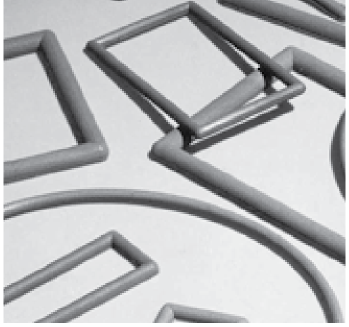

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Extruded EMI Gaskets

Products & Custom Solutions Catalog

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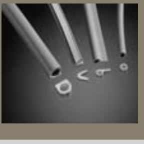
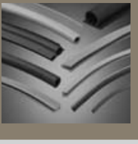
Extruded EMI Gaskets

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/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.

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, Chomerics' conductive elastomer extrusions have also become the progressive choice for packaging designers of consumer, telecommunications, business and 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, with modest tooling costs and short lead times for either prototypes or large orders. Chomerics can take a customer-supplied design and deliver extruded parts typically in just a few weeks. Chomerics offers hundreds of standard extrusions. Extrusions are also readily lathe-cut into washers, spliced, bonded, kiss-cut, or even die-cut to reduce the installation labor and conserve material, providing a cost-effective alternative to other methods of EMI shielding and environmental sealing.

Attachment methods range from friction-fit strategies to pressure-sensitive adhesive (PSA), and include clip-mount options.

CHO-SEAL® & CHO-SIL® CONDUCTIVE ELASTOMERS

Since 1961, Chomerics has invented and extended virtually every aspect of conductive elastomer materials technology – from the earliest silver- and silver/copper-filled silicones to the latest and more cost-effective silver/aluminum and nickel/graphite composites. Today we offer the most comprehensive selection and highest quality products available anywhere.

Each conductive elastomer consists of silicone, fluorosilicone or EPDM binder with a filler of pure silver, silver-plated copper, silver-plated nickel, silver-plated aluminum, silver-plated glass, nickel-plated graphite or conductive 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 polymeric binders produces materials with stable and consistent electrical and physical properties.

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 will provide an environmental or pressure seal, if required.

Our Applications Engineering Department is ready to assist with material selection and gasket design. We welcome your inquiry!

MATERIAL SELECTION

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 performance required. Price varies directly with shielding performance.

In general, certain types of Chomerics' 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 product selection.

For military/aerospace applications, we recommend that users of conductive elastomer gaskets specify that materials meet the requirements of MIL-DTL-83528 (formerly MIL-G-83528) and be procured from 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.

Commercial Materials:
CHO-SEAL 1273, CHO-SEAL S6305, CHO-SEAL 6370**, CHO-SEAL 6315, CHO-SEAL 6372**, CHO-SEAL 6308, CHO-SEAL L6303, CHO-SEAL 1285, CHO-SEAL 1350.

General Military/Aerospace Materials:
CHO-SEAL 1298*, CHO-SEAL 1215, CHO-SEAL 1217*, CHO-SEAL 1285, CHO-SEAL 1287*.

Specialty Materials:
CHO-SIL 1401, CHO-SEAL 6436, CHO-SEAL 860/862.

Corrosion-Sensitive Military/ Aerospace Materials:
CHO-SEAL 1298*, CHO-SEAL 1285, CHO-SEAL 1287*.

* Fluorosilicone; ** Flame-retardant version

Specific material properties are listed in Table 7: Material Guidelines, pages 15-18.

Table 1: General Material Applications

Elastomers for Typical Commercial Applications			
Material	Filler/Binder	Typical Equipment Shielding Requirements	Remarks
CHO-SEAL 1273	Silver-plated copper in silicone	100 dB	Material of choice for high-end indoor (non-corrosive) commercial applications requiring up to 100dB of shielding, can be produced in thin-wall extrusions to decrease the compression force required.
CHO-SEAL 1285 CHO-SEAL 1287	Silver-plated aluminum in silicone in fluorosilicone	95 – 100 dB	Material of choice in high end corrosive environments where corrosion and shielding of 95 -100 dB is required. Higher corrosion resistance than nickel graphite.
CHO-SEAL S6305, 6370, 6315, 6372, 6308 CHO-SEAL L6303	Nickel-clad graphite in silicone in fluorosilicone	80 – 100 dB	Best material for commercial applications requiring good performance in moderately corrosive environments; material of choice for flange finishes due to the hardness of the particles to penetrate through finishes to achieve good electrical contact. CHO-SEAL 6370 is UL94 V-0 rated. CHO-SEAL 6372 is 94 V-1 rated. CHO-SEAL 6315 and CHO-SEAL 6372 are cost effective alternatives to CHO-SEAL 6370 and CHO-SEAL S6305. CHO-SEAL 6308 has the ability to be produced in 0.012 inch (0.30 mm) wall thickness allowing designers to address mechanical design situations which demand small cross section gaskets.
CHO-SEAL 1350	Silver-plated glass in silicone	80 – 100 dB	Effective material for grounding applications where DC volume resistivity or moderate shielding is required.
Elastomers for Typical Military/Aerospace Applications			
Material	Filler/Binder	Typical Equipment Shielding Requirements	Remarks
CHO-SEAL 1298	Silver-plated aluminum in fluorosilicone	90 – 110 dB	High performance in harshest corrosive environments; material of choice for aircraft and marine military applications; good physical properties.
CHO-SEAL 1215 CHO-SEAL 1217	Silver-plated copper in silicone in fluorosilicone	105 - 120dB	Resists highest level of EMP induced current; military gasket of choice in non-corrosive environment; excellent processing for extrusions; 1215 preferred for thin-walled cross-sections.
CHO-SEAL 1285 CHO-SEAL 1287	Silver-plated aluminum in silicone in fluorosilicone	95 – 100 dB	Military gasket of choice for corrosive environments where the high performance of CHO-SEAL 1298 is not required but greater corrosion resistance than nickel graphite is required.

Table 1 (cont.)

Specialty Elastomers			
Material	Filler/Binder	Equipment Shielding Requirements	Remarks
CHO-SIL 1401	Silver in reticulate silicone	80 – 100 dB	High performance for non-corrosive environments; soft (45 Shore A) for low closure force where gasket shape cannot be used; low tear strength; no fluid resistance.
CHO-SEAL 6436	Silver plated nickel in EPDM	90 dB	Material of choice for high shielding where NBC fluid resistance is needed; moderate performance in corrosive environments.
CHO-SEAL 860/862	Conductive graphite in silicone	30 – 65 dB	Low-end shielding or ESD protection; no corrosion or fluid resistance. 862 is available in UL94 V-0.

ADDITIONAL INFORMATION ON CHO-SEAL 1298 CORROSION-RESISTANT EMI SHIELDING GASKET

CHO-SEAL 1298 elastomer incorporates unique particle plating and elastomer technology for increased corrosion resistance. When used in conjunction with the CHO-SHIELD® 2000 series of corrosion resistant conductive coatings on aluminum flanges, a corrosion-resistant EMI flange system is obtained.

CHO-SEAL 1298 gasket material is based upon a silver-plated aluminum filler dispersed in a fluorosilicone binder, with corrosion inhibiting additives that contain no chromates. It offers shielding effectiveness of 100 dB at 500 MHz and meets all requirements of MIL-DTL-83528 Type D. CHO-SEAL 1298 gasket material also has excellent resistance to fluids and fuels commonly used in aviation and industrial applications.

CORROSION RESISTANCE TESTING

Chomerics has completed extensive corrosion resistance testing on CHO-SEAL 1298 gasket material using a gravimetric weight loss procedure. A copy of the test method (CHO-TM 100) is available on request from Chomerics. Contact Chomerics' Applications Engineering Department for further information.

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.

ADDITIONAL INFORMATION ON CHO-SEAL 6370

Chomerics introduced the first conductive elastomer with a UL94 V-0 rating (UL file number 96ME 17043) with allowable thicknesses down to 0.014 inch (0.356 mm). This fully extrudable material is a corrosion-resistant nickel-clad graphite filled composite with shielding effectiveness equivalent to or better than other commercial grade gaskets: 95 dB from 50 MHz to 10 GHz.

CHO-SEAL 6372 is available with a UL 94 V-1 rating.

Table 2: Elastomers-Galvanic Compatibility

Elastomers-Galvanic Compatibility				
	Elastomer Filler Type			
Substrate	Nickel Graphite	Silver Aluminum	Silver Copper	Nickel
Aluminum Alloys: 6061-T6*	2	1	3	2
Aluminum Alloys: 6061-T6 (unplated)	2	1 to 2	3	N/A
Chromium Plating	1	1	1	N/A
Gold Plating	1	1	1	N/A
Magnesium	3	3	3	N/A
Nickel Plating**	1	2	2	1
Silver Plating	1	1	1	N/A
Stainless Steel: 304SS, 316SS	1	1	1	N/A
Tin Plating	1	2	3	N/A
Zinc-plated Galvanized Steel	2	2	3	N/A

Legend: 1 = Good 2 = Satisfactory 3 = Not Recommended

NOTE: All recommended compounds are suggested only. Customer should always test any seal material under actual operating conditions.

* Chromate conversion coating per MIL-DTL-5541F, Type I, Class 3

**Nickel plating per MIL-C-26074E, Class 1, Grade B (0.0015in. thick).

FLUID RESISTANCE – COMMON FLUIDS

Table 3 lists 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.

FLUID RESISTANCE – HARSH ENVIRONMENTS

Table 4 lists the qualitative assessment of fluid resistance by material type. The customer is encouraged to evaluate specific materials to the requirements called for by the application.

DUAL FUNCTIONALITY GASKETS, "CO-EXTRUSIONS"

Co-extruded gaskets (dual gaskets with a conductive and non-conductive element cured in parallel) provide additional environmental sealing and corrosion protection. Seam vulcanization ensures long term integrity and stability.

Co-extruded gaskets permit cost-effective use of existing flange designs, as well as attachment under the less-expensive, non-conductive material. Compared to bonding and mounting separate gaskets, or double-groove designs, Co-extruded gaskets offer design, cost and handling advantages. See case example at the end of the Performance Data section.

STANDARD TOLERANCES For Cross Sectional Dimensions, inch (mm)

- Less than 0.200 (5.08):
  ± 0.005 (0.13)
- 0.200 – 0.349 (5.08 – 8.86):
  ± 0.008 (0.20)
- 0.350 – 0.500 (8.89 – 12.70):
  ± 0.010 (0.25)
- Greater than 0.500 (12.70):
  ± 3% of the nominal dimension

NOTE: Tighter tolerances are available upon request.

Table 3: Exposure of CHO-SEAL® S6305 to Common Fluids

Exposure of CHO-SEAL® S6305 to Common Fluids				
		No Exposure	After Exposure	% Change
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 %
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	4 %
Tap Water	Tensile [psi]	203	199	-2 %
	Elongation [%]	414	439	6 %
Windshield Washer Solvent	Tensile [psi]	203	207	2 %
	Elongation [%]	414	418	1 %

Table 4: Elastomer Fluid Resistance

Elastomer Fluid Resistance			
Resistances	Polymer Choice		
	Silicone	Fluorosilicone	EPDM
High Temp	Excellent	Good	Fair
Low Temp	Excellent	Excellent	Excellent
ASTM 1 Oil	Fair/Good	Good	Poor
Hydraulic Fluids (Organics)	Fair	Good	Poor
Hydraulic Fluids (Phosphate Ester)	Poor	Good	Poor
Hydrocarbon Fuels	Poor	Good	Excellent
Hydrocarbon Fuels	Poor	Good	Excellent
Comp. Set	Good	Good	Good
Ozone, Weather	Poor	Poor	Good
STB (NBC Decontamination Fluid)	Poor	Fair/Good	Good
Dilute Acids	Fair	Good	Good
NOTE: All recommended compounds are suggested only. Customer should always test any seal material under actual operating conditions.			

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 2.00 inch (51 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 don't 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 29 of this guide, illustrates the variety and complexity that can be incorporated into extruded elastomers.

FINITE ELEMENTAL ANALYSIS – A POWERFUL DESIGN TOOL

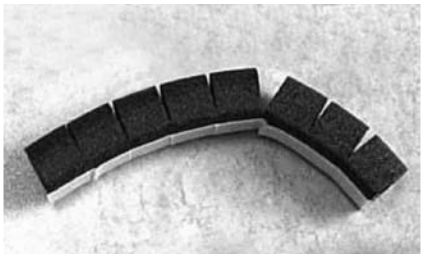
Chomerics offers sophisticated FEA technology to prevent false starts, design delays and repetitive prototyping for unusual shielding requirements. Advanced computer simulation software is employed to predict gasket behavior, bypassing trial-and-error testing. FEA not only predicts how a design will 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 and CHO-SIL 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 6*.

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): ± 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.

Product Forms

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.

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. For use with retention grooves, refer to Table 6 for recommended inside corner radii.

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 2 inches (51 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 5 below. The acrylic pressure-sensitive adhesive does not appreciably affect the through-flange resistance of the EMI gasket. 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)
- 0.100 (2.54)
- 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 5: PSA, Typical Properties

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).

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)

Scotch-Brite is a trademark of 3M.

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. Note: 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 that 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 water or alcohol containing mild soap. Do not use aromatic or chlorinated solvents.

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 or special package are generally denoted by -40 or -30 suffix, respectively.

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 below must be modified to designate the PSA tape requirement. 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: ☐ – ☐ – ☐ – ☐

10 = Extrusion type
19 = Extrusion type

Shape
04 = Round
05 = D-shaped
06 = P-shaped
07 = Rectangular
08 = U-Channel
09 = Custom

Optional
18 = Co-extrusion
20 = PSA tape applied
22 = Die Cut
23 = Kiss cut
24 = 4-Corner spliced

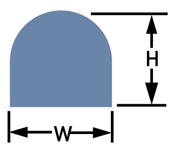
YYYY = Cross section serial number (i.e., 1687)

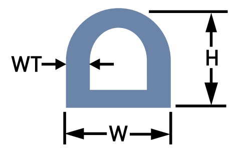
ZZZZ = Material Type (i.e., 1215)

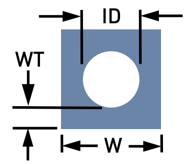
Refer to pg 15-17

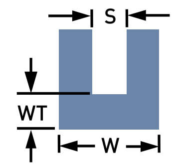
Table 6: Dimensional Guidelines

EXTRUSION PROFILE MINIMUM DIMENSIONAL GUIDELINES
Minimum dimensions suggested for manufacturing stability







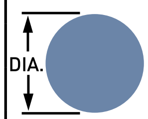
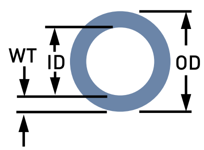
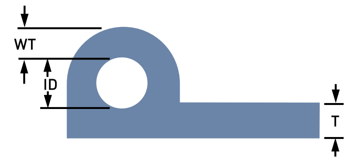
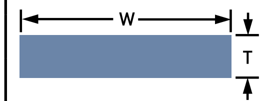


	SOLID D				HOLLOW D						HOLLOW RECT.				CHANNEL			
Min. Radii:**	1.5 x W				2.0 x W						2.0 x W				1.5 x W			
Units:	mm		inch		mm			inch			mm		inch		mm		inch	
	H	W	H	W	WT	H	W	WT	H	W	ID	WT	ID	WT	WT	S	WT	S
1215	0.889	0.889	0.035	0.035	0.413	0.290	0.290	0.017	0.114	0.114	0.508	0.635	0.020	0.025	0.508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

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.
**Typical Minimum Inside Corner Radii
*** Uniform wall thickness is ideal for manufacturability

Legend:
ID - Inside Diameter
W - Width
WT - Wall Thickness
S - Slot Width

Table 6: Dimensional Guidelines, (Cont.)

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

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 thickness is idea for manufacturability

***Typical Minimum Inside Corner Radii

Legend:
ID - Inside Diameter
T - Thickness
W - Width
WT - Wall Thickness

Table 7: Material Guidelines

	CONDUCTIVE EXTRUDED ELASTOMER SPECIFICATIONS						
		Test Procedure (Type of Test)	CHO-SEAL 1215	CHO-SEAL 1217	CHO-SEAL 1285	CHO-SEAL 1287	CHO-SEAL 1298
Physical	Conductive Filler	–	Ag/Cu	Ag/Cu	Ag/Al	Ag/Al	Passivated Ag/Al
	Elastomer Binder	–	Silicone	Fluoro-Silicone	Silicone	Fluoro-Silicone	Fluoro-Silicone
	Type (Ref. MIL-DTL-83528)	–	Type A	Type C	Type B	Type D	Type D
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 (Q/C; Note C.)	–	–	–	–	–
		MIL-DTL-83528 Para. 4.5.11 (Q/C)	0.004	0.010	0.008	0.012	0.012
	Hardness, Shore A	ASTM D2240 (Q/C)	65±5	75±5	65±5	70±5	70±7
	Specific Gravity (± 0.25)	ASTM D792 (Q/C)	3.70	3.80	1.90	2.00	2.00
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	200 (1.38)	180 (1.24)	200 (1.38)	180 (1.24)	180 (1.24)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	100/300	100/300	100/300	60/260	60/260
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q/C)	25 (4.38)	35 (6.13)	30 (5.25)	35 (6.13)	35 (6.13)
	Compression Set, 70 hrs at 100°C, % max. (Note A.)	ASTM D395 Method B (Q)	32	35	32	30	30
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q/C)	-65	-55	-65	-55	-55
	Maximum Continuous Use Temperature, °C (Note B.)	(Q)	125	125	160/200	160/200	160/200
	Apparent Thermal Conductivity, W/m-K (Typical)	ASTM D5470 (300 psi)	2.6	Not Tested	2.6	Not Tested	1.6
Electrical	Shielding Effectiveness, dB, min. (Note F.)	Method 1: CHO-TM-TP08 (Note C.) Method 2: MIL-DTL-83528 Para. 4.5.12 (Q)	Method 2	Method 2	Method 2	Method 2	Method 2
	200 kHz (H Field)	–	70	70	60	55	55
	100 MHz (E Field)	–	120	120	115	110	110
	500 MHz (E Field)	–	120	120	110	100	100
	2 GHz (Plane Wave)	–	120	115	105	95	95
	10 GHz (Plane Wave)	–	120	110	100	90	90
	40 GHz (Plane Wave)	CHO-TM-TP08	90	N/A	N/A	75	75
	Electrical Stability, ohm-cm, max.						
	Heat Aging	CEPS-0002 (Q/C; Note C.)	–	–	–	–	–
	Heat Aging	MIL-DTL-83528 Para. 4.5.15 (Q/C)	0.010	0.015	0.010	0.015	0.015
	Vibration Res., During	MIL-DTL-83528 Para. 4.5.13 (Q)	0.006	0.015	0.012	0.015	0.015
	Vibration Res., After	MIL-DTL-83528 Para. 4.5.13 (Q)	0.004	0.010	0.008	0.012	0.012
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.5.9 (Q/C)	0.008	0.015	0.015	0.015	0.015
Regulatory	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.5.16 (Q)	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9
	RoHS Compliant	-	Yes	Yes	Yes	Yes	Yes
	UL 94 Flammability Rating	-	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested

Table 7: Material Guidelines (Cont.)

	CONDUCTIVE EXTRUDED ELASTOMER SPECIFICATIONS					
		Test Procedure (Type of Test)	**CHO-SIL 1401**	**CHO-SEAL 1273**	**CHO-SEAL 1350**	**CHO-SEAL 6436**
Physical	Conductive Filler	–	Ag	Ag/Cu	Ag/glass	Ag/Ni
	Elastomer Binder	–	Silicone	Silicone	Silicone	EPDM
	Type (Ref. MIL-DTL-83528)	–	–	–	M	–
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 (Q/C; Note C.)	0.010	0.004	–	0.050
		MIL-DTL-83528 Para. 4.5.11 (Q/C)	–	–	0.01	–
	Hardness, Shore A	ASTM D2240 (Q/C)	45 ± 5	65 ± 8	65 ± 7	80 ± 7
	Specific Gravity (± 0.25)	ASTM D792 (Q/C)	1.60	3.70	1.80	3.80
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	200 (1.38)	175 (1.21)	200 (1.38)	200 (1.38)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	75	75	100/300	100
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q/C)	20 (3.50)	-	30 (5.25)	70 (12.25)
	Compression Set, 70 hrs at 100°C, % max. (Note A.)	ASTM D395 Method B (Q)	30	32	30	40
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q/C)	-55	-65	-55	-45
	Maximum Continuous Use Temperature, °C (Note B.)	(Q)	160/200	125	160	100
	Apparent Thermal Conductivity, W/m-K (Typical)	ASTM D5470 (300 psi)	Not Tested	Not Tested	Not Tested	Not Tested
Electrical	Shielding Effectiveness, dB, min. (Note F.)	Method 1: CHO-TM-TP08 (Note C.) Method 2: MIL-DTL-83528 Para. 4.5.12 (Q)	Method 2	Method 1	Method 2	Method 1
	200 kHz (H Field)	–	60	-	50	-
	100 MHz (E Field)	–	100	100	100	90
	500 MHz (E Field)	–	100	100	100	90
	2 GHz (Plane Wave)	–	90	100	90	90
	10 GHz (Plane Wave)	–	80	100	80	90
	40 GHz (Plane Wave)	CHO-TM-TP08	N/A	N/A	75	N/A
	Electrical Stability, ohm-cm, max.					
	Heat Aging	CEPS-0002 (Q/C; Note C.)	–	0.01	–	–
	Heat Aging	MIL-DTL-83528 Para. 4.5.15 (Q/C)	0.015	–	0.015	0.05 (Note D.)
	Vibration Res., During	MIL-DTL-83528 Para. 4.5.13 (Q)	0.015	-	0.009	-
	Vibration Res., After	MIL-DTL-83528 Para. 4.5.13 (Q)	0.010	-	0.006	-
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.5.9 (Q/C)	0.020	-	0.009	-
Regulatory	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.5.16 (Q)	-	-	-	-
	RoHS Compliant	-	Yes	Yes	Yes	Yes
	UL 94 Flammability Rating	-	Not Tested	Not Tested	Not Tested	Not Tested

Table 7: Material Guidelines (Cont.)

	CONDUCTIVE EXTRUDED ELASTOMER SPECIFICATIONS								
		Test Procedure (Type of Test)	CHO-SEAL S6305	CHO-SEAL 6315	CHO-SEAL 6308	CHO-SEAL 6370	CHO-SEAL 6372	CHO-SEAL L6303	CHO-SEAL 860/862
Physical	Conductive Filler	–	Ni/C	Ni/C	Ni/C	Ni/C	Ni/C	Ni/C	Carbon
	Elastomer Binder	–	Silicone	Silicone	Silicone	Silicone	Silicone	Fluoro-Silicone	Silicone
	Type (Ref. MIL-DTL-83528)	–	–	–	–	–	–	–	-
	Volume Resistivity, ohm-cm, max., as supplied without pressure sensitive adhesive	CEPS-0002 (Q/C; Note C.)	0.10	0.75	0.10	0.10	0.75	0.10	3/24
		MIL-DTL-83528 Para. 4.5.11 (Q/C)	–	–	–	–	–	–	–
	Hardness, Shore A	ASTM D2240 (Q/C)	65±10	57±7	65±10	60±10	57±7	65±10	70±5
	Specific Gravity (± 0.25)	ASTM D792 (Q/C)	2.00	1.80	1.75 2.25	2.10	1.80	2.20	1.28±0.03 1.20±0.03
	Tensile Strength, psi (MPa), min.	ASTM D412 (Q/C)	200 (1.38)	140 (0.96)	200 (138)	150 (1.03)	150 (1.03)	150 (1.30)	500 (3.45) 600 (4.14)
	Elongation, % min. or % min./max.	ASTM D412 (Q/C)	100	100	90 (Typ.)	100	100	60	75/100
	Tear Strength, lb/in. (kN/m), min.	ASTM D624 (Q/C)	35 (6.13)	35 (6.13)	40 (7.14)	35 (6.13)	35 (6.13)	35 (6.13)	50/60 (8.75)
	Compression Set, 70 hrs at 100°C, % max. (Note A.)	ASTM D395 Method B (Q)	30	30	30	40	30	25	-
Thermal	Low Temperature Flex TR10, °C, min.	ASTM D1329 (Q/C)	-45	-40	-60	-45	-40	-45	-51
	Maximum Continuous Use Temperature, °C (Note B.)	(Q)	150	150	150	150	150	150	177
	Apparent Thermal Conductivity, W/m-K (Typical)	ASTM D5470 (300 psi)	1.0	0.9	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
Electrical	Shielding Effectiveness, dB, min. (Note F.)	Method 1: CHO-TM-TP08 (Note C.) Method 2: MIL-DTL-83528 Para. 4.5.12 (Q)	Method 1	Method 1	Method 1	Method 1	Method 1	Method 2	Method 2
	200 kHz (H Field)	–	-	-	-	-	-	-	65/60
	100 MHz (E Field)	–	100	80	100	100	80	100	55/50
	500 MHz (E Field)	–	100	80	100	100	80	100	65/60
	2 GHz (Plane Wave)	–	100	80	100	95	80	100	55/45
	10 GHz (Plane Wave)	–	100	80	100	95	80	100	75/60
	40 GHz (Plane Wave)	CHO-TM-TP08	75	N/A		N/A	N/A	N/A	N/A
	Electrical Stability, ohm-cm, max.								
	Heat Aging	CEPS-0002 (Q/C; Note C.)	0.25 (Note E.)	0.85	–	0.25 (Note E.)	0.85	0.25	-
	Heat Aging	MIL-DTL-83528 Para. 4.5.15 (Q/C)	–	–	–	–	–	–	-
	Vibration Res., During	MIL-DTL-83528 Para. 4.5.13 (Q)	0.1	-	–	-	-	0.1	-
	Vibration Res., After	MIL-DTL-83528 Para. 4.5.13 (Q)	0.1	-	–	-	-	0.1	-
	Post Tensile Set Volume Resistivity	MIL-DTL-83528 Para. 4.5.9 (Q/C)	-	-	–	-	-	-	-
Regulatory	EMP Survivability, kA per in. perimeter	MIL-DTL-83528 Para. 4.5.16 (Q)	0.1	-	–	-	-	0.1	-
	RoHS Compliant	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	UL 94 Flammability Rating	-	HB	Not Tested	Not Tested	V-0	V-1	Not Tested	860-Not Tested 862- V-0

Table 7 Notes

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 and CHO-TM-TP08 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.

(Q): Qualification

(Q/C): Qualification & Conformance

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.

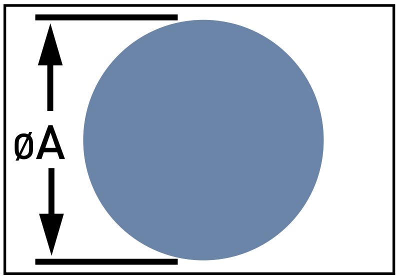


Table 8: Profiles, Solid O-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension A		Suggested Groove Dimensions* Depth +/- 0.002	+/- 0.005	Width 97% Max Groove Fill	
	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	0.029	0.74	0.063	1.60
19-04-22085-XXXX	0.040	1.02	0.029	0.74	0.063	1.60
19-04-22533-XXXX	0.043	1.09	0.032	0.81	0.064	1.63
10-04-9139-XXXX	0.048	1.22	0.037	0.94	0.067	1.70
19-04-25875-XXXX**	0.050	1.27	0.038	0.97	0.070	1.78
19-04-22087-XXXX	0.050	1.27	0.038	0.97	0.070	1.78
10-04-3560-XXXX	0.053	1.35	0.041	1.04	0.072	1.83
19-04-22354-XXXX	0.060	1.52	0.047	1.19	0.078	1.98
10-04-2561-XXXX	0.062	1.57	0.049	1.24	0.079	2.01
19-04-22049-XXXX	0.066	1.68	0.053	1.34	0.082	2.08
19-04-22951-XXXX	0.070	1.78	0.056	1.42	0.086	2.18
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	1.90	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
19-04-26425-XXXX**	0.090	2.29	0.074	1.88	0.103	2.62
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	3.17
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	2.59	0.131	3.33
10-04-2463-XXXX	0.125	3.17	0.102	2.71	0.139	3.53
10-04-2862-XXXX	0.130	3.30	0.107	2.79	0.142	3.61
19-04-12903-XXXX	0.134	3.40	0.110	2.84	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
19-04-12906-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	6.04
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
19-04-25051-XXXX	0.275	6.99	0.226	5.74	0.291	7.39
10-04-3076-XXXX	0.250	6.35	0.205	5.21	0.268	6.81
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	6.04	0.309	7.85
10-04-27818-XXXX	0.335	8.51				
19-04-12918-XXXX	0.367	9.32	0.301	7.64	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.

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.

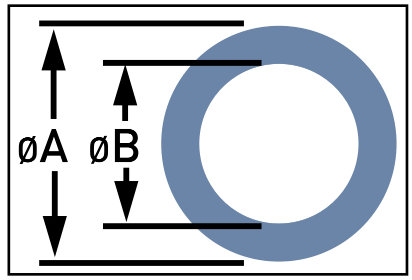


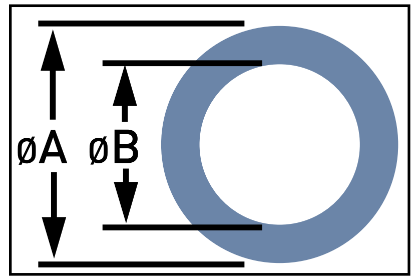
Table 9: Profiles, Hollow-O-Shape (Sorted by "A" Dimension)

Part Number	Nominal Dimension (inch)		Nominal Dimension (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
19-04-19890-XXXX	0.093	0.033	2.36	0.84
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
19-04-26381-XXXX	0.190	0.115	4.83	2.92
19-04-21194-XXXX	0.195	0.155	4.95	3.94

Table 9: Profiles, Hollow-O-Shape (Sorted by "A" Dimension) (Cont.)

Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
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



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

Part Number	Nominal Dimension (inch)		Nominal Dimension (mm)	
	A	B	A	B
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
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

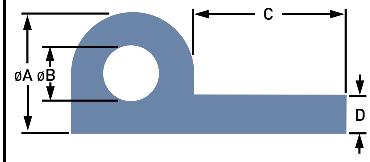


Table 10: Profiles, P-Shape (Sorted by "A" Dimension)

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

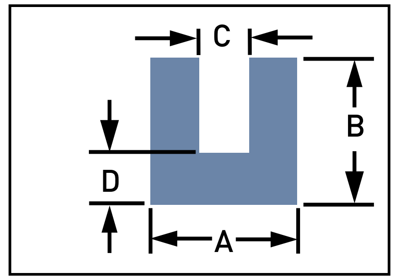


Table 11: Profiles, Channel-Shape (Sorted by "A" Dimension)

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

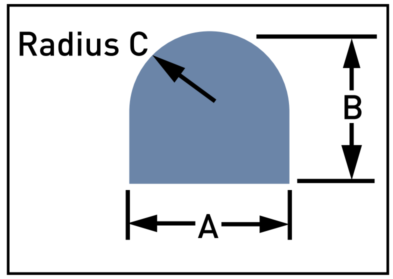


Table 12: Profiles, D-Shape (Sorted by "B" Dimension)

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

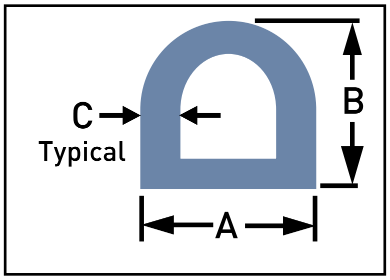


Table 13: Profiles, Hollow D-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
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	`.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

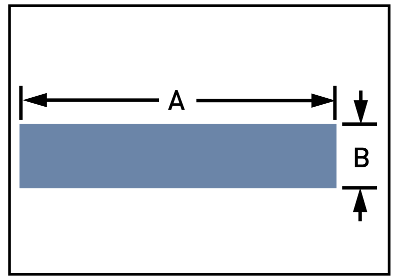


Table 14: Profiles, Rectangular Strip-Shape (Sorted by "B" Dimension)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
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	-	-
19-06-26385-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	-	-

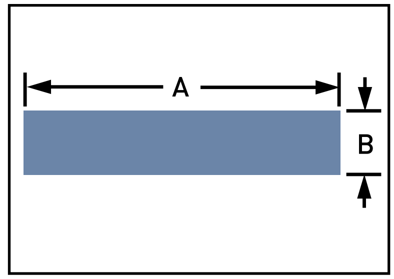


Table 14: Profiles, Rectangular Strip-Shape (Sorted by "B" Dimension) (Cont.)

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
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	-	-
19-07-12956-XXXX	0.508	0.063	-	-	12.90	1.60	-	-
17-07-25333-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.

Profile Description: Hollow Rectangle Shape

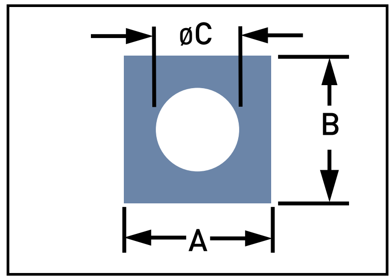


Table 15: Profiles, Hollow Rectangle-Shape (Sorted by "B" Dimension)

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: ±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: Mushroom D Shape

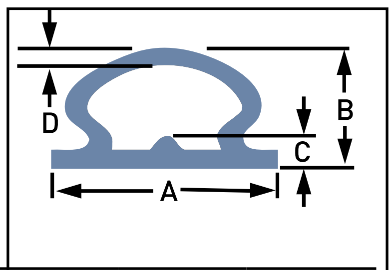


Table 16: Profiles, Mushroom D-Shape (Sorted by "B" Dimension)

0.170 Gap

Part Number	Nominal Dimension (inch)				Nominal Dimension (mm)			
	A	B	C	D	A	B	C	D
19-09-16802-XXXX	0.315	0.301	0.109	0.053	8.00	7.65	2.77	1.35
19-09-16503-XXXX	0.265	0.312	0.113	0.040	6.73	7.92	2.87	1.02
19-05-14587-XXXX	0.487	0.324	0.115	0.055	12.37	8.23	2.92	1.40
19-09-14377-XXXX	0.625	0.375	0.106	0.057	15.88	9.52	2.69	1.45
19-09-14926-XXXX	0.625	0.400	0.106	0.057	15.88	10.16	2.69	1.45
19-05-14282-XXXX	0.645	0.427	0.065	0.065	16.38	10.85	1.65	1.65
19-09-16339-XXXX	0.472	0.433	0.115	0.040	11.99	11.00	2.92	1.02
19-09-26470-XXXX	0.472	0.433	0.115	0.062	11.99	11.00	2.92	1.57
19-09-15486-XXXX	0.846	0.472	0.120	0.053	21.49	11.99	3.05	1.35
19-09-15523-XXXX	0.890	0.730	0.183	0.065	22.61	18.54	4.65	1.65

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.

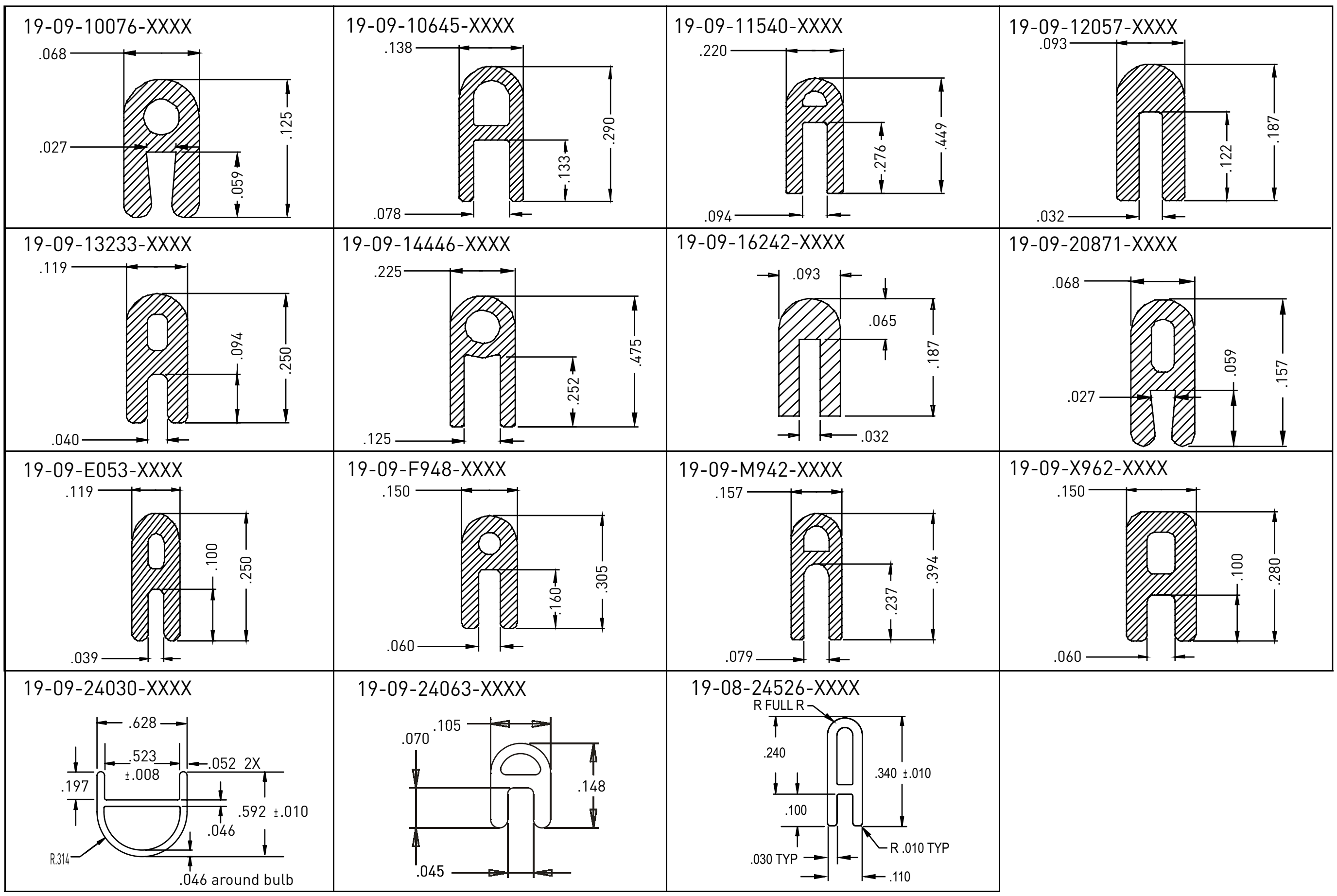
0.170 Gap is the smallest that the mushroom D is designed for 0.190 is preferred

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.

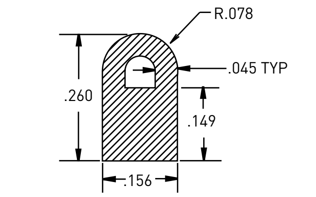
Custom A Profiles



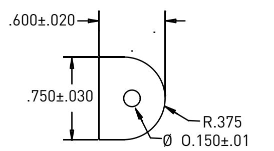
Dimensions shown in inches; 1 in. = 25.4 mm

Custom D Profiles

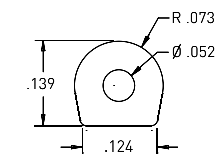
10-05-10648-XXXX



10-05-14081-XXXX



19-09-14757-XXXX



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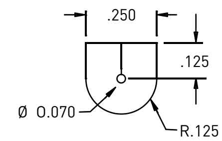

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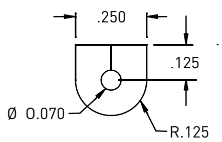

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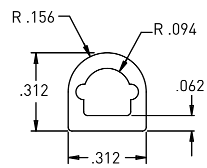

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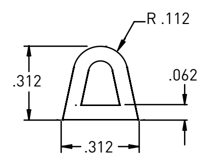

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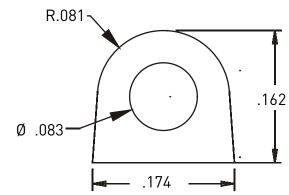

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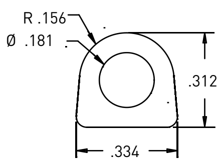

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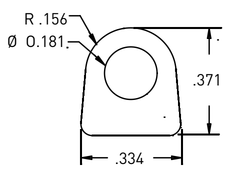

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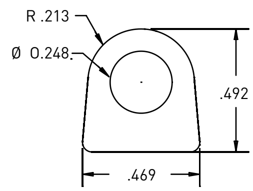

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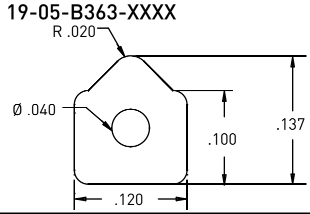

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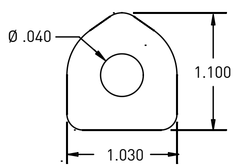

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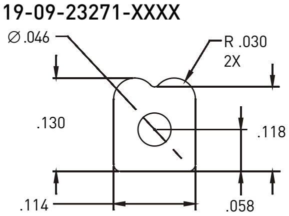

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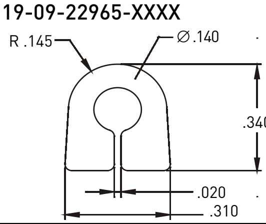

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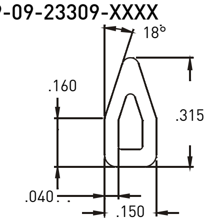

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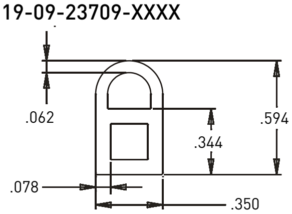

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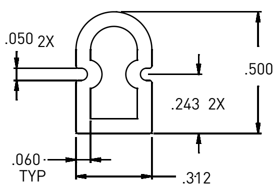

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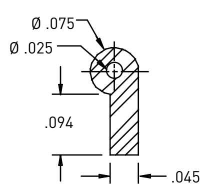

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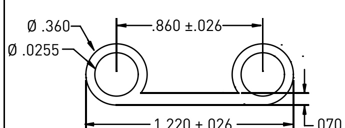

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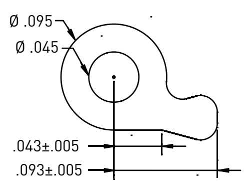

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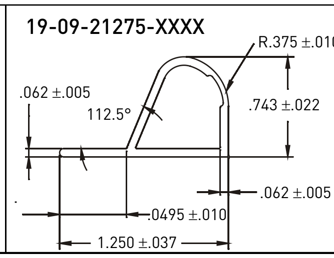

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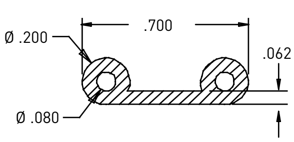

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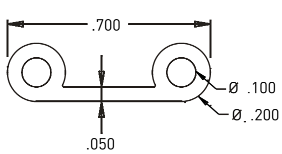

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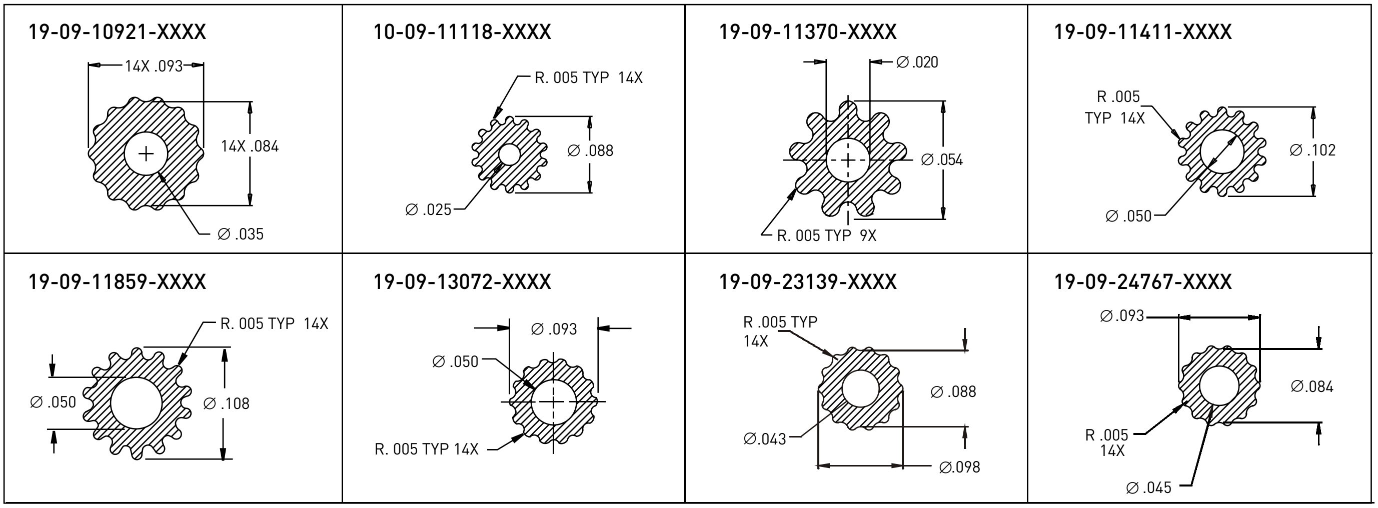

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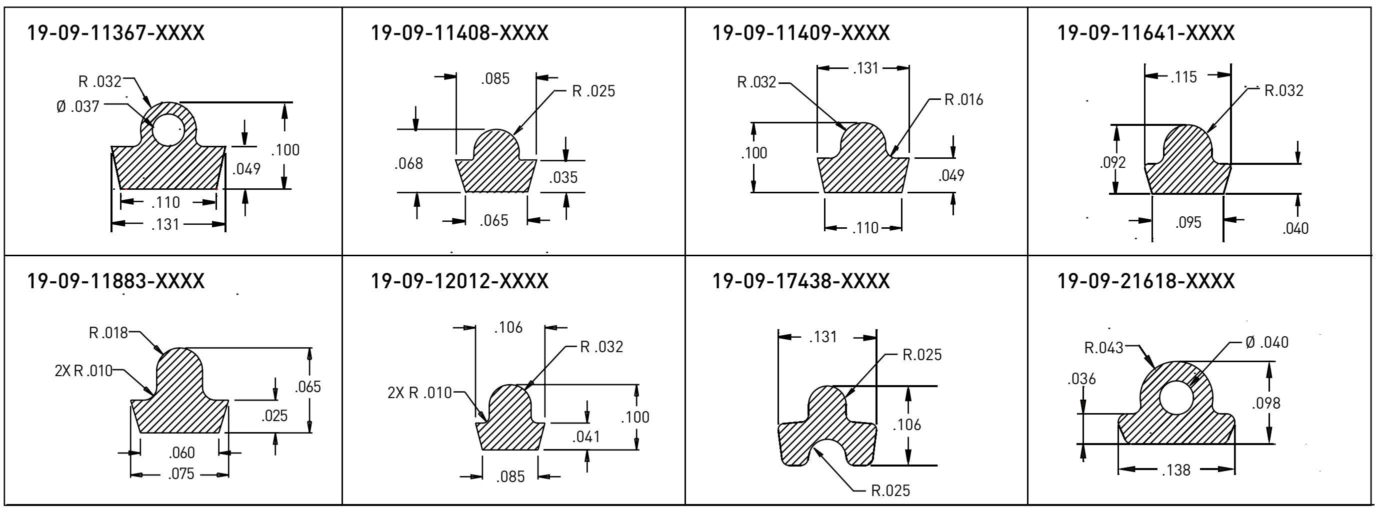

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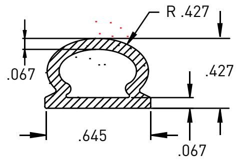

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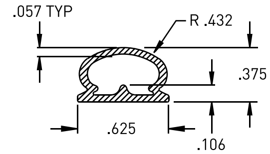

U.S. Patent No. 06075205

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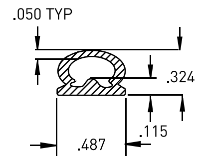

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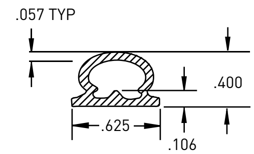

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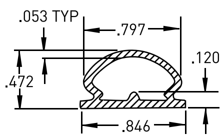

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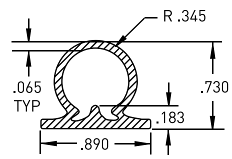

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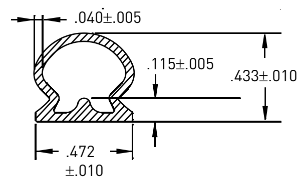

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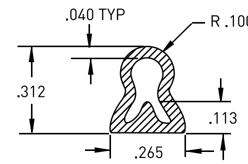

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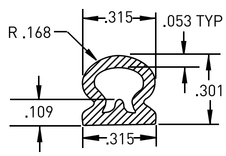

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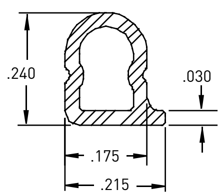

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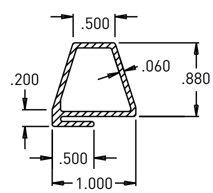

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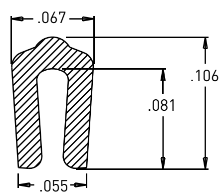

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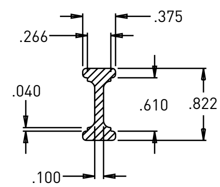

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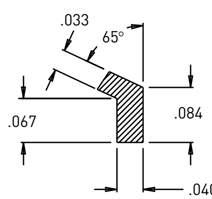

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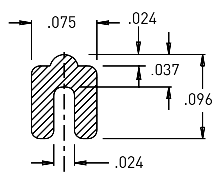

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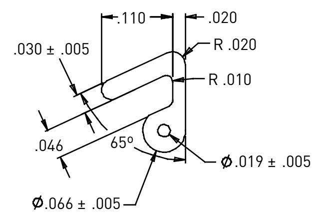

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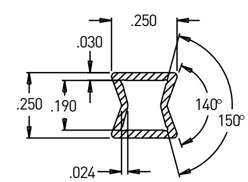

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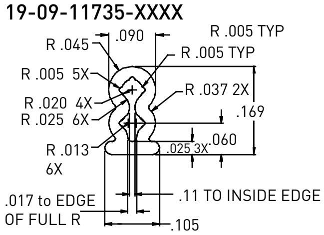

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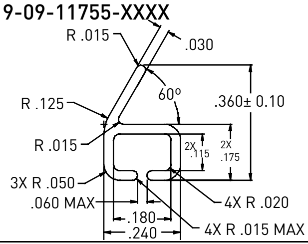

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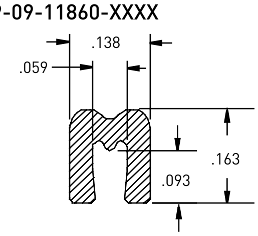

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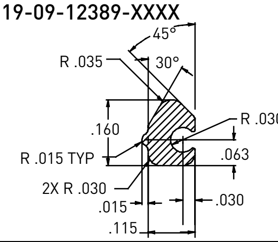

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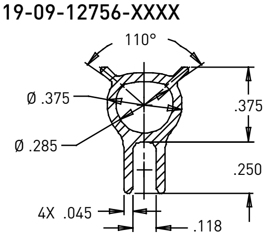

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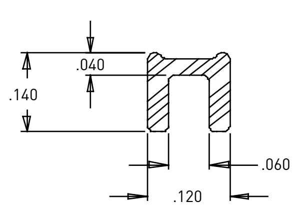

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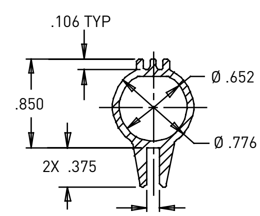

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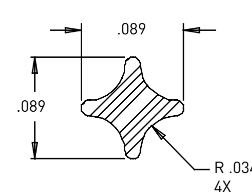

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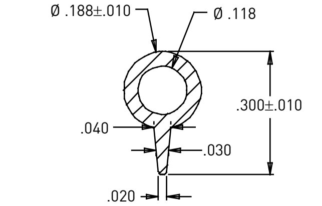

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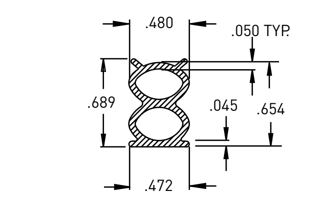

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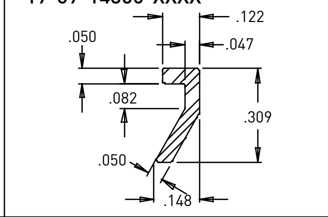

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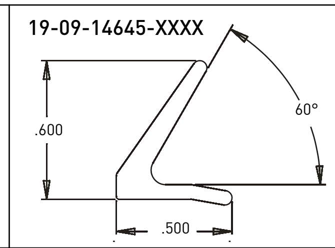

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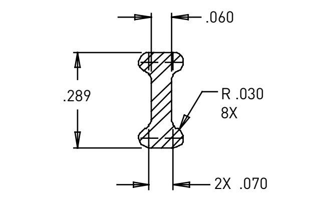

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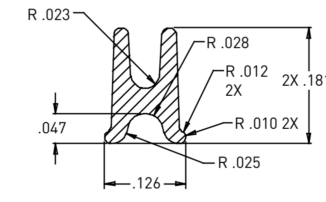

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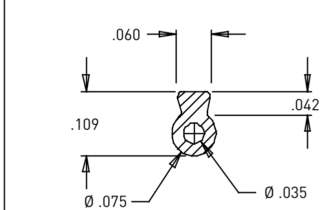

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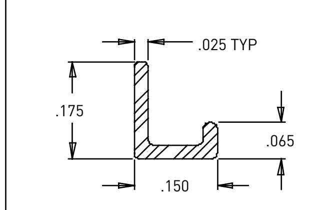

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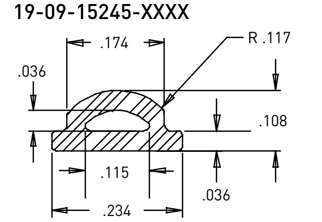

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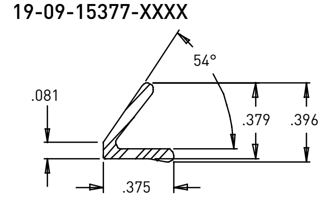

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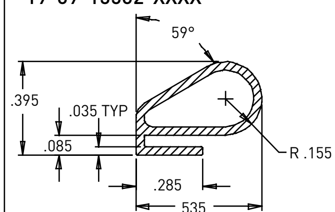

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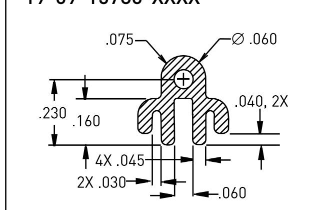

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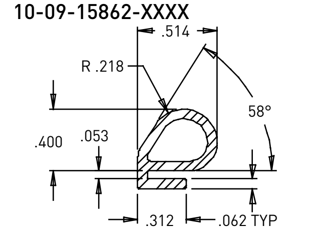

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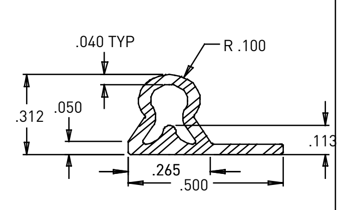

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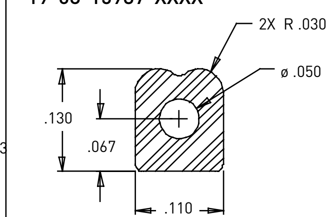

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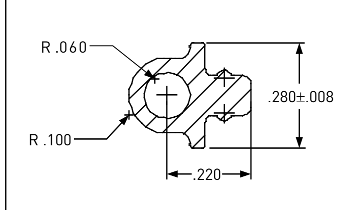

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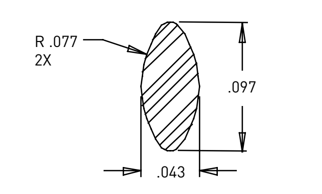

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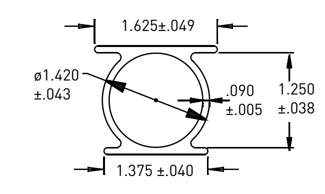

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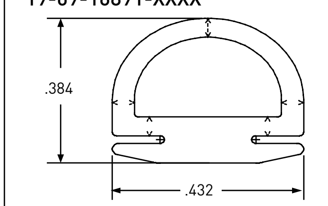

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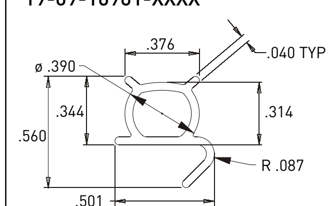

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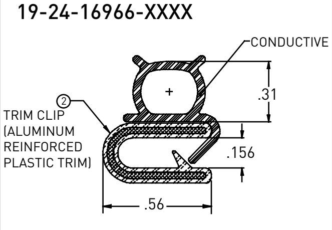

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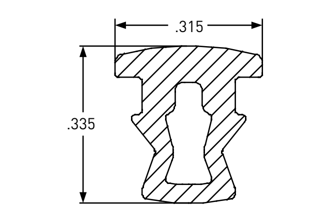

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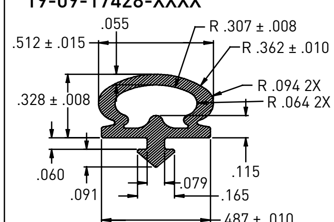

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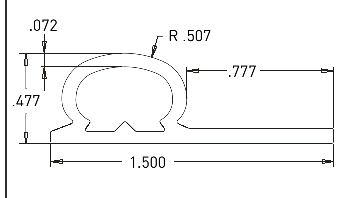

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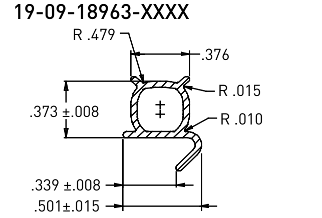

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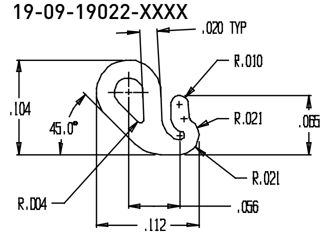

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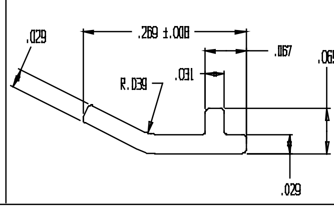

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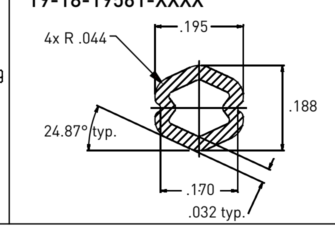

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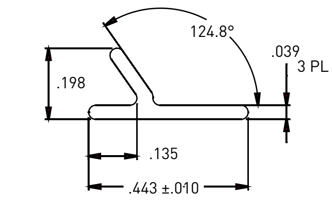

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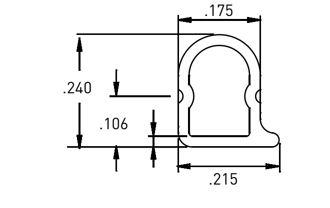

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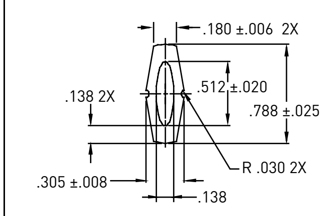

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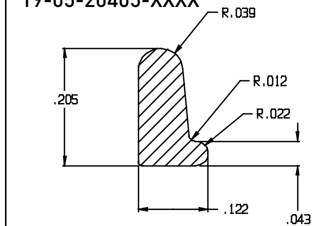

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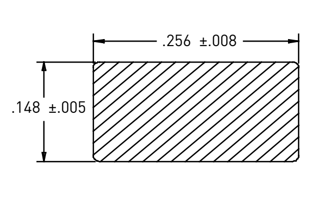

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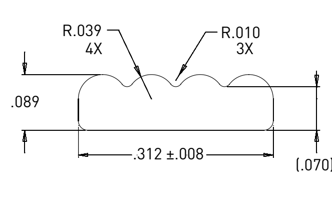

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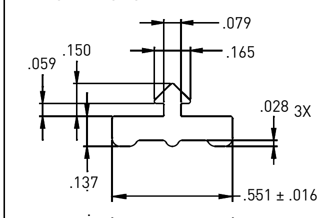

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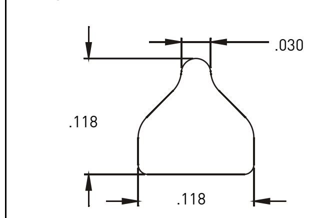

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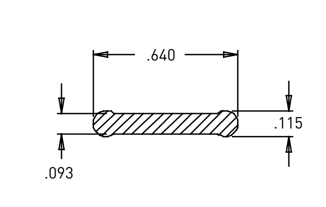

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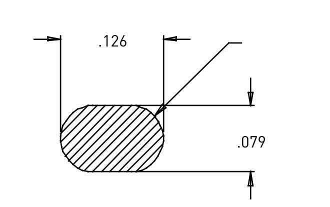

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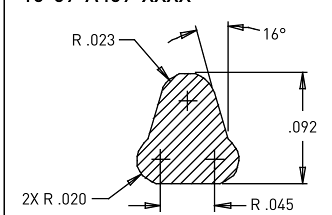

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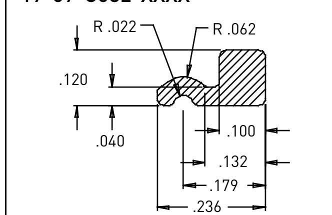

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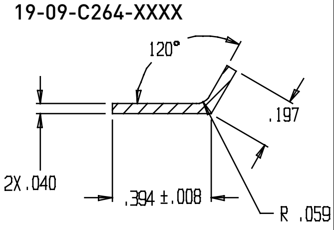

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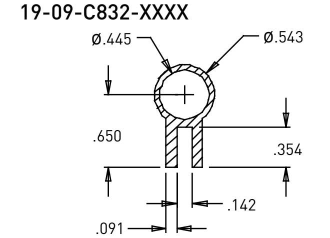

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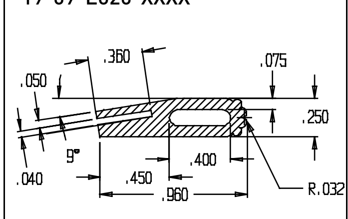

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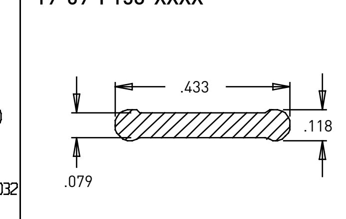

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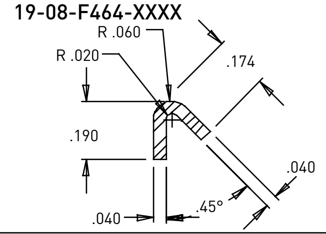

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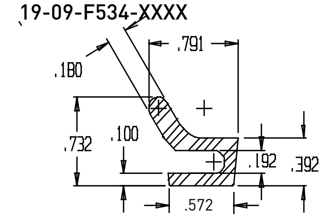

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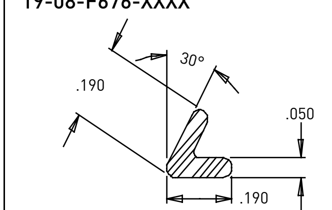

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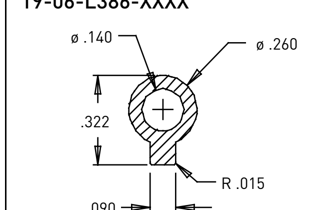

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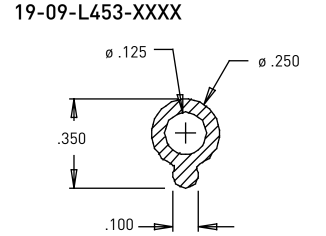

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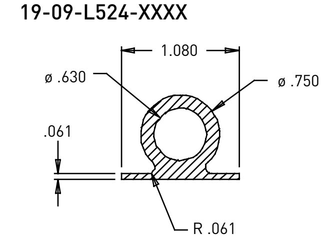

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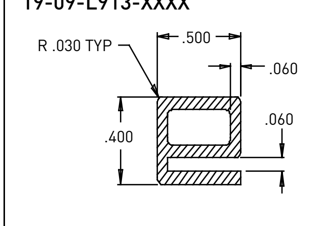

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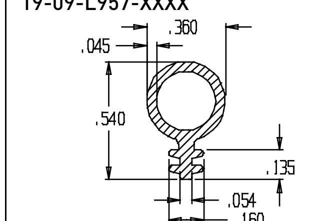

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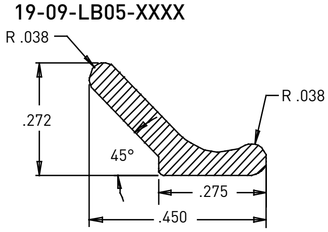

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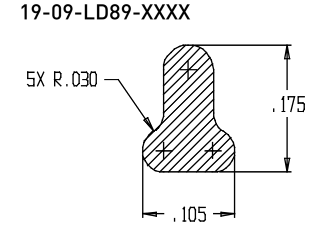

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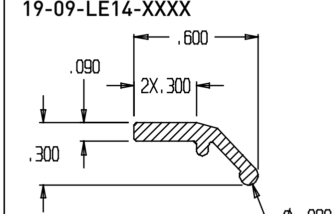

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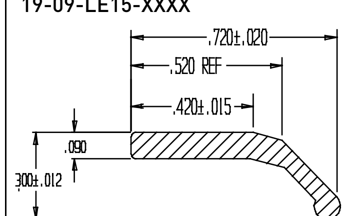

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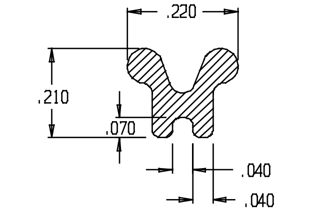

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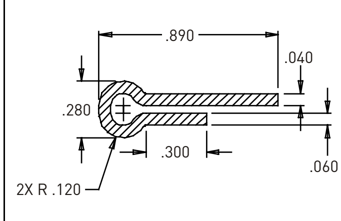

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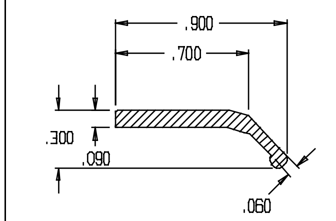

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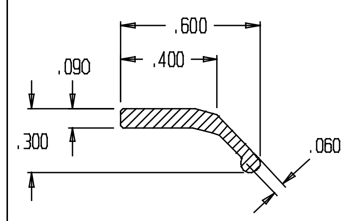

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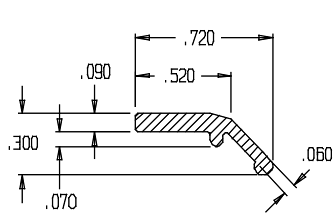

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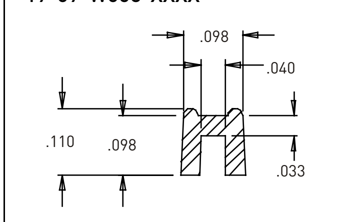

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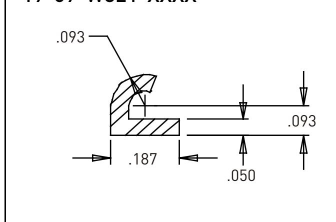

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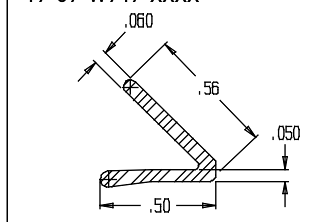

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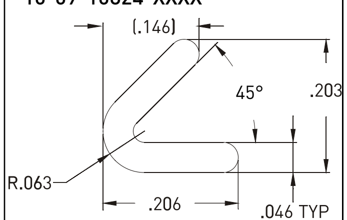

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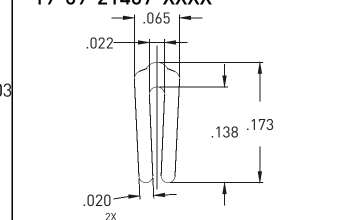

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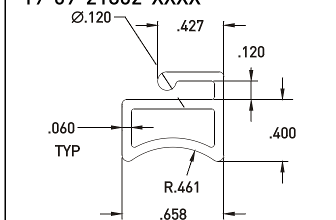

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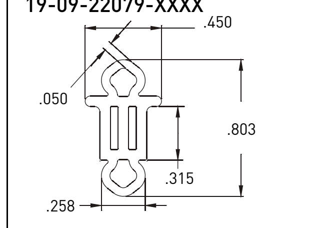

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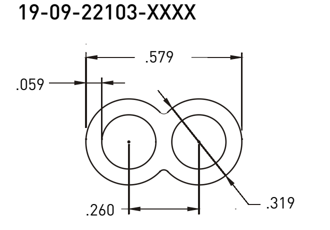

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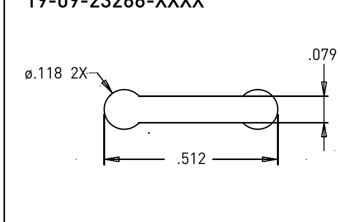

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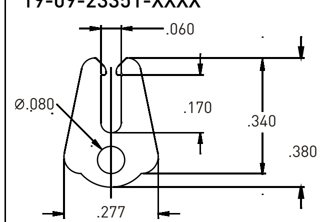

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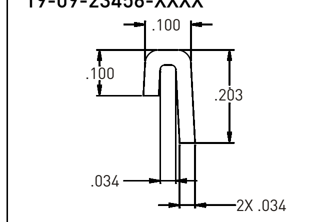

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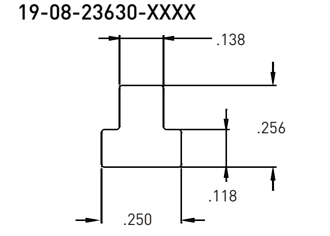

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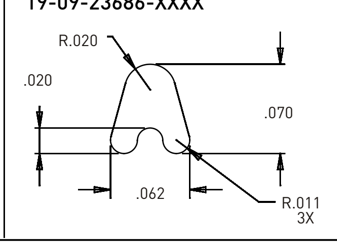

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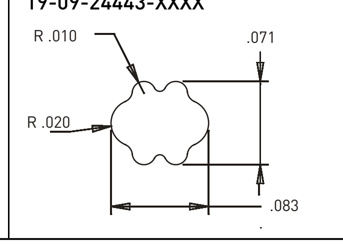

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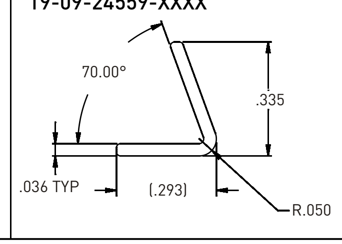
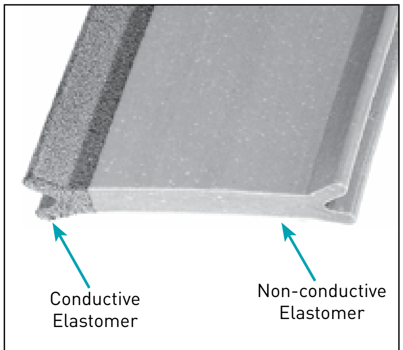
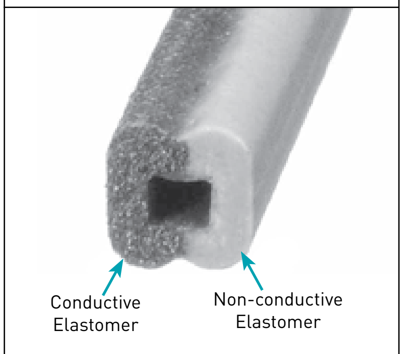
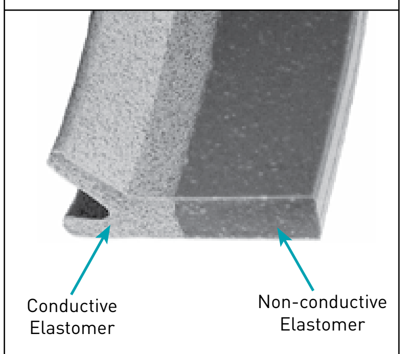
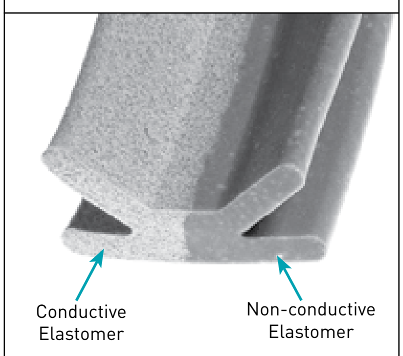


Dimensions shown in inches; 1 in. = 25.4 mm









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 pages 38-39 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

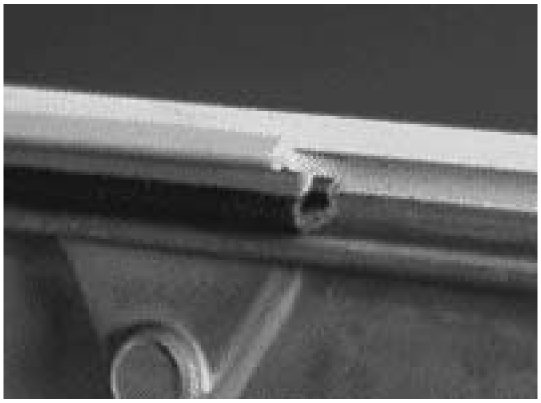
- Not available on round cross sections
- Not recommended for applications where solvent resistance is essential
- Not recommended for applications where resistance to excessive abuse due to moving parts or traffic is required

**Note: Refer to "Surface Preparation of Metallic Substrates" on page 11 for important information on proper cleaning and application. Also request Technical Bulletin 20.*

EMI PRODUCTS - CASE STUDIES

Co-Extruded Gasket Stops Corrosion on Outdoor Telecom Enclosure

.....A pole-mounted, aluminum telecom enclosure presented serious challenges for controlling EMI and keeping out the elements. The enclosure needed a conductive gasket capable of at least 80 dB shielding effectiveness in the high megahertz to low gigahertz range. A separate environmental seal was needed to protect against rain and moisture.



.....An early gasketing approach used a non-conductive hollow silicone strip with a pure-silver-filled silicone extruded onto its surface. But, in contact with the aluminum housing, and exposed to coastal salt fog and driving rain, severe corrosion of the housing flanges occurred.

.....To meet these shielding and environmental requirements, Chomerics produced a co-extruded EMI gasket. This was a CHO-SEAL® conductive elastomer extruded in parallel with a non-conductive elastomer. The gasket's conductive side is a nickel-plated-graphite filled silicone. The filler particles can bite through thin surface oxides and chemical treatments on aluminum housings. The vulcanized seam between the elastomers provides long-term integrity.

.....The conductive side of this gasket was positioned inboard, with the non-conductive silicone outboard. The non-conductive side of the cross section was designed with an additional sealing tab to fill an existing sump area in the seam where rain and moisture collected.

.....The co-extruded gasket allowed use of the existing flange design. It avoided the cost for separate shielding and weather sealing gaskets, and converting to a double-groove design. This is an example of how Chomerics co-extrusions offer performance and logistical advantages at attractive prices.

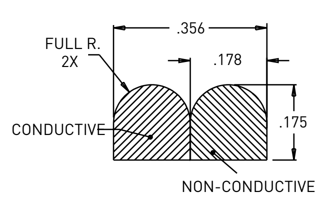
For more information, request Chomerics Co-extruded Elastomer Strips.

Table 17: 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.				

Custom Co-Extruded Strips

19-05-10168-XXXX



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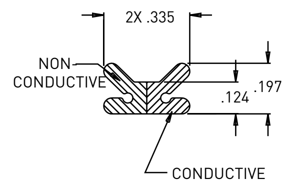

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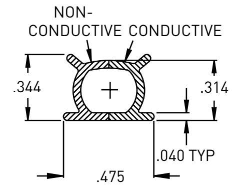

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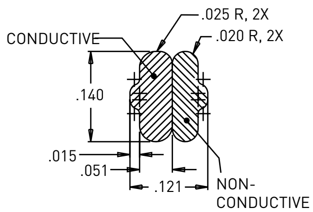

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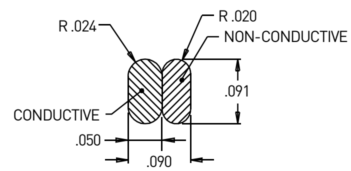

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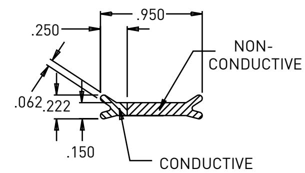

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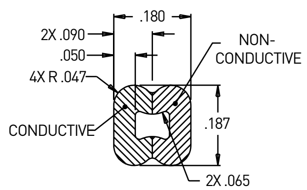

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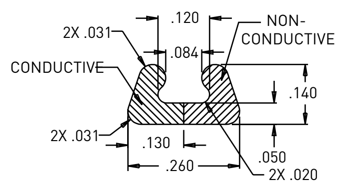

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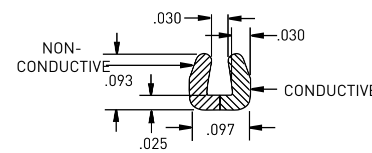

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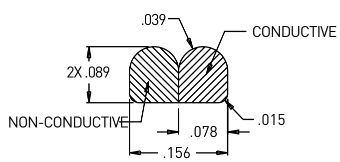

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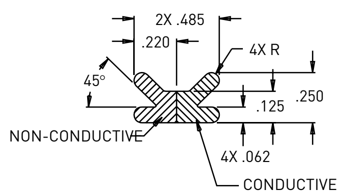

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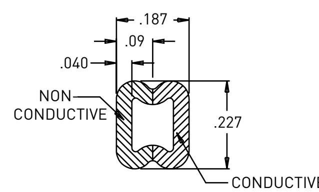

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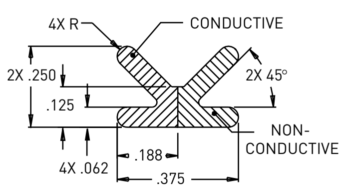

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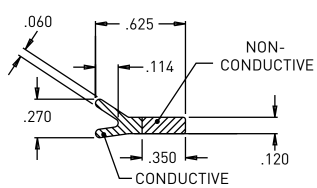

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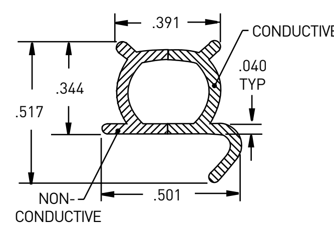

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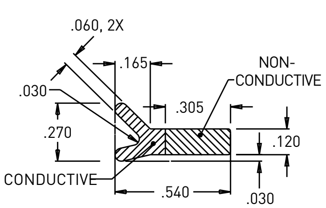

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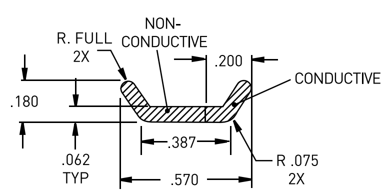

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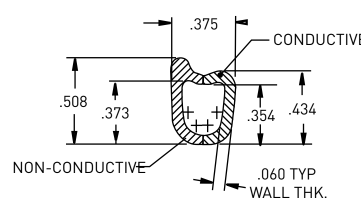

Dimensions shown in inches; 1 in. = 25.4 mm

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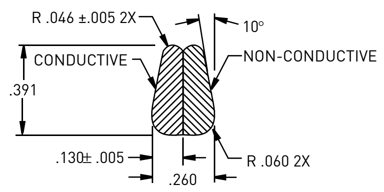

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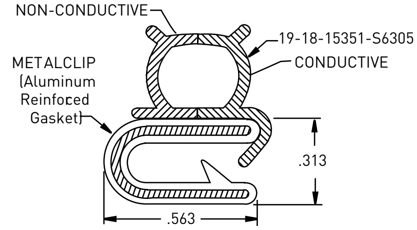
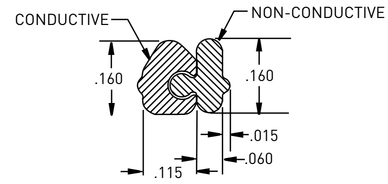


19-24-12391-XXXX Combination Gasket



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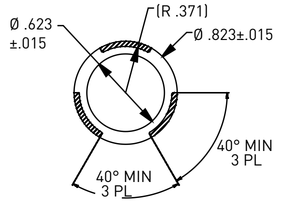

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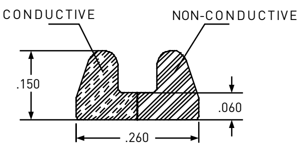

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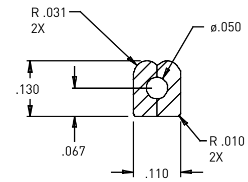

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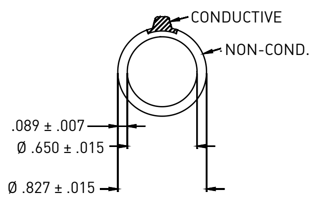

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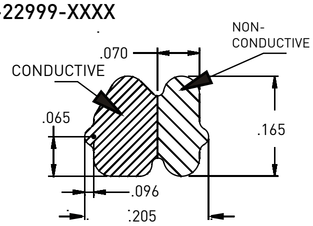

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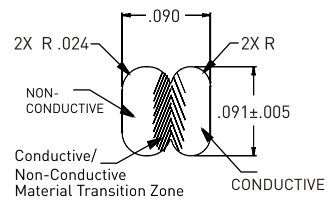

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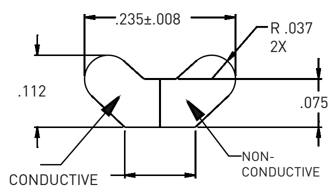


Dimensions shown in inches; 1 in. = 25.4 mm

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 36. To discuss your requirements, contact our Applications Engineering Department.

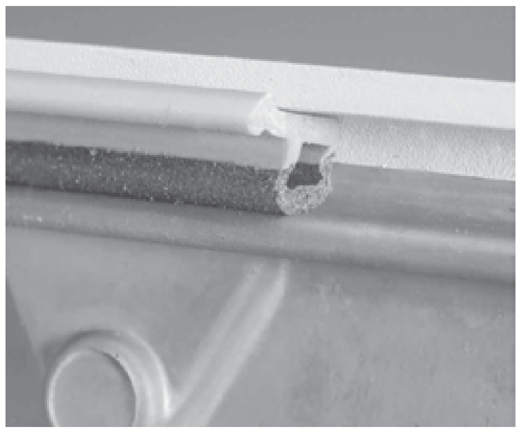


Table 18: MIL-DTL-83528 Part Number Cross Reference Chart - Sorted by MIL P/N

Chomerics Part Number	MIL Part Number		Profile Shape
	MIL P/N prefix*	Dash #	
10-04-6386-XXXX	M83528 001 Y -	001	Solid O
10-04-3560-XXXX	M83528 001 Y -	002	Solid O
10-04-2561-XXXX	M83528 001 Y -	003	Solid O
10-04-1687-XXXX	M83528 001 Y -	004	Solid O
10-04-2657-XXXX	M83528 001 Y -	005	Solid O
10-04-2865-XXXX	M83528 001 Y -	006	Solid O
10-04-1720-XXXX	M83528 001 Y -	007	Solid O
10-04-3077-XXXX	M83528 001 Y -	008	Solid O
10-04-2463-XXXX	M83528 001 Y -	009	Solid O
10-04-1721-XXXX	M83528 001 Y -	010	Solid O
19-04-F371-XXXX	M83528 001 Y -	011	Solid O
10-04-2864-XXXX	M83528 001 Y -	012	Solid O
10-04-3076-XXXX	M83528 001 Y -	013	Solid O
10-05-1362-XXXX	M83528 003 Y -	001	Solid D
10-05-3224-XXXX	M83528 003 Y -	002	Solid D
10-05-1363-XXXX	M83528 003 Y -	003	Solid D
19-05-Z586-XXXX	M83528 003 Y -	004	Solid D
10-05-2618-XXXX	M83528 003 Y -	006	Solid D
10-05-1364-XXXX	M83528 003 Y -	007	Solid D
10-05-1499-XXXX	M83528 003 Y -	008	Solid D
19-05-F173-XXXX	M83528 003 Y -	009	Solid D
10-05-1577-XXXX	M83528 003 Y -	010	Solid D
19-05-W469-XXXX	M83528 003 Y -	011	Solid D
10-05-6419-XXXX	M83528 007 Y -	001	Hollow D
10-05-4202-XXXX	M83528 007 Y -	002	Hollow D
10-05-4308-XXXX	M83528 007 Y -	003	Hollow D
10-05-3369-XXXX	M83528 007 Y -	004	Hollow D
10-05-4318-XXXX	M83528 007 Y -	005	Hollow D
10-05-4542-XXXX	M83528 007 Y -	006	Hollow D
10-05-6394-XXXX	M83528 007 Y -	007	Hollow D
10-06-3599-XXXX	M83528 008 Y -	001	Hollow P
10-06-4142-XXXX	M83528 008 Y -	002	Hollow P
10-06-3300-XXXX	M83528 008 Y -	003	Hollow P
10-06-4921-XXXX	M83528 008 Y -	004	Hollow P
10-06-5611-XXXX	M83528 008 Y -	005	Hollow P
10-06-2750-XXXX	M83528 008 Y -	006	Hollow P
10-06-8550-XXXX	M83528 008 Y -	007	Hollow P
10-06-6180-XXXX	M83528 008 Y -	008	Hollow P
Chomerics Part Number	MIL Part Number		Profile Shape
	MIL P/N prefix*	Dash #	

Table 18: MIL-DTL-83528 Part Number Cross Reference Chart (Cont.)

10-07-4272-XXXX	M83528 009 Y -	001	Rectangular
10-07-2981-XXXX	M83528 009 Y -	002	Rectangular
10-07-4014-XXXX	M83528 009 Y -	003	Rectangular
10-07-3225-XXXX	M83528 009 Y -	004	Rectangular
10-07-3047-XXXX	M83528 009 Y -	005	Rectangular
10-07-3226-XXXX	M83528 009 Y -	006	Rectangular
10-07-3522-XXXX	M83528 009 Y -	007	Rectangular
10-07-4217-XXXX	M83528 009 Y -	008	Rectangular
10-07-3080-XXXX	M83528 009 Y -	009	Rectangular
10-07-4483-XXXX	M83528 009 Y -	010	Rectangular
10-07-4523-XXXX	M83528 009 Y -	011	Rectangular
10-07-3797-XXXX	M83528 009 Y -	012	Rectangular
10-07-4538-XXXX	M83528 009 Y -	013	Rectangular
10-08-6475-XXXX	M83528 010 Y -	001	Channel
10-08-3215-XXXX	M83528 010 Y -	002	Channel
10-08-4315-XXXX	M83528 010 Y -	003	Channel
10-08-3157-XXXX	M83528 010 Y -	004	Channel
10-08-3253-XXXX	M83528 010 Y -	005	Channel
10-08-3872-XXXX	M83528 010 Y -	006	Channel
10-04-2999-XXXX	M83528 011 Y -	001	Hollow O
10-04-4180-XXXX	M83528 011 Y -	002	Hollow O
10-04-2737-XXXX	M83528 011 Y -	003	Hollow O
10-04-3004-XXXX	M83528 011 Y -	004	Hollow O
10-04-3122-XXXX	M83528 011 Y -	005	Hollow O
10-04-8817-XXXX	M83528 011 Y -	006	Hollow O
10-04-8363-XXXX	M83528 011 Y -	007	Hollow O
10-04-8133-XXXX	M83528 011 Y -	008	Hollow O

* 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.).

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 exceed the maximum deflection limits shown in Table 19.

Table 19: Recommended Deflections

Recommended Deflection for Various Conductive Elastomer Shapes			
Cross Section Geometery	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"			

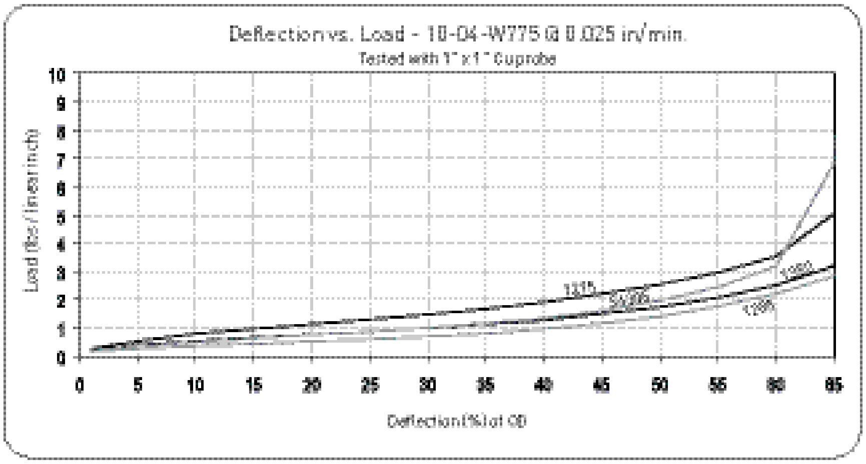


Figure 1. O-Strip 0.125" OD 0.085" ID

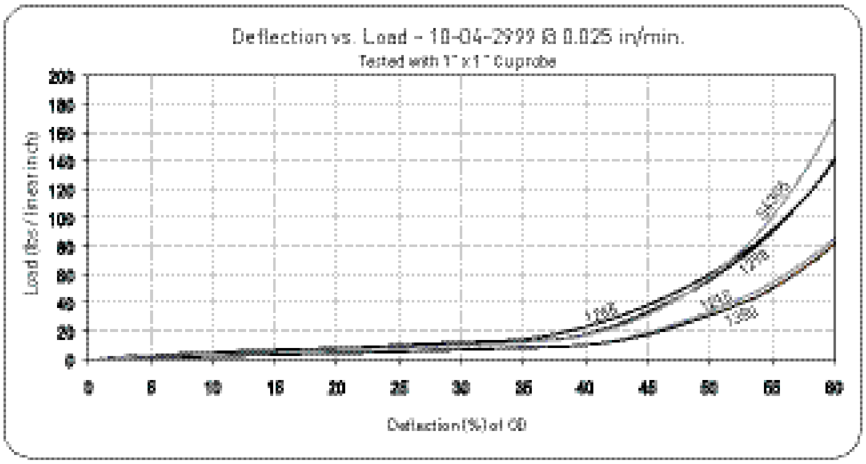


Figure 2. O-Strip 0.125" OD 0.045" ID

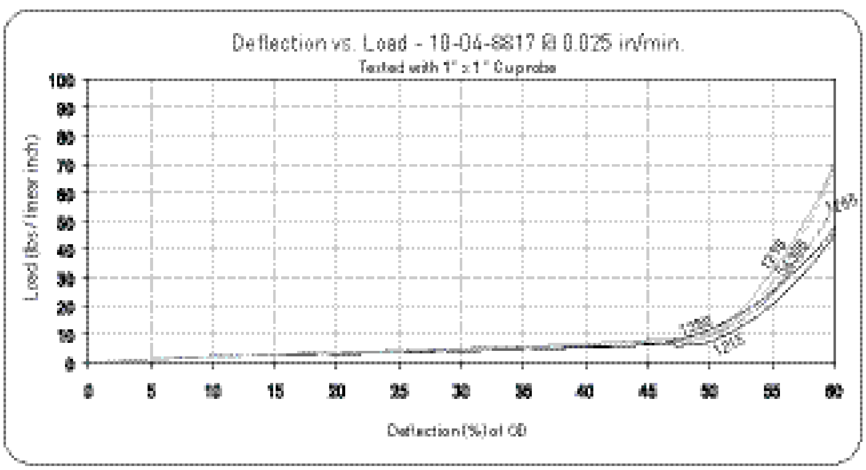


Figure 3. O-Strip 0.125" OD 0.062" ID

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.

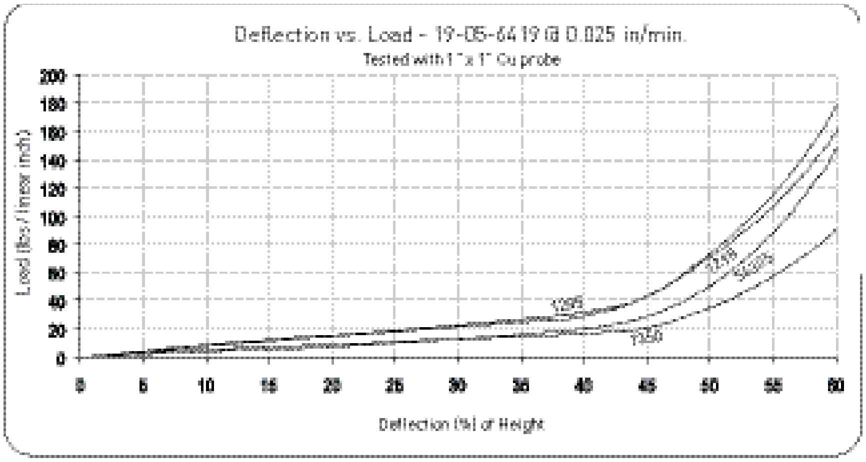


Figure 4. Hollow D H 0.156" Wall Thickness 0.45"

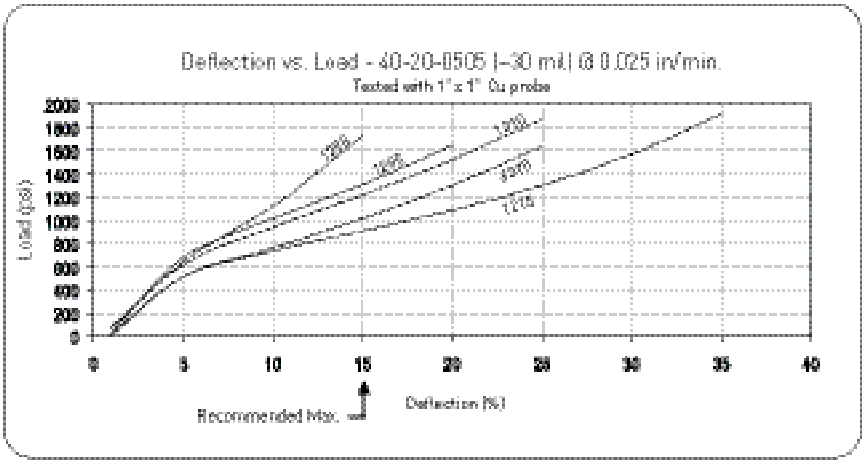


Figure 5. Sheet Stock 0.032"

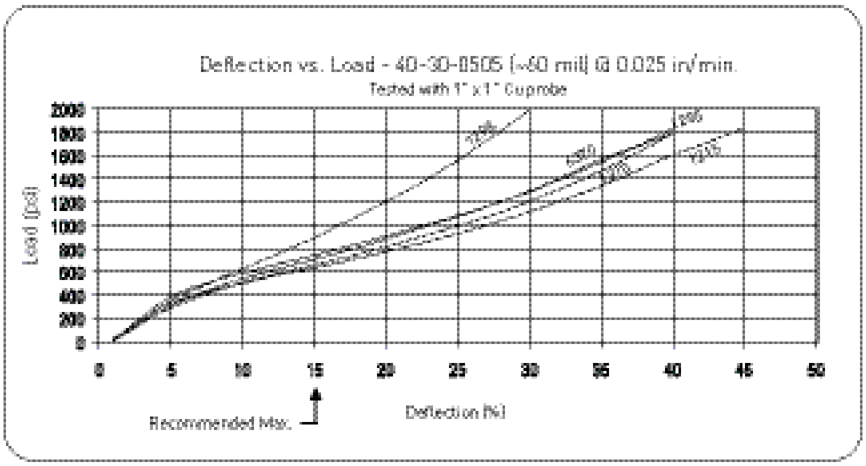


Figure 6. Sheet Stock 0.062"

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.

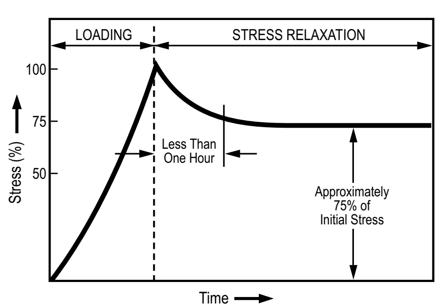


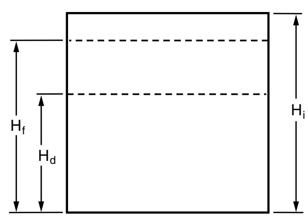
Figure 7. Stress Relaxation

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 reseated 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)

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

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 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.

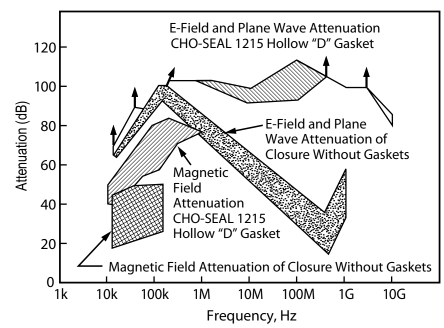


Figure 9. Shielding Effectiveness of a Shelter Door Gasket (14 kHz to 10 GHz)

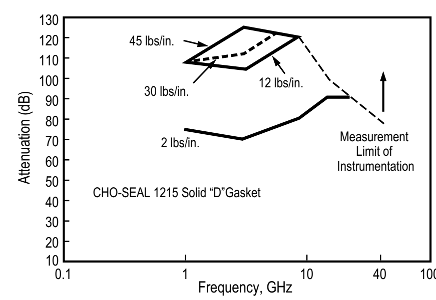


Figure 10. Effect of Closure Force on Shielding Effectiveness (1 GHz to 40 GHz)

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.

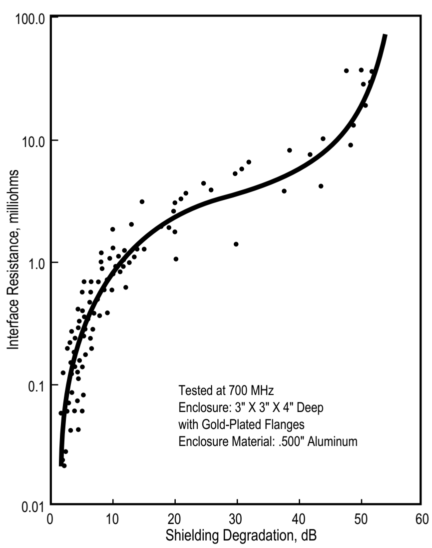


Figure 11. Interface Resistance vs. Shielding Degradation at a Flange Joint

EMP Survivability

In order for an enclosure to continue providing EMI isolation during and after an EMP 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 types of conductive elastomer gaskets. Note that gaskets based on silver-plated-glass fillers

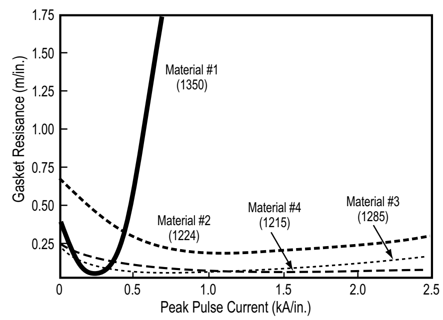


Figure 12. EMP Current Response of Conductive Elastomer Gaskets

(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 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

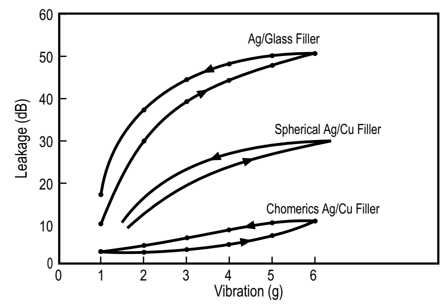


Figure 14. Effects of Vibration on Shielding Effectiveness of Conductive Elastomer Gaskets

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.

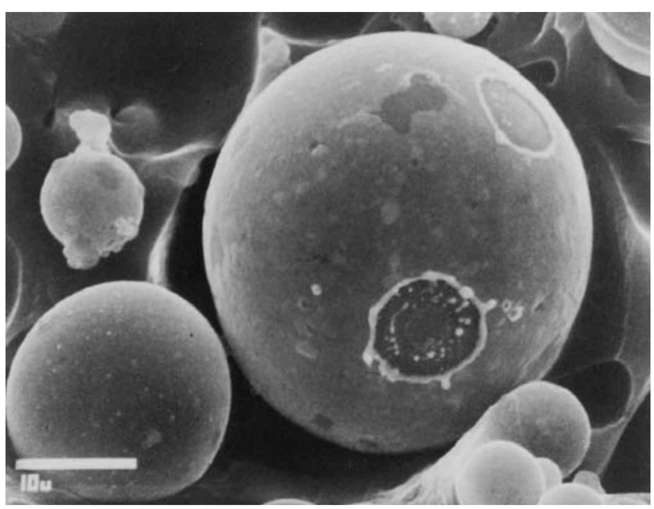


Figure 13. Scanning Electron Microscopy Illustrates EMP Damage Mechanism for Silver/Glass Elastomers

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.

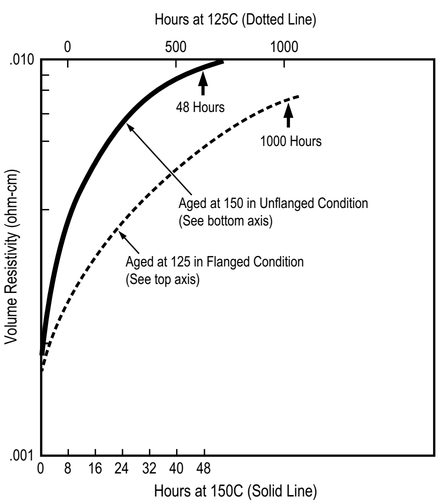


Figure 15. Typical heat aging characteristics of Chomerics plated-powder-filled conductive elastomers. Flanged 1000-hr test recommended for qualification. Unflanged 48-hr. test recommended for QC acceptance.

Outgassing

Many spacecraft specifications require that nonmetallic components be virtually free of 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 20. The normal specification limits or guide-lines on outgassing for NASA applications are 1% TML max., and 0.1% CVCM max.

Table 20: 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

CHO-SEAL® 1298 Corrosion Resistant EMI Shielding Gasket

KEY FEATURES

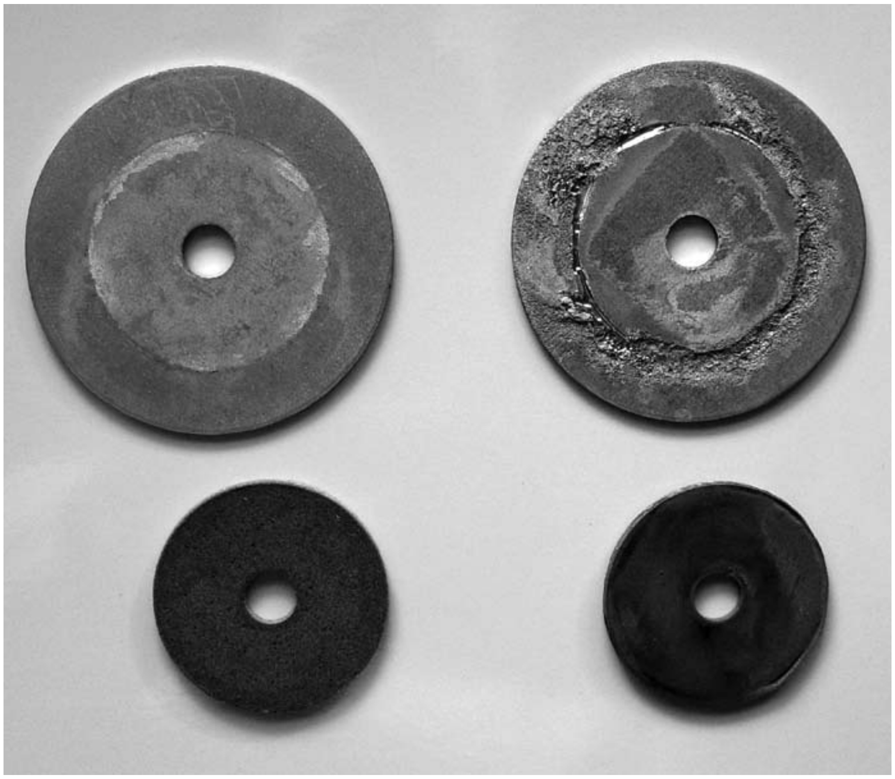
- New particle technology offers increased corrosion resistance with no chromates
- 90 dB shielding effectiveness – 100 MHz-10 GHz
- Meets all requirements of MIL-DTL-83528 Type D (initial and aged)
- Excellent resistance to jet fuels and fluids used in aviation and industrial applications.

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

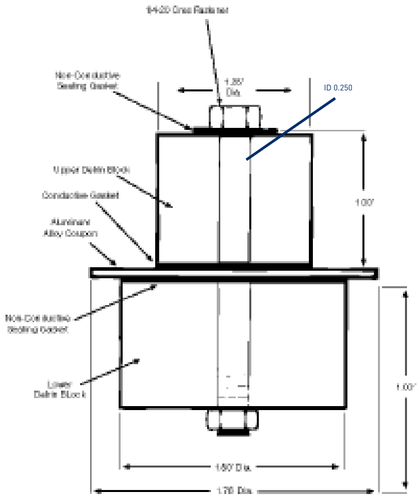


Figure 1: Test Fixture

bolt conductive elastomer/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 SO_2 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 SO_2 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 sealing system. Superior corrosion proof

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

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

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 SO_2 Salt Fog

	Volume Resistivity (ohm-cm)	
Material Type	**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 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 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-

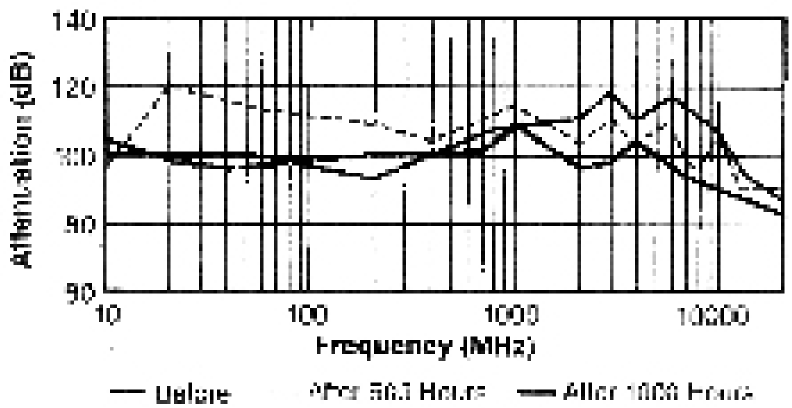


Figure 2: CHO-SEAL® 1298 Gasket Against Aluminum (CHO-SHIELD 2001 Coating) Before and After 500 and 1000 Hours of Salt Fog Exposure

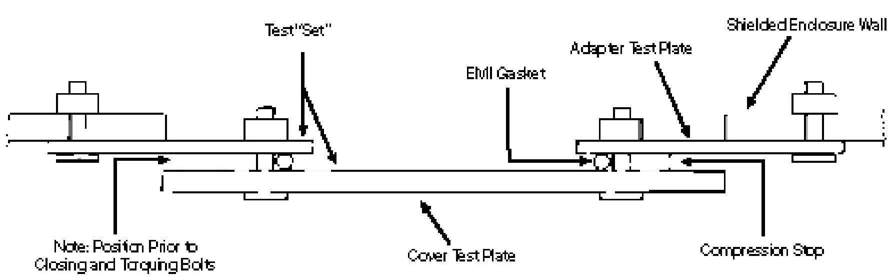


Figure 3: Test Set Assembly

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:
DELRIN is a registered trademark of E.I. DuPont de Nemours and Company.
DACRON is a registered trademark of Invista.

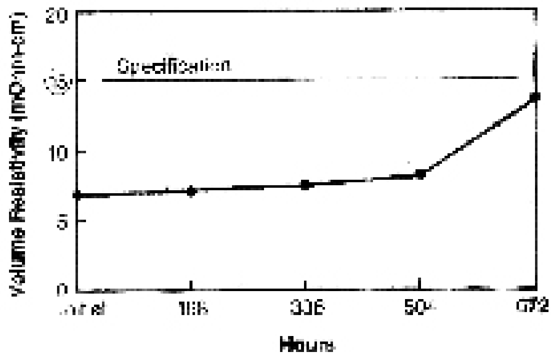


Figure 4: Volume Resistivity of the CHO-SEAL® 1298 EMI Gasket After Salt Fog Exposure

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-TR19E S.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, either solid or hollow.

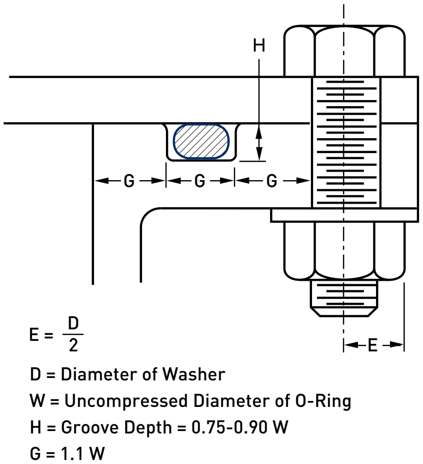


Figure 1. Machined Flange with Gasket Groove

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 µin. (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.

A basic difference between flanges constructed from sheet metal and those which are machined from

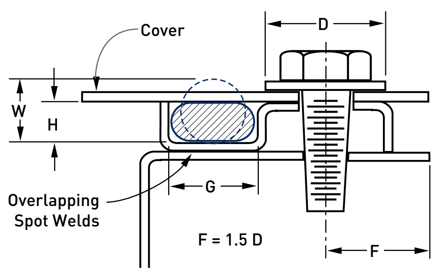


Figure 2a. Shaped Sheet Metal Container

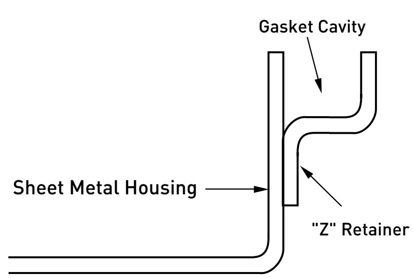


Figure 2b. Z-Retainer Forms Gasket Cavity

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 the flange to prevent tearing when the metal is punched.

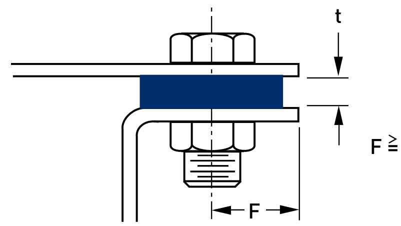


Figure 3. Flat Gasket on Sheet Metal Flange

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

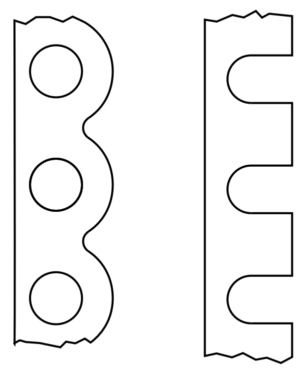


Figure 4. Ears or Slots in Sheet Metal Flanges or Flat Gaskets

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

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.

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.

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 tarrnish	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 expoxy 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

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.

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 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.

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 Calamel 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.

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.

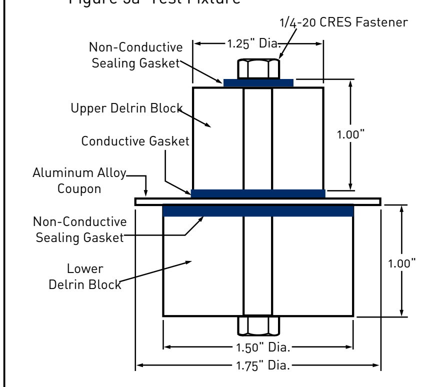


Figure 5a Test Fixture

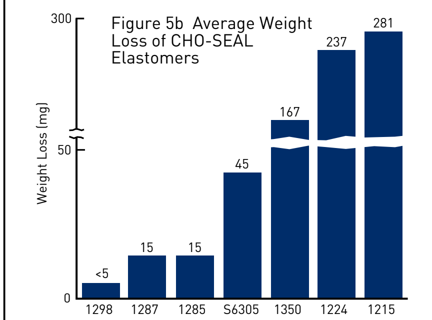


Figure 5b Average Weight Loss of CHO-SEAL Elastomers

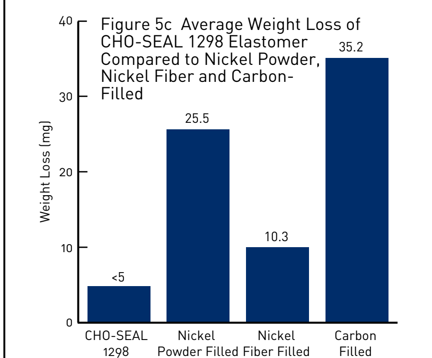


Figure 5c Average Weight Loss of CHO-SEAL 1298 Elastomer Compared to Nickel Powder, Nickel Fiber and Carbon-Filled

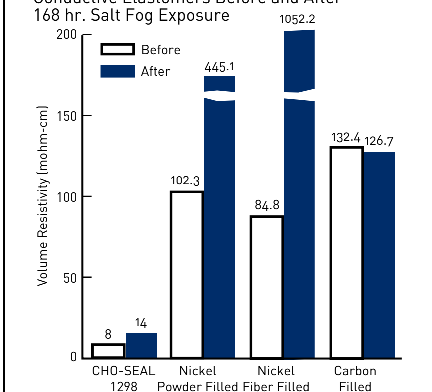


Figure 5d Volume Resistivity (mohm-cm) of Conductive Elastomers Before and After 168 hr. Salt Fog Exposure

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 iridited 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 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).

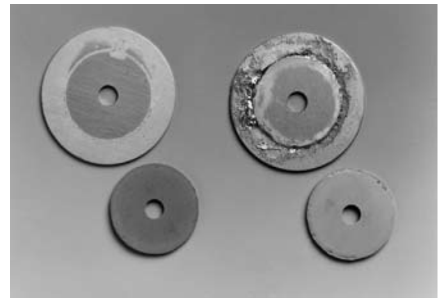


Figure 6. Comparison of corrosion results obtained from CHO-SEAL® 1298 conductive elastomer (left) and pure silver-filled elastomer (right) mated with aluminum after 168 hours of salt fog exposure.

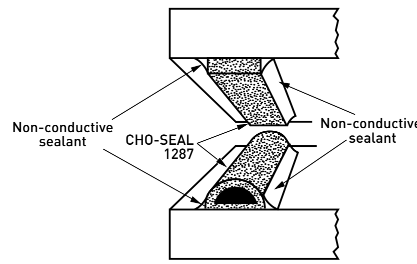


Figure 7. "Seal-to-seal" design incorporating CHO-SEAL® 1287 conductive silver-aluminum fluorosilicone gaskets on both mating flange surfaces. Gaskets are bonded and edge sealed to prevent moisture from entering the gasket/flange area.

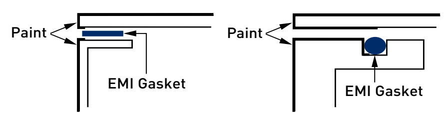


Figure 8. Non-Conductive Paint Intrudes Slightly Under Gasket to Provide Edge Protection

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).

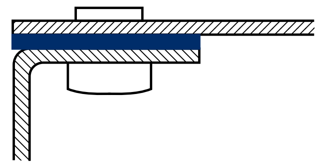


Figure 9a. External Bolting Prevents EMI Leakage

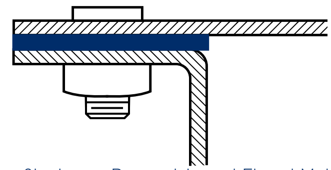


Figure 9b. Insert Pressed-In and Flared Makes EMI Tight Joint (Alternate: Weld or Cement with Conductive Epoxy)

2. Shaped or Molded Gaskets

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

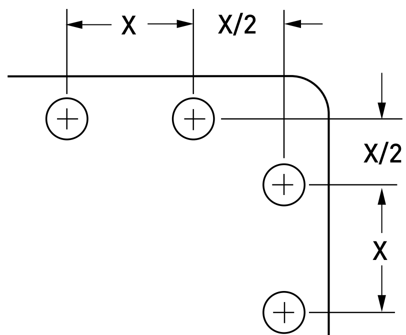


Figure 10. Fastener Location Near Corners

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 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

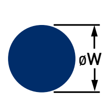
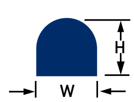
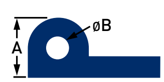
								
Deflection Range	øW	Deflection Range	H	Deflection Range	T	Deflection Range	A	øB
0.007-0.018 (0.178-0.457)	0.070 (1.778)	0.005-0.014 (0.127-0.356)	0.068 (1.727)	0.001-0.003 (0.025-0.076)	0.020 (0.508)	0.020-0.080 (0.508-2.032)	0.200 (5.08)	0.080 (2.032)
0.010-0.026 (0.254-0.660)	0.103 (2.616)	0.007-0.018 (0.178-0.457)	0.089 (2.261)	0.002-0.005 (0.051-0.127)	0.032 (0.813)	0.025-0.125 (0.635-3.175)	0.250 (6.35)	0.125 (3.175)
0.013-0.031 (0.330-0.787)	0.125 (3.175)	0.010-0.026 (0.254-0.660)	0.131 (3.327)	0.003-0.009 0.076-0.229)	0.062 (1.575)	0.036-0.255 (0.914-6.477)	0.360 (9.144)	0.255 (6.477)
0.014-0.035 (0.356-0.889)	0.139 (3.531)	0.012-0.031 (0.305-0.787)	0.156 (3.962)	0.005-0.014 (0.127-0.356)	0.093 (2.362)			
		0.014-0.035 (0.356-0.889)	0.175 (4.445)					

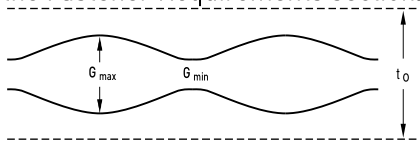
Figure 11. Gasket Deflection Ranges (mm dimensions in parentheses)

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.



$t_0 = 4\,(G_{max} - G_{min})$
(t_0 = Original thickness of gasket)

Figure 12. Gasket Deflection Along a Flange

Table 4. General Tolerances

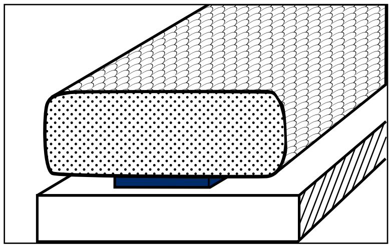
FLAT DIE-CUT GASKETS	
inch (mm)	Tolerance
Overall Dimensions	
≤10 (254)	±0.010 (0.25)
>10 to ≤15 (254 to 381)	±0.020 (0.51)
>15 (>381)	±0.20% Nom. Dim.
Thickness	
0.020 (0.51)	±0.004 (0.10)
0.032 (0.81)	±0.005 (0.13)
0.045 (1.14)	±0.006 (0.15)
0.062 (1.57)	±0.007 (0.18)
0.093 (2.36)	±0.010 (0.25)
0.125 (3.18)	±0.010 (0.25)
>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)	

MOLDED GASKETS	
inch (mm)	Tolerance
Overall Dimensions	
0.100 to 1.500 (2.54 to 38.10)	±0.010 (0.25)
1.501 to 2.500 (38.13 to 63.50)	±0.015 (0.38)
2.501 to 4.500 (63.53 to 114.30)	±0.020 (0.51)
4.501 to 7.000 (114.33 to 177.80)	±0.025 (0.64)
>7.000 (>177.80)	±0.35% Nom. Dim.
Cross Section	
0.040 to 0.069 (1.02 to 1.75)	±0.003 (0.08)
0.070 to 0.100 (1.78 to 2.54)	±0.004 (0.11)
0.101 to 0.200 (2.57 to 5.08)	±0.005 (0.13)
0.201 to 0.350 (5.11 to 8.89)	±0.008 (0.20)

EXTRUDED STRIP GASKETS	
inch (mm)	Tolerance
Cut Length	
<1.000 (25.40)	±0.020 (0.51)
1.0 to 30.000 (25.40 to 762)	±0.062 (1.58)
> 30.000 (762)	±0.20% Nom. Dim.
Cross Section	
< 0.200 (5.08)	±0.005 (0.13)
0.200-0.349 (5.08-8.86)	±0.008 (0.20)
0.350-0.500 (8.89-12.70)	±0.010 (0.25)
>0.500 (12.70)	±3% Nom. Dim.

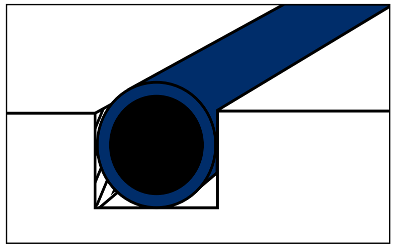
Gasket Mounting Choices

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.



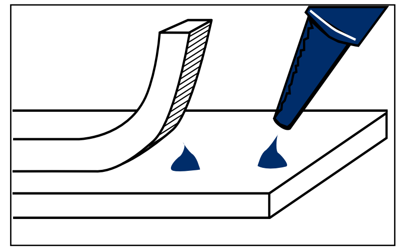
Pressure-Sensitive Adhesive
Quick, efficient attachment strip

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



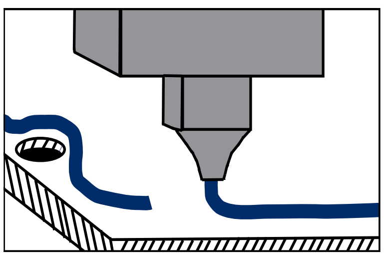
Friction Fit in a Groove
Prevents over-deflection of gasket
Retaining groove required

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

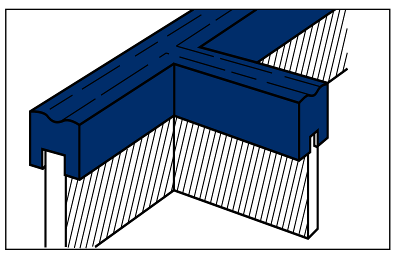


Adhesive Compounds
Conductive or non-conductive spot bonding

- Conductive Elastomers
- MESH STRIP™

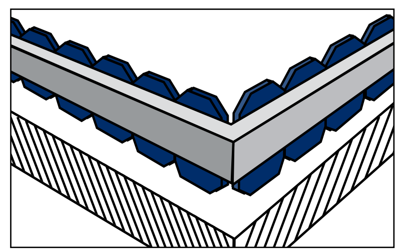


Robotically Dispensed Form-in-Place Conductive Elastomer
Chomerics' CHOFORM® automated technology applies high quality conductive elastomer gaskets to metal or plastic housings. Manufacturing options include Chomerics facilities, authorized Application Partners, and turnkey systems.

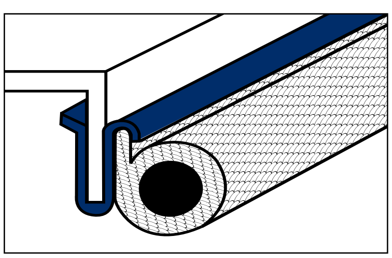


Friction Fit on Tangs
Accommodates thin walls, intricate shapes

- Conductive Elastomers

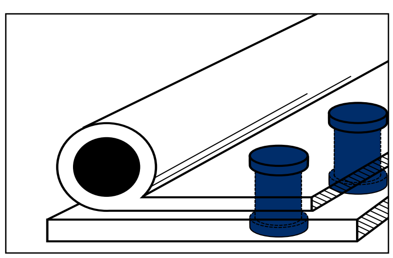


Spacer Gaskets
Fully customized, integral conductive elastomer and plastic spacer provide economical EMI shielding and grounding in small enclosures. Locator pins ensure accurate and easy installation, manually or robotically.



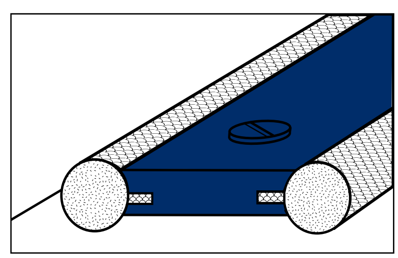
Metal Clips
Teeth bite through painted panels
Require knife edge mounting flange

- 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.

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 x 10^7. The modulus for aluminum is typically 1 x 10^7, and for brass it is about 1.4 x 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 expression[2]: $I_f = \frac{bh^3}{12}$

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.

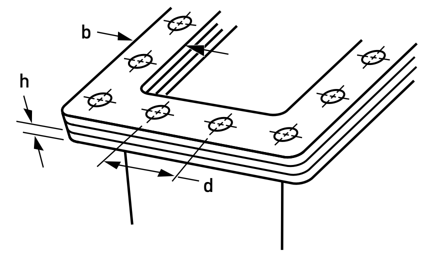


Figure 12. Bolt Spacings for Flanges

Assume the flange is to be made of aluminum.

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

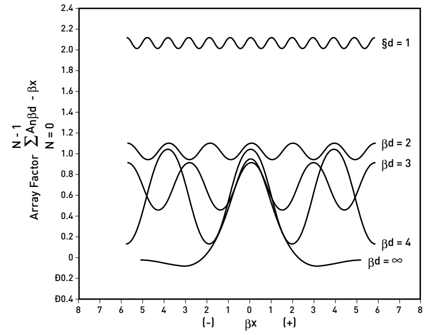


Figure 13. Array Factor vs. Spacing

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.

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:

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

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

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.

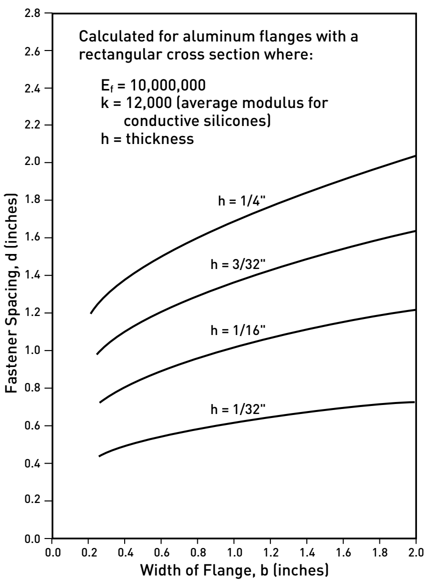


Figure 14. Fastener Spacing

For βd = 2, the flange deflection fluctuates by ±10 percent. Minimum deflection occurs midway between 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 apply adequate force for mild steel bolts is shown in Table 5.

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

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

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

Frequently the general value of 0.2 for the coefficient of friction can 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

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	4¾		0.0958
	48	6		0.0985
#5	40	7		0.1088
	44	8½		0.1102
#6	32	8¾		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

tighten the seal. Should the equipment be subjected to low 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 βd = 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

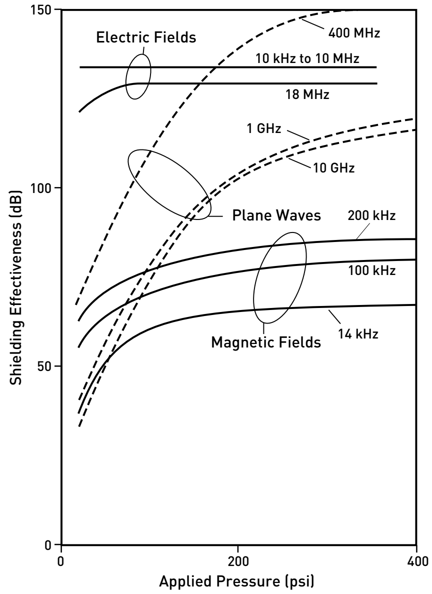


Figure 15. Shielding Effectiveness vs. Applied Pressure

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 βd = 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

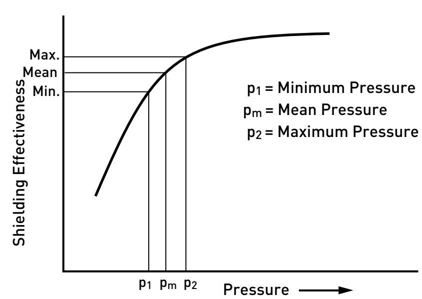


Figure 16. Typical Gasket Performance Curve

function of the minimum pressure, p1. 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.

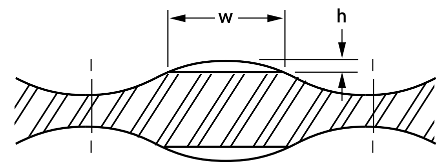


Figure 17. Unfilled Slot is Free to Radiate When Spacing is Equal to 1/2 Wavelength

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

$$A(dB) = 54.5\, d/\lambda c$$

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 βd = 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 toleranced 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 overfill, 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.

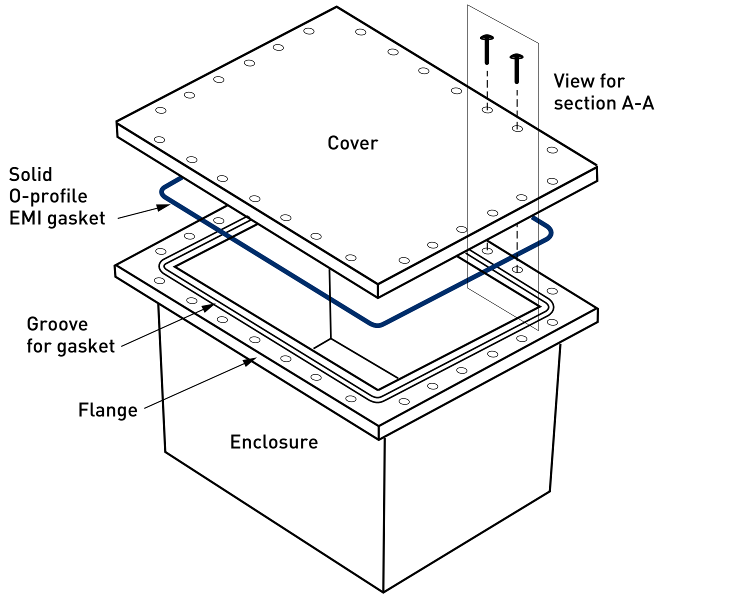


Figure 18a. Exploded View of Electronic Enclosure

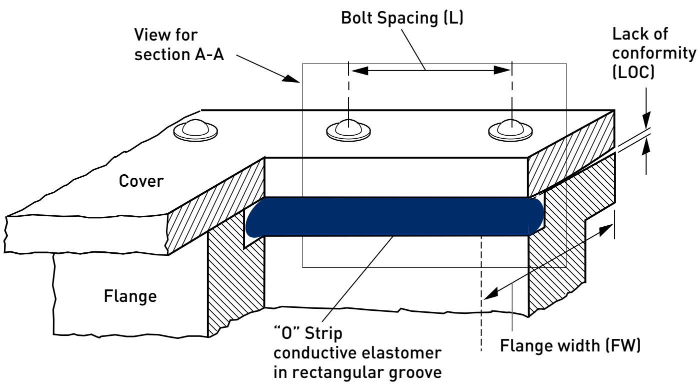


Figure 18b. Cut-away View of Assembly

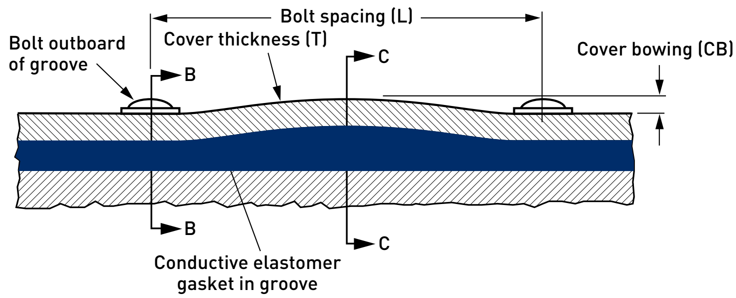
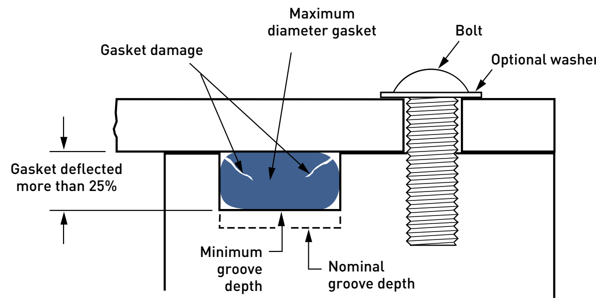


Figure 18c. Section A-A of Assembled Enclosure Flange and Gasket (Sectioned midway through gasket and groove)

Gasket Design

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.

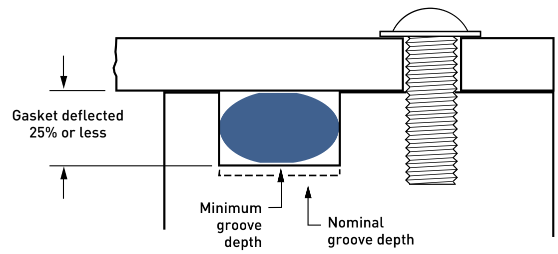
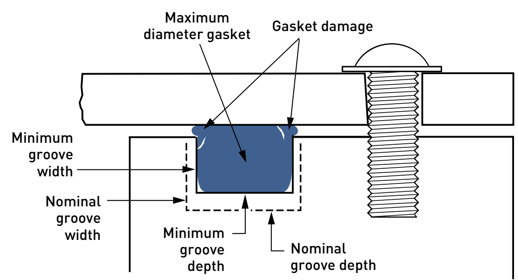


Figure 18e Section B-B from Figure 18c – Worst Case Maximum Groove Fill (Maximum gasket diameter in minimum groove depth and width)

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.

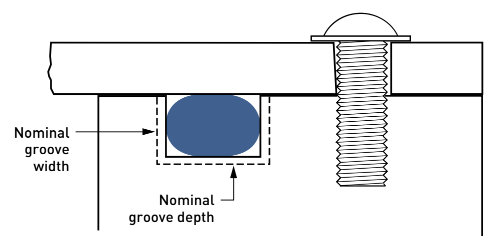
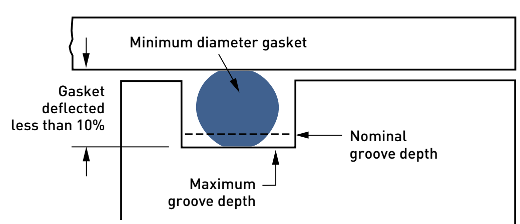
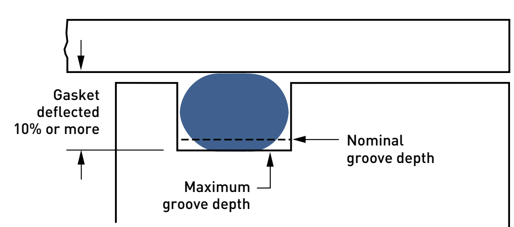


Figure 18f Section C-C from Figure 18c – Worst Case Minimum Deflection (Minimum gasket diameter in maximum depth groove, aggravated by cover bowing and lack of conformity between mating surfaces)

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.

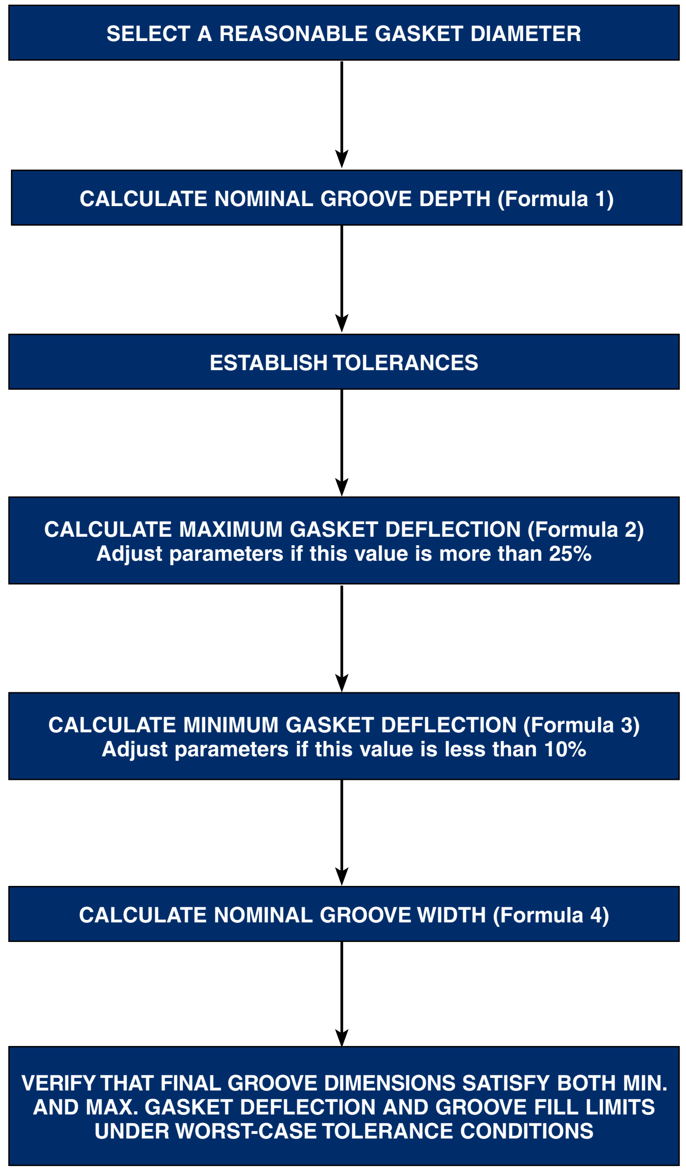


Calculating the Dimensions and Tolerances for the Groove and EMI Gasket

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 ÷ 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

$$GrD_{nom} = 0.82\ GaD_{nom}$$

2. Maximum Gasket Deflection
(Worst Case, expressed as a % of gasket diameter)

$$GaDf_{max} = 100 \left[\frac{(GaD_{nom} + GaT) - (GrD_{nom} - GrDT)}{(GaD_{nom} + GaT)} \right]$$

3. Minimum Gasket Deflection
(Worst Case, expressed as a % of gasket diameter)

a. $$GaDf_{min} = 10 \left[\frac{(GaD_{nom} + GaT) - (GrD_{nom} + GrDT) - CB - LOC}{(GaD_{nom} - GaT)} \right]$$

where

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

(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

a. $GaA_{max} = 0.7854^* (GaD_{nom} + GaT)^2$

b. $$GrW_{min} = \frac{GaA_{max}}{GrD_{min}}$$

c. $GrW_{nom} = GrW_{min} + GrWT$

*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 (in^2 or mm^2)

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 1×10^7 psi, or 7×10^5 kg/cm^2.)

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.

CHOMERICS DIVISION OF PARKER HANNIFIN CORPORATION TERMS AND CONDITIONS OF SALE (7/21/04)

1. Terms and Conditions of Sale: All descriptions, quotations, proposals, offers, acknowledgments, acceptances and sales of Seller's products are subject to and shall be governed exclusively by the terms and conditions stated herein. Seller's prices for the products have been established on the understanding and condition that the terms set forth herein shall apply to this sale to the exclusion of any other terms. Seller expressly reserves the right to an equitable adjustment to the price in the event that any material provision hereof is deemed not to govern the rights and obligations of the parties hereto. Buyer's acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of an offer by Seller, are hereby objected to. No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller. Seller's acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer's assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer's offer. Acceptance of Seller's products shall in all events constitute such assent.

2. Product Selection. If Seller has provided Buyer with any component and/or system recommendations, such recommendations are based on data and specifications supplied to Seller by Buyer. Final acceptance and approval of the individual components as well as the system must be made by the Buyer after testing their performance and endurance in the entire application under all conditions which might be encountered.

3. Payment: Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

4. Delivery: Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

5. Warranty: Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 365 days from the date of shipment to Buyer. THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED.

NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED, WHOLLY OR PARTIALLY, TO BUYER'S DESIGNS OR SPECIFICATIONS.

6. Limitation of Remedy: SELLER'S LIABILITY ARISING FROM OR IN ANY WAY CONNECTED WITH THE ITEMS SOLD OR THIS CONTRACT SHALL BE LIMITED EXCLUSIVELY TO REPAIR OR REPLACEMENT OF THE ITEMS SOLD OR REFUND OF THE PURCHASE PRICE PAID BY BUYER, AT SELLER'S SOLE OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING FROM OR IN ANY WAY CONNECTED WITH THIS AGREEMENT OR ITEMS SOLD HEREUNDER, WHETHER ALLEGED TO ARISE FROM BREACH OF CONTRACT, EXPRESS OR IMPLIED WARRANTY, OR IN TORT, INCLUDING WITHOUT LIMITATION, NEGLIGENCE, FAILURE TO WARN OR STRICT LIABILITY.

7. Inspection: Seller shall be given the opportunity to correct or replace defective products prior to cancellation. Final acceptance by Buyer shall take place not later than 90 days after shipment.

8. Changes, Reschedules and Cancellations: Buyer may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order; however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller's discretion, and shall be upon such terms and conditions as Seller may require.

9. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, 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 charg-

es 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 noninfringing, 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

crues.

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 it 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.

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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/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

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Parker Chomerics

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