

**WHERE THE BEST  
IDEAS IN RAIL BEGIN**







The Rail industry is changing rapidly, to match global demands for greener, more intelligent transportation. As such, railway systems must be engineered for efficiency and sustainability, whilst also delivering higher performance, greater innovation and improved reliability.

TE Connectivity is the world's largest provider of connectivity solutions. We offer our clients worldwide supply chain and logistical support, coupled with a truly local presence that is anchored by dedicated Design Centres, Manufacturing Centres of Excellence, and Sales and Support Offices - all located in the areas where our customers do business.

We have a strong R&D programme, with expertise in materials science, product design and process engineering - supported by our network of knowledgeable application engineers, sales representatives and customer service personnel.

## Key Statistics



Annual revenue of US \$14+ billion  
across 150 countries in 2013



20,000+ patents issued or pending



100,000+ employees



R&D investment of approx  
5% of sales per year



7,000 engineers

# LEADERS IN IDEAS AND INNOVATION

## Rail Heritage

TE Connectivity has more than 50 years of experience in developing and manufacturing innovative, quality-approved products and components, and has an enviable reputation in the Rail industry. Our expertise and our longevity in the industry means that your engineers can design for tomorrow, today - and you can guarantee that we will be around over the full lifetime of your latest purchase.

TE Connectivity is focused on delivering connectivity solutions for roof line, train power, train control, passenger comfort, on board data and information, signalling and infrastructure - leveraging the company's global engineering and manufacturing knowledge to provide dedicated Rail industry solutions.

As a global company, we have manufacturing, operations and design centres in 33 countries around the world. TE solves problems in partnership with industry leaders through the introduction of innovative, technically-advanced products, some of which are then refined for the Rail industry - having demonstrated proven performance in other industries.

- Power and signal connectors
- Data and information connectors
- Wire, cable and conductors
- Electromechanical components
- Roofline Systems
- Cable identification and panel labelling
- Harnessing and protection products
- Passive components
- Sensors and relays
- Tooling
- Servicing

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WITH AN EXTENSIVE TECHNOLOGY PORTFOLIO, BACKED BY POWERFUL INSIGHT INTO THE DAY TO DAY NEEDS OF THE RAIL INDUSTRY, WE UNDERSTAND THE CRITICAL IMPORTANCE OF SYSTEM-WIDE CONNECTIVITY - FOR IMPROVING THE WAY PEOPLE AND CARGO ARE TRANSPORTED ACROSS COUNTRIES AND CONTINENTS.

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## Engineering Expertise

We have 7,000+ engineers across 13 global design centres, so we can work with you every step of the way to engineer innovative, efficient Rail solutions - and to help solve your toughest connectivity challenges. From the high-voltage power line and throughout the entire train, we deliver the broadest product portfolio and the greatest systems expertise, to connect power and data safely and reliably - anywhere in the world.

TE Connectivity has 30 global Product Information Centres (PICs) which work closely with our sales and engineering teams to ensure continuity of support and knowledgeable assistance is always within reach, thanks to our English speaking multi-national engineers. These technical specialists are committed to providing you with dedicated support and assisting you in identifying the right solution for your application - as well as developing strong customer relationships through their professionalism and efficiency.

## Wire and Cable Solutions

TE Connectivity supplies high performance wire and cable to many key markets, including Rail, Aerospace, Commercial, Military (both air and ground), Space and Marine. In the Rail industry, this covers an extensive range of applications including:

- Control cabinets and lockers
- Inverters and converters
- Motors and propulsion units
- Intercar jumper cables
- HVAC
- Interior lighting
- Communications
- Automatic doors
- Data and Information Systems
- Braking systems
- Signalling
- Tunnels
- Trackside
- Battery chargers and power packs



## The Evolution of our Technology

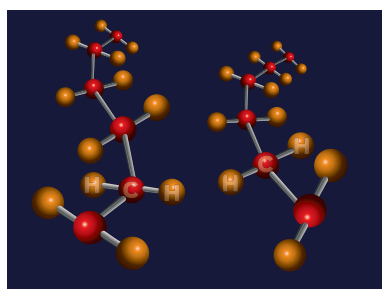
TE Connectivity acquired industry specialist Raychem in 1999. The Raychem brand has been recognised worldwide for over 50 years, and is backed by a history of proven performance, reliability, innovation and superior quality.

Raychem was one of the first companies to commercialise radiation cross-linking of insulation, initially for aerospace applications. To achieve cross-linking, a polymer product is exposed to high energy radiation - which is generally done by exposure to beta radiation (high energy electrons) using an electron beam.

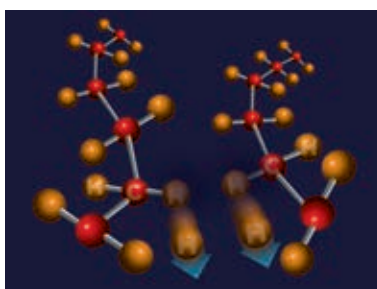
Conventional cables use filled soft polymer insulations, which by their nature have to be thick walled and hence bulky - but cross-linked insulation is lightweight, mechanically tough and thermally stable.

This expertise in materials technology and processing, which TE gained from Raychem, allows the wall thickness of our wire and cable insulation to be greatly reduced. On average, this means around a 50% saving in bulk of cabling, and weight savings of more than 30% over conventional insulations.

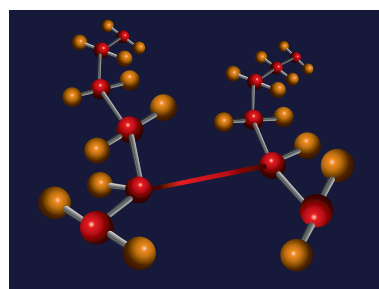
## Radiation Crosslinking



Molecular chain



Crosslinking



Crosslinked molecular chain

# SOLVING PROBLEMS WITH PIONEERING DESIGN

## Low Fire Hazard (LFH) Performance

Cables can significantly increase the collateral damage caused by fire when they propagate the flame. In some applications, Halogenated compounds can be used as flame retardants to stop the wire insulations from burning - but in the rail industry, where the threat to life has to be a major priority, Halogens should be avoided because of the undesirable effects which hinder evacuation and fire fighting.

TE Connectivity uses Zerohal®, a halogen free cable insulation material which was developed originally by Raychem. This combines the mechanical and electrical features of conventional cable insulations with flame retardancy, low smoke generation and low evolution of hazardous and corrosive gasses, as well as resistance to diesel fuel, lubricating oils and water.

Zerohal® is the most widely accepted material for these applications in mass transportation, and is approved to the most exacting global requirements for low hazard cables. It exhibits excellent flammability characteristics in industry testing, and typically has less than 10% of the toxicity of common PVC.

All of the above means that our wire and cable products not only offer significant size and weight reduction, when compared to conventional insulation systems - but also meet key criteria, including low fire hazard performance and mechanical robustness, as specified in international standards such as EN50306 and EN45545.

## Product Benefits

As wire and cable products from TE Connectivity are smaller and lighter than other products available in the marketplace, this enables a significant reduction in the bulk and the weight of wiring looms - which creates a wide range of benefits:

### Manufacturing

- Easier to install
- Greater options for cable routing
- Improved vehicle layout
- Reduced installation costs

### Design

- Easier to design
- Facilitates increases in sensors
- Compatible with greater passenger connectivity
- Delivers greater data for servicing and train safety

## Operation

- Less wire required, reduced weight and cost
- Easier and cheaper installation and maintenance
- Increased headroom and interior space
- Lower energy consumption
- Reduced CO<sub>2</sub> emissions
- Improved passenger experience
- Fewer cable trays and accessories required, reduced weight and cost

The hard polymer cross-linked insulation also has strong physical properties and low surface friction, making it tough against abrasion or cut-through and resistant to damage from sharp edges. This in turn reduces the instances of wire damage during installation and maintenance.

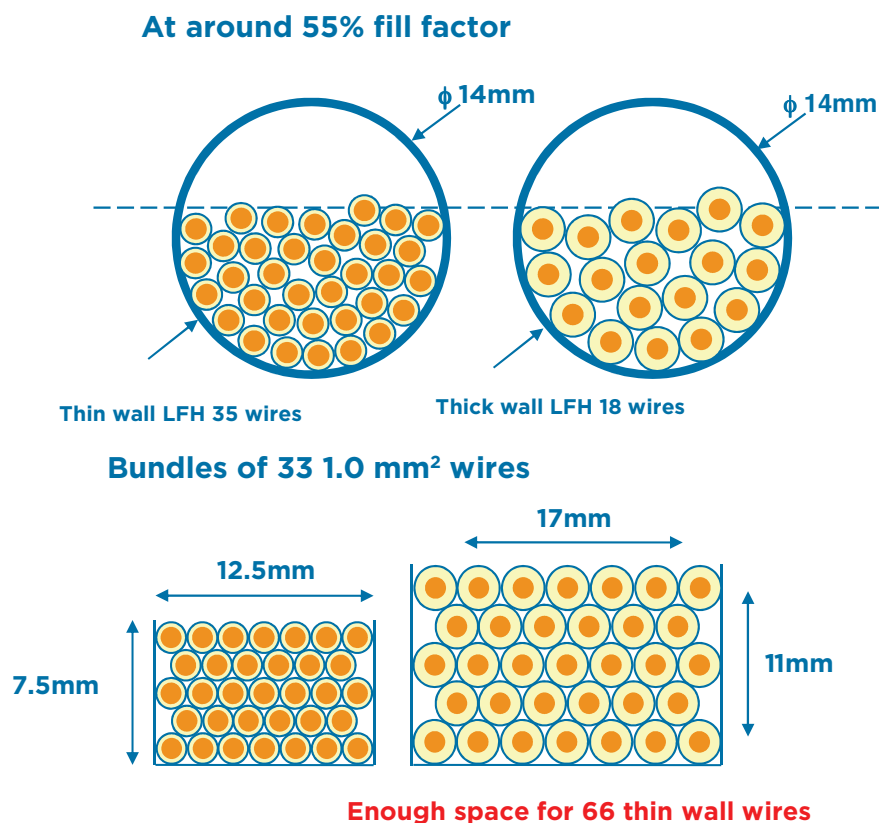
Our wire and cable also has excellent environmental stability, including a high resistance to fluids, temperature changes and other external factors. Shielded options are available to reduce electromagnetic interference, and we can also offer bespoke designs to meet your specific requirements.

# THE PRODUCTS SHAPING OUR INDUSTRY

## 1. 100G RAIL WIRE AND CABLE

Available in a full size range of 0.15mm<sup>2</sup> to 4.00mm<sup>2</sup>, and in bundles of up to nine wires, screened and unscreened, the 100G product range covers most requirements for signal and light power applications.

The use of circular concentric tin plated copper conductors and tough fluid resistant thin wall insulations underpins this small and lightweight range, which is supplied as both a single wire and as a multi core cable.



### Key features - 100G Wire

- Small and lightweight
- Dual wall zero halogen primary wire
- Meets the requirements of EN50306-2, EN45545-2 and DIN 5510-2
- Excellent handling and flexibility
- Does not wrinkle on bending
- Cut and abrasion resistant dual wall construction
- Outstanding resistance to oils
- Voltage rating of 750V
- Conductor cores 0.15mm<sup>2</sup> to 4.0mm<sup>2</sup>
- Continuous temperature rating of -55°C up to +125°C
- 19/37/56 strand conductors



## 100G Wire



- 100G zero halogen thin wall Rail wire
- 750/1300V AC and continuous temperature rating of -55°C to +125°C

1. Conductor - Tin Plated Copper

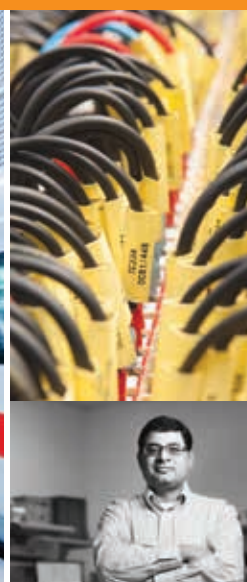
2. Insulation - Halogen Free Polymer

The full requirements for procuring 100G cable are included in this document.

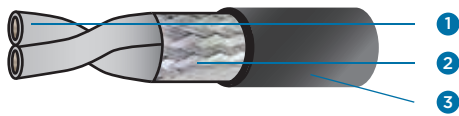
Part Description	Nominal Cross Sectional Area (mm²)	Nominal Conductor Stranding No./Diam. (mm)	Equivalent AWG Size	Conductor Diameter (mm)		Minimum Insulation Thickness (mm)	Finished Wire				
							Maximum Resistance @ 20 °C (ohms/km)	Diameter (mm)			Maximum Weight (kg/km)
				Lower Spec Limit	Target			Upper Spec Limit			
				Min.	Max.						
100G0111-0-15-*	0.15	19/0.10	26	0.45	0.50	0.20	132.9	0.98	1.03	1.08	2.59
100G0111-0-25-*	0.25	19/0.13	24	0.55	0.63	0.20	84.32	1.09	1.14	1.19	3.59
100G0111-0-40-*	0.40	19/0.16	22	0.73	0.79	0.20	50.50	1.28	1.33	1.38	5.18
100G0111-0-50-*	0.50	19/0.18	-	0.82	0.90	0.20	40.10	1.37	1.40	1.45	6.60
100G0111-0-60-*	0.60	19/0.20	20	0.95	1.01	0.20	31.10	1.47	1.52	1.57	7.40
100G0111-0-75-*	0.75	19/0.23	-	1.04	1.15	0.20	26.70	1.59	1.60	1.65	8.90
100G0111-1-00-*	1.00	19/0.25	18	1.17	1.26	0.20	20.00	1.69	1.75	1.80	10.70
100G0111-1-20-*	1.20	19/0.29	16	1.32	1.42	0.20	15.80	1.88	1.93	1.98	13.60
100G0111-1-50-*	1.50	37/0.23	15	1.46	1.58	0.20	13.70	2.03	2.08	2.13	16.00
100G0111-2-00-*	2.00	37/0.25	14	1.68	1.82	0.20	10.50	2.31	2.36	2.41	20.30
100G0111-2-50-*	2.50	37/0.29	13	1.85	2.01	0.25	8.21	2.50	2.55	2.63	25.70
100G0111-3-00-*	3.00	37/0.32	12	2.12	2.24	0.25	6.58	2.70	2.78	2.86	31.00
100G0111-4-00-*	4.00	56/0.30	-	2.41	2.57	0.25	4.89	3.01	3.09	3.17	43.60

## Key Features - 100G Cable

- Small and lightweight
- Zero halogen wires and jacket
- Tin coated copper braided constructions available
- Meets the requirements of EN50306-2, EN45545-2, DIN 5510-2
- Excellent handling and flexibility
- Does not wrinkle on bending
- Cutting and abrasion resistant dual wall constructions
- Outstanding resistance to oils
- Voltage rating of 750V
- Conductor cores 0.15mm<sup>2</sup> to 4.0mm<sup>2</sup>
- Continuous Temperature rating -30°C to +105°C
- 19/37/56 strand conductors



## 100G Cable - 2 Core Screened



- Two conductor cable with zero halogen insulation, shielded and zero halogen jacketed
- 750/1300v AC and continuous temperature rating of -30°C to +105°C

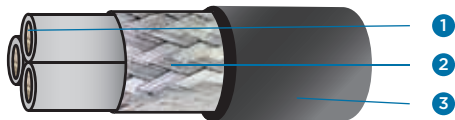
1. Component wire - 100G0111
2. Shield - Tin coated copper, optimised
3. Jacket - Black Zerohal®

The full requirements for procuring 100G cable are included in this document.

Part Description	Nominal Cross Sectional Area (mm <sup>2</sup> )	Equivalent AWG Size	Shield Size (mm)	Jacket Thickness (mm)		Overall Diameter (mm)		Maximum Weight (kg/km)
				Min.	Nom.	Nom.	Max.	
100G1121-0-15-*/*/-*	0.15	26	0.10	0.22	0.30	3.09	3.23	15.9
100G1121-0-25-*/*/-*	0.25	24	0.10	0.22	0.30	3.30	3.45	18.9
100G1121-0-40-*/*/-*	0.40	22	0.13	0.22	0.30	3.81	3.96	26.5
100G1121-0-50-*/*/-*	0.50	-	0.13	0.22	0.30	3.99	4.14	30.3
100G1121-0-60-*/*/-*	0.60	20	0.13	0.22	0.30	4.19	4.35	33.3
100G1121-0-75-*/*/-*	0.75	-	0.13	0.22	0.30	4.44	4.63	37.4
100G1121-1-00-*/*/-*	1.00	18	0.13	0.22	0.30	4.65	4.83	42.2
100G1121-1-20-*/*/-*	1.20	16	0.13	0.22	0.30	5.00	5.22	50.0
100G1121-1-50-*/*/-*	1.50	15	0.13	0.22	0.30	5.30	5.46	56.6
100G1121-2-00-*/*/-*	2.00	14	0.13	0.22	0.30	5.88	6.03	68.7
100G1121-2-50-*/*/-*	2.50	13	0.13	0.22	0.30	6.29	6.44	81.4
100G1121-3-00-*/*/-*	3.00	12	0.13	0.22	0.30	6.72	6.87	94.9
100G1121-4-00-*/*/-*	4.00	-	0.13	0.22	0.30	7.33	7.48	124

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## 100G Cable - 3 Core Screened



- Three conductor cable with zero halogen insulation, shielded and zero halogen jacketed
- 750/1300V AC and continuous temperature rating of -30°C to +105°C

1. Component wire - 100G0111
2. Shield - Tin coated copper, optimised
3. Jacket - Black Zerohal®

The full requirements for procuring 100G cable are included in this document.

Part Description	Nominal Cross Sectional Area (mm <sup>2</sup> )	Equivalent AWG Size	Shield Size (mm)	Jacket Thickness (mm)		Overall Diameter (mm)		Maximum Weight (kg/km)
				Min.	Nom.	Nom.	Max.	
100G1131-0.15-*/*/-*	0.15	26	0.10	0.22	0.30	3.26	3.39	20.0
100G1131-0.25-*/*/-*	0.25	24	0.13	0.22	0.30	3.60	3.77	26.9
100G1131-0.40-*/*/-*	0.40	22	0.13	0.22	0.30	4.04	4.20	34.0
100G1131-0.50-*/*/-*	0.50	-	0.13	0.22	0.30	4.23	4.38	39.5
100G1131-0.60-*/*/-*	0.60	20	0.13	0.22	0.30	4.40	4.55	43.6
100G1131-0.75-*/*/-*	0.75	-	0.13	0.22	0.30	4.70	4.86	49.3
100G1131-1.00-*/*/-*	1.00	18	0.13	0.22	0.30	4.93	5.09	56.2
100G1131-1.20-*/*/-*	1.20	16	0.13	0.22	0.30	5.25	5.41	67.4
100G1131-1.50-*/*/-*	1.50	15	0.13	0.22	0.30	5.65	5.85	76.5
100G1131-2.00-*/*/-*	2.00	14	0.13	0.22	0.30	6.22	6.41	92.8
100G1131-2.50-*/*/-*	2.50	13	0.13	0.22	0.30	6.70	6.85	111
100G1131-3.00-*/*/-*	3.00	12	0.13	0.22	0.30	7.15	7.31	131
100G1131-4.00-*/*/-*	4.00	-	0.13	0.22	0.30	7.83	7.98	173

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## 100G Cable - 4 Core Screened



- Four conductor cable with zero halogen insulation, shielded and zero halogen jacketed
- 750/1300V AC and continuous Temperature rating -30°C to +105°C

1. Component wire - 100G0111
2. Shield - Tin coated copper, optimised
3. Jacket - Zerohal®

The full requirements for procuring 100G cable are included in this document.

Part Description	Nominal Cross Sectional Area (mm²)	Equivalent AWG Size	Shield Size (mm)	Jacket Thickness (mm)		Overall Diameter (mm)		Maximum Weight (kg/km)
				Min.	Nom.	Nom.	Max.	
100G1141-0.15-*/*/*-*	0.15	26	0.13	0.22	0.30	3.65	3.79	27.0
100G1141-0.25-*/*/*-*	0.25	25	0.13	0.22	0.30	3.89	4.04	32.6
100G1141-0.40-*/*/*-*	0.40	22	0.13	0.22	0.30	4.38	4.53	41.6
100G1141-0.50-*/*/*-*	0.50	-	0.13	0.22	0.30	4.58	4.73	48.7
100G1141-0.60-*/*/*-*	0.60	20	0.13	0.22	0.30	4.82	4.99	54.0
100G1141-0.75-*/*/*-*	0.75	-	0.13	0.22	0.30	5.12	5.29	61.3
100G1141-1.00-*/*/*-*	1.00	18	0.13	0.22	0.30	5.36	5.51	70.3
100G1141-1.20-*/*/*-*	1.20	16	0.13	0.22	0.30	5.81	5.96	84.7
100G1141-1.50-*/*/*-*	1.50	15	0.13	0.22	0.30	6.17	6.32	96.7
100G1141-2.00-*/*/*-*	2.00	14	0.13	0.35	0.48	7.21	7.36	127
100G1141-2.50-*/*/*-*	2.50	13	0.13	0.35	0.48	7.70	7.85	152
100G1141-3.00-*/*/*-*	3.00	12	0.13	0.35	0.48	8.22	8.37	178
100G1141-4.00-*/*/*-*	4.00	-	0.13	0.35	0.48	8.97	9.12	235

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## Fire Hazard Properties

Product properties and requirements - see WSD 912 for full test details.

Test	Method	Requirement
Flammability - small scale	IEC 60332-1-2	Charring confined to between 50mm and 540mm
Flammability - large scale	Clause 9.1.2 EN50305	Max. burn length 1.5m
Smoke - large scale	EN 61034-2	3m cube box 90% min. transmittance
Current overload	VG 95 218	No smoke visible
Toxicity	Clause 9.2 EN50305	Index max. 6
Halogen content	IEC 60664-2	< 0.2% Cl +Br +I, < 0.1% F

## DIN 5510-2

See test report WT2387

Test	Method	Requirement
Flammability - small scale	EN60332-1-2	PASS
Flammability - large scale	EN50305	PASS
Smoke - 3m Cube	EN61034-2	PASS
Acidity of gasses	EN50267-2-2	PASS
Acidity of gasses	EN50267-2-1	PASS
Fluorine content	EN60684-2	PASS
Toxicity	Clause 9.2 EN50305	PASS

## Environmental Properties

Test	Method	Requirement
<b>GENERAL PROPERTIES</b>		
Concentricity	IEC 60811-1-1	70% min.
Mark Durability	Clause 10.1 EN50305	Legible after rubbing with wet cloth
<b>PHYSICAL PROPERTIES</b>		
Tensile Strength	IEC 60811-1-1	>20M Pa
Elongation at Break	IEC 60811-1-1	>200%
Scrape Abrasion	Clause 5.2 EN50305	>150 cycles load 7N to 11N
Dynamic Cut-through	Clause 5.6 EN50305	Minimum load 70N to 120N
Notch Propagation	Clause 5.3 EN50305	No cracking, no breakdown
Stripability	Clause 5.5.1/2 EN50305	Easily stripped with normal pliers
<b>THERMAL PROPERTIES</b>		
Thermal Endurance	Clause 7.2 EN50305	20,000 hours @ 125°C
Accelerated Aging (168 hours @ 180°C)	IEC 60811-2	No cracks, flow or breakdown
Stress Cracking (168 hours @ 180°C)	Clause 7.7 EN50305	No cracks or breakdown
Hot Set (15 min @ 200°C)	IEC 60811-2-1	Max elongation 100% under load
Shrinkage	Clause 7.6 EN50305	Max 0.5%
Cold Blend (4 hours @ -55°C)	IEC 60811-4	No cracking or breakdown
<b>ELECTRICAL PROPERTIES</b>		
Conductor Resistance	Clause 6.1 EN50305	See SCD
AC Voltage Test	Clause 6.2.1 EN50305	4kV AC for 5 min 20°C no breakdown
DC Voltage Test	Clause 6.2.1 EN50305	4.8kV DC for 5 min 20°C no breakdown
Dielectric Strength	Clause 6.8 EN50305	1 hour water immersion >4.0kV AC no breakdown
DC Stability	Clause 6.7 EN50305	No breakdown
Insulation Resistance	Clause 6.4.1/2 EN 50305	Table 2 of EN 50306-2
<b>ENVIRONMENTAL PROPERTIES IMMERSION</b>		
IRM 902 Oil 24 hours @ 100°C	Clause 8.1 EN50305	<5% diameter change, no breakdown
IRM 903 Oil 168 hours @ 70°C	Clause 8.1 EN50305	<5% diameter change, no breakdown
MEK 1 Hour @ 23°C	Clause 8.1 EN50305	<5% diameter change, no breakdown
0.5M-Oxalic Acid 168 hours @ 23°C	Clause 8.2 EN50305	<5% diameter change, no breakdown
1M Sodium Hydroxide 168 hours @ 23°C	Clause 8.3 EN50305	<5% diameter change, no breakdown





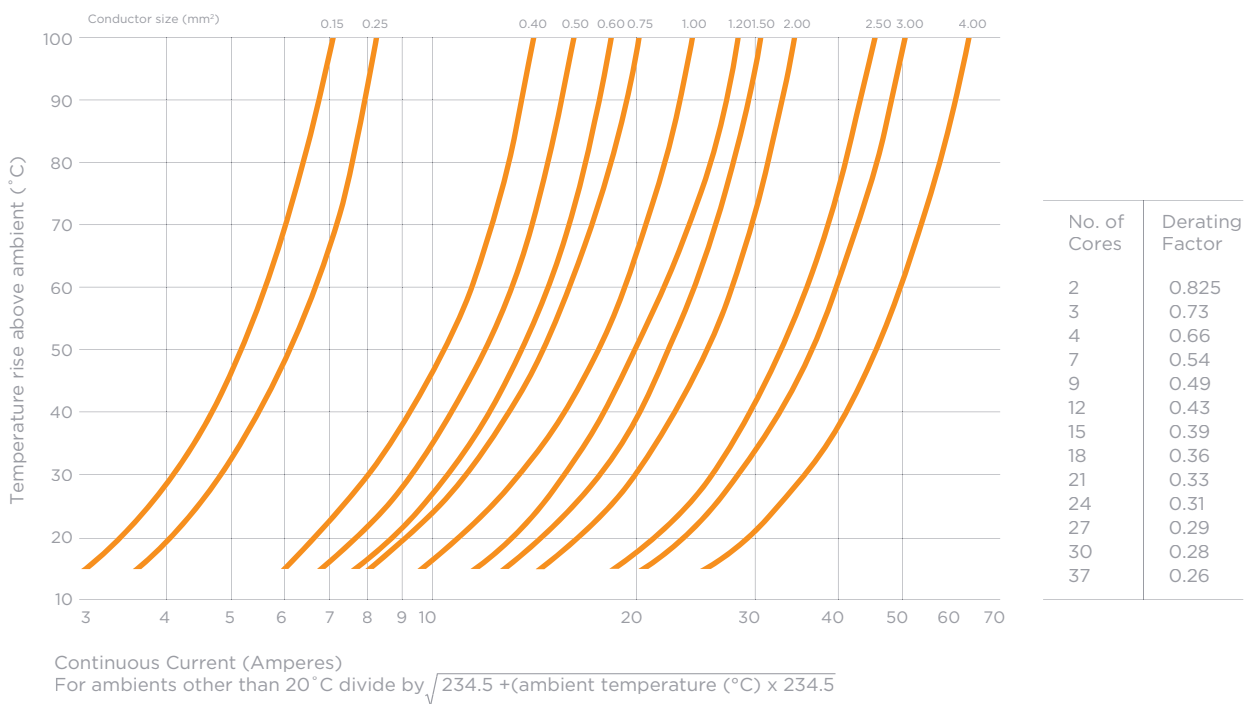
## Part Numbering System for 100G Wire and Cable

**100 G 0 1 1 1 - 4.0 - OCK0226**

- Rail designator
- Insulation colour
- Conductor size  
- 0.15mm<sup>2</sup> to 4.0mm<sup>2</sup>
- Conductor type  
- 1 = Tin plated copper
- Number of conductors  
- 1 to 9
- Class of wire  
(1=250V) for F  
(1=300V) for E  
(1=750V) for G
- Constructions  
0 = Wire  
1 = Screened cable  
4 = Jacketed, no screen
- Type  
E = White and marked  
F = Colour code  
G = Colours
- Basic specification number

## Technical Data

Temperature Rise vs Current Guide - for 100G Cable in free air (single core)



## 2. RAIL POWER CABLES

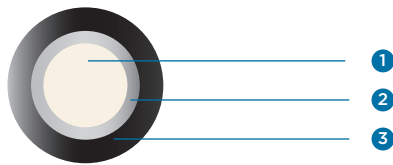
Cables with a conductor size of above 4mm<sup>2</sup> are generally deemed to be Power Cables by industry standards - and their main function is to carry large amounts of current, feeding power to key points in the vehicle. The insulation of these Power Cables needs to be flexible for ease of installation, and yet tough to avoid being cut, crushed or otherwise damaged during installation and routine operation.

### Key features

- Lightweight cross-linked insulation
- Dual wall and zero halogen
- Meet the requirements of WSD 1265, EN45545-2 and DIN 5510-2
- Low smoke and flame retardant
- Fluid resistant jacket
- Excellent handling and flexibility
- Full range of conductor cores from 1.0mm<sup>2</sup> to 400mm<sup>2</sup>
- Available in IEC 60228 Class 5 and 6 conductor stranding
- Tin plated copper conductors
- Continuous temperature rating of -25°C to +105°C

### 750V Zero Halogen Power Cable using IEC60228 Class 5 Conductors

The full requirements for procuring Power Cables are included in this document.



1. Conductor - Flexible tin plated copper special Class 5 to IEC 60228
2. Insulation - Flexible polyolefin containing no added Halogens
3. Outer Jacket - Black Zerohal®

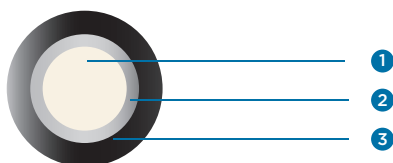
Part Description	Conductor		Max Resist @20 °C (Ohms/km)	Finished Wire		Maximum Weight (kg/km)
	Maximum Diameter of Strands (mm)	Maximum Diameter (mm)		Lower Spec Limit (mm)	Upper Spec Limit (mm)	
ZHPCG-15-1.0-#	0.21	1.25	20.00	3.62	4.00	28
ZHPCG-15-1.5-#	0.26	1.49	13.70	3.64	4.00	36
ZHPCG-15-2.5-#	0.26	1.97	8.21	4.07	4.50	45
ZHPCG-15-4.0-#	0.31	2.56	5.09	4.39	4.89	60
ZHPCG-15-6.0-#	0.31	3.05	3.39	5.06	5.56	85
ZHPCG-15-10.0-#	0.41	4.05	1.95	6.23	6.88	135
ZHPCG-15-16.0-#	0.41	5.20	1.24	7.63	8.48	195
ZHPCG-15-25.0-#	0.41	7.00	0.795	9.20	10.30	300
ZHPCG-15-35.0-#	0.41	7.75	0.565	10.70	11.90	443
ZHPCG-15-50.0-#	0.41	9.20	0.393	12.90	14.10	623
ZHPCG-15-70.0-#	0.51	11.50	0.277	14.90	16.30	847
ZHPCG-15-95.0-#	0.51	13.00	0.210	17.40	18.80	1119
ZHPCG-15-120.0-#	0.51	14.80	0.164	19.10	20.50	1445
ZHPCG-15-150.0-#	0.51	16.70	0.132	21.10	22.90	1775
ZHPCG-15-185.0-#	0.51	18.70	0.108	23.50	25.30	2115
ZHPCG-15-240.0-#	0.51	21.90	0.0817	26.90	28.70	2762
ZHPCG-15-300.0-#	0.51	26.90	0.0654	30.10	32.30	3452
ZHPCG-15-400.0-#	0.51	31.00	0.0495	34.10	36.30	4474

Zerohal® is a registered trademark of TE Connectivity



## 1800/3300V Zero Halogen Power Cable using IEC60228 Class 5 Conductors

The full requirements for procuring Power Cables are included in this document.



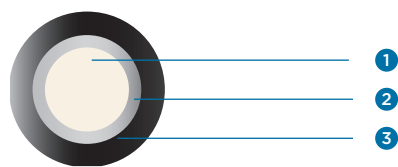
1. Conductor - Flexible tin plated copper special Class 5 to IEC 60228
2. Insulation - Flexible Polyolefin containing no added Halogens
3. Outer Jacket - Black Zerohal®

Part Description	Conductor		Max Resist @20 °C (Ohms/km)	Finished Wire		Maximum Weight (kg/km)
	Maximum Diameter of Strands (mm)	Maximum Diameter (mm)		Outer Diameter		
				Lower Spec Limit (mm)	Upper Spec Limit (mm)	
ZHPCG-35-1.5-#	0.26	1.55	13.7	4.40	4.70	37.9
ZHPCG-35-2.5-#	0.26	1.97	8.21	4.87	5.27	52.9
ZHPCG-35-4.0-#	0.31	2.56	5.09	5.41	5.91	72.7
ZHPCG-35-6.0-#	0.31	3.05	3.39	5.90	6.40	96.7
ZHPCG-35-10.0-#	0.41	4.05	1.95	7.03	7.63	141
ZHPCG-35-16.0-#	0.41	5.20	1.24	8.43	9.23	214
ZHPCG-35-25.0-#	0.41	7.00	0.795	10.00	11.0	316
ZHPCG-35-35.0-#	0.41	7.75	0.565	11.20	12.30	425
ZHPCG-35-50.0-#	0.41	9.2	0.393	12.90	14.10	582
ZHPCG-35-70.0-#	0.51	11.5	0.277	14.80	16.30	802
ZHPCG-35-95.0-#	0.51	13.0	0.210	17.30	18.60	1051
ZHPCG-35-120.0-#	0.51	14.8	0.164	19.10	20.50	1308
ZHPCG-35-150.0-#	0.51	16.7	0.132	20.80	22.30	1601
ZHPCG-35-185.0-#	0.51	18.7	0.108	22.70	24.20	1966
ZHPCG-35-240.0-#	0.51	21.9	0.0817	26.60	28.20	2542
ZHPCG-35-300.0-#	0.51	26.9	0.0654	31.70	33.60	3568
ZHPCG-35-400.0-#	0.51	31.0	0.0495	36.10	38.10	4652

Zerohal® is a registered trademark of TE Connectivity

## 1800/3300V Zero Halogen Power Cable using IEC60228 Class 6 Conductors

The full requirements for procuring Power Cables are included in this document.



- 1. Conductor - Flexible tin plated copper special Class 6 to IEC 60228
- 2. Insulation - Flexible Polyolefin containing no added Halogens
- 3. Outer Jacket - Black Zerohal®

Part Description	Conductor		Finished Wire			Maximum Weight (kg/km)
	Maximum Diameter of Stranding (mm)	Diameter (mm)	Max Resist @20 °C (Ohms/km)	Outer Diameter		
				Lower Spec Limit (mm)	Upper Spec Limit (mm)	
ZHPCG-36-1.5-#	0.16	1.68	12.80	3.20	4.91	42.1
ZHPCG-36-2.5-#	0.16	2.60	7.76	5.43	5.99	63.2
ZHPCG-36-4.0-#	0.16	3.00	4.76	5.80	6.41	84.0
ZHPCG-36-6.0-#	0.21	3.80	3.23	6.57	7.25	111
ZHPCG-36-10.0-#	0.21	4.87	1.88	7.69	8.47	169
ZHPCG-36-16.0-#	0.21	5.80	1.19	8.76	9.66	248
ZHPCG-36-25.0-#	0.21	7.70	0.780	10.67	11.76	363
ZHPCG-36-35.0-#	0.21	9.00	0.550	12.00	13.23	495
ZHPCG-36-50.0-#	0.31	10.70	0.393	13.71	15.12	666
ZHPCG-36-70.0-#	0.31	12.60	0.270	15.70	17.30	916
ZHPCG-36-95.0-#	0.31	14.80	0.200	18.29	20.16	1227
ZHPCG-36-120.0-#	0.31	17.10	0.160	20.48	22.58	1539
ZHPCG-36-150.0-#	0.31	18.30	0.132	21.28	23.48	1839
ZHPCG-36-185.0-#	0.31	20.90	0.108	23.52	25.93	2229
ZHPCG-36-240.0-#	0.41	23.50	0.081	27.33	30.14	2905
ZHPCG-36-300.0-#	0.41	26.00	0.060	30.10	33.18	3595

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## Product Properties and Requirements (See TE WSD 1265)

Cl.	Property	Requirements and relevant conditions				Test basis	Type	
10	GENERAL PROPERTIES							
10.1	Dimensions	As Specification Control Drawing				IEC 60811-203	L	
10.2	Concentricity	70% minimum				IEC 60811-201 & 202	L	
10.3	Weight per Unit Length	As Specification Control Drawing				(See TE WSD 1265)	L	
10.4	Colour	Black - Other colours on request				By inspection	L	
10.5	Workmanship	Insulation free of cracks, splits, irregularities or foreign material				By inspection	L	
10.6	Jacket Wrinkling	Insulation free of wrinkles or creases when flexed				(See TE WSD 1265)	L	
11	PHYSICAL PROPERTIES							
11.1	Insulation Tensile Strength & Ultimate Elongation	Tensile Strength 8 MPa minimum, Elongation ≥125%				IEC 60811-501	L	
11.2	Scrape Abrasion Resistance	Cable (mm²)	Load (N)	Minimum cycles at 20°C	Minimum cycles at 90°C	EN 50305	Q	
		1 – 6	10	250	20			
		10 – 25	15	350	150			
		35 – 95	20	500	400			
		120 – 400	25	650	550			
11.3	Dynamic Cut-through	Cable (mm²)	Minimum force at 20°C (N)		Minimum force at 90°C (N)		EN 50305	Q
		1 – 6	120		24			
		10 – 25	200		40			
		35 – 95	500		100			
		120 – 400	700		140			
11.4	Notch Propagation	No dielectric breakdown				EN 50305	Q	



Cl.	Property	Requirements and relevant conditions				Test basis	Type
12	THERMAL PROPERTIES						
12.1	Thermal Endurance	20,000 hours @ 105°C minimum				EN 50305	Q
12.2	Accelerated Aging	No cracks, flowing or dielectric breakdown				IEC 60811-401	Q
12.3	Cold Bend	No cracking or breakdown				IEC 60811-504	Q
12.4	Shrinkage	Change in length shall be no more than 1%				IEC 60811-502	L
12.5	Blocking	Cores to be separated without transfer of insulation				ENG-SYS-825-905	Q
13	ELECTRICAL PROPERTIES						
13.1	Conductor Resistance	See individual Specification Control Drawing				EN 50305	L
13.2	Dielectric Strength AC Voltage Test	No dielectric breakdown between conductor and water				EN 50305	Q
		Cable voltage rating		Min breakdown voltage			
		750V 1800V		3.0kV for 5 min 6.0kV for 5 min			
13.3	Breakdown Voltage	Cable voltage rating		Min breakdown voltage		EN 50305	Q
		750V 1800V		8kV 15kV			
13.4	Insulation Resistance K Factor	Temp (°C)	20	60	90	EN 50305	Q
		K (MΩ.km)	500	10	5		
13.5	Temperature Insulation Stability	No dielectric breakdown				EN 50305	Q
		Cable voltage rating		Voltage			
		750V 1800V		1.5kV DC 3.0kV DC			
13.6	Surface Leakage Current	Less than 1 mA				EN 50305	Q
13.7	Insulation Continuity Proof Test	No dielectric breakdown				BS 5099	100%
14	ENVIRONMENTAL PROPERTIES						
14.1	Fluid Immersion	No cracking, delamination or breakdown in voltage test					Q
		Fluid (temp/time)	% TS ret min	% Eb ret min	% Thickness swell maximum		
		Diesel (70°C/168h)	60	60	20	IEC 60811-404 IEC 60811-501	
		Diesel (20°C/168h)	70	60	10		
		IRM 902 (100°C/24h)	70	70	10		
		Silicone oil (100°C/24h)	70	70	10		
14.2	Ozone Resistance	No cracks, crazing or breakdown				EN 50305	Q
14.3	U.V. Stability	No cracking on 5 X mandrel. No breakdown following voltage test				ASTM G154	Q
14.4	Hydrolytic Stability	No damage on 5 X mandrel. No bend or breakdown when cooled				ENG-SYS-825-905	Q
14.5	Water Absorption	4% max				IEC 60811-402	Q
14.6	Salt Resistance	Tensile strength retention 85% minimum				ASTM B117 and IEC 60811-501	Q
15	FIRE HAZARD PROPERTIES						
15.1	Flammability - small scale	Lower edge of top support to inset of charring >50mm Lower edge of top support to lower limit of charring ≤540mm				IEC 60332-1-2	Q
15.2	Flammability - large scale	≤2.5m				EN 50305	Q
15.3	Smoke - large scale	75% minimum transmittance				IEC 61034-2	Q
15.4	Acid Gas Emission	pH greater than 4. Conductivity less than 10 µS/mm				EN 50267-2-2	Q
15.5	Toxicity Index	ITC less than 5				EN 50305	Q
15.6	Halogen Content	Less than 0.2% Cl + Br + I. Less than 0.1%F (Wet chemical analysis)				EN 60684-2	Q

### 3. CUSTOM MULTI-CORE RAIL CABLES

Selecting the correct combinations of signal, power and control cables to meet unique system requirements can be a huge challenge for cable system designers - when also working within the space budget available, and aiming to satisfy Rail industry specifications.

Typically cable specifications are written around a narrow range of designs with specific functionality, loosely classified as signal, power and data. Numerous specifications have been written governing these types of cables, and in order to meet those specifications, the designer is driven into choosing from a limited catalogue of parts listed in the applicable specifications. As a result, multiple cable constructions are chosen in combination, in order to meet the total system requirement.

Cable failure normally leads to systems failure which can be catastrophic. So choosing the correct cable for the environment, to ensure correct fit form and function, is essential. Parameters such as temperature rating, fluid resistance, mechanical strength, ease of use and installation all need to be carefully considered. EMC problems are difficult to detect and often happen at intermittent intervals. Abnormal operation of devices is often the result of incorrect or poor shielding of multi-core cables.

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#### Multi-core Cables from TE Connectivity

The optimum answer is a custom-designed multi-core cable which can support signal, power and data. This means that a single cable can often support all the needs of the system in one hybrid design, which makes multiple functions possible in one cable. Multi-core cables, when offered with a wide range of well proven insulation, shielding and jacketing materials, allow the cable design to be optimised to provide the best solution for the application.

The use of multi-core cables reduces weight, volume and handling complexity of the cabling - and these savings lead to easier terminating, tie down and maintenance of the cable in the available space, whilst also providing greater choice in routings and system functionality. Multi-core cables can also provide internal shielding between sensitive signal lines and noisy power lines, to allow both functions to operate successfully within the same cable.



#### Key Features

- Small size, lightweight
- Available using Low Fire Hazard materials
- Custom designed to application requirements
- Meets the requirements of EN45545 when using 100G components and zero halogen jackets
- Greater flexibility in the choice of routings
- Mixed sizes, component types and functionality
- Excellent handling and flexibility
- Optional internal and external shielding
- Segregation of cabling
- Easier to install and maintain
- Wide range of temperatures from -55°C up to 200°C
- Wide range of jacket materials to suit application requirements
- Zero Halogen constructions can be jacketed or screened and jacketed

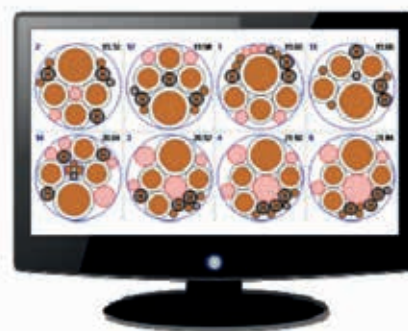
## Bespoke Cable Design

The usual turnaround to create a new bespoke cable design is less than 48 hours, with new designs always using existing inventory and standard constructions where practical. Coupled with our investment into extensive component stock and raw materials, this ensures that costs are kept down and lead times are kept as short as possible.

TE Connectivity's cable design system produces a scale drawing of the cross section of the cable with weights and dimensions - as well as various options for packing the cable bundle together. It will also identify the optimum layout to minimise size and weight.

Our computer aided design system then maps the capabilities of the wire and cable factory, to ensure that we have the process routes in place to handle subsequent demands for a specific bespoke cable.

### CAMCADS



## Part Numbering System for Multi-core Cable

The entire cable description is important. To clearly specify the cable design, always use the complete description when referring to these cables.

### **EPD- 123456 - A**

Revision letter - only one revision can be live  
Full description - defines component types, colours/ marks and quantity, screen type, jacket type and colour, cable dimensions and specifications

Sequential number - cannot be used to decipher the cable construction

Engineering product design

### About TE Connectivity

TE Connectivity (NYSE: TEL) is a \$14 billion global technology leader. Our connectivity and sensor solutions are essential in today's increasingly connected world. We collaborate with engineers to transform their concepts into creations – redefining what's possible using intelligent, efficient and high-performing TE products and solutions proven in harsh environments. Our 80,000 people, including 7,500 design engineers, partner with customers in over 150 countries across a wide range of industries. We believe EVERY CONNECTION COUNTS - **te.com**.

### About TTI, Inc.

TTI, Inc., a Berkshire Hathaway company, is the world's leading specialist distributor of passive, connector, electromechanical and discrete components. TTI's philosophy is "Lead by Design", and the company differentiates itself by focusing on people, parts and process. TTI in Europe strives to be the distributor of choice for customers and suppliers alike by introducing new product technologies and by stocking broad and deep inventory across its franchise base. TTI's sophisticated inventory management system ensures the ability to service changes in demand due to fluctuating markets and supply chains. For more information about TTI, please visit: **ttieurope.com**.

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