Greene Tweed

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WHO WE ARE | WHAT WE DO

Energy

Who We Are

Greene Tweed: An Overview

For more than 160 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.

All Greene Tweed products are manufactured under an ISO 9001:2015 Quality Management System (QMS).

Why Greene Tweed Energy?

We partner with our customers – from collaboration on concepts through prototype testing to the validation and production of finished parts – to deliver engineered, high-performance seals, wear parts, and electrical and data connectors for equipment used in the oil & gas, petrochemical, and power generation industries. Our products are relied upon in downhole drilling and completion tools, subsea production and artificial lift equipment, centrifugal compressors, pumps, valves, mechanical seals, and more.

Greene Tweed's industry-experienced design and application engineers focus on solving the industry's toughest sealing, connectivity, and wear applications through a deep understanding of materials science, equipment knowledge, and customer requirements. Our engineers evaluate and offer solutions to critical industry challenges such as high-pressure high-temperature (HPHT), shock and vibration, efficiency, and emissions through the innovative use of Greene Tweed's best-in-class materials portfolio. Our team of global field applications engineers are active in setting and understanding industry standards such as API 610 and 617. In-house design capabilities include 3D modeling, rapid prototyping, and finite element analysis (FEA), including thermal-electrical analysis; dynamic, thermal, and thermo-mechanical analysis; and material flow modeling. Greene Tweed's materials testing and product testing labs are ISO/IEC 17025:2017 accredited with world-class testing capabilities. We test our raw material production batches in accordance with strict compliance standards to ensure mechanical and other properties. Our labs also play an integral role in our research & development process for compounding new materials and designing new products. We routinely test our materials to 37 internationally recognized test methods. We have test equipment for materials characterization, processing properties, accelerated fluid aging, corrosion, rapid gas decompression (RGD), static pressure testing up to 42,000 psi and 600°F (315°C), vibration and shock testing up to 300g, and more. We can perform custom-designed tests upon customer request and use independent third-party labs for certification tests and capabilities as needed.

Greene Tweed adheres to the strictest of manufacturing standards at all of our facilities. Among other capabilities, we offer compression and injection molding, CNC milling, composite fiber placement, as well as waterjet and surface grinding processes. Where required, Greene Tweed offers cleanroom manufacturing in Class 100 and 1000 environments.

Greene Tweed has been pushing the limits of materials science for decades to develop high-performance solutions for the oil & gas, petrochemical, and power generation industries. Chemraz® perfluoroelastomers lead the way for critical sealing applications, while our patented Arlon 3000XT® promises to raise the bar in performance for key thermoplastics components. Greene Tweed's presence in the Americas, Europe, and Asia ensures local responsiveness that enables our customers' technologies around the world.

What We Do

MATERIALS PORTFOLIO

Greene Tweed's Advanced Technology Group researches and develops new materials for the Energy market while working closely with industry to understand market needs and technical gaps. Our stringent development and testing process ensures our materials are optimized and characterized for performance in harsh environments.

Greene Tweed's materials solutions for the oil & gas, refining, petrochemical, and power generation industries are formulated to address challenging pressure, temperature, chemical compatibility, and operational issues such as RGD resistance.

Our portfolio includes materials qualified to ISO 23936-2 and NORSOK M-710 standards for RGD resistance and fluid aging. We also hold patents on a variety of Chemraz® grades as well as Arlon 3000XT® and Fusion® 944.

ELASTOMERS

Greene Tweed's materials portfolio includes our best-in-class Chemraz® FFKM elastomers as well as our proprietary Fusion® FKM, Fluoraz® FEPM, and Xyfluor® elastomers. Greene Tweed also offers a variety of elastomer solutions in HNBR, NBR, and EPDM.

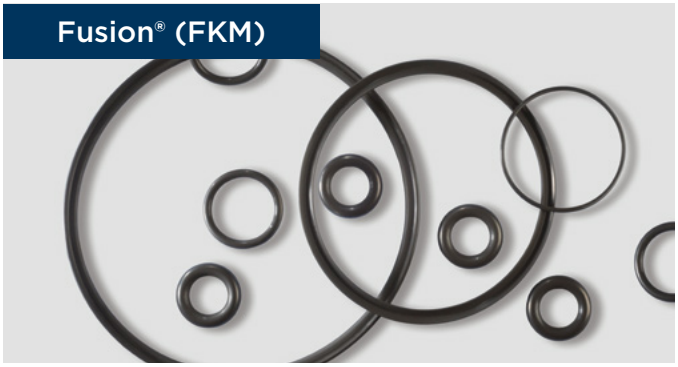
Chemraz® (FFKM)

- The Chemraz® brand of perfluoroelastomers (FFKM) has long been specified by the world's largest oil and gas service and equipment providers because of its reliability and proven performance in challenging environments
- Offers the broadest chemical compatibility range of any elastomeric material and is resistant to most aggressive chemicals, including reservoir fluids with high concentrations of H2S, stimulation treatments, completion fluids, corrosion inhibitors, aromatic solvents, strong acids and bases, ketones, and alcohols
- Provides superior high-temperature performance (up to 615°F/324°C) sealing solutions in a variety of hostile environment

The Chemraz® product portfolio includes:

- **Chemraz® 505** – standard compound with broad chemical compatibility to ensure reliability in a wide variety of applications
- **Chemraz® 510** – broad chemical compatibility with improved resistance to extrusion in applications with high differential pressure; qualified to ISO-23936-2 and NORSOK M-710 for fluid aging
- **Chemraz® 526** – the ultimate RGD resistant perfluoro-elastomer; qualified to ISO-23936-2 and NORSOK M-710 for RGD resistance
- **Chemraz® 555** – offers superior high-temperature capability and excellent compression set resistance
- **Chemraz® 585** – perfluoroelastomer optimized for use in high-temperature applications where contamination is a concern
- **Chemraz® 605** – low compression set and excellent performance in high temperatures and steam
- **Chemraz® 615** – highest-temperature FFKM rated to 615°F/324°C
- **Chemraz® 678** – specially designed with improved low-temperature capabilities; qualified to ISO-23936-2 and NORSOK M-710 for RGD resistance and fluid aging
- **Chemraz® 694** – best-in-class performance in hot steam environments

Fusion® (FKM)



- **Fusion® FKM** elastomers have excellent compression set resistance in high temperatures up to 450°F (232°C) in hydrocarbons, inorganic acids, and aromatic solvents
- **Fusion®** elastomers include specialty compounds formulated for unique operating conditions. Our portfolio of compounds includes solutions for improved low-temperature performance; high-pressure extrusion, steam, and electrical resistance; RGD resistance; and improved chemical resistance to methanol, bases, ketones, amines, and elevated H_2S concentrations

The Fusion® product portfolio includes:

- **Fusion® 731 & 927–731** is a general purpose compound widely specified in the oil & gas industry; 927 is a reliable solution for high-pressure sealing applications
- **Fusion® 755** – features low electrical conductivity for use in electrical boot seals
- **Fusion® 935** – formulated for improved low-temperature performance and chemical compatibility
- **Fusion® 938 & 944** – provide superior RGD resistance, having both successfully passed stringent ISO 23936-2 & NORSOK M-710 test protocols; both received a perfect score (0-0-0-0) for RGD resistance, showing no cracks, voids, or blisters

Fluoraz® (FEPM)

Fluoraz® has excellent chemical resistance against acids and bases, such as methanol, amines, ammonia, urea, and hydrochloric acid at temperatures up to 450°F/232°C.

The Fluoraz® product portfolio includes:

- **Fluoraz® 790A** – aramid-fiber-reinforced material
- **Fluoraz® 797** – general purpose applications
- **Fluoraz® 799** – improved extrusion resistance in applications with high differential pressure

Xyfluor®

Xyfluor® is a highly fluorinated compound with broad chemical resistance approaching that of FFKM and exceptional low-temperature capabilities (-76°F to 450°F/-60°C to 232°C). Xyfluor® products include o-rings, gaskets, and custom components required for mechanical seals, metering pumps, valves, and other high-performance equipment.

Other Elastomeric Sealing Materials

- **EPDM** – provides outstanding resistance to hot water, steam, and polar solvents (up to 300°F/149°C); used in applications including artificial lift, and in downstream and power generation, including nuclear
- **HNBR** – has excellent oil and chemical resistance and can sustain higher operating temperatures (-22°F to 350°F/-30°C to 177°C) than standard NBR
- **NBR** – high resistance to oils, fuels, and other chemicals; offers a wide temperature range (-60°F to 300°F/-51°C to 149°C)

ADVANCED ENGINEERING THERMOPLASTICS (AET)

Greene Tweed pioneered the use of thermoplastics in the upstream oil and gas industry in the 1980s, and has continued to build on that expertise today with innovative and industry-leading materials, including Arlon 3000XT®. Greene Tweed's Arlon 3000XT®, the first commercially available cross-linked PEEK, offers superior performance in HPHT and high-voltage applications.

Greene Tweed's Arlon® PEEK and Avalon® PTFE thermoplastic components are used in some of the world's most challenging environments. We offer a variety of grades, including unfilled, glass-filled, and carbon-filled.

Our product portfolio includes electrical connectors and back-up rings as well as other critical engineered components.

For more information about Greene Tweed products please call your sales representative or visit gtweed.com

Arlon 3000XT®

Arlon 3000XT® is a patented and ISO-23936-2-certified, cross-linked PEEK that provides highly improved mechanical properties in HPHT applications and enhanced performance in electrical applications.

- First commercially available cross-linked PEEK that maintains all expected benefits of conventional PEEK and PEK polymers while providing extended mechanical, electrical, and creep performance in HPHT environments (350°F/177°C)
- Provides improved volume resistivity 30 times that of PEK at 400°F (204°C) and dielectric strength, measured at 730 V/mil using a 40-mil-thick sample during ASTM D149 testing

Arlon® (PEEK)

- Offers broad chemical resistance and high-temperature capabilities
- Applications include components used in MWD/LWD, wireline/completion, downhole safety valves, artificial lift, and labyrinth seals for centrifugal compressors
- Unfilled and filled grades available

The Arlon® product portfolio includes:

- **Arlon® 1000** – recognized as the leading proprietary polyetheretherketone (PEEK) in the oil & gas and power generation markets; offers a unique combination of mechanical, thermal, chemical, and electrical properties; ISO 23936-2 certified for fluid aging by an independent third-party laboratory
- **Arlon® 1160** – a glass-reinforced PEEK featuring significantly higher tensile strength and increased shear strength; often selected when operating temperature exceeds 300°F (149°C)
- **Arlon® 1260** – a high-performance, carbon-filled thermoplastic ideal for applications requiring wear resistance, corrosion resistance, and dimensional stability
- **Arlon® 1330** – ideal for applications requiring exceptional wear resistance and chemical compatibility; provides good dimensional stability without the addition of carbon fibers

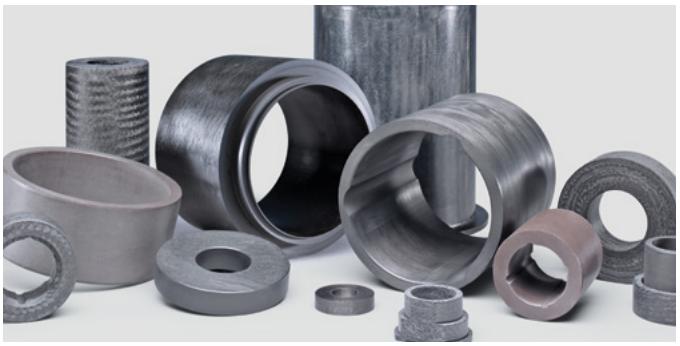
Avalon® (PTFE)

- Unfilled and compounded materials provide excellent lubricity and low friction
- Filled and reinforced materials improve high-temperature performance and wear, abrasion, and PV characteristics
- Custom grades formulated to provide wear resistance and low friction in applications
- Cryogenic-capable materials specifically developed to provide sealing and anti-extrusion functionality

The Avalon® product portfolio includes:

- **Avalon® 01** – an unfilled grade of PTFE, suitable for a variety of applications, including metal spring energized (MSE) seals and bushings, and within seal assemblies
- **Avalon® 09** – a graphite-filled PTFE; provides good wear and extrusion resistance and can be used in MSEs and v-rings, with a service temperature range of -436° to 500°F (-260° to 260°C)
- **Avalon® 11** – carbon- and graphite-filled PTFE; provides extrusion resistance and can be used as back-up rings
- **Avalon® 89** – lubricated and carbon-filled grade of PTFE; certified to ISO 23936-2 by an independent third-party laboratory; exhibits high creep and wear resistance

THERMOPLASTIC COMPOSITES



WR® & AR® Thermoplastic Composites

Greene Tweed's non-metallic wear-resistant (WR®) and abrasion-resistant (AR®) parts are made from thermoplastic composites (PTFE, PEEK, PFA) that withstand the most severe conditions and extend the service life of critical equipment.

Greene Tweed's WR® series of composites, constructed into high-performance, extremely reliable wear components, is replacing metal in demanding applications. Specialized products are available that provide superior dry run capability and optimum high-temperature performance (up to 500°F/260°C).

The WR® product portfolio includes:

- **WR® 300** – an API-610-recognized, carbon-fiber-reinforced, compression-molded PEEK; recognized for general wear resistance
- **WR® 525** – an API-610-recognized thermoplastic composite consisting of carbon fiber in a PEEK matrix; used as stationary and rotating wear parts; as a result of its long continuous fibers, resultant high-strength characteristics enable resistance to high-differential pressures; used for HPHT applications
- **WR® 650** – used in extended chemical compatibility and dry run conditions; offers enhanced performance over leading PFA-based material, including superior dry run capability, excellent chemical resistance, and an operating temperature up to 500°F (260°C)

AR® products combine excellent abrasion resistance, good dry run capability, and superior vibration dampening characteristics with little to no hydrolysis or swell. AR® products are well suited for a variety of abrasive pump applications, including those working with circulating water, open and closed cooling water, river water, screen wash, and crude oil pumps.

The AR® product portfolio includes:

- **AR® 1** – abrasion-resistant thermoplastic material; provides chemical resistance approaching that of PTFE
- **AR-HT®** – a proprietary thermoplastic material specifically developed for bushings, bearings, and wear rings in pumps handling abrasive media up to 250°F (121°C); API-610 recognized

SEALING SOLUTIONS

Greene Tweed uses its industry-leading materials to optimize sealing solutions in the most challenging conditions, including withstanding pressures up to 30,000 psi (2068 bar) and temperatures ranging from cryogenic to 615°F (324°C).

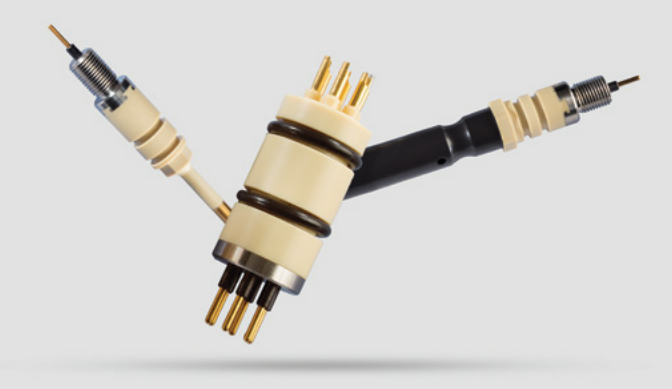
With a worldwide network of engineers and material experts, Greene Tweed collaborates with customers to offer standard and custom sealing solutions with the expertise to advise on fit-for-purpose material and seal designs. Greene Tweed's in-house R&D and testing facilities ensure that its sealing solutions meet customers' challenging requirements.

Greene Tweed's sealing portfolio includes:

- **O-ring** – available in ASTM international standard and custom sizes for mechanical seals or stand-alone static seals; can be designed with Arlon® back-up rings for high-pressure extrusion resistance
- **G-T® ring** – bi-directional seal with integrated Arlon® back-up rings that resist roll and spiral failure in dynamic applications when compared to o-rings
- **ACT® (Advanced Concept T) ring** – tapered wall provides reduced friction and longer life when compared to a t-ring
- **Advancap™** – provides a cost-effective, Avalon® PTFE cap sealing face that resists roll and spiral failure and provides better wear life in dynamic applications
- **Capped GT®** ring – eliminates roll and spiral failure; provides improved stability in high dynamic cycles and long-stroke applications
- **Enercap®** – eliminates roll and spiral failure; provides improved stability in high dynamic cycles and long-stroke applications; HP design available for high-pressure extrusion resistance and higher pressures and temperatures
- **Enerlip®** – unidirectional seal that provides low breakaway and running friction and maintains sealing force at low pressures; HP design available for high-pressure extrusion resistance and higher pressures and temperatures
- **CSA (Coil Spring Activated)** – unidirectional elastomer seal with a metal coil spring for improved resistance to compressive stress relaxation

- **MSE® (Metal Spring Energized)** – nearly chemically inert seals that provide low breakaway and running friction; maintain sealing force at low-pressure conditions
- **V-rings** – custom-designed v-rings and seal stacks; pressure-activated seal stacked in redundant series; particularly suited for applications that require multiple conditions with a combination of materials, such as Arlon® for wear resistance, Avalon® for reduced friction, and Chemraz® for tight sealing against gas; designed for uni- or bi-directional applications

SEAL-CONNECT® ELECTRICAL CONNECTORS



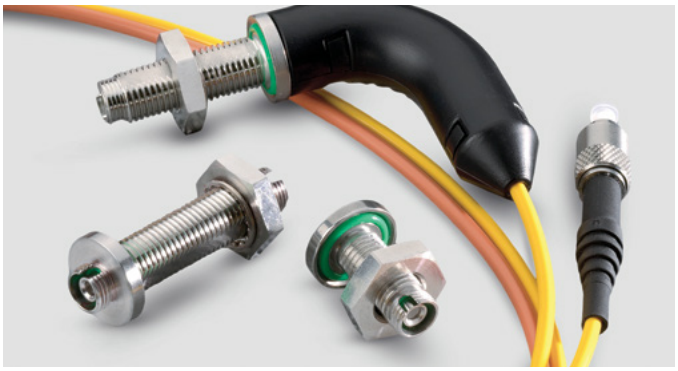
Greene Tweed's patented Seal-Connect® electrical components have been developed specifically for use in severe downhole environments with designs rated to 450°F (232°C) and up to 35,000 psid with specialized designs for 500°F (260°C) and 45,000 psid. We also provide robust designs which are more resilient to vibration and shock than glass to metal and other lower grade polymer connector bulkheads. Seal-Connect® electrical connectors are used in electrical submersible pumps, MWD/LWD and directional drilling tools, as well as wireline and subsea applications.

Seal-Connect® uses Greene Tweed's proprietary Arlon® grades of virgin or glass-reinforced PEEK thermoplastic, an extremely hard-working insulator with a very low coefficient of thermal expansion. Bonding Arlon® to a variety of metals produces a hermetic seal that is maintained throughout the operating temperature range. This ensures no "arcing," a common problem associated with conventional glass-to-metal-sealed electrical components. The use of Arlon® also allows for greater pin density, enabling smaller connector sizes in tools where space is at a premium.

In-house engineering provides the capability to design, test, and develop customized single-pin, coaxial, multi-pin, and rotatable configurations. Our engineers can provide recommendations if your multi-pin connector requires more than 48 contacts. We offer rotatable connectors with up to 10 contact bands with specialized designs of 11 to 13 contact bands possible.

Seal-Connect® body designs are offered in many different grades of Arlon®, including unfilled and glass filled. Connector boots and o-rings are available in various styles and materials, including Chemraz® FFKM and Fusion® FKM. We also offer:

- A variety of available pin materials (e.g., standard beryllium copper pins, corrosion-resistant Inconel or high-conductivity, oxygen-free copper) allows customers to choose the material that will provide the highest possible conductivity and reliability for their applications
- Designs may include corrosion-resistant support washers and specialized internal components to maintain geometric integrity in HPHT environments
- Extensive QA and validation systems ensure the resultant designs meet customer system needs for downhole and subsea requirements



Fiber Optics for Data Transmission

Greene Tweed's Seal-Connect® Fiber Optic Connectors are specified by leading oil and gas service companies for use in wellhead outlets and are used in other critical applications, such as rotary joints in wind turbines. Seal-Connect® Fiber Optic Connectors ensure data transmission when exposed to extreme pressures (up to 25,000 psi) and temperatures (up to 175°C/347°F).

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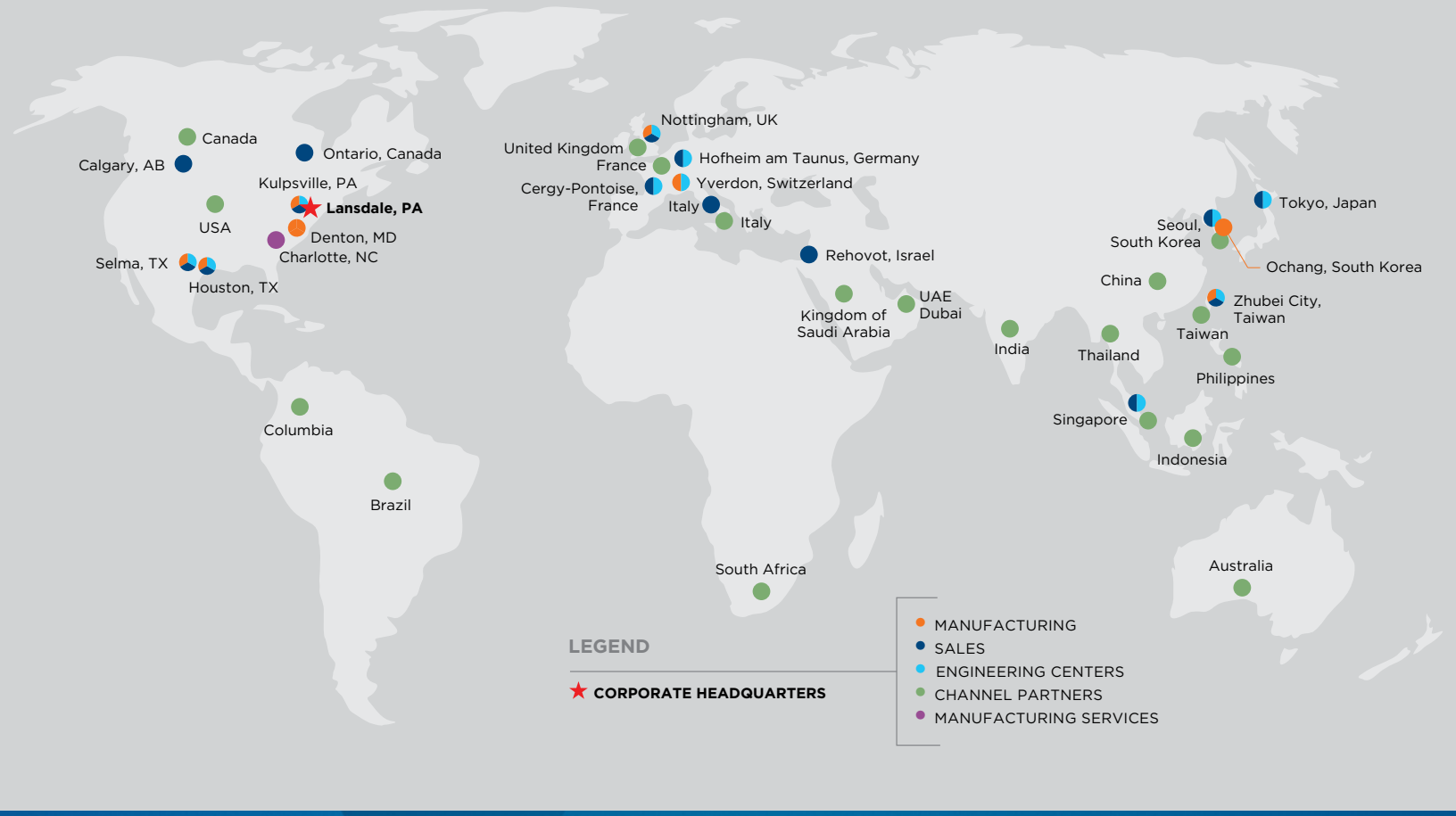

GLOBAL PRESENCE, LOCAL SERVICE.

With more than 1,900 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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