

Custom-designed and standard Multiconductor (Multicore) Cables

Product Facts

- Temperature capability: -55°C to +260°C [-67°F to +500°F]
- Small size, lightweight
- System compatibility with other Raychem products
- Complete range of components
- Specially formulated jacket materials
- Special shielding to address EMI/EMC problems
- Custom designed and purpose built
- Fast response—design, pricing, and delivery
- Prototype length facility
- Raychem Dynalink for extended flex-life and increased flexibility
- Fire-resistance; circuit integrity (IEC60331), enhanced 950°C [1742°F, 3 hours]
- Small size, lightweight, low fire-hazard for modern high-speed vessels



Applications

Tyco Electronics is the leading manufacturer of Raychem custom-designed, small-size, lightweight, high-performance multiconductor (multicore) cables. Applications are found in the aerospace, commercial marine, naval, mass transportation, automotive, offshore, military ground vehicle, ground support, high-performance instrumentation, industrial, and commercial markets. Raychem multiconductor (multicore) cables have been approved to many standards demanding high performance criteria in service use.

Multiconductor (Multicore) Cables Purpose Built and Designed Using Raychem Components and Technology

Multiconductor cables are used in widely varying applications and environments. Careful consideration must be given to the selection of components with the right combination of physical, chemical, and electrical properties for specific applications.

Tyco Electronics' leadership in the technologies of polymer blending and subsequent radiation crosslinking has led to the development of a particularly broad range of Raychem brand cables. High-performance component wires and miniature coaxial cables are combined with unique cable

jacket materials to meet the requirements of demanding environments.

Established as the leading manufacturer of special purpose Raychem cables, Tyco Electronics has continued to develop both its design and manufacturing expertise.

Development of a sophisticated CAD system has allowed increasingly rapid response to any design request, followed by manufacturing to the highest quality standards.

Available in:	
Americas	■
Europe	■
Asia Pacific	■

Specifications/Approvals

Agency	Industry	Military	Tyco Electronics
Underwriters' Laboratories	Lloyd's Register of Shipping	Def. Stan 61-12 Pt 25	WCD series
CSA (Canadian Standards Assn.)	Det Norske Veritas	MIL-DTL-24640	
ISO9001:2000		MIL-DTL-24643	
MSV 34410-34413; 34435; 34436		VG 95218 Pts 27 and 28	
ANSI/ISO/ASQ Q9001-2000			

Multicore Cables



Design Flexibility

Components

- SPEC 44 wire and cable
- SPEC 55 wire and cable
- Type 99 wire and cable
- 100 wire and cable
- ElectroLoss FilterLine cables
- Flexible power cables
- Optical fibers
- Controlled electrical cables

Wraps and Braids

- Fabric and film tapes
- Aramid or steel strength members
- Full range of electrical screens (including SuperScreens)

Jacket Materials

- FDR 25 - Fluid resistant, flexible, high temperature
- Thermorad/ Thermorad F - General purpose
- Thermorad HTF - Very high temperature fluoroelastomer, fluid resistant
- Raythane C - Tough and flexible
- Raythane FR - Tough, flexible, flame-retardant
- Rayolin - Low moisture transmission
- NT/ Thermorad NTFR - Low-temperature flexibility
- Zerohal - LFH (Low Fire Hazard)

How to Build a Multicore Cable

This guide is designed to help you identify the building blocks necessary to create a custom multicore cable design.

1. **What is your application/end-use?**

2. **What temperature rating is required (in degrees C)?**

3. **How many components are needed?**

4. **What is each component used for (data, signal or power)?**

5. **What would be the size of each of the components (in AWG)?**

6. **Are there any electrical shielding (EMI) requirements? If so, please list specifics (ex: component shielding, cable shielding)?**

7. **Are there specific flexibility, mechanical, or fluid resistance requirements? If so, please list specifics and rank the order of importance.**

8. **Do you require special lengths?**

9. **Is there a customer specification involved? If so, please provide a copy.**

10. **Please list any timelines and annual usage estimates.**

Computer Aided Design

Custom Design Capability



Applications

Every year, Tyco Electronics designs and builds several thousand custom, high-performance, multiconductor cables that meet unique product needs.

Design staff can draw on an extensive range of high-performance cable components and jacket materials, while incorporating both color-coding and alphanumeric marking techniques for component identification. These options, combined with a full range of EMI shields, lead to a huge variety of construction possibilities.

Tyco Electronics developed computer-aided design tools to provide a fast response to design requests. The software, used by factory engineers or product specialists in the field, can generate cable design proposals with drawings and quotations in minutes. A design drawing details all the cable data and can be used as the input to harness or cable splice (joint) design. The resulting cable is tailored to customers' exact needs in an efficient design that is superior to the competitor's cable selected from a product catalog.

Quality Assurance

Raychem WCD and WSD cable specifications ensure that performance and quality standards are maintained to the highest level. Tyco Electronics manufacturing sites have obtained the highest available quality system approvals, including ISO 9000 and QS9000. Raychem cables are manufactured to meet the requirements of several major specifications.

Available in:

- Americas ■
- Europe ■
- Asia Pacific ■

Custom Shipboard Cables

Product Facts

- Waterblocked cables are available using tapes and yarns vs. silicone, which improves size and flexibility
- Low smoke, zero halogen jackets compliant with current MIL Spec applications
- Small order quantities available on most designs
- Lightweight state-of-the-art cable insulation technology
- Tyco Electronics design specialists work directly with customers
- RoHS products available



Applications

Tyco Electronics offers a full range of customized shipboard cables that can save users time, money and weight by packaging multiple cables into a single zero-halogen jacket per MIL-DTL-24640 specification.

Cables can be used for a variety of applications including control, lighting, signal and power.

Consolidation of individual cables for various applications including weapons and communications systems.

Data and power cables can be combined in the same bundle to decrease weight and size on cable runs.

Available in:	
Americas	■
Europe	■
Asia Pacific	■

RayBraid Tubular Braiding

Tubular Braiding for the Electrical Screening of Wire Bundles

Product Facts

- Screening for military harnesses
- Easy removal from former
- Minimum 90% optical coverage
- Ray 101 and Ray 103 super flexible with high expansion ratios

To ease the assembly of hand built harnesses, Tyco Electronics manufactures a range of braids for the electrical screening of wire bundles.

RayBraid is supplied on a tube former which facilitates assembly and is more robust than braid supplied in flattened form.

Tyco Electronics also supplies connectors suitable for braid terminations.

Applications

When stored under typical conditions of less than 30°C and less than 70% relative humidity, the shelf life of the wire is effectively unlimited. Where the product contains a standard tin plated or bare copper conductor or braid there will be a progressive reduction in the solderability with increasing storage time. Under the conditions mentioned above, excellent solderability should be retained for about one year from manufacturing date, but if this is an important property, it should be checked before use. The suitability of the tin plated or bare copper conductor for use with crimped or welded termination techniques will not be affected by storage time.

Silver and nickel plated conductors are essentially unaltered by normal storage.



Types

Ray 90 (Tinned Copper Braid):

- Minimum 90% optical coverage available in 10 different sizes from 3.0 to 30.0 mm supplied diameter.

Ray 101 (Tinned Copper Braid):

- Minimum 93% maximum 100% optical coverage possess high usable expansion ratio (minimum 2:1).
- Available in a wide range of sizes to cover 2.5 to 38.0 mm diameters.
- Fully compatible with Tinel-Lock adapters for termination of the braid to associated connectors.

Ray 103 (Nickel Copper Braid):

- Minimum 93% maximum 100% optical coverage possess high usable expansion ratio (minimum 2:1).
- Available in a wide range of sizes to cover 2.5 to 38.0 mm diameters.
- Fully compatible with Tinel-Lock adapters for termination of the braid to associated connectors.

Operating Temperature Range

- Ray 90: up to 150°C [302°F]
- Ray 101: up to 150°C [302°F]
- Ray 103: above 150°C [302°F]

RayBraid Tubular Braiding (Continued)

Characteristics

Part Number	Diameter of former (mm)	Tinned Copper Wire						
		No. of Carriers	No. of Ends per Carrier	Individual Strand Size (AWG/mm)	Minimum Coverage (%)	Cable Bundle Tolerance		
						Maximum (mm)	Minimum (mm)	
Ray 90	-3.0	3.0 ± 0.13	16	5	36/0.13	90	3.5	2.0
	-4.0	4.0 ± 0.25	16	7	36/0.13	90	5.0	3.0
	-5.0	5.0 ± 0.25	24	6	36/0.13	90	6.0	4.0
	-6.0	6.0 ± 0.25	24	7	36/0.13	90	7.0	5.0
	-10.0	10.0 ± 0.25	24	9	34/0.16	90	12.0	7.0
	-12.5	12.5 ± 0.25	24	10	34/0.16	90	13.0	11.0
	-15.0	15.0 ± 0.38	24	11	32/0.20	90	18.0	13.0
	-20.0	20.0 ± 0.38	36	7	32/0.20	90	23.0	17.0
	-25.0	25.0 ± 0.38	36	9	30/0.25	90	28.0	22.0
	-30.0	30.0 ± 0.38	36	9	28/0.32	90	36.0	27.0
Ray 10X	-3.0	3.0 ± 0.13	16	10	38/0.10	93	5.0	2.5
	.4.0	4.0 ± 0.25	24	7	36/0.13	93	7.5	3.5
	-6.0	6.0 ± 0.25	24	9	36/0.13	93	9.5	4.5
	-7.5	7.5 ± 0.25	24	14	36/0.13	93	14.0	7.0
	-10.0	10.0 ± 0.25	36	12	36/0.13	93	22.0	8.0
	-12.5	12.5 ± 0.25	36	15	36/0.13	93	24.0	11.0
	-20.0	20.0 ± 0.38	48	16	36/0.13	93	38.0	16.0

The X in the part number shall be replaced with the plating type.

Weight

Part Number	Ray -90	Ray -101
	Weight (excluding former) kg/km (nom)	Weight (excluding former) kg/km (nom)
-3.0	13	10.3
-4.0	17	17.0
-5.0	21	—
-6.0	25	25.0
-7.5	52	31.0
-10.0	52	41.0
-12.5	65	51.0
-15.0	100	—
-20.0	165	81.0
-25.0	207	—
-30.0	310	—

Resistance

The following current ratings are to be used as general guidelines. Ratings based on an ambient temperature of 20°C and a temperature rise above ambient of 40°C.

Part Number	Ray -90			Ray 101			Ray 103
	CSA mm ²	Resistance @ 20°C in ohms/km	Current (amps)	CSA mm ²	Resistance @ 20°C in ohms/km	Current (amps)	Resistance @ 20°C in ohms/km
-3.0	1.0	28.0	17	1.3	17.0	18	17.3
-4.0	1.4	18.3	21	2.1	10.3	28	10.5
-5.0	1.8	13.8	25	—	—	—	—
-6.0	2.1	12.2	28	2.7	8.0	34	8.1
-7.5	—	—	—	4.3	5.2	42	5.23
-10.0	4.3	6.0	42	5.5	3.96	52	4.02
-12.5	4.8	6.1	48	6.8	3.23	57	3.28
-15.0	8.3	3.0	67	—	—	—	—
-20.0	12.8	2.2	81	9.7	2.32	69	2.35
-25.0	16.4	1.6	98	—	—	—	—
-30.0	26.0	1.0	125	—	—	—	—

Properties and Specifications

Properties and Specifications

Specifications and Approvals (Components and Jacket Materials)

Specifications UK Designation	FDR 25	Zerohal	Fluoro- elastomer	Thermorad	Rayolin	Raythane C	AFR	NT	44 Wire	55 Wire	100 Wire	99 Wire	Hytrel
US Designation	FDR 25	Zerohal	Thermorad HTF	Thermorad F		Raythane FR		Thermorad NTFR	44 Wire	55 Wire	100 Wire		
Def Stan 61-12 Part 31		X											
Def Stan 61-12 Part 25		X							X				X
Def Stan 61-12 Part 18 type 1 (issue in effect)		X											X
Def Stan 61-12 Part 26									X				
34435, 34436		X							X				
VG 95218 Part 20, 21, 22 and 23									X	X	X		
VG 95218 Part 24, 25 and 26	X												
VG 95218 Part 27 and 28	X	X							X		X		
VG 95218 Part 1000									X				
VG 95218 Part 1001 and 1002										X			
MIL-DTL-24640 (PMS 400/MII-C-915)		X							X				
SAE-AS-81044/NEMA WC27500									X				
SAE-AS-22759/NEMA WC27500										X			
A014000		X											X
O2-517		X			X				X				
MIL-DTL-24643		X											
Approvals													
Lloyds Register of Shipping		X		X		X			X				X
Bureau Veritas	X	X	X	X		X	X	X	X	X			
UL				X		X (FR)	X		X	X			
CSA									X	X			
BWB	X			X					X	X			
VDE	X			X					X	X			
Germanischer Lloyd		X										X	
American Bureau of Shipping		X										X	

* Please check with your Tyco Electronics representative to ensure the product required has the correct approval.

Properties and Specifications (Continued)

Major Cable Specifications

Country	Cable Specification	Specification Description	Approved Jacket
UK	Def Stan 61-12 Part 25	Royal Navy specification covering limited fire hazard thin-wall insulated electric cables using Def-Stan 61-12 Part 18 approved wire. Signal, control and light power circuits.	Zerohal
Germany	VG 95218 (parts 27 and 28)	Military ground systems specification for signal, control and power cables. Wire to VG 95218 Parts 20-23 and 1000.	FDR-25
USA	MIL-C-24640 (PMS 400/MIL-C-915)	Navy specification covering limited fire hazard thin-wall insulated electric cables for signal, control and light power circuits. Wire to SAE-AS81044.	Zerohal
USA	MIL-DTL-24643	Navy specification covering low smoke, watertight, and non-watertight electric cables for signal, control, and light power circuits for shipboard applications.	Zerohal

Summary of Typical Cable Jacket Properties

UK Designation	US Designation	Property					Chemical Resistance			
		Temperature Range °C*	Abrasion Resistance	Flexibility	Tensile Strength (MPa)	Elongation %	Flame Resistance	Acid	Alkaline	Hydrocarbon
FDR25	FDR25	-40 to 105	Fair	Very Good	20	500	Self-ext;ing	Good	Good	Very Good
Zerohal	Zerohal UK & US	-30 to 105	Good	Good	10	200	Self-ext;ing	Good	Good	Good
Fluoroelastomer	Thermorad HTF	-20 to 200	Good	Good	12	400	Nonburning	Excellent	Excellent	Excellent
Thermorad	Thermorad F	-55 to 125	Good	Good	22	400	Self-ext;ing	Good	Good	Good
Raythane C	—	-25 to 80	Excellent	Excellent	40	500	Self-ext;ing	Fair	Fair	Excellent
—	Raythane FR	-65 to 90	Excellent	Excellent	28	500	Self-ext;ing	Fair	Fair	Excellent
NT	Thermorad NTFR	-55 to 110	Very Good	Excellent	17	300	Self-ext;ing	Good	Good	Good
Rayolin	—	-55 to 95	Very Good	Fair	19	250	Self-ext;ing	Good	Good	Good
AFR	—	-40 to 105	Excellent	Good	10	150	Self-ext;ing	Good	Good	Good
—	Thermorad O	-55 to 125	Good	Good	15	400	Self-ext;ing	Good	Good	Good
—	Thermorad 770	-55 to 175	Very Good	Good	35	500	Nonburning	Excellent	Excellent	Excellent
—	Thermorad 780	-55 to 200	Very Good	Good	24	350	Nonburning	Excellent	Excellent	Excellent
—	Thermorad 790	-55 to 250	Very Good	Good	30	350	Nonburning	Excellent	Excellent	Excellent
Modified PVDF	Thermorad K	-65 to 150	Very Good	Fair	20	400	Nonburning	Excellent	Excellent	Excellent
Modified ETFE	Thermorad HT	-65 to 200	Very Good	Fair	34	100	Self-ext;ing	Excellent	Excellent	Excellent
Modified Flexible ETFE	Thermorad FL	-55 to 200	Very Good	Excellent	20	100	Self-ext;ing	Excellent	Excellent	Excellent
—	Thermorad HTOS	-65 to 200	Very Good	Very Good	34	100	Self-ext;ing	Excellent	Excellent	Excellent
—	Thermorad HTLF	-65 to 200	Very Good	Very Good	34	100	Self-ext;ing	Excellent	Excellent	Excellent
—	Thermorad HTASLF	-65 to 200	Very Good	Very Good	34	100	Self-ext;ing	Excellent	Excellent	Excellent
—	Thermorad VPB	-65 to 200	Very Good	Very Good	23	500	Self-ext;ing	Excellent	Excellent	Excellent

*Operating temperatures for cables are application dependent. Figures shown are for guidance only. In many cases the limits shown may be extended at both ends of the temperature range. Consult Tyco Electronics for guidance.

FDR25

**Flexible, Diesel Resistant
Wire and Cable Jacket
Material**

Product Facts

- Highly flame retardant
- Compatible with Raychem System 25 tubing, molded parts and adhesives
- Qualified to VG standards



Applications

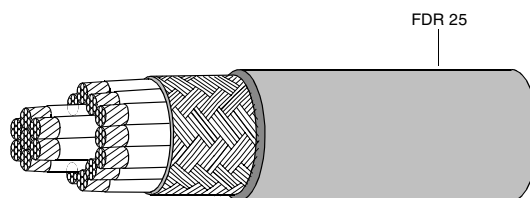
FDR 25 cable jacket was originally developed for the Leopard II main battle tank to provide an exceptional range of properties. Used in compartments exposed to hot diesel fuels and vibration, FDR 25 resists a wide range of aggressive fluids and offers excellent low temperature flexibility. These properties have also led to a widespread use of FDR 25 on other military vehicles and in many applications such as test and communications equipment. FDR 25 is fully compatible with the Raychem System 25 high performance harnessing system.

Operating Temperature Range

-40°C to 150°C
[-40°F to 302°F]

Available in:

- Americas ■
- Europe ■
- Asia Pacific ■



FDR25 (Continued)

Typical Characteristics when Tested in Accordance with Tyco Electronics Specification WCD 2002 (UK) and WCD 3304 (US)

Mechanical	Tensile strength (MPa)	20	
	Elongation (%)	500	
	Tear strength (N/mm)	5	
	Abrasion resistance (1.6 kg load) Cold bend	40 scrapes min. -40°C [-40°F]	
Thermal aging	Endurance IEC 60216-1	2500 h 150°C [302°F]	
	Heat aging 120h, 175°C [347°F]	TS 8 MPa (min). Eb 150% (min)	
	Heat shock 4 h at 225°C [437°F]	No cracks, drips or flowing, 6 mm total shrinkage in 300 mm	
Fluid resistance	24 h immersion	% Retention of properties Tensile strength Elongation	
	Diesel fuels 70°C [158°F]	70	70
	Hydraulic fluids 50°C [122°F]	70	70
	Lubricating oils 70°C [158°F]	70	80
	Cleaning fluids 23°C [73°F]	90	95
	Deicing fluids 23°C [73°F]	90	95
Electrical	Insulation resistance 20°C [68°F] M ohm.km min.	2	
	45° flammability	30 s (max) afterburn 100 mm (max) burn length	
Other	Vertical flammability	Self extinguishing	
	Acid gas	4% HCl equivalent (max.)	

Zerohal

**Low Fire Hazard
Performance Wire and
Cable Jacket Material**

Product Facts

- Halogen free
- Low smoke generation
- Highly flame retardant
- Low toxicity index
- Low corrosive gas emission
- Temperature rating -30°C to +105°C [-22°F to +221°F]



Available in:	
Americas	■
Europe	■
Asia Pacific	■

Applications

Cables rarely initiate fires, but they could be involved in them and can significantly increase the damage caused should they propagate the fire. Until recently the flame retarding of cables was achieved by the use of halogenated flame retardants which are effective fire suppressants, but which unfortunately produce dense smoke and corrosive acid gases when burned. These effects are highly undesirable in a fire, hindering evacuation and fire fighting, endangering life and causing corrosion damage to expensive and vital equipment.

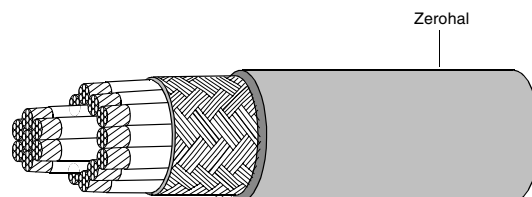
Raychem Zerohal is a halogen-free cable jacket material developed by Tyco Electronics and approved to the most exacting requirements for low fire hazard cables in many countries and, as such, is the most widely accepted material for these applications in the marine, process and mass transport industries. Combined with SPEC 44 wire or Type 99 and 100 wire, this jacket material provides small size, light weight cables (approximately 40% weight saving over conventional materials).

Zerohal combines the good mechanical and electrical features of some conventional cables with good flame retardancy, low smoke generation, low evolution of hazardous and corrosive gases, and good resistance to diesel fuel, lubricating oils and water.

Zerohal jacket material is fully compatible with the low fire hazard harnessing system - System 100.

System

- System 100



Zerohal (Continued)

Typical Characteristics when Tested in Accordance with Tyco Electronics Specification WCD 2015 and WC 2001 (Zerohal with Fungicide)

Mechanical	Tensile strength (MPa)	9
	Elongation (%)	200
	Tear strength (N/mm)	5
	Abrasion resistance (1.6 kg load)	30 scrapes min.
	Cold bend	-30°C [-22°F]
Thermal aging	Heat aging 120 h 130°C [266°F]	60% min retention of TS and Eb
	Heat shock 4 h at 225°C [437°F]	No cracks, drips or flowing, 6 mm total shrinkage in 300 mm
Retention of properties		
Fluid resistance		Tensile strength Elongation
	Diesel fuels 20°C [68°F] /24 h	85 75
	IRM 902 24h, 100°C [212°F]	90 75
	Lubricating oils 50°C [122°F]/24 h	80 75
	Water uptake (ASTM D570) 70°C [158°F] /28 days	4% weight uptake (max)
Electrical	Insulation resistance 20°C [68°F] M ohms km (min)	1
	45° flammability	Self extinguishing
Other	Vertical flammability (Swedish Chimney)	Self extinguishing
	Acid gas	1.2% HCl equivalent (max)
	Limiting oxygen index	32%
	Temperature index	275°C [527°F]
	Toxicity index	2.5 per 100 g
	Smoke index	18
	Halogen content	None detected

**Low Fire Hazard Performance
Flammability**

Current thinking on fire hazard defines the term 'Fire Risk'. This description recognizes that the risk in a fire situation is influenced strongly from several factors including, ignitability, heat release, smoke evolution and toxic gas emission together with flammability.

There are several test procedures available used to assess flammability of wires and cables. Still in widespread use is Limiting Oxygen Index (LOI), but it is now generally recognized that because the test is conducted on a single specimen (of cable jacket or wire) in laboratory conditions, the results are, at best, only weakly correlated to actual fire situations. Critical Temperature Index (CTI), is a related test and assesses performance at elevated temperature but nevertheless it is still conducted on a single specimen. The most common

flammability tests for a single wire specimen is the 60° flame test as defined by AS81044 and FAR Part 25. More recent evidence and thinking places significantly greater importance on large scale flammability tests, such as IEC IEEE 383 or UL1685, in which the sample consists of a tray of wires. These tests predict more accurately the likely behavior of cables in actual fire scenarios. Raychem Zerohal cable jackets give very good results in small scale laboratory based tests (e.g. LOI, CTI) and Zerohal cables perform very well in large scale tests (e.g. IEEE 383 or UL1685). Overall Zerohal jacketed cables have been shown to exhibit excellent flammability characteristics.

Corrosivity

Under fire conditions, polymers containing halogens, sulphur and phosphorous all form corrosive acid gases or liquids. These acids can then attack items such as printed circuit

boards, connectors, control relays and metal structures, including steel reinforcement bars embedded in concrete.

Test methods to evaluate corrosivity involve direct measurement of the amount of acid gas produced during pyrolysis, eg to MIL-DTL-24640 Acid Gas Generation or measurement of pH and electrical conductivities of solutions.

Toxicity Index

The various gases given off by combustion of polymeric materials are toxic to differing degrees.

The Def Stan 02-713, assesses the concentration of each of the possible by-products and, by measuring the amounts of these materials, a Toxicity Index is assigned.

Zerohal jacket material has a typical Toxicity Index of 1.7, compared to a typical value of 6 for CSP and 20 for PVC jacketed cable. The Def. Standard 61-12

Part 31 specification requirement for a cable jacket is <5.

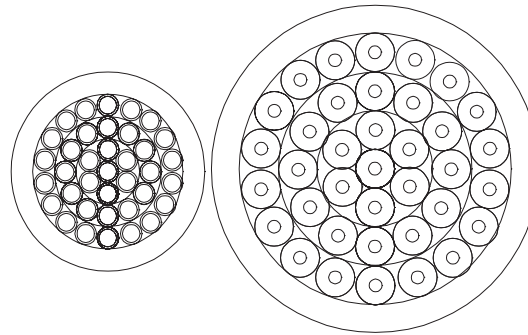
Smoke

The problems of classifying flammability and corrosive gas generation equally apply to measuring smoke generation. The method accepted by most authorities involves the use of the NBS smoke chamber where optical density of the chamber's atmosphere is constantly measured during pyrolysis.

The 10% visibility line indicates the density of smoke which would cause human disorientation and confusion. The rate of change of smoke density can be summarized to a single numerical value, as in Def. Standard 02-711, to give a smoke index for a material and thus offers simple comparison of materials performance.

Zerohal (Continued)

**Navy Applications
37 Component Cable
Comparison**



Tyco Electronics

Competition

	Tyco Electronics Cable to Def Stan 61-12 Pt25	Cable to DGS 212
Diameter	12.5 mm (nom.)	21.3 mm
Weight	328 g/m (nom.)	526 g/m
Conductor	0.60 mm ² (nom.)	0.5 mm ²

Ships are becoming smaller and more sophisticated, with an ever increasing complexity of electronic systems, sensors and weapons. As technology advances shipbuilders are called upon to update and modify existing systems or fit completely new ones. The proliferation of electronic hardware requires more and more communication systems to transfer data from one place to another. To provide all the necessary interconnections, hundreds of multicore cables have to run throughout the ship. These, along with cables for power, lighting and other basic services, create a severe space problem within ducts and hangers. For the vessel to achieve maximum speed, maneuverability and range, it is vital to

keep the “top weight” to a minimum and since most of the equipment is located on the upper decks, system weight must be kept as low as possible.

The diagram shows a lightweight cable compared with a traditional shipboard cable having the same cross-sectional area of copper. Both cables have the same number of conductors. A saving in size has been made on the insulation material, but without sacrificing the mechanical or electrical characteristics of the cable. A typical saving in cable tray volume could be as high as 40%. Lightweight cables can also save in excess of twenty tons on a typical frigate and three to five tons on a fast patrol boat.

Tyco Electronics lightweight, small size cables are giving reliable service in frigates, corvette's, fast patrol boats, hydrofoils and submarines in many major Navies.

Due to recent improvements in manufacturing, Tyco Electronics can now offer an even tighter tolerance of $\pm 2.5\%$ on cable diameter. This is well within the limits imposed by specifications such as Def Stan 61-12 part 25, MIL-DTL-24640/24643, and offers significant benefits to system designers, particularly where cable glanding is involved.

Weight savings within “maxima allowed” by existing specifications are also achievable.

Other applications

The increasing awareness of many areas of industry of the need to minimize fire hazard risk is leading to a rapid growth in the use of Zerohal jacketed cables. Applications include rail and mass transit, offshore platforms and other enclosed areas where a fire would present a significant threat to people or equipment.

Thermorad HTF/ Fluoroelastomer

High Temperature Performance Wire and Cable Jacket Material

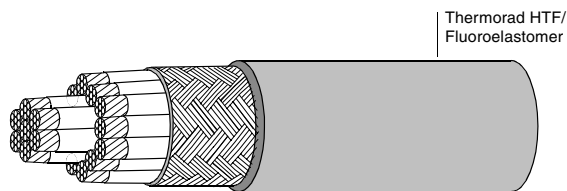
Product Facts

- High temperature capability
-20°C to +200°C [-4°F to 392°F]
- Excellent chemical resistance
- Flame retardant
- Continuous aircraft fuel immersion



Available in:

- Americas ■
- Europe ■
- Asia Pacific ■



Applications

Thermorad HTF/ Fluoroelastomer is a material specially formulated for use in applications where exceptional performance is required.

It displays excellent stability during continuous high temperature exposure to adverse chemical environments.

Thermorad HTF/ Fluoroelastomer has a continuous operating tempera-

ture of up to 200°C [392°F], and finds applications in aircraft fuel tanks and on high performance engine cables. Thermorad HTF/ Fluoroelastomer cable jackets are compatible with the Raychem high temperature harnessing systems — System 200.

System

- System 200

Typical Characteristics when Tested in Accordance with Tyco Electronics Specification WSD 51/1637

Mechanical	Tensile strength	12 MPa	
	Elongation	400%	
	Abrasion resistance (1.6 kg load)	40 scrapes min.	
Thermal aging	Cold bend -25°C ± 3°C [-13°F]	No cracking	
	Heat age	168 h 250°C [482°F]	
	Heat shock 4 h at 300°C ± 3°C [572°F]	No cracks, drips or flowing, 6 mm total shrinkage in 300 mm	
Fluid resistance	24 h immersion	% Retention	
	Diesel fuel 100°C [212°F]	Tensile strength	Elongation
	IRM902 oil 100°C [212°F]	60	60
Electrical	Insulation resistance 20°C [68°F] M ohms. km (min)	10	
Other	45° flammability	30 s (max) afterburn 100 mm (max) burn length	
	Vertical flammability	Self extinguishing	

Thermorad/Thermorad F

General Purpose Wire and Cable Jacket Material

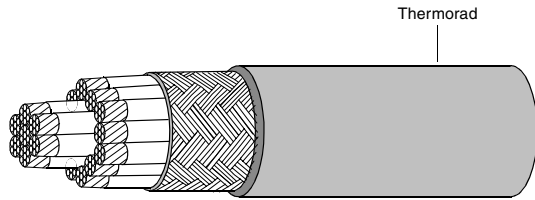
Product Facts

- Temperature rating -55°C to +125°C [-67°F to 257°F]
- Highly flame retardant
- Resistant to fuels, oils and greases
- UL approved



Available in:

- Americas ■
- Europe ■
- Asia Pacific ■



Applications

Thermorad is a general purpose jacket material which is unaffected by most common chemicals and solvents. Thermorad is highly flame retardant and has an overall balance of physical and chemical properties.

Thermorad cables find widespread use in industrial, commercial and military applications. This includes railways, commercial vehicles, medical equipment, communication equipment and commercial electronics. Thermorad cable jackets are compatible with Raychem polyolefin tubings, molded parts and adhesives.

Typical Characteristics when Tested in Accordance with Tyco Electronics Specification WCD 51/1602 (UK) and WCD 3310 (US)

Mechanical	Tensile strength	22 MPa	
	Elongation	400%	
	Abrasion resistance (1.6 kg load)	300 scrapes min.	
	Cold bend	-55°C [-67°F]	
Thermal aging	Heat aging 120 h, 170°C [338°F]	60% min. retention of TS and Eb	
	Heat shock 4 hours at 225°C [437°F]	No cracks, drips or flowing, 6 mm total shrinkage in 300 mm	
Fluid resistance	72 hour immersion, 50°C [122°F]	% Retention of properties	
		Tensile strength	Elongation
	IRM 902	60	60
	Skydrol®	60	60
Electrical	Insulation resistance 20°C [68°F] M ohms km (min)	20	
Other	45° flammability	30 s (max.) afterburn 75 mm (max.) burn length	
	Acid gas	4% HCl equivalent (max.)	

Raythane, NT/Thermorad NTFR, Rayolin and AFR

Specialized Wire and Cable Jacket Material

Product Facts

**Modified Polyurethanes
Raythane C**

- -25°C to +80°C
[-13°F to +176°F]

and Raythane FR

- -65°C to +90°C
[-85°F to +194°F]

- Mechanically tough
- Can be overmolded

Rayolin

- -55°C to +95°C
[-67°F to +203°F]
- XL or U-XL are available
- Excellent long term water immersion
- Can be overmolded
- Compatible with Tyco Electronics underwater cable splices

NT (US designation Thermorad NTFR)

- -55°C to +90°C
[-67°F to +194°F]
- Extreme flexibility
- Highly flexible at low temperatures

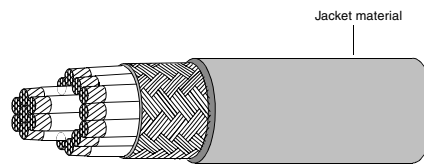
AFR

- -40°C to +105°C
[-40°F to +221°F]
- Abrasion resistant
- Fuel resistant
- Flame retardant



Applications

In addition to the preferred cable jacket materials, Tyco Electronics offers a variety of Raychem cable jackets for specialized applications. For example, specialized materials are available for extreme low temperature flexibility or for enhanced abrasion resistance, or non-cross-linked materials for cable splicing or overmolding.



Available in:	
Americas	■
Europe	■
Asia Pacific	■

Typical Characteristics when Tested in Accordance with Tyco Electronics Specification WCD

	WCD51/1625 Raythane C	WCD3310 Raythane FR	WCD51/147/WCD3314 NT/Thermorad NTFR	WCD51/1601 Rayolin	WCD51/1619 AFR	SPEC 44/ ASC 15865 Thermorad K	SPEC 55 Thermorad HT	
Mechanical	Tensile strength (MPa)	40	28	17	19	11	20	34
	Elongation (%)	500	500	300	250	150	400	100
	Abrasion resistance (1.6 kg load)	500 scrapes	500 scrapes	30 scrapes	300 scrapes	200 scrapes	Very good	Very good
	Cold bend	-25°C [-13°F]	-15°C [5°F]	-55°C [-67°F]	-55°C [-67°F]	-40°C [-40°F]	Pass	Pass
Thermal aging	Endurance (10000 h)	80°C [176°F]	90°C [194°F]	90°C [194°F]	95°C [203°F]	105°C [221°F]	N/A	N/A
	Fluid resistance	24 h immersion Diesel fuels 50°C [122°F]	Excellent	Excellent	Good	—	Good	Excellent
Skydrol® 50°C [122°F]		—	—	Excellent	Excellent	Excellent	—	—
Lubricating Oil 50°C [122°F]		—	—	—	—	—	Excellent	Excellent
IRM 902 100°C [212°F]		Excellent	Excellent	Good	Good	Good	—	—
Electrical	Insulation resistance 20°C [68°F] M ohms. km (min)	1	1	5	100	100	—	—
	Other	45° flammability	Pass	Pass	Pass	—	Pass	Pass

NBC

Product Facts

- **Temperature rating:**
 Thermorad 770:
 -55°C to 12°C
 Thermorad 780:
 -55°C to 175°C
 Thermorad 790:
 -65°C to 200°C
- **Tested in live agent test with HD, VX and TGD for interior and exterior exposure**
- **Tested in accordance with Army TOP 8-2-510 for NBC contamination survivability**
- **Tested to SC-X15111 and SC-X15112 fluid resistance requirements for commonly used military vehicle fluids**
- **Super Tropical Bleach (STB) and Decontamination Standard #2 (DS2), were used per TOP 8-2-511 to decontaminate specimens at interior (1 g/m²) and exterior (10 g/m²) exposure levels, respectively**



Applications

Thermorad 770/780/790 Jacket Material for applications requiring Nuclear Biological and Chemical contamination survivability (NBCCS).

Thermorad 770/780/790 is a revolutionary new fluoroelastomer material that is resistant to nuclear, chemical, and biological threats. This material has undergone testing and show resistance to levels as listed above.

Thermorad 770/780/790 cables are ideal for military ground vehicle applications, communication equipment, and any other equipment that may be at risk of exposure while in theater.

They are ideal for use in NBC decontamination stations. Thermorad 770/780/790 jackets are compatible with Tyco Electronics Raychem brand tubing and molded parts.

System

System 700

NBC (Continued)

Typical Characteristics when Tested in Accordance with:

		RT 770 Thermorad 770	RT 780 Thermorad 780	RT 790 Thermorad 790
Mechanical	Tensile strength (MPa)	35	24	30
	Elongation (%)	500	350	350
	Abrasion resistance	Very Good	Very Good	Very Good
	Cold bend -55° C [122° F]	Pass	Pass	Pass
Thermal aging	Endurance 250° C [482° F] for 336 hrs. 24 h immersion	Pass	Pass	Pass
Fluid resistance	Diesel fuels 23° C [73° F]	Excellent	Excellent	Excellent
	Lubricating oils 50° C [122° F]	Excellent	Excellent	Excellent
	Decontaminating agent 23° C [73° F]	Excellent	Excellent	Excellent
	JP-8 23° C [73° F]	Excellent	Excellent	Excellent
Electrical	Volume Resistivity (ohms-cm)	21.50E+15	6.20E+15	1.20E+16
Other	45° flammability	Pass	Pass	Pass