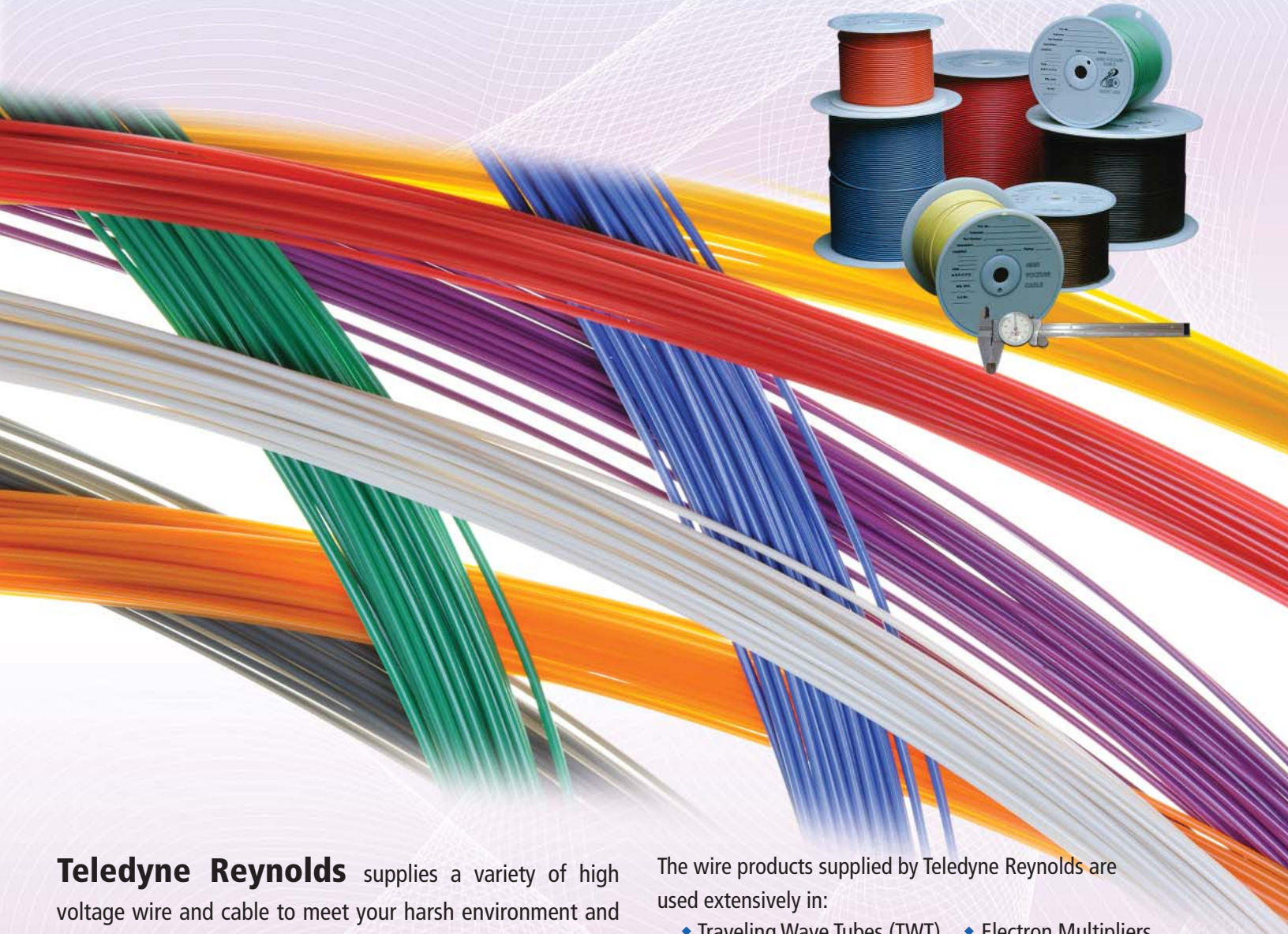
HIGH VOLTAGE WIRE AND CABLE PRODUCTS

Technical Manual and Product Brochure



Teledyne Reynolds supplies a variety of high voltage wire and cable to meet your harsh environment and high performance needs. Our products are engineered to reliably operate at voltages up to 60kVDC, which are lighter, smaller and more flexible than commercial and industry standard wire. We have over 70 years experience working with high voltage, developing high dielectric strength materials, operating in low partial discharge environments, that create a superior product to support the Defense, Medical, Energy, Instrumentation and Aerospace industries.

The wire products supplied by Teledyne Reynolds are used extensively in:

- Traveling Wave Tubes (TWT)
- RADAR / LIDAR
- Electronic Countermeasures
- Ordinance Systems
- HV Power Supplies
- High Energy Physics
- Electron Multipliers
- Magnetrons
- Klystrons
- Lasers
- Photomultiplier Tubes
- Plasma and Ion Generation

Teledyne Reynolds welcomes the opportunity to work with you on your current wire and cable requirements and to assist you in developing interconnect products for your next generation high reliability systems.

Approved for Public Release: MP/043/19

TELEDYNE REYNOLDS
Everywhereyoulook™

Rev. 020719

Technology
Tested
Trusted

TELEDYNE REYNOLDS
Everywhereyoulook™

Humble Beginnings to Industry Leader

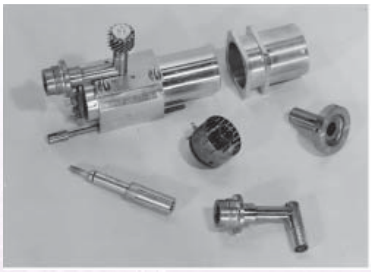
Teledyne Reynolds was founded in 1948 as Reynolds Industries in Culver City, California. The company started as a precision machine shop serving the aircraft industry. In 1949 the company added a plastic molding capability and began molding insulators for electrical connectors.

The 1960s proved to be a significant decade in the design and production of high voltage connectors and cable assemblies. The Series 31 connectors and their incorporation into cable assemblies had an impact on the future of the company. This series, and variations of it, are still produced today.

Over the next few decades, Teledyne Reynolds continued to grow in size, product offerings and manufacturing capabilities, quickly becoming the worldwide leader within the high voltage interconnect industry.

Teledyne Reynolds has grown to include four product groups in the U.S. with a manufacturing and design subsidiary in Great Britain to support the E.U. market.

Teledyne Reynolds' products include:



Connector Products

- High voltage connectors and cable assemblies
- Standard and specialized high voltage wire and cable
- Hybrid multi-pin connectors with fiber optic, RF and high voltage compatibility
- Instrumentation and control cable assemblies for nuclear reactors

Electro-Ceramic Products

- Ceramic-to-metal brazed connectors

High Energy Devices

- High current, triggered vacuum switches for electronic safe and arm devices
- Over voltage gas discharge tubes
- High voltage capacitors and Mica paper

Application Specific Products

- Helmet-mounted display (HMD) components
- Design, qualification and production of human-to-vehicle interface systems
- LED aircraft lighting products and systems

Approved for Public Release: MP/043/19

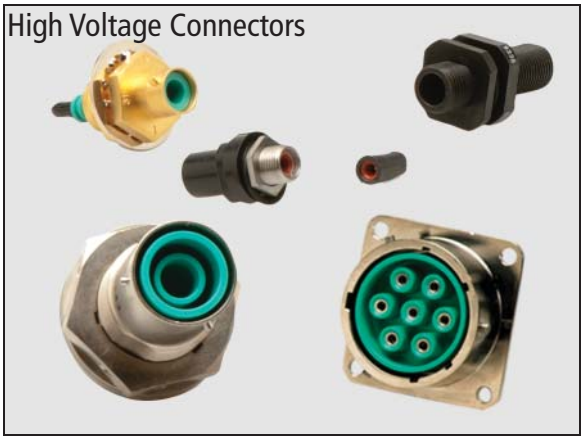
Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

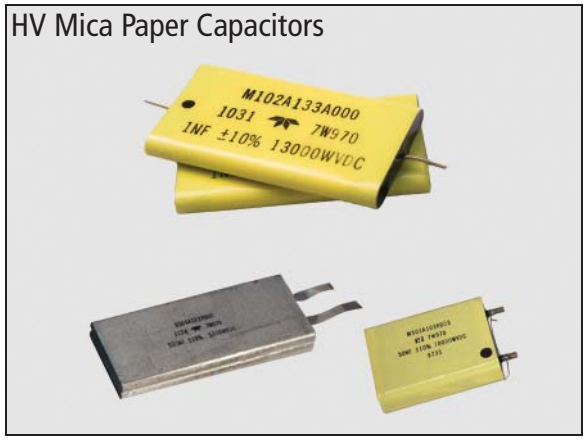
Teledyne Reynolds - *the very best in connector and cable assembly design and manufacturing*

Teledyne Reynolds has over 70 years of heritage supplying the highest quality, high voltage interconnect solutions to the most demanding of applications in the Military/Defense, High-end Industrial, Medical, Energy and Space industries.

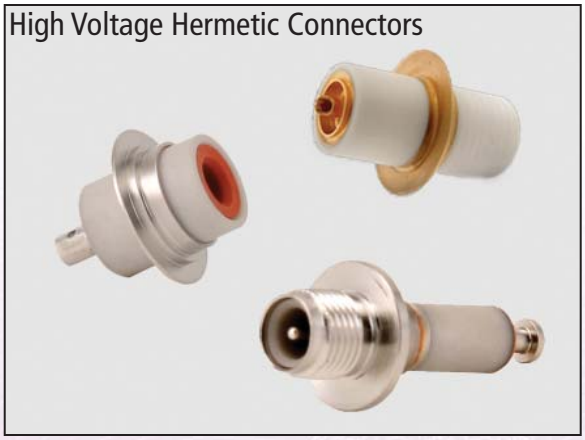
High Voltage Connectors



HV Mica Paper Capacitors

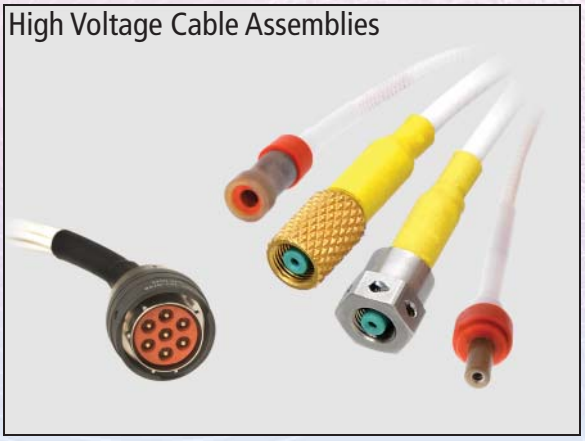


High Voltage Hermetic Connectors



High Reliability Custom Interconnects

High Voltage Cable Assemblies



Spark Gaps and Gas Discharge Tubes

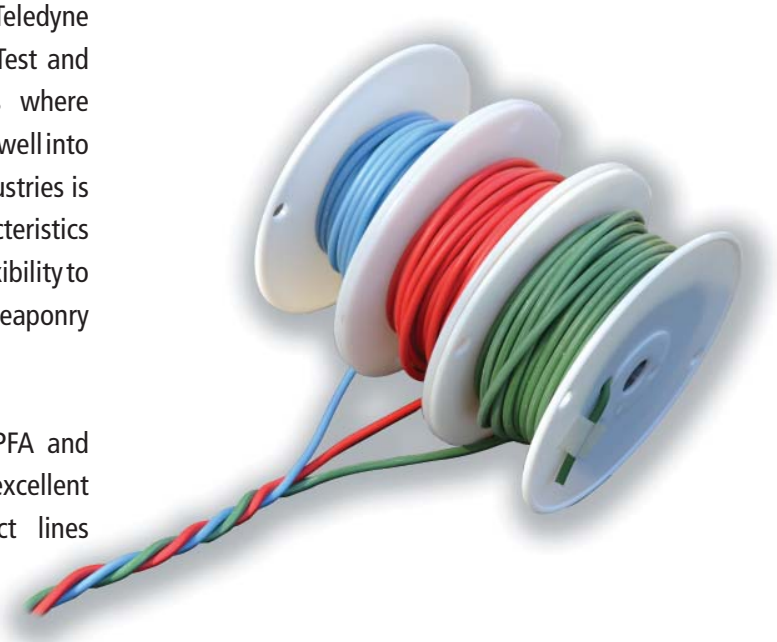
Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

INTRODUCTION TO WIRE

The wire products designed and supplied by Teledyne Reynolds are used extensively in the Aerospace, Test and Measurement, Medical and Defense industries where components are being designed into systems for use well into the 21st century. The recurring theme in these industries is the need for cables with higher performance characteristics but smaller diameters, lower weight, and greater flexibility to assist the payload factor whether in terms of fuel, weaponry or passengers.



Our standard wire products use primarily FEP, PFA and Silicone insulating materials to produce wire with excellent corona-resistant characteristics. These product lines are complemented by;

Micro Flex™ - A highly flexible PFA wire for high and low voltage applications

Ready-to-Bond™

Epox-i-Ready™- Etched FEP for epoxy encapsulate applications

Sil-con-Ready™- Silicone coated FEP, for RTV and silicone based encapsulates

Hi-wear-Ready™- Nomex® jacketed

Semi/Con™ - A unique wire that is specially designed to reduce partial discharges

Quiet Line™ - A high voltage, distributed loss, RF attenuation cable

ABBREVIATIONS

FEP	Fluorinated Ethylene Propylene
FG	Fiberglass
PE	Polyethylene
PFA	Perfluoroalkoxy
PO	Polyolefin
SIL	Silicone
SPC	Silver Plated Copper
TPC	Tin Plated Copper

Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

The high voltage wire and cable specified in this catalog are commonly used in a wide spectrum of applications:

- Traveling wave tubes, magnetrons and klystrons
- Photomultiplier tubes
- Mass spectrometers
- Semiconductor wafer inspection equipment
- Laser systems: rangefinders, LIDAR and ring laser gyroscopes
- Night vision systems
- High energy physics research
- High voltage power supplies
- RADAR
- Electronic Countermeasures (ECM)
- Spacecraft propulsion

Design Considerations for High Voltage Wire

There are three primary mechanisms for dielectric failure in a cable or cable assembly: thermal degradation, gradual degradation of the material by partial discharge, and mechanical stress. To minimize these effects, Teledyne Reynolds recommends the following:

- Select a wire with a specified operating temperature range that is greater than the thermal environment that the device will operate in.
- Select a wire with a voltage rating higher than the operating voltage to insure that the wire operates below a voltage that sustains partial discharge.
- Consider higher conductor strand counts for greater flexibility, insulator material for wear resistance or flexibility, and the wire diameter as it relates to bend radius.

If the wire or cable is to be terminated to a connector then the connector's insulation components and assembly techniques need to be considered to ensure the reliability of the high voltage cable assembly design. For that reason, Teledyne Reynolds encourages customers to take advantage of our unique and reliable fabrication methods, encapsulating processes, and bonding techniques, that include complete verification testing of all cable assemblies under simulated aerospace environments.

Quality Control

All the wire and cable presented in this catalog have a recommended steady state DC voltage ratings which are applicable within the altitude and temperature ranges specified. These ranges, unless otherwise noted, are typically at altitudes from sea level to 70,000 feet (21,336 meters) and at temperatures of -55° to 125°C.

As a quality control procedure, each of Teledyne Reynolds' products are, at a minimum, subjected to a dielectric strength test. The purpose of this test is to subject the wire product to a voltage greater than the designed operating voltage. The dielectric strength test value typically used by Teledyne Reynolds is determined by the scale shown below:

Dielectric Strength Test Voltage Rating	
0 to 12 kVDC	150% of rated voltage
12.1 to 20.0 kVDC	140% of rated voltage
20.1 to 30.0 kVDC	130% of rated voltage
30.1 kVDC and up	120% of rated voltage

AC and Pulsed DC Ratings

Teledyne Reynolds' products, including wire and cable, are solely rated for use at DC. For customers wanting to use these products with an AC component or at pulsed DC, it is recommended that the customer consult with the Teledyne Reynolds' Engineering Department or conduct tests on samples of the product to verify that it meets their specific requirements before final selection of a wire, connector or cable assembly is made.

Corona or Partial Discharge

Customers with concerns about partial discharge, also known as corona, should consult the Teledyne Reynolds Engineering Department before selecting a high voltage wire product. Teledyne Reynolds is extremely knowledgeable concerning the origins of corona, how it effects the reliability of a product and can apply design driven remedies to prevent its inception. Teledyne Reynolds is noted in the industry for its corona detection equipment and technical competence in analyzing the existence and level of corona in wire or connector products. Teledyne Reynolds makes no claim to manufacturing "partial discharge free" connectors, cable or cable assemblies and anyone in the industry that does is mistaken in doing so. Teledyne Reynolds does, however, maintain extensive corona research and test data on its products with the objective of manufacturing products as resistant to the effects of corona as possible.

Operating Temperature Range

For FEP, PFA and silicone rubber wire products, Teledyne Reynolds recommends an operating temperature range of -55° to 125°C, which, although very conservative, is in line with the specified requirements of most military applications. The majority of Teledyne Reynolds' testing and historical data is based on this range.

If the customer's application requires the operation of the product outside of this temperature range, additional testing can be done to verify the reliability of the product in that specific environment.

Cable Routing and Bend Radius

In routing cable, the user should take care to avoid making sharp bends. Sharp bends put added stress on the wire strands and can create a high electric field leading to a corona stress point. Also, sharp or rough metal edges in the routing area should be avoided, especially when using silicone cable.

Bend Radius Formulas

20x cable diameter if cable is to be flexed
10x cable diameter if cable is to be strapped down or in conductor trays
8x cable diameter if cable is potted

Ready-to-Bond™ – FEP/PFA Wire and Cable Etching or Coating

Teledyne Reynolds has a proprietary process of etching and coating the surface of FEP and PFA wire with silicone rubber to enable a cohesive bond when encapsulation with silicone rubber compounds or bonding to molded silicone rubber components using elastomeric bonding materials. FEP/PFA wire that has been etched, but not silicone coated, can also be used for encapsulation or bonding to most epoxy materials. These processes give the wires a versatility found in no other high voltage wire or cable and make them an excellent choice for most high voltage applications.

Loss Line Cable

Teledyne Reynolds manufactures a complete line of high voltage, loss line or distributed loss, R.F. attenuation cable called Quiet Line™. Customers requiring R.F. attenuation in their circuits should consider using Quiet Line™. Teledyne Reynolds' engineers are available for application consultation.

Space Use

Upon special request Teledyne Reynolds supplies wire and cable for use in Space applications. These products receive stringent cleaning, are 100% hi-pot tested, and can be 100% reel-to-reel corona tested. These wires also meet the Space community's outgassing requirements of TML< 1% and CVCM <0.1%.

Liquid Dielectrics and Oils

Silicone rubber cable is not compatible with many dielectric oils, including Coolanol® and Fluorinert™. While these are excellent dielectric mediums, they can cause silicone rubber to swell and lose its mechanical properties. Some of Teledyne Reynolds' connectors offer fluorsilicone seals and/or insulators for use with these dielectrics, but only uncoated FEP or PFA cable should be used where these dielectrics are present.

Approved for Public Release: MP/043/19

Rev. 020719

Properties of Insulation and Jacket Materials

Material	Specific Gravity (Nominal)	Volume Resistivity (ohm-cm)	Dielectric Strength (kV/mm)	Dielectric Constant (nominal) (ASTM D150)	Resistance to Abrasion	Resistance to Cold Flow	Flame Retardant Properties	Flexibility	Weatherability	Temperature Range (°C nominal)	De-Icing Fluids	Fuel/Oil Resistance	Cleaning Fluids
FLOUROSILICONE	1.40	10^{14}	13.4	7.0	Excellent	Good	Excellent	Excellent	Excellent	-60 to 200	Excellent	Excellent	Excellent
HYTREL®	1.20	10^{18}	33.8	6.0	Excellent	Good	Fair	Fair	Excellent	-50 to 105	Good	Good	Good
NYLON	1.07	10^{14}	17.7	4.0	Excellent	Good	Poor	Poor	Excellent	-40 to 120	Excellent	Good	Excellent
POLYETHYLENE SOLID	0.95	10^{18}	23.6	2.3	Poor	Poor	Poor	Fair	Excellent	-60 to 80	Good	Good	Good
POLYETHYLENE FOAM	0.50	10^{18}	N/A	1.5	Poor	Poor	Poor	Good	Excellent	-60 to 80	Poor	Poor	Poor
POLYPROPYLENE	0.91	10^{15}	25.6	2.2	Excellent	Good	Poor	Poor	Excellent	-40 to 105	Good	Good	Good
POLYURETHANE	1.10	10^{14}	19.7	7.0	Excellent	Good	Poor	Excellent	Excellent	-50 to 80	Good	Good	Good
POLYVINYL CHLORIDE (PVC)	1.37	10^{12}	19.7	5.8	Good	Fair	Excellent	Good	Excellent	-55 to 105	Poor	Poor	Fair
SILICONE RUBBER	1.32	10^{14}	23.6	3.0	Fair	Good	Fair	Excellent	Excellent	-65 to 200	Good	Good	Fair
TEFLON® FEP	2.20	10^{18}	23.6	2.1	Excellent	Fair	Excellent	Fair	Excellent	-70 to 250	Excellent	Excellent	Excellent
TEFLON® PFA	2.10	10^{18}	23.6	2.1	Excellent	Good	Excellent	Fair	Excellent	-70 to 250	Excellent	Excellent	Excellent
TEFZEL®	1.70	10^{16}	15.7	2.6	Excellent	Good	Excellent	Fair	Excellent	-70 to 180	Excellent	Excellent	Excellent
THERMOPLASTIC ELASTOMETER (TPE)	1.00	10^{17}	25.6	2.4	Excellent	Good	Good	Good	Excellent	-75 to 140	Fair	Poor	Fair

Hytrel® and Polyurethane are only recommended for outer jackets.

TPE materials vary widely, data given is for insulation properties as a reference.

Teflon® resins are listed 94 V-O by the Underwriters' Laboratories Inc. in their burning test classification for polymetric materials and they pass the UL 83 vertical flame test.

Characteristics of Shield Materials

Shield Method	Shield Effectiveness (Low Frequency)	Shield Effectiveness (High Frequency)	Percent Coverage	Flex Life	EMI/RFI EMP
COPPER BRAID	Excellent	Excellent	60-95%	Fair	Fair
ALUMINUM MYLAR	Poor	Excellent	100%	Poor	Poor
SPIRAL COPPER	Good	Fair	80-98%	Good	Poor
SEMI-CONDUCTIVE	Fair	Poor	100%	Good	Poor
STEEL BRAID	Excellent	Excellent	60-95%	Fair	Excellent

CABLE CONDUCTOR DATA

SIZE • STRANDING • CURRENT RATING

Technology Tested Trusted

AWG	Stranding	Approximate Diameter		Cross Section	DC Resistance	Current Rating
		inches	mm	mm^2	Ohms/1000 m	(amps) 70kft free air at 80° C*
30	Solid	.010	0.25	0.051	338.6	2.5
30	7/38	.012	0.30	0.056	309.1	2.5
30	19/42	.013	0.32	0.060	288.1	2.5
30	41/46	.012	0.30	0.051	337.3	2.5
29	Solid	.011	0.29	0.064	268.4	2.9
29	51/46	.014	0.35	0.064	271.3	2.9
28	Solid	.013	0.32	0.081	212.9	3.3
28	7/36	.015	0.38	0.089	194.6	3.3
28	19/40	.016	0.40	0.095	181.1	3.3
28	41/44	.015	0.37	0.081	212.3	3.3
28	65/46	.015	0.39	0.081	212.9	3.3
26	Solid	.016	0.40	0.130	133.9	4.3
26	7/34	.019	0.48	0.141	122.4	4.3
26	10/36	.020	0.51	0.130	136.2	4.3
26	19/38	.020	0.50	0.151	113.8	4.3
26	51/42	.022	0.56	0.160	107.3	4.3
26	66/44	.019	0.48	0.131	131.9	4.3
24	Solid	.020	0.51	0.205	84.3	5.7
24	7/32	.024	0.61	0.224	76.8	5.7
24	10/34	.025	0.64	0.201	85.6	5.7
24	16/36	.024	0.61	0.201	85.0	5.7
24	19/36	.025	0.64	2.441	71.5	5.7
24	41/40	.023	0.59	0.205	84.0	5.7
22	Soid	.025	0.64	0.326	52.8	7.5
22	7/30	.030	0.76	0.356	48.2	7.5
22	19/34	.032	0.80	0.383	44.9	7.5
22	26/36	.030	0.75	0.329	52.5	7.5
22	65/40	.031	0.78	0.326	52.5	7.5
20	Solid	.032	0.81	0.518	33.5	9.9
20	7/28	.038	0.96	0.567	30.5	9.9
20	10/30	.040	1.02	0.509	33.8	9.9
20	19/32	.040	1.01	0.609	28.2	9.9
20	26/34	.037	0.94	0.524	32.8	9.9
20	105/40	.039	0.99	0.526	32.8	9.9
18	Solid	.040	1.02	0.823	21.0	13.1
18	7/26	.048	1.21	0.901	19.0	13.1
18	16/30	.048	1.23	0.815	21.0	13.1
18	19/30	.050	1.27	0.968	17.7	13.1
18	41/34	.047	1.19	0.826	21.0	13.1
18	65/36	.049	1.25	0.823	21.0	13.1
18	168/40	.053	1.34	0.824	20.3	13.1
16	Solid	.051	1.29	1.309	14.1	15.0
16	7/24	.060	1.53	1.433	12.1	15.0
16	19/29	.056	1.43	1.220	14.1	15.0
16	26/30	.059	1.50	1.220	14.1	15.0
16	41/32	.059	1.50	1.326	13.3	15.0
16	65/34	.062	1.57	1.309	13.3	15.0
16	260/40	.068	1.73	1.303	13.3	15.0

*Ratings based on MIL-W-5088 for a single wire with maximum rated operating temperature of 125°C.

Approved for Public Release: MP/043/19

Rev. 020719

Extruded, FEP insulated, high voltage wire and cable offers exceptional dielectric strength without the disadvantages common to equally rated silicone rubber insulated cables. As a result, cable assemblies or cable bundles are smaller in diameter, volume and in bend radius thus allowing the system designer to better utilize space within their system. Also, its molecular structure gives it excellent durability and resistance to dielectric/ cooling fluid degradation.

FEP insulation, being a harder material than silicone rubber, is not prone to "pin-holing" and high voltage "punch-thru" when the cable surface is abraded or when strands break during in-field servicing. FEP is also more resistant to damage when making contact with sharp edges. Even so, sharp edges should always be avoided.

Although FEP is generally difficult to bond to, Teledyne Reynolds, has developed a Ready-to-Bond™ product line that is manufactured using proprietary abrading and surface preparation techniques that enable excellent silastic bonds. Teflon® tape wrapped cable, which is similar to FEP in dielectric strength and corona inception, is difficult to bond to because of its multiple spiral cross section, irregular surface and variations in diameter. Therefore, FEP cable should not only be considered for use in cable assemblies, but as high voltage hook-up wire within encapsulated high voltage power supplies, TWTs and transformers.

Ready-to-Bond™ silicone coated FEP wire is processed with a uniform silicone rubber coating applied to a prepared surface in the form of a thin wall. This continuous coating provides potting characteristics similar to silicone rubber wire and allows the user to achieve a superior dielectric bond when using silicone rubber potting materials or adhesives. Primer should be applied to the cable as required by the bonding or potting material manufacturer.

Properties of FEP Fluorocarbon Resin

Physical, Thermal and Electrical Properties	Typical Values
Specific Gravity	2.14
Tensile Strength (PSI)	3500
Elongation (%)	.325
Flexual Modules (PSI)	90,000
Thermal Conductivity (cal/sec-cm °F)	$6x10^{-4}$
Thermal Expansion (in/in/ °F)	7.5×10^{-5}
Continuous Use Temperature (°C)	204
Melt Temperature (°C)	255-265
Low Temperature Limit (°C)	-240
Hardness Durometer	D56
Water Absorption (%)	<01
Flame Resistance	Excellent
Dieletric Constant, 60-10^6 Hz	2.1
Dissipation Factor, 60-10^6 Hz	<.0007
Volume Resistivity (Ohms-cm)	$<10^{18}$
Surface Resistivity (Ohm/square)	$<10^{16}$
Resistance to:	Rating
Cold Flow or Cut Through	Fair
Ultraviolet Radiation	Excellent
Electro-Mechanical Stress Cracking	Excellent
Chemical-Mechanical Stress Cracking	Excellent

Conductor Material: Copper

Conductor Finish: Silver plated per test requirements of ASTM B298. Meets solderability per MIL-STD-202.

Note: Pre-conditioning of FEP cable after cutting to length is recommended because FEP cable will shrink when exposed to temperature cycling. Pre-conditioning should be conducted in an air circulating oven at 204°C (400°F) for one hour. No attempt should be made to condition wire or cable in bulk form or while spooled.

Teflon® is a registered trademark of Dupont

Approved for Public Release: MP/043/19
Rev. 020719

Ready-to-Bond, Etched and Coated FEP wire

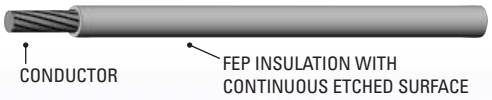
Teledyne Reynolds' proprietary processes are known worldwide as the leader in coated and value added wire for high voltage applications. Our processes and techniques produce wires that have the performance and versatility found in no other high voltage wire or cable, producing product that is an excellent choice for most high voltage applications.

Teledyne Reynolds offers multiple versions of our FEP wire, each designed to your address specific needs:

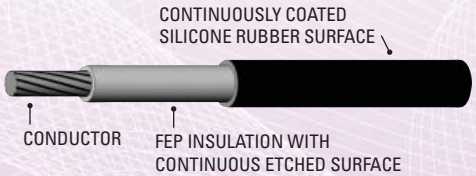
- FEP insulated
- Ready-to-Bond™
  - Epox-i-Ready™- Etched FEP for epoxy encapsulate applications
  - Sil-con-Ready™- Silicone coated FEP, for RTV and silicone based encapsulates
  - Hi-wear-Ready™- Nomex® jacketed

FEP wire - Ideal for low mass, small bend radii and harsh environment applications

Etched - FEP wire is processed through our proprietary etching system, to prepare the surface of the FEP to allow a cohesive bond between the wire insulation and epoxy encapsulates.



Silicone coated - We first prepare the surface of our high performance FEP wire, then a thin silicone layer is uniformly applied, effectively creating a cohesive bond between the FEP and silicone coating. This continuous coating provide potting characteristics similar to silicone rubber wire and allows the user to achieve a dielectric bond when using silicone rubber potting materials and adhesives, such as RTV.



Nomex® jacketed - to provide a high wear resistant wire and provide the benefits of silicone coated FEP wire, Teledyne can apply a Nomex® woven jacket over the Ready-to-Bond™ wires listed above.

Nomex® is a registered trademark of Dupont

Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

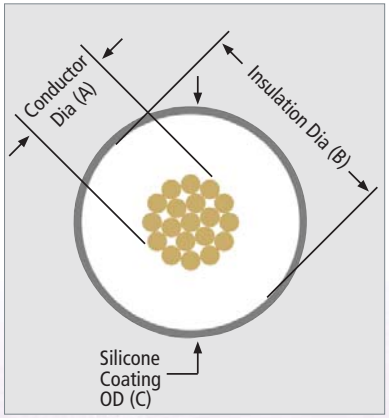
FEP
High Voltage Wire

70,000 ft (21.3km)
-55° to 125°C

Operating Voltage (kVDC)	Current (A)	Conductor		Plating	A	B	C	D	Base FEP Part Number	Ready-to-Bond™		Hi-wear-Ready™ Nomex® Jacket Part Number
		AWG	Strands		Conductor Diameter	Diameter over Insulation	Diameter over Silicone Coating	Ref. Dia over Nomex® Jacket		Epox-i-Ready™ (Etched) Part Number	Sil-con-Ready™ (Silicone Coated) Part Number	
					in/mm	in/mm	in/mm	in/mm				
10	9.9	20	19/32	SPC	.039 / 1.01	.060 / 1.52			178-9560	178-9559		
12	4.3	26	19/38	SPC	.019 / 0.48	.045 / 1.14	.055 / 1.40		178-9159		700771	
12	4.3	26	19/38	TPC	.019 / 0.48	.045 / 1.14			178-8094	178-8366		
12	15	16	19/29	SPC	.056 / 1.43	.080 / 2.00			178-5626			
18	3.3	28	41/44	SPC	.014 / 0.36	.042 / 1.07	.048 / 1.22		178-5079	700358	178-5186	
18	3.3	28	19/40	SPC	.015 / 0.40	.040 / 1.02			178-5790	178-5791		
18	3.3	28	19/40	TPC	.015 / 0.40	.040 / 1.02			178-8287	178-8289	178-5428	
18	4.3	26	19/38	SPC	.019 / 0.50	.050 / 1.27	.060 / 1.52		178-7680	178-9556	178-8074	
18	5.7	24	19/36	SPC	.025 / 0.64	.050 / 1.27	.060 / 1.52	.085 / 2.16	178-8072	178-8111	178-8066	178-5789
18	5.7	24	19/36	TPC	.025 / 0.64	.050 / 1.27	.060 / 1.52		178-8354	178-8355	178-8356	
18	5.7	24	19/36	SPC	.025 / 0.64	.060 / 1.52			178-8523	178-8524		
18	7.5	22	19/34	SPC	.031 / 0.80	.055 / 1.40	.065/ /1.65		178-8073	700360	178-8067	
20	7.5	22	19/34	SPC	.031 / 0.80	.060 / 1.52	.070/ /1.78		178-8679	178-9122	178-9277	
20	7.5	22	19/34	TPC	.031 / 0.80	.060 / 1.52	.070/ /1.78	.100 / 2.54	178-7633	178-8193	178-7599	178-7740
22	7.5	22	19/32	SPC	.039 / 1.01	.080 / 2.00	.090 / 2.29		178-7435	178-9035	178-9036	
22	9.9	20	19/34	SPC	.031 / 0.80	.080 / 2.00	.090 / 2.29		178-8316	178-9123	178-8315	
22	9.9	20	19/32	SPC	.039 / 1.01	.090 / 2.29	.100 / 2.54		178-8883	178-8914	178-8884	
22	9.9	20	19/32	TPC	.039 / 1.01	.080 / 2.00	.090 / 2.29		178-7454	178-8075	178-7600	
25	4.3	26	19/38	SPC	.019 / 0.50	.080 / 2.00			178-9490	178-9473		
25	15	16	41/32	SPC	.059 / 1.50	.125 / 3.17			178-9824	700362		
30	9.9	20	19/32	SPC	.039 / 1.01	.100 / 2.54	.110 / 2.79	.135 / 3.43	167-7628	178-8780	178-8781	178-9554
30	9.9	20	19/32	TPC	.039 / 1.01	.100 / 2.54	.110 / 2.79		178-7455	178-8195	178-7601	
40	9.9	20	19/32	TPC	.039 / 1.01	.150 / 3.81			167-9610			
40	9.9	20	19/32	SPC	.039 / 1.01	.150 / 3.81	.160 / 4.06		178-5923		178-5924	

SPC = Silver plated conductor
TPC = Tin Plated conductor

Blank = not available



When ordering, use part number and specify length in feet.

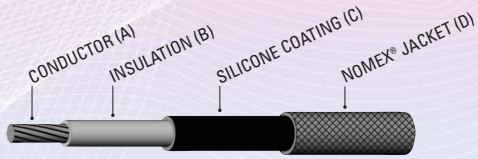
The standard color is Natural. Other colors are available on special order. Contact factory for color options and availability, or please specify color requested when ordering.

Note: Pre-conditioning of FEP wire or cable is recommended because FEP insulation will shrink when exposed to temperature cycling.

Pre-conditioning should be conducted in an air circulating oven at 204°C (400°F) for one hour. Pre-conditioning should only be performed on cut lengths prior to stripping and any termination procedure.

No attempt should be made to condition wire or cable in bulk form or while spooled.

Product numbers and specs subject to change without notice. Products listed represent only a small selection of Teledyne Reynolds' products.
Please visit www.teledynereynolds.com for the most up to date product information. Contact Teledyne Reynolds' Engineering to discuss custom designs.



Nomex® is a registered trademark of Dupont

TELEDYNE REYNOLDS Everywhereyoulook™

TELEDYNE REYNOLDS Everywhereyoulook™

Teledyne Reynolds has developed a range of highly flexible cables that are particularly suitable to the aircraft environment. This technology is a direct result of our research into light weight, durable and flexible cable assemblies needed for Helmet Mounted Display (HMD) systems. These wires have a PFA insulation and high strand count of silver plated copper conductors that enable the wire to have high tolerance to work hardening environments. They have been designed to operate over a wide temperature range of -55° to 125°C at their rated voltages and at altitudes up to 70,000 feet (21,336 meters).

For special ordered, custom applications, Teledyne Reynolds has a unique capability to manufacture Micro Flex™ cable bundles that involve the use of special winding tooling to take advantage of the flexibility of the individual wire when laying up a bundle.

Features

- Flexible
- Standard designs up to 18 kVDC operation
- Small and lightweight
- Durable
- Reliable
- Non-combustible, low smoke rating
- PFA insulation
- -55° to 125°C temperature rating

Micro Flex™ Testing

The following tests have been performed to MIL-W-22759 Guidelines:

- Wrap test
- Life cycle
- Low temperature (cold bend)
- Insulation resistance
- Bend test
- Thermal shock
- Blocking
- Dielectric test
- Humidity

Typical Applications

- Transformer winding
- Medical instrumentation cabling
- Electrostatic chuck cabling
- Helmet Mounted Display CRT cabling
- Night vision system
- Ejection safe Quick Disconnect Connector cabling
- Aerostat and UAV tethers
- High vibration aircraft cabling

Product numbers and specs subject to change without notice. Products listed represent only a small selection of Teledyne Reynolds' products.
Please visit www.teledynereynolds.com for the most up to date product information. Contact Teledyne Reynolds' Engineering to discuss custom designs.

Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

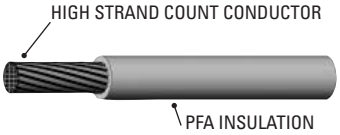
HIGH VOLTAGE
Micro Flex™ Wire and Cable

70,000 ft (21.3km)
-55° to 125°C

Micro Flex™ wire and cable is available uncoated or with a silicone rubber coating over the PFA insulation. The coated cable is processed with a silicone rubber coating continuously applied to the etched surface of the cable. The coated cable has characteristics similar to silicone rubber cable and a superior dielectric bond to silicone rubber potting or bonding material can be achieved.

High Voltage Micro Flex™ Attributes

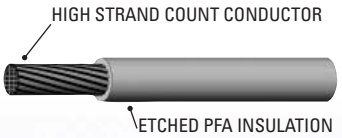
Operating Voltage (kVDC)	Conductor		Plating	Conductor Diamater	Diameter over Insulation	Part Number
	AWG	Strands		in/mm	in/mm	
3	29	51/46	SPC	.012 / 0.33	.019 / 0.48	**178-5132**
5	29	51/46	SPC	.012 / 0.33	.025 / 0.64	**178-5135**
13.5	28	41/44	SPC	.014 / 0.37	.042 / 1.07	**178-5138**
18	24	41/40	SPC	.022 / 0.58	.050 / 1.27	**178-5141**



Micro Flex™

High Voltage Etched Micro Flex™ Attributes

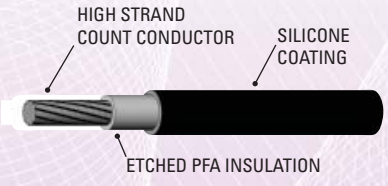
Operating Voltage (kVDC)	Conductor		Plating	Conductor Diamater	Diameter over Insulation	Part Number
	AWG	Strands		in/mm	in/mm	
3	29	51/46	SPC	.012 / 0.33	.019 / 0.48	**178-5133**
5	29	51/46	SPC	.012 / 0.33	.025 / 0.64	**178-5136**
13.5	28	41/44	SPC	.014 / 0.37	.042 / 1.07	**178-5139**
18	24	41/40	SPC	.022 / 0.58	.050 / 1.27	**178-5142**



Etched Micro Flex™

Silicone Coated High Voltage Micro Flex™ Attributes

Operating Voltage (kVDC)	Conductor		Plating	Conductor Diameter	Diameter over Silicone Coating	Part Number
	AWG	Strands		in/mm	in/mm	
3	29	51/46	SPC	.012 / 0.33	.029 / 0.79	**178-5134**
5	29	51/46	SPC	.012 / 0.33	.035 / 0.89	**178-5137**
13.5	28	41/44	SPC	.014 / 0.37	.052 / 1.32	**178-5140**
18	24	41/40	SPC	.022 / 0.58	.060 / 1.52	**178-5143**



Silicone Coated Micro Flex™

Contact factory for color options and availability, or please specify color requested when ordering.

Note: Pre-conditioning of PFA wire or cable is recommended because PFA insulation will shrink when exposed to temperature cycling. Pre-conditioning should be conducted in an air circulating oven at 204°C (400°F) for one hour. Pre-conditioning should only be performed on cut lengths prior to stripping and any termination procedure. No attempt should be made to condition wire or cable in bulk form or while spooled.

Product numbers and specs subject to change without notice. Products listed represent only a small selection of Teledyne Reynolds' products.
Please visit www.teledynereynolds.com for the most up to date product information. Contact Teledyne Reynolds' Engineering to discuss custom designs.

Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

Teledyne Reynolds' Quiet Line™ is a continuously extruded, distributed loss, low-pass filter cable for use in high voltage applications. The stranded center conductor is surrounded with a "lossy" insulation material comprised of ferrite-powder filled silicone. This cable functions much like an inductive low-pass filter, where magnetic losses are dissipated and EMI absorbed. The ferrite in the insulation increases the cable's inductance by concentrating the magnetic field. The increase in inductance, in turn, increases reactance which filters out high frequency noise. The cable's attenuation characteristics increase with frequency and are directly proportional to cable length.

Quiet Line™ is excellent for use in any high frequency, high voltage application requiring the suppression of undesired RF interference or EMI noise. In addition, use of Quiet Line™ alleviates the need for a traditional low-pass filter circuit with standalone inductors and resistors that increase the mass and take up volume in the system. These attributes make Quiet Line™ an ideal solution in radar, telecommunications, and electronic countermeasures. Other applications include filtering capacitive or inductive coupled noise.

Furthermore, Quiet Line™ has all the added benefits of TR's high voltage cables and wire:

- Lightweight with small overall diameter requiring minimal volume
- Compatibility with TRI's high performance, high voltage connectors
- Operating altitude: sea level through 70,000 feet (21 km)
- Custom designs available upon request

Quiet Line™ is available in a variety of configurations: with Ready-to-Bond™ silicone coating, shielding, and/or an outer jacket. In addition, a selection of loss core diameters are offered providing a range of rated voltages and RF insertion loss characteristics. The configurations and attributes of each are shown on the following page. If the standard products listed do not happen to meet your specific requirements, Teledyne Reynolds welcomes the opportunity to offer a custom solution. Please contact our factory to discuss your needs and options.

General Specifications

Conductor and braid	Copper, silver plated
Insulation	Extruded PFA or FEP
Jacket	PFA or FEP
Operating temperature	-55° to 125°C at 70,000 feet altitude
Voltage stress testing	100% test at 140% of rated voltage (room ambient)
Insertion loss testing	100% insertion loss verification performed on each extrusion lot. The swept frequency insertion loss technique is used within the specified frequency range per MIL-C-17F. Test specimens are shielded with a BNC termination.

Contact factory for color options and availability, or please specify color requested when ordering.

Product numbers and specs subject to change without notice. Products listed represent only a small selection of Teledyne Reynolds' products.
Please visit www.teledynereynolds.com for the most up to date product information. Contact Teledyne Reynolds' Engineering to discuss custom designs.

Approved for Public Release: MP/043/19
Rev. 020719

QUIET LINE™
Distributed Loss RF Attenuation Cable

70,000 ft (21.3km)
-55° to 125°C

Quiet Line™ Attributes

Operating Voltage (kVDC)	Attenuation (dB/FT nom)		Inner Conductor		Plating	Overall Diameter	Part Number
	480 MHz	2.4 GHz	AWG	Strands		in/mm	
FIGURE 1	**Non- jacketed, Silicone Coated "Quiet Line"**						
12			22	19/34	SPC	.058 / 1.47	**178-7973**
FIGURE 2	**FEP or PFA Jacketed "Quiet Line"**						
12	11	90	22	19/34	SPC	.087 / 2.20	**178-8051**
15	15	60	24	19/36	SPC	.080 / 2.00	**501-0041**
20	21	130	22	19/34	SPC	.130 / 3.30	**178-8050**
FIGURE 3	**FEP or PFA Jacketed Silicone Coated "Quiet Line"**						
5	15		28	19/40	SPC	.062 / 1.57	**178-5225**
12	11	90	22	19/34	SPC	.100 / 2.54	**178-8880**
12	11	90	22	19/34	SPC	.095 / 2.41	**178-8024**
15	15	60	24	19/36	SPC	.080 / 2.00	**178-8302**
20	21	130	20	19/32	SPC	.150 / 3.81	**178-8254**
FIGURE 4	**FEP or PFA Jacketed Shielded "Quiet Line"**						
12	11	90	22	19/34	SPC	.135 / 3.42	**178-8069**
FIGURE 5	**FEP or PFA Jacketed Silicone Coated and Shielded "Quiet Line"**						
20	21	130	22	19/34	SPC	.195 / 4.95	**178-8106**

Figure 1

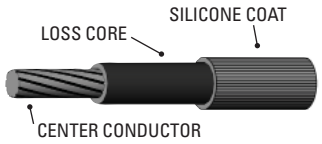


Figure 2

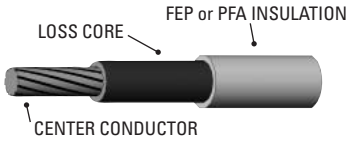


Figure 3

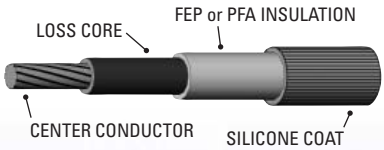


Figure 4

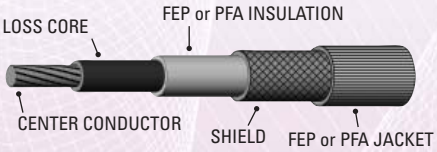
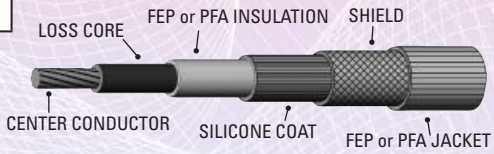


Figure 5



Product numbers and specs subject to change without notice. Products listed represent only a small selection of Teledyne Reynolds' products.
Please visit www.teledynereynolds.com for the most up to date product information. Contact Teledyne Reynolds' Engineering to discuss custom designs.

Approved for Public Release: MP/043/19

Rev. 020719

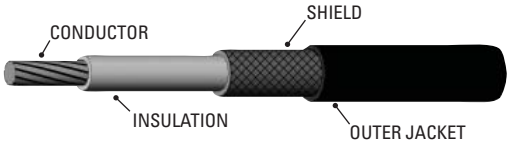
TELEDYNE REYNOLDS
Everywhereyoulook™

COAXIAL/SHIELDED
High Voltage Cable

70,000 ft (21.3km)
-55° to 125°C

Coaxial and shielded cables offered by Teledyne Reynolds have been used in space, military, medical and industrial high voltage applications including radar, electronic countermeasure (ECM) systems, power supplies and instrumentation. Many of the cables have controlled impedance.

- Cables 167-2669 has **controlled impedance, inductance and capacitance** for fast response times and are used extensively to connect Exploding Bridgewire Detonators (EBW) to a Capacitor Discharge Unit (CDU).



High Voltage Coaxial/Shielded Cable Attributes

Operating Voltage (kVDC)	Conductor			Insulation		Shielding			Jacket		Imp. (Ohms)	Atten. dB/100 ft @ 400 MHz	Cap. pF/ft @ 1 kHz	Part Number
	AWG	Strands	Plating	Material	Diameter in/mm	AWG	Plating	Diameter in/mm	Material	Diameter in/mm				
5	26	19/38	SPC	PO	.050 / 1.27	36	SPC	.075 / 1.90	PO	.095 / 2.41	46	25.0	33.7	**178-8022**[1]
18	18	19/30	TPC	FEP	.080 / 2.03	36	TPC	.160 / 4.06	FEP	.125 / 3.17	17-34	8-16	43-80	**167-8623**
18	26	19/38	SPC	FEP	.050 / 1.27	36	SPC	.075 / 1.90	FEP	.095 / 2.41	46	25.0	33.7	**167-2896**[2]
20	16	19/29	TPC	PE	.118 / 2.99	36	TPC	.150 / 3.51	PE	.195 / 4.95	31	16.0	48.0	**167-2669**[3]
20	16	19/29	SPC	PFA	.118 / 2.99	36	SPC	.150 / 3.51	PFA	.195 / 4.95	35	13.0	40.4	**178-6053**[4]
20	22	19/34	SPC	FEP	.050 / 1.27	36	SPC	.075 / 1.90	FEP	.095 / 2.41	27	19	45	**178-9822**
21	22	19/34	SPC	FEP	.080 / 2.03	36	SPC	.100 / 2.54	FEP	.125 / 3.17	43	10.6	31.0	**167-9346**
26	22	19/34	SPC	FEP	.100 / 2.54	36	SPC	.120 / 3.04	FEP	.145 / 3.68	50	8.1	29.3	**167-8726**
27	20	19/32	SPC	FEP	.118 / 2.99	36	SPC	.150 / 3.51	FEP	.200 / 5.08	51	6.4	29.7	**167-9639**[3]
35	20	19/32	TPC	FEP	.150 / 3.81	36	TPC	.180 / 4.57	FEP	.220 / 5.58	50	12.2	26.0	**167-9785**
35	20	19/32	SPC	FEP	1.25 / 3.18	36	SPC	.145/ 3.70	FEP	.176 / 4.49	51		95	**503-0001**

[1] Irradiated, cross-linked, polyolefin insulation and jacket rated for use in high radiation from -65° to 110°C
[2] Type "L" cable
[3] Type "C" cable. Rated for use to 85°C
[4] Rated for use to 150°C

FEP (Fluorinated Ethylene Propylene)
PE (Polyethylene)
PFA (Perfluoroalkoxy)
PO (Polyolefin)

Notes:

When ordering, use part number and specify length in feet.

Colors: 167-2896 standard cable jacket is white. 167-2669 standard cable jacket is red. 178-6053 standard color is yellow. All other cable jackets are black. Contact factory for color options and availability or please specify color needed when ordering.

Pre-conditioning of FEP and PFA wire or cable is recommended because these insulations will shrink when exposed to temperature cycling. Pre-conditioning should be conducted in an air circulating oven at 204°C (400°F) for one hour. Pre-conditioning should only be performed on cut lengths prior to stripping and any termination procedure. No attempt should be made to condition wire or cable in bulk form or while spooled.

Approved for Public Release: MP/043/19

Rev. 020719

TELEDYNE REYNOLDS
Everywhereyoulook™

Partial discharge (PD) is a localized incomplete dielectric breakdown between two conducting electrodes. In a high voltage wire or cable, one electrode is the center conductor, and the other electrode is the nearest ground plane which can be the shield, connector shell, or metal enclosure. The breakdown is identified as 'Partial' since it does not fully span the distance between the two electrodes. PD occurs at any point where an electric field strength his greater than the dielectric strength of that portion of insulation. Accordingly, PD is most likely to occur in locations where there are air gaps, cracks, or inclusions in the insulation, or at the interface between insulation layers.

Why is it important?

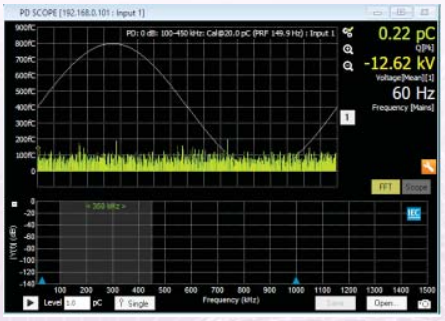
Partial discharging can cause two major detrimental effects to an interconnect system;

1. As they can cause progressive deterioration of the dielectric (insulation) resulting in electrical breakdown.
2. They can create transient current pulses resulting in RFI (radio frequency interference) affecting the performance of sensitive equipment.

Reducing or eliminating partial discharge, is a design goal in any high-voltage system design

Detect and measure

Teledyne Reynolds has significant experience in designing products for high voltage applications, and in testing these products using state-of-the-art PD test equipment and techniques. Our capabilities include the ability to test for and detect partial discharge, either in



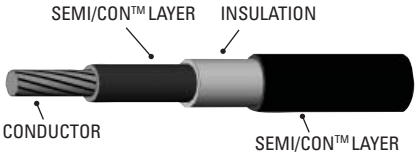
Continuous wire - Through the use of our continuous corona detection system, a wire can be subjected to 100% partial discharge testing to detect defects in the wire insulation.

Point to point, cable assembly - For your cable assembly or selected length of wire, we have capabilities to determine corona inception and extinction levels, and we have capabilities to detect and quantify the number of discharges at various voltages over time.

The Teledyne Difference

Teledyne's High Voltage wire and connectors lines are specifically designed and manufactured to minimize partial discharge. This is achieved by carefully selecting conductors, insulation materials, utilizing proprietary extrusion techniques, and adhering to a stringent quality assurance process. Additionally, Teledyne Reynolds has established voltage ratings that already incorporate a de-rating factor from test voltages to give the system designer the highest confidence when selecting our wire and cable products.

For unique applications where minimizing partial discharge and maximizing corona inception voltage is paramount, Teledyne Reynolds has experience in designing and constructing receptacle connectors and plug cable assemblies that utilize semi-conductive wire or cable, and other proprietary design and termination techniques to achieve high performance for these extreme applications.



Semi/Con™ high voltage (HV), semi-conductive (semicon) silicone cables have a distinct advantage over standard HV cables in that they are more resistant to electrical stress and exhibit very little to no corona at the rated voltage.

Standard high voltage interconnects are highly reliable and have a long service life when installed in equipment with adequate insulation or separations from grounded planes, especially sharp edges. When these requirements cannot be met or the voltage is pulsed DC or AC, and the need is still present for a high voltage cable that exhibits little to no corona discharge at the operating voltage, **Semi/Con™ cable may be your solution**.

Low PD Applications

- Semiconductor processing or inspection equipment
- X-ray equipment
- Radar
- Missile ignition
- Electrostatic equipment
- Scientific and analytical instrumentation
- Other EMI sensitive environments

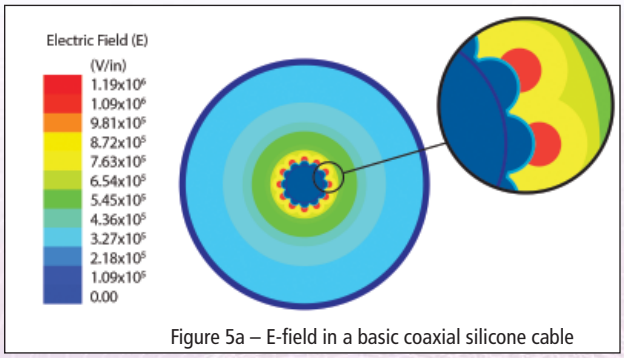


Figure 5a – E-field in a basic coaxial silicone cable

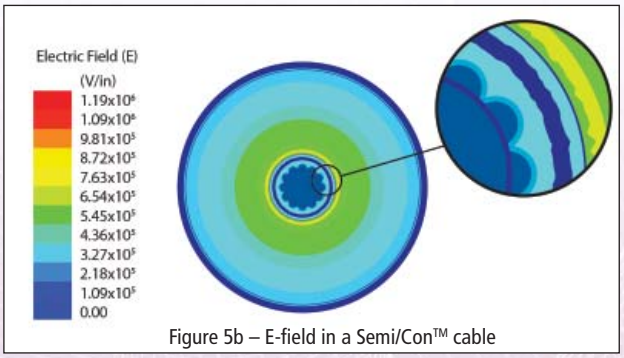


Figure 5b – E-field in a Semi/Con™ cable

Interconnect solution

To design and construct a highly reliable, low partial discharge cable assembly, it is **essential** that corona resistant cable be paired with compatible connectors, utilize special termination processes, and be tested utilizing sensitive corona and PD test equipment and testing techniques.

Contact Teledyne Reynolds with your application and needs, our engineers and technicians will work with you to develop a world-class interconnect solution.

For extreme low corona or partial discharge applications, or for extended life low pressure applications Teledyne Reynolds, upon special order, has the ability to apply the Hi/Pure™ process to many of our wire designs. The end products are ultra-pure high voltage wires that are designed to operate in high vacuum applications requiring thousands of hours of reliability. These cables can be supplied on reels or as leads in connectorized high voltage cable assemblies.

These wires are designed to meet the general requirements of specifications such as MIL-DTL-16878, MIL-W-22759, MIL-C-17, but in addition meet "higher level" performance required for low corona, high voltage applications. Unique processing and testing of these wires enables them to be used in low pressure applications such as in spacecraft or other vacuum systems.

Features and Benefits

Materials: The cable utilizes a High Purity (HP) insulation to assure lower size and amounts of inclusions or contamination within the cable insulation.

Processing: The enhanced purity of material is coupled with proprietary processing profiles to reduce the occurrence of voids within the insulation.

Testing: Through the use of our continuous corona detection system the wire is subjected to 100% partial discharge (corona) testing at AC voltages designed to detect defects, inclusion or voids in the wire insulation. Any sections in which discharges are detected, identified and are then removed before utilizing the wire on cable assemblies.

Applications for Hi/Pure™

- Semiconductor wafer inspection equipment
- Space rated traveling wave tubes, magnetrons and klystrons
- High energy physics research
- Scientific instrumentation

Contact our application engineering team to discuss your requirements via our online contact form, phone: (310) 823-5491 or email: tri_techsupport@teledyne.com

Approved for Public Release: MP/043/19

Rev. 020719

A high voltage interconnect system is only as reliable as its weakest link. Teledyne Reynolds has decades of experience in manufacturing high performance and high reliability cable assemblies using our world-renown high voltage wire and cables for your mission critical programs.

Benefits of Teledyne Reynolds cable assemblies

- Application engineered designs
- Best in class HV connectors
- Teledyne's high performance wire and cable
- Proprietary wire and cable (Ready-to-Bond) preparation techniques
- Expert and certified termination techniques
- Electrical, mechanical and environmental testing

TR supports a wide variety of customers by designing and manufacturing customized connectors and cable assemblies for their high reliability (Hi-Rel), mission critical requirements. These assemblies are not only specialized in high voltage, but TR also offers a variety of **hybrid configurations** combining

- Fiber-optic
- Signal (low voltage)
- High Current
- High Voltage
- Harsh Environment

Contact our application engineering team to discuss your requirements via our online contact form, phone: (310) 823-5491 or email: tri_techsupport@teledyne.com

Technology. Tested. Trusted.

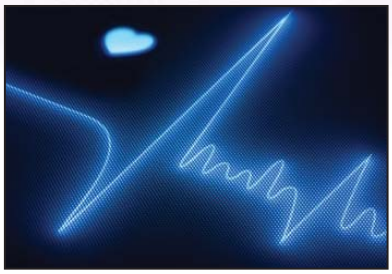
Approved for Public Release: MP/043/19
Rev. 020719

INDEX BY PART NUMBER

Technology
Tested
Trusted

Markets Served

MILITARY/DEFENSE



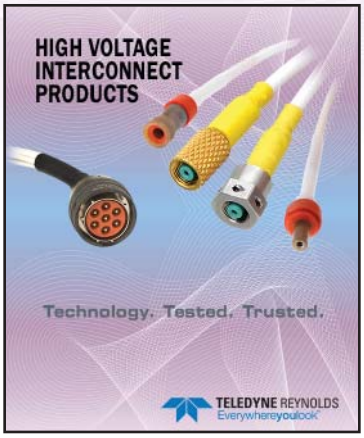
MEDICAL

HIGH END INDUSTRIAL

TEST AND INSTRUMENTATION

ENERGY

SPACE



TELEDYNE REYNOLDS
Everywhereyoulook™

Teledyne Reynolds
1001 Knox Street
Torrance, California 90502
Tel: (310) 823-5491
Fax: (310) 822-8046
www.TeledyneReynolds.com
TR_Sales@Teledyne.com

Teledyne Reynolds UK
Navigation House, Canal View Road
Newbury, Berkshire
RG14 5UR
England
Tel: +44 (0)1635 262200
Fax: +44 (0)1635 521936
www.TeledyneReynolds.co.uk
new_TRLSales@teledyne.com

Quality Policy

Teledyne Reynolds strives to satisfy customer expectations by providing quality products, on time, and in compliance with customer requirements.

As an organization, we are committed to continual process improvement and employee development.

In support of these objectives, quality objectives are established, measured, reported, and periodically reviewed for continuing suitability.

Teledyne Reynolds holds quality certifications for the following:

- ISO9001:2015
- AS9100:D
- IPC 610/620
- J-STD-001

Statement of Warranty
For a complete set of Teledyne Reynolds terms and conditions that expressly apply to all sales, please go to www.teledynereynolds.com/resource-library/Documents/Terms_and_Conditions_of_Sale.pdf