.012	0.008
	Hardness, Shore A	ASTM D2240 (Q/C)	75 ±7	65 ±7	65 ±10	74 ±7	70 ±7	65 ±7
	Specific Gravity	ASTM D792 (Q/C)	4.00 ±0.50	3.50 ±0.45	1.85 ± 0.25	2.05 ± 0.25	2.00 ± 0.25	2.00 ± 0.25
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	250 (1.72)	300 (2.07)	150 (1.03)	150 (1.03)	180 (1.24)	200 (1.38)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	100/300	200/500	100 min	65 min	60/260	100/300
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	40 (7.00)	50 (8.75)	40 (7.00)	35 (6.13)	35 (6.13)	30 (5.25)
	Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	60	45	30	30	30	32
	Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-65	-65	-55	-55	-55
Maximum Continuous Use Temperature, °C ^(B)		--	160/200	160/200	125	125	160/200	160/200
Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)		ASTM D5470	Not Tested	2.8	1.0	0.9	1.2	2.2
Electrical	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08 ^c (Q)	Method 2	Method 2	Method 3	Method 3	Method 2	Method 2
	200 kHz (H Field)		70	70	Not Tested	Not Tested	55	60
	100 MHz (E Field)	Method 2: MIL-DTL-83528 Para. 4.6.12 (Q)	120	120	100	95	110	115
	500 MHz (E Field)		120	120	Not Tested	Not Tested	100	110
	2 GHz (Plane Wave)		120	120	110	110	95	105
	10 GHz (Plane Wave)	Method 3: CHO-TM-TP09 ^c (Q)	120	120	85	100	90	100
	40 GHz (Plane Wave)		Not Tested				75	Not Tested
Electrical Stability, ohm-cm, max.								
Regulatory	Heat Aging	CEPS-0002 ^c (Q)	Not Applicable	Not Applicable	0.200 ^(H)	0.250 ^(H)	Not Applicable	Not Applicable
		MIL-DTL-83528 Para. 4.6.15 (Q/C)	0.010	0.010	Not Applicable	Not Applicable	0.015	0.010
	Resistance During Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	0.010	0.010	Not Applicable	Not Applicable	0.015	0.012
	Resistance After Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	0.002	0.002	Not Applicable	Not Applicable	0.012	0.008
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.6.9 (Q/C)	0.010	0.010	Not Applicable	Not Applicable	0.015	0.015
EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	>0.9	>0.9	Not Applicable	Not Applicable	>0.9	>0.9	
RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	Yes	
UL 94 Flammability Rating	--	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	

Elastomer Binder Legend

Silicone



Fluorosilicone



EPDM



Fluorocarbon/
Fluorosilicone



continued...Table 7: Material Guidelines - Military and Commercial

		Test Procedure (Type of Test)	CHO-SEAL® 1287	CHO-SEAL® 1215	CHO-SEAL® 1217	CHO-SEAL® 1270	CHO-SEAL® 1273	CHO-SEAL® S6305	
Physical	Molded (M) or Extruded (E)	--	M/E	M/E	M/E	M	M/E	M/E	
	Conductive Filler	--	Ag/Al	Ag/Cu	Ag/Cu	Ag/Cu	Ag/Cu	Ni/C	
	Elastomer Binder	--	Fluorosilicone	Silicone	Fluorosilicone	Silicone	Silicone	Silicone	
	Type (Ref. MIL-DTL-83528)	--	Type D	Type A	Type C	Not Applicable	Not Applicable	Not Applicable	
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	Not Applicable	Not Applicable	Not Applicable	0.050	0.004	0.100	
		MIL-DTL-83528 (Q/C)	0.012	0.004	0.010	Not Applicable	Not Applicable	Not Applicable	
	Hardness, Shore A	ASTM D2240 (Q/C)	70 ±7	65 ±7	75 ±7	40 ±7	65 ±8	65 ±10	
	Specific Gravity	ASTM D792 (Q/C)	2.00 ± 0.25	3.50 ±0.45	4.00 ± 0.50	2.90 ± 0.25	3.70 ± 0.25	2.00 ± 0.25	
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	180 (1.24)	200 (1.38)	180 (1.24)	80 (0.55)	175 (1.21)	200 (1.38)	
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	60/260	100/300	100/300	75	75	100	
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	35 (6.13)	40 (7.00) / 25 (4.38)	35 (6.13)	Not Tested	Not Tested	50 (8.75)	
	Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	30	32	35	30	32	30	
	Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-55	-65	-55	-60	-65	-45
Maximum Continuous Use Temperature, °C ^(B)		--	160/200	125	125	125	125	150	
Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)		ASTM D5470	Not Tested	2.1	Not Tested	0.8	Not Tested	0.8	
Electrical	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08 ^c (Q)	Method 2	Method 2	Method 2	Method 3	Method 1	Method 1	
			200 kHz (H Field)	55	70	70	Not Tested	Not Tested	Not Tested
			100 MHz (E Field)	110	120	120	80	100	100
			500 MHz (E Field)	100	120	120	80	100	100
			2 GHz (Plane Wave)	95	120	115	70	100	100
			10 GHz (Plane Wave)	90	120	110	70	100	100
			40 GHz (Plane Wave)	75	90	Not Tested	Not Tested	Not Tested	75
	Electrical Stability, ohm-cm, max.	Heat Aging	CEPS-0002 ^c (Q)	Not Applicable	Not Applicable	Not Applicable	0.100 ^e	0.010	0.250 ^e
			MIL-DTL-83528 Para. 4.6.15 (Q/C)	0.015	0.010	0.015	Not Applicable	Not Applicable	Not Applicable
		Resistance During Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	0.015	0.004	0.010	Not Applicable	Not Applicable	Not Applicable
Resistance After Vibration		MIL-DTL-83528 Para. 4.6.13 (Q)	0.012	0.008	0.015	Not Applicable	Not Applicable	Not Applicable	
Post Tensile Set Volume Resistivity		MIL-DTL-83528 Para. 4.6.9 (Q/C)	0.015	0.008	0.015	Not Applicable	Not Applicable	Not Applicable	
Regulatory	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	>0.9	>0.9	>0.9	Not Applicable	Not Applicable	Not Applicable	
	RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	Yes	
	UL 94 Flammability Rating	--	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	HB	

Elastomer Binder Legend

Silicone



Fluorosilicone



EPDM



Fluorocarbon/
Fluorosilicone



continued...Table 7: Material Guidelines - Military and Commercial

	Test Procedure (Type of Test)	CHO-SEAL® 6330	CHO-SEAL® 6370	CHO-SEAL® 6371	CHO-SEAL® 6372	CHO-SEAL® 6308	CHO-SEAL® L6303		
Physical	Molded (M) or Extruded (E)	--	M	E	M	E	M/E		
	Conductive Filler	--	Ni/C	Ni/C	Ni/C	Ni/C	Ni/C		
	Elastomer Binder	--	Silicone	Silicone	Silicone	Silicone	Silicone	Fluorosilicone	
	Type (Ref. MIL-DTL-83528)	--	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	0.250	0.100	0.100	0.750	0.100	0.100	
		MIL-DTL-83528 (Q/C)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	Hardness, Shore A	ASTM D2240 (Q/C)	40 ± 7	60 ± 10	65 ± 10	57 ± 7	65 ± 10	65 ± 10	
	Specific Gravity	ASTM D792 (Q/C)	1.70 ± 0.25	2.10 ± 0.25	2.00 ± 0.25	1.80 ± 0.25	2.00 ± 0.25	2.20 ± 0.25	
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	120 (0.83)	150 (1.03)	150 (1.03)	150 (1.03)	200 (1.38)	150 (1.03)	
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	75	100	100	100	75	60	
Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	Not Tested	35 (6.13)	Not Tested	35 (6.13)	40 (7.00)	35 (6.13)		
Thermal	Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	25	40	40	30	30	25	
	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-40	-45	-40	-40	-60	-45	
	Maximum Continuous Use Temperature, °C ^(B)	--	150	150	150	150	150	150	
	Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)	ASTM D5470	0.6	0.9	1.1	Not Tested	Not Tested	0.8	
	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08 ^c (Q)	Method 3	Method 1	Method 1	Method 1	Method 1	Method 1	
			200 kHz (H Field)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
		Method 2: MIL-DTL-83528 Para. 4.6.12 (Q)	100 MHz (E Field)	75	100	100	80	100	100
			500 MHz (E Field)	75	100	100	80	100	100
			2 GHz (Plane Wave)	70	95	80	80	100	100
		Method 3: CHO-TM-TP09 ^c (Q)	10 GHz (Plane Wave)	70	95	80	80	100	100
40 GHz (Plane Wave)		0.6	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
Electrical Stability, ohm-cm, max.									
Regulatory	Heat Aging	CEPS-0002 ^c (Q)	0.250 ^(e)	0.250 ^(e)	0.250 ^(e)	0.850 ^(e)	0.250 ^e	0.250 ^e	
		MIL-DTL-83528 Para. 4.6.15 (Q/C)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	Resistance During Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	Resistance After Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.6.9 (Q/C)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	
	RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	Yes	
	UL 94 Flammability Rating	--	V-1	V-0	V-0	V-1	Not Tested	Not Tested	

Elastomer Binder Legend

Silicone



Fluorosilicone



EPDM



Fluorocarbon/
Fluorosilicone



continued...Table 7: Material Guidelines - Military and Commercial

		Test Procedure (Type of Test)	CHO-SEAL® 1310	CHO-SEAL® 1350	CHO-SEAL® 0860	CHO-SEAL® 0862	CHO-SEAL® S6600	
Physical	Molded (M) or Extruded (E)	--	M	M/E	E	E	M	
	Conductive Filler	--	Ag/Glass	Ag/Glass	Carbon	Carbon	Carbon	
	Elastomer Binder	--	Silicone	Silicone	Silicone	Silicone	Silicone	
	Type (Ref. MIL-DTL-83528)	--	Not Applicable	Type M ^(f)	Not Applicable	Not Applicable	Not Applicable	
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	0.010	Not Applicable	3	24	7	
		MIL-DTL-83528 (Q/C)	Not Applicable	0.006	Not Applicable	Not Applicable	Not Applicable	
	Hardness, Shore A	ASTM D2240 (Q/C)	70 ±10	65 ±7	70 ±5	70 ±5	75 ±7	
	Specific Gravity	ASTM D792 (Q/C)	1.80 ± 0.25	1.90 ± 0.25	1.28 ±0.30	1.20 ±0.30	1.20 ±0.25	
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	200 (1.38)	200 (1.38)	500 (3.45)	600 (4.14)	650 (4.48)	
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	100	100/300	75	100	70	
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	Not Tested	30 (5.25)	50 (8.75)	60 (10.51)	Not Tested	
Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	35	30	Not Tested	Not Tested	45		
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-40	-55	-51	-51	-45	
	Maximum Continuous Use Temperature, °C ^(B)	--	160	160	177	177	200	
	Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)	ASTM D5470	Not Tested	1.2	Not Tested	Not Tested	0.6	
Electrical	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08 ^c (Q)	Method 1	Method 2	Not Applicable	Not Applicable	Method 1	
			200 kHz (H Field)	Not Tested	50	Not Tested	Not Tested	Not Tested
		Method 2: MIL-DTL-83528 Para. 4.6.12 (Q)	100 MHz (E Field)	100	100	Not Tested	Not Tested	80
			500 MHz (E Field)	100	100	Not Tested	Not Tested	80
			2 GHz (Plane Wave)	90	90	Not Tested	Not Tested	60
		Method 3: CHO-TM-TP09 ^c (Q)	10 GHz (Plane Wave)	80	80	Not Tested	Not Tested	50
			40 GHz (Plane Wave)	Not Tested	75	Not Tested	Not Tested	Not Tested
	Electrical Stability, ohm-cm, max.							
	Heat Aging	CEPS-0002 ^c (Q)	0.010	Not Applicable	Not Tested	Not Tested	7 ^(E)	
			MIL-DTL-83528 Para. 4.6.15 (Q/C)	Not Applicable	0.015	Not Applicable	Not Applicable	Not Applicable
MIL-DTL-83528 Para. 4.6.13 (Q)		Not Applicable	0.009	Not Applicable	Not Applicable	Not Applicable		
MIL-DTL-83528 Para. 4.6.13 (Q)		Not Applicable	0.006	Not Applicable	Not Applicable	Not Applicable		
MIL-DTL-83528 Para. 4.6.9 (Q/C)		Not Applicable	0.009	Not Applicable	Not Applicable	Not Applicable		
Regulatory	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	Not Applicable	0.015	Not Applicable	Not Applicable	Not Applicable	
	RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	
	UL 94 Flammability Rating	--	HB	Not Tested	Not tested	V-0	Not Tested	

Elastomer Binder Legend

Silicone



Fluorosilicone



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Table 8: Material Guidelines - Specialty Products

		Test Procedure (Type of Test)	CHO-SEAL® 1401	CHO-SEAL® 1239	CHO-SEAL® 1212	CHO-SEAL® 6435	CHO-SEAL® 6307	CHO-SEAL® 6452
Physical	Molded (M) or Extruded (E)	--	M/E	M	M	M	M	E
	Conductive Filler	--	Ag	Ag/Cu	Ag/Cu	Ag/Ni	Ni/C	Ni/C
	Elastomer Binder	--	Silicone	Silicone & Expd. Cu Foil	Silicone	EPDM	EPDM	EPDM
	Type (Ref. MIL-DTL-83528)	--	Not Qualified	Type G	Type K	Not Applicable	Not Applicable	Not Applicable
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	Not Applicable	Not Applicable	Not Applicable	0.006	5.000	Not Applicable
		MIL-DTL-83528 (Q/C)	0.010	0.007	0.005	Not Applicable	Not Applicable	0.500
	Hardness, Shore A	ASTM D2240 (Q/C)	45 ±5	80 ±7	85 ±7	80 ±7	75 ±7	70 ±10
	Specific Gravity	ASTM D792 (Q/C)	1.60 ± 0.25	4.75 ± 0.75	3.50 ± 0.45	3.70 ± 0.25	1.90 ± 0.25	1.95 ± 0.25
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	200 (1.38)	600 (4.14)	400 (2.76)	200 (1.38)	200 (1.38)	200 (1.38)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	75	20	100/300	200	75	200
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	20 (3.50)	70 (12.25)	40 (7.00)	75 (13.13)	60 (10.51)	55 (9.63)
Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	35	Not Tested	35	40	40	35	
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-55	Not Tested	-45	-40	-45	Pending
	Maximum Continuous Use Temperature, °C ^(B)	--	160/200	125	125	100	100	100
	Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)	ASTM D5470	0.9	1.9	1.8	1.8	0.6	Not Tested
Electrical	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08C (Q)	Method 2	Method 2	Method 2	Method 2	Method 2	Method 3
	200 kHz (H Field)		60	70	70	Not Tested	Not Tested	Not Tested
	100 MHz (E Field)	Method 2: MIL-DTL-83528 Para. 4.6.12 (Q)	100	110	120	105	95	75
	500 MHz (E Field)		100	110	120	100	90	Not Tested
	2 GHz (Plane Wave)		90	110	120	85	85	105
	10 GHz (Plane Wave)	Method 3: CHO-TM-TP09C (Q)	80	110	120	85	85	85
	40 GHz (Plane Wave)		Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
Electrical Stability, ohm-cm, max.								
Regulatory	Heat Aging	CEPS-0002 ^c (Q)	Not Applicable	Not Applicable	Not Applicable	0.0125 ^(d)	10 ^d	Not Applicable
		MIL-DTL-83528 Para. 4.6.15 (Q/C)	0.015	0.010	0.010	Not Applicable	Not Applicable	0.350
	Resistance During Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	0.015	0.007	0.010	Not Applicable	Not Applicable	Not Applicable
	Resistance After Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	0.010	Not Applicable	0.005	Not Applicable	Not Applicable	Not Applicable
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.6.9 (Q/C)	0.020	Not Applicable	0.010	Not Applicable	Not Applicable	Not Applicable
EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	>0.9	>0.9	>0.9	Not Applicable	Not Applicable	Not Applicable	
RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	Yes	
UL 94 Flammability Rating	--	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	

Elastomer Binder Legend

Silicone



Fluorosilicone



EPDM



Fluorocarbon/
Fluorosilicone



Table 9: Material Guidelines - Corrosion Resistant Materials

		Test Procedure (Type of Test)	CHO-SEAL® V6433	CHO-SEAL® 6502	CHO-SEAL® 6503	CHO-SEAL® 1298	CHO-SEAL® 1285	CHO-SEAL® 1287
	Molded (M) or Extruded (E)	--	M	M/E	M/E	M/E	M/E	M/E
Physical	Conductive Filler	--	Ag/Ni	Ni/Al	Ni/Al	Passivated Ag/Al	Ag/Al	Ag/Al
	Elastomer Binder	--	Fluorocarbon/ Fluorosilicone	Silicone	Fluorosilicone	Fluorosilicone	Silicone	Fluorosilicone
	Type (Ref. MIL-DTL-83528)	--	Not Applicable	Not Applicable	Not Applicable	Type D	Type B	Type D
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 ^c (Q/C)	Not Applicable	0.150	0.250	Not Applicable	Not Applicable	Not Applicable
		MIL-DTL-83528 (Q/C)	0.006	Not Applicable	Not Applicable	0.012	0.008	0.012
	Hardness, Shore A	ASTM D2240 (Q/C)	85 ±7	65 ±10	74 ±7	70 ±7	65 ±7	70 ±7
	Specific Gravity	ASTM D792 (Q/C)	4.80 ± 0.25	1.85 ± 0.25	2.05 ± 0.25	2.00 ± 0.25	2.00 ± 0.25	2.00 ± 0.25
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	400 (2.76)	150 (1.03)	150 (1.03)	180 (1.24)	200 (1.38)	180 (1.24)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	50	100 min	65 min	60/260	100/300	60/260
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q)	70 (12.25)	40 (7.00)	35 (6.13)	35 (6.13)	30 (5.25)	35 (6.13)
Compression Set, 70 hrs at 100°C, % max. ^(A)	ASTM D395, Method B (Q)	45	30	30	30	32	30	
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q)	-25	-55	-55	-55	-65	-55
	Maximum Continuous Use Temperature, °C ^(B)	--	200	125	125	160/200	160/200	160/200
	Thermal Conductivity, W/m-K (Typical) 300 psi (2.07 MPa)	ASTM D5470	2.1	1.0	0.9	1.2	2.2	Not Tested
Electrical	Shielding Effectiveness, dB, min. ^(F)	Method 1: CHO-TM-TP08 ^c (Q)	Method 2	Method 3	Method 3	Method 2	Method 2	Method 2
	200 kHz (H Field)		Not Tested	Not Tested	Not Tested	55	60	55
	100 MHz (E Field)	Method 2: MIL-DTL-83528 Para. 4.6.12 (Q)	105	100	95	110	115	110
	500 MHz (E Field)		100	Not Tested	Not Tested	100	110	100
	2 GHz (Plane Wave)		90	110	110	95	105	95
	10 GHz (Plane Wave)	Method 3: CHO-TM-TP09 ^c (Q)	90	85	100	90	100	90
	40 GHz (Plane Wave)		Not Tested	Not Tested	Not Tested	75	Not Tested	75
	Electrical Stability, ohm-cm, max.							
Regulatory	Heat Aging	CEPS-0002 ^c (Q)	0.008 ^g	0.200 ^(H)	0.250 ^(H)	Not Applicable	Not Applicable	0.200 ^(H)
		MIL-DTL-83528 Para. 4.6.15 (Q/C)	Not Applicable	Not Applicable	Not Applicable	0.015	0.010	Not Applicable
	Resistance During Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	Not Applicable	Not Applicable	Not Applicable	0.015	0.012	Not Applicable
	Resistance After Vibration	MIL-DTL-83528 Para. 4.6.13 (Q)	Not Applicable	Not Applicable	Not Applicable	0.012	0.008	Not Applicable
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.6.9 (Q/C)	Not Applicable	Not Applicable	Not Applicable	0.015	0.015	Not Applicable
EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.6.16 (Q)	Not Applicable	Not Applicable	Not Applicable	>0.9	>0.9	Not Applicable	
RoHS Compliant	--	Yes	Yes	Yes	Yes	Yes	Yes	
UL 94 Flammability Rating	--	Not tested	Not tested	Not tested	Not Tested	Not Tested	Not tested	

Note A: Compression set is expressed as a percentage of deflection per ASTM D395 Method B, at 25% deflection. To determine percent recovery, subtract 0.25 of the stated compression set value from 100%. For example, in the case of 30% compression set, recovery is 92.5%.

Note B: Where two values are shown, the first represents max. operating temp. for conformance to MIL-DTL-83528 (which requires Group A life testing at 1.25 times max. operating temp.) and the second value represents the practical limit for exposure up to 1000 hrs. (compressed between flanges 7-10%). Single values conform to both definitions.

Note C: Copies of CEPS-0002, CHO-TM-TP08 and CHO-TM-TP09 are available from Chomerics. Contact Applications Engineering.

Note D: Heat aging condition: 100°C for 48 hrs.

Note E: Heat aging condition: 150°C for 48 hrs.

Note F: It may not be inferred that the same level of shielding effectiveness provided by a gasket material tested in the fixture per MIL-DTL-83528 Para. 4.5.12 would be provided in an actual equipment flange, since many mechanical factors of the flange design (tolerances, stiffness, fastener location and size, etc.) could lower or enhance shielding effectiveness. This procedure provides data applicable only to the test fixture design of MIL-DTL-83528, but which is useful for making comparisons between different gasket materials. 40 ghz test data for all materials uses TP08 test method.

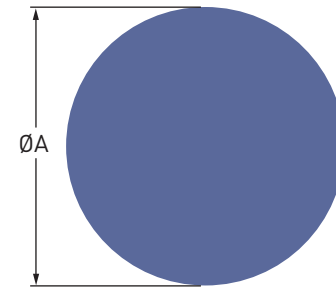
Note G: Heat aging condition: 200 °C for 48 hours

Note H: Heat aging condition: 125 °C for 1000 hours

Note I: Extruded version of 1350 meets Mil-DTL-83528 type M specifications except elongation (60/260).

Extrusion Product Guide

Guide for Standard Extruded Shapes (Profiles)



Profile Description: Solid O-Shape

Chomerics has or will build tooling for all outside diameters between 0.030 - 0.500 inch (0.76 - 12.7 mm). Please consult with an Applications Engineer if the size you need is not shown in the table, and part numbers will be assigned.

Table 10: Profiles, Solid O-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension		Suggested Groove Dimensions*			
	ØA		Depth		Width	
			± 0.002 inch	± 0.05 mm	± 0.002 inch	± 0.05 mm
	inch	mm	inch	mm	inch	mm
19-04-W993-XXXX	0.030	0.76	-	-	-	-
19-04-12897-XXXX	0.033	0.84	-	-	-	-
19-04-23913-XXXX	0.035	0.89	-	-	-	-
10-04-6386-XXXX**	0.040	1.02	0.031	0.79	0.054	1.37
19-04-22085-XXXX	0.040	1.02	0.029	0.74	0.063	1.60
19-04-22371-XXXX**	0.043	1.09	0.034	0.86	0.056	1.42
19-04-22533-XXXX	0.043	1.09	0.032	0.81	0.064	1.63
19-04-27855-XXXX**	0.048	1.22	0.038	0.97	0.061	1.55
10-04-9139-XXXX	0.048	1.22	0.037	0.94	0.067	1.70
10-04-9139-XXXX	0.048	1.22	0.037	0.94	0.067	1.70
19-04-25875-XXXX**	0.050	1.27	0.040	1.02	0.062	1.57
19-04-22087-XXXX	0.050	1.27	0.038	0.97	0.070	1.78
19-04-20581-XXXX**	0.053	1.35	0.043	1.09	0.064	1.63
10-04-3560-XXXX	0.053	1.35	0.041	1.04	0.072	1.83
19-04-28067-XXXX**	0.060	1.52	0.049	1.24	0.070	1.78
19-04-22354-XXXX	0.060	1.52	0.047	1.19	0.078	1.98
19-04-27546-XXXX**	0.062	1.57	0.051	1.30	0.072	1.83
10-04-2561-XXXX	0.062	1.57	0.049	1.24	0.079	2.01
19-04-28402-XXXX**	0.066	1.68	0.054	1.37	0.076	1.93
19-04-22049-XXXX	0.066	1.68	0.053	1.35	0.082	2.08
19-04-22951-XXXX**	0.070	1.78	0.057	1.45	0.080	2.03
10-04-1687-XXXX	0.070	1.78	0.056	1.42	0.086	2.18
19-04-24514-XXXX	0.073	1.85	0.059	1.50	0.088	2.24
19-04-12898-XXXX	0.074	1.88	0.060	1.52	0.089	2.26
19-04-11228-XXXX	0.075	1.91	0.061	1.55	0.090	2.29
19-04-12899-XXXX	0.077	1.96	0.063	1.60	0.091	2.31
19-04-12900-XXXX	0.079	2.01	0.064	1.63	0.094	2.39
10-04-2657-XXXX	0.080	2.03	0.065	1.65	0.095	2.41
19-04-12901-XXXX	0.085	2.16	0.069	1.75	0.100	2.54
19-04-M394-XXXX	0.090	2.29	0.074	1.88	0.103	2.62
10-04-2865-XXXX	0.093	2.36	0.076	1.93	0.107	2.72
10-04-3509-XXXX	0.100	2.54	0.082	2.08	0.113	2.87
10-04-1720-XXXX	0.103	2.62	0.084	2.13	0.117	2.97
19-04-12902-XXXX	0.106	2.69	0.087	2.21	0.119	3.02
10-04-2866-XXXX	0.112	2.84	0.092	2.34	0.125	3.18
19-04-22993-XXXX	0.115	2.92	0.094	2.39	0.129	3.28
10-04-3077-XXXX	0.119	3.02	0.098	2.49	0.131	3.33
10-04-2463-XXXX	0.125	3.18	0.102	2.59	0.139	3.53
10-04-2862-XXXX	0.130	3.30	0.107	2.72	0.142	3.61
19-04-12903-XXXX	0.134	3.40	0.110	2.79	0.146	3.71
19-04-23338-XXXX	0.136	3.45	0.112	2.84	0.148	3.76
10-04-1721-XXXX	0.139	3.53	0.114	2.90	0.152	3.86
19-04-12904-XXXX	0.147	3.73	0.120	3.05	0.160	4.06
10-04-3982-XXXX	0.150	3.81	0.123	3.12	0.163	4.14
19-04-25361-XXXX	0.156	3.96	0.128	3.25	0.169	4.29
19-04-12906-XXXX	0.158	4.01	0.129	3.28	0.171	4.34
10-04-3231-XXXX	0.160	4.06	0.131	3.33	0.173	4.39
19-04-12907-XXXX	0.170	4.32	0.139	3.53	0.182	4.62
19-04-F371-XXXX	0.188	4.78	0.154	3.91	0.200	5.08
19-04-12908-XXXX	0.195	4.95	0.160	4.06	0.207	5.26
19-04-20919-XXXX	0.210	5.33	0.173	4.39	0.227	5.77
10-04-2864-XXXX	0.216	5.49	0.177	4.50	0.234	5.94
19-04-12909-XXXX	0.219	5.56	0.179	4.55	0.238	6.05
19-04-12910-XXXX	0.236	5.99	0.193	4.90	0.254	6.45
19-04-12911-XXXX	0.247	6.27	0.202	5.13	0.265	6.73
10-04-3076-XXXX	0.250	6.35	0.205	5.21	0.268	6.81
19-04-25051-XXXX	0.275	6.99	0.226	5.74	0.291	7.39
10-04-9769-XXXX	0.280	7.11	0.230	5.84	0.297	7.54
19-04-12912-XXXX	0.291	7.39	0.238	6.05	0.309	7.85
19-04-27818-XXXX	0.335	8.51	0.275	6.99	0.351	8.92
19-04-12918-XXXX	0.367	9.32	0.301	7.65	0.387	9.83
19-04-12919-XXXX	0.379	9.63	0.310	7.87	0.400	10.16
19-04-12920-XXXX	0.393	9.98	0.322	8.18	0.413	10.49

Standard Tolerances (inch)

<0.200: ±0.005

0.200 - 0.349: ±0.008

0.350 - 0.500: ±0.010

>0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

*Contact Chomerics Applications Engineering for groove design assistance.

** This part diameter is held to ±.003".

Profile Description: Hollow O Shape

Chomerics has or will build tooling for all outside diameters between 0.030 -0.500 inch (0.76 - 12.7 mm). Please consult with an Applications Engineer if the size you need is not shown in the table, and part numbers will be assigned.

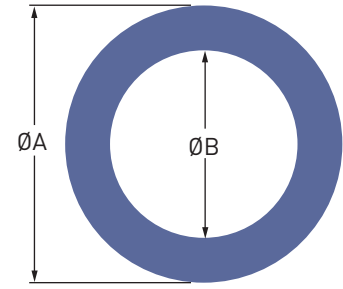


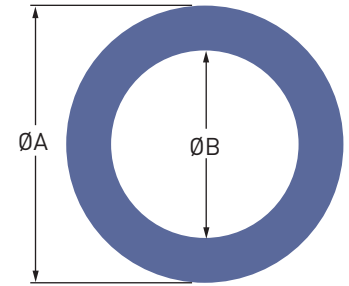
Table 11: Profiles, Hollow-O-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension			
	inch		mm	
	A	B	A	B
10-04-21120-XXXX	0.053	0.020	1.35	0.51
10-04-W137-XXXX	0.060	0.020	1.52	0.51
10-04-W163-XXXX	0.062	0.035	1.57	0.89
19-04-22710-XXXX	0.063	0.023	1.60	0.58
19-04-14964-XXXX	0.070	0.020	1.78	0.51
19-04-25856-XXXX	0.070	0.040	1.78	1.02
19-04-22129-XXXX	0.073	0.033	1.85	0.84
19-04-24444-XXXX	0.074	0.020	1.88	0.51
19-04-23365-XXXX	0.075	0.045	1.90	1.14
19-04-26950-xxxx	0.078	0.043	1.98	1.09
19-04-15465-XXXX	0.080	0.030	2.03	0.76
19-04-14206-XXXX	0.080	0.040	2.03	1.02
19-04-11204-XXXX	0.081	0.020	2.06	0.51
19-04-22678-XXXX	0.083	0.043	2.11	1.09
19-04-12570-XXXX	0.083	0.050	2.11	1.27
19-04-26087-XXXX	0.085	0.045	2.16	1.14
19-04-23086-XXXX	0.090	0.020	2.29	0.51
10-04-W267-XXXX	0.090	0.050	2.29	1.27
10-04-W293-XXXX	0.090	0.060	2.229	1.52
19-04-22970-XXXX	0.093	0.033	2.36	0.84
19-04-20072-XXXX	0.093	0.040	2.36	1.02
19-04-25602-XXXX	0.100	0.040	2.54	1.02
19-04-12744-XXXX	0.100	0.060	2.54	1.52
19-04-16162-XXXX	0.100	0.070	2.54	1.78
19-04-11205-XXXX	0.102	0.039	2.59	0.99
19-04-20946-XXXX	0.102	0.051	2.59	1.30
10-04-8363-XXXX	0.103	0.040	2.62	1.02
19-04-24415-XXXX	0.103	0.053	2.62	1.35
19-04-24652-XXXX	0.103	0.075	2.62	1.90
19-04-11218-XXXX	0.110	0.045	2.79	1.14
19-04-14120-XXXX	0.110	0.062	2.79	1.57
19-04-15278-XXXX	0.110	0.068	2.79	1.73
19-04-15586-XXXX	0.118	0.050	3.00	1.27
19-04-12534-XXXX	0.118	0.079	3.00	2.01
19-04-11216-XXXX	0.122	0.061	3.10	1.55
10-04-2999-XXXX	0.125	0.045	3.17	1.14
19-04-25964-XXXX	0.125	0.050	3.17	1.27

Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
19-04-23836-XXXX	0.125	0.055	3.17	1.40
10-04-8817-XXXX	0.125	0.062	3.17	1.57
19-04-13564-XXXX	0.125	0.070	3.17	1.78
10-04-W204-XXXX	0.125	0.078	3.17	1.98
19-04-11283-XXXX	0.125	0.080	3.17	2.03
10-04-W775-XXXX	0.125	0.085	3.17	2.16
10-04-5514-XXXX	0.130	0.045	3.30	1.14
19-04-25964-XXXX	0.130	0.050	3.30	1.27
19-04-23097-XXXX	0.130	0.090	3.30	2.29
19-04-16390-XXXX	0.135	0.045	3.43	1.14
19-04-16104-XXXX	0.135	0.055	3.43	1.40
19-04-16009-XXXX	0.135	0.085	3.43	2.16
19-04-X787-XXXX	0.135	0.097	3.43	2.46
19-04-14632-XXXX	0.137	0.087	3.48	2.21
19-04-11497-XXXX	0.140	0.046	3.56	1.17
19-04-11289-XXXX	0.145	0.070	3.68	1.78
19-04-13118-XXXX	0.145	0.080	3.68	2.03
19-04-14930-XXXX	0.151	0.094	3.84	2.39
19-04-21919-XXXX	0.153	0.105	3.89	2.67
19-04-13545-XXXX	0.153	0.115	3.89	2.92
19-04-23209-XXXX	0.156	0.035	3.96	0.89
10-04-4180-XXXX	0.156	0.050	3.96	1.27
10-04-9732-XXXX	0.156	0.080	3.96	2.03
19-04-26590-XXXX	0.156	0.102	3.96	2.59
19-04-26424-XXXX	0.168	0.110	4.27	2.79
19-04-26610-XXXX	0.170	0.062	4.32	1.57
19-04-26593-XXXX	0.1777	0.077	4.50	1.96
10-04-8133-XXXX	0.177	0.079	4.50	2.01
19-04-21639-XXXX	0.177	0.090	4.50	2.29
19-04-13189-XXXX	0.177	0.110	4.50	2.79
19-04-20982-XXXX	0.177	0.125	4.50	3.17
19-04-22324-XXXX	0.177	0.137	4.50	3.48
19-04-11214-XXXX	0.180	0.140	4.57	3.56
19-04-12128-XXXX	0.188	0.125	4.78	3.17
19-04-14537-XXXX	0.189	0.111	4.80	2.82
10-04-4254-XXXX	0.190	0.080	4.83	2.03

Table 11: Profiles, Hollow-O-Shape (Sorted by "A" Dimension) (Cont.)

Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
19-04-26381-XXXX	0.190	0.115	4.83	2.92
19-04-21194-XXXX	0.195	0.155	4.95	3.94
19-04-12015-XXXX	0.207	0.077	5.26	1.96
19-04-15435-XXXX	0.207	0.090	5.26	2.29
19-04-16084-XXXX	0.207	0.134	5.26	3.40
19-04-26772-XXXX	0.207	0.144	5.26	3.66
19-04-E483-XXXX	0.210	0.093	5.33	2.36
19-04-22066-XXXX	0.210	0.100	5.33	2.54
19-04-15479-XXXX	0.210	0.120	5.33	3.05
19-04-C627-XXXX	0.216	0.090	5.49	2.29
19-04-20848-XXXX	0.220	0.170	5.59	4.32
19-04-23158-XXXX	0.236	0.118	5.99	3.00
19-04-21163-XXXX	0.250	0.110	6.35	2.79
10-04-2737-XXXX	0.250	0.125	6.35	3.17
19-04-15434-XXXX	0.250	0.140	6.35	3.56
19-04-21162-XXXX	0.250	0.147	6.35	3.73
19-04-12792-XXXX	0.250	0.150	6.35	3.81
19-04-15443-XXXX	0.250	0.187	6.35	4.75
19-04-21161-XXXX	0.250	0.192	6.35	4.88
19-04-14349-XXXX	0.250	0.200	6.35	5.08
19-04-W049-XXXX	0.290	0.156	7.37	3.96
10-04-3221-XXXX	0.290	0.175	7.37	4.44
19-04-19133-XXXX	0.312	0.115	7.92	2.92
10-04-3004-XXXX	0.312	0.192	7.92	4.88
19-04-16906-XXXX	0.335	0.202	8.51	5.13
19-04-22253-XXXX	0.343	0.168	8.71	4.27
19-04-13759-XXXX	0.348	0.250	8.84	6.35
19-04-14292-XXXX	0.373	0.200	9.47	5.08
10-04-3122-XXXX	0.375	0.250	9.52	6.35
19-04-12102-XXXX	0.376	0.148	9.55	3.76
19-04-22230-XXXX	0.390	0.295	9.91	7.49
19-04-19324-XXXX	0.390	0.328	9.91	8.33
19-04-14467-XXXX	0.394	0.253	10.01	6.43
19-04-12338-XXXX	0.430	0.330	10.92	8.38
19-04-3685-XXXX	0.437	0.250	11.10	6.35
10-04-4034-XXXX	0.437	0.347	11.10	8.81
19-04-14261-XXXX	0.461	0.295	11.71	7.49
10-04-3649-XXXX	0.470	0.345	11.94	8.76
19-04-11651-XXXX	0.524	0.315	13.31	8.00
19-04-22208-XXXX	0.543	0.184	13.79	4.67
19-04-21440-XXXX	0.545	0.395	13.84	10.03
19-04-27626-XXXX	0.610	0.075	15.49	1.90
10-04-5516-XXXX	0.620	0.515	15.75	13.08



NOTE:
Due to the hollow profile's nature, multiple groove sizes are possible. Contact Chomerics Applications Engineering for design assistance.

19-04-15181-XXXX	0.625	0.250	15.88	6.35
10-04-4148-XXXX	0.630	0.515	16.00	13.08
19-04-23379-XXXX	0.644	0.581	16.36	14.76
19-04-21493-XXXX	0.676	0.613	17.17	15.57
19-04-11875-XXXX	0.812	0.500	20.62	12.70
19-04-20951-XXXX	0.893	0.770	22.68	19.56
19-04-17364-XXXX	1.240	1.150	31.50	29.21

Standard Tolerances (inch)

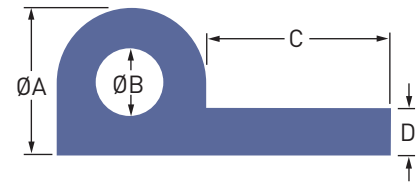
- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.
Please see Chomerics drawing for revision-controlled specifications.
*Contact Chomerics Applications Engineering for groove design assistance.

Profile Description: P Shape

Table 12: Profiles, P-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
19-06-12489-XXXX	0.075	0.025	-	0.045	1.90	0.64	-	1.14
19-06-10819-XXXX	0.076	0.028	0.124	0.033	1.93	0.71	3.15	0.84
19-06-26676-XXXX	0.090	0.045	0.160	0.025	2.29	1.14	4.06	0.64
19-06-M151-XXXX	0.125	0.045	0.250	0.062	3.17	1.14	6.35	1.57
19-06-Z731-XXXX	0.140	0.100	0.135	0.030	3.56	2.54	3.43	0.76
19-06-C442-XXXX	0.164	0.084	0.040	0.095	4.17	2.13	1.02	2.41
19-06-M412-XXXX	0.168	0.047	0.200	0.062	4.27	1.19	5.08	1.57
10-06-B227-XXXX	0.190	0.130	0.312	0.062	4.83	3.30	7.92	1.57
19-06-20879-XXXX	0.190	0.136	0.312	0.030	4.83	3.45	7.92	0.76
10-06-A778-XXXX	0.200	0.080	0.215	0.062	5.08	2.03	5.46	1.57
19-06-11223-XXXX	0.200	0.080	0.310	0.052	5.08	2.03	7.87	1.32
10-06-8560-XXXX	0.200	0.080	0.425	0.062	5.08	2.03	10.80	1.57
19-06-12942-XXXX	0.200	0.080	0.400	0.062	5.08	2.03	10.16	1.57
10-06-8550-XXXX	0.200	0.080	0.275	0.062	5.08	2.03	6.99	1.57
10-06-8737-XXXX	0.200	0.080	0.250	0.062	5.08	2.03	6.35	1.57
19-06-13514-XXXX	0.200	0.080	0.125	0.062	5.08	2.03	3.17	1.57
10-06-6175-XXXX	0.200	0.080	0.550	0.062	5.08	2.03	13.97	1.57
10-06-3599-XXXX	0.200	0.080	0.650	0.062	5.08	2.03	16.51	1.57
19-06-13217-XXXX	0.200	0.125	0.650	0.062	5.08	3.17	16.51	1.57
10-06-6180-XXXX	0.250	0.125	0.625	0.062	6.35	3.17	15.88	1.57
10-06-4142-XXXX	0.250	0.125	0.250	0.062	6.35	3.17	6.35	1.57
10-06-3300-XXXX	0.250	0.125	0.375	0.062	6.35	3.17	9.52	1.57
10-06-4921-XXXX	0.250	0.150	0.375	0.062	6.35	3.81	9.52	1.57
10-06-8778-XXXX	0.250	0.125	0.350	0.062	6.35	3.17	8.89	1.57
10-06-C716-XXXX	0.254	0.153	0.254	0.062	6.45	3.89	6.45	1.57
19-06-22037-XXXX	0.310	0.210	0.145	0.050	7.87	5.33	3.68	1.27
10-06-5611-XXXX	0.312	0.187	0.563	0.062	7.92	4.75	14.30	1.57
10-06-2750-XXXX	0.360	0.255	0.420	0.070	9.14	6.48	10.67	1.78
19-06-27536-XXXX	0.250	0.188	0.500	0.062	6.35	4.78	12.70	1.57
19-06-16770-XXXX	0.375	0.250	0.625	0.075	9.52	6.35	15.88	1.90
19-06-L064-XXXX	0.600	0.400	0.350	0.110	15.24	10.16	8.89	2.79
19-06-15899-XXXX	0.610	0.350	0.875	0.130	15.49	8.89	22.22	3.30
19-06-11384-XXXX	0.750	0.625	0.725	0.062	19.05	15.88	18.41	1.57



Standard Tolerances (inch)

- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

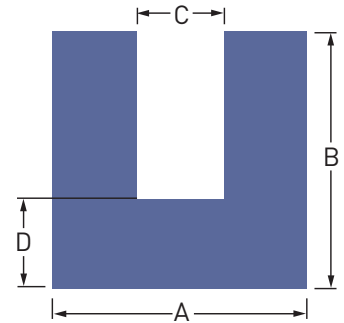
Contact Chomerics Applications Engineering for groove design assistance.

(For PSA, change -06 to -20)

Profile Description: Channel Shape

Table 13: Profiles, Channel-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
19-08-14054-XXXX	0.075	0.099	0.025	0.032	1.90	2.51	0.64	0.81
10-08-6475-XXXX	0.100	0.100	0.034	0.033	2.54	2.54	0.86	0.84
19-08-22217-XXXX	0.125	0.188	0.025	0.062	3.17	4.78	0.64	1.57
19-08-12880-XXXX	0.126	0.078	0.044	0.048	3.20	1.98	1.12	1.22
19-08-12881-XXXX	0.126	0.099	0.047	0.059	3.20	2.51	1.19	1.50
10-08-3215-XXXX	0.126	0.110	0.025	0.050	3.20	2.79	0.64	1.27
10-08-4315-XXXX	0.126	0.225	0.020	0.075	3.20	5.71	0.51	1.90
19-08-17623-XXXX	0.154	0.114	0.082	0.048	3.91	2.90	2.08	1.22
10-08-3157-XXXX	0.156	0.156	0.062	0.047	3.96	3.96	1.57	1.19
19-08-12844-XXXX	0.156	0.175	0.046	0.075	3.96	4.44	1.17	1.90
10-08-3253-XXXX	0.175	0.156	0.047	0.075	4.44	3.96	1.19	1.90
10-08-F815-XXXX	0.188	0.188	0.062	0.062	4.78	4.78	1.57	1.57
19-08-23568-XXXX	0.190	0.270	0.050	0.065	4.83	6.86	1.27	1.65
19-08-C929-XXXX	0.250	0.250	0.130	0.062	6.35	6.35	3.30	1.57
19-08-12885-XXXX	0.260	0.184	0.140	0.062	6.60	4.67	3.56	1.57
19-08-17068-XXXX	0.312	0.187	0.190	0.061	7.92	4.75	4.83	1.55
19-08-12886-XXXX	0.320	0.315	0.193	0.197	8.13	8.00	4.90	5.00
10-08-3872-XXXX	0.327	0.235	0.062	0.115	8.31	5.97	1.57	2.92
10-08-8754-XXXX	0.330	0.215	0.170	-	8.38	5.46	4.32	-
19-08-E622-XXXX	0.375	0.500	0.187	0.125	9.52	12.70	4.75	3.17



Standard Tolerances (inch)

- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

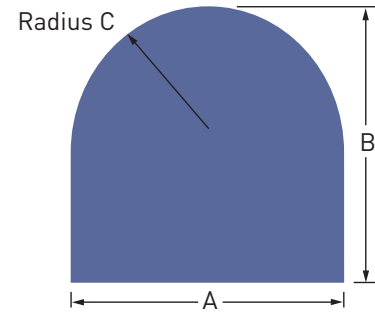
Please see Chomerics drawing for revision-controlled specifications.

Contact Chomerics Applications Engineering for groove design assistance.

Profile Description: D Shape

Table 14: Profiles, D-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)			Nominal Dimension (mm)		
	A	B	C	A	B	C
19-05-2116-XXXX	0.035	0.035	0.018	0.89	0.89	0.46
19-05-16047-XXXX	0.021	0.040	0.010	0.53	1.02	0.25
19-05-20935-XXXX	0.150	0.052	0.200	3.81	1.32	5.08
19-05-14769-XXXX	0.035	0.062	0.018	0.89	1.57	0.46
10-05-5589-XXXX	0.055	0.064	0.028	1.40	1.63	0.71
10-05-1362-XXXX	0.062	0.068	0.031	1.57	1.73	0.79
19-05-14422-XXXX	0.055	0.070	0.055	1.40	1.78	1.40
19-05-E163-XXXX	0.062	0.074	0.031	1.57	1.88	0.79
10-05-Z337-XXXX	0.060	0.075	0.030	1.52	1.90	0.76
10-05-3224-XXXX	0.094	0.078	0.047	2.39	1.98	1.19
19-05-12888-XXXX	0.088	0.081	0.044	2.24	2.06	1.12
19-05-12883-XXXX	0.062	0.085	0.031	1.57	2.16	0.79
10-05-1363-XXXX	0.078	0.089	0.039	1.98	2.26	0.99
19-05-Z586-XXXX	0.094	0.094	0.047	2.39	2.39	1.19
10-05-4699-XXXX	0.062	0.100	0.031	1.57	2.54	0.79
19-05-23159-XXXX	0.125	0.110	0.062	3.17	2.79	1.57
10-05-2618-XXXX	0.150	0.110	0.075	3.81	2.79	1.90
19-05-C128-XXXX	0.102	0.115	0.051	2.59	2.92	1.30
19-05-21124-XXXX	0.165	0.118	0.083	4.19	3.00	2.11
19-05-F084-XXXX	0.125	0.125	0.062	3.17	3.17	1.57
19-05-25354-XXXX	0.125	0.125	0.062	3.17	3.17	1.57
10-05-A283-XXXX	0.122	0.131	0.061	3.10	3.33	1.55
19-05-A611-XXXX	0.091	0.134	0.045	2.31	3.40	1.14
10-05-1364-XXXX	0.122	0.135	0.061	3.10	3.43	1.55
19-05-11558-XXXX	0.098	0.150	0.039	2.49	3.81	0.99
10-05-1499-XXXX	0.118	0.156	0.059	3.00	3.96	1.50
19-05-F173-XXXX	0.156	0.156	0.078	3.96	3.96	1.98
10-05-1577-XXXX	0.178	0.175	0.089	4.52	4.44	2.26
19-05-W469-XXXX	0.188	0.188	0.094	4.78	4.78	2.39
10-05-A381-XXXX	0.187	0.200	0.093	4.75	5.08	2.36



Standard Tolerances (inch)

- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

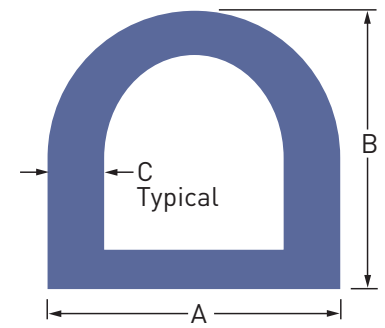
Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.
Contact Chomerics Applications Engineering for groove design assistance.
(For PSA, change -05 to -20)

Profile Description: Hollow D Shape

Table 15: Profiles, Hollow D-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)			Nominal Dimension (mm)		
	A	B	C	A	B	C
19-05-14960-XXXX	0.157	0.076	0.020	3.99	1.93	0.051
19-05-24810-XXXX	0.125	0.093	0.025	3.17	2.36	0.64
19-05-23617-XXXX	0.085	0.095	0.020	2.16	2.41	0.51
19-05-11440-XXXX	0.246	0.145	0.030	6.25	3.68	0.76
19-05-9514-XXXX	0.100	0.148	0.040	2.54	3.76	1.02
19-05-15343-XXXX	0.125	0.156	0.040	3.17	3.96	1.02
19-05-20355-XXXX	0.135	0.156	0.040	3.43	3.96	1.02
10-05-6419-XXXX	0.156	0.156	0.045	3.96	3.96	1.14
19-05-21357-XXXX	0.200	0.156	0.045	5.08	3.96	1.14
19-05-19354-XXXX	0.126	0.185	0.028	3.20	4.70	0.71
19-05-17261-XXXX	0.186	0.186	0.040	4.72	4.72	1.02
10-05-4202-XXXX	0.187	0.187	0.050	4.75	4.75	1.27
19-05-11231-XXXX	0.207	0.187	0.050	5.26	4.75	1.27
19-05-10277-XXXX	0.296	0.187	0.030	7.52	4.75	0.76
19-05-21741-XXXX	0.296	0.187	0.030	7.52	4.75	0.76
19-05-L467-XXXX	0.296	0.187	0.050	7.52	4.75	1.27
19-05-17485-XXXX	0.217	0.188	0.030	5.51	4.78	0.76
19-05-X254-XXXX	0.187	0.227	0.040	4.75	5.77	1.02
19-05-16720-XXXX	0.400	0.230	0.035	10.16	5.84	0.89
19-05-25074-XXXX	0.374	0.235	0.031	9.50	5.97	0.79
10-05-6991-XXXX	0.250	0.250	0.062	6.35	6.35	1.57
10-05-6394-XXXX	0.250	0.250	0.065	6.35	6.35	1.65
10-05-4308-XXXX	0.312	0.312	0.062	7.92	7.92	1.57
19-05-19369-XXXX	0.312	0.312	0.038	7.92	7.92	0.97
19-05-C589-XXXX	0.488	0.312	0.055	12.40	7.92	1.40
19-05-16657-XXXX	0.487	0.324	0.055	12.37	8.23	1.40
19-05-12375-XXXX	0.487	0.324	0.062	12.37	8.23	1.57
10-05-4542-XXXX	0.487	0.324	0.080	12.37	8.23	2.03
19-05-12066-XXXX	0.487	0.324	0.045	12.37	8.23	1.14
19-05-20410-XXXX	0.750	0.324	0.062	19.05	8.23	1.57
19-05-E429-XXXX	0.500	0.500	0.062	12.70	12.70	1.57
10-05-4282-XXXX	0.700	0.600	0.100	17.78	15.24	2.54
19-05-L362-XXXX	0.750	0.750	0.075	19.05	19.05	1.90



Standard Tolerances (inch)

- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

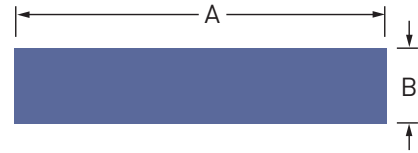
Contact Chomerics Applications Engineering for groove design assistance.

(For PSA, change -05 to -20)

Profile Description: Rectangular Strip Shape

Table 16: Profiles, Rectangular Strip-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
19-07-21642-XXXX	0.188	0.031	4.78	0.79
19-07-26306-XXXX	0.625	0.032	15.88	0.81
19-07-10959-XXXX	0.870	0.032	22.10	0.81
19-07-M327-XXXX	1.000	0.032	25.40	0.081
19-07-25114-XXXX	1.300	0.032	33.02	0.81
19-07-26385-XXXX	1.500	0.032	38.10	0.81
19-07-Z499-XXXX	0.114	0.039	2.90	0.99
19-07-11206-XXXX	0.120	0.040	3.05	1.02
19-07-12675-XXXX	0.500	0.040	12.70	1.02
10-07-4272-XXXX	0.063	0.042	1.60	1.07
19-07-11081-XXXX	1.000	0.042	25.40	1.07
19-07-21881-XXXX	0.177	0.045	4.50	1.14
19-07-19506-XXXX	0.320	0.045	8.13	1.14
19-07-20218-XXXX	0.157	0.050	3.99	1.27
19-07-20362-XXXX	0.157	0.059	3.99	1.50
10-07-F743-XXXX	0.375	0.060	9.52	1.52
19-07-12959-XXXX	0.640	0.060	16.26	1.52
10-07-L525-XXXX	1.120	0.060	28.45	1.52
19-07-26267-XXXX	1.250	0.060	31.75	1.52
19-07-12949-XXXX	0.095	0.062	2.41	1.57
10-07-2981-XXXX	0.095	0.062	2.41	1.57
10-07-3225-XXXX	0.125	0.062	3.17	1.57
10-07-3047-XXXX	0.156	0.062	3.96	1.57
19-07-F463-XXXX	0.188	0.062	4.78	1.57
10-07-3226-XXXX	0.250	0.062	6.35	1.57
19-07-L463-XXXX	0.390	0.062	9.91	1.57
19-07-12200-XXXX	0.500	0.062	12.70	1.57
19-07-12958-XXXX	0.569	0.062	14.45	1.57
19-07-11294-XXXX	0.750	0.062	19.05	1.57
10-07-4483-XXXX	0.750	0.062	19.05	1.57
19-07-22989-XXXX	0.825	0.062	20.95	1.57
19-07-22989-XXXX	0.825	0.062	20.95	1.57
10-07-4523-XXXX	0.880	0.062	22.35	1.57
19-07-27623-XXXX	0.920	0.062	23.37	1.57
19-07-E431-XXXX	1.000	0.062	25.40	1.57
10-07-4538-XXXX	1.180	0.062	29.97	1.57
19-07-12961-XXXX	1.210	0.062	30.73	1.57
19-07-16941-XXXX	1.250	0.062	31.75	1.57
19-07-W391-XXXX	1.600	0.062	40.64	1.57
19-07-F067-XXXX	2.000	0.062	50.80	1.57
19-07-26620-XXXX	2.500	0.062	63.50	1.57
19-07-25333-XXXX	4.000	0.062	101.60	1.57
19-07-12954-XXXX	0.255	0.063	6.48	1.60



Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
19-07-12956-XXXX	0.508	0.063	12.90	1.60
19-07-25333-XXXX	0.768	0.067	19.51	1.70
10-07-4014-XXXX	0.120	0.075	3.05	1.90
10-07-3522-XXXX	0.500	0.075	12.70	1.90
19-07-12948-XXXX	0.085	0.085	2.16	2.16
19-07-11080-XXXX	1.000	0.090	25.40	2.29
19-07-12953-XXXX	0.188	0.093	4.78	2.36
19-07-12491-XXXX	0.500	0.093	12.70	2.36
19-07-24976-XXXX	0.625	0.093	18.88	2.36
19-07-11079-XXXX	0.780	0.100	19.81	2.54
19-07-13026-XXXX	0.188	0.125	4.78	3.17
19-07-21339-XXXX	0.250	0.125	6.35	3.17
10-07-4217-XXXX	0.500	0.125	12.70	3.17
19-07-12877-XXXX	0.620	0.125	15.75	3.17
19-07-11495-XXXX	0.880	0.125	22.35	3.17
19-07-8345-XXXX	0.980	0.125	24.89	3.17
19-07-12951-XXXX	0.126	0.126	3.20	3.20
19-07-12957-XXXX	0.564	0.127	14.33	3.23
19-07-F627-XXXX	0.219	0.156	5.56	3.96
10-07-14592-XXXX	0.438	0.188	11.13	4.78
10-07-3080-XXXX	0.500	0.188	12.70	4.78
10-07-B447-XXXX	0.500	0.250	12.70	6.35
10-07-3797-XXXX	1.000	0.250	25.40	6.35
19-07-27622-XXXX	1.190	0.250	30.23	6.35
19-07-12955-XXXX	0.330	0.305	8.38	7.75
19-07-L956-XXXX	0.875	0.312	22.22	7.92
19-07-16977-XXXX	1.250	0.500	31.75	12.70

Standard Tolerances (inch)

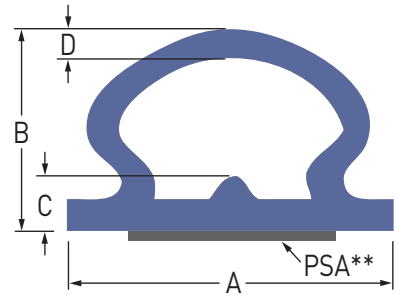
<0.200: ±0.005
 0.200 - 0.349: ±0.008
 0.350 - 0.500: ±0.010
 >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

Contact Chomerics Applications Engineering for groove design assistance.

For PSA, change -07 to -20.



Profile Description: Mushroom D Shape

Table 18: Profiles, Mushroom D-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)				REF PSA width (inch)	Suggested Gap Range (inch)			
	A	B	C	D	A	B	C	D		Min. Gap	Nominal Gap	Max. Gap	Deflection Range
19-09-16802-XXXX	0.315	0.301	0.109	0.053	8.00	7.65	2.77	1.35	0.160	0.175	0.213	0.250	0.075
19-09-16503-XXXX	0.265	0.312	0.113	0.040	6.73	7.92	2.87	1.02	0.090	0.188	0.224	0.260	0.072
19-05-14587-XXXX	0.487	0.324	0.115	0.055	12.37	8.23	2.92	1.40	0.250	0.175	0.223	0.270	0.095
19-09-14377-XXXX	0.625	0.375	0.106	0.057	15.88	9.52	2.69	1.45	0.375	0.175	0.243	0.310	0.135
19-09-14926-XXXX	0.625	0.400	0.106	0.057	15.88	10.16	2.69	1.45	0.375	0.200	0.265	0.330	0.130
19-05-14282-XXXX	0.645	0.427	0.065	0.067	16.38	10.85	1.65	1.65	0.300	0.225	0.290	0.355	0.130
19-09-16339-XXXX	0.472	0.433	0.115	0.040	11.99	11.00	2.92	1.02	0.250	0.188	0.274	0.360	0.172
19-09-15486-XXXX	0.846	0.472	0.120	0.053	21.49	11.99	3.05	1.35	0.375	0.188	0.292	0.395	0.207
19-09-15523-XXXX	0.890	0.730	0.183	0.065	22.61	18.54	4.65	1.65	0.500	0.250	0.405	0.560	0.310

Standard Tolerances (inch)

- <0.200: ±0.005
- 0.200 - 0.349: ±0.008
- 0.350 - 0.500: ±0.010
- >0.500: ±3% Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

*Contact Chomerics Applications Engineering for groove design assistance.

**For optional PSA on surface "A", change the second syllable of the part number from -05 or -09 to -20. The PSA will be centered on the part.

Custom Mushroom Profiles

<p>19-20-14282-XXXX</p>	<p>19-20-14377-XXXX</p> <p>U.S. Patent No. 06075205</p>	<p>19-20-14587-XXXX</p> <p>U.S. Patent No. 06075205</p>	<p>19-20-14926-XXXX</p> <p>U.S. Patent No. 06075205</p>
<p>19-20-15523-XXXX</p> <p>U.S. Patent No. 06075205</p>	<p>19-20-16339-XXXX</p> <p>U.S. Patent No. 06075205</p>	<p>19-20-16503-XXXX</p> <p>U.S. Patent No. 06075205</p>	<p>19-20-16802-XXXX</p> <p>U.S. Patent No. 06075205</p>

Profile Description: Hollow Rectangle Shape

Table 17: Profiles, Hollow Rectangle-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)			Nominal Dimension (mm)		
	A	B	C	A	B	C
10-07-13944-XXXX	0.100	0.059	0.020	2.54	1.50	0.51
19-07-15804-XXXX	0.126	0.126	0.048	3.20	3.20	1.22
19-09-22260-XXXX*	0.500	0.280	-	12.70	7.11	-
10-07-2998-XXXX	0.305	0.330	0.125	7.75	8.38	3.17
10-07-4481-XXXX	0.375	0.375	0.188	9.52	9.52	4.78
10-07-E263-XXXX	0.500	0.500	0.250	12.70	12.70	6.35

*Profile 19-09-22260 is symmetrical hollow rectangle with 0.060 in. interior wall.

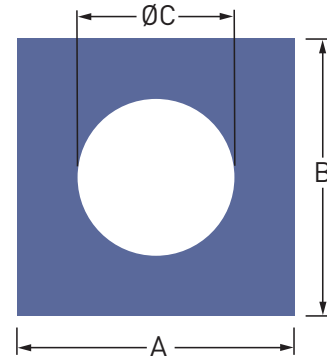
Standard Tolerances (inch)

- <0.200: ± 0.005
- 0.200 - 0.349: ± 0.008
- 0.350 - 0.500: ± 0.010
- >0.500: $\pm 3\%$ Nom. Dim.

Dimensions listed for reference only.

Please see Chomerics drawing for revision-controlled specifications.

Contact Chomerics Applications Engineering for groove design assistance.



Extrusion Product Guide

Custom Extrusions

Custom Extrusion Capabilities

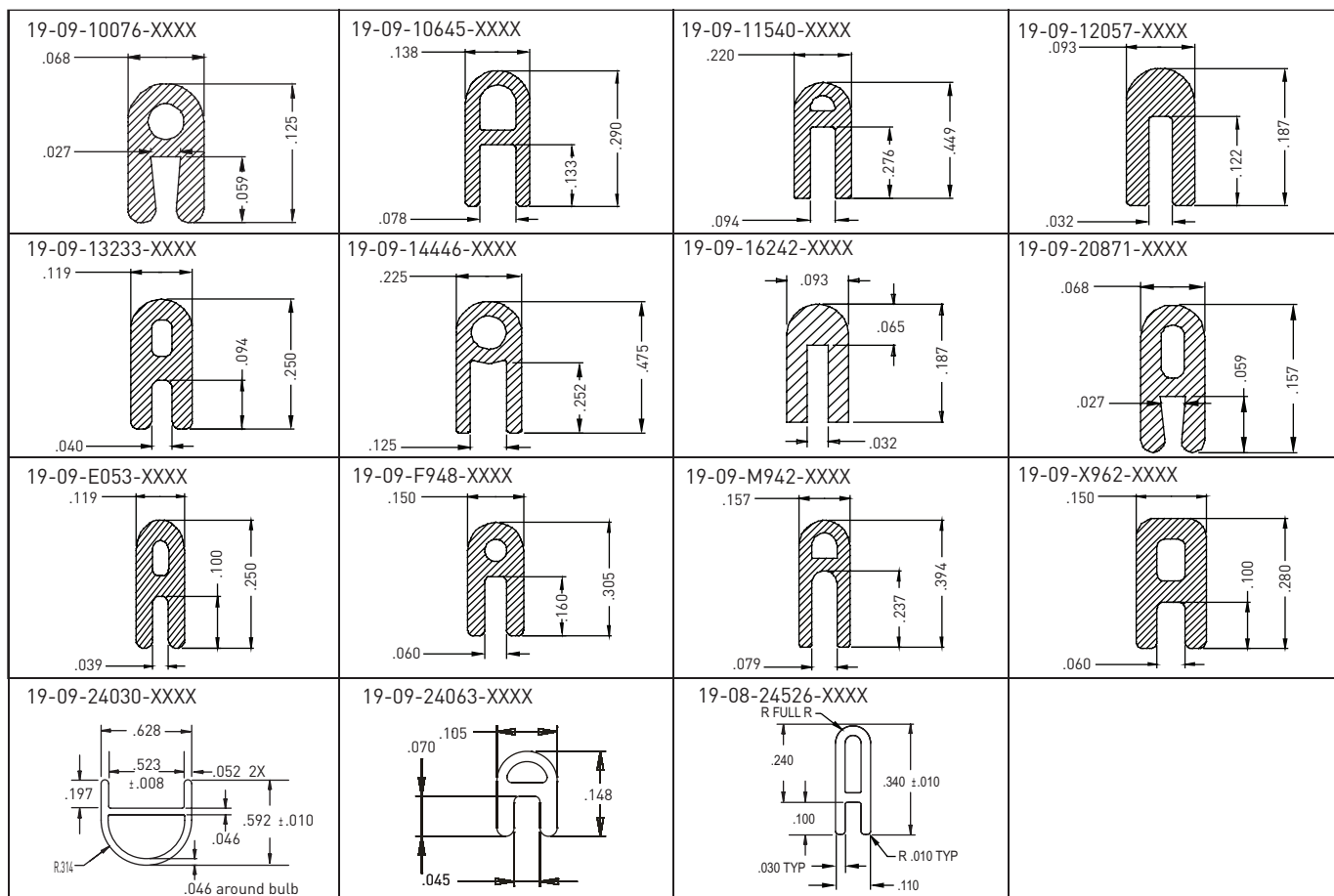
As the world's leading supplier of conductive elastomer gaskets, Chomerics routinely supports its customers by producing extruded gaskets in special configurations. These range from unusual sizes in

standard shapes to highly complex designs that meet specialized shielding and environmental sealing requirements.

The following "showcase" includes representative examples of our custom extrusion capabilities. If you are interested in adapting one of

these shapes to your design, or developing an altogether new gasket design, contact our Applications Engineering Department. We welcome the opportunity to assist you.

Custom A Profiles



Dimensions shown in inches; 1 in. = 25.4 mm

Custom D Profiles

<p>10-05-10648-XXXX</p>	<p>10-05-14081-XXXX</p>	<p>19-09-14757-XXXX</p>	<p>19-09-19925-XXXX</p>
<p>19-09-19926-XXXX</p>	<p>10-5-3369-XXXX</p>	<p>10-05-4318-XXXX</p>	<p>10-05-8635-XXXX</p>
<p>19-05-B248-XXXX</p>	<p>19-05-B250-XXXX</p>	<p>19-05-B254-XXXX</p>	<p>19-05-B363-XXXX</p>
<p>19-09-L547-XXXX</p>	<p>19-09-23271-XXXX</p>	<p>19-09-22965-XXXX</p>	<p>19-09-23309-XXXX</p>
<p>19-09-23709-XXXX</p>	<p>10-05-4035-XXXX</p>		

Custom P Profiles

<p>19-06-11400-XXXX</p>	<p>19-09-19944-XXXX</p>	<p>19-09-20733-XXXX</p>	<p>19-09-21275-XXXX</p>
<p>19-09-LA06-XXXX</p>	<p>19-09-22539-XXXX</p>		

Dimensions shown in inches; 1 in. = 25.4 mm

Custom Ribbed Profiles

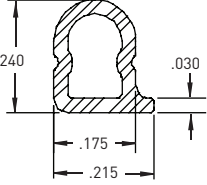
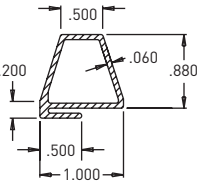
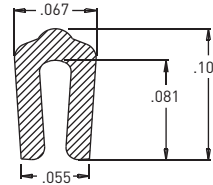
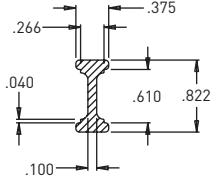
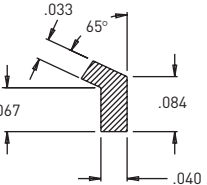
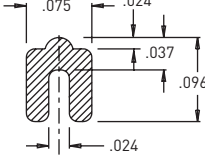
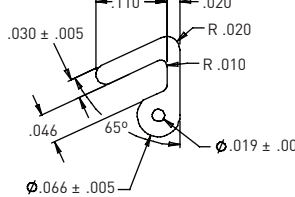
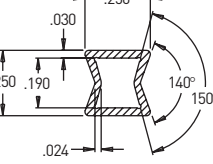
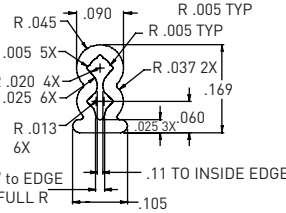
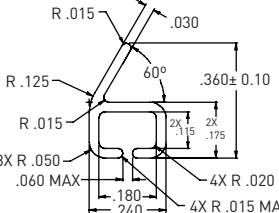
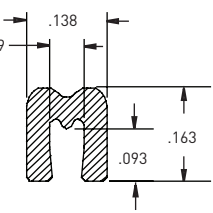
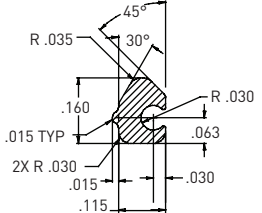
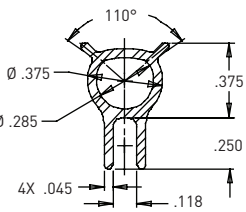
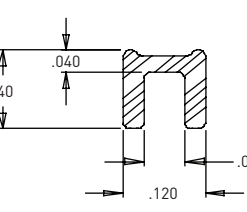
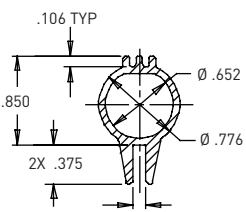
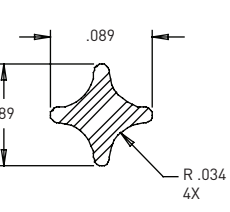
<p>19-09-10921-XXXX</p>	<p>10-09-11118-XXXX</p>	<p>19-09-11370-XXXX</p>	<p>19-09-11411-XXXX</p>
<p>19-09-11859-XXXX</p>	<p>19-09-13072-XXXX</p>	<p>19-09-23139-XXXX</p>	<p>19-09-24767-XXXX</p>

Custom Hat Profiles

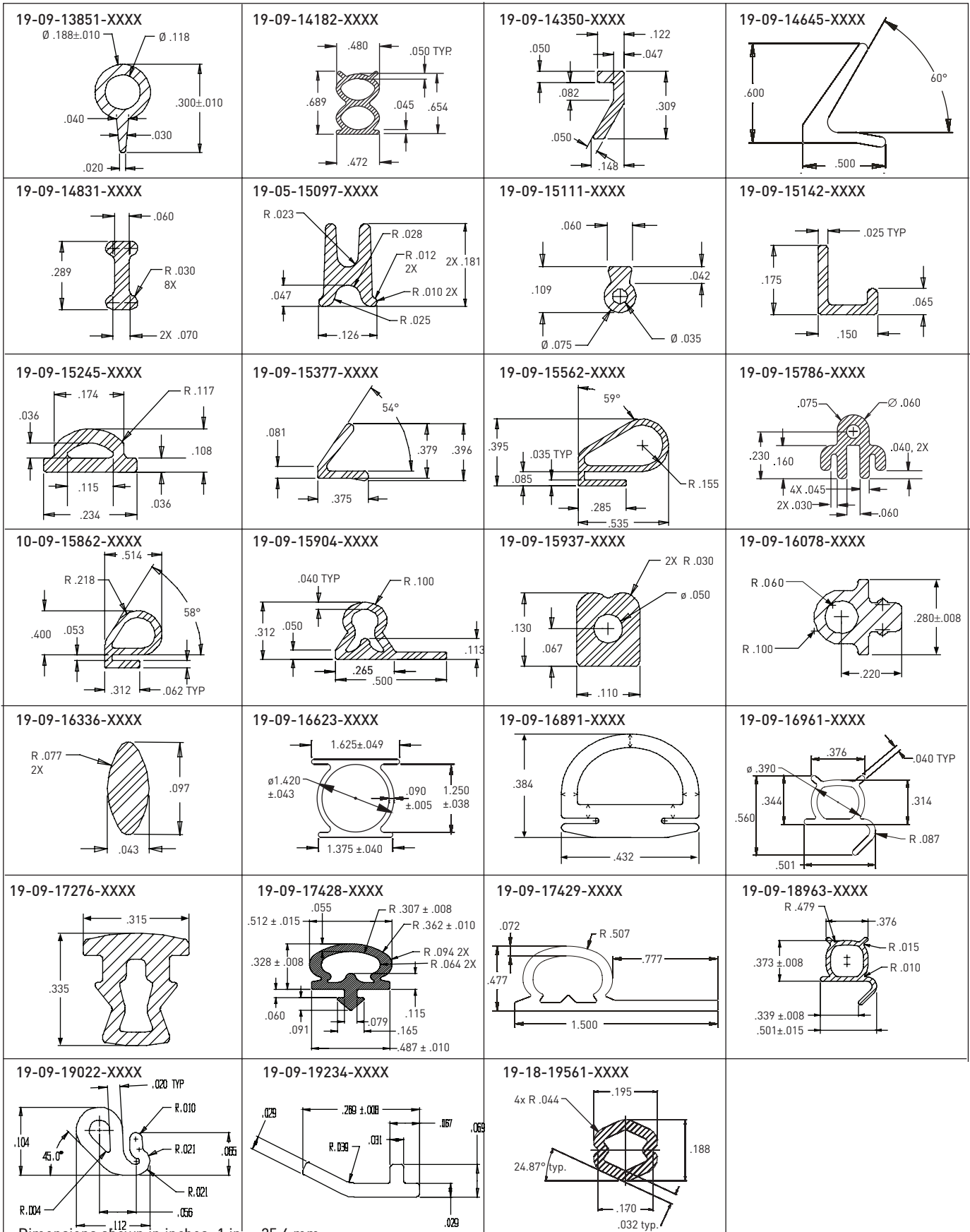
<p>19-09-11367-XXXX</p>	<p>19-09-11408-XXXX</p>	<p>19-09-11409-XXXX</p>	<p>19-09-11641-XXXX</p>
<p>19-09-11883-XXXX</p>	<p>19-09-12012-XXXX</p>	<p>19-09-17438-XXXX</p>	<p>19-09-21618-XXXX</p>

Dimensions shown in inches; 1 in. = 25.4 mm

Custom Profiles

<p>19-09-10357-XXXX</p> 	<p>19-09-10843-XXXX</p> 	<p>19-08-10873-XXXX</p> 	<p>19-09-11219-XXXX</p> 
<p>19-09-11225-XXXX</p> 	<p>19-08-11240-XXXX</p> 	<p>19-09-11401-XXXX</p> 	<p>19-09-11434-XXXX</p> 
<p>19-09-11735-XXXX</p> 	<p>19-09-11755-XXXX</p> 	<p>19-09-11860-XXXX</p> 	<p>19-09-12389-XXXX</p> 
<p>19-09-12756-XXXX</p> 	<p>19-08-12876-XXXX</p> 	<p>19-09-13225-XXXX</p> 	<p>19-09-13569-XXXX</p> 

Dimensions shown in inches; 1 in. = 25.4 mm



Dimensions shown in inches, 1 in. = 25.4 mm

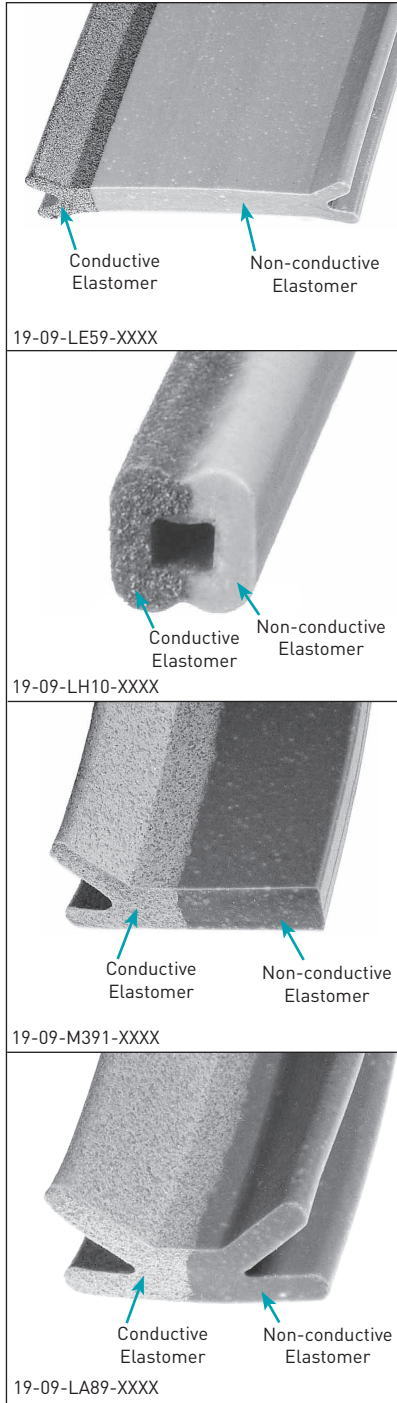
<p>19-09-19681-XXXX</p>	<p>19-09-19787-XXXX</p>	<p>19-09-19880-XXXX</p>	<p>19-05-20405-XXXX</p>
<p>19-09-20407-XXXX</p>	<p>19-09-20670-XXXX</p>	<p>19-09-21048-XXXX</p>	<p>19-09-21717-XXXX</p>
<p>19-09-A150-XXXX</p>	<p>19-09-A240-XXXX</p>	<p>10-09-A469-XXXX</p>	<p>19-09-C032-XXXX</p>
<p>19-09-C264-XXXX</p>	<p>19-09-C832-XXXX</p>	<p>19-09-E620-XXXX</p>	<p>19-09-F158-XXXX</p>
<p>19-08-F464-XXXX</p>	<p>19-09-F534-XXXX</p>	<p>19-08-F676-XXXX</p>	<p>19-06-L386-XXXX</p>
<p>19-09-L453-XXXX</p>	<p>19-09-L524-XXXX</p>	<p>19-09-L913-XXXX</p>	<p>19-09-L957-XXXX</p>
<p>19-09-LB05-XXXX</p>	<p>19-09-LD89-XXXX</p>	<p>19-09-LE14-XXXX</p>	<p>19-09-LE15-XXXX</p>

Dimensions shown in inches; 1 in. = 25.4 mm

<p>19-09-LE24-XXXX</p>	<p>19-09-LF15-XXXX</p>	<p>19-09-LF60-XXXX</p>	<p>19-09-LF69-XXXX</p>
<p>19-09-LG41-XXXX</p>	<p>19-09-W068-XXXX</p>	<p>19-09-W321-XXXX</p>	<p>19-09-W949-XXXX</p>
<p>10-09-10824-XXXX</p>	<p>19-09-21467-XXXX</p>	<p>19-09-21862-XXXX</p>	<p>19-09-22079-XXXX</p>
<p>19-09-22103-XXXX</p>	<p>19-09-23266-XXXX</p>	<p>19-09-23351-XXXX</p>	<p>19-09-23456-XXXX</p>
<p>19-08-23630-XXXX</p>	<p>19-09-23686-XXXX</p>	<p>19-09-24443-XXXX</p>	<p>19-09-24559-XXXX</p>

Dimensions shown in inches; 1 in. = 25.4 mm

Extrusion Product Guide



**Note: Refer to "Surface Preparation of Metallic Substrates" on page 14 for important information on proper cleaning and application. Also request Technical Bulletin 20.*

Co-Extruded Strips

Optimum Shielding Performance Plus Corrosion Prevention

Chomerics manufactures a dual performance extruded gasket in one simple design. By a seam vulcanization process, CHO-SEAL or CHO-SIL conductive elastomers are extruded in parallel with non-conductive elastomers to provide EMI shielding and corrosion protection from one gasket. The outer, non-conductive gasket acts as an extra environmental seal to keep moisture away from the conductive gasket/flange interface. This prevents corrosion of the mating flange in marine or airborne environments. Co-extruded gaskets are also cost-effective, as they permit the use of existing flange designs and provide for gasket attachment via a less expensive non-conductive elastomer. A similar two gasket shielding system requires a costly double groove flange design.

Technically Superior Design

Typical examples of effective co-extruded gaskets include commercial and military communications equipment, rack mounted cabinetry, and aircraft doors and panels. These applications vary in required shielding performance. Each Chomerics co-extruded gasket is engineered in our applications laboratory to match the geometric constraints, closure requirements and shielding performance demanded by the application.

Availability

Many of the gasket cross section shapes and sizes listed on the previous pages can also be co-extruded. Common co-extruded configurations are pictured at left. Also refer to the following pages for a selection of co-extruded shapes currently available. Contact Chomerics to assist you in material selection.

Fast, Easy Conductive Elastomer Gasket Installation with Chomerics Adhesive Tape Attachment

Chomerics has developed a unique adhesive attachment material for CHO-SEAL or CHO-SIL conductive EMI gaskets. This non-conductive pressure-sensitive adhesive (PSA) tape is available on most extruded profiles with a flat tape attachment area, such as D-, P-, K- and rectangular cross sections.

PSA Application: This method of gasket attachment is easy and effective with a clean surface. Simply clean the surface prior to mounting the gasket.* Remove the release film and position the gasket using light pressure. When the gasket is properly positioned, firmly press onto the flange.

Advantages

- Peel strength (90°) in excess of 4.5 pounds per inch of width (ppi)
- Available in continuous length or cut to length. (Note: Some cross sections cannot be packaged in continuous lengths.)
- Eliminates fasteners or other adhesives
- Can function as a "third hand" to facilitate difficult installations
- Available with fluorosilicones as a permanent attachment method
- Quick stick – readily adheres to clean surfaces
- Conformable adhesion to curved surfaces
- Resists humidity, moisture, natural elements
- Eliminates solvent emissions and long set-up times

Disadvantages

- Not available on round cross sections
- Not recommended for applications where solvent resistance is essential
- Not recommended for applications where resistance to excessive abuse due to moving parts or traffic is required

Table 20: Non-Conductive Extruded Elastomer Specifications*

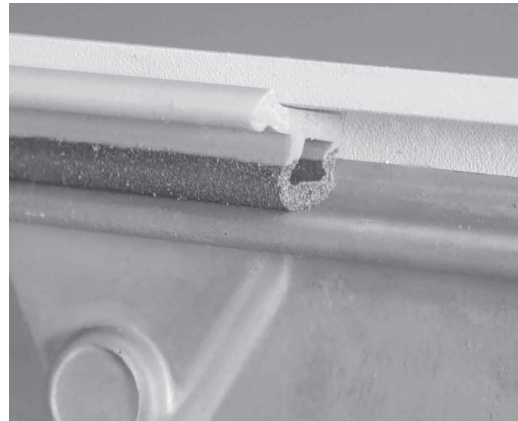
Non-Conductive Extruded Elastomer Specifications*				
	Test Procedure (Type of Test)	CHO-SEAL 2532	CHO-SEAL 2542	CHO-SEAL 2557
Conductive Match	-	1215/1273	1287/1298/L6303	S6305/1285/1350/ 1215/1273/6372
Elastomer Binder	-	Silicone	Fluoro-Silicone	Silicone
Color	-	Black	Light Blue	Light Blue
Hardness, Shore A	ASTM D2240 (Q/C)	60±5	70±5	65±10
Specific Gravity (±0.25)	ASTM D792 (Q/C)	1.5	1.68	1.55
Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	400 (2.76)	500 (3.45)	200 (1.38)
Elongation, % min.	ASTM D412 (Q/C)	130	65	100
Tear Strength, lb/in/ (kN/m), min.	ASTM D624 (Q/C)	35 (6.13)	30 (5.25)	35 (6.13)

*Materials used in the above chart are available to be used as Co-extrusions or bonded together with an EMI gasket.

Dimensions shown in inches; 1 in. = 25.4 mm

Custom Co-Extruded Gaskets

Extruded in parallel, dual conductive/non-conductive gaskets provide optimum EMI shielding and corrosion protection in a single, cost-effective design. For performance and cost advantages of this approach, refer to page 41. To discuss your requirements, contact our Applications Engineering Department.



Custom Co-Extruded Strips

<p>19-05-10168-XXXX</p>	<p>19-09-11771-XXXX</p>	<p>19-18-13715-XXXX</p>
<p>19-18-F775-XXXX</p>	<p>19-09-LD55-XXXX</p>	<p>19-09-LE59-XXXX</p>
<p>19-09-LH10-XXXX</p>	<p>19-18-LJ12-XXXX</p>	<p>19-18-15489-XXXX</p>
<p>19-05-F011-XXXX</p>	<p>19-09-LA89-XXXX</p>	<p>19-09-X869-XXXX</p>
<p>19-09-Z721-XXXX</p>	<p>10-09-LH17-XXXX</p>	<p>19-18-15351-XXXX</p>
<p>19-18-M391-XXXX</p>	<p>19-18-M635-XXXX</p>	<p>19-18-16499-XXXX</p>

Dimensions shown in inches; 1 in. = 25.4 mm

<p>19-09-LF27-XXXX</p> <p>R.046 ±.005 2X 10° CONDUCTIVE NON-CONDUCTIVE .391 .130 ±.005 .260 R.060 2X</p>	<p>19-24-12391-XXXX Combination Gasket</p> <p>CONDUCTIVE NON-CONDUCTIVE .160 .115 .060 .015</p>	<p>19-18-19078-XXXX</p> <p>Ø .623 ±.015 (R .371) Ø .823 ±.015 40° MIN 3 PL 40° MIN 3 PL</p>
<p>19-18-19247-XXXX</p> <p>CONDUCTIVE NON-CONDUCTIVE .150 .260 .060</p>	<p>19-18-19358-XXXX</p> <p>R.031 2X ø.050 .130 .067 .110 R.010 2X</p>	<p>19-18-21184-XXXX</p> <p>CONDUCTIVE NON-COND. .089 ±.007 Ø .650 ±.015 Ø .827 ±.015</p>
<p>19-18-22999-XXXX</p> <p>CONDUCTIVE NON-CONDUCTIVE .070 .065 .096 .205 .165</p>	<p>19-18-23616-XXXX</p> <p>2X R.024 .090 2X R NON-CONDUCTIVE CONDUCTIVE/Non-Conductive Material Transition Zone .091 ±.005 CONDUCTIVE</p>	<p>19-18-24773-XXXX</p> <p>.235 ±.008 R.037 2X .112 .075 CONDUCTIVE NON-CONDUCTIVE</p>

Extrusion Product Guide

MIL-DTL-83528 Part Number Cross Reference Chart

Table 21: MIL-DTL-83528 Part Number Cross Reference Chart - Sorted by MIL P/N

Chomerics Part Number	MIL Part Number	Profile Shape	Chomerics Part Number	MIL Part Number	Profile Shape	
	MIL P/N prefix*			MIL P/N prefix*		
10-04-6386-XXXX	M83528/001Y001	Solid O	10-07-4272-XXXX	M83528/009Y001	Rectangular	
10-04-3560-XXXX	M83528/001Y002		10-07-2981-XXXX	M83528/009Y002		
10-04-2561-XXXX	M83528/001Y003		10-07-4014-XXXX	M83528/009Y003		
10-04-1687-XXXX	M83528/001Y004		10-07-3225-XXXX	M83528/009Y004		
10-04-2657-XXXX	M83528/001Y005		10-07-3047-XXXX	M83528/009Y005		
10-04-2865-XXXX	M83528/001Y006		10-07-3226-XXXX	M83528/009Y006		
10-04-1720-XXXX	M83528/001Y007		10-07-3522-XXXX	M83528/009Y007		
10-04-3077-XXXX	M83528/001Y008		10-07-4217-XXXX	M83528/009Y008		
10-04-2463-XXXX	M83528/001Y009		10-07-3080-XXXX	M83528/009Y009		
10-04-1721-XXXX	M83528/001Y010		10-07-4483-XXXX	M83528/009Y010		
19-04-F371-XXXX	M83528/001Y011		10-07-4523-XXXX	M83528/009Y011		
10-04-2864-XXXX	M83528/001Y012		10-07-3797-XXXX	M83528/009Y012		
10-04-3076-XXXX	M83528/001Y013		10-07-4538-XXXX	M83528/009Y013		
10-05-1362-XXXX	M83528/003Y001		Solid D	10-08-6475-XXXX		M83528/010Y001
10-05-3224-XXXX	M83528/003Y002	10-08-3215-XXXX		M83528/010Y002		
10-05-1363-XXXX	M83528/003Y003	10-08-4315-XXXX		M83528/010Y003		
19-05-2586-XXXX	M83528/003Y004	10-08-3157-XXXX		M83528/010Y004		
10-05-2618-XXXX	M83528/003Y006	10-08-3253-XXXX		M83528/010Y005		
10-05-1364-XXXX	M83528/003Y007	10-08-3872-XXXX		M83528/010Y006		
10-05-1499-XXXX	M83528/003Y008	10-04-2999-XXXX		M83528/011Y001	Hollow O	
19-05-F173-XXXX	M83528/003Y009	10-04-4180-XXXX		M83528/011Y002		
10-05-1577-XXXX	M83528/003Y010	10-04-2737-XXXX		M83528/011Y003		
19-05-W469-XXXX	M83528/003Y011	10-04-3004-XXXX		M83528/011Y004		
10-05-6419-XXXX	M83528/007Y001	10-04-3122-XXXX	M83528/011Y005			
10-05-4202-XXXX	M83528/007Y002	10-04-8817-XXXX	M83528/011Y006			
10-05-4308-XXXX	M83528/007Y003	10-04-8363-XXXX	M83528/011Y007			
10-05-3369-XXXX	M83528/007Y004	10-04-8133-XXXX	M83528/011Y008			
10-05-4318-XXXX	M83528/007Y005	Hollow D				
10-05-4542-XXXX	M83528/007Y006					
10-05-6394-XXXX	M83528/007Y007					
10-06-3599-XXXX	M83528/008Y001		Hollow P			
10-06-4142-XXXX	M83528/008Y002					
10-06-3300-XXXX	M83528/008Y003					
10-06-4921-XXXX	M83528/008Y004					
10-06-5611-XXXX	M83528/008Y005					
10-06-2750-XXXX	M83528/008Y006					
10-06-8550-XXXX	M83528/008Y007					
10-06-6180-XXXX	M83528/008Y008					

* MIL part number is MIL P/N prefix with Dash # as suffix. "Y" should be replaced by applicable MIL-DTL-83528 material type (e.g., A, B, C, etc.).

Performance Data

Conductive Elastomers

Compression-Deflection

While standard test procedures have been established for measuring the deflection of elastomers under compressive loads, the practical use of such data is to provide a qualitative comparison of the deformability of different elastomeric materials when in the particular configuration of the test sample.

Solid (non-foam) elastomers are essentially incompressible materials; i.e., they cannot be squeezed into a smaller volume. When a solid elastomer is subject to a compressive load, it yields by deformation of the part as a whole. Because of this behavior, the actual deflection of a gasket under a compressive load depends upon the size and shape of the gasket as well as on its modulus and the magnitude of the load.

The design of a seal should be such that it will be subjected to the minimum squeezing force sufficient to provide the required mechanical and electrical performance. The designed deflection of conductive elastomer gaskets should never

Table 22: Recommended Deflections

Recommended Deflection for Various Conductive Elastomer Shapes			
Cross Section Geometry	Min. Deflection	Nominal Deflection	Max. Deflection
Solid O	10% O.D.	18% O.D.	25% O.D.
Solid D	8% Height	15% Height	20% Height
Rectangular (including die-cut)	5% Height	10% Height	15% Height
Hollow O, D and P	10%-15%* O.D.	50% of inside opening	100% of inside opening

NOTE: For increased deflection requirements, Chomerics can provide specific shapes.
 *15% on thin wall <0.030"
 10% on walls ≥ 0.030"

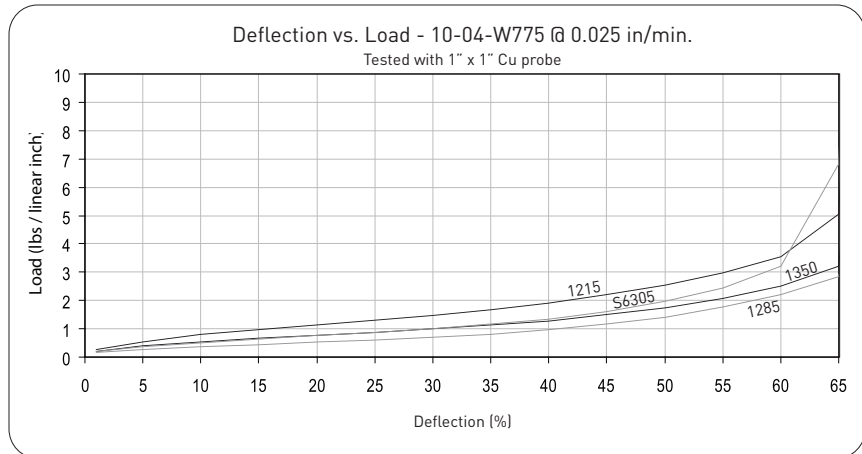


Figure 1. O-Strip 0.125" OD 0.085" ID

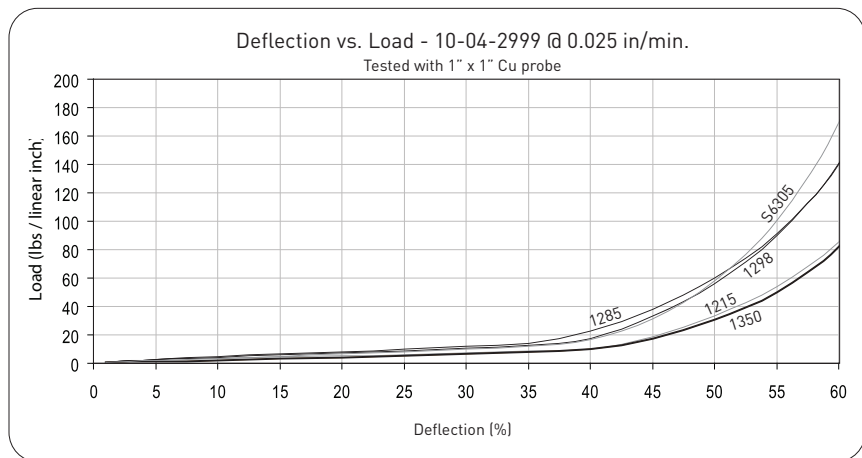


Figure 2. O-Strip 0.125" OD 0.045" ID

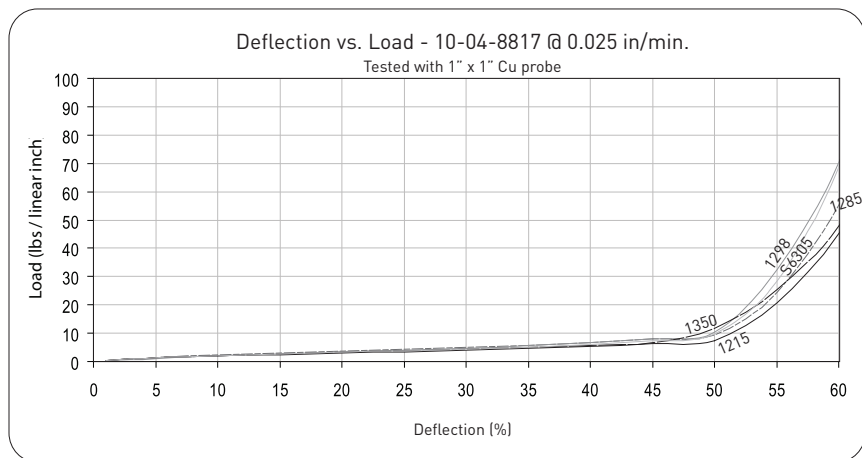


Figure 3. O-Strip 0.125" OD 0.062" ID

exceed the maximum deflection limits shown in Table 22.

There is an approximate relationship between the force required to deflect a pure elastomer a given amount, and the hardness of the elastomer. In general, the harder the elastomer, the greater the force required. In the case of Chomerics' metal particle-filled elastomers, this relationship is much less definite, and in some instances, these materials demonstrate deflection/hardness and deflection/thickness behavior contrary to that which would be anticipated for conventional elastomer compounds.

The inclusion of metal particles in the elastomer results in a mechanically structured material. This mechanical structure has a marked effect on the deflection of the elastomer under compressive loads, and in some instances, harder materials deflect more than softer materials.

Compressive load-deflection data for many popular conductive elastomer materials and shapes are given in Figures 1-6. (For "line contact" gaskets, it is more convenient to express the load in terms of pounds per linear inch instead of pounds per square inch). For compression-deflection data on other Chomerics gaskets, contact our Applications Engineering Department.

Figure 4. Hollow D H 0.156" Wall Thickness 0.45"

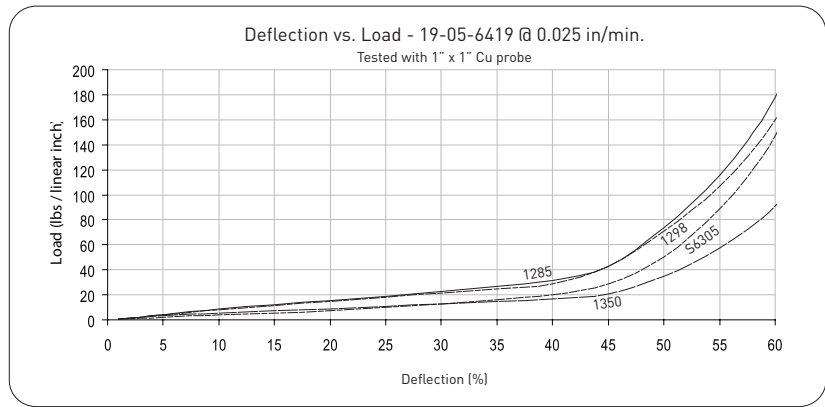


Figure 5. Sheet Stock 0.032"

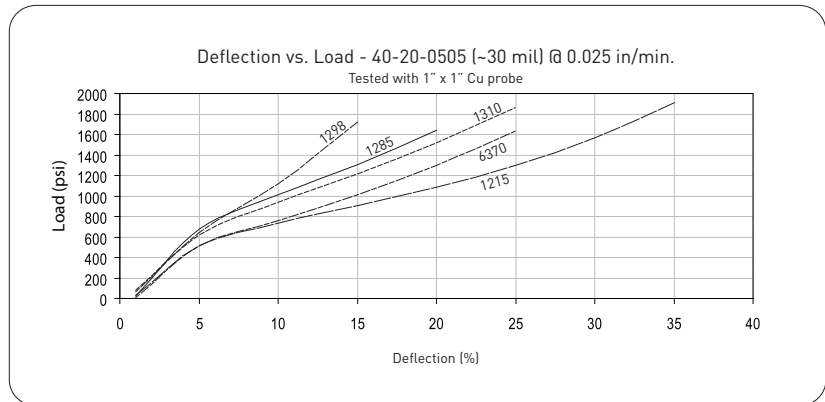
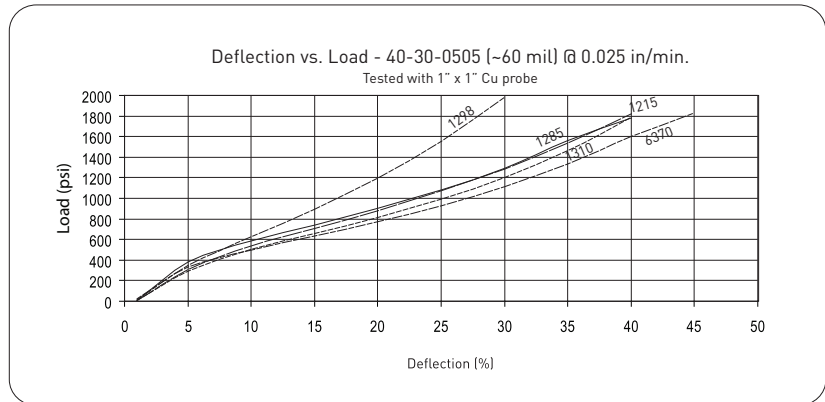


Figure 6. Sheet Stock 0.062"



Stress Relaxation

As important as Compression Set and Compression-Deflection, is the Stress Relaxation characteristic of a gasket.

If an elastomer gasket is subject to a compressive load, it will deflect. There is a stress/strain relationship, which for an elastomer is generally non-linear except for very small deflections. After the load is applied, a stress decay occurs within the polymer resulting from the internal rearrangement of the molecular structure. An approximate rule is that the relaxed stress for cured silicone will finally settle at 70 to 75 percent of the initial stress.

There are two ways in which an elastomer gasket can be loaded to a desired value. One way is to load it to a point, let it relax, and reapply the load to restore the original stress. The next time it will relax, but not as much. If this is repeated a sufficient number of times, the correct static load on the gasket will reach equilibrium.

A more practical way to reach the design value of stress is to load the gasket to 125 percent of its final design value, so that after the relaxation process is completed the gasket will settle to 100 percent of the design load. This is very reproducible.

Figure 7 shows a typical stress relaxation curve for Chomerics' conductive elastomers.

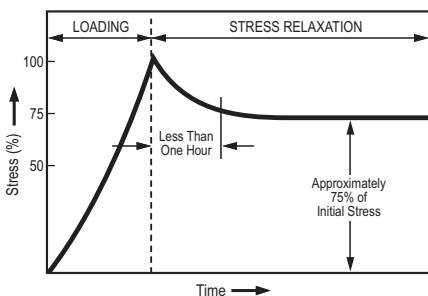


Figure 7. Stress Relaxation

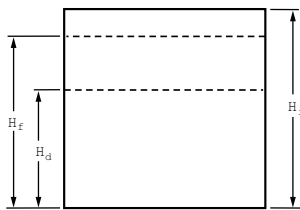
Compression Set

When any elastomer is deformed for a period of time, some of the deformation is retained permanently even after the load is

removed. The amount of permanent deformation, as measured by ASTM D395, is termed "Compression Set." Compression set is measured under conditions of constant deflection (ASTM D395 Method B) and is normally expressed as a percentage of the initial deflection, not as a percentage of the initial height.

For gaskets that are used once, or where the gasket/flange periphery relationship is constant (such as a door gasket), compression set is of minor significance if the original load condition and the service temperature are within the design limitations of the gasket material.

For gaskets that are randomly resealed one or more times in normal service life, it is important that the maximum change in gasket thickness does not exceed twice the maximum mismatch between the opposing mating surfaces.



Hi = Initial height
 Hd = Deflected height (Normally 75% of Hi)
 Hf = Final height (After load is removed)

$$\text{Compression Set} = \frac{(Hi-Hf)}{(Hi-Hd)} \times 100\%$$

Figure 8. Formula for Calculation of Compression Set

Shielding Effectiveness

Most shielding effectiveness data given in Table 7 of the Extrusion Product Guide is based on a MIL-DTL test method, with a 24 in. x 24 in. aperture in a rigid enclosure wall and about 100 psi on the gasket. It is a valid and useful way of comparing various gasket materials, but does not reflect the shielding effectiveness one can expect at seams of typical enclosures. CHO-TM-TP08 is a modified version of the MIL test that provides typical values achieved in actual applications. Since many factors will affect the actual shielding

effectiveness of an enclosure seam (flange design, stiffness, flatness, surface resistivity, fastener spacing, enclosure dimensions, closure force, etc.), the only way to determine shielding effectiveness for real enclosures is to test them.

Figures 9 and 10 provide data on shielding effectiveness for actual enclosures. The data in Figure 9 shows the difference in attenuation between a shelter door closed with no gasket and the same door closed against a CHO-SEAL 1215 hollow D-strip gasket. Instead of single data points at each frequency tested, a range of data is shown for each frequency, representing the worst and best readings measured at many points around the door.

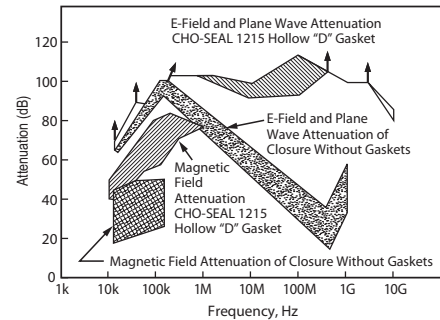


Figure 9. Shielding Effectiveness of a Shelter Door Gasket (14 kHz to 10 GHz)

Figure 10 shows the effects of closure force on shielding effectiveness of an enclosure tested at high frequencies (1-40 GHz) using CHO-SEAL 1215 solid D-strip gaskets.

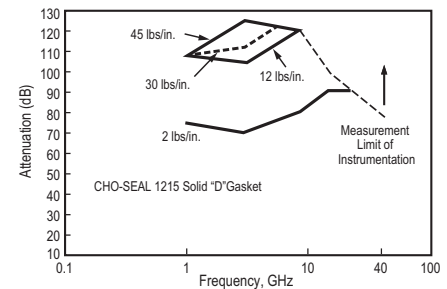


Figure 10. Effect of Closure Force on Shielding Effectiveness (1 GHz to 40 GHz)

In order to establish reasonable upper limits on gasket resistivity, it is necessary to understand the relationship between flange interface resistance and EMI leakage through the flange.

Figure 11 presents this relationship for an aluminum enclosure 3 in. x 3 in. x 4 in. deep, measured at 700 MHz. Die-cut gaskets 0.144 in. wide by 0.062 in. thick, in a wide range of resistivities, were clamped between the gold-plated flanges of this enclosure. Simultaneous measurements of flange interface resistance (all attributable to the gaskets) versus RF leakage through the seam produced a classic S-shaped curve. For the gasket configuration used in this test, the dramatic change in shielding effectiveness occurs between gasket volume resistivities of 0.01 and 0.4 ohm-cm. Since real enclosures do not have gold-plated flanges, but rather have surface finishes (such as MIL-DTL-5541F, Type I, Class 3 chromate conversion coatings) which also increase in resistance over time, it is recommended that gasket volume resistivity be specified at 0.01 ohm-cm max. for the life of the equipment.

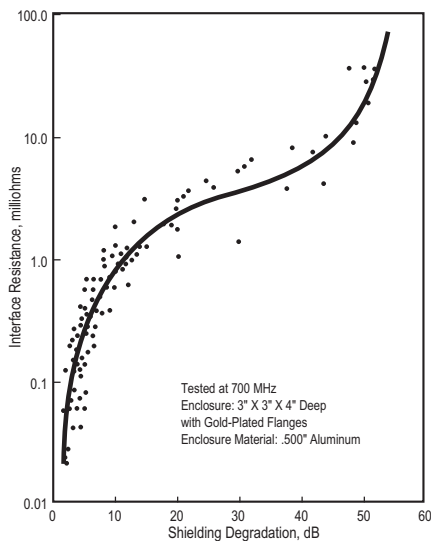


Figure 11. Interface Resistance vs. Shielding Degradation at a Flange Joint

EMP Survivability

In order for an enclosure to continue providing EMI isolation during and after an EMP (Electro-Magnetic Pulse) environment, the conductive gaskets at joints and seams must be capable of carrying EMP-induced current pulses without losing their conductivity. Figure 12 shows the EMP current response of various

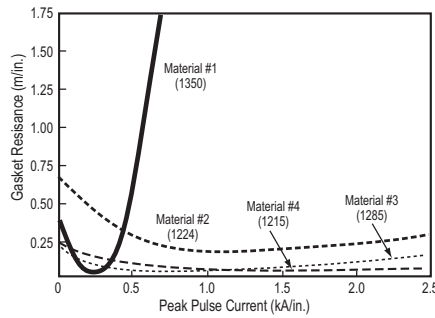


Figure 12. EMP Current Response of Conductive Elastomer Gaskets

types of conductive elastomer gaskets. Note that gaskets based on silver-plated-glass fillers (1350) become nonconductive at low levels of EMP current, and should therefore not be used when EMP is a design consideration. Figure 13 is an electron microscope photo which clearly shows the damage mechanism. Silver-plated-copper filled (1215) gaskets have the highest resistance to EMP type currents, showing no loss of conductivity even at 2.5 kA/inch of gasket (peak-to-peak). Pure silver (1224) and silver-plated-aluminum filled (1285) gaskets have less current carrying capability than silver-plated-copper materials, but are generally acceptable for EMP hardened systems (depending on specific EMP threat levels, gasket cross section dimensions, etc.).

Vibration Resistance

Certain conductive elastomers are electrically stable during aircraft-level vibration environments, while

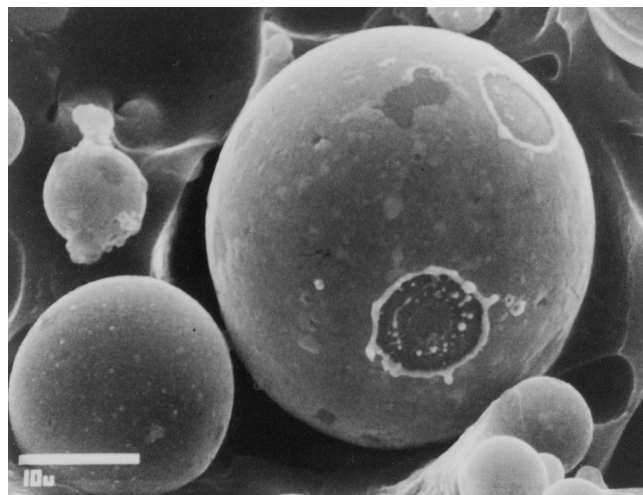


Figure 13. Scanning Electron Microscopy Illustrates EMP Damage Mechanism for Silver/Glass Elastomers

others are not. The key factor which determines vibration resistance is the shape and surface texture of the filler particles. Smooth, spherical fillers (such as those used in silver-plated-glass materials) tend to move apart during vibration, leading to dramatic increases in resistance and loss of shielding effectiveness (although they normally recover their initial properties after the vibration has ended). Rough, less spherical particles resist vibration with very little electrical degradation. Figure 14 shows the effects of vibration on three types of conductive gaskets. Although Chomerics silver-plated-copper filled 1215 gasket, with rough, irregular particle agglomerations, exhibits excellent stability during vibration, users of conductive elastomers should be aware that smooth, spherical silver-plated-copper fillers can be almost as unstable as silver-plated-glass fillers.

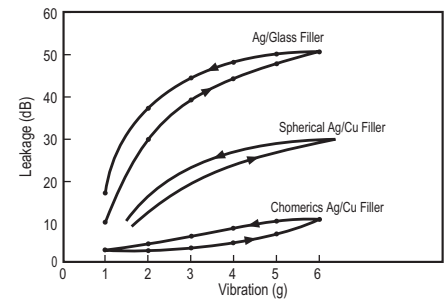


Figure 14. Effects of Vibration on Shielding Effectiveness of Conductive Elastomer Gaskets

Heat Aging

The primary aging mechanism which affects electrical stability of conductive elastomers is the oxidation of filler particles. For materials based on pure silver fillers, particle oxidation is not generally a problem because the oxide of silver is relatively soft and reasonably conductive. If the filler particles are non-noble (such as copper, nickel, aluminum, etc.) they will oxidize readily over time and become nonconductive. Even silver-plated base metal powders, such as silver-plated-copper or silver-plated-aluminum will become non-conductive over time if the plating is not done properly (or if other processing variables are not properly controlled). These are generally batch control problems, with each batch being potentially good or bad.

The most reliable method of predicting whether a batch will be electrically stable is to promote the rate at which poorly plated or processed particles will oxidize, by heat aging in an air circulating oven. For qualification, 1000 hours (42 days) at maximum rated use temperature (with the gasket sample deflected 7-10% between flanges) is the recommended heat aging test for accelerating the effects of long-term aging at normal ambient temperatures. A quicker heat aging test, which correlates well with the 1000 hour test and is useful for QC acceptance testing, involves a 48 hour/150°C oven bake with the gasket sample on an open wire-grid tray (rather than being clamped between flanges). Figure 15 shows typical data for volume resistivity versus time for each of these tests.

Note: It is essential that no source of free sulfur be placed in the aging oven, as it will cause the material to degrade electrically and mask any oxidation aging tendencies. Common sources of sulfur are neoprenes, most cardboards and other paper products.

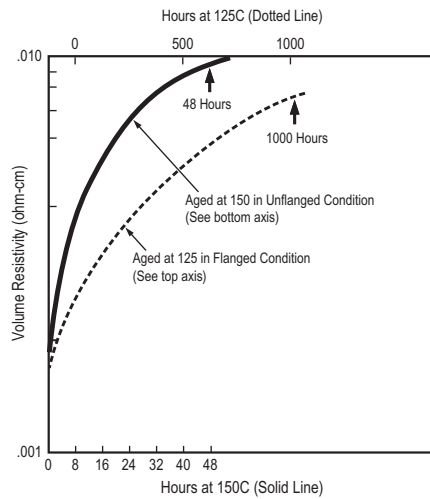


Figure 15. Typical heat aging characteristics of Chomerics plated-powder-filled conductive elastomers. Flanged 1000-hr test recommended for qualification. Unflanged 48-hr. test recommended for QC acceptance.

volatile residues which might outgas in the hard vacuum environment of space. The standard test method for determining outgassing behavior is ASTM E595-93, which provides for measurement of total mass loss (TML) and collected volatile condensable materials (CVCM) in a vacuum environment. Data for a number of Chomerics conductive elastomers, based on ASTM E595-93 testing done by NASA Goddard Spaceflight Center, is presented in Table 23. The normal specification limits or guide-lines on outgassing for NASA applications are 1% TML max., and 0.1% CVCM max.

Outgassing

Many spacecraft specifications require that nonmetallic components be virtually free of

Table 23: Outgassing Data for Conductive Elastomers

Outgassing Data for Conductive Elastomers (Per ASTM E595-93)				
	Special Post Curing	TML % Limit <1.0%	CVCM% Limit <0.1%	NASA GSFC Data Reference
CHO-SEAL 1212	None	0.40	0.13	15140
CHO-SEAL 1215	None	0.45	0.10	15142
CHO-SEAL 1217	None	0.45	0.01	15231
CHO-SEAL 1221	None	0.35	0.02	15249
CHO-SEAL 1224	None	0.41	0.10	15211
CHO-SEAL 1285	None	0.62	0.09	15251
CHO-SEAL 1287	None	0.63	0.03	15165
CHO-SEAL 1298	None	0.12	0.02	28381
CHO-SEAL 1501	None	0.50	0.10	15247
CHO-SEAL S6305	Yes	0.15	0.09	23961
CHO-SEAL 6370	Yes	0.19	0.10	23964
CHO-SIL 1401	None	0.92	0.37	15213

Application Note

CHO-SEAL® 1298 Corrosion Resistant EMI Shielding Gaskets

KEY FEATURES

- New particle technology offers increased corrosion resistance with no chromates
- 90 dB shielding effectiveness – 100 MHz-10 GHz
- Meets all requirements of MIL-DTL-83528 Type D (initial and aged)
- Excellent resistance to jet fuels and fluids used in aviation and industrial applications.

PRODUCT DESCRIPTION

Through the use of new proprietary particle plating and elastomer compounding technology, CHO-SEAL® 1298 shielding elastomer offers approximately a 200% increase in corrosion resistance over products previously available. In fact, a virtually corrosion-proof EMI flange system is obtained when CHO-SEAL® 1298 gaskets are used in conjunction with Chomerics' CHO-SHIELD® 2000 series corrosion-resistant coatings on aluminum flanges. Using a combination of fabric reinforcement and wire mesh for superior lightning current handling abilities, CHO-SEAL® 1298 elastomer is highly recommended for HIRF/lightning seals for commercial and military aircraft.

Unlike nickel-filled and carbon-filled elastomers, CHO-SEAL® 1298 is electrically stable even after accelerated heat aging. In every respect, CHO-SEAL® 1298 outperforms nickel, nickel-graphite and carbon-filled EMI gasket materials in aluminum joints. See Table 1 for product specifications.

CHO-SEAL® 1298 material has a fluorosilicone binder, with corrosion inhibiting additives which contain no chromates. This allows for safe handling and easy material storage without the use of protective clothing or restricted areas.



Comparison of corrosion results obtained from CHO-SEAL® 1298 conductive elastomer (left) and pure silver-filled elastomer (right) mated with aluminum after 168 hours of salt fog exposure.

The proprietary additives do not degrade the physical performance expected of fluorosilicone materials. CHO-SEAL® 1298 material has excellent resistance to fluids and fuels commonly used in aviation and industrial applications.

CORROSION RESISTANCE

Using a weight loss procedure, the corrosivity of CHO-SEAL® 1298 material and other EMI gaskets was measured. Table 2 shows the weight loss 6061-T6 aluminum in contact with different EMI gasket materials after 168 hours of ASTM B117 salt fog exposure. The coupon is conversion-coated per MIL-DTL-5541F, Type I, Class 3.

These results show that using the galvanic series to predict corrosivity of conductive elastomers can be incorrect and misleading. Conductive elastomers are composite materials and

the metal core plays a role in determining corrosion properties. CHO-TM100 is a test method to determine, in a quantitative manner, the corrosivity of conductive elastomers toward aluminum alloys and the electrical and dimensional stability of the conductive elastomer after exposure to salt fog environment. This is a non-subjective test resulting in repeatable, measurable hard data and not subjective ratings.

The test fixture is shown in Figure 1. The conductive elastomer and aluminum coupon are held in contact by compression between two cylindrical Delrin® blocks. Compressive force is supplied by a central 3.25" (8.26cm) long ¼-20, 18-8 stainless steel bolt and an 18-8 stainless steel nut. Fluid is prevented from penetrating to the bolt conductive elastomer/

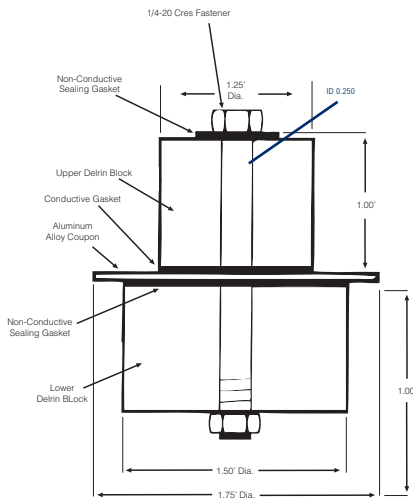


Figure 1: Test Fixture

aluminum alloy coupon interface by use of non-conductive silicone sealing washers between the bolt head and the upper Delrin block and between the bottom of the aluminum coupon and the lower Delrin block.

Test results are based on 168 hours exposure to chromate treated aluminum per MIL-DTL-5541F, Type I, Class 3. The fixture is exposed to neutral salt fog according to the conditions given in ASTM B117. This test procedure can be used with SO₂ salt fog and/or other substrates in place of aluminum.

CHO-TM100 test procedure has been adopted by major aerospace, military and aircraft manufacturers. A copy of the test is available on request from Chomerics. Chomerics will supply test fixtures and elastomer samples for testing under your control.

Table 3 compares the electrical stability of several conductive elastomers after 192 hours of SO₂ salt fog exposure (ASTM G85, Annex A4).

CORROSION PROOF FLANGE DESIGN WITH CHO-SHIELD 2000 SERIES COATINGS

CHO-SEAL® 1298 gaskets and CHO-SHIELD® 2000 series of conductive flange coatings form a virtually corrosion proof EMI

Table 1: Specifications

Property	Test Method	CHO-SEAL 1298
Elastomer Binder	-	Fluorosilicone
Conductive Filler	-	Passivated Ag/Al
Volume Resistivity, as supplied ohm-cm, max.	MIL-DTL-83528 Para. 4.6.11	0.012
Gravimetric Weight Loss, mg	CHO-TM100	<5.0 typical
Volume Resistivity ohm-cm, max.	MIL-DTL-835282 Para. 4.6.11	0.015
Hardness, Shore A (± 7)	ASTM D2240	70
Specific Gravity (± .25)	ASTM D792	2.0
Tensile Strength, psi (Mpa), min.	ASTM D412	180 (1.24)
Tear Strength, lb/in (kN/m), min.	ASTM D624	35 (6.13)
Elongation, %, min./ma.	ASTM D412	60/260
Compression Set, %, max. 70 hours @ 100°C	ASTM D395, Method B	30
Low Temp Flex, TR10 °C, min.	ASTM D1329	-55
Maximum Continuous Use Temperature, °C	-	160
Shielding Effectiveness, dB, min. 200 kHz (H Field) 100 MHz (E Field) 500 MHz (E Field) 2 GHz (Plane Wave) 10 GHz (Plane Wave)	MIL-DTL 83528 Para. 4.6.15	55 110 100 95 90
Volume Resistivity, Life Test, ohm-cm, max.	MIL-DTL 83528 Para. 4.6.15	0.015
Vibration Resistance, During, ohm-cm, max.	MIL-DTL 83528 Para. 4.6.13	0.015
Vibration Resistance, After, ohm-cm, max.	MIL-DTL 83528 Para. 4.6.13	0.012
Post Tensile Set Volume Resistivity, ohm-cm, max.	MIL-DTL 83528 Para. 4.6.9	0.015
EMP Survivability, kA/in. perimeter	MIL-DTL 83528 Para. 4.6.16	>0.9
<small>1 After 168 hours exposure to neutral salt fog per ASTM B117 with chromate treated aluminum per MIL-DTL 5541F, Type I, Class 3 2 After 168 Hours exposure to neutral salt fog per CHO-TM100 and ASTM B117 against chromate treated aluminum per MIL-DTL 5541F, Type I, Class 3</small>		

Table 2: Typical Weight Loss of 6061-T6 Aluminum Coupons*

Material Type	Typical Weight Loss (mg)	Volume Resistivity (ohm-cm)
CHO SEAL 1298	<5.0	0.008
Standard Ag/Al, MIL-DTL-83528C, Type D	<15.0	0.004
Ni-filled silicone	<30.0	0.80
Ag/Glass-filled silicone	167	0.006
Ag/Ni-filled silicone	168	0.005
Ag-filled silicone	237	0.001
Ag/Cu-filled silicone	281	0.007
Standard Ag/Al MIL-DTL-83528C Type B	<15.0	0.005
Ni/Graphite-filled silicone	<50	0.050
*Tested per Chomerics Test Method CHO-TM100. Weight loss values represent the average of several specimens.		

Table 3: Typical Volume Resistivity Before and After SO₂ Salt Fog

Material Type	Volume Resistivity (ohm-cm)	
	Before	After
CHO-SEAL 1298	0.008	0.014
Standard Ag/Al, MIL-DTL-83528, Type D*	0.005	0.020
Ni-filled Silicone	0.011	3.57
Ni/Graphite-filled silicone	0.081	0.253

*Values represent averages based on samples from various vendors.

sealing system. Superior corrosion proof sealing results have been obtained following both CHO-TM 200 and 201 Test Procedures. CHO-TM200 is a test method for performing shielding effectiveness measurements on EMI gasketed flange systems before and after environmental exposure. CHO-TM201 is intended to allow evaluation of shielding

effectiveness of different flange treatments, gasket materials and configurations after each cycle of environmental exposure. Both procedures are available on request from Chomerics. The shielding effectiveness of CHO-SEAL® 1298 gasket against Class 3 chromate conversion coated aluminum protected with

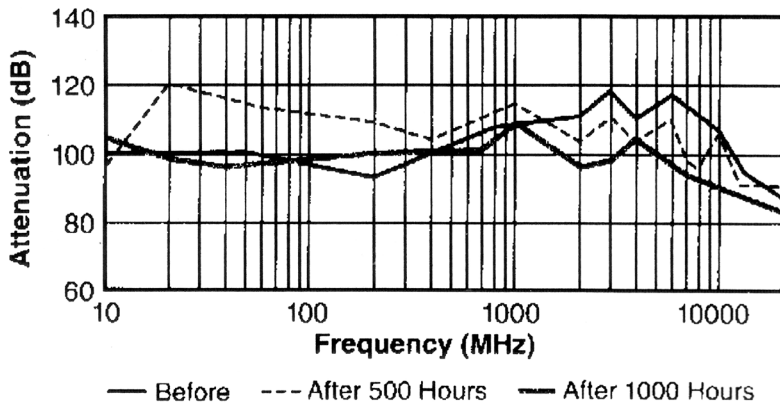


Figure 2: CHO-SEAL® 1298 Gasket Against Aluminum (CHO-SHIELD 2001 Coating) Before and After 500 and 1000 Hours of Salt Fog Exposure

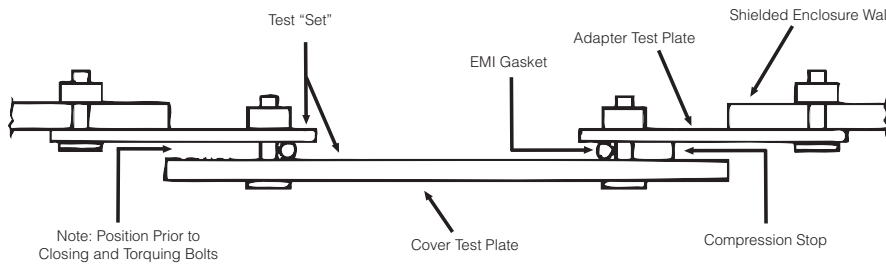


Figure 3: Test Set Assembly

CHO-SHIELD 2001 or 2002 coatings is higher even after 1000 hours of ASTM B117 salt fog than the same gasket against conversion coated flanges with no salt fog exposure. See Figure 2.

Chomerics test report CHO-TR19E describes how the effects of salt fog exposure on the shielding effectiveness of CHO-SEAL® 1298 gaskets against various aluminum flange treatments were determined. This was configured as defined within Chomerics' shielding effectiveness test method CHO-TM201. Figure 3 illustrates the test plate set assembly. A copy of CHO-TH19 is available on request from Chomerics.

Figure 4 illustrates the retention of volume resistivity and lack of weight loss in CHO-SEAL® 1298 gaskets after 1,000 hours of neutral salt fog.

CHO-SHIELD 2001, 2002, and 2003 electrically conductive coatings provide corrosion protection for enclosure flanges which mate with EMI shielding gaskets. They can also provide a corrosion resistant conductive surface coating on aluminum or plastic substrates.

CHO-SHIELD 2000 series coatings are three-part, copper-filled urethanes with filler systems treated to remain electrically stable at elevated temperatures. A number of stabilizers prevent the copper from corroding in high humidity and/or marine environments.

CHO-SHIELD 2001 and 2003 contain soluble chromates to minimize the effects of galvanic corrosion of the aluminum substrate, even in the event of a coating scratch. The CHO-SHIELD 2002 coating, primarily intended for composite substrates or as 2001 repair coating, is chromate-free. They can also provide a corrosion resistant conductive surface coating on aluminum or plastic substrates.

LIGHTNING STRIKE RESISTANCE

Lightning strike testing of CHO-SEAL® 1298 material has demonstrated survivability beyond 5kA/n. The survivability of any system to lightning strike is dependent on specific flange design. For detailed information, contact Chomerics' Applications Department or request Chomerics' test Report TR34A.

ORDERING INFORMATION

CHO-SEAL® 1298 gaskets are available in all standard forms including molded, die-cut, and extruded. The material is also available with Dacron® fabric, woven wire mesh reinforcement or 3M Nextel for firewall applications.

NOTE:

DELTRIN is a registered trademark of E.I. DuPont de Nemours and Company.

DACRON is a registered trademark of Invista.

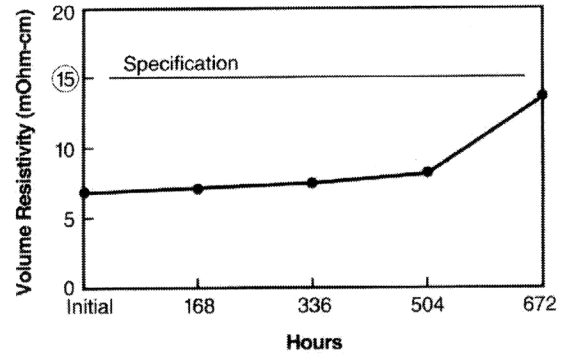


Figure 4: Volume Resistivity of the CHO-SEAL® 1298 EMI Gasket After Salt Fog Exposure

CHOMERICS' CORROSION PROTECTION PUBLICATIONS

Test Method CHO-TM100	Test Method for Assessing Galvanic Corrosion Caused Conductive Elastomers
Test Method CHO-TM200	Shielding Effectiveness Measurements of EMI Gaskets Subjected to Salt Fog Exposure
Test Method CHO-TM201	S.E. Measurements of EMI Gaskets and Flange Treatments Subjected to Salt Fog Exposure
Test Report CHO-TC001	Product Evaluation: Acrylic Based Copper Filled Coating in a Salt Fog Environment
Test Report CHO-TC002	Product Evaluation: Carbon Filled TPE Elastomer Corrosion Resistance
Test Report CHO-TR19A	Corrosion Resistance of Conductive Elastomers: Silver and Silver-Plated Filters
Test Report CHO-TR19B	Corrosion Resistance of Conductive Elastomers: Nickel and Nickel-Coated Filters
Test Report CHO-TR19C	Corrosion Resistance of Conductive Elastomers Silver-Plated Aluminum Filters
Test Report CHO-TR19DS.E.	Measurements on Various Conductive Elastomers Subjected to SO2 Salt Fog
Test Report CHO-TR19ES.E.	Measurements on CHO-SEAL 1298 Gaskets Subjected to Salt Fog Exposure
Test Report CHO-TR19F	Determination of the Corrosion Resistance of CHO-SEAL 1298 Conductive Elastomer Used in Conjunction with CHO-SHIELD 2001 Conductive Coating
Test Report CHO-TR30A	Evaluation of CHO-SHIELD 2000 Series Coatings Subjected to Salt Fog Exposure
Test Report CHO-TR34A	Lightning Strike Evaluations of Reinforced, Conductive Airframe Seals
Test Report CHO-TR34B	Flammability Evaluations of Reinforced, Conductive Airframe Seals

Conductive Elastomer Gasket Design

Gasket Junction Design

The ideal gasketing surface is rigid and recessed to completely house the gasket. Moreover it should be as conductive as possible. Metal surfaces mating with the gasket ideally should be non-corrosive. Where reaction with the environment is inevitable, the reaction products should be electrically conductive or easily penetrable by mechanical abrasion. It is here that many gasket designs fail. The designer could not, or did not treat the mating surface with the same care as that given to the selection of the gasketing material.

By definition, a gasket is necessary only where an imperfect surface exists. If the junction were perfect, which includes either a solidly welded closure, or one with mating surfaces infinitely stiff, perfectly flat, or with infinite conductivity across the junction, no gasket would be necessary. The more imperfect the mating surfaces, the more critical the function of the gasket. Perfect surfaces are expensive. The final solution is generally a compromise between economics and performance, but it should not be at the expense of neglecting the design of the flange surfaces.

The important property that makes a conductive elastomer gasket a good EMI/EMP seal is its ability to provide good electrical conductivity across the gasket-flange interface. Generally, the better the conformability and conductivity, the higher the shielding effectiveness of the gasket. In practice, it has been found that surface conductivity of both the gasket and the mating surfaces is the single most important property that makes the gasketed seam effective; i.e., the resistance between the flange and gasket should be as low as possible. At this stage of the design every

effort should be given to choosing a flange that will be as stiff as possible consistent with the construction used and within the other design constraints.

1. Flange Materials

Flanges are generally made of the same material as the basic enclosure for reasons of economy, weldability, strength and resistance to corrosion. Wherever possible, the flanges should be made of materials with the highest possible conductivity. It is advisable to add caution notes on drawings not to paint the flange mating surfaces. If paint is to be applied to outside surfaces, be sure that the contact surfaces are well masked before paint is applied, and then cleaned after the masking tape is removed. If the assembled units are subject to painting or repainting in the field, add a cautionary note in a conspicuous location adjacent to the seal that the seal areas are to be masked before painting.

Ordinarily, the higher the conductivity of a material, the more readily it oxidizes – except for noble metals such as gold and silver. Gold is impervious to oxidation, and silver, although it oxidizes, forms oxides that are soft and relatively conductive.

Most oxides, however, are hard. Some of the oxide layers remain thin while others build up to substantial thickness in relatively short time. These oxides form insulating, or semi-conducting films at the boundary between the gasket and the flanges. This effect can be overcome to a degree by using materials that do not oxidize readily, or by coating the surface with a conductive material that is less subject to oxidation. Nickel plating is generally recommended for aluminum parts, although tin has become widely accepted. Zinc

is primarily used with steel. Consult the applicable specifications before selecting a finish. A good guide to finishing EMI shielded flanges for aerospace applications has been published by SAE Committee AE-4 (Electromagnetic Compatibility) under the designation ARP 1481. A discussion of corrosion control follows later in this guide.

2. Advantages of Grooved Designs

All elastomer materials are subject to “Compression Set,” especially if over compressed. Because flange surfaces cannot be held uniformly flat when the bolts are tightened (unless the flanges are infinitely stiff), gaskets tend to overcompress in the areas of the bolts. Proper groove design is required to avoid this problem of over compression. A groove also provides metal-to-metal contact between the flange members, thereby reducing contact resistance across the junction.

A single groove will suffice for most designs. Adding a second groove parallel to the first adds approximately 6 dB to the overall performance of a single-groove design. Adding more grooves beyond the second does not increase the gasketing effectiveness significantly.

3. Flange Design Considerations

Most designers fight a space limitation, particularly in the vicinity of the gasketed seam. Complex fasteners are often required to make the junctions more compact.

The ideal flange includes a groove for limiting the deflection of a gasket. The screw or bolt fasteners are mounted outboard of the gasket to eliminate the need for providing gaskets under the fasteners. A machined flange and its recommended groove dimensions are shown in Figure 1. The gasket may be an “O” or “D”-shaped gasket,

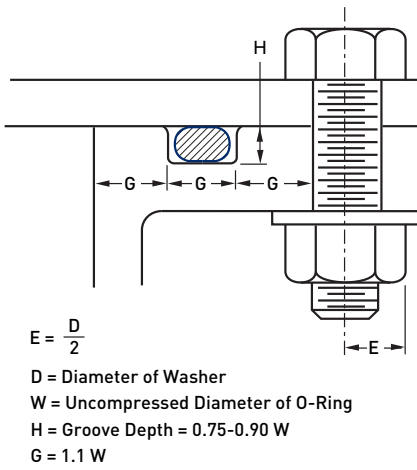


Figure 1. Machined Flange with Gasket Groove

either solid or hollow.

Solid conductive O-rings are normally limited to a deflection of 25 percent. Therefore, the minimum compressed height of the O-ring (also the groove depth) is related to the uncompressed height (or diameter) by the expression $H = 0.75 W$, where W is the uncompressed diameter. The width of the groove, G , should be equal to $1.1 W$. Allow sufficient void in the groove area to provide for a maximum gasket fill of 97 percent. Conductive elastomer gaskets may be thought of as “incompressible fluids.” For this reason, sufficient groove cross sectional area must be allowed for the largest cross-sectional area of the gasket when tolerances are taken into account. Never allow groove and gasket tolerance accumulations to cause an “over-filled” groove (see gasket tolerances in section which follows).

When a seal is used to isolate pressure environments in addition to EMI, the bottom of the gasket groove should have a surface finish of 32-64 $\mu\text{in. (RMS)}$ to minimize leakage along the grooves. Avoid machining methods that produce longitudinal (circumferential) scratches or chatter marks. Conversely, a surface that is too smooth will cause the gasket to “roll over” or twist in its groove.

The minimum distance from the edge of the groove to the nearest terminal edge, whether this terminal

be the edge of a casting, a change in cross section, or a fastening device, should be equal to the groove width, G .

Bolts should be located a minimum distance, E (equal to one-half the diameter of the washer used under the head of the bolt) from the edge of the flange.

Square or rectangular cross section gaskets can be used in the same groove provided sufficient void is allowed for displacement of the elastomer. A good design practice is not to allow the height of the gasket to exceed the base width. A better, or a more optimum ratio is a height-to-width ratio of one-half. Tall gaskets tend to roll over when loaded.

The thickness of a flange is governed by the stiffness required to prevent excessive bowing between fastener points. Fewer, but larger bolts, require a thicker flange to prevent excessive deflections. For calculations of elastic deformation, refer to pages 61 to 63.

O-shaped and D-shaped gaskets may also be used in sheet metal flanges. The gaskets can be retained in a U-channel or Z-retainer, and are deflection-limited by adjusting the channel or retainer dimensions with respect to gasket height. Suggested retainer configurations are shown in Figures 2a and 2b.

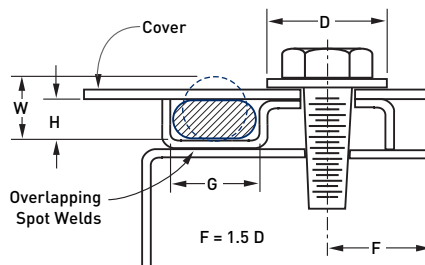


Figure 2a. Shaped Sheet Metal Container

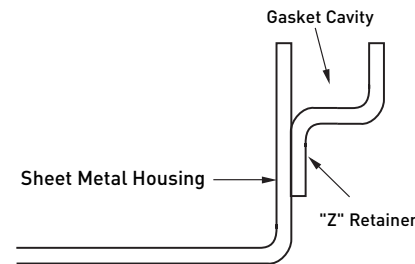


Figure 2b. Z-Retainer Forms Gasket Cavity

A basic difference between flanges constructed from sheet metal and those which are machined from castings is that the bolts cannot be located as close to the edge of the part when the flange is made of sheet metal. Note, in Figure 2a, F is recommended to be $1.5 D$, where D is the diameter of the washer.

Flat gaskets are ordinarily used with sheet metal or machined flanges as typically illustrated in Figure 3. Bolt holes in the flanges should be located at least 1.5 times the bolt diameter from the edge of

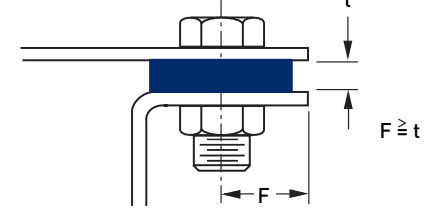


Figure 3. Flat Gasket on Sheet Metal Flange

the flange to prevent tearing when the metal is punched.

If the holes are drilled, the position of the holes should be not less than the thickness of the gasket material from the edge of the flange. If holes must be placed closer to the edge than the recommended values, ears or slots should be considered

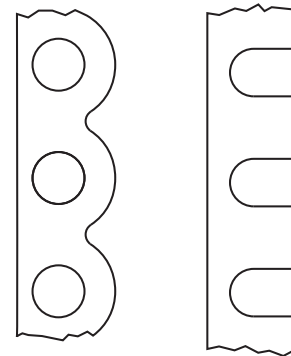


Figure 4. Ears or Slots in Sheet Metal Flanges or Flat Gaskets

as shown in Figure 4. Holes in flat gaskets should be treated in a similar manner.

4. Dimensional Tolerances

Grooves should be held to a machined tolerance of ± 0.002 in.

Holes drilled into machined parts should be held to within ± 0.005 in. with respect to hole location. Location of punched holes should be within ± 0.010 in. Sheet metal bends should be held to $+0.030$ and -0.000 in. Gasket tolerances are given in the "Selection of Seal Cross Section," later in this guide.

5. Waveguide Flanges

The three concerns for waveguide flanges are to ensure maximum transfer of electromagnetic energy across the flange interface to prevent RF leakage from the interface, and to maintain pressurization of the waveguide. Conductive elastomeric gaskets provide both an electrical and a seal function. For flat cover flanges, a die-cut sheet gasket (CHO-SEAL 1239 material), incorporating expanded metal reinforcement to control gasket creep into the waveguide opening, provides an excellent seal. Raised lips around the gasket cut-out improve the power handling and pressure sealing capability of the gasket. Choke flanges are best sealed with molded circular D-Section gaskets, and contact flanges with molded rectangular D-gaskets in a suitable groove (both in CHO-SEAL 1212 material).

The peak power handling capabilities of waveguide flanges are limited primarily by misalignment and sharp edges of flanges and/or gaskets. Average power handling is limited by the heating effects caused by contact resistance of the flange-gasket interface ("junction resistance").

CORROSION

All metals are subject to corrosion. That is, metal has an innate tendency to react either chemically or electrochemically with its environment to form a compound which is stable in the environment. Most electronic packages must be designed for one of four general environments:

Class A. Controlled Environment

Table 1: Minimum Finish Requirements

Minimum Finish Requirements for Structural Metals			
Metal	ENVIRONMENT		
	Class A	Class B	Class C
Carbon and Alloy Steel	0.0003 in. cadmium plate 0.0005 in. zinc plate 0.0003 in. tin	0.0005 in. zinc plate 0.001 in. zinc 0.0005 in. tin	0.003 in. nickel 0.001 in. tin
Corrosion-Resistant Steels	No finish required	No finish required; 0.0005 in. nickel to prevent tarnish	No finish required; 0.001 in. nickel to prevent tarnish
Aluminum 2000 & 7000 series	Chromate conversion coat (MIL-DTL-5541F, Type I, Class 3)	Chromate conversion coat (MIL-DTL-5541F, Type I, Class 3) plus conductive epoxy or urethane	0.001 in. tin
Aluminum 3000, 5000, 6000 series and clad	No finish required, unless shielding requirements are high (see above)	Chromate conversion coat	Chromate conversion coat plus conductive epoxy or urethane
Copper and Copper Alloys	0.0003 in. tin	0.0005 in. tin	0.003 in. nickel 0.001 in. tin
Magnesium	0.0003 in. tin	0.0005 in. tin	0.001 in. tin
Zinc Base Castings	No finish required	0.0003 in. tin	0.0005 in. tin

Temperature and humidity are controlled. General indoor, habitable exposure.

Class B. Uncontrolled Environment

Temperature and humidity are not controlled. Exposed to humidities of 100 percent with occasional wetting. Outdoor exposure or exposure in uncontrolled warehouses.

Class C. Marine Environment

Shipboard exposure or land exposure within two miles of salt water where conditions of Class A are not met.

Class D. Space Environment

Exposure to high vacuum and high radiation.

FINISHES

Table 1 shows the minimum finish necessary to arrest chemical corrosion and provide an electrically conductive surface for the common metals of construction. Only the Class A, B, and C environments are shown in the table because the space environment is not a corrosive one (i.e., metals are not generally affected by the space environment).

Some metals require finishing because they chemically corrode.

These are listed in Table 1, and should be finished in accordance with the table. To select a proper finish for metals not given in Table 1, refer to the material groupings of Table 2. Adjacent groups in Table 2 are compatible. Another excellent source of information on corrosion-compatible finishes for EMI shielded flanges is ARP 1481, developed and published by SAE's Committee AE-4 (Electromagnetic Compatibility).

When a finish is required to make two mating metals compatible, finish the metal which is found in the lower numbered grouping of Table 2. Metals given in Table 2 will, because of their inherent corrodibility, already be finished and the finish metal will be subject to the same rule.

For example, to couple metals separated by two or more groups (e.g., 4 to 2), find a finish which appears in Group 3 and 4. The Group 3 metal should be plated onto the Group 2 metal to make metals 2 and 4 compatible. The reason for this is, if the finish metal breaks down, or is porous, its area will be large in comparison to the exposed area of the Group 2 metal, and the galvanic corrosion will be less.

Table 2: Metals Compatibility

Metals Compatibility	
Group	Metal Groupings*
1	Gold – Platinum – Gold/Platinum Alloys – Rhodium – Graphite – Palladium – Silver – Silver Alloys – Titanium – Silver Filled Elastomers – Silver Filled Coatings
2	Rhodium – Graphite – Palladium – Silver – Silver Alloys – Titanium – Nickel – Monel – Cobalt – Nickel and Cobalt Alloys – Nickel Copper Alloys – AISI 300 Series Steels – A286 Steel – Silver Filled Elastomers – Silver Filled Coatings
3	Titanium – Nickel – Monel – Cobalt – Nickel and Cobalt Alloys – Nickel Copper Alloys – Copper – Bronze – Brass – Copper Alloys – Silver Solder – Commercial Yellow Brass and Bronze – Leaded Brass and Bronze – Naval Brass – Steels AISI 300 Series, 451, 440, AM 355 and PH hardened – Chromium Plate – Tungsten – Molybdenum – Certain Silver Filled Elastomers
4	Leaded Brass and Bronze – Naval Brass – Steels AISI 431, 440, 410, 416, 420, AM 355 and PH hardened – Chromium Plate – Tungsten – Molybdenum – Tin-Indium – Tin Lead Solder – Lead – Lead Tin Solder – Aluminum 2000 and 7000 Series – Alloy and Carbon Steel – Certain Silver Filled Elastomers – CHO-SHIELD 2000 Series Coatings
5	Chromium Plate – Tungsten – Molybdenum – Steel AISI 410, 416, 420, Alloy and Carbon – Tin – Indium – Tin Lead Solder – Lead – Lead Tin Solder – Aluminum – All Aluminum Alloys – Cadmium – Zinc – Galvanized Steel – Beryllium – Zinc Base Castings
6	Magnesium – Tin

*Each of these groups overlap, making it possible to safely use materials from adjacent groups.

On aluminum, chromate conversion coatings (such as Iridite) can be considered as conductive finishes. MIL-DTL-5541F, Type I, Class 3 conversion coatings are required to have less than 200 milliohms resistance when measured at 200 psi contact pressure after 168 hours of exposure to a 5 percent salt spray. Recommended MIL-DTL-5541F, Type I, Class 3 coatings are Alodine 600, or Alodine 1200 and 1200S dipped.

Organic Finishes

Organic finishes have been used with a great deal of success to prevent corrosion. Many organic finishes can be used, but none will be effective unless properly applied. The following procedure has been used with no traces of corrosion after 240 hours of MIL-STD-810B salt fog testing.

Aluminum panels are cleaned with a 20% solution of sodium hydroxide and then chromate conversion coated per MIL-DTL-5541F, Type I, Class 3 (immersion process). The conversion coated panels are then coated with MIL-C-46168 Type 2 urethane coating, except in the areas where contact is required. For maximum protection of aluminum

flanges, a CHO-SHIELD 2000 series conductive coating and CHO-SEAL 1298 conductive elastomer gasket material are recommended. For additional information, refer to Design Guides for Corrosion Control, page 55.

The finish coat can be any suitable urethane coating that is compatible with the MIL-C-46168 coating. It is important to note that test specimens without the MIL-C-46168 coating will show some signs of corrosion, while coated test specimens will show no traces of corrosion.

CHO-SHIELD® 2000 Series Coatings

When using CHO-SHIELD 2000 series conductive urethane coatings it is important to prepare the surface to attain maximum adhesion. The easily mixed three-component system allows minimum waste with no weighing of components, thus eliminating weighing errors. Because of the filler loading of the 2000 series coatings, it is recommended that an air agitator cup be incorporated into the spray system to keep the conductive particles in suspension during the spraying sequence. It is recommended that approximately

7 mils of wet coating be applied. This thickness can be achieved by spraying multiple passes, with a ten minute wait between passes.

A 7-mil wet film coating will yield a dry film thickness of 4 mils, which is the minimum thickness required to attain the necessary corrosion and electrical values referenced in Chomerics' Technical Bulletin 30. The coating thickness plays an important role in the electrical and corrosion properties. Thinner coatings of 1-3 mils do not exhibit the corrosion resistance of 4-5 mil coatings.

The coating will be smooth to the touch when cured. It is recommended that the coating be cured at room temperature for 2 hours followed by 250°F +/-10°F for one-half hour whenever possible. Alternate cure cycles are available, but with significant differences in corrosion and electrical properties. Two alternate cure schedules are two hours at room temperature followed by 150°F for two hours, or 7 days at room temperature.

Full electrical properties are achieved at room temperature after 7 days. It should be noted that the 250°F cure cycle reflects the ultimate in corrosion resistance properties. The 150°F/2 hour and room temperature/7 day cures will provide less corrosion resistance than the 250°F cure, but are well within the specification noted in Technical Bulletin 30.

1091 Primer

Because of the sensitivity of surface preparation on certain substrates and the availability of equipment to perform the etching of aluminum prior to the conversion coating, Chomerics has introduced 1091 primer, which is an adhesion promoter for CHO-SHIELD 2000 series coatings. When used in conjunction with an alkaline etch or chemical conversion coating per MIL-DTL-5541F, Type I, Class 3, the 1091 primer will provide maximum adhesion when correctly applied. (See Technical Bulletin 31.) This

primer is recommended only for the 2000 series coatings on properly treated aluminum and is not recommended for composites.

For further assistance on the application of CHO-SHIELD 2000 series coatings on other metallic and non-metallic substrates, contact Chomerics' Applications Engineering Department.

Galvanic Corrosion

The most common corrosion concern related to EMI gaskets is galvanic corrosion. For galvanic corrosion to occur, a unique set of conditions must exist: two metals capable of generating a voltage between them (any two unlike metals will do), electrically joined by a current path, and immersed in a fluid capable of dissolving the less noble of the two (an electrolyte). In summary, the conditions of a battery must exist. When these conditions do exist, current will flow and the extent of corrosion which will occur will be directly related to the total amount of current the galvanic cell produces.

When an EMI gasket is placed between two metal flanges, the first condition is generally satisfied because the flanges will probably not be made of the same metal as the gasket (most flanges are aluminum or steel, and most EMI gaskets contain Monel, silver, tin, etc.). The second condition is satisfied by the inherent conductivity of the EMI gasket. The last condition could be realized when the electronic package is placed in service, where salt spray or atmospheric humidity, if allowed to collect at the flange/gasket interface, can provide the electrolyte for the solution of ions.

Many users of EMI gaskets select Monel mesh or Monel wire-filled materials because they are often described as "corrosion-resistant." Actually, they are only corrosion-resistant in the sense that they do not readily oxidize over time, even in the presence of moisture. However, in terms of electrochemical

compatibility with aluminum flanges, Monel is extremely active and its use requires extensive edge sealing and flange finish treatment to prevent galvanic corrosion. Most galvanic tables do not include Monel, because it is not a commonly used structural metal. The galvanic table given in MIL-STD-1250 does include Monel, and shows it to have a 0.6 volt potential difference with respect to aluminum – or almost the same as silver.

A common misconception is that all silver-bearing conductive elastomers behave galvanically as silver. Experiments designed to show the galvanic effects of silver-filled elastomer gaskets in aluminum flanges have shown less corrosion than predicted. Silver-plated-aluminum filled elastomers exhibit the least traces of galvanic corrosion and silver-plated-copper filled elastomers exhibit more. (See Table 3).

Tables of galvanic potential do not accurately predict the corrosivity of metal-filled conductive elastomers because of the composite nature of these materials. Also, these tables do not measure directly two important aspects of conductive elastomer "corrosion resistance": 1) the corrosion of the mating metal flange and 2) the retention of conductivity by the elastomer after exposure to a corrosive environment.

Instead of using a table of galvanic potentials, the corrosion caused by different conductive elastomers was determined directly by measuring the weight loss of an aluminum coupon in contact with the conductive elastomer (after exposure to a salt fog environment). The electrical stability of the elastomer was determined by measuring its resistance before and after exposure. Figure 5a describes the test fixture that was used. Figure 5b shows the aluminum weight loss results for several different silver-filled conductive elastomers. The aluminum weight loss shows a two order of

Table 3: Corrosion Potentials for Metals and Gasket Materials

Corrosion Potentials of Various Metals and EMI Gasket Materials (in 5% NaCl at 21°C, after 15 minutes immersion)	
Material	E _{corr} vs. SCE* (Millivolts)
Pure Silver	-25
Silver-filled elastomer	-50
Monel mesh	-125
Silver-plated-copper filled elastomer	-190
Silver-plated-aluminum filled elastomer	-200
Copper	-244
Nickel	-250
Tin-plated Beryllium-copper	-440
Tin-plated copper-clad steel mesh	-440
Aluminum* (1100)	-730
Silver-plated-aluminum filled elastomer (die-cut edge)	-740

*Standard Calomel Electrode. Aluminum Alloys approximately -700 to -840 mV vs. SCE in 3% NaCl. Mansfield, F. and Kenkel, J.V., "Laboratory Studies of Galvanic Corrosion of Aluminum Alloys," Galvanic and Pitting Corrosion – Field and Lab Studies, ASTM STP 576, 1976, pp. 20-47.

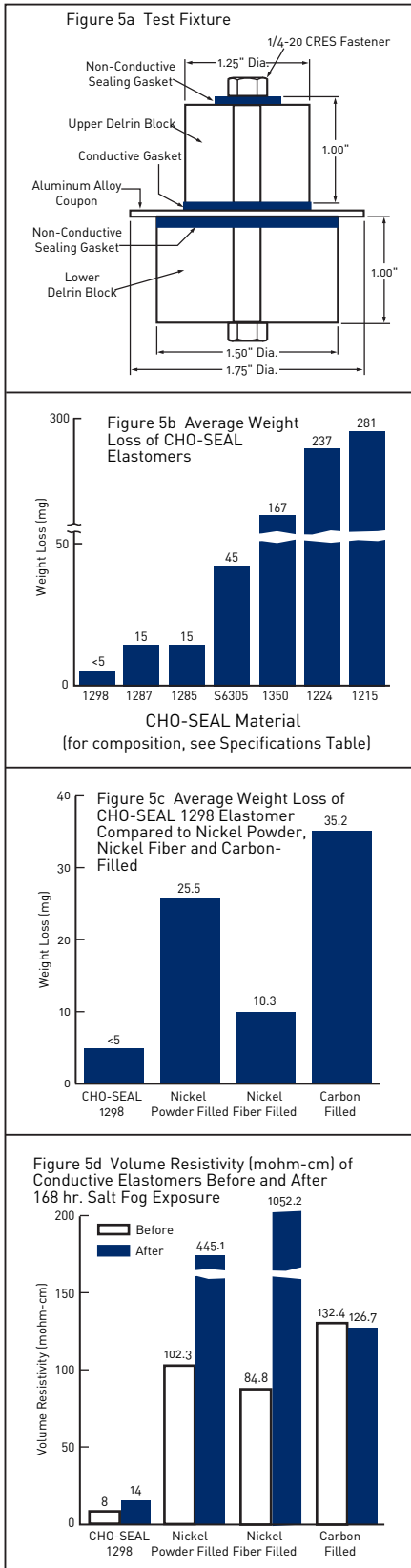
magnitude difference between the least corrosive (1298 silver-plated-aluminum) and most corrosive (1215 silver-plated-copper) filled elastomers. For silver-containing elastomers, the filler substrate that the silver is plated on is the single most important factor in determining the corrosion caused by the conductive elastomer

Figure 5c shows the weight loss results for nickel and carbon-filled elastomers compared to 1298. The nickel-filled materials are actually more corrosive than the silver-plated-aluminum filled elastomers. The carbon-filled materials are extremely corrosive.

Figure 5d compares the electrical stability of several conductive elastomers before and after salt fog exposure. In general, silver-containing elastomers are more electrically stable in a salt fog environment than nickel-containing elastomers.

Design Guides for Corrosion Control

The foregoing discussion is not intended to suggest that corrosion



should be of no concern when flanges are sealed with silver-bearing conductive elastomers. Rather, corrosion control by and large presents the same problem whether the gasket is silver-filled, Monel wire-filled, or tin-plated. Furthermore, the designer must understand the factors which promote galvanic activity and strive to keep them at safe levels. By "safe", it should be recognized that some corrosion is likely to occur (and may be generally tolerable) at the outer (unsealed) edges of a flange after long-term exposure to salt-fog environments. This is especially true if proper attention has not been given to flange materials and finishes. The objective should be control of corrosion within acceptable limits.

The key to corrosion control in flanges sealed with EMI gaskets is proper design of the flange and gasket (and, of course, proper selection of the gasket material). A properly designed interface requires a moisture-sealing gasket whose thickness, shape and compression-deflection characteristics allow it to fill all gaps caused by uneven or unflat flanges, surface irregularities, bowing between fasteners and tolerance buildups. If the gasket is designed and applied correctly, it will exclude moisture and inhibit corrosion on the flange faces and inside the package.

Bare aluminum and magnesium, as well as iridized aluminum and magnesium, can be protected by properly designed conductive elastomer gaskets. It is important to note that magnesium is the least noble structural metal commonly used, and a silver-filled elastomer in contact with magnesium would theoretically produce an unacceptable couple.

Some specific design suggestions for proper corrosion control at EMI flanges are:

1. Select silver-plated-aluminum filled elastomers for best overall sealing and corrosion protection

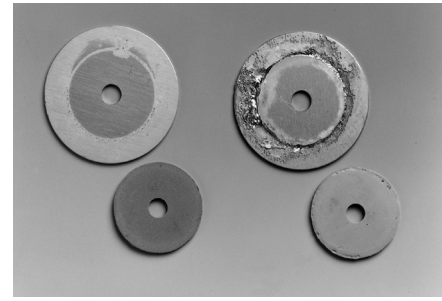


Figure 6. Comparison of corrosion results obtained from CHO-SEAL® 1298 conductive elastomer (left) and pure silver-filled elastomer (right) mated with aluminum after 168 hours of salt fog exposure.

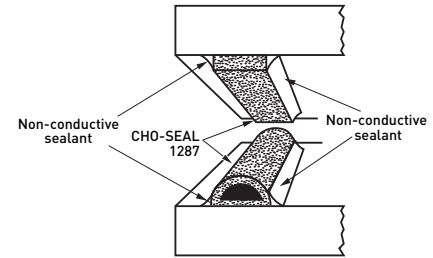


Figure 7. "Seal-to-seal" design incorporating CHO-SEAL® 1287 conductive silver-aluminum fluorosilicone gaskets on both mating flange surfaces. Gaskets are bonded and edge sealed to prevent moisture from entering the gasket/flange area.

against MIL-DTL-5541F, Type I, Class 3 coated aluminum. CHO-SEAL 1298 material offers more corrosion resistance than any other silver-filled elastomer (see Figure 6).

2. For aircraft applications, consider "seal-to-seal" designs, with same gasket material applied to both flange surfaces (see Figure 7).

3. To prevent corrosion on outside edges exposed to severe corrosive environments, use dual conductive/non-conductive gaskets or allow the non-conductive protective paint (normally applied to outside surfaces) to intrude slightly under the gasket (see Figure 8).



Figure 8. Non-Conductive Paint Intrudes Slightly Under Gasket to Provide Edge Protection

4. If moisture is expected to reach the flange interfaces in Class C (marine) environments, flange surfaces should be coated or plated

to make them more compatible with the EMI gasket material. Chomerics' CHO-SHIELD 2000 series coatings are recommended for silver-filled elastomer or Monel wire gaskets, and tin plating for tin-plated gaskets.

5. Avoid designs which create sump areas.

6. Provide drainage and/or drain holes for all parts which would become natural sumps.

7. Provide dessicants for parts which will include sumps but cannot be provided with drain holes. Dessicant filters can also be provided for air intake.

8. Avoid sharp edges or protrusions.

9. Select proper protective finishes.

The definition of a "safe" level of galvanic activity must clearly be expanded to include the requirements of the design. If all traces of corrosion must be prevented (e.g., airframe applications) the structure must be properly finished or must be made of materials which will not corrode in the use environment. In these cases, the outside edges of EMI-gasketed flanges might also require peripheral sealing as defined in MIL-STD-1250, MIL-STD-889 or MIL-STD-454. MIL-STD-1250 deserves special mention. Although it was developed many years prior to the availability of CHO-SEAL 1298 conductive elastomer and CHO-SHIELD 2000 series conductive coatings, it offers the following useful corrosion control methods applicable to electronic enclosures:

1. Bonds made by conductive gaskets or adhesives, and involving dissimilar contact, shall be sealed with organic sealant.

2. When conductive gaskets are used, provision shall be made in design for environmental and electromagnetic seal. Where practical, a combination gasket with conductive metal encased in resin or elastomer shall be preferred.

3. Attention is drawn to possible moisture retention when sponge

elastomers are used.

4. Because of the serious loss in conductivity caused by corrosion, special precautions such as environmental seals or external sealant bead shall be taken when wire mesh gaskets of Monel or silver are used in conjunction with aluminum or magnesium.

5. Cut or machined edges of laminated, molded, or filled plastics shall be sealed with impervious materials.

6. Materials that "wick" or are hygroscopic (like sponge core mesh gaskets) shall not be used.

7. In addition to suitability for the intended application, nonmetallic materials shall be selected which have the following characteristics:

- a. Low moisture absorption;
- b. Resistance to fungi and microbial attack;
- c. Stability throughout the temperature range;
- d. Freedom from outgassing;
- e. Compatibility with other materials in the assembly;
- f. Resistance to flame and arc;
- g. For outdoor applications, ability to withstand weathering.

Selection of Seal Cross Section

Selection of the proper conductive elastomer gasket cross section is largely one of application, compromise, and experience with similar designs used in the past. Some general rules, however, can be established as initial design guidelines in selecting the class of gasket to be used.

1. Flat Gaskets

When using flat gaskets, care must be taken not to locate holes closer to the edge than the thickness of the gasket, or to cut a web narrower than the gasket thickness.

This is not to be confused with the criteria for punching holes in sheet metal parts discussed earlier.

Keep in mind also that flat gaskets should be deflected typically 10 percent, compared with 15 to 18 percent for molded and solid extruded gaskets and 50% inside diameter for hollow gaskets. Standard thicknesses for flat gaskets are 0.020, 0.032, 0.045, 0.062, 0.093 and 0.125 in. (see General Tolerances, Table 4.)

Where possible, the flange should be bent outward so that the screws or bolts do not penetrate the shielded compartment (see Figure 9a). If the flange must be bent inward to save space, the holes in the gasket must fit snugly around the threads of the bolts to prevent leakage along the threads and directly into the compartment. This calls for closely toleranced holes and accurate registration between the holes in the flange and the holes in the gasket, and would require machined dies (rather than rule dies) to produce the gasket. An alternate solution can be achieved by adding an EMI seal under the heads of bolts penetrating the enclosure, or by using an insert similar to an acorn nut that has been inserted in the flange and flared to make the joint RF-tight. "Blind nuts" can also be welded or attached with a conductive epoxy adhesive (see Figure 9b).

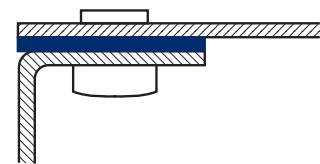


Figure 9a. External Bolting Prevents EMI Leakage

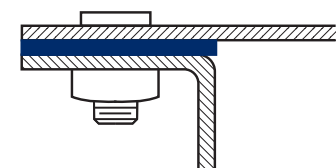


Figure 9b. Insert Pressed-In and Flared Makes EMI Tight Joint (Alternate: Weld or Cement with Conductive Epoxy)

2. Shaped or Molded Gaskets

Groove designs for O- or D-shaped configurations are effective because gasket deflection can be controlled and larger deflections

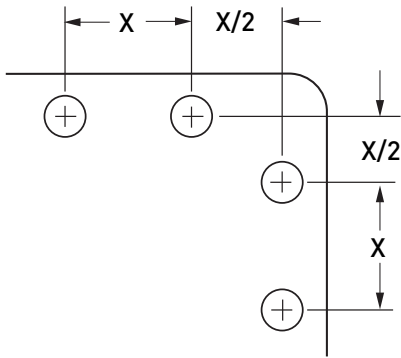


Figure 10. Fastener Location Near Corners

can be accommodated. O-ring cross sections are preferred because they can be deflected more easily under a given load. D-shapes or rectangular cross sections are excellent for retrofit applications because they can be made to accommodate almost any groove cross section. Groove designs also provide metal-to-metal flange contact for superior shielding, and require fewer fasteners, thereby minimizing the number of paths where direct leakage can occur.

Fasteners should be located such that pressure distribution is uniform at the corners (see Figure 10).

3. Hollow Gaskets

Hollow gasket configurations are very useful when large gaps are encountered, or where low closure forces are required. Hollow gaskets are often less expensive,

and they can be obtained with or without attachment tabs. Hollow gaskets with tabs are referred to in the text and in the tables as “P-gaskets”. The minimum wall thickness of hollow gaskets is 0.020 in. depending on material. Contact Chomerics’ Applications Department for details. Hollow gaskets will compensate for a large lack of uniformity between mating surfaces because they can be compressed to the point of eliminating the hollow area.

4. Compression Limits

When compression cannot be controlled, compression stops should be provided to prevent gasket rupture caused by over-compression. Grooves provide built-in compression stops. Figure 11 gives nominal recommended compression ranges for CHO-SEAL and CHO-SIL materials, assuming standard tolerances.

5. Elongation

The tensile strength of conductive elastomer gaskets is not high. It is good practice to limit elongation to less than 10 percent.

6. Splicing

When grooves are provided for gasket containment, two approaches are possible. A custom gasket can be molded in one piece

and placed into the desired groove, or a strip gasket can be spliced to length and fitted to the groove. To properly seat a spliced solid “O” cross section gasket, the inner radius of the groove at the corners must be equal to or greater than 1.5 times the gasket cross section width. Other cross sections need greater inner radius and may not be practical due to twisting when bent around corners. Splices can be simply butted (with no adhesive) or bonded with a conductive or non-conductive compound. If it has been decided that a spliced gasket will provide a satisfactory seal, the decision between splicing and molding should be based on cost, flash and tolerance. When a standard extrusion is available, splicing is generally recommended. For custom extrusions, splicing is generally more cost effective in quantities over 500 feet.

7. Gasket Limitations Imposed by Manufacturing Methods

Current manufacturing technology limits conductive elastomer gasket configurations to the following dimensions and shapes :

■ Die-cut Parts

Maximum Overall Size: 32 in. long x 32 in. wide x 0.125 in. thick (81 cm x 81 cm x 3.18 mm)

Minimum Cross Section: Width-to-thickness ratio 1:1 (width is not to be less than the thickness of the gasket).

■ Molded Parts

Currently available in any solid cross section, but not less than 0.040 in. in diameter. The outer dimensions of the gasket are limited to 34 inches in any direction. Larger parts can be made by splicing. Molded parts will include a small amount of flash (0.008 in. width and 0.005 in. thickness, maximum).

■ Extruded Parts

No limitation on length. Minimum solid cross-section is limited to 0.028 in. extrusions. Wall thickness of hollow extrusions varies with

Deflection Range ØW	Deflection Range H	Deflection Range T	Deflection Range A ØB
0.007-0.018 (0.178-0.457)	0.005-0.014 (0.127-0.356)	0.001-0.003 (0.025-0.076)	0.020-0.080 (0.508-2.032)
0.010-0.026 (0.254-0.660)	0.007-0.018 (0.178-0.457)	0.002-0.005 (0.051-0.127)	0.200 (5.08)
0.013-0.031 (0.330-0.787)	0.010-0.026 (0.254-0.660)	0.003-0.009 (0.076-0.229)	0.080 (2.032)
0.014-0.035 (0.356-0.889)	0.012-0.031 (0.305-0.787)	0.005-0.014 (0.127-0.356)	0.250 (6.35)
	0.014-0.035 (0.356-0.889)		0.125 (3.175)
			0.255 (6.477)

Figure 11. Gasket Deflection Ranges (mm dimensions in parentheses)

material but 0.020 in. can be achieved with most materials (S6308, 1215, 1273).

8. General Tolerances

Table 4 provides general tolerances for conductive elastomer gaskets. It is important to note that all flat die-cut, molded, and extruded gaskets are subject to free-state variation in the unrestrained condition. The use of inspection fixtures to verify conformance of finished parts is common and recommended where appropriate.

Also note that “Overall Dimensions” for flat die-cut gaskets and molded gaskets includes any feature-to-feature dimensions (e.g., edge-to-edge, edge-to-hole, hole-to-hole).

9. Gasket Cross Section Based on Junction Gaps

Gasket geometry is largely determined by the largest gap allowed to exist in the junction. Sheet metal enclosures will have larger variations than machined or die castings. The ultimate choice in allowable gap tolerance is a compromise between cost, performance and the reliability required during the life of the device. When

a value analysis is conducted, it should be made of the entire junction, including the machining required, special handling, treatment of the surfaces and other factors required to make the junction functional. Often, the gasket is the least expensive item, and contributes to cost-effectiveness by allowing loosely-toleranced flanges to be made EMI-tight.

The maximum gap allowed to exist in a junction is generally determined by the minimum electrical performance expected of the seal. A secondary consideration must be given to the barrier as a pressure seal if gas pressures of significant magnitude are expected. The gasket will blow out if the pressure is too high for the gap.

The minimum gap allowed in the junction is determined by the allowable squeeze that can be tolerated by the gasket material. Deflection of conductive elastomer gaskets is given in Figure 11. Flat gaskets may be deflected as much as 6-10 percent (nominal), depending on initial thickness and applied force. O-shaped and

D-shaped gaskets are normally deflected 10 to 25 percent; however, greater deflections can be achieved by manipulating cross section configuration.

Determination of the exact gasket thickness is a complex problem involving electrical performance, flange characteristics, fastener spacing and the properties of the gasket material. However, an initial estimate of the necessary thickness of a noncontained gasket can be determined by multiplying the difference in the expected minimum and maximum flange gaps by a factor of 4, as illustrated in Figure 12. A more detailed discussion, and a more accurate determination of gasket performance under loaded flange conditions, can be found in the Fastener Requirements section.

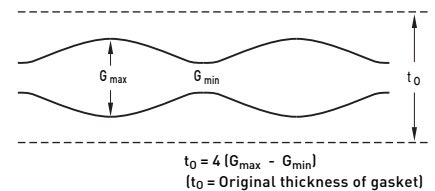


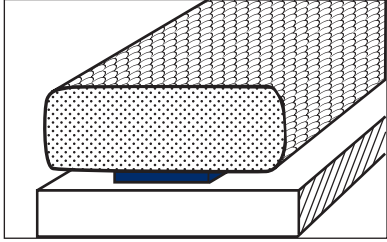
Figure 12. Gasket Deflection Along a Flange

Table 4. General Tolerances

FLAT DIE-CUT GASKETS		MOLDED GASKETS		EXTRUDED STRIP GASKETS	
inch (mm)	Tolerance	inch (mm)	Tolerance	inch (mm)	Tolerance
Overall Dimensions		Overall Dimensions		Cut Length	
≤10 (254)	±0.010 (0.25)	0.100 to 1.500 (2.54 to 38.10)	±0.010 (0.25)	<1.000 (25.40)	±0.020 (0.51)
>10 to ≤15 (254 to 381)	±0.020 (0.51)	1.501 to 2.500 (38.13 to 63.50)	±0.015 (0.38)	1.0 to 30.000 (25.40 to 762)	±0.062 (1.58)
>15 (>381)	±0.20% Nom. Dim.	2.501 to 4.500 (63.53 to 114.30)	±0.020 (0.51)	> 30.000 (762)	±0.20% Nom. Dim.
Thickness		4.501 to 7.000 (114.33 to 177.80)	±0.025 (0.64)	Cross Section	
0.020 (0.51)	±0.004 (0.10)	>7.000 (>177.80)	±0.35% Nom. Dim.	< 0.200 (5.08)	±0.005 (0.13)
0.032 (0.81)	±0.005 (0.13)	Cross Section		0.200-0.349 (5.08-8.86)	±0.008 (0.20)
0.045 (1.14)	±0.006 (0.15)	0.040 to 0.069 (1.02 to 1.75)	±0.003 (0.08)	0.350-0.500 (8.89-12.70)	±0.010 (0.25)
0.062 (1.57)	±0.007 (0.18)	0.070 to 0.100 (1.78 to 2.54)	±0.004 (0.11)	>0.500 (12.70)	±3% Nom. Dim.
0.093 (2.36)	±0.010 (0.25)	0.101 to 0.200 (2.57 to 5.08)	±0.005 (0.13)		
0.125 (3.18)	±0.010 (0.25)	0.201 to 0.350 (5.11 to 8.89)	±0.008 (0.20)		
>0.125 (>3.18)	Contact a Chomerics Applications or Sales Engineer				
Hole Diameters	+/- 0.010 (0.25)				
Location of Hole Center ±0.010 (0.25)					

Gasket Mounting Choices

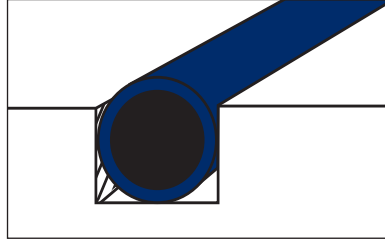
Our various EMI gasket mounting techniques offer designers cost-effective choices in both materials and assembly. These options offer aesthetic choices and accommodate packaging requirements such as tight spaces, weight limits, housing materials and assembly costs. Most Chomerics gaskets attach using easily repairable systems. Our Applications Engineering Department or your local Chomerics representative can provide full details on EMI gasket mounting. The most common systems are shown here with the available shielding products.



Pressure-Sensitive Adhesive

Quick, efficient attachment strip

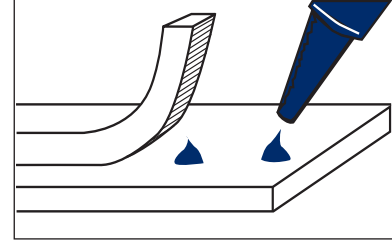
- Conductive Elastomers
- SOFT-SHIELD®
- SPRING-LINE®
- POLASHEET®
- POLASTRIP®



Friction Fit in a Groove

Prevents over-deflection of gasket
Retaining groove required

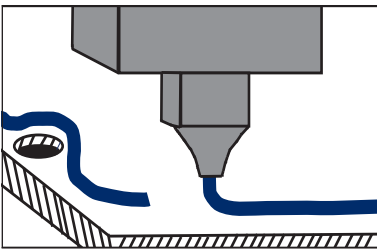
- Conductive Elastomers
- SOFT-SHIELD®
- MESH STRIP™
- POLASTRIP®
- SPRINGMESH®



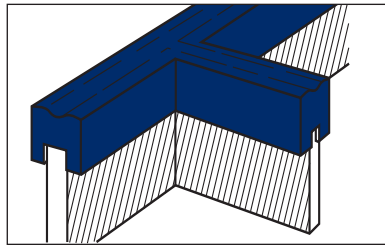
Adhesive Compounds

Conductive or non-conductive
spot bonding

- Conductive Elastomers
- MESH STRIP™



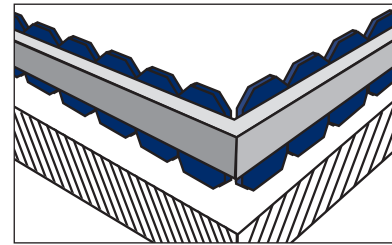
Robotically Dispensed Form-in-Place Conductive Elastomer
Chomerics' CHOFORM® automated technology applies high quality conductive elastomer gaskets to metal or plastic housings. Manufacturing options include Chomerics facilities, authorized Application Partners, and turnkey systems.



Friction Fit on Tangs

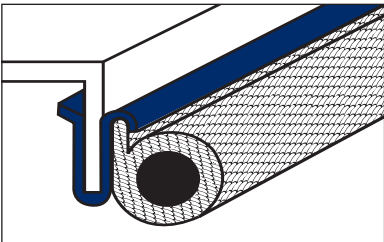
Accommodates thin walls,
intricate shapes

- Conductive Elastomers



Spacer Gaskets

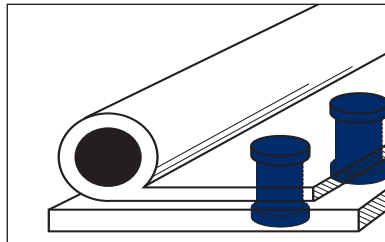
Fully customized, integral conductive elastomer and plastic spacer provide economical EMI shielding and grounding in small enclosures. Locator pins ensure accurate and easy installation, manually or robotically.



Metal Clips

Teeth bite through painted panels
Require knife edge mounting flange

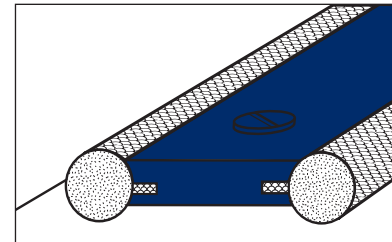
- Conductive Elastomers
- METALKLIP™
- SPRING-LINE®



Rivets/Screws

Require integral compression stops
Require mounting holes on flange

- Conductive Elastomers
- SPRING-LINE
- SHIELDMESH®
- COMBO STRIP®



Frames

Extruded aluminum frames and strips add rigidity. Built-in compression stops for rivets and screws.

- Conductive Elastomers
- MESH STRIP™

FASTENER REQUIREMENTS

1. Applied Force

Most applications do not require more than 100 psi (0.69 MPa) to achieve an effective EMI seal. Waveguide flanges often provide ten times this amount. Hollow strips require less than 10 pounds per in. Compression deflection data for many shapes, sizes and materials is included in the Performance Data section of this Design Guide.

The force required at the point of least pressure, generally midway between fasteners, can be obtained by using a large number of small fasteners spaced closely together. Alternatively, fasteners can be spaced further apart by using stiffer flanges and larger diameter bolts. Sheet metal parts require more fasteners per unit length than castings because they lack stiffness.

To calculate average applied force required, refer to load-deflection curves for specific gasket materials and cross sections (see Performance Data).

2. Fastener Sizes and Spacing

Fastener spacing should be determined first. As a general rule, fasteners should not be spaced more than 2.0 inches (50 mm) apart for stiff flanges, and 0.75 inch (19 mm) apart for sheet metal if high levels of shielding are required. An exception to the rule is the spacing between fasteners found in large cabinet doors, which may vary from 3 inches (76.02 mm) between centers to single fasteners (i.e., door latches). The larger spacings are compensated for by stiffer flange sections, very large gaskets, and/or some reduction in electrical performance requirements.

The force per bolt is determined by dividing the total closure force by the number of bolts. Select a fastener with a stress value safely below the allowable stress of the fastener.

References

- Galagan, Steven, *Designing Flanges and Seals for Low EMI, Microwaves*, December 1966.
- Roark, R. J., *Formulas for Stress and Strain*, McGraw-Hill, 4th Ed., p. 74.

3. Flange Deflection

The flange deflection between fasteners is a complex problem involving the geometry of the flange and the asymmetrical application of forces in two directions. The one-dimensional solution, which treats the flange as a simple beam on an elastic foundation, is much easier to analyze and gives a good first order approximation of the spacings required between fasteners, because most EMI gaskets are sandwiched between compliant flanges

Variation in applied forces between fasteners can be limited to ± 10 percent by adjusting the constants of the flange such that

$$\beta D = 2,$$

where

$$\beta = \sqrt[4]{\frac{k}{4 E_f I_f}}$$

k = foundation modulus of the seal

E_f = the modulus of elasticity of the flange

I_f = the moment of inertia of the flange and seal

d = spacing between fasteners

The modulus of elasticity (E_f) for steel is typically 3×10^7 . The modulus for aluminum is typically 1×10^7 , and for brass it is about 1.4×10^7 .

The foundation modulus (k) of seals is typically 10,000 to 15,000 psi.

The moment of inertia (I_f) of rectangular sections, for example, may be obtained from the following expression²:

$$I_f = \frac{bh^3}{12}$$

where

b = the width of the flange in contact with the gasket (inches) and

h = the thickness of the flange (inches).

Example

Calculate the bolt spacings for flanges with a rectangular cross-section, such as shown in Figure 12, where

h is the thickness of the flange.

b is the width of the flange.

d is the spacing between fasteners.

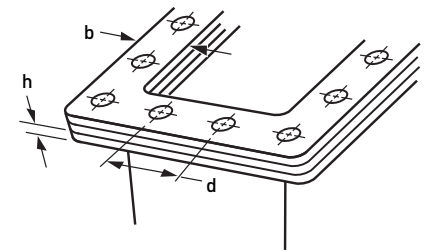


Figure 12. Bolt Spacings for Flanges

Assume the flange is to be made of aluminum.

To maintain a pressure distribution between bolts of less than ± 10 percent, βd must be equal to 2 (see Figure 13 and discussion).

Assume an average foundation modulus (k) of 12,500 psi for the seal. If the actual modulus is known (stress divided by strain), substitute that value instead.

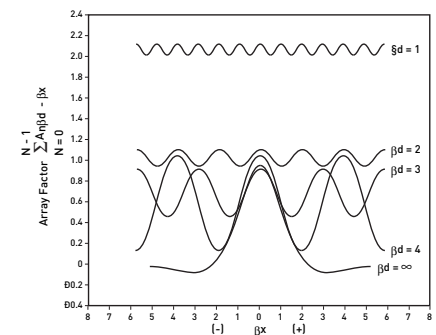


Figure 13. Array Factor vs. Spacing

The bolt spacings for aluminum flanges for various thicknesses and widths have been calculated for the previous example and are shown in Figure 14.

The previous example does not take into account the additional stiffness contributed by the box to which the flange is attached, so the results are somewhat conservative.

Actual deflection vs. distance between fasteners may be computed from the following expression:

$$y = \frac{\beta p}{2k} \sum_{n=0}^{N-1} A_{n\beta d - \beta x}$$

where p is the force applied by the fastener, and β and k are the constants of the flange as determined previously. N represents the number of bolts in the array.

The array factor denoted by the summation sign adds the contribution of each fastener in the array. The array factor for various bolt spacings (βd) is shown in Figure 13. Although any value can be selected for βd , a practical compromise between deflection, bolt spacing and electrical performance is to select a bolt spacing which yields a value βd equal to 2.

For $\beta d = 2$, the flange deflection fluctuates by ± 10 percent. Minimum deflection occurs midway between

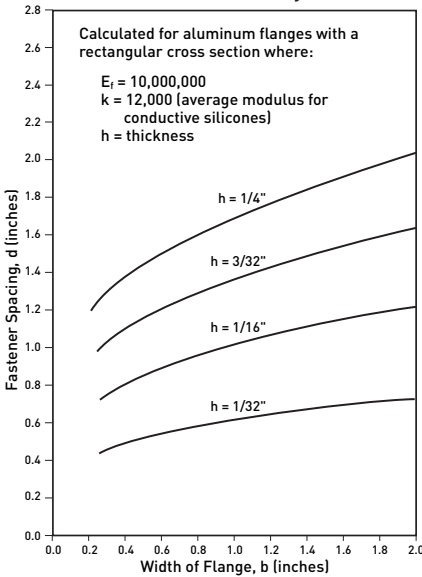


Figure 14. Fastener Spacing

fasteners and is 20 percent less than the deflection directly under the fasteners. The variation in deflection is approximately sinusoidal.

Table 5 lists a few recommendations for bolts and bolt spacings in various thin cross section aluminum flanges.

Bolt spacings for waveguide flanges are fixed by Military and EIA Standards. Waveguide flanges normally have bolts located in the middle of the long dimension of the flange because the flow of current is most intense at this point.

4. Common Fasteners

Many different types of fasteners are available, but bolts are the most widely used fastening devices. The approximate torque required to

Table 5: Bolt/Spacing Recommendations

SCREW SIZE	Centerline to Centerline (in.)	Thickness (in.)	Max. Torque to Prevent Stripping for UNC-2A Thread (in.-lbs.)
#2	3/8	0.062	4.5
#4	3/4	0.125	10.0
#6	1	0.125	21.0
#8	1 1/4	0.156	37.5
#10	1 3/8	0.156	42.5

apply adequate force for mild steel bolts is shown in Table 5.

These values are approximate and will be affected by the type of lubricants used (if any), plating, the type of washers used, the class and finish of the threads, and numerous other factors.

The final torque applied to the fasteners during assembly should be 133 percent of the design value to overcome the effect of stress-relaxation. When torqued to this value, the gasket will relax over a period of time and then settle to the design value.

Torque may be converted to tension in the bolts by applying the formula. Frequently the general value of 0.2 for the coefficient of friction can

$$\text{Tension} = \frac{\text{Torque}}{0.2 \times \text{Bolt Dia.}}$$

result in torque and bolt estimates which may be seriously in error. Excessive bolt preload may lead to RF leakage. Therefore, if lubricants are used for any reason, refer to the literature for the proper coefficient values to be applied.

In soft materials, such as aluminum, magnesium and insulating materials, inserts should be provided if the threads are "working threads." A thread is considered a "working thread" if it will be assembled and disassembled ten or more times.

Torque loss caused by elongation of stainless steel fasteners should also be considered. High tensile strength hardware is advised when this becomes a problem, but care must be taken of the finish specified to minimize galvanic corrosion.

Thermal conductivity of high tensile strength hardware is lower than most materials used in electro-mechanical packaging today, so that the enclosure expands faster than the hardware and usually helps to tighten the seal. Should the equipment be subjected to low

Table 6: Recommended Torque Values

RECOMMENDED TORQUE VALUES FOR MILD STEEL BOLTS				
Size	Threads per in.	Max. Recommended		Basic Pitch Dia. (inches)
		Torque (in.-lbs)	Tension* (lbs.)	
#4	40	4 3/4		0.0958
	48	6		0.0985
#5	40	7		0.1088
	44	8 1/2		0.1102
#6	32	8 3/4		0.1177
	40	11		0.1218
#8	32	18		0.1437
	36	20		0.1460
#10	24	23		0.1629
	32	32		0.1697
1/4"	20	80	1840	0.2175
	28	100	2200	0.2268
5/16"	18	140	2530	0.2764
	24	150	2630	0.2854
3/8"	16	250	3740	0.3344
	24	275	3950	0.3479
7/16"	14	400	5110	0.3911
	20	425	5250	0.4050
1/2"	13	550	6110	0.4500
	20	575	6150	0.4675
9/16"	12	725	7130	0.5084
	18	800	7600	0.5264
5/8"	11	1250	11,040	0.5660
	18	1400	11,880	0.5889

$$*\text{Tension} = \frac{\text{Torque}}{0.2 \times \text{Bolt Dia.}^f}$$

^f Basic Pitch Diameter

temperatures for long periods of time, the bolts may require tightening in the field, or can be pretightened in the factory under similar conditions.

Under shock and vibration, a stack up of a flat washer, split helical lockwasher and nut are the least reliable, partly because of elongation of the stainless steel fasteners, which causes the initial loosening. The process is continued under shock and vibration conditions. Elastic stop nuts and locking inserts installed in tapped holes have proven to be more reliable under shock and vibration conditions, but they cost more and are more expensive to assemble.

5. Electrical Performance as a Function of Fastener Spacing

The electrical performance (shielding effectiveness) provided by a gasket sandwiched between two flanges and fastened by bolts spaced “d” distance apart is equivalent to the shielding effectiveness obtained by applying a pressure which is the arithmetic mean of the maximum and minimum pressure applied to the gasket under the condition that the spacing between fasteners is considerably less than a half wavelength. For bolt spacings equal to or approaching one-half wavelength at the highest operating frequency being considered, the shielding effectiveness at the point of least pressure is the governing value.

For example, assume that a gasket is sandwiched between two flanges which, when fastened together with bolts, have a value of βd equal to 2. Figure 13 shows that a value of $\beta d = 2$ represents a deflection change of ± 10 percent about the mean deflection point. Because applied pressure is directly proportional to deflection, the applied pressure also varies by ± 10 percent.

Shielding effectiveness values for typical silver-plated-copper filled, die-cut gaskets as a function of applied pressure are shown in

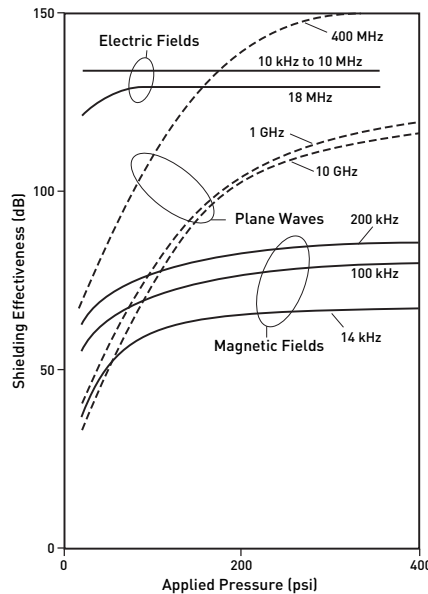


Figure 15. Shielding Effectiveness vs. Applied Pressure

Figure 15. The curves show that the shielding effectiveness varies appreciably with applied pressure, and changes as a function of the type of field considered. Plane wave attenuation, for example, is more sensitive to applied pressure than electric or magnetic fields.

Thus, in determining the performance to be expected from a junction, find the value for an applied pressure which is 10 percent less (for $\beta d = 2$) than the value exerted by the bolts directly adjacent to the gasket. For example, examine a portion of a typical gasket performance curve as shown in Figure 16.

The average shielding effectiveness of the gasketed seam is a function of the mean applied pressure, p_m .

For spacings which approach or are equal to one-half wavelength, the shielding effectiveness is a

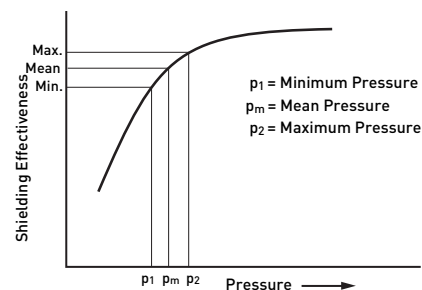


Figure 16. Typical Gasket Performance Curve

function of the minimum pressure, p_1 . Therefore, the applied pressure must be 20 percent higher to achieve the required performance. For this condition, the space between the fasteners can be considered to be a slot antenna loaded with a lossy dielectric. If the slot is completely filled, then the applied pressure must be 20 percent higher as cited. Conversely, if the slot is not completely filled (as shown in Figure 17), the open area will be free to radiate energy through the slot.

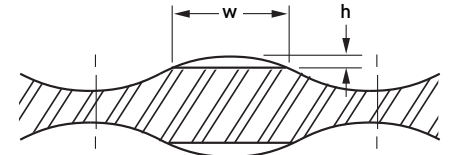


Figure 17. Unfilled Slot is Free to Radiate When Spacing is Equal to 1/2 Wavelength

The cut-off frequency for polarizations parallel to the long dimension of the slot will be determined by the gap height, h . The cut-off frequency for the polarization vector perpendicular to the slot will be determined by the width of the slot, w . The attenuation through the slot is determined by the approximate formula

$$A(\text{dB}) = 54.5 d / \lambda c$$

where

d = the depth of the slot,

and

λc is equal to $2w$ or $2h$, depending upon the polarization being considered.

This example also illustrates why leakage is apt to be more for polarizations which are perpendicular to the seam.

For large values of βd , the percentage adjustments must be even greater. For example, the percentage increase required to satisfy $\beta d = 3$ is 64 percent. It is desirable, therefore, that βd should be kept as small as possible. This can be achieved by using stiff flanges or spacing bolts closer together.

Designing a Solid-O Conductive Elastomer Gasket-in-a-Groove

The “solid-O profile” is the most often specified conductive elastomer EMI gasket for several key reasons. Compared to other solid cross sections, it offers the widest deflection range to compensate for poorly tolerated mating surfaces and to provide reliable EMI shielding and pressure sealing. It can be installed in a relatively small space, and is the most easily installed and manufactured. It also tends to be less prone to damage, due to the absence of angles, corners or other cross section appendages.

The “gasket-in-a-groove” design offers five significant advantages over surface-mounted EMI gaskets:

1. Superior shielding, due to substantial metal-to-metal contact achieved when the mating surfaces are bolted together and “bottom out”. (Flat die-cut gaskets prevent metal-to-metal contact between mating flange members, which reduces EMI shielding performance – especially in low frequency magnetic fields.)

2. Positive control over sealing performance. Controlling the size of the gasket and groove can ensure that required shielding and sealing are achieved with less careful assembly than is required for flat gaskets. In other words, the gasket-in-a-groove is more foolproof.

3. Built-in compression stop provided by the groove eliminates the risk of gasket damage due to excessive compression.

4. A gasket retention mechanism can be provided by the groove, eliminating the need for adhesives or mounting frames.

5. High current-handling characteristics of the metal-to-metal flange design improves the EMP and lightning protection offered by an enclosure.

This section presents the method for calculating groove and gasket

dimensions which will permit the shielding system to function under worst-case tolerance conditions. Adherence to these general guidelines will result in optimum shielding and sealing for typical electronics “boxes”. It should be understood that they may not be suitable for designing shielding for sheet metal cabinets, doors, rooms or other large, unconventional enclosures.

Important Notes: The guidelines presented here are intended to consider only “solid O” gasket cross sections. The calculations for hollow O, solid and hollow D, and custom gasket cross sections differ from these guidelines in several key areas.

Chomerics generally does not recommend bonding solid O gaskets in grooves. If for some reason your design requires gasket retention, contact Chomerics’ Applications Engineering Department for specific recommendations, since the use of adhesives, dove-tailed grooves or “friction-fit” techniques require special design considerations not covered here.

Extreme design requirements or unusually demanding specifications are also beyond the scope of the guidelines presented here. Examples would include critical specifications for pressure sealing, exceptionally high levels of EMI shielding, exceptional resistance to corrosion, harsh chemicals, high temperatures, heavy vibration, or unusual mounting and assembly considerations.

Mechanical Considerations Causes of Seal Failure

In order to produce a gasket-in-a-groove system which will not fail, the designer must consider three mechanical causes of seal failure: gasket over-deflection and associated damage (see Figure 18d); gasket under-deflection and loss of seal (see Figure 18f); groove over-fill, which can destroy the

gasket (see Figure 18e).

Designing to avoid these problems is made more complicated by the effects of:

- worst-case tolerance conditions
- deformation of the cover (cover bowing)
- poor fit of mating surfaces.

The key to success involves selection of the appropriate gasket size and material, and careful design of the corresponding groove.

Deflection Limits

In nearly every solid-O application, Chomerics recommends a minimum deflection of 10% of gasket diameter. This includes adjustments for all worst-case tolerances of both the gasket and groove, cover bowing, and lack of conformity between mating surfaces. We recommend a maximum gasket deflection of 25% of gasket diameter, considering all gasket and groove tolerances.

Although sometimes modified to accommodate application peculiarities, these limits have been established to allow for stress relaxation, aging, compression set, elastic limits, thermal expansion, etc.

Maximum Groove Fill

Solid elastomer gaskets (as opposed to foam elastomer gaskets) seal by changing shape to conform to mating surfaces. They cannot change volume. The recommended limit is 100% groove fill under worst-case tolerances of both gasket and groove. The largest gasket cross sectional area must fit into the smallest cross sectional groove area.

Analyzing Worst-Case Tolerances

Figures 18a-c illustrate the issues of concern, and identify the parameters which should be considered in developing an effective design.

Figures 18d and e illustrate two different cases which can result in gasket damage in the area of

torqued bolts. In Figure 18d, the relationship between groove depth and gasket diameter is critical in avoiding over-deflection. In Figure 18e, sufficient groove volume must be provided for a given gasket volume to permit the gasket to deflect without over-filling the groove.

As shown in Figure 18f, cover deformation and groove sizing must be controlled to make sure the gasket is sufficiently deflected to seal the system.

Since a single gasket and groove are employed for the entire perimeter, the design must be optimized for each of the worst-case examples illustrated in Figures 18d-f.

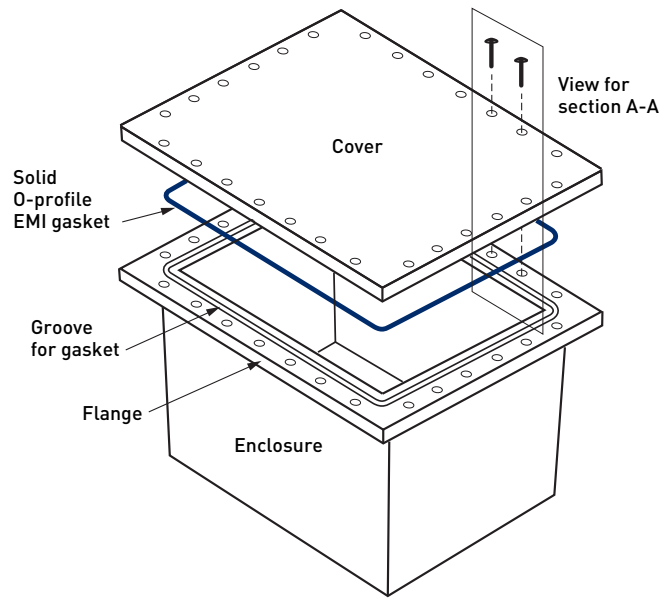


Figure 18a. Exploded View of Electronic Enclosure

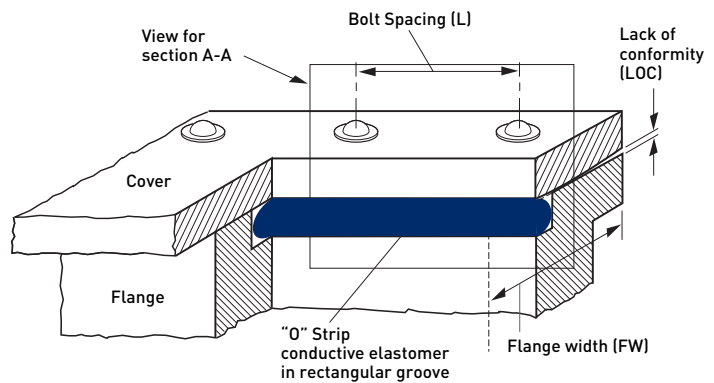


Figure 18b. Cut-away View of Assembly

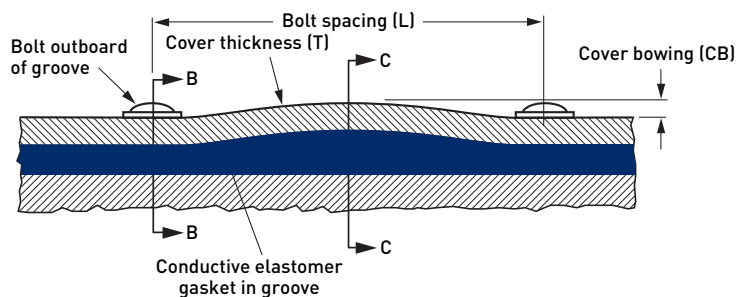
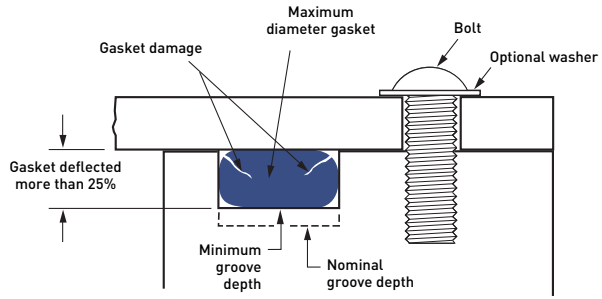


Figure 18c. Section A-A of Assembled Enclosure Flange and Gasket (Sectioned midway through gasket and groove)

Figure 18d Section B-B from Figure 18c – Worst Case Maximum Deflection (Maximum gasket diameter, minimum groove depth)

Problem: Gasket too tall for minimum groove depth (deflection beyond elastic limit). Results in gasket damage or fracture.



Solution: Over-deflection avoided with smaller maximum gasket diameter and/or deeper minimum groove depth.

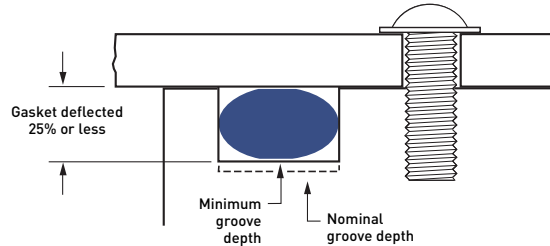
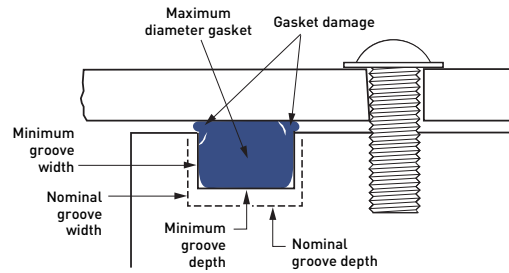


Figure 18e Section B-B from Figure 18c – Worst Case Maximum Groove Fill (Maximum gasket diameter in minimum groove depth and width)

Problem: Minimum groove dimension cannot accommodate maximum gasket diameter, resulting in gasket damage.



Solution: Groove over-fill avoided with smaller maximum gasket diameter and/or greater minimum groove depth and/or width.

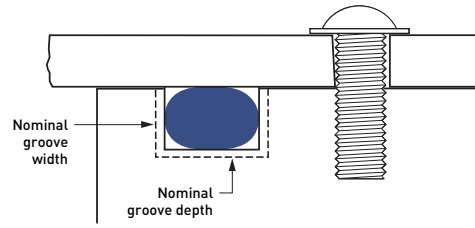
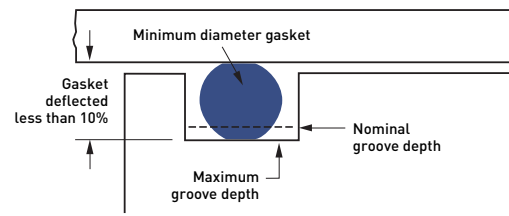
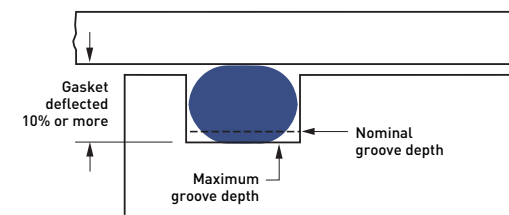


Figure 18f Section C-C from Figure 18c – Worst Case Minimum Deflection (Minimum gasket diameter in maximum depth groove, aggravated by cover bowing and lack of conformity between mating surfaces)

Problem: Gasket will not be deflected the recommended 10% minimum. Combined effects of tolerances, cover bowing, and lack of conformity can result in complete loss of cover-to-gasket contact over time, and consequent seal failure.



Solution: Under-deflection avoided with larger minimum gasket diameter and/or shallower maximum groove depth.

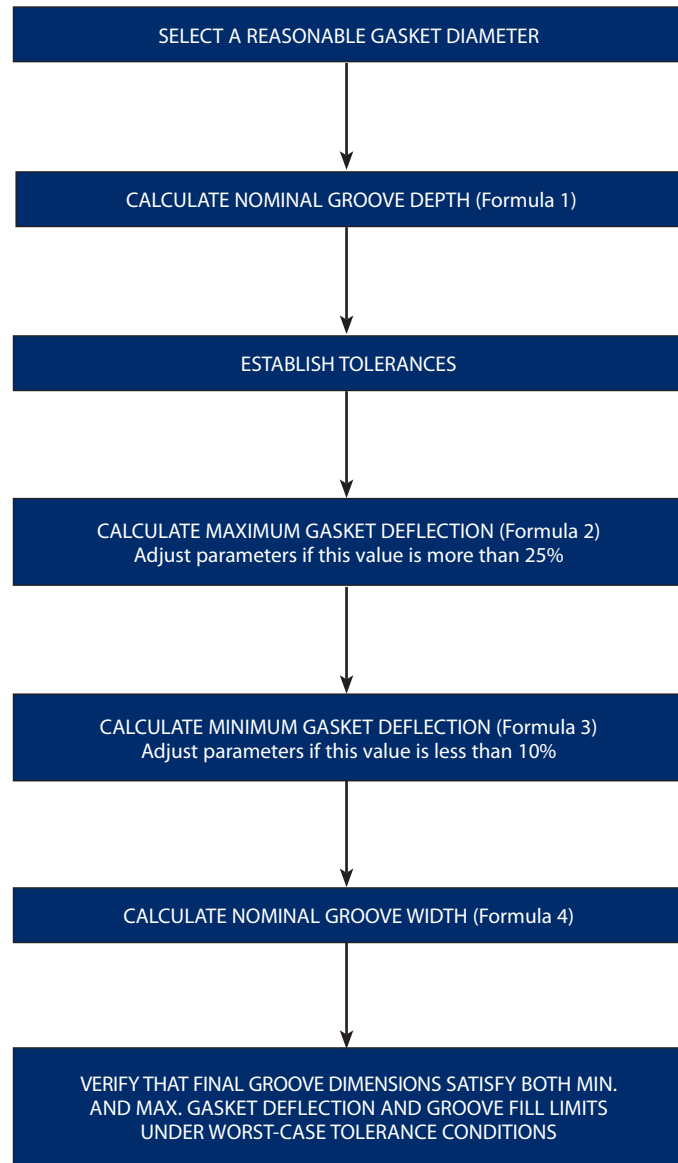


Calculating the Dimensions and Tolerances for the Groove and EMI Gasket

Figure 19 diagrams the calculation and decision sequence required to determine the dimensions for a groove system. Because the relationship between groove depth and gasket diameter is central to seal performance, groove depth is selected as the key variable to determine first.

Start by making an educated guess as to reasonable values for groove and gasket sizes and tolerances, based on desired nominal gasket deflection of 18%. For example, if 0.025 in. of gasket deflection is desired, start with a nominal gasket diameter of 0.139 in. This is calculated by dividing the desired total gasket deflection by 0.18 to estimate the required gasket size. (Total Gasket Deflection \div 0.18 = Approx. Nominal Gasket Size.) This relationship is an alternate form of Formula 1. Final groove dimensions can only be determined after completing all of the calculations called for in Figure 19, and arriving at values which remain within the recommended limits for gasket deflection and groove fill.

Figure 19. Procedure for Calculating Gasket and Groove Dimensions



Formulas (see definition of terms at right)

1. Nominal Groove Depth

$$\text{GrD}_{\text{nom}} = 0.82 \text{ GaD}_{\text{nom}}$$

2. Maximum Gasket Deflection

(Worst Case, expressed as a % of gasket diameter)

$$\text{GaDf}_{\text{max}} = 100 \left[\frac{(\text{GaD}_{\text{nom}} + \text{GaT}) - (\text{GrD}_{\text{nom}} - \text{GrDT})}{(\text{GaD}_{\text{nom}} + \text{GaT})} \right]$$

3. Minimum Gasket Deflection

(Worst Case, expressed as a % of gasket diameter)

$$\text{a. GaDf}_{\text{min}} = 10 \left[\frac{(\text{GaD}_{\text{nom}} + \text{GaT}) - (\text{GrD}_{\text{nom}} + \text{GrDT}) - \text{CB} - \text{LOC}}{(\text{GaD}_{\text{nom}} - \text{GaT})} \right]$$

where

$$\text{b. CB}_{\text{min}} = \frac{\text{GDF} \times \text{L}_{\text{max}}^4}{\text{FW}_{\text{min}} \times \text{T}^3 \times \text{E} \times 32}$$

(Note: Formula must be adjusted when using metric units)

and

c. LOC = 0.001 in. for machined surfaces with surface roughness of 32-64 μin. RMS.

(For discussion, see Terms.)

4. Nominal Groove Width

$$\text{a. GaA}_{\text{max}} = 0.7854 * (\text{GaD}_{\text{nom}} + \text{GaT})^2$$

$$\text{b. GrW}_{\text{min}} = \frac{\text{GaA}_{\text{max}}}{\text{GrD}_{\text{min}}}$$

$$\text{c. GrW}_{\text{nom}} = \text{GrW}_{\text{min}} + \text{GrWT}$$

$$*\text{Note: } 0.7854 = \frac{\pi}{4}$$

Terms

All values may be calculated in inches or mm unless otherwise indicated.

GaA_{max} – Maximum gasket cross section area (in² or mm²)

GaD_{nom} – Nominal gasket diameter

GaT – Gasket tolerance (difference between max. and nom. or min. and nom.)

GrW_{min} – Minimum groove width

GrWT – Groove width tolerance

GrW_{nom} – Nominal groove width

GrD_{min} – Minimum groove depth

GrD_{nom} – Nominal groove depth

GrDT – Groove depth tolerance (difference between max. and nom. or min. and nom.)

GaDf_{max} – Maximum gasket deflection (%)

GaDf_{min} – Minimum gasket deflection (%)

L_{max} – Maximum bolt spacing

FW_{min} – Minimum flange width

T_{min} – Minimum cover thickness

GDF – Gasket deflection force (ppi or Newtons per meter).

Note: For the purpose of this guide, the GDF value should represent the worst-case minimum gasket deflection arising from cover bowing. For example, the GDF is taken at 10% deflection for the calculation in Formula 3b.

E – Young’s modulus. (For aluminum, use 1 x 10⁷ psi, or 7 x 10⁵ kg/cm².)

CB – Cover bowing, generally calculated by modeling the elastic deformation of the cover as a uniformly loaded beam with two fixed supports. (The moment of inertia of the cover is modeled as a rectangular beam, the “height” of which is taken to be equal to the cover thickness, while “width” is considered equal to flange width. The moment of inertia can be adjusted for cover configurations other than flat. Refer to an engineering handbook for the necessary revisions to Formula 3b.) An assumption is made that one side of a cover/flange interface is infinitely stiff, typically the flange. If this is not essentially true, elastic deformation of each is computed as though the other were infinitely stiff, and the two values combined.

LOC – Lack of conformity, the measure of the mismatch between two mating surfaces when bolted together, expressed in inches. Experience has shown that machined surfaces with a surface roughness of 32-64 μin. RMS exhibit an LOC of 0.001 in. It is left to the engineer’s judgment to determine LOC for other surfaces. LOC can be determined empirically from measurements made of actual hardware. In this guide, LOC applies only to the surfaces which form the EMI shielding interface.

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dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller that is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

10. Buyer's Property: Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

11. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefor upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are

held to be taxable.

12. Indemnity For Infringement of Intellectual Property Rights: Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade secrets or similar rights except as provided in this Part 12. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it non infringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 12 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual

Property Rights. If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade secret or any similar right.

13. Export Limitations. The items sold hereunder are authorized by the U.S. government for export only to the country of ultimate destination indicated on the face hereof for use by the end-user. The items may not be transferred, transshipped on a non-continuous voyage, or otherwise be disposed of in any other country, either in their original form or after being incorporated into other end-items, without the prior written approval of the U.S. government.

14. Commercial Items. Unless otherwise indicated on the face hereof, the items being sold hereunder if sold for military or government purposes constitute Commercial Items in accordance with FAR 2.101, and as such the assertions delineated in the DFAR's 252.227-7013, 252.227-7014, 252.227-7017 and FAR 52.227-15 (c) shall not apply to this contract. Additionally, in view of the Commercial Item status, any deliverable technical data and/or computer software to be provided will contain Seller's normal commercial legend subject to the restrictions contained therein.

15. Force Majeure: Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods,

delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller's control.

16. Premier™ Conductive Plastics: Parker Chomerics™ Premier™ conductive plastics are sold under license solely for use in the following applications: (i) EMI/RFI shielding, i.e., electromagnetic and/or radio frequency interference shielding or compatibility and surface grounding therefore; (ii) earth grounding, corona shielding, and anti-static and/or electrostatic discharge protection shielding; and (iii) as thermally conductive members to dissipate heat generated by electronic devices. The resale of Premier™ conductive

plastics in pellet or any other raw material form is expressly prohibited, as is their use in any application other than as stated above, and any such resale or use by you or your customers shall render any and all warranties null and void ab initio.

You shall defend, indemnify, and hold Parker Hannifin Corporation and its subsidiaries (Parker) harmless from and against any and all costs and expenses, including attorney's fees, settlements, and any awards, damages, including attorney's fees, and costs, resulting from any claim, allegation, suit or proceeding made or brought against Parker arising from any prohibited use of Premier™ conductive

plastics by you or your customers.

17. Entire Agreement/Governing Law: The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder or this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

Parker Hannifin plc

Conditions of Sale

(Practice Note: These terms are not suitable for use in other countries unless Parker Hannifin Plc is the Seller) (as of March, 08 2005)

Goods sold under these conditions are subject to retention of title - Condition 10

1. Definitions

In these Conditions:

"the Company" means Parker Hannifin plc including all divisions and businesses thereof and any subsidiary undertaking thereof (as defined in Sections 258 and 259 Companies Act 1985 as amended);

"Conditions" means the Standard Conditions of Sale set out in this document together with any special terms agreed in writing between the Company and the Buyer;

"Contract" means any contract between the Company and the Buyer for the sale and purchase of the Goods formed in accordance with Condition 2;

"the Buyer" means any company, firm or individual or agent thereof to whom the Company's quotation or acknowledgement of order is addressed;

"the Goods" means the products (including any parts or accessories), materials and/or services to be supplied by the Company.

2. Applicability Of Conditions

The Company concludes Contracts for the supply of Goods subject only to these Conditions. The Buyer accepts that these Conditions shall govern relations between himself and the Company to the exclusion of any other terms and conditions including, without limitation, conditions and warranties written or oral express or implied even if contained in any of the Buyer's documents which purport to provide that the Buyer's own terms and conditions shall prevail. No variation or qualification of these Conditions or of any quotation or

Contract arising herefrom shall be valid unless agreed in writing by the Secretary or a Director of the Company or other person duly authorised by the Board of Directors of the Company.

3. Quotations

The Company's quotations are given without commitment and no Contract between the Company and the Buyer shall arise unless and until the Company has accepted in writing the Buyer's order placed on the Company's quotation. Quotations shall be valid for a period of 30 days from the date of issue, or (if different) the period specified with the quotation itself.

4. Representations

No employee of the Company other than the Secretary or a Director of the Company is authorised to make any statement or representations as to the Goods, save that this restriction shall not apply to any notice or statement

containing a warning or restriction of use ("Warnings") which may be provided in connection with the Goods. Subject to such Warnings, the Buyer, therefore, shall not be entitled to rely or to seek to rely upon any statement or representation made by an employee or agent of the Company other than the Secretary or a Director.

5. Prices

(i). Subject to Condition 3, prices contained in a quotation price list catalogue and similar matter shall be based upon current costs ruling at the date thereof and are for guidance only. Subject to the later provisions of this Condition 5 the contract price shall be the price current at the date of delivery of the goods and/or when services are performed as the case may be.

(ii). Where firm prices are agreed (including without limitation any quotation where the price is fixed pursuant to Condition 3) the prices will remain firm provided that full information permitting manufacture to proceed is received by the Company promptly after acknowledgement of the order by the Company, and further provided the Buyer takes delivery of the order when ready. If delivery of the order or any part thereof is delayed at the Buyer's request or through the Buyer's failure to provide the full information mentioned above, the Company reserves the right to amend the price of the undelivered portion to the Company's price list prevailing at the date when delivery is made.

(iii). Where a quotation is given dependent on information supplied by the Buyer, the Buyer will be responsible for the accuracy of the information given, and for the supply of all relevant particulars. Any increased cost incurred either during or after manufacture resulting from any inaccuracy or omission shall be borne by the Buyer alone and shall be paid promptly, and independently of the main contract price.

(iv). Unless otherwise stated prices do not include VAT which will be chargeable at the date of despatch and/or performance of services as the case may be.

6. Despatch And Delivery

(i). Delivery shall be deemed to occur and the risk of loss or damage of any kind in the Goods shall pass to the Buyer on whichever of the following events occur earlier.

(a) collection by or on behalf of the Buyer or by a carrier for despatch to the Buyer (whether or not such carrier be the Company's agent or servant)

(b) 14 days from the date of notice given by the Company that the Goods are ready for collection or despatch.

(ii). In the event that the Company shall at the specific request of the Buyer store the Goods or arrange for the Goods to be despatched or dealt with otherwise than by collection by the Buyer then the Buyer shall pay to the Company any reasonable charges made in the Company's absolute discretion for the provision or procurement of such services. Any such services provided by the Company shall be performed subject to these Conditions. In the event that such services are to be provided by a carrier or other third party then the Company shall in arranging for the provision of the same act only as the agent of the Buyer and the Buyer shall indemnify the Company against any cost, charge liability or expense (including demurrage) thereby incurred by the Company.

(iii). The Buyer shall carefully examine the Goods on receipt of the same and shall by written notice to be received by the Company within 21 days of receipt of the Goods notify the Company of any short delivery, over delivery or any defects reasonably discoverable on careful examination. In the absence of receipt of such notice, then subject only to Condition 11, the Company shall be discharged from all liability

in respect of such defects or short or over delivery.

(iv). If the Buyer neglects to serve notice under sub Condition (iii) above of any over delivery then the Company may at its option either repossess the excess Goods or invoice them and be paid forthwith by the Buyer for the excess Goods at the price ruling at the date of delivery.

7. Time For And Form Of Delivery

(i). The Company will use reasonable commercial endeavours to deliver the Goods and to perform services in accordance with any time stated in the contract but time of delivery or performance shall not be of the essence to the contract. Any such times are stated by way of general information only and in the event of failure to despatch or deliver or perform within such times for any cause (whether within or) outside the Company's reasonable control, the same shall not be a breach or repudiation of the contract nor shall the Company have any liability to the Buyer for any direct, indirect or consequential loss (all three of which terms include without limitation pure economic loss, loss of profits, loss of business, depletion of goodwill and like loss) however caused (including as a result of negligence) by delay or failure in delivery except as set out in this Condition 7(i). Any delay or failure in delivery will not entitle the Buyer to cancel the order unless and until the Buyer has given 60 days' written notice to the Company requiring delivery to be made and the Company has not fulfilled delivery within that time. If the Buyer then cancels the order:

(a) the Company will refund the Buyer any sums the Buyer has paid to the Company in respect of that cancelled order; and

(b) the Buyer will be under no liability to make any payments in respect of that cancelled order.

(ii). (a) If the Contract does not otherwise provide the Company shall be entitled to deliver Goods by

single delivery or by instalments at its option.

(b) If the Contract provides for delivery by instalments or the Company so elects each instalment shall be deemed to be the subject of a separate contract on these conditions and without prejudice to sub-paragraph (i) hereof non-delivery or delay in delivery shall not affect the balance of the contract nor entitle the Buyer to terminate the same.

(iii). In the event that the Goods shall not have been collected by or on behalf of the Buyer or by a carrier for despatch to the Buyer within 14 days of the Company's written notice pursuant to Condition 6 (i) (b) hereof then the Company may at any time thereafter send to the Buyer a further notice notifying the Buyer of the Company's intention to sell the same after the expiration of a period of not less than 7 days from the date of the notice and any such sale by the Company may be on a forced sale basis. The Buyer shall be liable for the Company's charges and expenses for the sale and for the storage of the Goods (which shall be at the risk of the Buyer) pending their sale hereunder or delivery to the Buyer. The Company shall charge all costs incurred on a weekly basis for storage.

8. Performance Prevented Or Hindered

The Company shall not be liable for any delay of failure in carrying out its obligations which is caused wholly or partly by reason of act of God, delay in transportation, labour disputes, fire, flood, war, accident, Government action, inability to obtain adequate labour, materials, manufacturing facilities or energy, or any other cause beyond the Company's control or that of its servants or agents, and if the delay or failure has continued for a period of 3 months then either party may give notice in writing to the other determining the contract and on

such termination the Company shall refund to the Buyer the price of the Goods or any part thereof already paid to the Company after deduction of any amount due to the Company including any amount under Condition 17 hereof.

9. Payment

(i). Unless expressly agreed in writing payment shall be made in sterling in cleared funds without any deduction set-off, restriction condition or deferment on account of any disputes or cross claims or present or future taxes, levies, duties or charges whatsoever (unless and to the extent the Buyer is required by law to make such deduction) on or before the last day of the month following the month of the invoice for the Goods. Where full payment is not received by the due date interest shall accrue on the sum outstanding at the rate of 3% per annum above the base rate of Lloyds Bank plc (as varied from time to time) calculated on a daily basis but without prejudice to the Company's rights to receive payments on the due dates.

(ii). Time for payment shall be of the essence and in the event of delay or default in any payment for more than 7 days, the Company shall be entitled to suspend deliveries of Goods (being those Goods the subject of the default and any other Goods the subject of any agreed order) and/or treat the Contract (and any other Contract between the Company and the Buyer) as repudiated and/or re sell any of the Goods in its possession and be indemnified by the Buyer for any loss thereby incurred.

(iii). All sums payable to the Company under the Contract will become due immediately on termination of the Contract.

(iv). The Buyer shall pay for any samples, sale or return, loan or demonstration goods and/or materials, including drawings, plans, specifications etc. not returned within one month from the

date of receipt by the Buyer unless a different period for the return of such goods and/or materials is agreed between the Company and the Buyer.

10. Property In Goods

(i) The Company shall retain absolute ownership of the property in the Goods which shall not pass to the Buyer and the Buyer shall keep and retain the Goods as bailee for and on behalf of the Company and shall deliver up the Goods to the Company at the Company's request until the Company has received full payment of the price of the Goods and full payment of any other sums whatsoever which are outstanding from the Buyer to the Company whether or not due and owing, and until such time the Buyer:

(a) shall insure the Goods against the usual risks with an insurance office of repute;

(b) shall store separately the Goods or in some other way ensure that the Goods are readily identifiable as the property of the Company;

(c) irrevocably authorises the representatives of the Company at any time in circumstances where the provisions of Condition 19 may apply to enter the Buyer's premises where the Goods are or are thought by the Company to be stored for the purpose of repossessing the Goods;

(d) shall keep and retain the Goods free from any charge lien or other encumbrance thereon.

(ii). Provided always that no circumstances have arisen where the provisions of Condition 17 may apply the Buyer shall be entitled to offer for sale and sell the Goods in the ordinary course of business as principal and not as agent at the best obtainable price, and shall be a sale of the Company's property on the Buyer's own behalf and the Buyer will deal as principal in respect of such sale. Notwithstanding the other provisions of the Contract, payment shall become due (unless payment

has already become due or been paid) when the Buyer receives payment upon its own sale of the Goods (or other items incorporating the Goods).

(iii). If the Buyer incorporates any Goods within other equipment or products provided that the Goods remain readily identifiable and a removable part of such other equipment or products the provisions of Condition 10(i) shall apply.

(iv). If the provisions of Condition 10(iii) apply the Buyer shall store separately the other equipment or products incorporating the Goods and shall notify the Company of the precise location and position thereof. The provisions of Condition 10(ii) hereof shall apply mutatis mutandis in respect of the Goods contained within such other equipment or products owned by the Company.

(v). The Company shall be entitled to exercise a general lien or right of retention on all goods or any parts thereof in the Company's possession which are the Buyer's property for any sums whatsoever due to the Company and pursuant to such lien or right the Company shall be entitled without notice to the Buyer to sell all or any part of such Goods or part thereof privately or by auction or otherwise and to keep the proceeds of sale in diminution of such sums and of all costs and expenses incurred by the Company in effecting the said sales.

11. Warranty And Limitation Of Liability

(i). The Company warrants that products, parts or materials manufactured by it will be of good materials and workmanship and that reasonable care will be employed in assembling or incorporating items not manufactured by it and in performing services so that upon the Buyer giving written notice to the Company that Goods have not been supplied or services performed as aforesaid if the same

be established the Company will at its own expense at its option replace or repair such defective goods or remedy such defaults in service. The warranty obligation shall not apply where the Goods have been tampered with, improperly altered, repaired or maintained, installed or connected or subject to misuse (in each case other than as a result of the Company's own acts or omissions). The Buyer shall at its own cost return the Goods to the Company for inspection.

(ii). The same term shall apply mutatis mutandis in respect of such replacement, repair or remedial services.

(iii). The above warranty shall apply in respect of matters whereof the Buyer gives written notice within 12 months of delivery or 6 months from installation (whichever is the shorter period) or within 12 months of performance or of replacement repair or remedial services respectively after which any claim in respect thereof shall be absolutely barred (subject to the other provisions of this Condition 11).

(iv). The Company does not exclude its liability (if any) to the Buyer:

(a) for breach of the Company's obligations arising under Section 12 Sale of Goods Act 1979 or Section 2 Supply of Goods and Services Act 1982;

(b) for personal injury or death resulting from the Company's negligence;

(c) under section 2(3) Consumer Protection Act 1987;

(d) for any matter which it would be illegal for the Company to exclude or to attempt to exclude its liability; or

(e) for fraud.

(v). Except as provided in Conditions 7(i) and 11(i) to (iv), the Company will be under no liability to the Buyer whatsoever (whether in contract, tort (including negligence), breach of statutory duty, restitution or otherwise) for any injury, death, damage or direct, indirect

or consequential loss (all three of which terms include, without limitation, pure economic loss, loss of profits, loss of business, depletion of goodwill and like loss) howsoever caused arising out of or in connection with:

(a) any of the Goods, or the manufacture or sale or supply, or failure or delay in supply, of the Goods or performance or failure or delay in performance of services by the Company or on the part of the Company's employees, agents or sub-contractors;

(b) any breach by the Company of any of the express or implied terms of the Contract;

(c) any use made or resale by the Buyer of any of the Goods, or of any product incorporating any of the Goods;

(d) any statement made or not made, or advice given or not given, by or on behalf of the Company.

(vi). Except as set out in Conditions 7(i) and 11(i) to (iv), the Company excludes to the fullest extent permissible by law all conditions, warranties and stipulations, express (other than those set out in the Contract) or implied, statutory, customary or otherwise which, but for such exclusion, would or might subsist in favour of the Buyer.

(vii) Each of the Company's employees, agents and subcontractors may rely upon and enforce the exclusions and restrictions of liability in Conditions 7(i) and 11(iv) to (vi) in that person's own name and for that person's own benefit as if the words "its employees, agents and subcontractors" followed "Company" where it appears in those Conditions (save for Condition 11(v)(a)).

(viii). Without prejudice to the foregoing if called upon so to do by the Buyer in writing the Company shall use its best endeavours to assign to the Buyer the benefits of any warranty, guarantee, indemnity, claim, privilege or other rights which the Company may

have in regard to manufacturers or suppliers of any goods not manufactured by the Company in relation to the quality, condition or description of such goods.

12. Operating Instructions

(i) The Company supplies with the Goods adequate information as to their design and conditions of the instructions for operation for compliance with its obligations under Section 6 (1) (c) of the Health and Safety at Work Act 1974.

(ii) The Buyer undertakes that all necessary steps will be taken to ensure that the Goods will be safe and without risk to health when properly used in accordance with Section 6 (8) of the Health and Safety at Work etc. Act 1974.

13. Drawings, Specifications Etc.

(i) All descriptions, drawings, illustrations, particulars of weights and measures rating standard statements or details or specifications or other descriptive matter, whether or not contained in the contract document, are approximate only. The Goods will be in accordance with the Company's specifications at the time of manufacture and any earlier specifications drawings, descriptions, illustrations, particulars as to weights and measures rating standard statements or details shall not form part of the description of the parts or services supplied or to be supplied so that the Company shall not be under any liability in respect thereof.

(ii) Where Goods are supplied by the Company to the Buyer in accordance with the Buyer's design or specification or where the Company shall design items not within the standard range of products at the Buyer's request no warranty is given or implied as to the suitability of such goods or items unless the Buyer has made the Company aware of the

particular purpose for which the Buyer is proposing to use the goods or items in which case Condition 11 shall apply. The Company shall be entitled to charge a fee for any research or design undertaken in connection with the supply of Goods not within their standard range of products.

14. Inspection And Testing

The Company undertakes inspection of all Goods prior to delivery and where practicable submits to standard tests at the Company's premises Special tests or standard tests in the presence of the Buyer or his representative may be undertaken by the Company at the request and expense of the Buyer but unless otherwise agreed such tests shall be conducted at the Company's premises.

15. Industrial Property Rights

(i) All intellectual property rights subsisting in or relating to any calculations, data, specifications, designs, drawings, papers, documents, procedures, techniques, acceptance, maintenance and other tests special and recommended parts and other equipment and any other material and information whatsoever given to the Buyer by the Company in connection with the supply of the Goods by the Company to the Buyer or otherwise are vested in the Company. The Buyer will not whether by itself its officers servants agents or any of them or otherwise howsoever copy or reproduce any such items or material in whole or in part nor will it disclose any such information in whole or in part to any third party. Further the Company shall be entitled to the ownership of all intellectual property rights subsisting in or relating to any calculations, data, specifications, designs, drawings, papers, documents or other items material or information conceived originated developed or produced by the Company for the Buyer pursuant to

the contract for the supply of Goods.

(ii) The Buyer shall not at any time for any reason whatsoever disclose or permit to be disclosed to any person or persons whatsoever or otherwise make use of or permit to be made use of any trade secrets or other confidential information relating to the equipment technology business affairs or finances of the Company or any associated Company or organisation of the Company or relating to the Company's agents distributors licensees or other customers or in respect of any of their dealings or transactions.

(iii) The Buyer shall not seek to apply or apply to register in its own name any of the Company's intellectual property rights and in particular those subsisting in or relating to the Goods or a part thereof nor shall it represent in any way that it has any right or title to the ownership of any such intellectual property rights nor shall it do any act or thing which might be contrary to the interest or rights of the Company in such rights and in particular challenge the ownership or validity of such rights.

(iv) The Buyer at its own expense shall do all such acts and things and shall sign and execute all such deeds and documents as the Company in its sole discretion may require in connection with any steps or proceedings taken by the Company to restrain the infringement of its intellectual property rights.

(v) The Buyer undertakes and agrees that the use of any of its calculations, data, specifications, designs, drawings, papers, documents, procedures, techniques, acceptance, maintenance and other tests special and recommended parts and other equipment and other material and information by the company when manufacturing and supplying the Goods will not infringe any intellectual property

rights of a third party and shall indemnify the Company in respect of any such infringement.

(vi) The Buyer shall not alter or remove any trade mark of the Company which has been applied to the Goods nor apply any other trade mark to the Goods nor make any alteration to their packaging and get up.

(vii) The provisions of this Condition 15 shall survive the expiry or termination of any Contract for whatever reason.

16. Sub Contracting

The Company shall be entitled to sub contract all or any of its obligations hereunder.

17. Determination

If the Buyer shall make default in or commit a breach of the contract or of any of his obligations to the Company or if any distress or execution shall be levied upon the Buyer's property or assets, or if the Buyer shall make or offer to make any arrangement or composition with creditors or commit any act of bankruptcy, or if any petition or receiving order in bankruptcy shall be presented or made against him, or if the Buyer is a limited company and any resolution or petition to wind up such company's business (other than for the purpose of a solvent amalgamation or reconstruction) shall be passed or presented, or if a receiver of such company's undertaking property or

assets or any part thereof shall be appointed the Company shall have the right forthwith to determine any Contract then subsisting and upon written notice of such determination being given to the Buyer any subsisting Contracts shall be deemed to have been determined and the Company shall be entitled to recover from the Buyer all losses thereby arising including but not limited to those under Condition 18 of these Conditions or otherwise.

18. Partial Completion

In the case of partial completion of an order by reason of any of the events referred to in Conditions 8 or 17 the Company shall be entitled to a quantum meruit in respect of all work done by it including labour costs and materials and any charges or expenses which the Company is committed to pay sub contractors or third parties without prejudice to its rights should non completion be occasioned by the Buyer.

19. Notices

Unless otherwise provided in writing any written communication or notice under the Contract shall be made or given by sending the same by ordinary prepaid first class letter post in the case of the Company to its current address and in the case of the Buyer to its last known address and if so sent shall be deemed to be made or given two days after the date when posted.

20. Waiver

Any failure by the Company to enforce any or all these Conditions shall not be construed as a waiver of any of the Company's rights.

21. Contracts (Rights Of Third Parties) Act

The parties to the Contract do not intend that any of its terms will be enforceable by virtue of the Contracts (Rights of Third Parties) Act 1999 by any person not a party to it.

22. Law And Interpretation

The Contract shall be governed by English law and the Buyer shall submit to the non exclusive jurisdiction of the English Courts. If any of these Conditions or any part thereof is rendered void or unenforceable by any legislation to which it is subject or by any rule of law it shall be void or unenforceable to that extent and no further.

Parker Chomerics Capabilities include:

THERMAL MANAGEMENT & CONTROL

- Thermally conductive gap filler pads
- Fully cured dispensable thermal gels
- Silicone-free thermal pads
- Phase-change materials (PCM)
- Polymer solder hybrids (PSH)
- Dispensable thermal compounds
- Thermal grease
- Insulator pads
- Thin flexible heat spreaders
- Custom integrated thermal/EMI assemblies
- RF absorbing gap filler pads

EMI SHIELDING & COMPLIANCE

- Conductive elastomers – molded, extruded, and form-in-place (FIP)
- Conductive foam based gaskets – fabric-over-foam and z-axis foam
- Conductive compounds – adhesives, sealants and caulks
- RF absorbing materials
- EMI shielding plastics and injection molding services
- Coatings – direct metallization and conductive paints
- Metal gaskets – Springfingers, metal mesh and combination gaskets
- Foil laminates and conductive tapes
- EMI shielding vents – commercial and military honeycomb vents
- Shielded optical windows
- Cable shielding – ferrites and heat-shrink tubing/wire mesh tape/zippered cable shielding
- Compliance and safety test services

OPTICAL DISPLAY PRODUCTS

- EMI shielding filters (conductive coating & wire mesh)
- Ant-reflective/contrast enhancement filters
- Plastic or glass laminations
- Hard coated lens protectors
- Touchscreen lenses

PLASTIC INJECTION MOLDING

- PREMIER® and other filled, electrically-conductive plastics
- Traditional thermoplastics
- EMI and cosmetic coating services
- EMI and environmental gasket integration
- Assembly, pad printing, hot stamping, welding, and heat staking
- Insert molding, two-shot molding, and overmolding capability

About Parker Hannifin Corporation

With annual sales exceeding \$10 billion, Parker Hannifin is the world's leading diversified manufacturer of motion and control technologies and systems, providing precision-engineered solutions for a wide variety of mobile, industrial and aerospace markets. The company's products are vital to virtually everything that moves or requires control, including the manufacture and processing of raw materials, durable goods, infrastructure development and all forms of transport. Traded on the New York Stock Exchange under the symbol "PH," Parker is strategically diversified, value-driven and well positioned for global growth as the industry consolidator and supplier of choice.

Chomerics Worldwide

Corporate Facilities

To Place an Order Please Contact a Customer Service Representative at the Following Locations

North America

Division Headquarters

Woburn, MA

Phone +1 781-935-4850

Fax +781-933-4318

chomailbox@parker.com

Europe

High Wycombe, UK

Phone +44 1494 455400

Fax +44 14944 55466

chomerics_europe@parker.com

Asia Pacific

Hong Kong

Phone +852 2428 8008

Fax +852 2786 3446

chomerics_ap@parker.com

Cranford, NJ

Phone +1 908-272-5500

Fax + 1 908-272-2741

Saint Ouen l'Aumône, France

Phone +33 1343 23900

Fax +33 1343 25800

Manufacturing Facilities

Woburn, MA; Cranford, NJ ; Millville, NJ; Fairport, NY; Grantham, UK, Beijing; Shanghai; Shenzhen; Tokyo, Japan.

Additional Facilities:

Hudson, NH; Guadalajara & Monterrey, Mexico; Oulu, Finland; Sadska, Czech Republic; Tianjin, China; Chennai, India.

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