Greene Tweed

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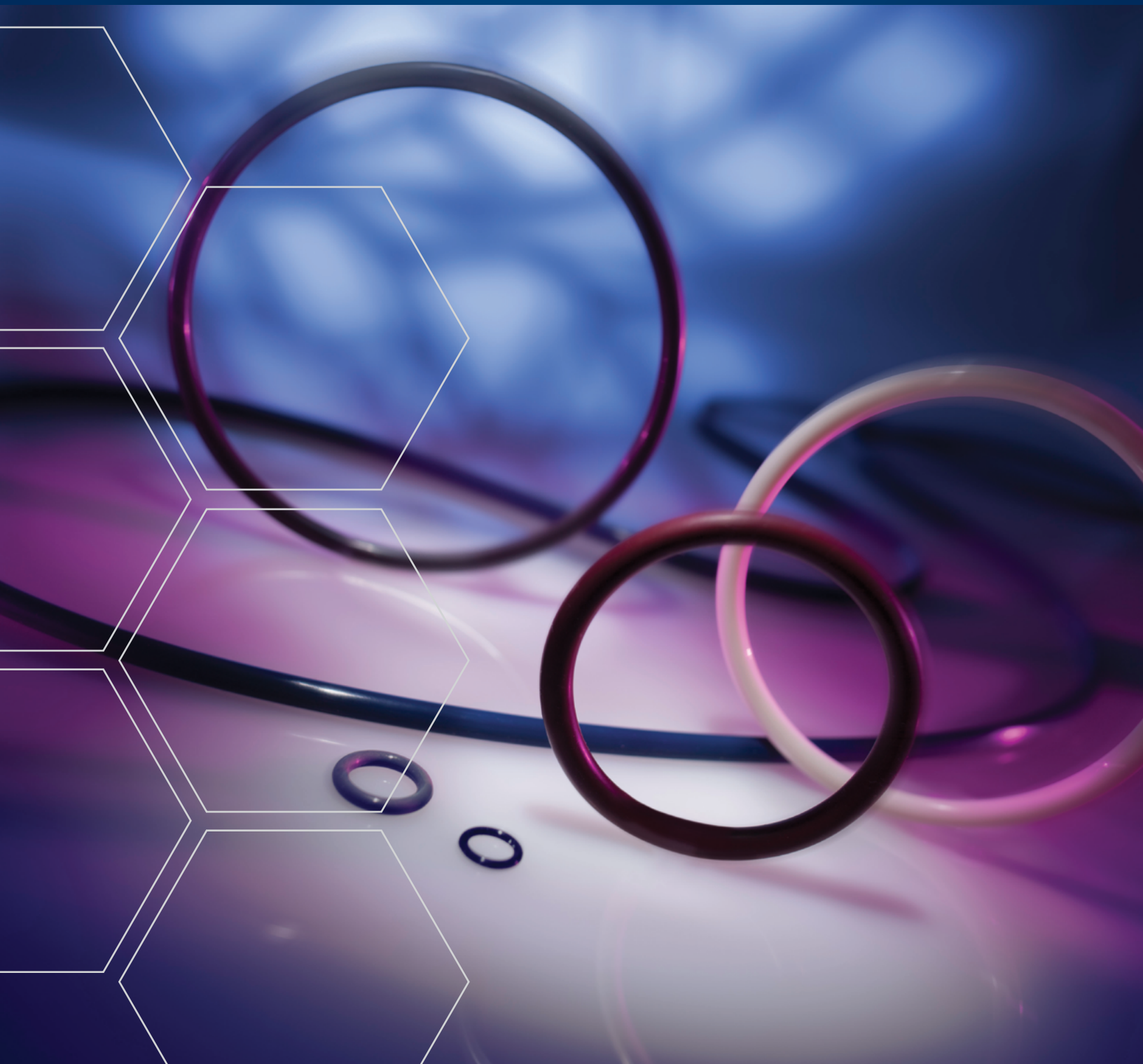
ELASTOMER SOLUTIONS



INTRODUCTION

Greene Tweed has developed a line of high-performance elastomer materials to protect equipment and prevent leaks in even the most extreme upstream, midstream, downstream, petrochemical, and power generation applications. We have designed elastomeric seals for applications with temperatures ranging from -60°C to 324°C (-76°F to 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 elastomeric materials expertise when they cannot afford downtime, lost production, damaged equipment, or health, safety, and environmental issues. We solve application challenges with our best-in-class materials. At Greene Tweed, we understand the material's characteristics and properties, and how to use these materials to process and manufacture finished parts.

Our portfolio of elastomers has been developed over decades in collaboration with polymer, curative, and filler suppliers, equipment manufacturers, service providers, and operators. During our long history of research and development, we have commercialized hundreds of unique elastomeric materials, including our flagship Chemraz® perfluoroelastomers (FFKM). We have been granted more than 80 U.S. and foreign patents, including those on elastomer recipes, processing, and products, as well as a recent patent on processing elastomers for optimal rapid gas decompression (RGD) resistance.

Our Advanced Technology Group (ATG), which concentrates on new material development, focuses on solving our customers' current and future problems. The ATG 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, RGD, high-pressure and high-temperature (HPHT) cycling, and more.

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.

Our applications engineering team has experience designing equipment at OEMs and service companies in the industries we serve. As such, Greene Tweed's engineers understand the needs of the energy industry, as well as the failure modes of materials in a wide range of operating environments. We collaborate with our customers to select and provide the best material for the application to keep operations running safely and reliably.

MATERIALS DEVELOPMENT

When customers face difficult materials problems, they call on Greene Tweed to recommend a compound to meet their needs. Our scientists are experts in compounding elastomers from the right polymer, cure system, and fillers to achieve optimal performance for specific application needs.

As a major purchaser of these ingredients, and with our reputation as a research & development leader, we get a first look from the suppliers when they develop new materials. You can trust that our elastomers perform because we are careful and methodical in our development of new compounds, and we undertake numerous studies of processing variability to ensure our manufacturing team can deliver a consistent, quality product made from any new material.

THE CASE FOR ELASTOMERS

An elastomer is a polymer chain with viscoelasticity, which enables it to be stretched and retracted. Elastomers make excellent sealing materials. Because they are self-energizing, elastomers provide a sealing force response when compressed. Elastomeric seals are flexible, durable, and easy to install. Elastomers also conform well against many different surfaces.

Our elastomers lead the market because they are durable and withstand aggressive chemicals, HPHT conditions, thermal cycling, pressure cycling, compression set, and RGD.

Greene Tweed's high-performance proprietary elastomeric materials for the energy industry include our flagship 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.

CHEMRAZ® MATERIALS FAMILY

Greene Tweed has been developing perfluoroelastomers for more than 30 years. We introduced our first Chemraz® FFKM compound in 1989. Since then, we have continued to introduce new compounds for increasingly complex applications.

Chemraz® FFKM is the ultimate elastomeric material. Perfluoroelastomers are made from fluorinated monomers including tetrafluoroethylene, perfluorovinylether, and a cure site monomer for crosslinking. FFKMs offer the broadest chemical resistance of any elastomer, compatible with nearly all chemicals, and can operate in temperatures as high as 324°C (615°F). Specialty Chemraz® compounds have been formulated for optimal performance in specific applications.

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
541	• Universal compound suitable for broad applications • Excellent chemical resistance to acids, amines, and steam. • High strength and good compression set properties	-16° C to 230° C (3°F to 446°F)	76
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 with a chemical compatibility which surpasses that of an FKM and can handle amines, ketones, and hydrofluoric acid for static applications in temperatures ranging from -60°C to 232°C (-76°F to 450°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, and steam at temperatures up to 232°C (450°F). Fluoraz® is generally not recommended for aromatic hydrocarbons.

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. FKMs are generally not recommended for strong bases or strong organic acids. We have formulated specialty compounds for RGD resistance, low temperatures, low electrical conductivity, and improved resistance to polar solvents such as methanol.

FKM is a fluorinated elastomer of the polymethylene type that uses vinylidene fluoride as a co-monomer and has substituent fluoro, alkyl, perfluoroalkyl, or perfluoroalkoxy groups on the polymer chain, with or without a cure site monomer. FKM elastomers are classified into different types, based on the monomer used to manufacture the polymers.

Fusion® Compound	Features and Benefits	Temperature Range	Durometer Hardness (Shore A)
731	• Our first FKM, 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 is not recommended for hydrocarbons or mineral oils.

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 and NBR elastomers can be a cost-effective and efficient solution for non-extreme environments.

HNBR elastomers can operate in temperatures up to 177°C (350°F), while NBRs can operate in temperatures up to 149°C (300°F). The materials are often used for o-rings, v-rings, and t-seals.

HNBR and NBR elastomers are not recommended for methanol or high hydrogen sulfide (H_2S) concentrations.

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

SOCIAL PROOF & MARKETS

Day after day, Greene Tweed elastomer materials are placed into service in the energy industry's most demanding applications. Our premium materials run the gamut of applications, with a focus on enhancing reliability, improving safety, and reducing cost of ownership. Our flagship elastomer, Chemraz®, is widely specified in multiple industries.

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 for 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. Our seals are used in the largest refineries and petrochemical facilities in the world.

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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