

White Paper Series – Part IV:

# ***EXTREME MATERIALS***

ROBUST PERFORMANCE FROM CABLE TO CONNECTOR



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EXTREME ENVIRONMENTS | COMPLEX REQUIREMENTS

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**CUSTOM INNOVATIONS**  
**CONNECTOR + CABLE**

## EXECUTIVE SUMMARY

Combining decades of field-proven life science experience, LEMO and Northwire credit their global success and reputation largely to their customers' positive experiences with their Subject Matter Experts (SMEs). Leaning on these experts, the manufacturing companies have supported customers in designing customized solutions for a diverse range of extreme applications. LEMO and Northwire's SMEs dedicate their focus to developing cutting-edge products and materials that solve complex, new, and evolving challenges. This white paper offers insight into the deciding factors influencing tailored connectivity systems. From specifying the correct stranding configuration to creating specialty blends to ensure optimal jacket performance, selecting the right combination of variables plays a critical role in the success of products. By streamlining processes and communication between Northwire's cable designers and the connector specialists at LEMO, the connectivity resources ensure that precise products are manufactured for every customer, from *Concept to Completion*.

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## GATHER REQUIREMENTS TO ENSURE SUCCESS

In all environments, especially extreme conditions, high reliability and zero down-time are imperative and even the smallest factor can be the difference between success and a costly failure. It is vital to consider every factor influencing performance. By conferring with Subject Matter Experts and experienced manufacturing companies, projects and programs have the best chance of successful performance.

Far beyond vetting best in class materials, SMEs identify attributes that compliment functionality needs, anticipate environmental challenges, and adhere to budgets and schedules.

LEMO and Northwire utilize new product introduction processes and project management in the design and manufacture of connectivity solutions. By understanding the core functionality of the product and the different factors that will contribute to the attainment of each customer's goals, the companies' SMEs begin the critical process of requirements gathering.

### LEMO and NWI's SMEs ask key questions such as:

- What is the end-application of the product?
- Who are the users?
- In what environment(s) will this cable assembly need to perform?
- What element(s) will this cable assembly be exposed to (water, oil, chemicals, extreme heat, etc.)?
- What challenges could be encountered with transportation and installation?
- How will the connectivity solution be monitored and controlled?
- Will this product be subject to agency approvals or government regulations?
- What is the budget and schedule for this project?

In addition to on-site SMEs and the manufacturing companies' global network of experienced professionals, LEMO and Northwire collaborate with colleagues for manufacturing, testing, approvals, and more to provide customers a one-stop shop experience.

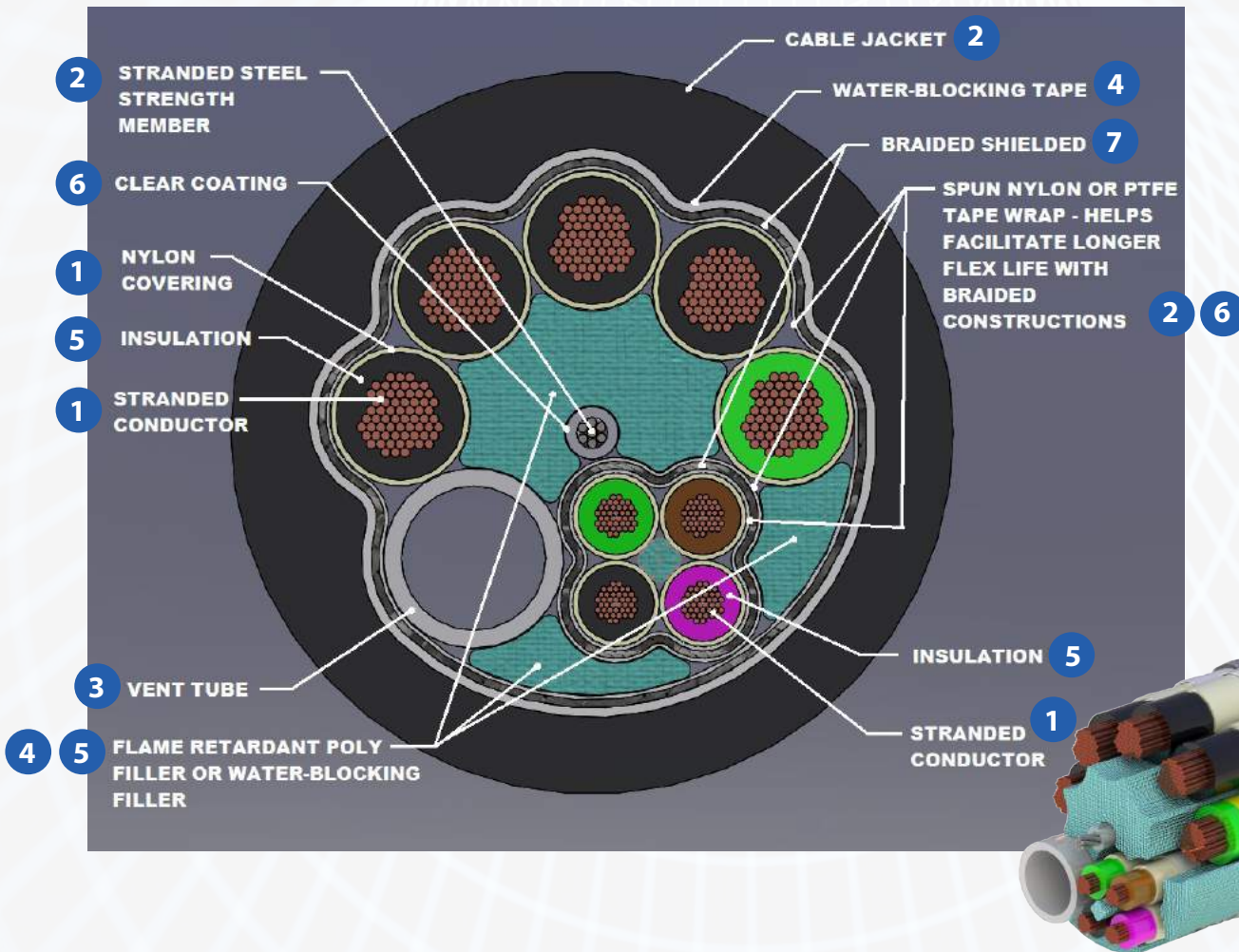


### Gain added value through services that include:

- Rapid prototyping and 3D prototyping capabilities
- Full testing with on and off-site independent facilities
- Certifications with UL, CSA, MIL-Spec, cUL, cULus, CE, MSHA, NFPA, ANSI, ABS, IEEE, SAE, USP, ISO-10993, FDA and more
- Compliance to RoHS2 and REACH directives
- Maintenance and repair operations
- Integrated cable assembly services
- And more

Learn more about requirements gathering, follow the selection guidelines in this white paper, or connect directly with LEMO and Northwire SMEs at 1.800.468.1516, or [CableInfo\\_Northwire@lemo.com](mailto:CableInfo_Northwire@lemo.com).

# INSIDE-OUT CABLE CONSTRUCTION



## 1 | COPPER STRANDING

Copper strands conduct electric signals through the cable

## 2 | STRENGTH MEMBER

Strength members can add push strength, pull strength, and rigidity

## 3 | BREATHER TUBE

Breather tubes allow heat and pressure to vent and dissipate in addition to fluid management

## 4 | WATER BLOCKING MATERIAL

These materials expand on contact with moisture to stop a leak and protect essential electrical components from water damage

## 5 | FILLERS

Fillers add shape and can improve resistance to environmental factors

## 6 | BARRIERS

Tapes, wraps, and other separators provide protection, support, and insulation

## 7 | SHIELDING

Foils and braided shields protect signal integrity and add strength

## 8 | JACKETING

The outer jacket provides critical protection from environmental factors

## FAILURE PROOFING CABLE SELECTION

*If factors such as flex, temperature, and dangerous environments are not properly taken into account, a number of failures may occur.*



If there is **constant motion** or twisting, internal conductor bundles may corkscrew and eventually one or more conductors may break.



If there is **constant motion** or **flexing**, inner conductor insulation may fail due to internal heating and/or abrasion and then short-circuit.

The presence of other additional environmental factors may accelerate cable failure in constant motion applications, such as **oil** or **chemicals** that may cause premature failure of the cable outer jacket. **Welding slag** introduces **heat** and **highly abrasive material** to the environment.



If the cable operates in **high heat** or **harsh environments**, the outer jacket may fail due to **heat** and/or **abrasion**, exposing the inner conductors to the outside environment.

**Water, sunlight** and **temperature extremes** are additional hazards.

LEARN MORE AT [NORTHWIRE.COM/TECHNICAL-RESOURCES/FLEX](http://NORTHWIRE.COM/TECHNICAL-RESOURCES/FLEX)

### HOW TO PREVENT FAILURE

- Know the specifications – create a detailed list of needs.
- Understand the environment of the application – what temperatures will the system operate in? Will motion and flex be constant? How many cycles? Will the cable be subject to damage from oil, chemicals, UV rays, or welding slag? How long will the cable be exposed to these elements?
- Create a plan for installing, connectorizing, and terminating the cable.
- List all agency standards, government regulations, and other approvals needed.
- Are there aesthetic requirements for the finished cable assembly's look and feel?
- Discuss the project with an SME in a relevant field to determine how to best fit the requirements while staying on schedule and within budget.



## CORE KNOWLEDGE: COPPER STRANDING 101

Copper has been the conductor of choice for electrical wiring since the early 1800s. With a higher conductivity rating than any other non-precious metal, copper has become the standard for measuring conductive materials. Copper is also uniquely suited for use in electrical wiring due to its relatively high tensile strength, flexibility, and ductility – the pliable property of copper that allows it to be further processed without breaking or cracking. These properties, among others, make it the ideal material for wire and cable.

### Why Copper?

- High Conductivity
- Natural Flexibility
- Resists Corrosion
- High Tensile Strength
- Dissipates Heat Well
- Low Thermal Expansion
- High Ductility
- Resists Deformation
- Easy to Solder

### COPPER COATING

Bare copper is preferred in most situations, though some copper alloys are better suited in environments where excellent abrasion or corrosion resistance is needed. More commonly, copper strands have a coating applied to add the properties required for a given application.



**Dennis Langer**  
NWI Design Specialist

*"There are several coatings that we can purchase the stranding in. Silver plate and nickel plate would be two of them, and bare copper is always an option. Different coatings would be for different applications. Tin coating would be a preferred method when soldering is being used or something of that nature. The nickel plate and silver plate come into play when a higher temperature material is being used, such as a fluoropolymer. The nickel and silver melt and reflow at a higher rate, which is why we process with those at higher temperatures."*

### COPPER CONSTRUCTION AND CONFIGURATION

Copper stranding is defined by both its overall size and an individual strand's size. For example, a .75 mm<sup>2</sup> construction would be defined as 32 ends of .2 mm. The .75mm<sup>2</sup> would be the overall size, and then there are 32 strands of .2mm for each strand.

Application often determines the size of stranding that will be needed. In a power application, the ampacity requirements for the stranding will define the size needed to handle the power load, taking into account all of the conductors that are in play.

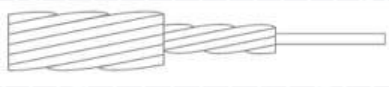
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## CONCENTRIC



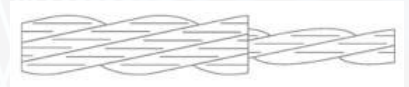
In a concentric strand, there is a solid conductor running down the center that is surrounded by layers of rotating strands. Each layer is comprised of strands running the same direction, but the direction alternates for each layer.

## UNILAY



The unilay configuration is similar to concentric, with layers of stranding around a center conductor. Unlike concentric, all layers rotate the same way; typically, these layers have a left-hand rotation.

## ROPE LAY



With the rope lay configuration, there are a number of individual bundles of stranding twisted into groups that make up one larger, solid configuration.

Stranding configuration selection depends on the end-application of the cable and the environment in which the cable must perform. Key deciding factors are flex and movement requirements. The typical rule of thumb is “the more strands, the more flexible and the longer the lifespan”. From a movement and motion standpoint, a rope lay construction is by far the most flexible configuration – it is also by far the most expensive, highlighting the trade-offs buyers and engineers must constantly consider when choosing materials.

For static in-situ applications, stranding matters less. Dramatic temperature fluctuation does not affect copper as much as movement does, but it is important to consider the connection point and how the cable will be terminated, as this could be a vulnerable area.

Other factors to consider are applicable regulatory agency requirements. As a North American company, Northwire adheres to many guidelines, with UL as one of the most predominant. UL requires twisted stranding in most applications.. With other approvals and some agencies, manufacturers can run stranding without twisting it together.



## When selecting copper stranding, ask:

- 1 | What is the primary end-application and use for this cable?
- 2 | What environmental factors will this cable need to perform in successfully?
- 3 | What approvals or agency certifications are required for the application?

### NWI CABLE OPTIONS

- Copper stranding options
  - 36-2 AWG (7,19 strands or higher)
  - 18-16 AWG (19 strands or higher)
  - 14-2 AWG (41 strands or higher)
- Up to 2" (50.8 mm) O.D.
- 0V to 2000V
- -200°C to 260°C
- UL listed, CSA certified and approved for CE Mark
- RoHS2 and REACH compliant

### NWI STRANDING OPTIONS

- Bunched
- Unilay
- Rope lay
- Concentric
- And more

### NWI COATING OPTIONS

- Temperature rated from 150°C to 260°C
- Tin
- Silver, Nickel
- High-strength alloys



## STRENGTH MEMBER PERFORMANCE

Strength members add both function and protection to connectivity solutions. Specific strengthening materials may be added for unique solutions such as pull strength, push strength, mechanical strength, or rigidity. Fiberglass rods, steel strength members, and aramid fiber are three of the more common types of strength members.



Kevin DePratter  
Director of R&D

### FIBERGLASS RODS

*"We use fiberglass rods when a cable has to be extremely rigid because the cable is being pushed through the pipe. One extreme application is for sewer system inspections where there is a camera and connector on the cable. The rod enables the cable to stand straight out. This gives the cable great compressive properties and a lot of push/pull strength."*

### STEEL STRENGTH MEMBERS

These steel cords are used in applications such as LEMO and Northwire's SMPTE HD AV product line where pulling strength and compressive strength are critical. There are different types of steel strength members that may be used depending on weight requirements and durability. Stainless steel strength members provide excellent strength at just 3/16th of an inch. Galvanized steel provides pull strength of about 500 Newtons without breaking, along with superior compressive strength.

### ARAMID FIBER

Aramid fiber, or Kevlar® when referring to DuPont's brand, is the extremely strong material used commonly in bulletproof vests. Ideal for extreme pulling strength in cable, aramid fiber can be stranded in a variety of configurations to achieve differing levels of strength. A bundle of four strands provides 450-600 Newtons of pull strength. While it is not rigid, it does offer high compressive strength without adding significant weight. If aramid fiber is used in a cable system, special attention must be given to the cable's termination, as incorrect termination can lead to weak points in the fiber.



When selecting strength members, ask:

- 1 | What type(s) of strength are required?
- 2 | Does this cable need to be rigid or flexible?
- 3 | What is the plan for termination and connectorization?

# BREATHE EASY WITH MULTI-FUNCTIONAL TUBING

Breather tubes are integral to functionality in some extreme environments. With a wide range of material types, sizes, and durometers, these cable compliments can offer increased protection against high heat, pressure, oil, water, chemicals, flame, and abrasion.

*"There are many important functions for breather tubes. They can be incorporated into wiring harness applications where they'll bundle together inner components. This will help to separate those bundles and provide protection or abrasion resistance. They can be used for gas and fluid transfer and also for dissipating heat, pressure or steam."*



Linda Brown  
NWI Application Engineer

## RANGE OF APPLICATIONS

Given the wide scope of customization options available for breather tubes, they can be used in many diverse applications:

- Automotive
- Food and Beverage
- Medical Equipment
- Fiber Optics
- Dental Equipment
- Liquid or Gas Transfer
- Oil and Gas Fields
- Factory and Automation
- And More

Whether they are housing fiber optical components, venting heat in electrical equipment, or used in pneumatic lines in an oil field, breather tubes prevent damage caused by high temperatures and pressure while adding helpful functions to the cable system.

## MATERIAL SELECTION

Breather tubes come in a number of different materials to fit the large variety of applications. Breather tube material options include:

- PE: Polyethylene
- Nylon
- PVC: Polyvinyl Chloride
- PUR: Polyurethane
- PTFE: Fluoropolymers

Find the right breather tube for any application by consulting with a Subject Matter Expert at Northwire for material section, construction, and more.



### When selecting breather tubes, ask:

- 1 | What is the primary purpose of the tube?
- 2 | Are there secondary desired functions for the tube?
- 3 | Will the cable be in high heat or wet environments?



## STOP LEAKS AT THE SOURCE

Even with resilient, durable cable assembly solutions, there is always the chance of cut, abrasion, or faulty termination. In wet environments, a small fissure could spell disaster. To mitigate epic failures, water blocking agents quickly react to moisture seeping into a damaged part of the cable, sealing off the leak and preventing migration of the liquid.



### When selecting water-blocking materials, ask:

- 1 | Will the cable be partially or fully submerged?
- 2 | Are there moving parts or high flex requirements for the cable system?
- 3 | What types of liquid will the cable encounter?

### WATER BLOCKING CAPABILITIES

Traditionally, cables meant for use in wet environments would have a layer of water-blocking gel throughout the cable or filling the ends only, where leaks are more likely to occur. Upon contact with moisture, the gel would block the moisture from moving further down the cable.

With effectiveness limited to the small area of gel coverage, gels are also difficult to apply and can add mess and complication down the line. Newer solutions are more advantageous, with the added benefit of easy installation and termination. These include dry yarns and tapes that are impregnated with water-blocking chemicals. If moisture comes into contact with these yarns and tapes, the chemicals activate to produce and release water-blocking gels. The moisture is unable to spread and the leak is trapped and sealed effectively.

Northwire's field-proven solutions have been tested up to 15 PSI to ensure that there is no further water penetration from the point of contact. These options may be selected and customized based upon additional factors such as the temperature and type of water (salt, fresh, sewer) in which the cable assembly must perform.

NiCorAl™, LEMO's newest surface treatment for rugged connectors, provides exceptional protection to salt water corrosion for cable systems in wet environments. This treatment lengthens the life of aluminum components and passes the 500 hours salt spray test under AECTP 300 / MIL-STD-810 / MIL-STD-202 standards. It is also RoHS2 and REACH 2017 qualified. NiCorAl was the second runner up in the 2016 i-NOVO Awards for the Tech Category, highlighting LEMO's continued commitment to high-performance products of recognized quality. To learn more about this product, click [here](#).





# FILLER FUNDAMENTALS: FORM AND FUNCTION FACTS

At first glance, fillers may seem like the simplest aspect of cable and wire. Their primary function is to fill the space between other components in order to provide the desired form. However, it gets more complicated – fillers made of a variety of materials may be added to enhance functionality and give the cable additional strength and protection against environmental factors.

## FILLER MATERIALS

Common fillers are made of polypropylene (PP), polyester (PES), nylon, cotton, and paper. These can be bundled, twisted, or layered as needed. Materials may add benefits such as:

### PVC OR POLYETHYLENE PLASTICS

- Common and easy to source
- Available in any size

### FOAMED POLYPROPYLENE

- Light weight
- Adds insulation
- Resists many environmental factors

### FIBRILLATED POLYETHYLENE

- Common and easy to source
- Primarily used for proper shaping

### POLYETHYLENE OR POLYPROPYLENE RODS

- Adds push and pull strength

### POLYESTER

- Provides insulation
- Minimal shrinkage

### NYLON

- Resists heat
- Adds strength

### COTTON

- Will not melt in high temperatures
- Cost effective
- Can be infused with water blocking chemicals

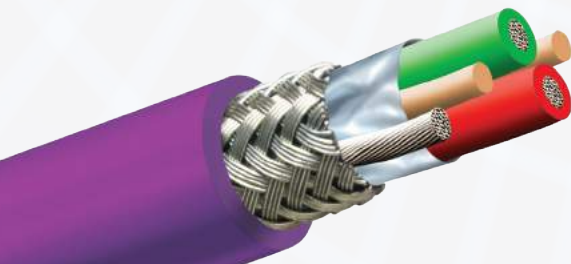
### PAPER

- Commonly used in power cables
- Options for flame and moisture resistance

### ARAMID FIBERS (KEVLAR®)

- Adds superior strength

Ensure performance by taking advantage of multi-functional filler materials. Keep inner components in place, add strength, and gain other benefits by working with a Subject Matter Expert to find the right filler for every application.



### When selecting filler materials, ask:

- 1 | What form is desired?
- 2 | How can filler impact the cable's function?
- 3 | Given the other cable components, what literal and practical gaps could filler materials address for this application?

## BARRIER BASICS: TAPES, WRAPS AND SEPARATORS

Tapes, wraps, and separators serve as barriers between a cable's core components and the outer jacket material so that they do not bond together. However, like fillers, there are many additional functions that these layers can perform based on individual needs and applications.

### ADDED FUNCTIONS AND ADVANTAGES

Beyond acting as a barrier, adding certain tapes, wraps, and separators can provide a number of helpful functions.

- Aluminized backing can be used for shielding and insulation.
- Binder wraps hold components together to make sure tensions stay the same.
- Based on coverage and material, tapes can increase flex life or rigidity.
- Materials like Kapton® tapes are designed specifically for high temperatures.
- Polyester excels in low temperatures, and PTFEs and nylon can be used at any temperature.
- Wraps and tapes can be designed to protect from moisture and chemicals.

Configurations to isolate and separate internal components are very customizable. Additionally, coverage can range from full to minimal depending on needs.

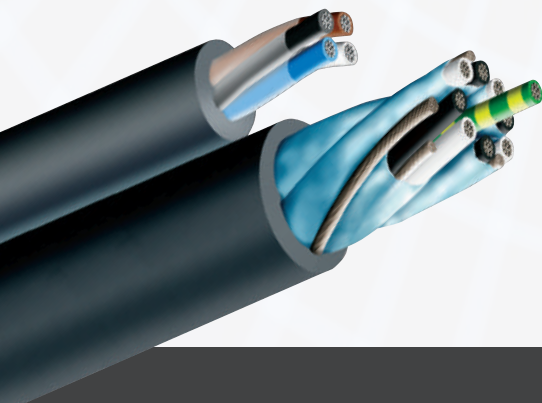
### CONNECTOR CONSIDERATIONS

From a connector standpoint, the dimensional aspect of wraps and tapes is the most important. There are some tapes – cloth tape for example – that are thicker than a polyester tape and could affect the housing of the connector.



**Dennis Langer**  
NWI Design Specialist

*"There are a number of different tapes that are available. They can be applied at various operations to achieve a range of functions. Focus on the unique capabilities tape materials offer and the end-application requirements."*



**When selecting tapes, wraps, and separators, ask:**

- 1 | What internal components must be accommodated?
- 2 | What other functions would be helpful for this application?
- 3 | How will the cable be connectorized?



# FIND A KNIGHT IN SHINING SHIELDING

Shielding provides protection by increasing both structural integrity and signal integrity. Selecting the right shielding materials and configurations can add strength, flexibility, and noise suppression.

## MATERIALS AND ORIENTATION

The primary types of shields offered by Northwire include a foil shield, a box weave or basket weave braid shield, and a spiral shield. These can be made from aluminum, tin, stainless steel, aluminized polyester, and more.

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## SHIELDING

- Aluminum foil tape
- Aluminized polyester tape
- Foil tape, braiding with tinned copper, stainless steel, bronze and other materials
- Drain wire

## BRAIDING STYLES

- Box weave
- Spiral

## REDUCE INTERFERENCE

The most effective shielding against interference is a combination of braid and foil shields. From an electrical standpoint, foil guards against high frequency noise and a braid guards against low frequency noise. The combination is ideal for signal integrity.

## INCREASE FLEX LIFE

Foil provides a layer of shielding without adding a lot of weight or cost, but when high flex life is required, it may not be the best material. A spiral shield provides more flexibility, but may have a shorter life span in high flex environments. A box weave, while stiffer, will stay together throughout the flex life of the application due to its interlocking nature.

## CONNECTOR CONSIDERATIONS

When connectorizing a cable, the shield must be terminated as effectively as possible on both ends. If there are multiple twisted pairs inside the cable that each have their own shield, it is most effective to terminate each shield independently without touching each other. This allows noise to dissipate and not interfere with signal.

### When selecting shielding, ask:

- 1 | What type of noise interference will the cable encounter?
- 2 | What flex life demands will there be for the cable system?
- 3 | If there are multiple shields, what is the plan for connectorizing?



# JACKETING: THE FIRST LINE OF DEFENSE

A cable's outer jacket is its primary means of protection against environmental factors and application demands. With that in mind, Northwire offers a diverse range of jacket materials and constructions to protect critical inner components from extreme environments throughout the life of the cable.



**Krista Lindquist**  
Materials Engineer

*"Northwire has a wide variety of commercial materials available and the resources to develop specialty compounds to meet your specific needs. For extreme temperatures, we have an assortment of different fluoropolymers, thermoplastic urethanes (TPUs), and thermoplastic elastomers (TPEs). For extreme cut, crush, and abrasion, we recommend our superior selection of TPUs, fluoropolymers, PVC, and TPEs. These material families also meet your needs for oil, chemical, and UV resistance. We are also working on expanding our LSZH product offerings to withstand extreme environments while maintaining critical agency compliances."*

## EXTREME TEMPERATURES

There are several materials that excel in extreme temperatures. Northwire's fluoropolymer jackets can be rated from -200°C to 260°C. Additionally, NWI offers polyethylene jackets that perform up to 125°C and a wide range of specialty PVC and TPE blends that can be rated from -60°C to 105°C.

## CUT, CRUSH, AND ABRASION

For other extreme applications where superior cut, crush, and abrasion resistance is required, fluoropolymers can be ideal as they are extremely rigid, even at high temperatures. Fluoropolymers can be stiff, however; TPU jacking is a softer material that can be just as strong and rigid. TPUs, along with Hytrel® (thermoplastic polyester), coil very well while maintaining damage resistance.

A wide range of material alloys can be specially compounded to meet the performance needs for any extreme environment. Jackets with these material blends can come in shiny or matte finishes as well as variations for exposed run or direct burial when additional crush resistance is needed.

### Specialty Blends

Northwire works with boutique compounders to develop specific materials that meet unique needs. NWI was tasked with creating a new jacket material to achieve a direct burial rating. This rating requires a 1,000lb weight to be applied to the cable over a ½" steel rod and held for one minute without any tears in the insulation or jacket material. NWI's materials engineers designed a unique material blend that passed this intense direct burial rating.

## LOW SMOKE ZERO HALOGEN

The need for high performing Low Smoke, Zero Halogen (LSZH) products is increasing. Northwire offers a commercial TPU to fit these requirements, but with new innovation and evolving requirements, the cable manufacturer is expanding this line to include additional characteristics such as rigidity, flexibility, oil and chemical resistance, and varying flame resistance.

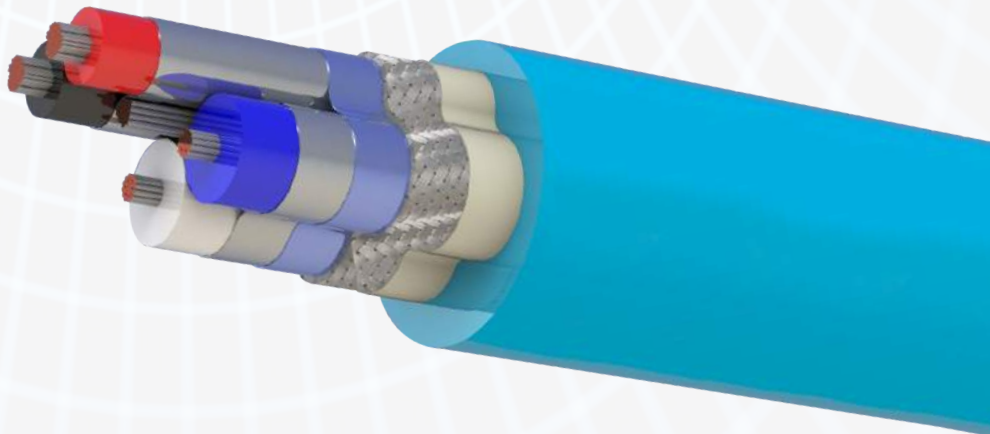


**Krista Lindquist**  
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## JACKET MATERIALS

- USP Class VI approved
- Medical and Food Grade
  - PUR (Polyurethane)
  - TPR (Thermoplastic Rubber)
  - PVC (Polyvinyl Chloride)
- Fluoropolymers
- PES (Polyester Elastomer)
- TPE (Thermoplastic Elastomer)
- TPU (Thermoplastic Urethane)



Given the importance of a cable's jacket to its performance and lifespan, Northwire is dedicated to offering a wide range of standard and custom options that give each customer the right material for their application.



### When selecting jacketing, ask:

- 1 | What type of noise interference will the cable encounter?
- 2 | What flex life demands will there be for the cable system?
- 3 | What environment will the cable operate in?
- 4 | If there are multiple shields, what is the plan for connectorizing?



## INTEGRATING SEAMLESSLY

In addition to ensuring that cable assemblies can withstand extreme environments, consideration should be given to the connector and assembly manufacturing. The connection is often more vulnerable to the elements than other parts of the assembly, work instructions will detail the special attention needed in terminating and connectorizing the cable.

The connector itself must also provide protection and resilience to extreme environments. LEMO provides a broad range of connectors designed specifically for severe applications.

### EXTREME COLD

Extreme temperatures and temperature changes are one of the biggest considerations when choosing connectors. At LEMO, connectors are designed for temperatures ranging from 250°C down to -55°C. For these types of applications, LEMO's B or K series connectors are commonly used. Extreme cold applications range from transportation and research to filming and photography. Find out more by reading the "Burning Cold" special feature (page 20) within **LEMO's CONNECTED magazine**.



The Arctic Trucks company manufactures and enhances vehicles for extreme freezing environments. When they adapt their trucks, LEMO connectors are commonly used in ignition and other equipment for temperatures as low as -40°C.

Additional challenges come with fluctuating temperature changes, often even more so than the cold itself. Some plastic materials, such as insulators and gaskets, are more vulnerable to rapidly dropping temperatures. LEMO provides arctic-grade connector materials to hold up to these temperatures swings.

Paralympic gold medalist Cato Zahl Pederson set out on a successful South Pole expedition in 1994. Included in his equipment were LEMO connectors. LEMO contributed to the solar cell panel design used to power the trekking equipment and the GPS satellite navigator – these connectors were also used in a heating device in Mr. Pedersen's mechanical arm.

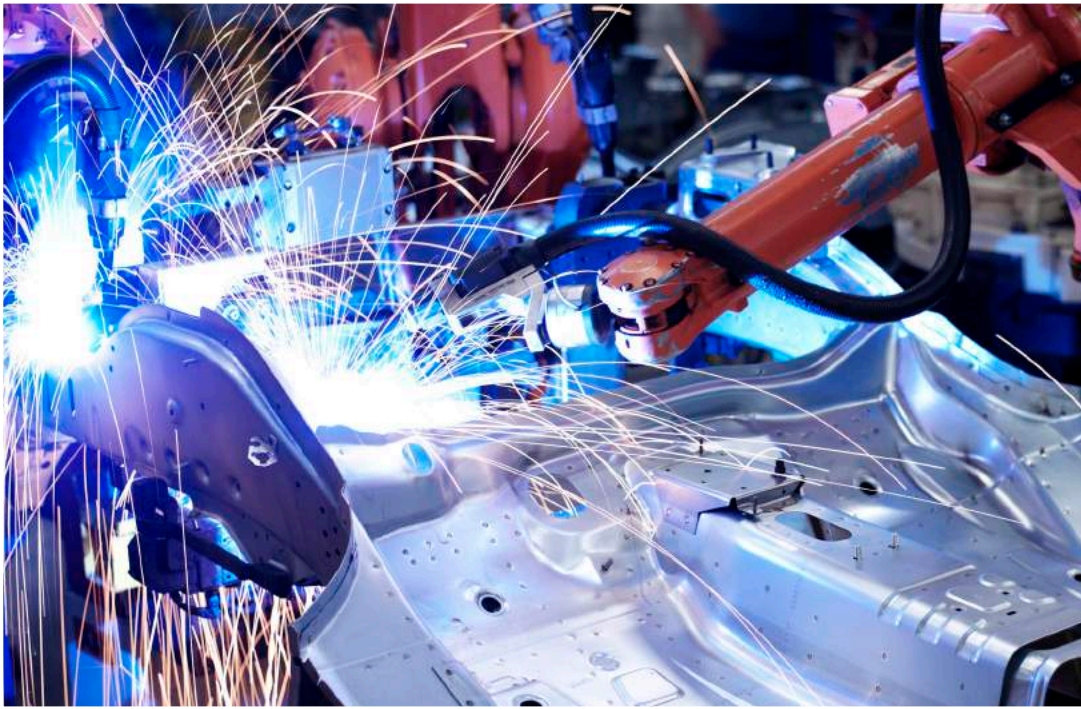
To further aid in these extreme expeditions and applications, LEMO designed an arctic grip connector for its M series connector, which is dedicated to robust performance in freezing temperatures. This grip uses a scallop shape for easy manipulation while wearing gloves.





## **EXTREME HEAT**

For connectors that must perform in high temperatures, LEMO uses materials such as PEEK® insulation for applications up to 250°C. Teflon™ and PTFE are also excellent for high temperatures. For extremely high heat, LEMO has a range of thermocouple connectors dedicated to temperature measurement. Occasionally connectors use ceramic insulation materials that allow reaching extended temperatures. These connectors have been used to measure heat near engines, turbines, and even rocket launches.



**READ MORE ABOUT LEMO'S SUPERIOR ATTENTION TO TEMPERATURE EXTREMES [HERE](#).**



## **BEYOND TEMPERATURE**

LEMO connectors can be adapted for every application. Whether a project calls for waterproof or watertight connectors, performance in high-pressure or high-altitude environments, resistance against corrosion and chemicals, protection from noise and vibration, or other needs for harsh environments, LEMO's SMEs leverage thousands of professionals around the globe to find ideal solutions for every customer.

## CUSTOM SOLUTIONS FOR EXTREME ENVIRONMENTS

Cable assemblies operating in extreme settings rarely have only one environmental factor to overcome. The number of variables to take into consideration when designing connectivity solutions, along with the number of challenges these products will face, usually means that the best course of action is to work with an experienced SME. LEMO and Northwire's professionals have helped thousands of customers navigate complex requirements and elements such as:



**Linda Brown**  
NWI Application Engineer

*"Bring your next challenge to the SMEs at LEMO and Northwire. With a comprehensive selection of standard wire and cable assemblies and a complete suite of custom cable capabilities, our innovative TEAM looks forward to finding the ideal solution for your applications involving extreme environments and complex requirements."*

Ensure that critical project requirements are met and that end application goals are achieved by selecting critical wire and cable assemblies that offer superior performance in the toughest environments.



## ABOUT US

LEMO is the acknowledged leader in the design and manufacture of precision custom connection and cable solutions. LEMO's high quality Push-Pull connectors are found in a variety of challenging application environments including medical, industrial control, test and measurement, audio-video, and telecommunications.

LEMO has been designing custom connectors for over six decades. Offering more than 75,000 combinations of products that continue to grow through tailored, specific designs, LEMO and its affiliated sister companies REDEL, NORTHWIRE, and COELVER currently serve more than 100,000 customers in over 80 countries around the world.

In the summer of 2014, LEMO Group acquired Northwire, Inc. with the goal of providing a seamless experience with expanded capabilities to both companies' valued customers by offering a comprehensive suite of custom connector, cable and assembly offerings for a diverse range of extreme applications. This means comprehensive product offerings, a wider range of resources, and rapid responses to your project needs.

Northwire, celebrating over 43 years of innovation, has corporate headquarters and manufacturing in Osceola, Wisconsin and engineering and manufacturing in Santa Teresa, New Mexico. The cable supplier is the premier partner for the design, manufacture and contract services of custom technical products including wire and cable, retractable cable, cable assemblies, connectors, harnesses, injection molding, over-molding and contract engineering and OEM (Original Equipment Manufacturer) for diverse applications in life sciences, energy, MIL-Spec, industrial, machine vision, architectural lighting, underwater, and more.

The custom wire and cable, retractable cables, and cable assemblies from Northwire work seamlessly with the diverse selection of wire connectors produced by LEMO.



### LEMO

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