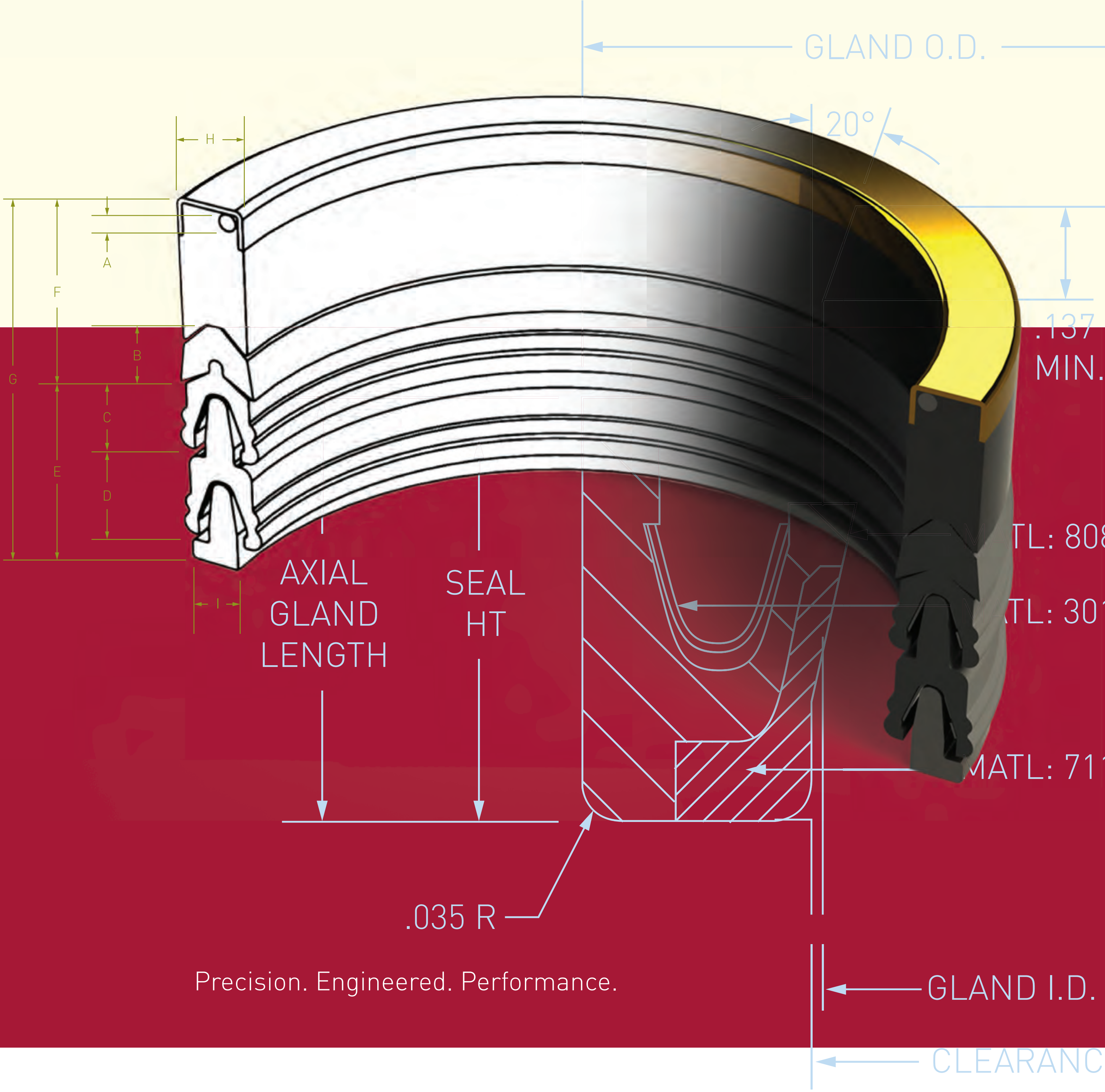
The **OptiSeal®** System

A Custom Engineered Sealing Solution



Precision. Engineered. Performance.

A member of the global group Fenner

CDI ENERGY PRODUCTS

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Products and Solutions for the Energy Industry

As applications make high demands on the performance of critical equipment, energy companies look for innovative engineering designs to protect their assets, personnel, and the environment. With decades of experience in providing leading-edge critical service sealing solutions for some of the industry's toughest challenges, CDI Energy Products is your responsive partner.

Materials Science, Engineering Design, and Manufacturing

The broad range of customized seals and packing assemblies offered by CDI Energy Products is backed by extensive research and some of the industry's most advanced manufacturing capabilities. Our multidisciplinary project team provides you with a versatile resource for developing unique sealing solutions for your applications.

Materials Science Expertise

Ready to implement the latest advancements in materials science, our engineering team provides sealing solutions capable of withstanding the broad range of pressures, temperatures, and media found in the energy industry.

Our materials portfolio, which includes API-, NACE-, ISO-, and NORSOK-approved compounds, is continually updated by a global team of material scientists on the forefront of new technology development.

Table 1. CDI Materials Portfolio

To provide the best solution for every application,
CDI experts work with a portfolio of materials including:

- NBR
- HNBR
- XNBR
- PA (Nylon)
- FKM (Viton®, Fluorel®)
- FFKM
- EPM, EPDM
- FEPM (Aflas®)
- PFA
- PVDF (Kynar®)
- CTFE
- PEI (Ultem®)
- PI (Vespel®)
- PE, UHMW
- POM (Acetal, Delrin®)
- ETFE (Tefzel®)
- ECTFE (Halar®)
- Polypropylene
- PPS (Ryton®, Fortron®)
- PEEK, PEK, PEKEKK, PEKK
- PTFE (Teflon®)
- M-PTFE
- FVMQ (Fluorosilicone)
- Filled PTFE
- PF (Phenolic)
- Fluoropolymers
- Patented SinterMesh®
- Engineered thermoplastics
- Polyurethane

We are CDI Energy Products, specialists in engineered sealing solutions.

With multiple locations around the world, we are your global partner in engineering critical sealing solutions, on time and to your specification.

Custom seals and seal assemblies for the most extreme conditions, including:

- **High-pressure and low-pressure ranges**
- **Broad temperature requirements**
- **Large extrusion gaps**
- **Static and dynamic applications**
- **Potential misalignment**
  - **Run-out**
- **Rough surface finishes**
- **Fire-safe applications**
- **Fugitive emissions requirements**

Engineering Design

We design and manufacture custom elastomeric seals, plastic components, and ancillary metal sealing components able to withstand the extremes of the global energy industry. As an industry leader in providing innovative, high-performance engineered solutions, we apply advanced materials science, superior design, and a broad system of manufacturing processes to provide what you need, when you need it.

The spring-energized OptiSeal system has been designed, manufactured, and marketed by CDI Energy Products for more than three decades. Years of engineering and design expertise have resulted in a robust sealing system able to withstand variations in temperature, pressure, and media while providing a superior, high-performance seal.

Manufacturing

Each customized solution benefits from our extensive machining and molding capabilities. Our highly skilled manufacturing specialists and programmers apply unique designs to precisely transform advanced materials into finished products that meet your specifications.

Sophisticated CNC machining equipment greatly enhances our manufacturing flexibility, versatility, and process control. A range of manufacturing processes and methods enables us to produce with efficiency, high quality, and tight tolerance control. With manufacturing facilities in the US, Singapore, Germany, Brazil, and the UK, we employ more than 30 different molding methods and manufacturing processes, including:

- Bonding
  - Rubber-Metal
  - Rubber-Plastic
  - Rubber-Rubber
- Composite Fabrication
- Compression Molding
  - Rubber
  - PTFE
  - Advanced Thermoplastics
- Custom Compounding
- Custom Tooling and Machine Designs
- Extrusion
  - Melt
  - Paste
  - Ram
- Injection Molding
- Isostatic Molding
- Machining
  - CNC
  - Manual
  - Screw

1. Seal Design

Basic Configuration

The OptiSeal® system is a high-performance, low-friction, full-spectrum sealing solution. This widely used spring-energized seal offers performance benefits ranging from enhanced media compatibility to superior performance in broad temperature ranges.

The basic design consists of a U-shaped jacket made from inert thermoplastic materials specifically selected for the application. The addition of a metal spring actuates the jacket material used in the system, which provides sealing at low system pressures. At higher system pressures, the seal becomes pressure-energized by the fluid media—a sealing combination that ensures adequate sealing throughout the entire pressure range.

By coupling the OptiSeal system with other specialty components such as anti-extrusion devices, PakRings, V-Rings, adapters, bushings, and bearings, users can achieve an expanded operational envelope.

With diameters from .040" (1mm) to 110" (2,8m), customizable heights, and special geometries, the OptiSeal system can be configured to fit in almost any hardware, making it the ideal choice for critical-service sealing.

Common Seal Functions

- Retains lubrication
- Excludes contaminants
- Separates media
- Seals under pressure

Design Criteria and Considerations

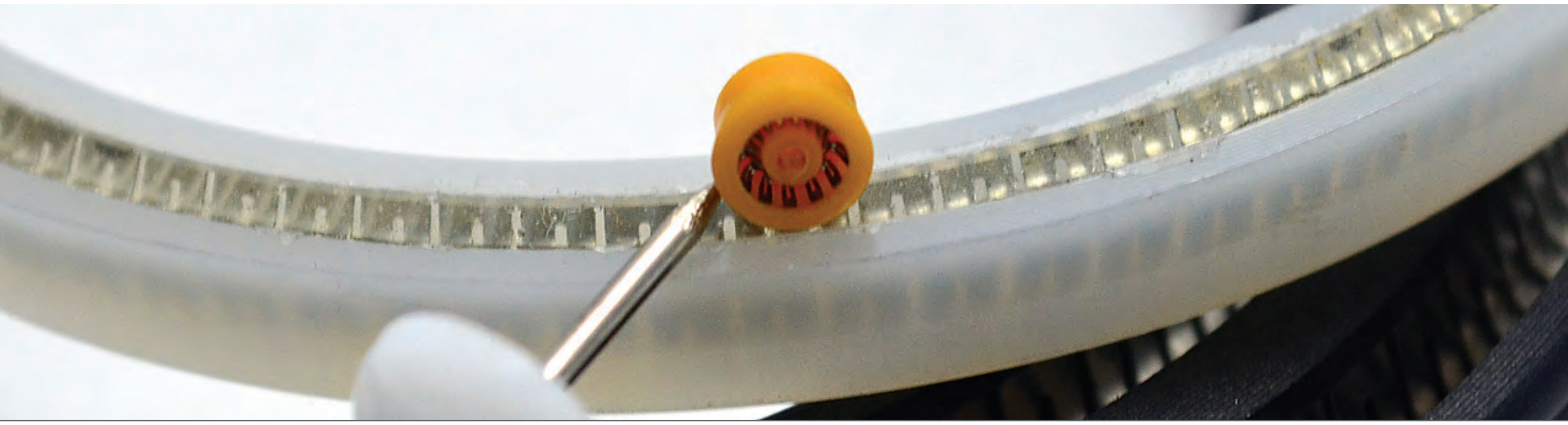
In designing the ideal sealing solution for your application, our team of experts carefully evaluates and incorporates seal design parameters based on your specific requirements.

Evaluating Factors and Conditions

- Temperature
- Pressure
- Velocity
- Media or chemical resistance
- Material
- Friction
- Wear resistance
- Extrusion gap
- Hardware (gland envelope)
- Service requirements
- Seal geometry
- Industry and customer specifications

Table 2. Parameters for Seal Design

Seal Applications	Environmental	Service Life
• Fluid power • Pneumatic • Energy or shock absorption • Media separation • Pressure containment	• Pressure • Temperature • Aggressive media • Wet or dry environment • Continuous or cyclical loads • Dynamic or static stress • Fluid compatibility	• Wear resistance • Material properties • Resistance to creep and cold flow • Compression set • Resistance to aging and embrittlement • Resilience



2. Material Selection

Common Material Testing

We perform plastic and elastomeric material testing to various national standards (such as ASTM and ISO) to ensure CDI products meet the pressure, thermal, extrusion, life cycle, and operational performance required by our customers.

Table 3. Material Testing

Material Type	Testing Performed
Elastomers & Thermoplastics	**Compressive properties:** Useful in determining pressure resistance capabilities for various materials. In conjunction with other data, this testing determines overall mechanical properties. **Hardness:** Durometer testing is for process control purposes. No simple relationship exists between hardness and any fundamental physical property. **Heat aging:** Provides materials with resistance to long-term dry heat exposure. **Immersion testing:** Provides resistance and chemical compatibility of a material to various media at operational parameters such as time, temperature, pressure, and concentration. **Specific gravity:** The ratio of the density of a material to the density of water. It is used as a quality assurance measurement to assure lot-to-lot consistency. **Stress-strain properties:** Physical properties for tensile strength, elongation, modulus, and tear are used for material selection and quality control.
Elastomers	**Adhesion:** Primarily a quality control test for the bonding of dissimilar materials. **Compression set:** A measure of permanent deformation after aging in a compressed state. **Tear resistance:** A force measurement to determine a material's resistance to crack, propagation, and tear.
Thermoplastics	**Deflection temperature:** The temperature at which a plastic beam will deflect with a given load to a predetermined distance.

In addition to the tests listed above, CDI Energy Products can conduct other tests to meet your specific needs and requirements.

Available Certifications

Each polymer type and material compound has its own group of applicable tests, available certifications, and industry standards. When developing a material specification, OEMs and service companies may develop requirements based on the needs of their individual applications.

To address these concerns, our material specialists are able to conduct standard tests for each of our materials, as well as develop additional test values per your specification. CDI Energy Products is always available to help you write meaningful specifications, and to provide certification. The chart below shows the standard test data available for various material types:

Table 4. Material Certifications

Data and Certifications	Elastomeric Compounds		PTFE Compounds		Thermoplastic Compounds	
Typical Data Available for a Certificate of Conformance (COC)	**Type-A Hardness**	D2240	**Type-D Hardness**	D2240	N.A.	N.A.
Standard Data Typically Available for a Physical Property Certification (C11)	**Tensile**	D412	**Tensile**	D1708/D638	**Tensile**	D638
	Elongation	D412	**Elongation**	D1708/D638	**Elongation**	D638
	100% Modulus	D412	**Specific Gravity**	D792	**Flex Modulus**	D790
	Specific Gravity	D792	**Type-D Hardness**	D2240	**Specific Gravity**	D792
	Type-A Hardness	D2240				
Additional Information Available with Additional Charges and Lead Time	**Compression Set**	D395B	Consult CDI Materials Engineering		**Type-D Hardness**	D2240
	Immersions	D471			**Notched Izod**	D256
Notes:	Other tests can be provided on a batch or qualification basis for an additional charge. Additional lead time required.		Overall standards are covered by the following ASTM standards: Filled Compounds - D4745 Unfilled/Virgin Resin - D4894/D4895		Other tests can be provided on a batch or qualification basis for an additional charge. Additional lead time required.	

Jacket Materials

Proper material selection and compatibility rank high among the factors that contribute to good sealability. In seal design, materials are chosen for the physical attributes, performance properties, and performance characteristics required by the application.

The application environment, including temperature, pressure, and dynamic conditions, as well as design factors such as squeeze and seal geometry and energizer selection, are essential in material selection. The materials used in the OptiSeal® system perform exceptionally well in applications with variations in temperature, pressure, and media. The result is a sealing solution capable of performing in dynamic, hostile environments where standard elastomeric seals fail.

Table 5. Common Jacket Materials

Materials	Benefits and Features
PTFE	• Thermal stability across broad temperature range • Low coefficient of friction • Inherent lubricating properties • Excellent chemical and corrosion capabilities • Reduced stick-slip • Unlimited shelf life • No explosive decompression • No swelling due to moisture absorption • Safe for vacuum conditions • Excellent dielectrical properties
UHMW (PE)	• High toughness • High abrasion resistance • Self-lubricating • Low coefficient of friction • Broad chemical resistance
Elastomer	• Great sealability • High toughness • Very flexible • Broad selection of polymer types with unique properties • Available in both thermoset and thermoplastic
PEEK	• Excellent chemical and corrosion capabilities • Good extrusion resistance • Thermal stability across broad temperature range • Lubricated grades available • Wide range of mechanical properties
Acetal	• General-purpose plastic material • Very high flex or fatigue resistance • Low moisture absorption • Dimensionally stable

Fillers

To enhance performance capabilities, a range of fillers and additives can be added to materials. Reinforcing fibers, conductive fillers, and colorants are among the additives available.

Common Fillers

Glass Fibers The most common filler. Minor effect on electrical properties. Increased abrasion on mating metal surfaces.

Carbon/Carbon Fibers Low abrasion and wear. Good deformation and extrusion resistance.

Graphite Non-abrasive. Low friction. Minor effect on deformation properties.

MoS_2 Lowers break-in wear and starting friction.

Bronze Very high wear resistance and load bearing capability. Poor chemical resistance.

Stainless Steel High wear resistance and load bearing capability. Wider chemical resistance than bronze.

PPS Low wear and abrasion. Excellent deformation and extrusion resistance. Large reduction in tensile and elongation values.

CaF_2 Hydrofluoric acid service.

Mineral Properties similar to glass, but less abrasive.

While maintaining its inherent properties and characteristics in material compounds, PTFE can benefit from the improved mechanical strength, stability, and wear resistance provided by the additive. The various mechanical properties of PTFE can be enhanced by adding a range of fillers, including glass fiber, carbon, and bronze.

Table 6. Fillers and Their Relative Effects on PTFE

Filler	Wear Resistance	Friction	Creep Resistance	Thermal Conductivity	Mating Metal Wear	Electrical Resistance
Glass Fibers	▲▲▲	▲▲	▲▲	▲	▲▲▲	▲
Carbon	▲▲▲	▲	▲▲▲	▲▲	▲	▼
Graphite	▲▲	◆	▲▲	▲▲	◆	▼▼
MoS_2	▲	◆	◆	▲	◆	▼
Bronze	▲▲▲	▲▲	▲▲	▲▲▲	▲	▼▼
Carbon Fibers	▲▲▲	▲	▲▲	▲▲	▲	▼
Mineral	▲▲▲	▲▲	▲▲	▲▲	▲▲	◆
Stainless Steel	▲▲▲	▲▲	▲▲	▲▲▲	▲▲	▼▼
High-Temp Polymers	▲▲▲	▲	▲▲▲	◆	◆	◆

Effect Trend

▲	Slight Increase	▼	Slight Decrease	◆	No Effect
▲▲	Moderate Increase	▼▼	Moderate Decrease		
▲▲▲	Significant Increase	▼▼▼	Significant Decrease		

Table 7. Common PTFE Jacket Materials

Compound	Polymer	Filler	Color	Abrasion Resistance	Metal Mating Wear	Relative Sealability	Relative Extrusion Resistance	NORSOK M710 Compound	Media Resistance: Hydrocarbons	Oxygenated Solvents	Steam	Acids	Bases	Operating Temperatures F°	C°
700	PTFE	None	White	P	L	E	P	Yes	E	E	E	S	S	-300° to +400°	-184° to +204°
701	PTFE	25% Glass	White	E	H	G	E	Yes	E	E	E	S	S	-100° to +550°	-73° to +288°
702	PTFE	15% Glass, 5% MoS_2	Gray	E	H	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
711	PTFE	25% Carbon, Graphite	Black	G	M	G	E	Yes	E	E	E	S	S	-100° to +550°	-73° to +288°
755	PTFE	10% Ekonol®	Cream	E	L	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
782	PTFE	15% Carbon Fiber	Black	G	M	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
777	MPTFE	Premium Virgin	White	P	L	E	G	Yes	E	E	E	S	S	-300° to +450°	-184° to +232°
Key		E-Excellent G-Good H-High M-Medium L-Low P-Poor NR-Not Recommended										W-Resistant to weak acid/base S-Resistant to strong acid/base			

Conditions shown are approximate. Actual operating conditions are contingent upon media, pressure, and design factors as well as polymer types. Testing in your assembly is always recommended, especially when applications approach or exceed the conditions shown above.

Table 8. Specialty Jacket Materials

Compound	Polymer	Filler	Color	Abrasion Resistance	Metal Mating Wear	Relative Sealability	Relative Extrusion Resistance	NORSOK M710 Compound	Media Resistance					Operating Temperatures	
									Hydrocarbons	Oxygenated Solvents	Steam	Acids	Bases	F°	C°
703	PTFE	PPS, Carbon, MoS_2	Black	E	M	G	E		E	E	E	S	S	-100° to +550°	-73° to +288°
712	PTFE	5% MoS_2	Gray	A	L	E	A		E	E	E	S	S	-200° to +450°	-129° to +232°
716	PTFE	15% Graphite	Black	A	M	E	G	Yes	E	E	E	S	S	-100° to +500°	-73° to +260°
720	PTFE	2% Carbon	Black	A	L	E	A		E	E	E	S	S	-200° to +500°	-129° to +260°
721	PTFE	15% Mineral	White	G	M	G	G		E	E	E	W	S	-100° to +500°	-73° to +260°
733	PTFE	15% Carbon Graphite	Black	G	M	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
734	PTFE	10% Carbon Graphite	Black	G	M	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
741	PTFE	40% Bronze	Bronze	E	M	A	G		E	E	E	NR	W	-100° to +550°	-73° to +288°
756	PTFE	25% Ekonol®	Cream	E	M	G	E		E	E	E	S	S	-100° to +500°	-73° to +260°
777PS3	PTFE	$PPSO_2$	Cream	P	L	G	G		E	E	E	S	S	-100° to +500°	-73° to +260°
780	PTFE	None	Turquoise	A	L	E	A		E	E	E	S	S	-300° to +450°	-184° to +232°
728	ACETAL	None	Black	A	M	A	G		E	E	E	W	W	-70° to +300°	-56° to +149°
Arylex™ 745	PEEK	None	Beige	A	M	G	G	Yes	E	E	E	S	S	-70° to +500°	-56° to +260°
748	UHMWPE	None	Translucent	E	L	E	G		E	E	E	S	S	-300° to +180°	-184° to +82°

Key		
Key	E-Excellent G-Good H-High A-Average M-Medium L-Low P-Poor NR-Not Recommended	W-Resistant to weak acid/base S-Resistant to strong acid/base

Conditions shown are approximate. Actual operating conditions are contingent upon media, pressure, and design factors as well as polymer types. Testing in your assembly is always recommended, especially when applications approach or exceed the conditions shown above.

Proprietary Fillers and Compounds

The CDI material portfolio contains additional compounds and that are not mentioned in this listing. Our specialists can work with you to provide the ideal engineering solution for your specific needs. If your application requires a custom compound or material that is not listed, visit CDIproducts.com to submit your inquiry or submit an inquiry at CDI-Global.Sales@CDIproducts.com.

Jacket Material Suggestions

Table 9. This guide assists in selecting the appropriate jacket materials for a particular application.

Applications	STATIC			STATIC											
				Rotating				Oscillating				Reciprocating			
				Low Speed		High Speed		Low Speed		High Speed		Low Speed		High Speed	
	Low Pressure	Medium Pressure	High Pressure	Low Pressure	High Pressure	Low Pressure	High Pressure	Low Pressure	High Pressure	Low Pressure	High Pressure	Low Pressure	High Pressure	Low Pressure	High Pressure
Hydrocarbon Oils and Lubrication Typically fuels and lubricants of petroleum-based products	700	777 711	703 745 701	716 720 780	741 782	755 782	741 782	716 720 780	741 782 711	782 755	741 782	780 720 712	741 702 748 711	741 711	741 748
Pneumatic and Gases Primarily for air and other gases	700 777 748	777 748	777 748 745	780 777	755 782	711 755 782	782 756	780 777	755 782	782 755	782 756	780 777	748 777PS3	711 782	741 711
Chemical Processing Typical service includes the handling and dispensing of acidic and basic products	700 777	777 748	703 745 701	716 720	782 711	755 782	711 703	716 720 712	782 711	782 755	711 703	720 712	748 711	711 703	748 703

Conditions shown are approximate. Actual operating conditions are contingent upon media, pressure, and design factors as well as polymer types. Testing in your assembly is always recommended, especially when applications approach or exceed the conditions shown above.

Spring Types

The addition of a metal spring or elastomer actuates the jacket material used in the system. Upon seal installation, the spring energizer responds with an outward force, thereby energizing the jacket material and providing positive sealing. Characteristics such as load value, deflection range, and corrosion resistance are among the primary spring factors that affect seal performance in a given application.

V-Spring

The most versatile of all the spring types, the V-Spring design is suited for use in a wide range of applications and services, from static to those with rotary or reciprocating motion. The materials used in this design option enhance sealing performance without degradation of material properties.

Available in our internal and external pressure face seal design, the V-Spring energizer features a wide deflection range and can be designed with medium or heavy spring loads. This spring is a good choice for glands with wide tolerance variations.

Flat Band Helical

For applications with less dynamic operating conditions, the flat band helical spring design is an ideal choice because of its small deflection range. The high unit load of this spring-energized design makes it the optimal solution for static applications where wear and friction are not great concerns. In addition, it is the preferred design for cryogenic services.

Canted Coil

This spring offers light constant loading over a wide deflection range, reducing frictional drag and seal wear. Typically, applications include measurement and instrumentation, high speed/low pressure, and single-seal applications.

Table 10. Spring Materials

Material	Application Description	Media Resistance: Hydrocarbons	Media Resistance: Oxygenated Solvents	Media Resistance: Steam	Media Resistance: Acids	Media Resistance: Bases	Operating Temperatures F°	Operating Temperatures C°	Spring Type V	Spring Type Helicial
301 Stainless Steel	General Service Hydraulics	E	E	E	W	S	-300° to +400°	-184° to +204°	Yes	Yes
Elgiloy Alloy	Harsh Service, NACE MR-01-75	E	E	E	S	S	-300° to +800°	-184° to +427°	Yes	Yes
Inconel X750	Harsh Service, NACE MR-01-75	E	E	E	S	S	-300° to +800°	-184° to +427°	No	Yes
301 SS/ Silicone Filled	Food and Pharmaceuticals	P	E	E	W	W	-300° to +400°	-184° to +204°	Yes	No
Hastalloy		E	E	E	S	S	-300° to +800°	-184° to +427°	No	Yes

Key E-Excellent P-Poor W-Resistant to weak acid/base S-Restistant to strong acid/base

3. Configuration

Lip Profiles

Seal characteristics such as sealability, wear, and friction are greatly affected by lip profile construction and seal geometry. In addition to our standard forms, lip profiles can be customized for specific gland configurations such as highly abrasive environments and rough surface finishes.

S Lip **Double Radius Lip**

The S lip is the standard lip profile design. It offers redundant sealing surfaces with radiused contact areas for medium unit loading. This design feature provides the best combination of wear and sealability, making the S lip suitable for the widest range of applications.

Sealability: Medium **Wear:** Medium **Friction:** Medium

A Lip **Single Radius Lip**

The A lip employs a large radius, and therefore low unit loading, resulting in low friction and low wear. This lip profile is recommended for applications with high surface speeds or those that require low friction. The profile also facilitates installation in glands with insufficient lead-in chamfers.

Sealability: Low **Wear:** Low **Friction:** Low

B Lip **Bevel Lip**

The B lip profile produces the highest unit loading of all of the lip profiles offered by CDI. The B lip is recommended for use in static applications, and is required when the OptiSeal component diameter is less than 3/16" (4,7mm).

Sealability: High **Wear:** High **Friction:** High

D Lip **Scraper Lip**

The D lip profile's low unit loading characteristics offer long wear, with somewhat less effective sealing than higher unit loaded seals. This design is particularly well suited for reciprocating applications.

Sealability: Medium **Wear:** Low **Friction:** Medium

F Lip **Dual Scraper Lip**

The F lip features a profile suitable for systems contaminated with abrasives. Lower unit loadings offer extended seal life in rotary applications.

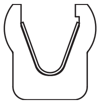
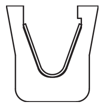
Sealability: Medium **Wear:** Medium **Friction:** Low

J Lip **Scraper Radius Lip**

The J lip also has redundant sealing surfaces, with the sharp front edge protecting the secondary, radiused surface from abrasive media. Besides use in scraping applications, this lip is also used with step-cut glands and is the preferred profile for use with high-viscosity media.

Sealability: Medium **Wear:** Medium **Friction:** Medium

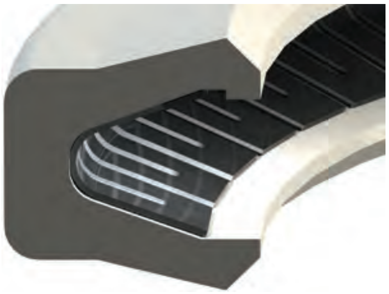
Table 11. Lip Profile Usage Guide

Profile & Code	 S	 A	 B	 D	 F	 J
Reciprocating	Preferred	Preferred	Preferred	Preferred	Preferred	Preferred
Rotating	Preferred	Preferred			Preferred	Preferred
Static	Preferred		Preferred			
Oscillating	Preferred	Preferred			Preferred	Preferred
High Sealability	Preferred		Preferred			
Exclusion				Preferred	Preferred	Preferred
Low Friction		Preferred		Preferred		
Step Gland	Do Not Use			Preferred	Preferred	Preferred
<3/16" ID	Do Not Use	Do Not Use	Preferred	Preferred	Do Not Use	Do Not Use

Key Preferred | Do Not Use | Neutral

Specialty Types

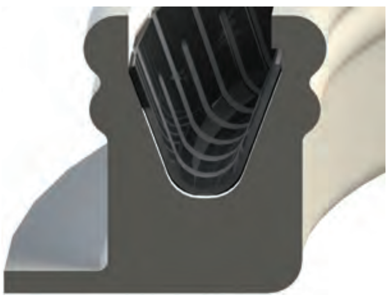
Components based on the basic seal design can be further customized to provide sealing performance that is application and industry specific. Our engineering team is able to incorporate a variety of shapes and geometries to optimize seal performance and versatility.



OptiFace™ Seal

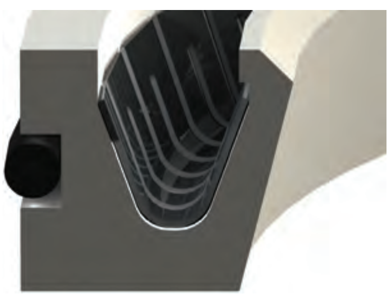
OptiFace seals are used in static seal applications and feature an axial squeeze design offered for either external or internal pressure. As compression against the seal is increased, the lips of the jacket are pressed against the gland surface, providing resistance and sealability while ensuring stability within the gland. The beveled lip featured in this design provides excellent sealability in applications that require high unit loading.

The internal or external preload is based on the application. For components such as flanges and swivel joints, the design is configured for internal pressure. In sealing vacuum applications, the design can be configured for external pressure.



Flanged OptiSeal® Component

Best suited for rotary applications, this seal is designed to prevent seal movement on the static gland surface. The clamped flange prevents seal movement and blocks potential leak paths. In cryogenic applications, the clamped flange also reduces the thermal contraction of the seal OD away from the gland.

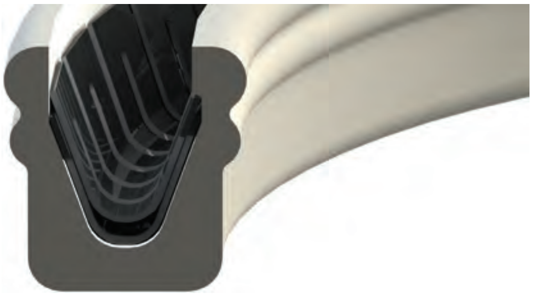


Opti-Oil™ Seal

The Opti-Oil seal is the ideal choice for low-pressure, dynamic shaft seals. The outer diameter of this configuration is tightly sealed with an O-Ring, reducing slippage on the static surface in rotary applications. The inner diameter contact surface of this seal features a low-friction, spring-loaded jacket, enabling adequate sealing along the surface of the shaft.

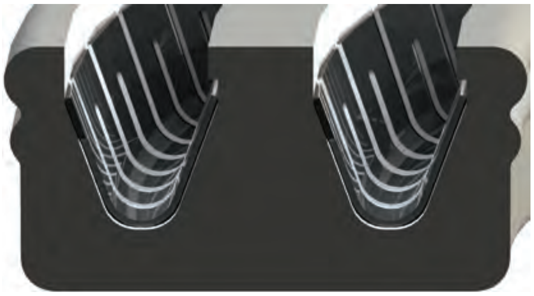
Custom Seal Design Characteristics

In addition to jacket and material customization, the standard OptiSeal design can be further customized based on the service conditions of the individual application, enabling it to perform in a wide range of services and applications.



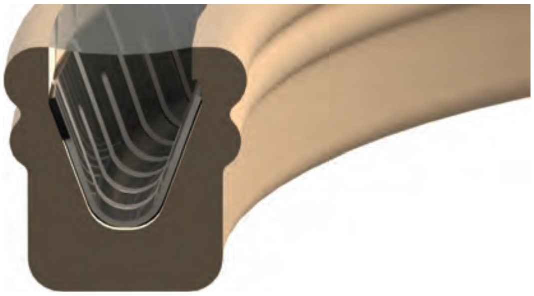
OptiSeal® Component with Nested Springs

Multiple or nested springs are used when greater sealing force is required, such as in low-pressure or low-temperature applications. This design is able to increase the force exerted by the sealing lips without increasing the lip interference. Examples of such applications are valve stems, choke seals, and low-pressure systems.



OptiSeal® Component with Large Cross Section

In larger diameter applications where existing glands have radial cross sections greater than 0.600" (15,2mm) or have limited axial lengths, two springs may be radially spaced. Dual springs are also used when retrofitting existing glands where the axial gland length is less than the radial gland cross section. This allows the sealing system to be employed in cross sections that are greater than 1" (25,4mm).



OptiSeal® Component Silicone-Filled Cavity

In sanitary applications, the spring cavity of the OptiSeal system can feature a silicone filling to effectively protect against contamination. This configuration prevents media from becoming entrapped in the cavity, enabling excess media to be completely flushed out if necessary.

Additional Custom Designs

Bidirectional spring-energized floating piston seal design.

Flanged seal design with internal spring energizer.

OptiSeal design principles can be applied to a variety of custom configurations. For such custom seal geometries, please contact our engineering support team by submitting an inquiry at CDIproducts.com.

4. Back-Up Rings/Anti-Extrusion Devices

Back-Up and Adapter Material Selection

The materials and compounds selected in a seal's design will differ in their ability to resist seal extrusion once installed in a given application. The effects that temperature, pressure, and media have on the compound used are key considerations.

When determining whether or not a sealing system requires the use of a back-up ring or anti-extrusion device, the magnitude of pressure a seal must contain and the clearance gap should be considered. The properties of the jacket materials used in the seal design provide varying levels of resistance to seal extrusion in a given application.

Table 12. Back-Up and Adapter Materials

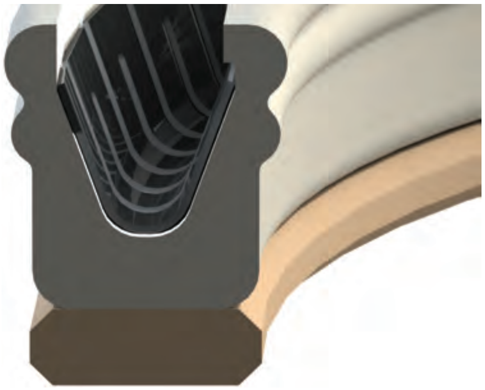
FDA Approved	Compounds	Polymer	Filler	Color	Abrasion Resistance	Metal Mating Wear	Relative Sealability	Relative Extrusion Resistance	Media Resistance					Operating Temperature	
									Hydrocarbons	Oxygenated Solvents	Steam	Acids	Base	F°	C°
Yes	728	ACETAL	None	Black	A	M	A	G	E	G	G	W	W	-70° to +300°	-56° to +149°
No	744	PPS	40% Glass	Grey	G	H	P	E	E	E	E	S	S	-70° to +500°	-56° to +260°
Yes	Arylex™ 745	PEEK	None	Beige	A	M	G	G	E	E	E	S	S	-70° to +500	-56° to +260°
No	Arylex™ 747	PEEK	30% Glass	Beige	G	H	P	E	E	E	E	S	S	-70° to +550°	-56° to +288°
Yes	748	UHMW-PE	None	Translucent	E	L	E	G	G	G	P	S	S	-300° to +180°	-184° to +82°
No	Arylex™ 754	PEEK	30% Carbon	Black	G	H	P	E	E	E	E	S	S	-70° to +550°	-56° to +288°

Key: E-Excellent G-Good H-High A-Average M-Medium L-Low P-Poor NR-Not Recommended; W-Resistant to weak acid/base S-Restistant to strong acid/base

To learn how CDI Energy Products can improve performance in your operations, please visit our website at CDIproducts.com or submit an inquiry: CDI-Global.Sales@CDIproducts.com

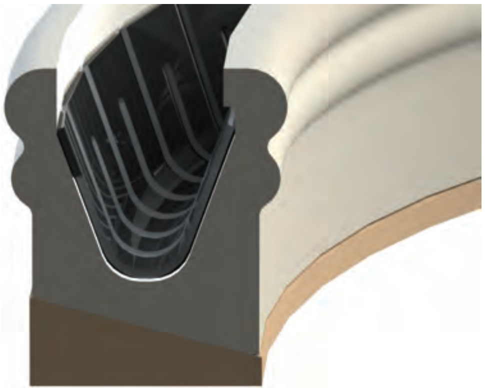
Back-Up Ring Design Options

When back-up or auxiliary devices are required, CDI can provide a range of components that prevent seal extrusion. Several geometries are used for anti-extrusion devices that allow the extrusion-resistant material to move into the clearance gap quickly and efficiently. Constructed from materials that are stronger than the seal jacket, the back-up ring blocks extrusion paths, allowing for maximum seal life in high-temperature and high-pressure applications.



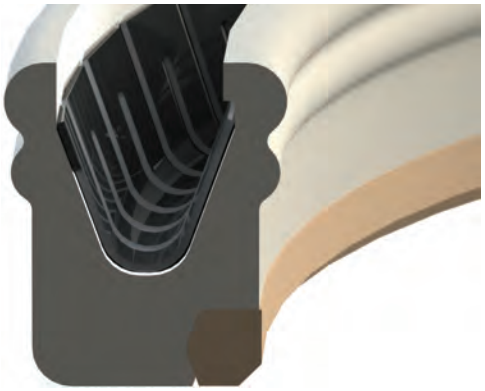
OptiBack™ Component

The standard back-up ring offered by CDI features a close-tolerance rectangular OptiBack design. The chamfered edges on the OptiBack ring aid in installation.



Delta Back-Up Ring

The Delta Back-Up uses system pressure to prevent seal extrusion when using the OptiSeal system. The force induced by the system pressure will cause the Delta Back-Up to move into the extrusion gap and close it off.



Integral Back-Up Ring

The Integral Back-Up is placed at the corner of the seal where the extrusion gap is located. This configuration is ideal when the axial gland length is so short as to prevent the use of a standard back-up. Its snap-in feature also eliminates loose components, thereby providing easier installation.

5. Packing Configuration

Our OptiPak® packing configuration applies the benefits of the OptiSeal system to more traditional packing. This configuration allows OptiSeal components to be used successfully in conditions that require redundant sealing surfaces. Such conditions include high pressures and broad pressure ranges, large extrusion gaps, dynamic conditions, potential misalignment, and rough surface finishes.

Our OptiPak packing configurations can be found in a range of services and applications, such as:

- Stem packing
- Seat seals
- Firesafe assemblies
- Geothermal assemblies

OptiPak® Assemblies

Female Adapter

The female adapter prevents extrusion of the sealing components in the OptiPak assembly. It may be made from thermoplastic or graphite and mesh for firesafe applications. This ring spans the extrusion gap and provides added pressure capabilities.

VS V-Ring

The VS style V-Ring is a harsh-service seal profile. Made from elastomer, plastic, or both, it provides built-in interference with moderate pressure sensitivity. Used in an OptiPak assembly, it offers redundant sealing lips.

OptiVee® Component

Used in multi-ring assemblies, this component is used with a female adapter for extrusion resistance. This addition is generally used with either a PakRing or Opti-Ipak components. The design allows for mating to a female adapter or V-Ring for retrofitting existing V-Packing designs.

OptiVee® Component with Nipple

When the OptiVee sealing system is paired with a standard VS-Ring, a nipple can be added to nest into the mating surface of the V-Ring to provide higher unit loading. It can be used individually or combined with PakRings and Opti-Ipak components.

Opti-Ipak™ Component

The Opti-Ipak component combines the OptiSeal design with a PakRing element. This reduces the need for multiple PakRings and allows the OptiSeal components to stack where short stack height is critical.

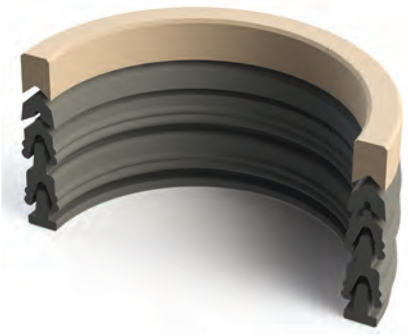
PakRing™

The PakRing prevents reverse sealing lip damage and spring collapse. It is used on the high-pressure side of the OptiSeal device but does not mechanically load the seal.

OptiPak® Assembly Variations

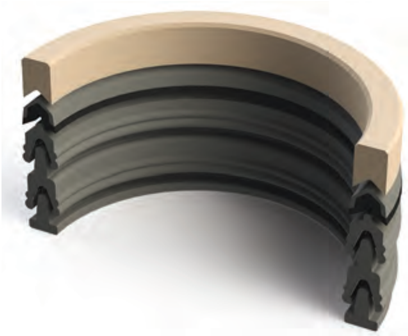
Standard Configuration
Tested and qualified by customers to meet API-6A-PR2 standards, this configuration boasts a robust non-elastomeric design for use in liquid and gas applications, such as valve stems on high-pressure valves and chokes.

This particular configuration is composed of a female adapter, a VS-Ring made from a high-fill PTFE compound, and high-fill PTFE Opti-IPak and PakRing components.

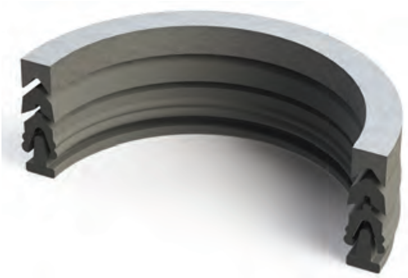


Composite Stem Packing /Low-Emission Configuration
The elastomeric composite V-Ring within this assembly provides enhanced sealability for low-emission performance. This is accomplished by replacing the VS-Ring with the V3-Ring, which features a PTFE shell bonded to an elastomeric core.

The positive seal and resilience provided by the V3-Ring enhancement work in tandem with the PTFE shell to ensure low-friction operation and improved sealability.

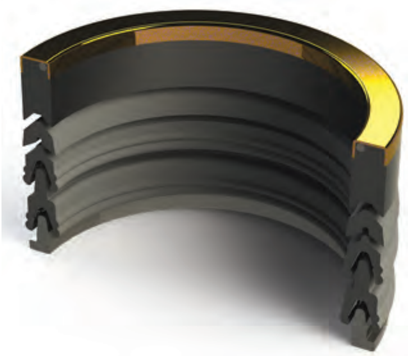


High-Temperature Configuration
This composite assembly combines the functionality of the standard OptiPak assembly with a high-temperature graphite female adapter. The thermal limit of the female adapter maximizes the useful thermal limit of the PTFE OptiSeal components. This set is commonly used in valves and PBRs found in steam injection applications.

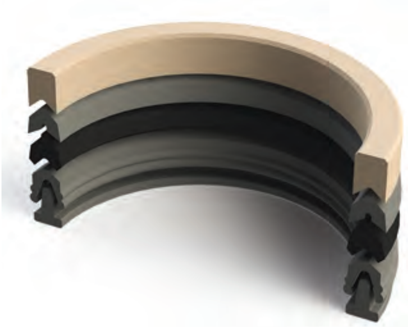


Firesafe Configuration

This set also finds high usage in valve stem applications that require firesafe packings. While the PTFE components may be damaged by the extreme temperatures found in the API-607 Fire Test, the remaining graphite component provides a seal suitable to meet the requirements of the test. This set is generally recommended for rotating and rising stems.

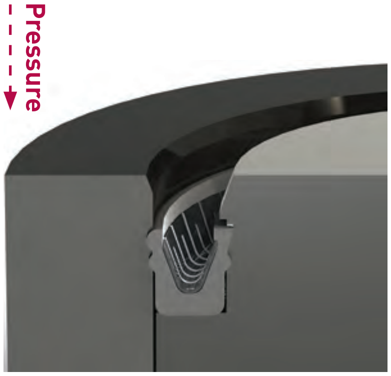


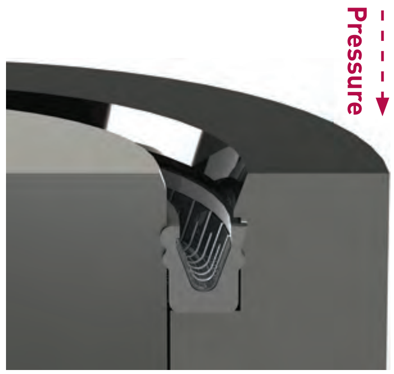
Rough Surface Configuration
For applications with rough surface finishes, a BL-Ring may be added to the OptiPak assembly. The BL-Ring is made from a homogeneous elastomer for superior sealability on rough gland surfaces.



6. Gland Configuration

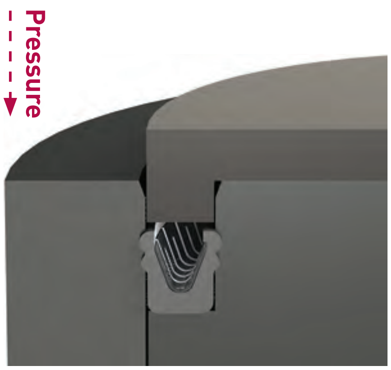
Gland Design Options





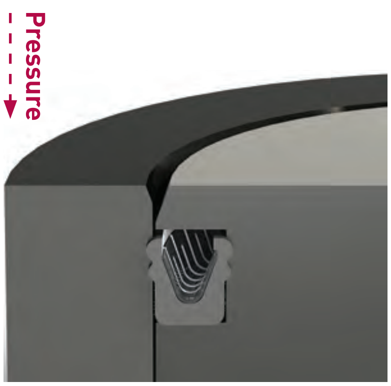
Step-Cut Gland

This modification of the one-piece gland minimizes the deformation of the OptiSeal® jacket during installation and eliminates the need for a separate retaining piece. Dimensions for step-cut glands are available upon request.



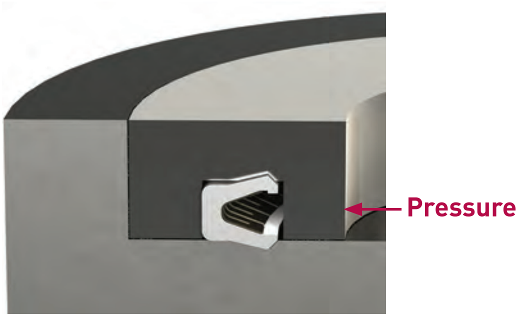
Two-Piece Gland

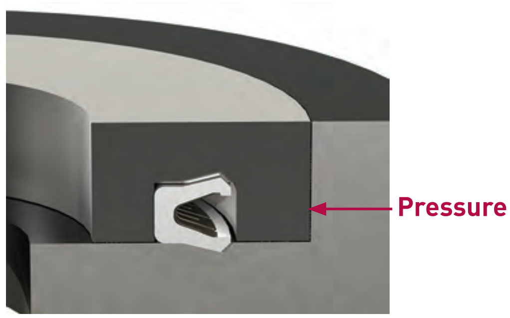
The two-piece gland eliminates deformation during installation and is required for small diameter or large cross section designs. In reciprocating applications, the gland must be carefully designed, or a PakRing must be used to prevent the sealing lips from shifting on to the installation bevel.



One-Piece Gland

The one-piece gland is used only for OptiSeal systems with larger diameters or small cross sections to prevent damage from stretching or buckling during installation. Please consult CDI for installation tools and instruction before installing OptiSeal® components into this gland configuration.





Face Seal Gland

Face seal gland design and seal design are different from the design of radial seals. Gland recommendations are available from CDI for individual applications, or OptiFace seals may be proposed based upon existing gland dimensions.

Gland Recommendations: OptiGland

Larger gland diameters require greater tolerances to manufacture at reasonable and comparable costs . OptiSeal® components have a "designed-in" squeeze on the cross section, but manufacturing tolerances determine the minimum and maximum. If the minimum squeeze is too small, the seal can tolerate less wear before it fails. If the maximum squeeze is too large, the friction and wear will be unacceptable.

The CDI OptiGland system of gland dimension recommendations is centered around the active gland diameter (the bore diameter for piston seals and the rod diameter for rod seals) and takes into account manufacturing capabilities, wear, and friction concern; extrusion gaps; and expenses incurred during manufacturing. The OptiGland system calculates the optimum cross section for a given active gland diameter or working backwards, the optimal active diameter for a given cross section, giving consideration to the rationale of tolerance selection.

The result is a set of gland dimensions that balances the best seal performance and longevity with the lowest manufacturing costs required for that gland. The processes and examples below demonstrate how to effectively use OptiGland measurements.

A	S	B	L	F	E	C
Active gland diameter	Minimum gland cross section	Non-active gland diameter	Minimum axial gland length	Minimum installation bevel length	Diametrical clearance	Gland clearance diameter

Piston Seals

8-Step Process

Step 1: Determine the active gland diameter. For piston seals, "A" equals the bore diameter and is the minimum gland OD.

Step 2: Determine the minimum gland cross section. This value is based on A and can be found in Table 8 and Table 9.

Step 3: Determine the non-active gland diameter. For piston seals, "B" equals A-2S and is the maximum gland ID.

Step 4: Determine tolerances for gland diameters. Tolerances are given in Table 8 and Table 9, dependent only upon cross section in order to control seal squeeze.

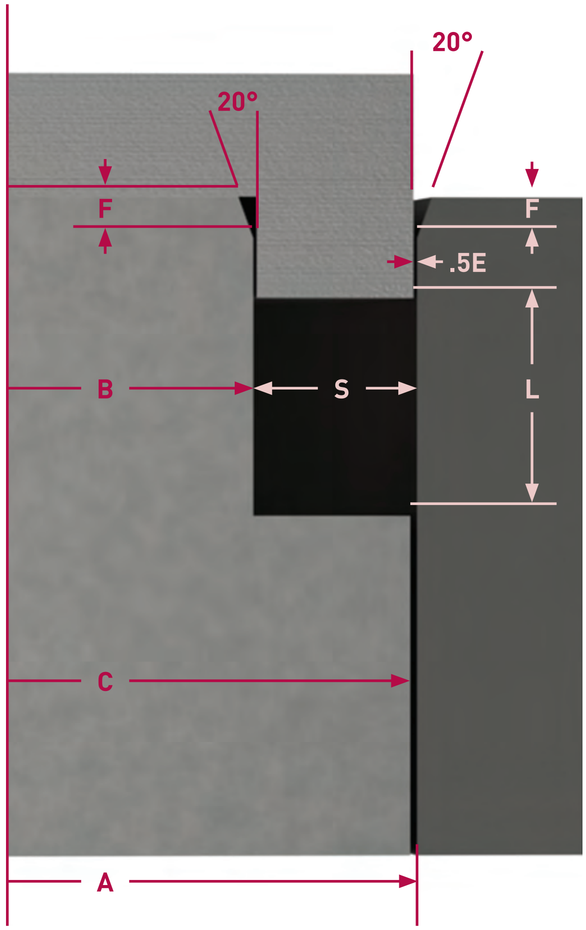
Step 5: Determine the minimum axial gland length. For pressures less than 10,000 psi (690 bar), use the value L1. Value L2 accommodates the addition of an OptiBack back-up ring and can be used for pressure above 10,000 psi (690 bar) up to 17,000 psi (1172 bar). For pressures above 17,000 psi (1172 bar), please consult CDI. The tolerance for both L1 and L2 is +.010" (+0,25mm).

Step 6: Determine the minimum installation bevel length. This value is also given in Table 8 and Table 9 according to the cross section.

Step 7: Determine the minimum and maximum diametrical clearance. These values are shown in the table. The minimum diametrical clearance will be used to calculate "C"—the gland clearance diameter.

Step 8: Determine the gland clearance diameter and tolerance. For piston seals, C equals A-E minimum and is the maximum clearance diameter. Shaft and hole tolerances can be applied to these values using the table.

Diagram 1. Piston Seal Recommendation



A	S	B	L	F	E	C
Active gland diameter	Minimum gland cross section	Non-active gland diameter	Minimum axial gland length	Minimum installation bevel length	Diametrical clearance	Gland clearance diameter

Rod Seals

8-Step Process

Step 1: Determine the active gland diameter. For rod seals, "A" equals the rod diameter and is the maximum gland ID.

Step 2: Determine the minimum gland cross section. This value is based on A and can be found in Table 8 and Table 9.

Step 3: Determine the non-active gland diameter. For rod seals, "B" equals A+2S and is the minimum gland OD.

Step 4: Determine tolerances for gland diameters. Tolerances are given in Table 8 and Table 9, dependent only upon cross section in order to control seal squeeze.

Step 5: Determine the minimum axial gland length. For pressures less than 10,000 psi (690 bar), use the value L1. Value L2 accommodates the addition of an OptiBack back-up ring and can be used for pressure above 10,000 psi (690 bar) up to 17,000 psi (1172 bar). For pressures above 17,000 (1172 bar), please consult CDI. The tolerance for both L1 and L2 is +.010" (+0,25mm).

Step 6: Determine the minimum installation bevel length. This value is also given in Table 8 and Table 9 according to the cross section.

Step 7: Determine the minimum and maximum diametrical clearance. These values are shown in the table. The minimum diametrical clearance will be used to calculate "C"—the gland clearance diameter.

Step 8: Determine the gland clearance diameter and tolerance. For rod seals, C equals A+E min and is the minimum clearance diameter.

Diagram 2. Rod Seal Recommendation

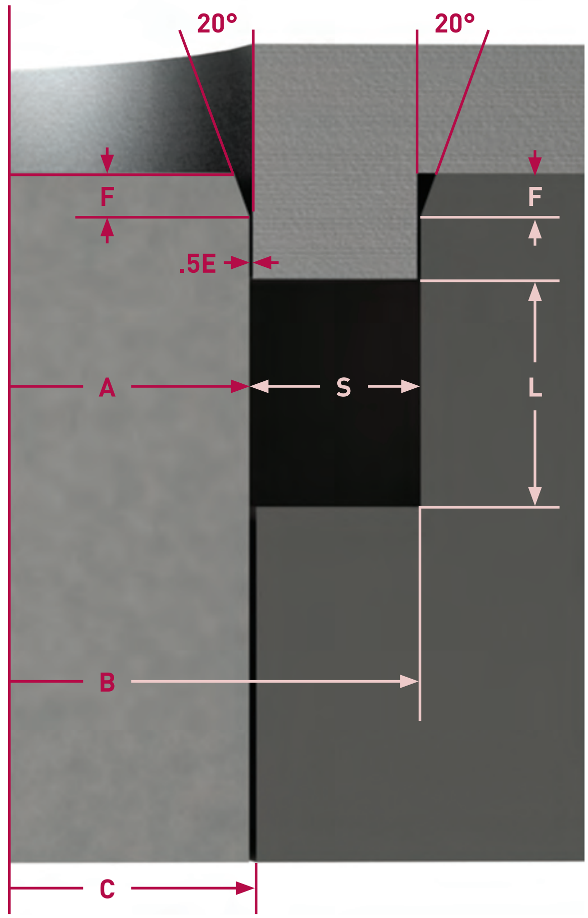


Table 13. Suggested Gland Surface Finishes

Static	Dynamic
16 to 32 RMS	8 to 16 RMS
RA 0.8 μm max.	RA 0.4 μm max.

Gland Dimension Examples

These examples show a relationship between active diameter and gland cross section.

Table 14. Gland Dimensions—Inch

Rod Diameter or Cylinder Bore	Nominal Gland Cross Section	Minimum Gland Cross Section	Minimum Axial Gland Length	Minimum Axial Gland Length	Minimum Installation Bevel Length	Minimum Diametrical Clearance	Maximum Diametrical Clearance	Shaft Tolerance	Hole Tolerance
A		S	L1+.010	L2+.010	F min.	E min.	E max	-.xxx	+.xxx
.215-.749	.125	.124	.169	.226	.036	.001	.004	.001	.002
.750-2.499	.188	.186	.250	.336	.054	.002	.009	.003	.004
2.500-6.499	.250	.248	.329	.443	.071	.003	.012	.004	.005
6.500-16.999	.375	.372	.488	.658	.107	.005	.018	.006	.007
17.000-20.000	.500	.496	.646	.872	.142	.007	.023	.007	.009

Table 15. Gland Dimensions—Metric

Rod Diameter or Cylinder Bore	Nominal Gland Cross Section	Minimum Gland Cross Section	Minimum Axial Gland Length	Minimum Axial Gland Length	Minimum Installation Bevel Length	Minimum Diametrical Clearance	Maximum Diametrical Clearance	Shaft Tolerance	Hole Tolerance
A		S	L1+0,25	L2+0,25	F min.	E min.	E max	-x,xx	+x,xx
5,0-14,9	3,00	2,98	4,06	5,45	0,86	0,02	0,11	0,03	0,06
15,0-24,9	4,00	3,97	5,37	7,19	1,14	0,04	0,17	0,05	0,08
25,0-59,9	5,00	4,96	6,64	8,92	1,43	0,05	0,20	0,06	0,09
60,0-169,9	7,50	7,44	9,82	13,24	2,14	0,09	0,33	0,10	0,14
170,0-409,9	10,00	9,92	13,01	17,53	2,85	0,12	0,45	0,15	0,18
410,0-500,0	12,50	12,41	16,16	21,81	3,56	0,17	0,60	0,20	0,23

Notes:
- For pressures less than 10,000 psi (690 bar), the OptiSeal system can be used without back-up ring, and axial gland length L1.
- For pressures greater than or equal to 10,000 psi (690 bar) but less than 17,000 psi (1172 bar), the OptiBack back-up ring can be used with the OptiSeal® system and axial gland length L2.

Contact CDI or submit an inquiry at CDIProducts.com for consultation regarding the following:
- All pressures exceeding 17,000 psi (1172 bar).
- Piston seals with bore diameters of .500"/,254m or less.

Table 16. Gland Dimension Example—Inch

Dimension	4" Rod, 15k PSI	
	Dimension	Tolerance
Max. Gland ID	4.000	-.004
Min. Gland OD	4.496	+.005
Nom. Gland Cross Section	.250	Nominal
Min. Gland Cross Section	.248	Minimum
Min. Axial Gland Length	.443	+.010
Min. Installation Bevel Length	.071	Minimum
Min. Diametrical Clearance	.003	Minimum
Gland Clearance Diameter	4.003	+.005
Max. Diametrical Clearance	.012	Maximum

Table 17. Gland Dimension Example—Metric

Dimension	200mm Rod, 125 bar	
	Dimension	Tolerance
Max. Gland ID	181,16	-0,15
Min. Gland OD	200,00	+0,18
Nom. Gland Cross Section	10,00	Nominal
Min. Gland Cross Section	9,92	Minimum
Min. Axial Gland Length	13,01	+0,25
Min. Installation Bevel Length	2,85	Minimum
Min. Diametrical Clearance	0,12	Minimum
Gland Clearance Diameter	199,88	+0,15
Max. Diametrical Clearance	0,45	Maximum

OptiSeal® Installation

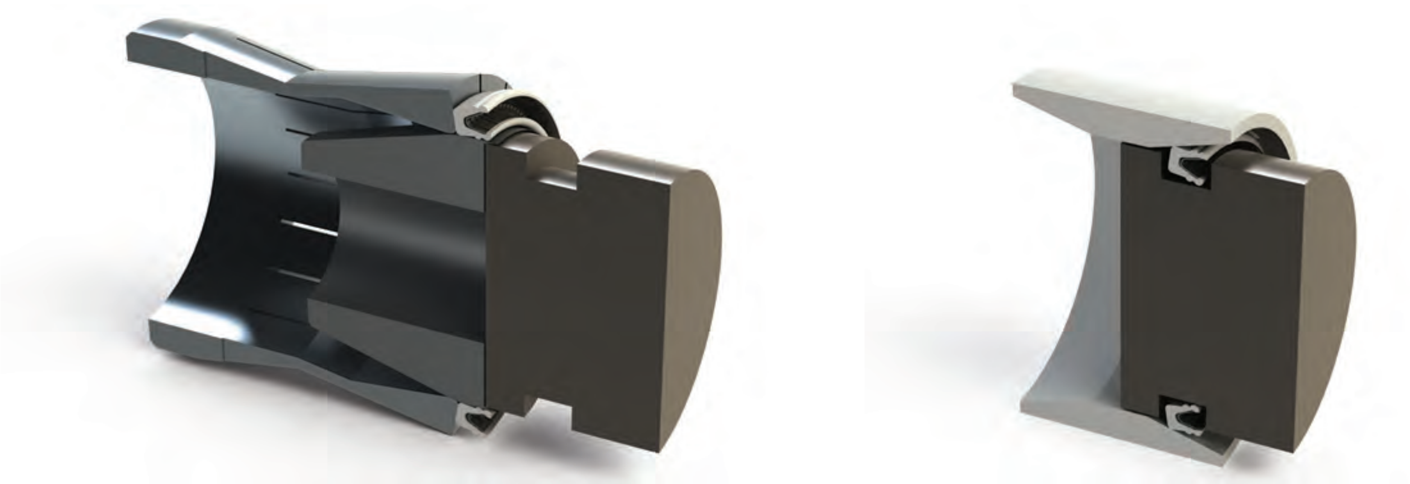
It is highly recommended that the two-piece, step-cut, or snap-ring gland be used. A full one-piece gland should only be used when modification of the existing gland is impossible. The following applies only to one-piece gland installation.

One-Piece Piston Groove

Place the installation cone on the piston. Then place the seal on the cone so that the spring faces the installed direction on the piston. Push seal over the cone and into the groove using the installation expander.

If the seal does not return to its original size, use the resizing sleeve to reshape the seal. The installation cone, expander, and resizing sleeve are all available from CDI. Additional tooling can be designed and manufactured for step-cut glands. Please contact your sales representative for more information, or submit your inquiry at CDIProducts.com.

Diagram 3. One-Piece Piston Groove Installation

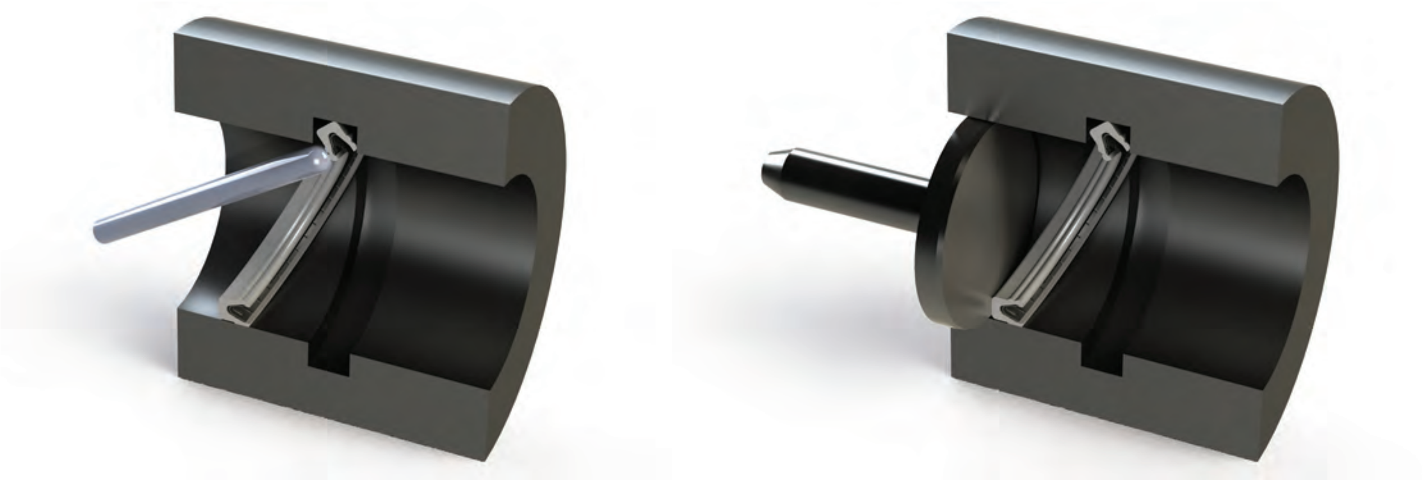


One-Piece Rod Groove

This type of gland should not be used for rods less than 1.500" (38mm). Below this diameter a two-piece or step-cut gland must be used. Begin installation by squeezing the seal into an elliptical shape, enabling it to fit onto the gland bore. With fingers or a radiused tool, push approximately 1/3 of the seal into the grove, being careful the seal component does not sustain damage.

Following this step, use a pusher tool the same diameter as the rod to push the remainder of the seal into the groove.

Diagram 4. One-Piece Rod Groove Installation



Application Data

Customer Information

Date: ____________

Company Name: ____________ Phone: ____________

Address: ____________ Fax: ____________

City: ____________ State: ____________ Zip: ____________

Contact: ____________ Title: ____________

Distributor: ____________ E-mail: ____________

Current Seal Information

Current Seal: ____________

Current Material: ____________ Preference: ____________

Reason for Inquiry: ____________

Application Information

☐ Static ☐ Reciprocating ☐ Rotary ☐ Oscillatory

☐ Rod Seal ☐ Piston Seal ☐ Internal Face Seal ☐ External Face Seal

☐ Other: ____________ Surface Speed (Ft/Minute): ____________

Stroke Length: ________ Cycles Per Minute: ________ RPM: ________ Degrees Rotation: ________

Seal Environment

	Maximum	Nominal	Minimum	Test
Temperature:				
Pressure:				

☐ Bi-Directional ☐ Uni-Directional ☐ Lubrication: ____________

Media: ____________ Contaminants: ____________

Hardware

	Minimum	Maximum	Material	Finish	Hardness	Coating
Gland ID:						
Gland OD:						
Gland Length:						
Diametrical Clearance:						

Can modifications be made to the hardware? ____________

Gland Type: ____________

Box Adjustment: ____________

Type of Equipment: ____________ Model: ____________

Operation

Service Life: ________ Allowable Leakage: ________

Breakout Friction: ________ Dynamic Friction: ________

Other: ____________

Required

☐ Proposal Assembly ☐ Material Data Sheet ☐ Sales Drawing

☐ Inspection Drawing ☐ Prototypes (Quantity): ____________

☐ Quote Request (Quantities): ____________

☐ Other: ____________

Application Sketch

Application Data

Additional Application Sketches

Additional Notes: ____

Index

CDI ENERGY PRODUCTS

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CDIproducts.com

Or talk with our experts at your regional office.

In-depth Solutions

CDI Energy Products is a designer and manufacturer of custom plastic and elastomeric products, seals, and ancillary metal components. As part of the global group Fenner, our multiple locations enable us to partner with clients worldwide to produce unique, high-performance solutions for the energy industry.

Global Challenges. Global Capabilities.

CDI-BR007GL-0114-R01-US