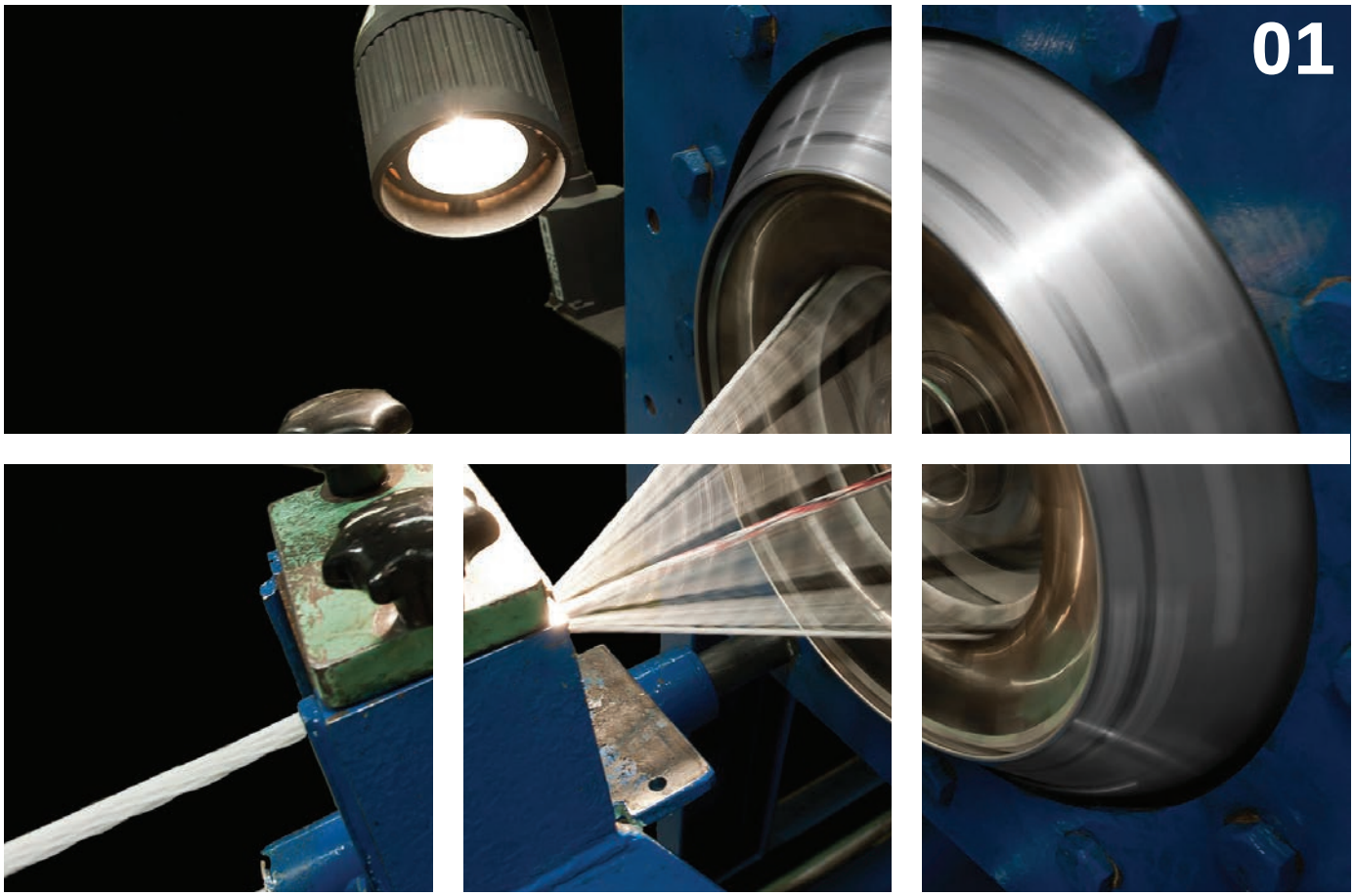
Habia Cable



CustomDesign

Specialist, high performance cables

Custom Design

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Introduction

Habia Cable has built an enviable reputation for the design and manufacture of high performance, custom-designed cables. Elements may include signal, power, coaxial, pneumatics, strain-relief, thermocouples and even fibre optics. Any number of pairs, triples etc. can be individually and / or overall screened to meet specific electrical requirements. A wide range of insulation and sheathing materials gives us the flexibility to offer for even the most demanding customer applications.

Contact us...

Register your enquiry via the Internet at www.habia.com, by e-mail, telephone or fax (contact details for your nearest sales office can be found on the back cover of this document).

What we need from you...

All you need to provide is a little information. As well as who you are we will need to know roughly what environment the cable will be used in and how it will be expected to perform. You tell us the number and size of cores you need, together with any specific electrical performance and / or screening requirements you may have and our designers and sales engineers will do the rest.

How do we design your cable...

Every designer in Habia Cable has instant access to an archive comprising thousands of current and historical designs. Regular training and a network of contacts throughout the industry ensures that Habia Cable is always at the leading edge of custom design electrical wire and cable. Our designers work in close liaison with you as the customer, our sales and production facilities and R&D. The demands that will be placed on the cable are balanced with the physical considerations of production in order to provide you with the optimum solution in performance and price. The entire process is contained within our ISO 9001 quality system ensuring that everything runs smoothly from order to delivery.

What we will provide to you...

If your demands cannot be met from our wide range of semi-standard items (details of which can be found on the website and in our printed literature) then a customer specific technical drawing will be raised. This document provides details of the cable's in-going components, the mechanical and electrical performance of the cable and a cross-sectional drawing of the proposed design. If the situation should change, modifications can be quickly and easily accommodated at all stages of the design process. Your quotation (e-mail or faxed to suit you) will detail the quantities (which can be as low as 200m) and cost of the cable, along with drawings of the design and a copy of our terms and conditions.

Helpful information Checklist of information

Questions...

Where will the cable be used?

How will the cable be used?

How soon do you require it?

Required information

Although we appreciate that many cable projects are a work-in-progress, and not all information is necessarily available at the enquiry stage, the following checklist gives an indication of what information will help Habia Cable to design the best possible cable at the best possible price for our customers.

Requirements	
commercial / delivery	
Expected delivery	How much cable do you require for this order?
Expected per year	Will you require the cable again? Prices can often be reduced for volumes if more cable will be required.
Unbroken lengths	Cable will be supplied in 'unspecified random lengths' unless otherwise requested.
Multiples	Do you require several pieces of a certain length?
Lengths per spool	Many customers prefer to have only one length per spool, but there is a cost for this.
construction	
Number of cores	How many cores do you require to transmit your signal / power?
Conductor size	Is there a particular conductor size? Perhaps specified by the pins in the connector or the current rating.
Insulation	Is there a particular material that has been specified for your application?
Individual shields	Do you require different elements of the cable to be electrically or mechanically shielded from one another?
Individual sheaths	Do individual shields need to be isolated from one another or can they be in contact?
Overall shields	Does the cable need to be electrically or mechanically shielded from external interference?
Overall sheaths	Does the cable require an overall sheath?
Sheath material	Is there a particular material that has been specified for your application?
Identification method	Standard options are full colour coding (depending on the number of cores), numbering or mark and trace.
Outer diameter	Are there size constraints on the cable, for example, the diameter imposed by the connector?
Smooth and round design	This is particularly necessary for mating moulded connectors to a sheath.
Colour and marking	Black is the standard colour unless otherwise specified. Cables will be marked with Habia's standard.
Any other special requirements	Do you require any other elements in the cable: tubes? strain relief?
application / environment	
Temperature	What is the temperature range over which the cable must operate and/or be stored?
Halogen content	An important consideration if your cable is to be installed in enclosed areas where people are present.
Flame retardancy	An important consideration if your cable is likely to be exposed to fire (and flame spread is an issue).
Radiation resistance	Habia Cable typically use 'Total Integrated Dose (TID)' or 'per hour' values in either Gray (Gy) or Rad.
Chemical resistance	Will the cable be exposed to any oils, fuels or other chemicals that may degrade some plastics?
Water resistance	Will the cable be immersed in water? Can the cable be flooded, or is water-blocking required?
Dynamic or static	Will the cable be flexed once to be installed in a static application, or will it be constantly flexing?
Minimum Bending Radius (MBR)	Unless otherwise required and specified, Habia will offer 10x the OD for static use and 20x the OD dynamic.
electrical	
DC resistance	Expressed in Ohms/km, this is a function of conductor size, a larger conductor offers less resistance.
Current rating	Expressed in Amps, this is determined by the conductor size, insulation thickness and temperature rating.
Voltage rating	Expressed in Volts, this is a function on the insulation material and thickness.
Capacitance (coaxes / data cables)	Expressed in nF/km or pF/m, this is the amount of electrostatic energy stored in a coaxial.
Impedance (coaxes / data cables)	Expressed in Ohms, this is the ratio of voltage to current. (Impedance and Capacitance are linked properties and as such one can be calculated from the other)
Attenuation (coaxes / data cables)	Expressed in dB/100m at a specified frequency, this is the loss of power over the length of a coaxial.
Frequency range (coaxes / data cables)	Expressed in MHz or GHz, this is the frequency range over which the signal or power is transmitted.

Helpful information Guide to Habia descriptions

Additives...

With many possible combinations of sizes, materials and components, Habia Cable has developed an identification system of code letters and numbers to quickly and easily help us identify your cable.

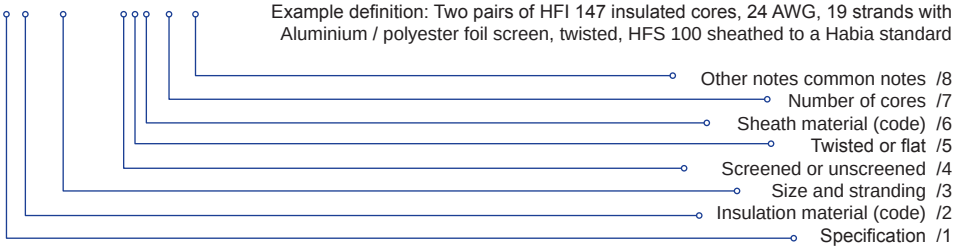
Composite cables with many elements can't always use this description method.

For composites, we use a simplifed format: normally describing the insulation and sheath material, and the number of overall cores: (e.g. ETFE / HFS 100 - 2x2 + RG 179)

Description format

1-2 3333 - 456-7 (8) *Example: H-RN 2419 - STI 2x2 (Al/Pr)*

Example definition: Two pairs of HFI 147 insulated cores, 24 AWG, 19 strands with Aluminium / polyester foil screen, twisted, HFS 100 sheathed to a Habia standard



Identifier			Meaning			
	Example	Option / Example	Definition		Notes	
1	Specification	(no letter)	NEMA	French norm.		
		B	British Standard			
		D	Defence Standard			
		H	Habia Internal Standard	VG spec.		
		M	Mil Spec.		In general accordance only (Habia are not QPL listed)	
2 and 6	Insulation / sheath material	A	PFA		Insulation	Sheath
		B	HFI 150		Insulation	Sheath
		C	HFS 105 XL			Sheath
		D	HFI 140		Insulation	
		E	PTFE		Insulation	Sheath
		F	LSI 155		Insulation	Sheath
		G	MPR 105		Insulation	Sheath
		H	TWI 205		Insulation	Sheath
		I	HFS 100	TPU 90		Sheath
		K	FEP		Insulation	Sheath
		M	HFI 260		Insulation	
		N	HFI 120		Insulation	
		P	HFI 90		Insulation	
		Q	HFS 105 XL B			Sheath
		R	TPS 130		Insulation	
		RN	HFI 147		Insulation	
		Si	HFR 150		Insulation	Sheath
		U	HFS 110 XL			Sheath
		V	PVC			Sheath
		W	HFS 80	HFS 80 T		Sheath
		XC	HFI 121 XL		Insulation	Sheath
		XU	HFI 110 XL		Insulation	
		Y	TPS 125 XL			Sheath
		Z	ETFE		Insulation	Sheath
3	Conductor size / stranding	3001	AWG size / Stranding	1 strand of 0,25mm	Solid AWG conductor (example is 30 AWG)	
		2807	AWG size / Stranding	7 strands of 0,13mm	Stranded AWG conductor (example is 28 AWG)	
		8133	AWG size / Stranding	133 strands of 0,29mm	Large AWG conductor (example is 8 AWG)	
		1000	AWG size	1045 strands of 0,26mm	Extra large AWG conductor (example is 1/0 AWG)	
		0,5	Metric size (class 5)	16 strands of 0,20mm	Metric, standard conductor (example is 0,5mm^2)	
		35	Metric size (class 6)	1110 strands of 0,20mm	Metric, high strand (example is 35mm^2) - see section 8	
4	Shield type		Unscreened			
		S	Screened		Braid as standard - see section 8	
		SS	Double screened		Braid as standard - see section 8	
5	Cabling	(no letter) or F	Flat cable		'F' is rarely used, usually code for this is usually a blank	
		T	Twisted cable		Some screened single cores also sometimes use 'T'	
7	Number of cores	2	2 Cores			
		3x2	3 Pairs			
		4x3	4 Triples			
		5x4	5 Quads			
8	Other common notations	(Al/Pr)	Aluminium / Polyester		At least one screen is a foil, usually with a drain wire	
		(Arm)	Armour		Usually refers to a Stainless Steel (St St) braid	
		(Aramide)	Aramide strain relief		Usually refers to a braid, can also mean a central core	
		(Class 6)	Conductor stranding		The conductor used within the cable is highly stranded	
		Superscreened	Braid / foil / braid combination		Screened for both electrical and magnetic interference	

Specifications National and international standards

Additives...

Habia Cable is constantly striving to extend its range of approvals and approved items.

Habia uses a range of criteria to determine if new approvals can be included.
It is always worth enquriring if you require an approval that isn't listed on these pages.

Approvals

As a global company, Habia Cable is frequently asked to supply to a wide variety of international as well as national standards and specifications.

With so many different types in circulation, we have selected and qualified a number of our wires, cables and coaxial cables.

Many more standards exist where Habia Cable can produce a non-qualified, but fully compliant product, or where no third party approval is required by the standard.

It is often possible to take many of these approved standards and incorporate them into custom-designed multicore cables. Habia Cable will usually offer these cables as being "generally in accordance with the specification" and will detail what devaitions have been made.

Standard		Type		Materials	Voltage	Temperature	Status
British Standard	BS 3G 210 Type A	B-ET	Wire	PTFE	300	190°C	Y
	BS 3G 210 Type B	B-E			600	190°C	Y
	BS 3G 210 Type C	B-EE			1000	190°C	Y
French Norm.	NF C 93-523	KZ 04	Wire	PTFE	250	200°C	N
		KZ 05	Wire	PTFE	600	200°C	
		KZ 06	Wire	PTFE	1000	200°C	
		KZ 07	Wire	PTFE	250	260°C	
		KZ 08	Wire	PTFE	600	260°C	
		KZ 09	Wire	PTFE	1000	260°C	
		KZ 54	Shield Wire	PTFE	250	200°C	
		KZ 55	Shield, Jacketed Wire	PTFE / FEP	250	200°C	
		KZ 56	Shield Wire	PTFE	600	200°C	
		KZ 57	Shield, Jacketed Wire	PTFE / FEP	600	200°C	
		KZ 58	Shield Wire	PTFE	1000	200°C	
		KZ 59	Shield, Jacketed Wire	PTFE / FEP	1000	200°C	
		KZ 66	Shield Twisted Pair	PTFE / FEP	250	200°C	
		KZ 67	Shield, Jacketed Twisted Pair	PTFE / FEP	250	200°C	
		KZ 68	Shield Twisted Pair	PTFE / FEP	600	200°C	
		KZ 69	Shield, Jacketed Twisted Pair	PTFE / FEP	600	200°C	
		KZ 70	Shield Twisted Pair	PTFE	1000	200°C	
		KZ 71	Shield, Jacketed Twisted Pair	PTFE / FEP	1000	200°C	
		KZ 78	Shield, Twisted Triple	PTFE / FEP	250	200°C	
		KZ 79	Shield, Jacketed Twisted Triple	PTFE / FEP	250	200°C	
		KZ 80	Shield Twisted Triple	PTFE / FEP	600	200°C	
		KZ 81	Shield, Jacketed Twisted Triple	PTFE / FEP	600	200°C	
		KZ 82	Shield, Twisted Triple	PTFE	1000	200°C	
		KZ 83	Shield, Jacketed Twisted Triple	PTFE / FEP	1000	200°C	
	NF C 93-524	KU 01	Wire	ETFE	600	150°C	N
		KU 02	Shield, Jacketed Wir	ETFE / ETFE	600	150°C	
		KU 03	Twisted Pair	ETFE	600	150°C	
		KU 04	Twisted Triple	ETFE	600	150°C	
		KU 05	Shield, Jacketed Twisted Pair	ETFE / ETFE	600	150°C	
		KU 06	Shield, Jacketed Twisted Triple	ETFE / ETFE	600	150°C	
Mil Spec.	MIL-C-17...	Various	RG Coaxial Cable	PTFE / FEP	Various	Various	G
	MIL-C-17/176-00002	700024756	Twinax 1553 Databus Cable	PTFE / PTFE	750	200°C	
	MIL-W-16878/4	M-E	Wire	PTFE	600	200°C	
	MIL-W-16878/5	M-EE			1000	200°C	
	MIL-W-16878/6	M-ET			250	200°C	
	MIL-W-16878/11	M-K		FEP	600	200°C	
	MIL-W-16878/12	M-KK			1000	200°C	
	MIL-W-16878/13	M-KT			250	200°C	
	MIL-W-16878/20	M-RET		Wrapped PTFE	250	200°C	
	MIL-W-16878/21	M-RE			600	200°C	
	MIL-W-16878/22	M-REE			1000	200°C	
	MIL-W-16878/23	M-ET...NPC		PTFE	250	260°C	
	MIL-W-16878/24	M-RET...NPC		Wrapped PTFE	250	260°C	
	MIL-W-16878/25	M-E...NPC		PTFE	600	260°C	
	MIL-W-16878/26	M-RE...NPC		Wrapped PTFE	600	260°C	
	MIL-W-16878/27	M-EE...NPC		PTFE	1000	260°C	
	MIL-W-16878/28	M-REE...NPC		Wrapped PTFE	1000	260°C	
	MIL-W-22759/16	M-ZN		ETFE	600	150°C	
	MIL-W-22759/17	M-ZNA		ETFE	600	150°C	
British Standard	BS 3G 210 Type A	B-ET	Wire	PTFE	300	190°C	Y
	BS 3G 210 Type B	B-E			600	190°C	Y
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Standard		Type		Materials	Voltage	Temperature	Status
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		KZ 08	Wire	PTFE	600	260ºC	
		KZ 09	Wire	PTFE	1000	260ºC	
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		KZ 81	Shield, Jacketed Twisted Triple	PTFE / FEP	600	200ºC	
		KZ 82	Shield, Twisted Triple	PTFE	1000	200ºC	
		KZ 83	Shield, Jacketed Twisted Triple	PTFE / FEP	1000	200ºC	
	NF C 93-524	KU 01	Wire	ETFE	600	150ºC	N
		KU 02	Shield, Jacketed Wir	ETFE / ETFE	600	150ºC	
		KU 03	Twisted Pair	ETFE	600	150ºC	
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		KU 05	Shield, Jacketed Twisted Pair	ETFE / ETFE	600	150ºC	
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	MIL-W-16878/11	M-K		FEP	600	200ºC	
	MIL-W-16878/12	M-KK			1000	200ºC	
	MIL-W-16878/13	M-KT			250	200ºC	
	MIL-W-16878/20	M-RET		Wrapped PTFE	250	200ºC	
	MIL-W-16878/21	M-RE			600	200ºC	
	MIL-W-16878/22	M-REE			1000	200ºC	
	MIL-W-16878/23	M-ET...NPC		PTFE	250	260ºC	
	MIL-W-16878/24	M-RET...NPC		Wrapped PTFE	250	260ºC	
	MIL-W-16878/25	M-E...NPC		PTFE	600	260ºC	
	MIL-W-16878/26	M-RE...NPC		Wrapped PTFE	600	260ºC	
	MIL-W-16878/27	M-EE...NPC		PTFE	1000	260ºC	
	MIL-W-16878/28	M-REE...NPC		Wrapped PTFE	1000	260ºC	
	MIL-W-22759/16	M-ZN		ETFE	600	150ºC	
	MIL-W-22759/17	M-ZNA		ETFE	600	150ºC	

Additives...

Up-dated copies of Habia's IS0 9001 and ISO 14001 certificates are available on our website along with statements regarding REACH and RoHS compliance.
Please see: www.habia.com.

Background

The accelerated development of society over recent years has seen many benefits to humankind, however this has resulted in some negative effects on the global environment.

Habia has commissioned a new purification installation for hydrocarbonds. This new facility is the most efficient in the market, providing better than 99.5% purification.

Efforts in waste management have also been pursued; and as a result of these efforts, Habia's facility in Söderfors is now completely deposit free, which means that all waste is recycled.

ISO 9001, ISO 14001, REACH and RoHS

For many years Habia Cable has worked to develop a reputation for producing high quality products. This approach to quality extends to every aspect of Habia's business and is reflected in our ISO certifications.

ISO 9001:2008

Major efforts are directed towards the total process orientation of the company's operations. Among the results of these efforts are that the production units in Sweden, Germany, China and Poland have been certified according to the new ISO 9001:2008 standard. Full product traceability can be provided to a level requested by the customer.

Unless otherwise requested, all orders will have Habia's C order status whereby a sample from production and the order paperwork will be kept for 1 year this also includes Certificate of Conformity and test reports that have been supplied on request. In addition to this Habia can arrange for a B order status in which additional paper-work from Habia's suppliers will be stored along with the elements from the C order, providing full traceability for 3 years. Finally, Habia can arrange for an A order status. As an A order, samples of all in-going components and compounds will be stored along with a sample of the completed cable and all paperwork for 10 years, again providing full traceability.

ISO 14001

Habia Cable is committed to improve our processes towards environmental sustainable and economic use of resources. This means that we shall:

- Comply or exceed environmental requirements from authorities in an active and preventive way.
- Work with environmental objectives using relevant key-figures to monitor Habia's environmental performance.
- Integrate customers and suppliers to continuously reduce the environmental impact during the life cycle of our products.
- Continuously improve knowledge to a level where environmental issues is a natural part of the daily work.

REACH

Habia Cable Group is aware of EU's regulation 1907/2006, concerning Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and we will continuously work to ensure our compliance within this legislation. Habia is identified as a downstream user as we produce wire and cables and do not manufacture or distribute any chemicals. This means that we are not required to pre-register our products.

There will not be any market for companies that do not comply with REACH and it is therefore of key importance that the pre-registration is performed and according to information from our raw material suppliers they have done the pre-registration and included our area of use in the material safety data sheets. With reference to the updated SVHC list (Substances of Very High Concern) that is dated 13th of January 2010 and published on ECHAs webpage we have established that to the best of our knowledge none of our products contain any of the substances listed. We understand our customers' concern that their products can be delivered without interruption and do our utmost to ensure that is the case. We do not foresee that the REACH directive will endanger our possibility to manufacture and deliver product into the future.

RoHS

Following the directives laid down in July 2006 with regard to hazardous materials and their use in industry, Habia Cable are pleased to confirm that all products* manufactured by the Habia Cable group are fully compliant with the EU Directive 2002/95/EC, RoHS as of the 1st July 2006.
* Exemptions: If specific customers wish to purchase non-RoHS compliant products and they can provide evidence of the necessary exemption, Habia Cable can support these request.

Conductors

Additives...

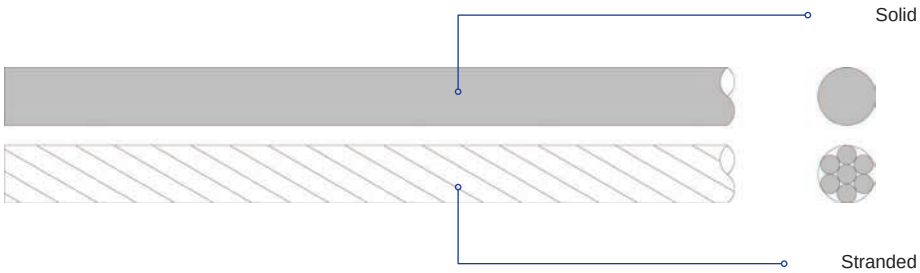
Conductors are sized to meet a given CSA. This means that solid and stranded cores have different diameters even though they are the same size. For example:

- 20 AWG Solid = 0.81mm OD
- 20 AWG 7 Strands = 0.96mm OD
- 20 AWG 19 Strands = 0.97mm OD

There are differences in strand diameters between standards. 26 AWG for example is:

- BS Spec. = 7 x 0,15 = 0.45mm
- Mil Spec. = 7 x 0,16 = 0.48mm

Illustration



General information

The central component of any cable, the conductor is the term for the metallic wire or wires that carry the signal and/or power through the cable.

Metals

There is a wide range of metals that can be used as a conductor, however Copper (Cu) is by far the most common due to its relative low cost and availability. Other common options such as aluminium, steel or tinsel wire (mixed strands of copper and cotton) may offer advantages in strength, weight or flex-life, however they almost always come at the cost of reduced conductivity.
Plated copper such as Tin Plated Copper (TPC), Silver Plated Copper (SPC) and Nickel Plated Copper (NPC) offer additional features such as elevated temperatures and improved conductivity or solderability. Purer conductors such as Oxygen Free High Conductivity (OFHC) plated copper can improve the signal performance, and are often used for audio frequencies, whilst High Strengh Copper Alloy (HSA) conductors can provide a much improved dynamic performance over standard copper conductors.

A variety of other metals and alloys are often used for their unique conducting properties when exposed to heat. Commonly known as Resistance Wires, they are used in Thermocouple cables where combinations of resistance wires can be used to detect variations in temperature. Some of the most commonly used are Nickel- Chromium (NiCr), Copper-Nickel (CuNi) and Iron (Fe).

Strandings

The simplest form of conductor is a single, solid strand, however although this offers the smallest diameter, the purest signal and the largest cross-sectional area, this is also the weakest option and solid conductors are prone to breaking after just a few bending cycles. To improve the durability and flexibility of a conductor it is common to strand multiple wires together, the more wires that are stranded together to make a given size, the more flexible the conductor will be. Metric sizes categorise the number of strands into Classes, the higher the class, the more strands in the conductor:

- Class 1 — Solid, round.
- Class 2 — Stranded conductor, 7 strands (larger sizes will be 19 strands).
- Class 5 — Multi-stranded conductor for flexible ‘general purpose’ installations.
- Class 6 — Extra-multi-stranded conductor for improved flexibility / flex-life.

Sizes

There are many different national and international standards for identifying the size of a conductor, and terminology such as BWG, SWG and Cmils can still be found. However most parties now standardise on either American Wire Gauge (AWG) or Metric (mm^2) which is also referred to as Cross Sectional Area (CSA). It is also quite common to use both of these methods as they indicate subtly different sizes (see Habia’s AWG / Metric conversion table for details). One important note regarding AWG sizes is that the higher the number, the smaller the wire. For example: AWG 2 is a large conductor with a diameter of 8,64mm. AWG 20 by contrast is a small conductor with a diameter of just 0,96mm.

Other factors

The intended use of the cable is the key reason for selecting one type of conductor over another. Whilst the applications are as varied as the custom design cables made to meet them, some examples might include:

- Crimp terminations — Use as few strands as possible and avoid rope-lay or bunched conductors.
- Soldered terminations — Use tin or silver plated copper for best results and avoid nickel plated copper.
- Data/signal use — Use solid, smooth-surfaced conductors and SPC or steel for best results.
- Dynamic use — Use as many strands as possible and high strength copper alloy for best results.
- High temperature use — Use silver plated (+200°C) or nickel plated (+260°C) for best results.

Conductors AWG vs Metric conversion

Additives...

Different platings give different values for conductor resistance. A good example of the differences that can be expected is with AWG 3007:

- TPC = 355 Ohms/km
- SPC = 328 Ohms/km
- NPC = 348 Ohms/km
- HSA = 373 Ohms/km

Cable sizes

Habia Cable's production range runs from the sub-miniature end of the spectrum, where a four core screened cable can be little more than 1mm in diameter, up to single power cores of 400mm².

The information presented here is intended as a rough guideline only. For all sizes, the table reflects Habia Cable's most commonly used stranding (e.g. Class 5 metric conductors) and should not be considered a definitive list.

Weight and conductor resistance values may vary slightly for the different platings that can be offered (see 'useful facts' for more information). It should also be noted that the same conductor may use different strandings depending on the specification to which the end wire is approved (e.g. 24 AWG wire to NEMA HP-3 uses: 19 x 0,127mm compared to BS 3G 210 which uses: 19 x 0,120mm).

Sizes 32 AWG to 36 AWG commonly use High Strength Copper Alloy (HSA) as their size is too small to process safely with weaker materials.

Size		Conductor			Resistance					Weight
AWG	CSA mm²	specification	stranding	nominal diameter	Maximum Ω/km at 20°C TPC	SPC	NPC	HSA	SCCS	nominal g/m
-	400,00	IEC 60228 Cl. 6	3172 x 0,400	30,00	0,0480	-	-	-	-	3550
		IEC 60228 Cl. 5	2013 x 0,500	30,00	0,0495	-	-	-	-	3588
-	300,00	IEC 60228 Cl. 6	2379 x 0,400	26,00	0,0602	-	-	-	-	2660
		IEC 60228 Cl. 5	1525 x 0,500	26,00	0,0654	-	-	-	-	2718
-	240,00	IEC 60226 Cl. 6	1924 x 0,400	23,00	0,0800	-	-	-	-	2152
		IEC 60228 Cl. 5	1221 x 0,500	23,00	0,0817	-	-	-	-	2176
-	185,00	IEC 60228 Cl. 6	2590 x 0,300	20,00	0,105	-	-	-	-	1865
		IEC 60228 Cl. 5	925 x 0,500	20,00	0,108	-	-	-	-	1649
-	150,00	IEC 60228 Cl. 6	2109 x 0,300	18,00	0,132	-	-	-	-	1520
		IEC 60228 Cl. 5	777 x 0,500	18,00	0,132	-	-	-	-	1385
-	120,00	IEC 60228 Cl. 6	1702 x 0,300	16,30	0,164	-	-	-	-	1225
		IEC 60228 Cl. 5	629 x 0,500	16,00	0,164	-	-	-	-	1121
0000	106,80	ASTM B	2109 x 0,254	15,20	0,189	-	-	-	-	1018
-	95,00	IEC 60228 Cl. 6	1330 x 0,300	14,30	0,210	-	-	-	-	960
		IEC 60228 Cl. 5	475 x 0,500	14,30	0,210	-	-	-	-	847
000	-	ASTM B	646 x 0,410	13,70	0,250	-	-	-	-	760
-	70,00	IEC 60228 Cl. 6	988 x 0,300	12,40	0,277	-	-	-	-	720
		IEC 60228 Cl. 5	361 x 0,500	12,40	0,277	-	-	-	-	643
00	68,00	BS 3G 231	1330 x 0,260	11,80	0,290	0,280	-	-	-	654
0	53,00	BS 3G 231	1045 x 0,260	10,50	0,370	0,460	-	-	-	504
-	50,00	IEC 60228 Cl. 6	703 x 0,300	10,30	0,393	-	-	-	-	445
		IEC 60228 Cl. 5	399 x 0,404	10,30	0,393	-	-	-	-	455
-	35,00	IEC 60288 Cl. 6	1110 x 0,200	8,40	0,565	-	-	-	-	312
		IEC 60228 Cl. 5	278 x 0,404	8,40	0,565	-	-	-	-	319
2	34,00	BS 3G 231	665 x 0,260	8,40	0,580	0,560	-	-	-	318
-	25,00	IEC 60228 Cl. 6	779 x 0,200	7,20	0,795	-	-	-	-	218
		IEC 60228 Cl. 5	196 x 0,404	7,20	0,795	-	-	-	-	224
4	22,00	BS 3G 231	133 x 0,460	6,50	0,900	0,870	-	-	-	206
	21,63	ASTM B	133 x 0,455	6,60	0,920	-	-	-	-	192
-	16,00	IEC 60228 Cl. 6	513 x 0,200	5,70	1,240	-	-	-	-	144
		IEC 60228 Cl. 5	126 x 0,404	5,70	1,240	-	-	-	-	144
6	14,00	BS 3G 231	133 x 0,360	5,15	1,430	1,37	-	-	-	127
	13,60	ASTM B	133 x 0,361	5,20	1,37	-	-	-	-	128
-	10,00	IEC 60228 Cl. 5	80 x 0,404	3,93	1,80	-	-	-	-	89,5
8	9,00	BS 3G 231	133 x 0,290	4,10	2,28	2,16	-	-	-	83,0
	8,60	ASTM B	133 x 0,287	4,10	2,29	-	-	-	-	77,7
-	6,00	IEC 60228 Cl. 5	84 x 0,300	2,92	3,120	-	-	-	-	53,0
10	5,00	BS 3G 231	37 x 0,400	2,77	4,20	4,00	-	-	-	44,0
	4,74	ASTM B	37 x 0,404	2,85	4,13	-	-	-	-	43,5
-	4,00	IEC 60228 Cl. 5	56 x 0,300	2,48	4,670	-	-	-	-	36,0
12	3,09	ASTM B	19 x 0,455	2,150	6,299	5,938	-	-	-	27,67
	3,00	BS 3G 231	37 x 0,320	2,200	6,800	6,40	-	-	-	27,50
-	2,50	IEC 60228 Cl. 5	50 x 0,254	1,950	7,56	-	-	-	-	21,90
14	2,00	BS 3G 231	37 x 0,250	1,730	10,90	-	-	-	-	17,30
	1,94	ASTM B	19 x 0,361	1,706	10,00	9,416	-	-	-	17,41
-	1,50	IEC 60228 Cl. 5	30 x 0,254	1,500	12,60	-	-	-	-	13,60

Conductors AWG vs Metric conversion

Additives...

As with cross-sectional area, further small differences can be found between different international and national specifications.

Stranded conductors have a resistance of around 3% higher than their equivalent solid conductor size.

The process of twisting cores increases the conductor resistance with values around 5% higher than a straight, insulated conductor.

Standards

Athough this is far from an exhaustive list, Habia Cable manufacture wires and cables using the following wire standards:

- Wires and cables with the prefix: B- and D- use AWG conductors according to BS 3G 231.
- Wires and cables with the prefix: H- use either metric conductors according to IEC 60228 or AWG conductors according to ASTM B.
- Wires and cables with no prefix (according to NEMA) such as 'KT' use AWG conductors according to ASTM B.

Size		Conductor			Resistance					Weight
AWG	CSA mm²	specification	Stranding	nominal diameter	Maximum Ω/km at 20°C					g/m
					TPC	SPC	NPC	HSA	SCCS	
	1,23	ASTM B	19 x 0,287	1,358	15,81	14,89	-	-	-	11,00
16	1,20	BS 3G 231	19 x 0,290	1,360	15,80	14,30	14,60	-	-	12,50
	1,30	ASTM B	1 x 1,290	1,290	13,99	13,45	-	-	-	11,63
-	1,00	IEC 60228 Cl. 5	32 x 0,203	1,200	18,40	-	-	-	-	9,000
	1,00	BS 3G 231	19 x 0,250	1,210	21,10	-	-	-	-	8,900
	0,963	ASTM B	19 x 0,254	1,201	20,40	18,99	-	-	-	8,634
18	0,897	ASTM B	7 x 0,404	1,212	21,45	20,21	-	-	-	8,049
	0,823	ASTM B	1 x 1,024	1,024	22,23	21,38	-	-	-	7,330
-	0,750	IEC 60228 Cl. 5	24 x 0,203	1,050	24,60	-	-	-	-	6,800
19	0,650	ASTM B	1 x 0,912	0,912	28,08	26,94	-	-	-	5,814
	0,615	ASTM B	19 x 0,203	0,961	32,02	29,85	-	-	-	5,512
20	0,600	BS 3G 231	19 x 0,200	0,960	33,20	-	-	-	-	5,700
	0,563	ASTM B	7 x 0,320	0,960	34,12	32,18	-	-	-	5,046
	0,519	ASTM B	1 x 0,813	0,813	35,21	33,90	-	39,9	86,2	4,620
-	0,500	IEC 60228 Cl. 5	16 x 0,203	0,880	36,90	-	-	-	-	4,500
	0,400	BS 3G 231	19 x 0,150	0,710	60,00	-	-	-	-	3,260
22	0,382	ASTM B	19 x 0,160	0,757	52,16	48,55	-	-	-	3,433
	0,354	ASTM B	7 x 0,254	0,762	54,79	51,18	-	-	-	3,188
	0,324	ASTM B	1 x 0,643	0,643	56,62	53,68	-	63,7	138,0	2,890
23	0,283	BS 3G 230	1 x 0,600	0,600	-	-	-	-	-	2,516
	0,241	ASTM B	19 x 0,127	0,600	83,33	77,42	-	-	-	2,159
24	0,220	ASTM B	7 x 0,203	0,609	85,95	80,38	-	-	-	2,033
	0,205	ASTM B	1 x 0,511	0,511	89,35	85,93	-	101,0	218,0	1,825
	0,155	ASTM B	19 x 0,102	0,480	131,5	122,3	-	-	-	1,392
26	0,140	ASTM B	7 x 0,160	0,480	139,7	130,2	-	-	-	1,263
	0,128	ASTM B	1 x 0,404	0,404	146,6	137,3	-	161,0	351,0	1,141
	0,095	ASTM B	19 x 0,079	0,372	222,1	207,0	-	-	-	0,835
28	0,089	ASTM B	7 x 0,127	0,381	223,7	208,7	-	-	-	0,793
	0,080	ASTM B	1 x 0,320	0,320	231,3	218,7	-	257,0	554,0	0,716
30	0,057	ASTM B	7 x 0,102	0,306	354,3	328,1	-	-	802,0	0,511
	0,050	ASTM B	1 x 0,254	0,254	372,7	347,2	-	408,0	884,0	0,451
32	0,035	ASTM B	7 x 0,079	0,237	597,1	557,7	-	-	-	0,307
	0,032	ASTM B	1 x 0,203	0,203	585,3	545,2	-	643,0	1388	0,288
34	0,020	ASTM B	1 x 0,160	0,160	950,2	885,2	-	1040	2254	0,179
36	0,013	ASTM B	1 x 0,127	0,127	1521	1417	-	1670	3609	0,113
38	0,008	ASTM B	1 x 0,102	0,102	2401	2237	-	2610	5697	0,073
40	0,005	ASTM B	1 x 0,079	0,079	4058	3780	-	4410	9628	0,044
42	0,003	ASTM B	1 x 0,064	0,064	6230	5907	-	6950	-	0,029
44	0,002	ASTM B	1 x 0,051	0,051	-	9425	-	11200	-	0,018

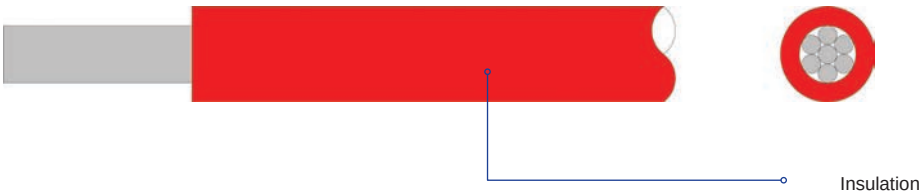
Insulation

Additives...

Regardless of flame barriers or screens, a cable should always be rated to its lowest performing component.

Insulations can be damaged when applying the sheath if the extrusion temperature is too high or if the sheath must be cross-linked and the insulation is not irradiation suitable. This is the reason why PTFE cores cannot be used beneath an irradiated sheath.
Habia takes these risks into account to avoid compromising the finished cable design.

Illustration



General information

Insulation is necessary to provide electrical isolation between the conductor and the earth-plane. The choice of insulation can also have a significant impact on the overall performance of the cable. There is a wide range of materials that can be used for insulation, and some can also be used for sheathing cables, all have their own advantages and limitations. For more information see 'Habia's Over-view of insulation materials'.

Abrasion

Measures the rugged properties of a material. High abrasion resistance is ideal in dynamic cables where cores are required to move in relation to one other, and to any shield as the cable is flexed. LSI 155 has excellent abrasion resistance.

Corrosivity

Under fire conditions, many materials such as FEP, although very good in fire, will release toxic and corrosive gasses once they eventually ignite. Corrosive gasses can damage sensitive equipment such as circuit-boards and consideration to this should be given when installing cable in potentially sensitive areas. HFI 140 is a good example of low corrosivity.

Flammability

The degree to which the insulation will burn and/or spread a fire once ignited. Most materials used by Habia will self-extinguish once the flame source has been removed. With many different national and international fire standards in use, Habia recommends IEC 60331 and IEC 60332 (in applicable parts) as these test the completed cables and are therefore more truly representative of the application. The other test that is commonly requested is flammability to UL 94. This method tests a small sample of the sheath material and does not assess the overall cable. PTFE is one of the best flame retardant insulations.

Flexibility

There are two key aspects to this. Flexibility is the degree to which a cable can bend whilst flex-life is the frequency over which a cable can be flexed without breaking. Some materials may have poor flexibility, but are actually so strong that they can exhibit a very good flex-life. Although not the most flexible by any means, ETFE is ideal as insulation for flexible cables as its combines abrasion resistance and flex-life.

Fuels and oils

Many fluids will actively break-down the chemical bonds of the insulation. This effect is often magnified when the fluids are at temperature (such as an engine-bay). PFA is amongst the best insulation materials for fuel and oil resistance as it is able to operate in fluids at very high temperatures.

Radiation

As with fuels and oils, continued exposure to radiation will break-down plastic. Many different measurement scales exist, however the most common are Rads and Grays. Habia will quote the Total Integrated Dose (TID) in Grays (Gy) unless otherwise specified. HFI 260 is the best example of a highly radiation tolerant insulation.

Smoke

This refers to the level of smoke that is generated by a material under fire conditions. This is of key importance where visibility must not be impeded (for example: the route to an exit). As with flexibility and flex-life there is no link between smoke corrosivity and smoke generation, although FEP is one of the most corrosive materials, it is also one of the best examples of a low smoke-generation insulation.

Water

Where the insulation is concerned, this is the degree to which water can permeate through it, creating an electrical path from conductor to earth (known as arc tracking). ETFE is again one of the best materials for use in water.

Zero halogen

The other side of smoke corrosivity, halogen content refers to the toxic gasses that can be emitted under fire conditions. Halogens can affect health and therefore halogen free cables should be installed in areas of high foot-traffic and/or enclosed spaces. HFI 140 is one of the best examples of a zero halogen insulation material.

Insulation Comparison of insulation materials

Additives...

Please note that in some instances the method of exposure will affect the result. An example is ETFE which demonstrates much more effective in radiation at high dose-rates than it is if the dose-rate is low.

5	Excellent
4	Good
3	Average
2	Below average
1	Poor

Approvals

This table attempts to present a clear comparison of the key strengths and weaknesses of Habia Cable's range of insulation and sheathing materials.

The information presented here is compiled from what are believed to be authoritative sources and/or independent testing of appropriate material samples and knowledge of the relevant compounds.

In some instances Habia Cable have drawn comparisons and offered expectations based on alternative test protocols and their results. As such it is believed that the information provided is accurate and factual as of the date printed, however it should be noted that new testing is constantly being carried out which may result in changes to the published data.

This information is offered solely as a convenience to Habia Cable's customers. Reference should always be made to the original test report wherever possible.

Overview of general properties

material	abrasion resistance	flammability FR	flexibility	fuel & oil resistance	radiation tolerance	smoke corrosivity	smoke generation	water resistance	zero halogen ZH
ETFE	4	4	2	5	10^5 Gy	2	5	5	No
FEP	4	5	2	5	10^4 Gy	1	5	5	No
HFI 90	3	1	3	2	10^6 Gy	5	4	5	Yes
HFI 110 XL	3	3	2	4	10^5 Gy	5	4	4	Yes
HFI 120 *	3	3	3	4	10^5 Gy	4	3	3	Yes
HFI 121 XL	3	3	4	2	10^5 Gy	5	5	4	Yes
HFI 140	5	4	2	5	10^5 Gy	5	5	4	Yes
HFI 147	3	3	3	4	-	4	3	3	Yes
HFI 150	2	4	3	4	>10^6 Gy	4	4	4	Yes
HFI 260	5	4	1	5	>10^7 Gy	5	5	4	Yes
HFR 150	3	3	5	4	10^5 Gy	3	3	3	Yes
LSI 155	4	4	2	5	10^5 Gy	2	5	5	No
MPR 105	2	1	5	3	10^5 Gy	4	1	5	Yes
PFA	4	5	2	5	10^4 Gy	1	5	5	No
PTFE	4	5	2	5	10^3 Gy	1	5	5	No
TPS 125 XL	3	3	4	5	10^5 Gy	2	2	4	No
TPS 130	4	1	3	5	10^5 Gy	4	3	3	Yes
TWI 205	5	4	2	5	10^4 Gy	2	5	1	No

* HFI 120 is no longer available for new designs - please contact one of our sales offices

Insulation De-rating factors

Additives...

High conductor temperatures will also create a high voltage drop.

High conductor temperatures can cause damage to their surroundings.

Temperature increases in a confined space more than is calculated.

Instructions

Refer to the temperature rating of the insulation and the current rating stated on the individual wire datasheet and apply the de-rating factors below to correct for the ambient air temperature and for the number of cores.

Temperature ratings should be calculated based on the lowest material rating (e.g. ETFE cores with an HFS 100 jacket should be calculated at 100°C for the HFS 100 sheath material).

Temperature de-rating factors shown here assume a single wire hanging in free air or laid in an aerated metal tray. Additional de-rating must be made for solid cable-trays, clipped installations or drag-chains.

All de-rating factors stated here assume the insulation to be operating at its maximum permissable temperature (e.g. for an 80°C rated material at 40°C ambient air temperature, the heat generated by the current passing through the conductor will increase the temperature by an additional 40°C to its maximum 80°C rating)

Temperature de-rating

Ambient air temperature	Insulation temperature rating							
	80°C	100°C	125°C	135°C	150°C	180°C	200°C	260°C
0°C	1.52	1.37	1.28	1.24	1.21	1.18	1.15	1.10
10°C	1.40	1.28	1.21	1.19	1.16	1.14	1.11	1.08
20°C	1.28	1.19	1.15	1.13	1.10	1.08	1.07	1.05
30°C	1.14	1.09	1.07	1.06	1.05	1.04	1.03	1.02
40°C (Habia considers this to be nominal ambient air temperature)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50°C	0.82	0.89	0.92	0.93	0.94	0.95	0.96	0.97
60°C	0.65	0.78	0.83	0.86	0.88	0.90	0.92	0.94
70°C	0.42	0.65	0.74	0.79	0.82	0.85	0.88	0.91
80°C	-	0.50	0.65	0.71	0.76	0.81	0.84	0.88
90°C	-	0.40	0.54	0.63	0.69	0.76	0.79	0.85
100°C	-	-	0.42	0.54	0.61	0.71	0.75	0.82
110°C	-	-	0.27	0.44	0.53	0.65	0.70	0.79
120°C	-	-	0.17	0.32	0.45	0.59	0.65	0.75
130°C	-	-	-	0.16	0.35	0.53	0.60	0.72
140°C	-	-	-	-	0.23	0.46	0.54	0.69
150°C	-	-	-	-	-	0.38	0.49	0.65
160°C	-	-	-	-	-	0.30	0.42	0.61
170°C	-	-	-	-	-	0.19	0.36	0.57
180°C	-	-	-	-	-	-	0.28	0.53
190°C	-	-	-	-	-	-	0.18	0.49
200°C	-	-	-	-	-	-	-	0.45
210°C	-	-	-	-	-	-	-	0.40
220°C	-	-	-	-	-	-	-	0.35
230°C	-	-	-	-	-	-	-	0.29
240°C	-	-	-	-	-	-	-	0.23
250°C	-	-	-	-	-	-	-	|-
Examples	HFI 90	HFS 100	HFI 147	HFI 150	ETFE	HFR 150	FEP	PTFE

Multi-core de-rating

	Number of cores												
	2	3	4	6	8	10	12	16	20	24	28	36	40
Factor	1.00	0.88	0.80	0.69	0.62	0.59	0.55	0.51	0.48	0.43	0.41	0.38	0.36

Multi-core installation de-rating

	Installation method											
	Clipped to vertical structure			Clipped to horizontal structure			On solid metal trays			On aerated metal trays		
Number of cores	1	2	3	1	2	3	1	2	3	1	2	3
Without spacing	0.94	0.80	0.76	0.89	0.76	0.57	0.97	0.85	0.74	1.00	0.87	0.74
With spacing	0.94	0.90	0.87	0.89	0.81	0.77	0.97	0.96	0.93	1.00	1.00	1.00

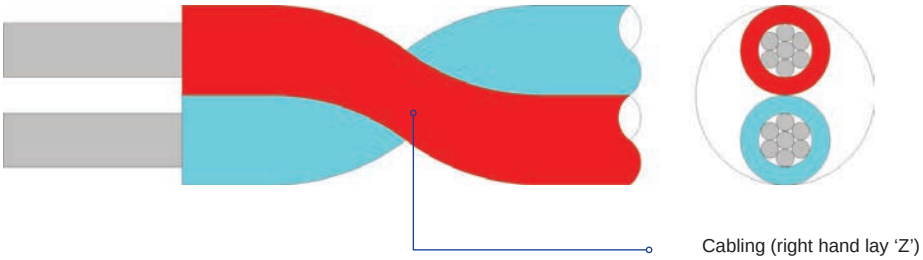
Cabling

Additives...

With the exception of a single core placed in the centre, the length of each core in a multi-core is longer than that of the cable they are contained within as they rotate around one another. Up to 10% should be allowed to compensate for this extra length.

The maximum conductor resistance Habia specifies for cores within a multi-core cable will nominally be 5% higher than that specified in the single core datasheets to account for this extra length within the cable.

Illustration



Cabling (right hand lay 'Z')

General information

Cabling (also known as twisting) is the process where cores are wrapped around one another, enabling the cable to be flexed. Without this rotation the core/s on the inside of the bend would be placed under compression and the core/s on the outside of the bend would be placed under tension, causing deformation of the cable, damage to the other cores in the centre of the cable and also breakages within the connectors.

Many different types of components can be cabled together, however unlike hand-laid constructions it is essential that the diameter of the central layer is large enough to support further layers. For example in an 8 core cable with cores of equal size it is common in hand-building a cable to place a single core in the centre and 7 cores around it. Mathematically it is only possible to place 6 cores around a central core. Machined cables must follow the mathematical model and so an 8 core cable must be made with a filler.

Direction

Most cables will be manufactured with alternating left-hand (S) and right-hand (Z) layers. This is done to make the cable evenly balanced which can prevent it from twisting up in a single direction under dynamic use. Each core will also often have back-twist applied to further prevent this twisting process and to ensure that the cable is as 'dead' as possible. It is most common to have the final layer as a left-hand layer, an example of which is a typical 19 core cable that would have:

- Centre 1x core laid straight.
- First layer 6x cores laid around the centre core with a right-hand lay.
- Second layer 12x cores laid around the first layer with a left-hand lay.

Torsion

The exception to the rule of alternating layers is where the application will require torsion to be applied to the cable (such as coiled/spiral cables). In this instance it is advantageous to have all the elements cabled in a single direction as this will help the cable to return to its original form each time, even when extended and retracted frequently.

Lay-lengths

The lay-length is the distance in mm or inches over which a core travels from it's starting position in a layer, for example: 12 o'clock on a clock face, around the cable and back to its original position at 12 o'clock. A cable with a short lay length will have a more 'springy' flexible feel to it, whilst a cable with a long lay length results in a stiffer cable. However cables with longer lay-lengths can be produced significantly quicker and use less material which provides benefits in both manufacturing time and cost, so there are good reasons for using a long lay-length where flexibility is not critical to the cable design. Habia Cable will nominally use a lay length of between 8x and 16x the cabled diameter, so for flexible cables, a lay-length close to 8x the cabled diameter will be used, whilst normal use cables will be closer to 16x the cabled diameter.

Twists per inch

Lay length is often specified as a given number of twists per inch. This relates to the number of times a core should travel from its starting position at 12 o'clock, around the cable and back again over a given distance. A cable requirement of 3 twists per inch would therefore require the same core to rotate around the cable and return to the 12 o'clock position 3 times over the distance of 1 inch (25.4mm) giving a lay length of approximately 8mm.

Flat cables

Habia Cable also has the capability to lay up to 8 components (depending on size) side by side for inclusion in a flat cable design. Flat cables provide a significant benefit with regard to bend radius if the cable is being flexed in a single direction, as the cable can be made with a noticeably smaller overall dimension and yet still contain several elements. However flat cables are not ideal for applications which require freedom of movement in more than one direction.

Shielding

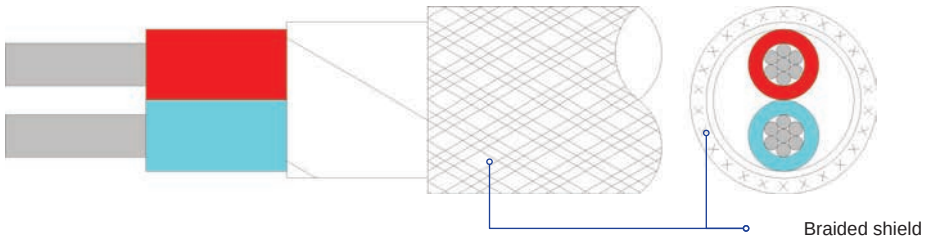
Additives...

Foil screens require a drain wire in order to terminate them into a connector. Drain wires will normally be the same size as the other cores in the cable, and are normally placed in the interstices of the other cores.

Drain wires are not always necessary if the foil is paired up with a braid.

Depending on the cable construction, drain wires can create a lump (known as a 'nose') on the cable. This can be minimised with a pressure-extruded sheath, but is not ideal.

Illustration



General information

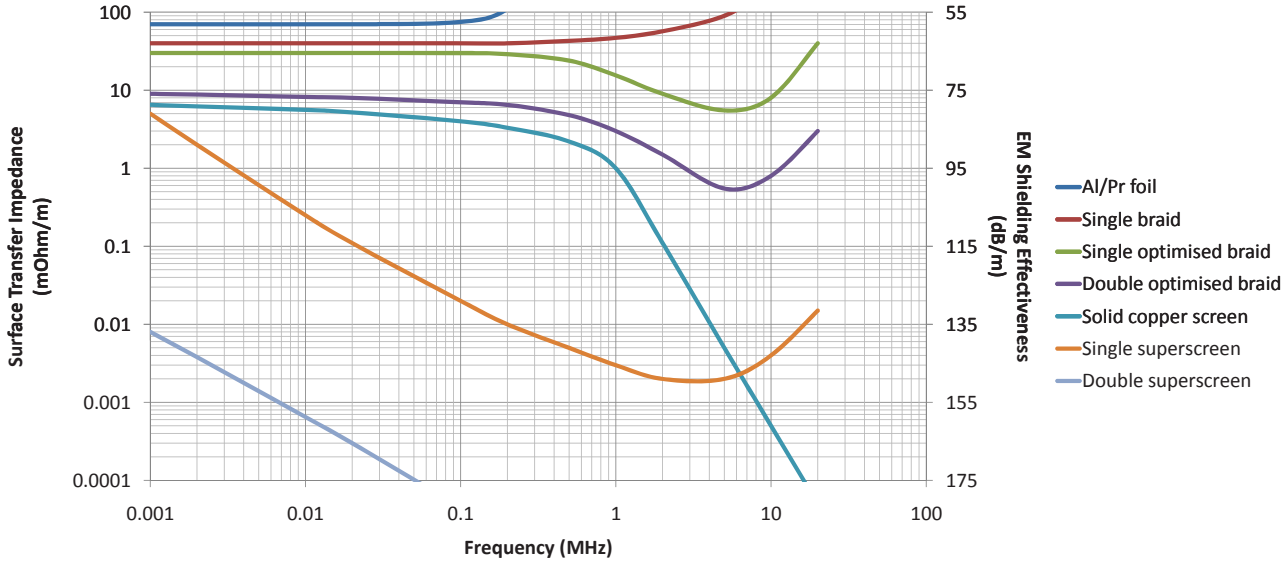
Shielding or screening as it is also known can be applied for mechanical, electrical and magnetic protection.

Electrical

Braided screens of Tin Plated Copper (TPC) wires and Aluminium/Polyester (Al/Pr) foils provide protection from electrical interference either from other sources within the cable (such as power and data cores in the same cable) or from external sources. Braided screens offer a large amount of copper which is beneficial at lower frequencies whilst foil screens offer 100% coverage which is more effective at higher frequencies. A combination of both foil and braid will therefore often provide the best screening over a wide range of frequencies. Manufacturers vary in the coverage they offer as standard on a braided screen, however most screens will be in excess of 70% optical coverage. Habia Cable standardises on a minimum coverage of 85%, although as electrical interference becomes more important, it is increasingly common to specify 'optimised' braided screens which have an optical coverage of >90% and/or two layers of braided screens.

Perfomance

There are two common methods of measuring the performance of an electrical screen. Shielding effectiveness is measured in dB, where the higher the value, the better the screen. The second method (used by Habia) is surface transfer impedance which is measured in mohms/m. In this instance, the lower the value, the better the screen. The performance levels for the different types of screen can be compared in the following graph:



Super-screened

This is the process whereby multiple braided screens and a my-metal foil screen are used in conjunction with one another to provide complete protection. This combination of screen does significantly limit cable flexibility.

Mechanical

There are three commonly used methods of mechanical protection. Stainless steel wire braids are offered by Habia Cable in preference to heavy Galvanised steel as these offer significant crush and cut-through resistance without the bulk of a Galvanised steel wire armour. Aramid braids can also be used where the cable must remain flexible. Aramid also offers significant cut-through resistance, along with excellent tensile strength.

Shielding Harnbraid over-shielding

Additives...

Habia Cable manufactures a range of braids for the electrical screening of wire bundles, for hand-built assembly purposes.

Harnbraid is supplied over a tube former of PE which makes both the storage and subsequent handling more straight-forward.

Harnbraid 90

Available in a range of ten different sizes, with diameters from 3,0mm to 36mm. Standard Harnbraid 90 uses Tin Plated Copper (TPC), although other finishes are available.

Harnbraid 101

Harnbraid 101 posesses a high usable expansion ratio (minimum of 2:1). It is available in a wide range of supplied diameters from 2.5mm to 54.0mm. The standard Harnbraid 101 is Tin Plated Copper (TPC).
Optical coverage is a minimum of 93% and a maximum of 100%.

Harnbraid 103

The standard Harnbraid 103 is nickel plated copper and as such is suitable for higher temperatures. Optical coverage is similar to that of Harnbraid 101 (min 93%) and it is also available in the same wide range of supplied diameters.

Description	Former	Construction				Cable bundle		Order reference
	diameter	number of	number of	individual	min cov.	min tolerance	max tolerance	
	mm	carriers	ends	strand size	%	mm	mm	
Harnbraid 90 -3.0	3.0 - 0.13	16	5	36 / 0.13	90	2.0	3.5	9003
Harnbraid 90 -4.0	4.0 - 0.25	16	7	36 / 0.13	90	3.0	5.0	9004
Harnbraid 90 -5.0	5.0 - 0.25	24	6	36 / 0.13	90	4.0	6.0	9005
Harnbraid 90 -6.0	6.0 - 0.25	24	7	36 / 0.13	90	5.0	8.0	9006
Harnbraid 90 -10.0	10.0 - 0.25	24	9	34 / 0.16	90	7.0	12.0	9010
Harnbraid 90 -12.5	12.5 - 0.25	24	10	34 / 0.16	90	11.0	14.0	9012
Harnbraid 90 -15.0	15.0 - 0.38	24	11	32 / 0.20	90	13.0	18.0	9015
Harnbraid 90 -20.0	20.0 - 0.38	36	7	30 / 0.25	90	17.0	23.0	9020
Harnbraid 90 -25.0	25.0 - 0.38	36	9	30 / 0.25	90	22.0	28.0	9025
Harnbraid 90 -30.0	30.0 - 0.38	36	9	28 / 0.32	90	27.0	40.0	9030

	diameter	number of	number of	individual	min cov.	min tolerance	max tolerance	
	mm	carriers	ends	strand size	%	mm	mm	
Harnbraid 101 -3.0	3.0 - 0.13	16	10	38 / 0.10	93	2.5	5.0	10103
Harnbraid 101 -4.0	4.0 - 0.25	24	7	36 / 0.13	93	3.5	9.0	10104
Harnbraid 101 -6.0	6.0 - 0.25	24	9	36 / 0.13	93	4.5	11.0	10106
Harnbraid 101 -7.5	7.5 - 0.25	24	14	36 / 0.13	93	7.0	16.0	10107
Harnbraid 101 -10.0	10.0 - 0.25	36	12	36 / 0.13	93	8.0	22.0	10110
Harnbraid 101 -12.5	12.5 - 0.25	36	15	36 / 0.13	93	11.0	24.0	10112
Harnbraid 101 -15.0	15.0 - 0.38	36	16	36 / 0.13	93	13.0	28.0	10115
Harnbraid 101 -20.0	20.0 - 0.38	36	16	34 / 0.16	93	16.0	38.0	10120
Harnbraid 101 -25.0	25.0 - 0.38	36	16	32 / 0.20	93	22.0	50.0	10125

	diameter	number of	number of	individual	min cov.	min tolerance	max tolerance	
	mm	carriers	ends	strand size	%	mm	mm	
Harnbraid 103 -3.0	3.0 - 0.13	16	10	38 / 0.10	93	2.5	5.0	10303
Harnbraid 103 -4.0	4.0 - 0.25	24	7	36 / 0.13	93	3.5	9.0	10304
Harnbraid 103 -6.0	6.0 - 0.25	24	9	36 / 0.13	93	4.5	11.0	10306
Harnbraid 103 -7.5	7.5 - 0.25	24	14	36 / 0.13	93	7.0	16.0	10307
Harnbraid 103 -10.0	10.0 - 0.25	36	12	36 / 0.13	93	8.0	22.0	10310
Harnbraid 103 -12.5	12.5 - 0.25	36	15	36 / 0.13	93	11.0	24.0	10312
Harnbraid 103 -15.0	15.0 - 0.38	36	16	36 / 0.13	93	13.0	28.0	10315
Harnbraid 103 -20.0	20.0 - 0.38	36	16	34 / 0.16	93	16.0	38.0	10320
Harnbraid 103 -25.0	25.0 - 0.38	36	16	32 / 0.20	93	22.0	50.0	10325

Sheathing

Additives...

Habia Cable recycles waste material for re-use. For this reason Habia will offer black sheaths wherever possible.

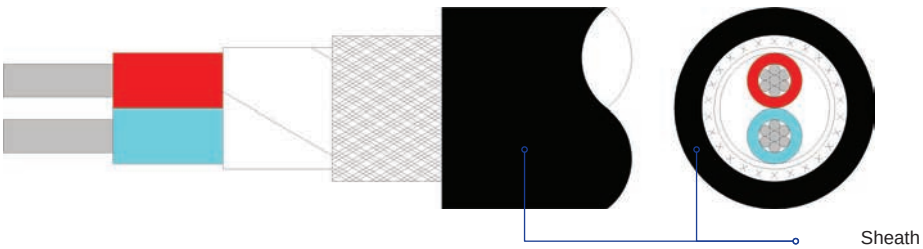
Some materials have a lot of carbon black in them meaning that these materials cannot be coloured and are available only in black.

- TPS 125 XL is one example.

Other flame retardant materials use an additive that is naturally white in colour. These can be made in any colour, but cannot be made either transparent or translucent.

- HFS 100 is one example.

Illustration



General information

Although the sheath (or jacket) offers isolation from the earth-plane for any shielding of the cable, it is primarily used to provide mechanical protection from a wide variety of hazards. There is a wide range of materials that can be used for sheathing cables, all with their own advantages and limitations.

Abrasion

Measures the rugged properties of a material. Typically softer, more flexible sheaths will exhibit a high degree of abrasion loss. HFI 260 when used as a sheath exhibits possibly the best abrasion resistance.

Corrosivity

Under fire conditions, many materials such as FEP, although very good in fire, will release toxic and corrosive gasses once they eventually ignite. Corrosive gasses can damage sensitive equipment such as circuit-boards and consideration to this should be given when installing cable in potentially sensitive areas. HFS 80 is one such example.

Flammability

The degree to which the sheath will burn and/or spread a fire once ignited. Most materials used by Habia will self-extinguish once the flame source has been removed. With many different national and international fire standards in use, Habia recommends IEC 60331 and IEC 60332 (in applicable parts) as these test the completed cables and are therefore more truely representative of the application. The other test that is commonly requested is flammability to UL 94. This method tests a small sample of the sheath material and does not assess the overall cable construction. Some materials can be improved by flame retardant (FR) additives.

Flexibility

There are two key aspects to this. Flexibility is the degree to which a cable can bend; flex-life is the frequency over which a cable can be flexed without breaking. Some materials may have poor flexibility, but are actually so strong that they can exhibit a very good flex-life. MPR 105 is an example of both good flexibility and flex-life.

Fuels and oils

Many fluids will actively break-down the chemical bonds of the sheath. An effect magnified when the fluids are at temperature (such as an engine-bay). Cross-linked materials such as TPS 125 XL are particularly good at resisting damage from chemicals.

Radiation

As with fuels and oils, continued exposure to radiation will break-down plastic. Many different measurement scales exist, however the most common are Rads and Grays. Habia will quote the Total Integrated Dose (TID) in Grays (Gy) unless otherwise specified. HFS 100 is an example of a highly radiation tolerant sheath.

Smoke

This refers to the level of smoke that is generated by a material under fire conditions. This is of key importance where visibility must not be impeded (for example: the route to an exit). As with flexibility and flex-life there is no link between smoke corrosivity and smoke generation, so whilst materials such as FEP might be very corrosive, they actually generate very little smoke. HFS 107 XL is one of the best examples of a low smoke-generation sheath.

Water

Where the sheath is concerned, this is the degree to which water can either be absorbed by the sheath (swelling its size) or permeate through it, flooding the cable interstices and allowing water to track back up to the connector. Habia's TPU 90 is one of the best examples of a water resistant sheath.

Zero halogen

The other side of smoke corrosivity, halogen content refers to the toxic gasses that can be emitted by the sheath under fire conditions. Halogens can affect health and therefore halogen free cables should be installed in areas of high foot-traffic and/or enclosed spaces. HFS 80 is one of the best zero halogen sheath materials.

Sheathing Comparison of sheathing materials

Additives...

Please note that some additives can change the material properties significantly.
An example is TPS 100 which is halogen free. The FR additive improves the smoke and fire performance but contains halogens.

5	Excellent
4	Good
3	Average
2	Below average
1	Poor

Comparison

This table attempts to present a clear comparison of the key strengths and weaknesses of Habia Cable's range of insulation and sheathing materials.

The information presented here is compiled from what are believed to be authoritative sources and / or independent testing of appropriate material samples and knowledge of the relevant compounds
In some instances Habia Cable has drawn comparisons and offered expectations based on alternative test protocols and results. As such it is believed that the information provided is accurate and factual as of the date printed, however new testing is constantly being carried out which may result in changes to the published data.

This information is offered solely as a convenience to Habia Cable's customers. Reference should always be made to the original test report wherever possible and Habia is unable to accept liability for the use of incorrect data where the original report has not been consulted.

Overview of general properties

material	abrasion resistance	flammability FR	flexibility	fuel & oil resistance	radiation tolerance	smoke corrosivity	smoke generation	water resistance	zero halogen ZH
ETFE	4	4	2	5	10^5 Gy	2	5	5	No
FEP	4	5	2	5	10^4 Gy	1	5	5	No
HFI 121 XL	3	3	4	2	10^5 Gy	5	5	4	Yes
HFI 150	2	4	3	4	>10^6 Gy	4	4	4	Yes
HFR 150	3	3	5	4	10^5 Gy	3	3	3	Yes
HFS 80	3	4	3	3	10^6 Gy	5	4	4	Yes
HFS 80 T	3	3	3	3	10^6 Gy	5	4	4	Yes
HFS 100	2	3	4	4	10^7 Gy	4	2	5	Yes
TPU 90	3	1	5	4	10^7 Gy	4	3	5	Yes
HFS 105 XLB	3	4	3	3	10^6 Gy	5	4	4	Yes
HFS 107 XL	3	4	3	3	10^6 Gy	5	5	4	Yes
HFS 110 XL	3	4	3	3	10^5 Gy	5	5	4	Yes
LSI 155	4	4	2	5	10^5 Gy	2	5	5	No
MPR 105	2	1	5	3	10^5 Gy	4	1	5	Yes
PFA	4	5	2	5	10^4 Gy	1	5	5	No
PTFE	4	5	2	5	10^3 Gy	1	5	5	No
TPS 100	3	1	3	5	10^5 Gy	4	3	2	Yes
TPS 100 FR	3	3	3	5	10^5 Gy	2	2	2	No
TPS 120	4	1	3	5	10^5 Gy	4	3	2	Yes
TPS 120 FR	4	3	3	5	10^5 Gy	2	2	2	No
TPS 125 XL	3	3	4	5	10^5 Gy	2	2	4	No
TWI 205	5	4	2	5	10^4 Gy	2	5	1	No

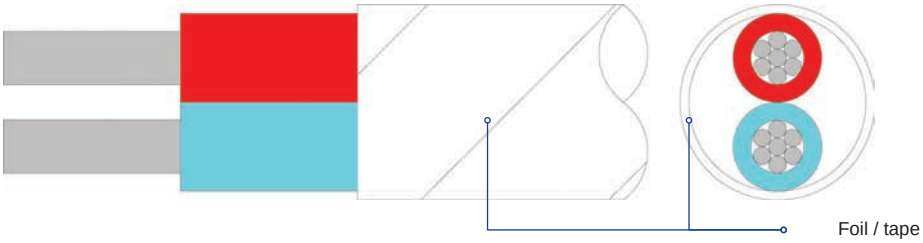
Tapes, binders and fillers

Additives...

Most binders can be applied during the same process as cabling and braiding, meaning little added cost for the inclusion of a binder.

A binder is not a suitable insulating layer as binders can move when the cable is flexed.
This means that screens may come into contact with one another.
If isolation of the screen is required, an inner sheath or a sintered tape such as Polyimide or PTFE must be used.

Illustration



General information

Although often considered incidental in the design of a cable, there are many reasons, both production and performance based for applying fillers, foils and tape binders.

Available tapes

The two primary types of tapes and foils used by Habia Cable are polyester (also known as Mylar) and PTFE. Each is available in a hard 'foil' and soft 'tape' version. Polyester is typically used for general purpose and halogen free constructions whilst PTFE provides a high temperature option. Other tapes and foil include:

- Al/Polyimide — A polyester-backed, polyimide foil used for electrical screening at high temperatures.
- Al/Pr foil — A polyester-backed, aluminium foil used for electrical screening.
- Cu/Pr foil — A polyester-backed, copper foil used for electrical screening and improved fire performance over Al/Pr.
- Polyimide — Foil used for high temperatures and high radiation. Can be FEP coated for sintering.
- Low noise — Carbon-loaded tape that can reduce electrical noise and interference.
- Mica — Used as a flame barrier in Habiaflame^2 constructions.
- My-Metal — A metallic foil that provides magnetic shielding.
- Water-swellable — Used to absorb water and prevent it from tracking through the interstices of the cable to the connector.

Production

Cable manufacture is a process that has to be carried out in many stages. It is therefore often necessary to apply a foil or tape in order to physically hold a cable together as it moves between the different stages in production. As a general rule, any cable with 8 or more cores in the final layer of cabling, or a cable with a filling compound to remove all air-spaces in the cable will require a foil or tape to be applied for this purpose. A typical overlap is between 25% and 50%.

Protection

Braided electrical screens and armours can be abrasive to the cores over which they are placed. The application of a foil or tape can often prevent wear and tear to the cores within the cable as it is flexed.

Flexibility

Some tapes and foils such as PTFE are very soft and low friction. This can enable the elements within a cable to move past one another, improving both the overall flexibility and flex-life of the cable.

Roundness

The addition of a binder can also improve the roundness of a cable, particularly when used beneath a pressure extruded outer sheath. Pressure extrusion allows the sheath of the cable to be made perfectly smooth and round, however this pressure also forces the sheath material into the interstices of the braid and/or cores which makes it very difficult to remove the sheath by hand and virtually impossible to remove with automated cut-and-strip equipment. The addition of a binder gives a smooth surface over which to extrude, enabling the sheath to be removed with relative ease.

Available fillers

As with tapes, there are two primary types of filler used by Habia Cable,HT and LT. In addition to these common types, there are a number of other variants that can offer specific performance advantages:

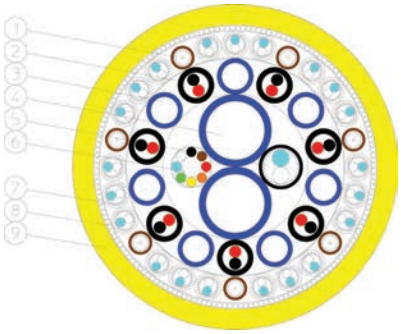
- HT — A fibrous, glass yarn, HT or High Temperature fillers can withstand the full temperature range of Habia's other materials. They are also soft, allowing for deformation within the cable that is necessary for dynamic use.
- LT — A (normally) solid, plastic filler, LT or Low Temperature fillers are used in the majority of cables and applications in the nominal to moderate temperature range.
- Polyester — Although a more expensive option than LT, Polyester fillers have a softer, rope construction that improves flexibility and offers a slightly better temperature range.
- PTFE — Some data cables require the use of PTFE fillers in order to provide better electrical stability.
- Water-swellable — Complementing the Water-swellable tapes, these fillers are also used to minimise the interstices within a cable and prevent water from tracking through the cable.

Composite cables

Additives...

Position 1	Coaxials
Position 2	Shielded data pairs
Position 3	Vent tubes
Position 4	Hydraulic tubes
Position 5	Ethernet pair
Position 6	Signal cores
Position 7	Twisted pairs
Position 8	Braided wire shield
Position 9	Overall sheath

Illustration



General information

The core of Habia Cable's business model is the design and manufacture of high specification, custom designed cables for demanding applications. Habia's ability to take many and varied components and combine them into a working, composite cable that is fit for function both electrically and mechanically is one of the best in the industry.

Composite cables offer a key benefit in umbilical and reeling cables as a single composite cable can do the work of a strain cable, electrical cable, power cable and even a number of hydraulic hoses. Components can include (but are by no means limited to):

Coaxials

With a wide variety of sizes and impedances available, Habia are able to combine any of the RG Style, Multibend, Speedflex or Speedfoam coaxes can be included within the design (Flexiform is not recommended for inclusion within composite cables due to its limited flex-life). Habia Cable is also frequently called upon to design customised coaxials for use within composite cables and these can be modified to feature varied impedances, additional screening or alternative sheaths and colours (including unsheathed coaxial cables).

Data pairs

As with the coaxial cables, data and ethernet pairs are available in a range of sizes and impedances. Perhaps the most common are 90 Ohms (USB) and 100 Ohms (Cat 5) however 77 Ohms, 120 Ohms and 125 Ohms are also often requested. Depending on the performance requirements of the cable, Habia can make these components using either PE, PTFE or FEP dielectrics.

Power cores

Power cores can be varied in size and colour coding. They can also be electrically isolated from the rest of the cable if required.

Signal cores

Probably the main component of any composite cable, signal wires can also be electrically isolated from the rest of the cable and are often specified as screened twisted pairs, triples and quads. Either colour coded or numbered (depending on size and cost) for ease of termination, Habia Cable can manufacture cables with hundreds of signal cores if required.

Strain wires

Can be applied as either a single, central strain cores or and overall braid (multiple strain wires throughout the cable are occasionally requested, but these are inadvisable as they often move within the cable when placed under strain, damaging the other components of cable as they do so). The level of load that can be supported varies from cable to cable, but Habia Cable have had experience with cables that can take loads of several tonnes.

Tubes

Vent tubes are incorporated within cables for a variety of purposes as they are able to provide air in the cable for cooling, they can aid the buoyancy of a cable and they can carry high pressure air or oil for pneumatic and hydraulic use.

Once arranged in a suitable lay-up that can be produced by machine, the cable will be cabled together with back-twist and alternating layer directions to ensure the best possible construction.

Braids of plated copper, stainless steel wire or Aramid strands can be added.

Depending on the performance of the materials within the cable a wide variety of inner and outer sheaths can be applied over the whole construction. These sheaths can be marked with either Habia's standard printing, designed to simply identify the cable for future reference, or with the customer's requested printing.

Delivery Lengths and reels

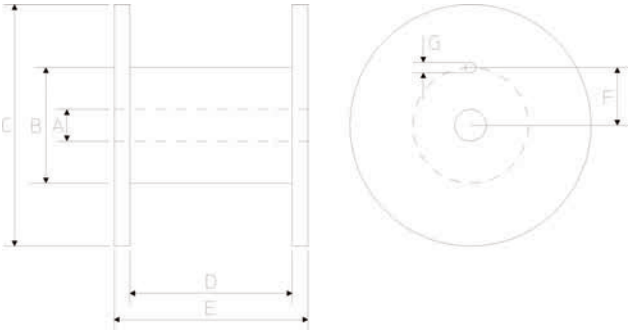
Additives...

Habia delivers on any number of standard spool sizes providing that the inner diameter of the spool is consistent with the MBR (Minimum Bend Radius) of the cable.

Habia Cable will supply with ends out and capped unless otherwise specified.

PP and PS	Plastic spool
Wood	Wooden spool

Illustration



Delivery Spools

designation	A	B	C	D	E	F	G	material	weight
	mm	mm	mm	mm	mm	mm	mm		kg
SD100/60K	16,5	60	100	38	45	25,0	3,5	PS	0,06
E 100	16,0	80	100	80	100	20,0	7,0	PS	0,09
E 125	16,0	80	125	100	125	20,0	7,0	PS	0,15
E 160	22,0	100	160	128	160	32,0	13,0	PS	0,25
E 200	22,0	125	200	160	200	32,0	13,0	PS	0,45
SH370K	305,0	311	370	70	80	-	-	PS	0,41
SD300K	51,5	212	300	91	103	44,5	11,0	PS	0,65
B60	33,0	110	255	148	165	43,5	11,5	PP	0,60
P3	75,0	110	280	265	285	43,5	9,5	PP	0,73
P4	75,0	175	400	300	340	62,0	20,0	PP	2,00
P5	75,0	202	480	340	380	65,0	20,0	PP	2,00
K6	75,0	250	600	400	464	100,0	40,0	Wood	12,00
K7	75,0	325	700	500	576	100,0	40,0	Wood	20,00
K8	75,0	375	800	500	576	100,0	40,0	Wood	25,00
K9	75,0	425	900	550	627	100,0	10,0	Wood	34,00
K10	107,0	500	1000	600	715	150,0	50,0	Wood	46,00
K11	107,0	575	1100	650	765	150,0	50,0	Wood	55,00
K12	107,0	675	1200	850	980	300,0	50,0	Wood	90,00
K14	107,0	800	1400	850	980	300,0	50,0	Wood	115,00
K16	107,0	950	1600	850	1012	300,0	50,0	Wood	195,00
K18	132,0	1100	1800	850	1012	500,0	65,0	Wood	230,00
K250	33,0	155	250	160	200	30,0	13,0	PS	1,05
K355	33,0	220	355	160	200	80,0	25,0	PS	1,85
H400	35,0	200	400	200	230	85,0	22,0	Wood	3,00
H470	35,0	200	470	230	250	85,0	22,0	Wood	3,50

Recommended MBR

Type of cable usage	minimum bend radius
Static (installation)	10x overall cable diameter
Dynamic	20x overall cable diameter