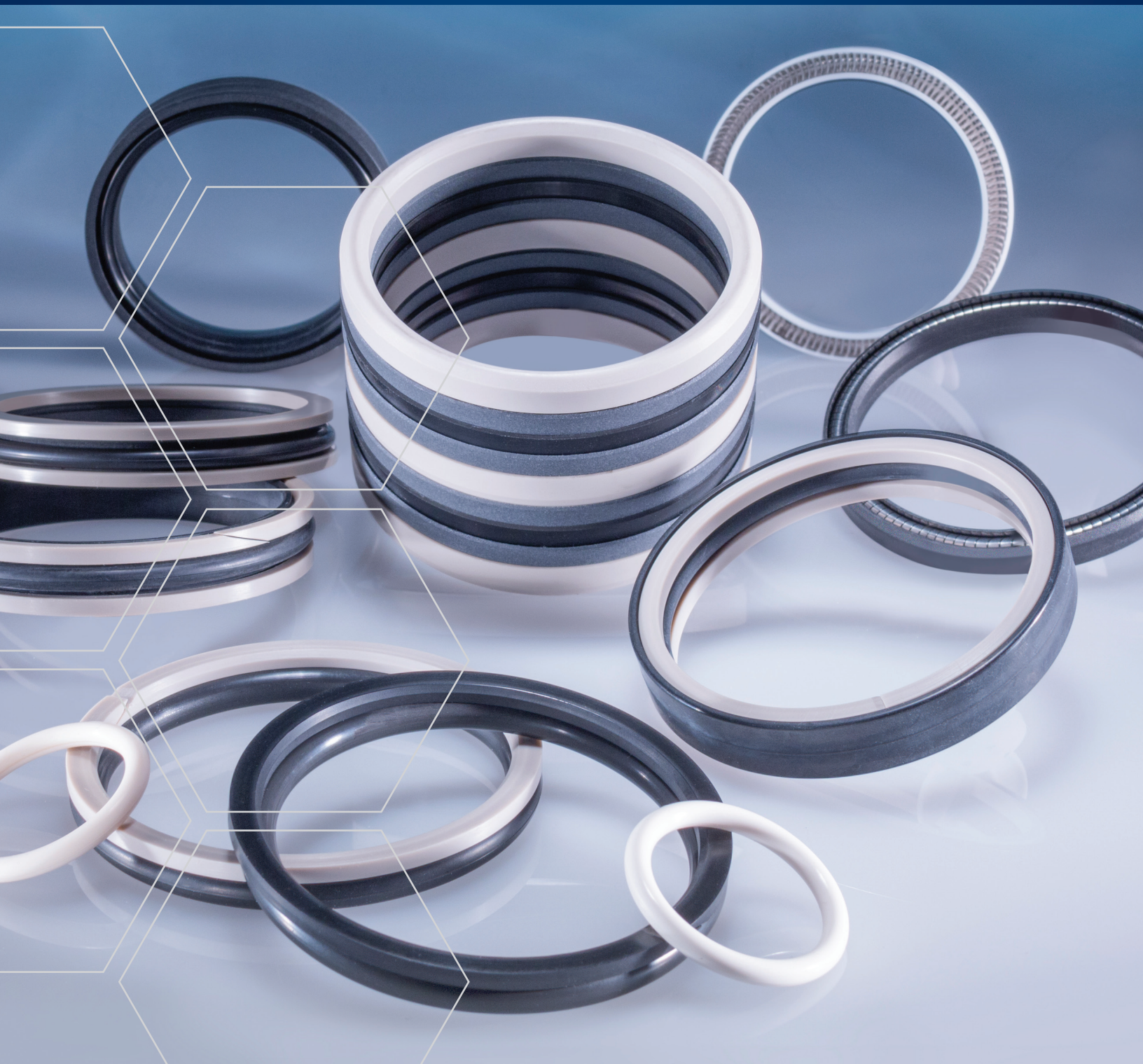
Greene Tweed

gtweed.com

SEALING SOLUTIONS



For more than 150 years, Greene Tweed's customers have relied on the company's materials expertise and collaborative approach to the design and manufacture of elastomeric, thermoplastic, and thermoplastic composite solutions that deliver proven performance in extreme and demanding operating environments.

A global company with facilities across North America, Europe, and Asia, Greene Tweed serves customers throughout a diverse range of markets, including energy, aerospace, defense, industrial, life sciences, and semiconductor.

WHY GREENE TWEED SEALING SOLUTIONS?

Greene Tweed has engineered a line of high-performance sealing materials that prevent fluid leaks in even the most extreme upstream, midstream, downstream, petrochemical, and power generation applications. We have designed for applications with temperatures ranging from cryogenic to 324°C (615°F), pressures up to 2,413 bar (35,000 psi), and aggressive chemicals in all of our market segments.

Our customers turn to Greene Tweed for our sealing expertise when they cannot afford downtime or risk leakage or data loss during operations. We solve application challenges with high-quality seals made from our best-in-class materials.

Greene Tweed seals:

- Enhance safety compliance
- Improve uptime
- Increase equipment reliability
- Decrease instances of unplanned downtime, leading to better production rates

Greene Tweed developed our portfolio of sealing solutions over decades in collaboration with equipment manufacturers, service providers, and operators. During our long history of research and development, we have commercialized hundreds of unique elastomeric and thermoplastic materials and have been granted more than 80 U.S. and foreign patents. Our Advanced Technology Group focuses on new material development, and the team includes PhDs in diverse disciplines such as Polymer Science, Chemistry, Mechanical Engineering, and Coatings. We have in-house testing capabilities for material characterization, fluid aging, rapid gas decompression (RGD), high-pressure and high-temperature (HPHT) cycling, and more.

Greene Tweed's high-performance elastomeric materials include Chemraz® FFKM, Fusion® FKM, Xyfluor®, and Fluoraz® FEPM. Although we are best known for our fluoroelastomers, we also offer EPDM, HNBR, and NBR materials for less extreme application needs. Avalon® PTFE and Arlon® PEEK thermoplastics round out our sealing materials portfolio.

We rigorously batch test our compounds at our ISO 17025-accredited materials lab before we manufacture those materials into seals at our ISO 9001-certified manufacturing facilities, using industry-leading compression and injection-molding capabilities. All of our finished products must pass strict quality inspection criteria prior to shipping.

Many of our applications engineers have previous work experience at equipment manufacturers and service companies in the industries we serve. As such, Greene Tweed's engineers understand the needs of the energy industry. We collaborate with our customers to custom-design the right seal with the best material to keep operations running safely longer, while providing technical support as needed. We also offer a range of off-the-shelf solutions.

THE CASE FOR SEALS

Seals prevent fluids – liquids and gases – or debris from leaking from one location into another or into the environment. A damaged seal on a safety valve that allows toxic or harmful emissions to escape may lead to fines from environmental agencies and a host of health, safety, and environmental issues. A seal failure in a critical service application can shut down an entire production facility, resulting in millions of dollars of lost revenue.

Greene Tweed's sealing solutions, engineered to exacting specifications, can be the difference between high levels of uptime and leaks that lead to unplanned downtime.

We manufacture our seals from our proprietary elastomeric and thermoplastic materials in designs ranging from standard o-rings to custom-engineered seal stacks for complex applications. Greene Tweed primarily offers six core types of seals — o-rings, G-T® rings, Metal Spring Energized (MSE®) seals, seal stacks, capped seals, and labyrinth seals. We also offer a number of other seals for niche application needs.

O-Rings

The o-ring – the most universally recognized seal design – has a simple geometry made from an elastomeric material. O-rings are used in mechanical seals, as standalone seals in static applications, or as an energizer in capped seals. Greene Tweed may recommend a precision-machined thermoplastic backup ring for extrusion resistance in high-pressure applications.

Greene Tweed offers o-rings in AS568 or ISO 3601-1 standard sizes, and we also design and manufacture them in non-standard sizes to meet individual customer needs.

G-T® Rings

Greene Tweed invented the G-T® ring in the 1960s. The design, now commonly known as a T-seal, is widely used throughout the industry. The T-shaped elastomeric seal element provides more stability and eliminates roll and spiral failure in dynamic applications compared to o-rings. Integrated thermoplastic backup rings provide extrusion resistance in a compact design that has a smaller footprint than an o-ring with separate backup rings. The G-T® ring provides a bi-directional seal. We also offer the GTL™ ring, which is a unidirectional version of the G-T® ring.

The Advanced Concept G-T® (ACT®) ring has a slightly modified sealing profile with a beveled sealing stem and crown that offers improved resistance to stress-strain fatigue in demanding long-stroke applications.

MSE®s

Metal Spring Energized (MSE®) seals are uni-directional seals that are well suited for reciprocating or rotary dynamic applications that require sealing force at both low and high pressures, such as tools that undergo pressure cycling.

They are also applicable for cryogenic operations below the temperature capabilities of elastomeric seals. MSE®s consist of a thermoplastic jacket energized with a corrosion-resistant metallic spring. Greene Tweed has extensive experience with this type of seal, having designed more than 300,000 MSE®s.

Seal Stacks

Seal stacks are a custom-designed sealing solution for complex applications, such as port crossing hardware configurations, with multiple redundant sealing elements including v-rings, adapters, load rings, and MSE®s. Greene Tweed's wide portfolio of elastomeric and thermoplastic materials allow us to balance requirements for wear resistance, low friction, extrusion resistance, and other challenges to design a customized sealing solution. For example, a seal stack may contain an MSE® for reliable sealing force at low pressures, with backing elastomeric v-rings for additional tight sealing against gas along with thermoplastic v-rings for superior wear resistance under high dynamic cycling.

Capped Seals

Capped seals contain an elastomeric energizing element with a thermoplastic cap on the sealing face. The thermoplastic cap provides lower breakaway and running friction and better wear resistance than an elastomer alone in high dynamic applications, reciprocating or rotary. Capped seal designs may include thermoplastic backup rings for resistance to extrusion in high-pressure applications. Greene Tweed offers three main types of capped seals: the Advancap™, the Ener-Cap®, and the Capped G-T® ring.

- The Advancap™ is our simplest capped seal design for general-purpose duty cycles. The curved cap design resists roll and spiral failure of the o-ring energizer compared to traditional rectangular capped seals.
- The Ener-Cap® seal cap geometry provides improved stability compared to the Advancap™ and eliminates roll and spiral failure. The elastomeric energizer's profile provides more evenly distributed loading to the sealing cap for improved wear life in high duty cycle applications.
- The Capped G-T® ring, a capped version of the G-T® ring, consists of a T-shaped elastomeric energizer fitted with a contoured sealing cap and integrated pressure-activated backup rings.

Labyrinth Seals

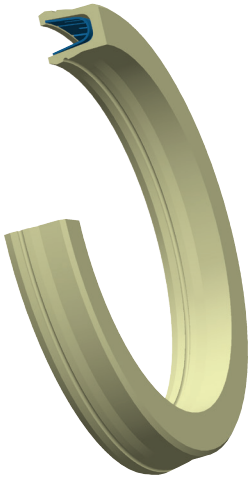
Non-contacting labyrinth seals deliver leakage reduction in centrifugal pumps and compressors by restricting flow through a sequence of chambers formed between the rotating element and the teeth. Traditional metallic labyrinth seals require large clearances to avoid potential heat generation, deformation, and galling and can suffer from corrosion and erosion in certain environments. We make labyrinth seals from our thermoplastic materials, incorporating a tooth profile design that creates a more controlled flow pattern and higher dimensional stability, allowing for cyclic flex-and-return motion to withstand contact during critical speeds. This allows for tighter clearances, which dramatically increase the efficiency and reliability compared to metallic labyrinth seals.

SEAL DESIGNS

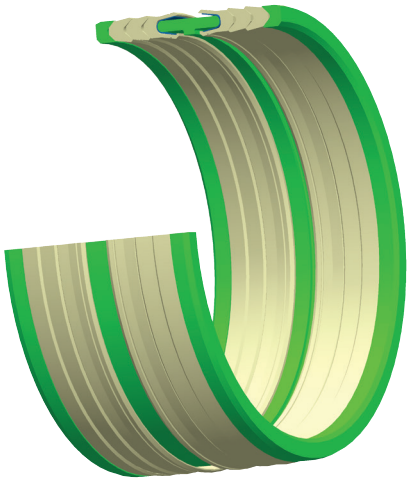
O-Ring

G-T® Ring

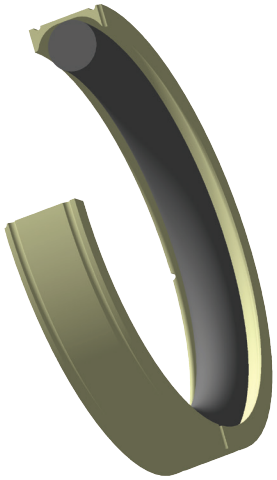
ACT® Ring



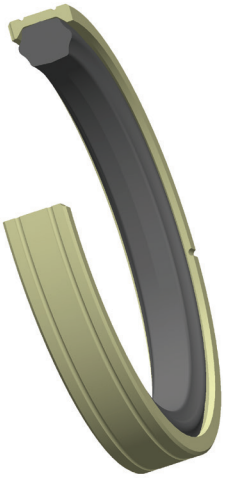
MSE®



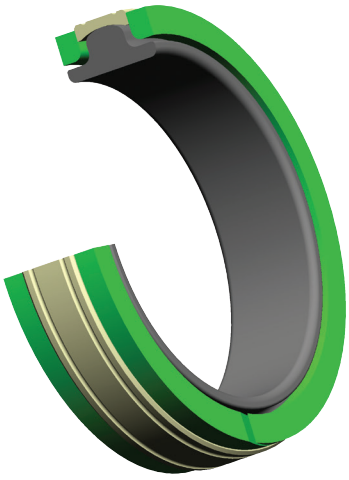
Seal Stack



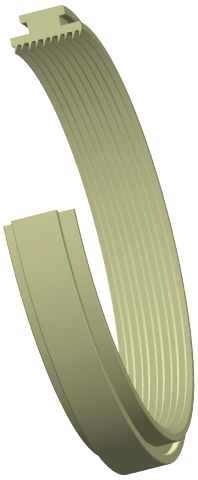
Advancap™



Ener-Cap®



Capped G-T® Ring



Labyrinth Seal

CHEMRAZ® MATERIALS FAMILY

Chemraz® (FFKM) is the ultimate elastomeric material. It offers broad chemical resistance to nearly all chemicals and can operate in temperatures as high as 324°C (615°F).

Chemraz® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
505	• Our original perfluoroelastomer compound, commercialized in 1989 • Often chosen for its broad chemical compatibility and good performance in steam applications • Widely specified at major oil and gas equipment and services providers	-30°C to 230°C (-22°F to 446°F)	75
510	• Similar to Chemraz® 505 but a higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressures • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-30°C to 230°C (-22°F to 446°F)	90
526	• Developed for excellent resistance to RGD • Certified by independent labs as resistant to RGD per ISO 23936-2, NORSOK M-710, and TOTAL GS PVV 142 testing standards, having received perfect scores (0-0-0-0) and showing no cracks, voids, or blisters • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-20°C to 250°C (-4°F to 482°F)	95
605	• Developed for improved steam and high-temperature performance compared to Chemraz® 505	-20°C to 260°C (-4°F to 500°F)	80
600	• Similar to Chemraz® 605 but a higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressures • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-20°C to 260°C (-4°F to 500°F)	90
562	• Developed for superior high-temperature capability versus Chemraz® 605 • Excellent resistance to steam and compression set • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-12°C to 316°C (10°F to 601°F)	80
615	• Our highest temperature capability elastomer • Excellent resistance to compression set	-18°C to 324°C (0°F to 615°F)	80
694	• Developed for superior performance at high temperatures in steam applications such as Steam Assisted Gravity Drainage (SAGD)	-12°C to 316°C (10°F to 601°F)	87
564	• Developed for improved low-temperature performance • Excellent resistance to compression set	-40°C to 230°C (-40°F to 446°F)	80
678	• Developed for improved low-temperature performance and RGD resistance • Certified by an independent lab as resistant to RGD per ISO 23936-2 & NORSOK M-710 testing standards, having received a perfect score (0-0-0-0) and showing no cracks, voids, or blisters • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-40°C to 230°C (-40°F to 446°F)	90

CHEMRAZ® MATERIALS FAMILY (CONTINUED)

Chemraz® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
514	• A white specialty compound formulated without carbon-black • Excellent performance in hot aqueous solutions and oxidizing media that attack carbon-black • Ideal for industrial and chemical processing applications with strict contamination requirements	-30°C to 220°C (-22°F to 428°F)	70
517	• Similar to Chemraz® 514, but a higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressure	-30°C to 220°C (-22°F to 428°F)	80
584	• A cream-colored specialty compound formulated without carbon-black • Excellent performance in hot aqueous solutions and oxidizing media that attack carbon-black • Ideal for industrial and chemical processing applications with strict contamination requirements	-30°C to 220°C (-22°F to 428°F)	70
585	• Similar to Chemraz® 584, but a higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressure	-30°C to 220°C (-22°F to 428°F)	80
629	• Developed for improved electrical insulation for applications such as electrical boot seals	-20°C to 260°C (-4°F to 500°F)	75

XYFLUOR® MATERIALS FAMILY

Xyfluor® is a proprietary, highly fluorinated elastomer. Xyfluor®'s chemical compatibility surpasses that of FKM and approaches that of Chemraz® in applications with temperatures up to 232°C (450°F). Xyfluor® can operate at temperatures as low as -60°C (-76°F).

Xyfluor® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
860	• Optimized for compression molding	-60°C to 232°C (-76°F to 450°F)	70
870	• Optimized for injection molding	-60°C to 232°C (-76°F to 450°F)	70

FLUORAZ® MATERIALS FAMILY

Fluoraz® FEPM elastomers deliver excellent chemical resistance against acids and bases such as methanol, amines, ammonia, urea, hydrochloric acid, hydrogen sulfide (H_2S), and steam at temperatures up to 232°C (450°F).

Fluoraz® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
797	• A general purpose compound using internationally renowned Aflas® base polymer	-5°C to 232°C (23°F to 450°F)	80
799	• Similar to Fluoraz® 797, but a higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressures	-7°C to 232°C (19°F to 450°F)	90
790A	• An aramid fiber-reinforced compound for use in high-pressure v-rings	-7°C to 232°C (19°F to 450°F)	95

FUSION® MATERIALS FAMILY

Fusion® FKM elastomers have excellent compression set resistance at temperatures up to 232°C (450°F) and are compatible with a broad range of chemicals, including hydrocarbons, inorganic acids, and aromatic solvents such as benzene, toluene, and xylene.

Fusion® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
731	• Our first FKM compound, commercialized in 1979 • Widely specified at major oil and gas equipment and services providers	-30°C to 232°C (-22°F to 450°F)	75
927	• A higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressures	-30°C to 232°C (-22°F to 450°F)	91
761	• Developed for improved low-temperature performance and chemical resistance	-40°C to 232°C (-40°F to 450°F)	75
935	• Developed for improved low-temperature performance, chemical resistance, and RGD resistance • A higher durometer compound with improved strength and resistance to extrusion in applications with high differential pressures	-37°C to 232°C (-35°F to 450°F)	90
938	• Developed for improved low-temperature performance, chemical resistance, and RGD resistance • Certified by independent labs as resistant to RGD per ISO 23936-2, NORSOK M-710, and TOTAL GS PVV 142 testing standards, having received perfect scores (0-0-0-0) and showing no cracks, voids, or blisters • Certified by an independent lab as resistant to sour service per ISO 23936-2 and NORSOK M-710 testing standards	-37°C to 232°C (-35°F to 450°F)	90
944	• Developed for best-in-class RGD resistance at extreme decompression rates • Certified by an independent lab as resistant to RGD per ISO 23936-2 & NORSOK M-710 testing standards, having received perfect scores (0-0-0-0) and showing no cracks, voids, or blisters • Optimized for molding in large diameter o-rings for large compressors	-37°C to 232°C (-35°F to 450°F)	90
755	• Developed for low electrical conductivity for use in electrical boot seals	-40°C to 232°C (-40°F to 450°F)	77
929A	• An aramid fiber-reinforced compound for use in high-pressure v-rings	-30°C to 204°C (-22°F to 399°F)	95

EPDM MATERIALS FAMILY

EPDM elastomers provide outstanding resistance to hot water, steam, and polar solvents such as ethanol, methanol, and ammonia at temperatures up to 149°C (300°F). EPDM elastomers also provide good resistance to nuclear radiation.

EPDM Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
846	• A soft compound	-45°C to 149°C (-50°F to 300°F)	60

HNBR & NBR MATERIALS FAMILY

HNBR elastomers have excellent resistance to oil and a wide range of chemicals. HNBR elastomers can operate in continuous service temperatures up to 177°C (350°F) while NBR can operate in temperatures up to 149°C (300°F).

HNBR/NBR Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
207	• A general purpose HNBR compound	-40°C to 177°C (-40°F to 351°F)	70
208	• A general purpose HNBR compound	-40°C to 149°C (-40°F to 300°F)	80
209	• A general purpose HNBR compound	-34°C to 149°C (-29°F to 300°F)	90
173	• A general purpose NBR compound	-34°C to 149°C (-29°F to 300°F)	75

AVALON® MATERIALS FAMILY

Our Avalon® PTFE thermoplastic materials have lower friction coefficients than elastomers but are still relatively flexible and conform well to sealing surfaces. Our Avalon® materials are incorporated into seal designs for high dynamic applications.

Avalon® Compound	Features and Benefits
02	• Virgin, unfilled PTFE • A cost-effective material for low-friction needs
56	• Virgin, unfilled PTFE • Modified for improved gas permeability and cold flow properties
09	• Graphite-filled PTFE • Self-lubricating for lower breakout friction than virgin PTFE
59	• Carbon- and graphite-filled PTFE • Improved wear resistance and compressive strength as well as low breakout friction, though higher dynamic friction than virgin PTFE • Good for applications which require higher thermal conductivity
69	• Thermoplastic- and carbon-filled PTFE • Improved wear-resistance and compressive strength while maintaining low static and dynamic friction
89	• Thermoplastic- and carbon-filled PTFE • Superior wear- resistance to Avalon® 69 • Certified by an independent lab as resistant to sour service per ISO 23936-1 and NORSOK M-710 testing standards
87	• Glass-filled PTFE • Higher strength than virgin PTFE while maintaining chemical inertness
29	• Bronze-filled PTFE • Good for thermal and electrical conductivity • Improved wear resistance • Attenuates the non-stick and chemical inertness of the PTFE
57	• Thermoset-resin-filled PTFE • Lowest friction filler option, supports dry-running and stop-start applications • Non-abrasive for softer mating surfaces like aluminum or plastic

ARLON® MATERIALS FAMILY

Our Arlon® PEEK thermoplastics have high strength and wear resistance. They are incorporated into seal designs that require structural reinforcement for high-pressure applications or ultra-wear resistance in highly dynamic applications.

Arlon® Compound	Features and Benefits
1000	• Virgin PEEK • Certified by an independent lab as resistant to multi-phase, sour, aromatic fluids per ISO 23936-1 and NORSOK M-710 testing standards
1160	• Glass-filled PEEK • Improved strength versus virgin PEEK
1260	• Carbon-filled PEEK • Improved strength and wear resistance compared to Arlon® 1160
1330	• PTFE-filled PEEK • Lower friction than virgin PEEK
1555	• Carbon-, graphite-, and PTFE-filled PEEK • Improved strength and wear resistance compared to virgin PEEK • Self-lubricating for low breakout friction and low dynamic friction
2000	• Unfilled PEK • Higher temperature than PEEK with similar chemical compatibility
3000 XT	• Modified, unfilled PEEK for higher strength and higher temperature capabilities • The glass transition (TG) temperature is 178°C (352°F), approximately 30°C higher than virgin PEEK • Certified by an independent lab as resistant to multi-phase, sour, aromatic fluids per ISO 23936-1 and NORSOK M-710 testing standards
4020	• Carbon- and mineral-filled PEEK for use in labyrinth seals

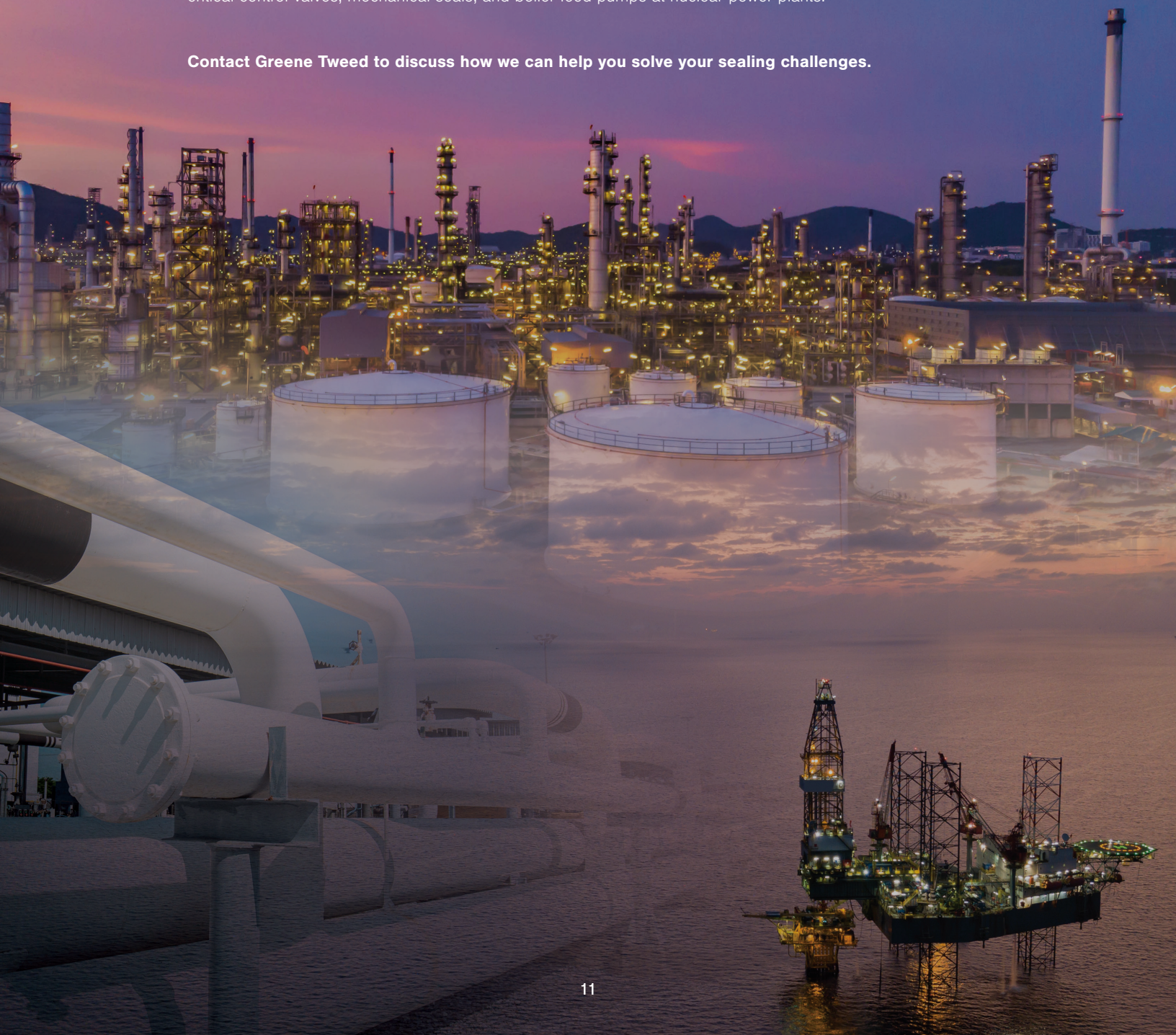
SOCIAL PROOF & MARKETS

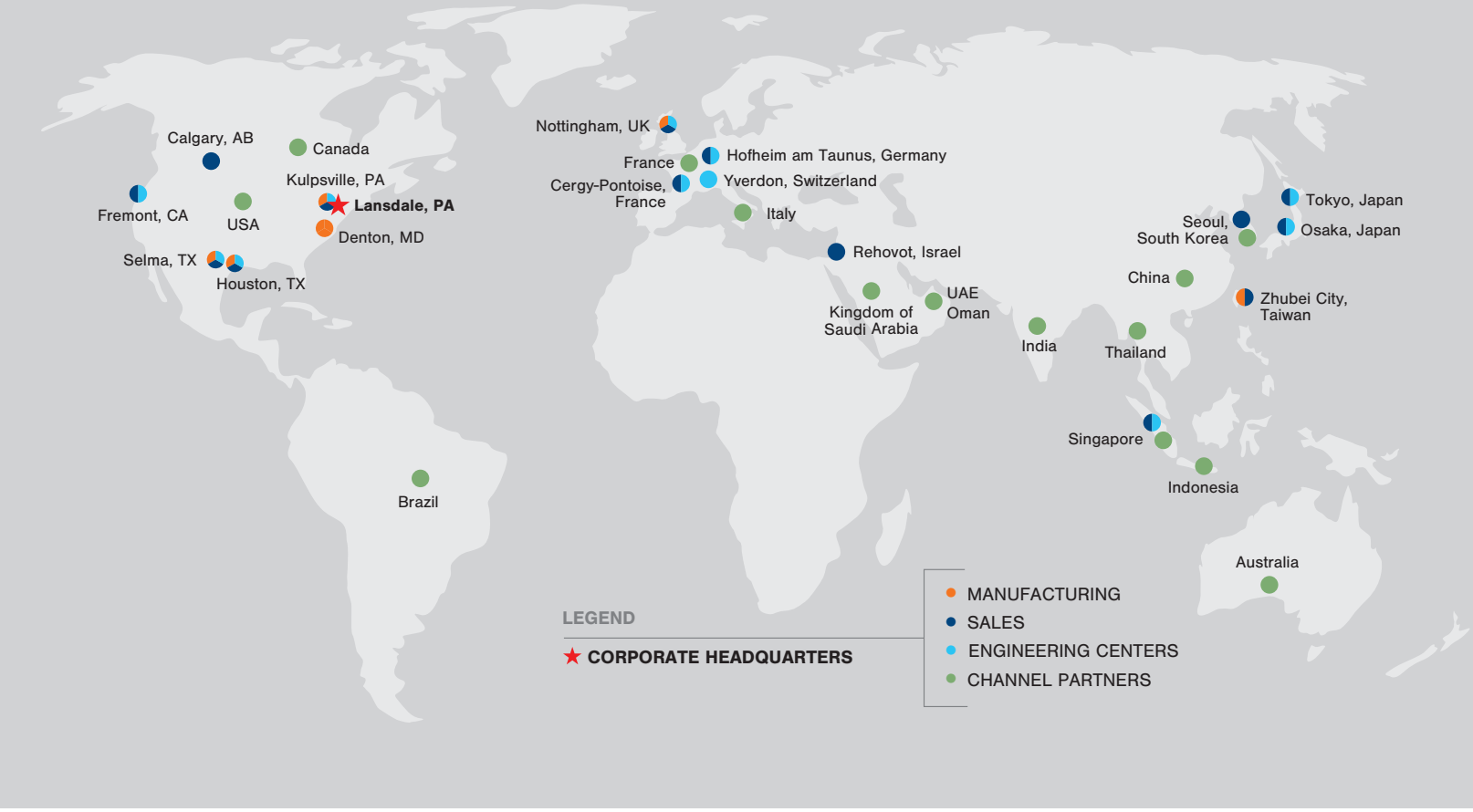
Day after day, Greene Tweed seals are placed into service in the most demanding locations. Our premium seals run the gamut of energy applications, with a focus on enhancing reliability, improving safety, and reducing cost of ownership.

Greene Tweed is present in the upstream industry. When it comes to drilling operations, our seals protect sensors in the drillstring for applications such as logging and measuring while drilling. Our sealing solutions are specified and used in safety valves, drilling and completions tools, electrical submersible pumps, liner hangers, chokes, blowout preventers, and more. Greene Tweed sealing solutions are present in hundreds of operations, including production facilities operated by supermajors around the world.

Greene Tweed's seals protect valves, compressors, and pumps in the midstream industry, refineries, and petrochemical plants. We provide gaskets for railcars and seal couplings for tanker loading and unloading operations. The largest refineries and petrochemical facilities in the world depend on our seals to safeguard critical applications. For power generation, Greene Tweed delivers seals for demanding applications such as critical control valves, mechanical seals, and boiler feed pumps at nuclear power plants.

Contact Greene Tweed to discuss how we can help you solve your sealing challenges.





GLOBAL PRESENCE, LOCAL SERVICE.

With more than 1,600 employees across 11 countries, Greene Tweed offers material, design, engineering, and manufacturing expertise worldwide, collaborating with customers to meet their critical challenges through the development of custom-designed, leading-edge components.

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