Seal-Connect®

SEAL-CONNECT®

THE ADVANTAGE

Today's challenging drilling environment has put extreme focus on reliable equipment for ever-increasing operating parameters. This focus is passed on by equipment manufacturers to suppliers of critical components. One key element in most systems is reliable communication of power and data through connectors and other electrical components.

Historically, high-temperature/high-pressure connectors were specified from one genre: the glass, ceramic and metal composite. A variety of factors now allows equipment manufacturers to take a fresh look at connector requirements and consider the advantage offered by the Seal-Connect® product line solutions for subsea and downhole connection.

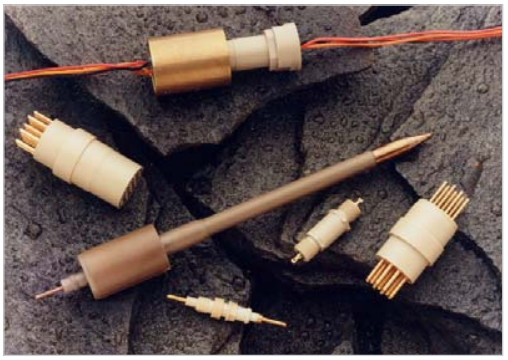
GLASS, CERAMIC TO METAL COMPOSITE CONNECTORS

Typical Failure Modes

There can be inherent problems with glass to metal-sealed connectors in that they are a precise assembly of a variety of materials. Connector pins and bodies are often made from limited materials due to thermal expansion compatibility problems. The fitting together of many parts invites tolerance "stacking" problems and improper assembly, and the tooling is expensive and inflexible for prototyping. Additionally, the smallest void or defect can be catastrophic when the insulation is bridged and arcing to the metal body occurs.

Seal-Connect Solutions

The Seal-Connect solution utilizes a specially designed ceramic or ceramic-reinforced glass matrix to minimize thermal expansion issues and extend life. Arlon® thermoplastics include as additional shock and insulation resistance. Extensive QA systems ensure accuracy of components and assemblies.



SEAL-CONNECT ARLON THERMOPLASTIC CONNECTORS

The most obvious advantage of overmolding a conductive pin with a high-quality thermoplastic is complete isolation of the conductor. Further specification of thermoplastic materials with good elongation and mechanical strength eliminates the possibility of leakage to ground. The various grades of Arlon can be molded over many pin materials and subsequently machined to precise tolerances. This produces a finished connector that is void free with good mechanical strength and consistent properties throughout its operating temperature range.

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03/05-GT DS-US-OF-019

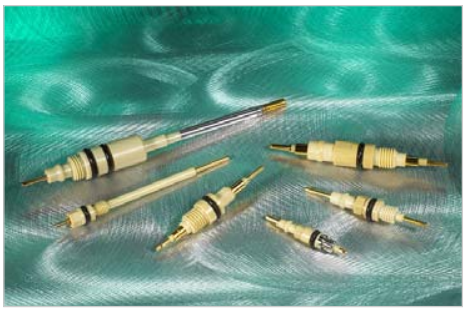
SEAL-CONNECT®
Product Series

ELECTRICAL CONNECTORS

Greene, Tweed has developed a wide range of solutions for consistent and reliable electrical connection in downhole and subsea environments.

Single Pin and Coaxial

Single Pin and Coaxial designs are manufactured from Arlon® 2000 and beryllium copper, unless otherwise specified. Designs can be made to customer specifications or can be purchased from stock per the relevant Greene, Tweed print.



Single Pin

Multi-Pin

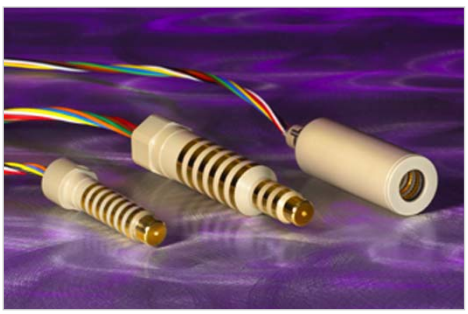
The Seal-Connect® 8-pin connector is an injected-molded and machined multi-pin connector. Available in a variety of designs, Seal-Connect multi-pin connectors can be configured to withstand up to 30,000 psi and 450°F (232°C) of continuous service through innovative techniques to minimize deformation and creep. Arlon's excellent insulative properties provide stability through the entire temperature range. In addition, the Seal-Connect technology enables tighter pin destiny than outdated glass to metal technology. Seal-Connect multi-pin connectors are perfect for oil-filled systems or as seals against fluid intrusion and failure transgression along the length of any downhole tool.

Multi-Pin

Seal-Connect multi-pin connectors are available in custom designs and in standard configurations (32, 27, 17, 15, 12, 8, 7, 4 and 3 multi-pin connectors).

Rotatable

Both male and female rotatable connectors are available with temperature capability to 450ºF (232ºC). Standard products are available (10, 8, 7 and 4 contact rotatable connectors).



Rotatable

Boots

Connector boots are available in various styles to allow inter-changeability with existing connector systems or the exclusive use of a Seal-Connect® system. Internal details can be adjusted with minimal tooling expense and modular tooling allows short or long runs economically.

03/05-GT DS-US-OF-020

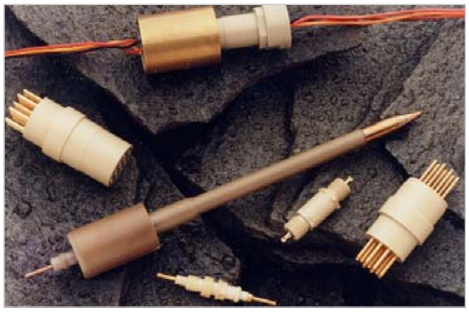
Standard products—Boot material & design

- Boot – Smooth radius single pins
- Boot – Small radius single pins
- Boot – Teardrop seal single pins
- Small tear drop
- High voltage

Other Electrical Components

Greene, Tweed has developed numerous custom solutions for electrical connection applications downhole.

Boots



Other Electrical Components

Seal-Connect®

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SEAL-CONNECT®

Electrical Component Solutions

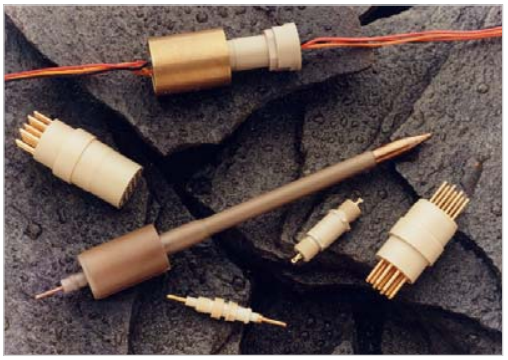
CAPABILITIES

Greene, Tweed's custom-designed electrical components have been developed specifically for use in severe environments like those found downhole. The unique designs utilize Greene, Tweed's proprietary Arlon® grades of virgin or glass-reinforced thermoplastic. This thermoplastic is an extremely hard-working insulator with a very low coefficient of thermal expansion. Bonding these thermoplastics 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.

Greene, Tweed works with customers to evaluate current electrical components in terms of effectiveness and recommends design alternatives. Greene, Tweed offers the ability to turn around new product developments very rapidly from prototype to production, working closely with customers' design engineers and procurement specialists.

Given the increasing sophistication of measurement/logging while drilling sensing devices, it is critical that electrical signals are uninterrupted and free from noise. Because these tools are often extremely expensive, reliability is paramount in terms of cost of ownership.

Contact Greene, Tweed for a full overview of custom, single and multi-pin electrical components, cable and hardness assemblies, and other electrical components.



TYPICAL APPLICATION AREAS

- MWD (measurement while drilling)
- LWD (logging while drilling)
- Wireline
- Feedthrough connectors• Capacitance sensors
- Weight on bit sensors
- Geosteering devices
- Resistivity tools
- Flow sensors
- Water hold up tools
- Bore hole pressure sensors
- Gamma ray sensors
- Formation evaluation tools

electrical components \ product data

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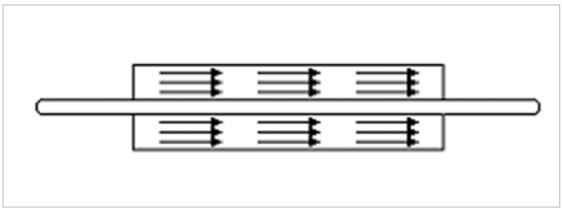
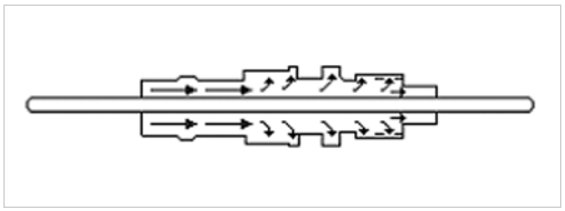
ARLON® MATERIALS & DESIGN

THERMOPLASTIC MATERIAL

Greene, Tweed uses PEEK™ (Polyetheretherketone) and PEEK-HT™ (Polyetherketone) to produce the injection-molded outer connector body of SEAL-CONNECT® connectors. Complete certification testing on each resin lot ensures full traceability and compliance to specifications.





In order to manufacture a repeatable high-quality part, injection molds are designed with simplicity and consistency in mind. While many parts could be molded completely to print, experience shows that an overmolding of Arlon® with subsequent machining provides more uniform physical properties and enables economic tooling. Proprietary stress relieving anneal cycles further alleviate inconsistencies. The figure on the right indicates differences in complexity of flow patterns in a detailed molding vs. an oversized blank molding.

For most applications Arlon 1000 injection molded PEEK™ performs adequately. Limitations of Arlon 1000 become evident at service temperatures above 350°F (175°C) or when the outer sealing diameter produces extreme loading. Arlon 1160 30 percent glass-reinforced-grade PEEK can be used for applications requiring higher mechanical properties, but it experiences some degradation above 350°F (175°C). For the most extreme temperature applications Arlon 2000 PEEK-HT should be considered because its higher glass transition temperature gives improved mechanical properties to 400°F (204°C). Please refer to Arlon Material Properties for a full listing.

Connector bodies can be machined to tolerances of .001" total with excellent positional control of all machined diameters relative to the conductor. CNC machining centers produce parts quickly without sacrificing quality. Laser engraving to identify lot numbers or manufacturing dates can be provided at a minimal additional cost and, in most cases, the exposed conductors are gold plated at the end of the process to minimize damage during manufacture.

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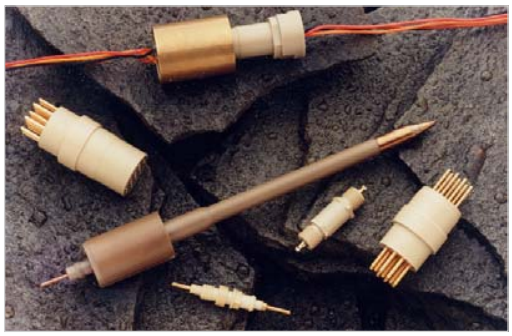
Statements and recommendations in this publication are based on our experience and knowledge of typical applications of this product and shall not constitute a guarantee of performance nor a modification or alteration of our standard warranty that shall be applicable to such products.

03/05-GT DS-US-OF-035

SEAL-CONNECT®
Electrical Characteristics

CONNECTOR COMPONENTS



Arlon® is a consistently dependable insulation material. Precision-machined connector bodies, induction coil spools, coaxial assemblies, chassis and single-pin connectors are but a few of the historical uses of this material.

Each single-pin connector assembly is carefully inspected to ensure electrical integrity. Insulation measurements consistently indicate 500 Giga-ohms of isolation @ 500 VDC and ambient temperature. In the single-pin connector design we see the benefit of a material with good strength and elongation as temperature increases. The low coefficient of thermal expansion not withstanding, Arlon connector bodies will expand at a slightly greater rate than most of the metal conductors. However, no gaps between the pin and body are formed throughout the operating temperature range. Therefore, while temperature rise affects the insulation resistance of nearly all materials, the Arlon single-pin connectors exhibit 10,000 mOhms minimum at 2500 volts DC and temperatures as high as 500°F (260°C).

Mating pairs of pins and sockets are also checked for contact resistance. Although materials and plating selection greatly influence this parameter, no designs to date have shown more than 10 mOhms increase when mated. Connector and harness assemblies are also checked during prototyping to proof the design and manufacturing techniques.

Further material properties allow specification of Arlon thermo-plastic in a wide variety of components besides single-pin connectors. A consistent dielectric constant, low dissipation factor and excellent dielectric strength have proved indispensable in coaxial, triaxial and high-frequency applications.

03/05-GT DS-US-OF-023

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SEAL-CONNECT®

Conductor Material & Design Solutions

INNOVATIVE CONNECTORS

Traditionally conductor materials in hermetic high-temperature and high-pressure connectors have been chosen based on the coefficients of thermal expansion as related to glass-sealing materials. This was required to maintain the integrity of the brittle glass seal. When manufacturing glass to metal sealed hermetic connectors, extreme temperatures must be considered to ensure full compression of the glass during firing.

Without the constraint of matching thermal expansion coefficients in glass seals, conductor materials can be chosen to fit the application rather than the method of manufacture.

Automatic screw machines fabricate conductors from a wide variety of materials.

Materials	Specifications
Beryllium Copper	ASTM B196
Nickel Silver	ASTM B151
Inconel X 750	AMS 5698
17-4 PH Stainless Steel	AMS 5643
316 Stainless Steel	ASTM A276

**Preferred material is Beryllium Copper for up to 400ºF (204ºC). For higher than 400ºF (204ºC), consult Greene, Tweed.*

High-precision equipment and rigorously controlled raw material allow standard tolerances on the order of .0015" total.

The pin of a reliable connector should have uniform, consistent size in order to ensure proper contact force with the spring-finger socket. This allows full interchangeability among mating pins and sockets without variation in contact resistance.

Several standard sizes are readily produced. Sizes are numbered to correspond with the American Wire Gage (AWG) standard wire sizes. The following table represents the male pin diameter.

Typical Pin Diameters	
#20	0.040"
#18	0.047"
#16	0.062"
#14	0.078"
#12	0.094"
#8	0.125"

**Any other size pin/socket combination can also be produced depending on customer requirements.*

Standard sockets produced to properly engage these pin diameters will have the following load characteristics. The minimum contact force is characterized by the amount of load the socket will retain using the smallest possible male pin diameter. This extraction force is measured using an Ametek Accuforce® III digital force gauge.

Greene, Tweed utilizes four-way split sockets, unless size dictates moving to a two-way split socket, designed to assure uniform contact under vibration. Nickel-plated, brass cover sleeves protect in most applications.

Typical Sockets Extraction Force	
#20	2 – 6 oz
#18	2 – 6 oz
#16	8 – 16 oz
#14	8 – 16 oz
#12	10 – 24 oz
#8	10 – 24 oz

Gold plating produces mating contacts with the minimal contact resistance and removes the possibility of corrosion. A ductile nickel underplate minimizes contact resistance and provides excellent adherence to the gold.

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MECHANICAL CHARACTERISTICS
SEAL-CONNECT®

CONNECTOR COMPONENTS

Single pin connectors have for decades been indispensable in sealing off electronics from the abusive downhole environment. In many cases these connectors are the last line of defense against flooding extremely expensive and vital electronic assemblies.

In a less catastrophic context, the ability of a connector to seal reliably and not introduce unanticipated current drain is important with respect to power consumption and accurate data collection. Therefore, the mechanical integrity of the connector system has a significant impact on downhole tool performance.

The booted bulkhead single pin connector assembly has four critical sealing elements. The first of these is the Arlon® to metal interface around the conductive pin. The injection molded thermoplastic doesn't chemically bond to most of the conductor materials. Instead, what is created is a homogeneous molding whose viscosity and shrinkage allow it to conform to specially designed pins. Post molding annealing cycles proprietary to Greene, Tweed relieve excess stress levels without corrupting this plastic to metal "bond".

Other sealing elements include the standard o-ring glands, and two critical areas of the connector boot. Seal-Connect® O-ring glands are typically held to .001" total tolerance and are slightly modified to insure high pressure sealing and proper loading on the Arlon connector body. Excellent surface finishes of 32 RMS or better are obtained both in the O-ring area and on the Arlon at the boot interface.

Mechanically, thermoplastic connectors are not as robust as their metal counterparts. However, in most applications the benefits of electrical isolation far outweigh the reduction in total strength. As mentioned in the testing section of this guide, Greene, Tweed. stands behind the mechanical integrity of these connectors. Each relevant mechanical parameter is addressed as follows.

The main load induced in a pressurized environment is that transferred by the o-ring to compression on the load bearing shoulder. For example, a 5/16" diameter o-ring in a 20,000 psi differential pressure environment will impart an ultimate force of 1530 lbs onto the shoulder. This could mean compressive stress levels as high as 55,000 psi on the small bearing area. Of course, no grade of Arlon exhibits compressive strength values of this magnitude as defined by ASTM method D695. However, when the Arlon connector bodies are contained in a properly machined mounting bore they survive stress levels far above this value. The material's excellent elongation allows it to move somewhat to absorb these stress levels without substantial permanent deformation. This movement, usually referred to in a negative context as creep, is actually beneficial in a properly designed Seal-Connect connector system.

Other loading prevalent in many connectors is the installation torque. As expected, Arlon\ connectors cannot be stressed highly during installation. Typically, seating torque of 8-10 in-lbs is specified for a 1/4-28 UNF class 2 thread form. Over-torqueing these connectors will cause the Arlon threads to strip. This failure, while rendering the connector scrap, is much better than installation torque damage on a comparable glass to metal part. Over-torqueing a glass to metal part could cause a small crack in the brittle internal seals that would not be detected until inservice when enough moisture infiltrates this crack and causes electrical leakage.

Similarly, slightly bent pins during the installation or use of a glass to metal part can cause a failure. Not only does the Seal-Connect manufacturing method enable higher strength conductor pin materials but if a bending load is imparted to the pin, the Arlon again responds with enough elongation to preserve a hermetic seal. This coupled with the fact that the Arlon to metal bond extends along the entire length of the pin ensures that a bent exposed pin is no reason to discard the part. If possible, the pin could be realigned adequately to mate with its socket and used repeatedly.

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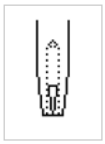
In a completely nonmagnetic environment the nickel underplate can be replaced with a copper strike. In the case of certain stainless steels, a copper strike precedes nickel underplate. Unless otherwise specified, a 10 µin thick gold plate will be used. Plating thickness up to 50 µin or more can also be accommodated. The following are applicable plating specifications.

- Gold plating per MIL-G-452004 C, type I or II, Grade C or D
- Nickel plating per Fed. Spec QQ-N-290A, Class I Grade G
- Copper Strike per MIL-C-14550 Class I

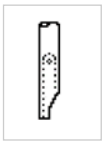
**Alternative plating can also be supplied depending on customer requirements.*

End terminations of the conductor may be specified as shown below with pins, sockets, solder cups, eyelets, hooks, crimp barrels, etc., or any combination.


Straight

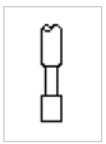

Socket


Eyelet


Solder Cup


Crimp Barrel


Threaded


Undercut


Hook

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SEAL-CONNECT®
Boot Materials & Design

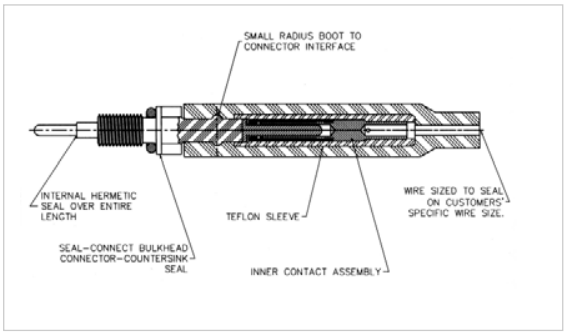
CONNECTOR COMPONENTS

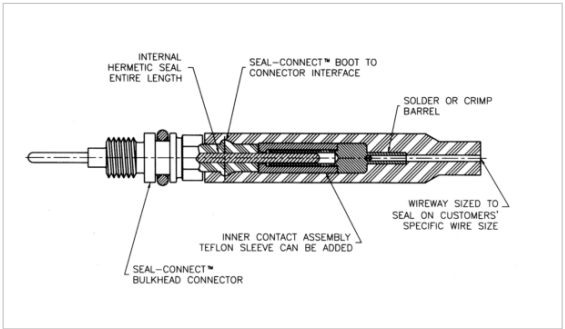
The injection-molded, machined connector is often coupled with an elastomeric connector boot. Historically these boots have been responsible for a large number of leakage failures. Recent innovations in materials and design along with proper installation and maintenance give users more confidence in critical service applications.

As a world leader in elastomeric material formulation and production for high-performance sealing systems, we have drawn on this core competence to produce our first nonconductive grades of high-temperature elastomers for Seal-Connect® boots. R&D in this area continues with new formulations for the varying needs of our customers. To date a nonconductive Fluorocarbon elastomer (FKM) based on the Viton® GF1 Polymer and another based on the Fluorel® 26502 Polymer are available. Other compounds can be selected or formulated very quickly for prototyping applications due to our extended experience in chemical compatibility.

In rubber molding, as with Arlon® injection molding, we have simplified mold-design and share-tooling costs to enable economic prototyping and production. Extended resources in rubber-molding capabilities include dozens of presses, in-house or outsourced tooling design and construction, and rubber-injection partnering for extremely high-volume components.

Single-pin connector boots are designed to accommodate two variations depending on customer requirements. To mate with popular existing connectors, a boot with a smooth radius is provided. However, to ensure positive locking and more reliable sealing, an improved “teardrop”-shaped boot seal is recommended. These boot designs are easier to install and have enough retention to remain in place even when low viscosity greases are used inside the boot assembly. Smaller diameter sealing surfaces typically use a smaller radius that provides the same positive lock of the boot to the connector.





The boot assemblies, as shown above, can be constructed simply of a contact and boot or with the addition of a Teflon® sleeve. Again, many designers use Teflon to ensure high-temperature insulation resistance properties while others delete the sleeve to rely solely on the insulation resistance provided by the elastomeric boot material. Unless otherwise specified, new designs utilize three-piece construction to guarantee adequate high-temperature insulation resistance.

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03/05-GT DS-US-OF-021

SEAL-CONNECT®

Testing Capabilities & Specifications

TEST EQUIPMENT	
Color	Fully integrated one liter (3" dia. X 9" long) pressure vessel with heating/cooling jacket and programmable controllers featuring closed-loop PID componentry
Proof Pressure	30,000 psi (206.8 Mpa)
Temperature	70ºF - 650ºF (21ºC - 343ºC)
Pressure/Temp. Max	28,000 psi (193 Mpa) @ 500ºF (260ºC)
Helium Leak Detector	Varian Auto-Test 947
Thermal Cycle Oven	Blue M 650ºF (343ºC) with programmable controller
Digital Force Gage	Ametek AccuForce III, 0 - 50 lb.
Electrical	Kiethly Micro-ohm Meter—"Contact Resistance Meter;" Simpson Model 405 Megohmeter 0 - 5000 VDC; Fluke Model 8062A Digital Multimeter
Evaluation	Sciencescope XLT-V plus microscope with minitron CCD video camera and Hitachi color video monitor

TESTS	
High Pressure	20,000 psi (137.9 Mpa) @ ambient temperature, hold one hour.
Visual	Inspect thermoplastic surface at 20X magnification to ensure no dimples or cracks indicating the presence of molding voids
High Temperature & Pressure	20,000 psi (137.9 MPa) @ 400°F (204°C) Ramp to ultimate temperature and pressure simultaneously, hold one hour
Dimensional Stability	Verify and record dimensional changes, if any, during pressure and temperature testing
Hermeticity	Using one atmosphere differential pressure, verify that parts are hermetic; they must resist the passage of helium at a leakage rate less than 1 X 10^{-8} /cc/sec
Insulation Resistance	Verify 20,000 mOhms minimum @ 2500 VDC and ambient temperature; 5000 mOhms minimum @ 2500 VDC and 400°F (204°C)

As new products are added, Greene, Tweed engineers determine appropriate testing to qualify the design. However, all new Seal-Connect® products are qualified per a standard testing sequence.

In addition, long-term tests are run to characterize creep tendencies on many designs, and pressure/temperature cycling is used to verify service ratings and estimate life cycles. Consult Greene, Tweed Seal-Connect engineers for other tests and specifications.

testing capabilities \ product data

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