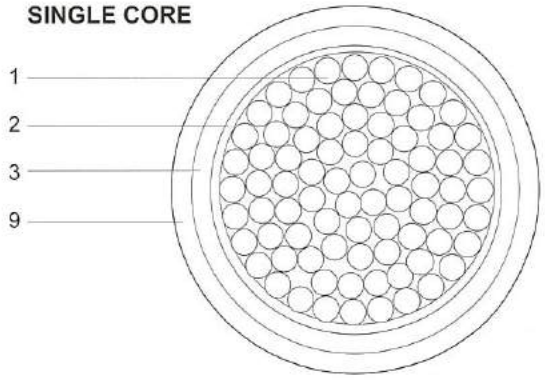
MAX-FOH

CONSTRUCTION OF CABLE

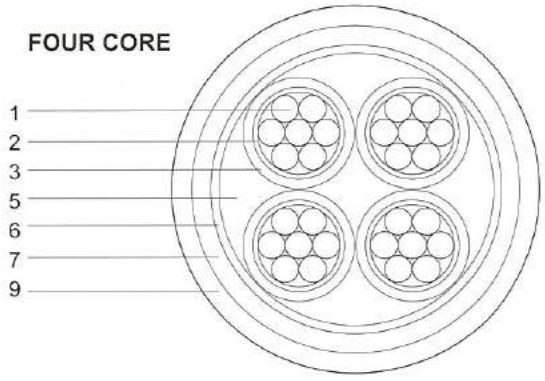
Construction	MAX-FOH	MAX-FOH-EVA
1 - Conductor	Stranded annealed copper	Stranded annealed copper
2 - Fire Barrier	Mica tape	Mica tape
3 - Insulation	Cross-linked polyethylene (XLPE)	Cross-linked EVA ** (XLEVA)
4 - Shield*	Aluminium foil with tinned copper drain wire	Aluminium foil with tinned copper drain wire
5 - Filler*	LSF filler or polypropylene split yarn	LSF filler or polypropylene split yarn
6 - Binder Tape*	Polyester tape	Polyester tape
7 - Bedding*	Low smoke halogen free (LSF) compound (Orange)	Low smoke halogen free (LSF) compound (Orange)
8 - Armour*/#	Galvanised steel wire (aluminium or copper wire for single core)	Galvanised steel wire (aluminium or copper wire for single core)
9 - Sheath	Low smoke halogen free (LSF) compound (Orange)	Low smoke halogen free (LSF) compound (Orange)

* Optional: Depending on requirement
\# Braided armour also available on request
** XLEVA material used are suitable for operating temperature of up to 125°C

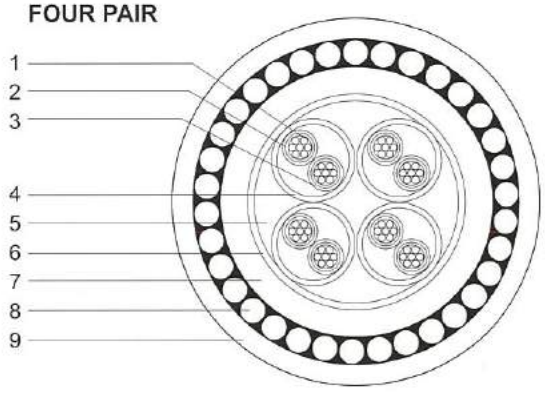
SINGLE CORE



FOUR CORE



FOUR PAIR



Identification of cores:

No. of cores	Single	Two	Three	Four	Five & above	Pairs
Colour	Natural or other colour on request	Red and Black	Red, Yellow and Blue	Red, Yellow, Blue and Black	Black with white numbering (others on request)	Black with white numbering

Note: Special construction and design to customers' specification can be provided upon request.

Applicable Standards

IEC 60502 **AS 3198**	Extruded solid dielectric insulated power cables for rated voltage of 1 kV up to 30 kV
IEC 60228 **BS 6360** **AS 1125**	Conductors of insulated cables
IEC 60754-1 **BS 6425-1** **AS 1660.5**	Test on gases evolved during combustion of electric cables - Determination of the amount of halogen acid gases
IEC 60754-2 **BS 6425-2** **AS 1660.5.4**	Test on gases evolved during combustion of electric cables - Determination of degree of acidity of gases evolved by measuring pH and conductivity
IEC 60331 **AS 1660.5.5**	Fire resistant characteristics of electric cable (750°C for 3 hours)
IEC 60332 Part 1 **BS 4066 Part 1**	Test on electric cables under fire conditions - Test on a single vertical insulated wire or cable
IEC 60332 Part 3 **BS 4066 Part 3** **Category A,B,C/AS 1660.5.1**	Test on electric cables under fire conditions - Test on bunched wires or cables
IEC 61034 **BS 7622** **AS1660.5.2**	Measurement of smoke density of electric cables burning under defined conditions
BS 6378 **SS 299 Part 1**	Performance requirements for cables required to maintain circuit integrity under fire conditions - Category C tested at 950°C for 3 hours Category W: fire with water Category Z: fire with mechanical shock
BS 6724	Armoured cables for electricity supply having thermosetting insulation with low emission of smoke and corrosive gases when affected by fire
BS 7211	Thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire
BS 7846	600/1000V armoured fire-resistant electric cables having low emission of smoke and corrosive gases when affected by fire
AS 3013	Electrical installations - Classification of the fire and mechanical performance of wiring systems

* Standards applied will vary depending on cable construction.

Comparision between test standards IEC 60331 & SS 299 Part 1

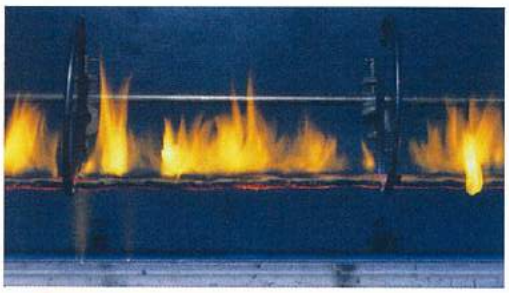
Ref	Description of tests	IEC 60331	0.6/1kV cables	Data Cables	Optical fibre cables	SS 299 Part 1	0.6/1kV cables	Data Cables	Optical fibre cables
1	**Resistance to FIRE alone**	Part 21							
	Flame temperature / Duration	750°C/90 min	✓	✓	✓	Cat A- 650°C/3hr Cat B- 750°C/3hr Cat C- 950°C/3hr Cat S - 650°C/20min	✓ ✓ ✓ ✓		
2	**Resistance to FIRE with mechanical shock**	Part 12							
	Flame temperature / Duration	830°C/120 min	✓			Cat X- 650°C/3hr Cat Y- 650°C/3hr Cat Z- 650°C/3hr	✓ ✓ ✓		
	Mechanical shock	Every 5 min	✓			Every 30 sec	✓		
3	**Resistance to FIRE with water spray**								
	Flame temperature / Duration	Not available				Cat W- 650°C/15min	✓		
4	**Other tests**								
	Electrical requirements for completed cables	Not available				Available	✓		
	Bending characteristics	Not available				Available	✓		
	Resistance of cable to impact	Not available				Available	✓		

STANDARDS AND APPROVALS

BS 6387/SS 299: 1994 - Fire, FIre with Water & Fire with Mechanical Shock Tests

The following test is the nationally recognised United Kingdom and Singapore test used to determine if a cable is capable of maintaining circuit integrity under fire conditions, fire with water and fire with mechanical shock. These tests use a number of alternative time and temperature parameters and depending on the level achieved by the cable, a corresponding letter is assigned to denote the category the cable passed.

Resistance to fire:	Symbol
650°C for 3 hours	A
750°C for 3 hours	B
950°C for 3 hours	C
950°C for 20 minutes	S



Resistance to fire and water:	Symbol
650°C for 15 minutes, then for 15 minutes with fire and water	W

Resistance to fire with mechanical shock:	Symbol
650°C for 15 minutes, with 30 second hammer blows	X
750°C for 15 minutes, with 30 second hammer blows	Y
950°C for 15 minutes, with 30 second hammer blows	Z

During the tests the cables are energised at their rated voltage.

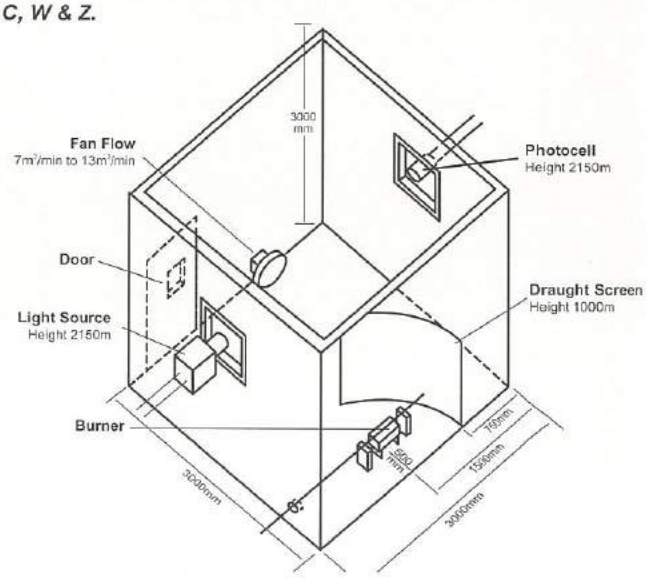
MAX-FOH cables meet the highest categories of BS 6387 i.e. C, W & Z.

IEC 61034 - Smoke Density Test

This test measures the smoke emission from electric cables during fire. The test is carried out in a 3m cubed chamber where a cable sample is subjected to fire.

The smoke emission and density are measured by transmitting a beam of light across the inside of the chambers to a photo electric cell which measures the amount of light received.

All MAX-FOH cables comply to IEC 61034 requirements.



IEC 60754 - Acid Gas Emission Test

Due to the concern regarding the amount of acid gas which could be produced when cables are burnt, this international test was developed to determine the amount of gas evolved by burning cables.

The recommended values of the test state that the weighted pH value should not be less than 4.3, when related to 1 litre of water. The weighted value of conductivity should not exceed 10*us*/mm.

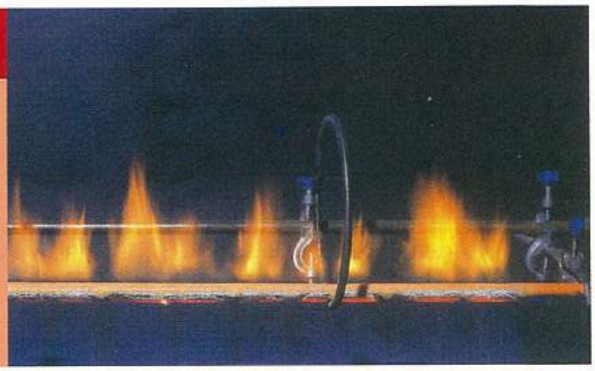
MAX-FOH cables meet the above requirements.

IEC 60331 - Fire Test

This international fire test is designed to establish whether a cable can maintain circuit integrity during and after exposure to fire.

A sample of cable is exposed to fire for 3 hours at a temperature of between 750°C and 800°C, after 3 hours the fire is extinguished and the current is turned off. After a further 12 hours, the sample of cable is re-energised and must maintain its circuit integrity.

MAX-FOH cables meet the requirements of IEC 60331.



IEC 60332 Part 3 - Flame Propagation Test

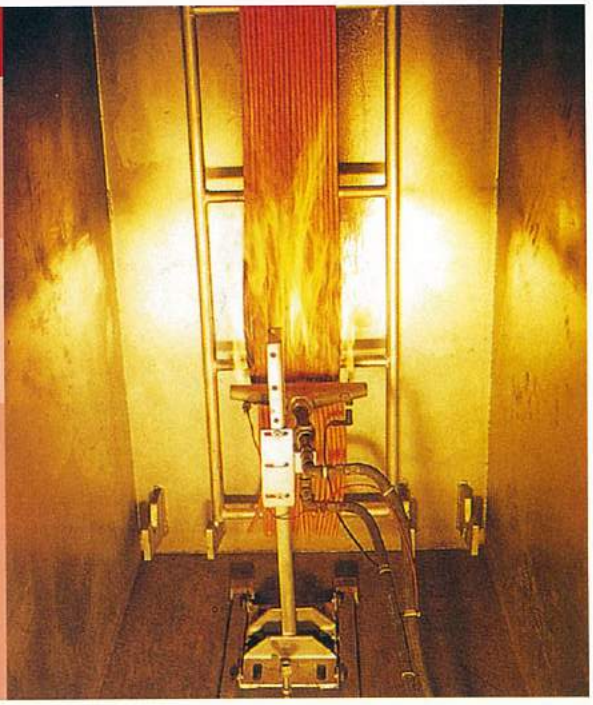
This test defines the ability of bunched cables to restrict vertical flame propagation when laid in trunking, cable trays or conduit. The test comprises of 3 categories each determined by the amount of combustible material in a 1 metre sample, as shown in the table below.

Category	A	B	C	D
No. of litres of combustible material in a 1 metre sample.	7	3.5	1.5	0.5
Exposure (mins)	40	40	20	20

The cable samples are placed vertically next to one another on a vertical ladder where they are exposed to fire from a ribbon gas burner for the pre-arranged times.

After burning, the samples are wiped clean to examine for char (the crumbling) fo the cable surface. The charring should not have reached a height exceeding 2.5m above the bottom edge of the burner.

MAX-FOH cables meet the requirement of IEC 60332 part 3



Additional Considerations

As well as the requirements written into International and British cable standards, there are other essential criteria which designers and consultants need to consider - Is the cable able to withstand voltage spikes, transmit data and prevent flame propagation?

All MAX-FOH cables do comply with these additional benefits, including the added advantage that MAX-FOH requires fewer joints in a cable run compare to mineral, reducing the risk of weak links in the chain. MAX-FOH does not require complicated terminations and is therefore quicker and easier to install.

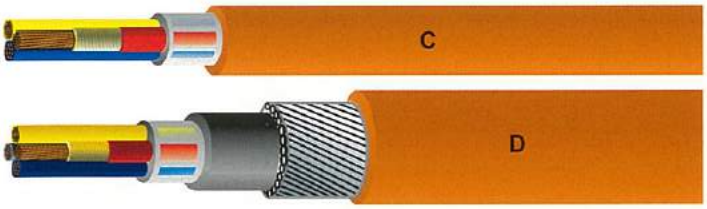
TABLE OF CONSTRUCTION

600/1000V, Unarmoured and Armoured Fire Resistant Cables

Table 1

		(A) Unarmoured Cables							(B) Armoured Cables				
		Insulated, non-sheathed			Insulated and Sheathed				Insulated and Sheathed				
	Nominal area of conductor	Insulation Thickness	Approx. diameter overall	Approx. weight	Insulation Thickness	Sheath Thickness	Approx. diameter overall	Approx. weight	Bedding Thickness	Armour wire diameter	Sheath Thickness	Approx. diameter overall	Approx. weight
	mm²	mm	mm	kg/km	mm	mm	mm	kg/km	mm	mm	mm	mm	kg/km
Single Core	1.5	0.7	3.9	32	0.7	1.4	6.4	55	-	-	-	-	-
	2.5	0.8	4.6	43	0.7	1.4	6.8	70	-	-	-	-	-
	4	0.8	5.1	55	0.7	1.4	7.4	90	-	-	-	-	-
	6	0.8	5.6	85	0.7	1.4	7.9	110	-	-	-	-	-
	10	1.0	7.1	146	0.7	1.4	8.9	160	-	-	-	-	-
	16	1.0	8.1	198	0.7	1.4	9.9	220	-	-	-	-	-
	25	1.2	9.8	320	0.9	1.4	12.2	330	-	-	-	-	-
	35	1.2	10.9	410	0.9	1.4	13.5	430	-	-	-	-	-
	50	1.4	13.4	549	1.0	1.4	15.0	560	1.0	0.90	1.8	2.0	800
	70	1.4	15.2	770	1.1	1.4	17.0	770	1.0	1.25	1.8	22.5	1000
	95	1.6	17.6	1140	1.1	1.5	19.0	1040	1.0	1.25	1.8	24.0	1400
	120	1.6	19.3	1425	1.2	1.5	20.8	1290	1.0	1.60	1.8	27.0	1700
	150	1.8	21.3	1720	1.4	1.6	23.0	1580	1.0	1.60	1.8	29.0	2000
	185	2.0	23.7	2155	1.6	1.6	25.3	1950	1.0	1.60	1.9	31.3	2400
	240	2.2	26.8	2900	1.7	1.7	28.3	2530	1.0	1.60	2.0	35.0	3300
	300	2.4	29.7	3540	1.8	1.8	31.0	3140	1.0	1.60	2.1	37.0	3800
	400	2.6	33.3	4410	2.0	1.9	34.7	3970	1.2	2.00	2.3	42.0	4800
	500	2.8	37.2	5660	2.2	2.0	38.5	4970	1.2	2.00	2.4	46.0	5900
	630	2.8	41.3	7140	2.4	2.2	43.5	6400	1.2	2.00	2.5	51.0	7400
	800	-	-	-	2.6	2.3	48.0	8000	1.4	2.50	2.8	57.0	9400
	1000	-	-	-	2.8	2.4	53.2	10200	1.4	2.50	2.9	62.0	11000
Two Cores	1.5	-	-	-	0.7	1.8	10.4	150	1.0	0.90	1.8	15.0	400
	2.5	-	-	-	0.7	1.8	11.2	180	1.0	0.90	1.8	16.0	450
	4	-	-	-	0.7	1.8	12.3	240	1.0	0.90	1.8	17.0	530
	6	-	-	-	0.7	1.8	13.5	300	1.0	0.90	1.8	18.0	620
	10	-	-	-	0.7	1.8	15.7	420	1.0	1.25	1.8	20.0	900
	16	-	-	-	0.7	1.8	17.8	590	1.0	1.25	1.8	22.0	1050
	25	-	-	-	0.9	1.8	21.2	860	1.0	1.60	1.8	26.5	1600
	35	-	-	-	0.9	1.8	23.7	1120	1.0	1.60	1.9	29.0	1964

A Unarmoured cables
B Armoured cables



600/1000V, Unarmoured and Armoured Fire Resistant Cables

Table 2

	(C) Unarmoured Cables					(D) Armoured Cables				
	Nominal area of conductor	Insulation Thickness	Sheath Thickness	Approx. diameter overall	Approx. weight	Bedding Thickness	Armour wire diameter	Sheath Thickness	Approx. diameter overall	Approx. weight
	mm^2	mm	mm	mm	kg/km	mm	mm	mm	mm	kg/km
Three Cores	1.5	0.7	1.8	11.4	170	1.0	0.90	1.8	15.9	450
	2.5	0.7	1.8	12.3	215	1.0	0.90	1.8	16.8	510
	4	0.7	1.8	13.44	280	1.0	0.90	1.8	18.0	610
	6	0.7	1.8	14.7	360	1.0	1.25	1.8	20.0	820
	10	0.7	1.8	16.7	510	1.0	1.25	1.8	21.6	1000
	16	0.7	1.8	18.5	740	1.0	1.25	1.8	23.8	1300
	25	0.9	1.8	22.0	1100	1.0	1.60	1.8	28.0	1900
	35	0.9	1.8	25.0	140	1.0	1.60	1.8	31.0	2400
	50	1.0	1.8	28.0	1900	1.0	1.60	1.9	34.5	3000
	70	1.1	1.9	32.0	2600	1.2	2.00	2.1	40.5	4300
	95	1.1	2.0	37.0	3500	1.2	2.00	2.2	45.0	5400
	120	1.2	2.1	42.0	4400	1.2	2.00	2.3	49.0	6600
	150	1.4	2.4	47.0	5500	1.4	2.50	2.5	55.0	8300
	185	1.6	2.4	52.0	6800	1.4	2.50	2.7	60.0	10000
	240	1.7	2.6	58.0	8800	1.4	2.50	2.9	67.0	12000
	300	1.8	2.7	64.0	10000	1.6	2.50	3.0	74.0	15000
Four Cores	1.5	-	1.8	12.3	200	1.0	0.90	1.8	16.6	500
	2.5	-	1.8	13.3	255	1.0	0.90	1.8	17.7	580
	4	-	1.8	14.6	335	1.0	1.25	1.8	19.5	800
	6	-	1.8	16.0	440	1.0	1.25	1.8	21.0	950
	10	-	1.8	18.2	640	1.0	1.25	1.8	23.0	1200
	16	-	1.8	21.0	915	1.0	1.60	1.8	26.4	1700
	25	-	1.8	25.6	1410	1.0	1.60	1.8	30.5	2300
	35	0.9	1.8	28.6	1500	1.0	1.60	1.9	34.2	2900
	50	1.0	1.8	32.1	1950	1.0	2.00	2.0	39.0	3900
	70	1.1	2.0	37.0	3100	1.2	2.00	2.2	44.0	4900
	95	1.1	2.1	42.0	3600	1.2	2.00	2.3	49.0	6600
	120	1.2	2.3	47.0	5700	1.4	2.50	2.5	45.0	8500
	150	1.4	2.4	51.7	7000	1.4	2.50	2.7	60.0	9900
	185	1.6	2.6	57.7	8700	1.4	2.50	2.8	66.0	12000
	240	1.7	2.8	65.0	11000	1.6	3.15	3.1	75.0	16000
	300	1.8	3.0	71.6	14000	1.6	3.15	3.2	82.0	19000

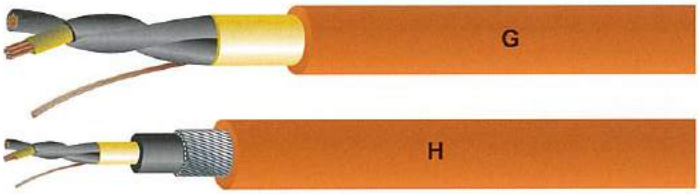
C Unarmoured cables
D Armoured cables
* Multicore unarmoured and armoured fire resistant cables are available upon request

300/500V, Unarmoured and Armoured Fire Resistant Cables

Table 3

	(E) Unarmoured Cables						(F) Armoured Cables				
	Nominal area of conductor	No. & Diameter of wires	Insulation Thickness	Sheath Thickness	Approx. diameter overall	Approx. weight	Bedding Thickness	Armour wire diameter	Sheath Thickness	Approx. diameter overall	Approx. weight
	mm^2	No./mm	mm	mm	mm	kg/km	mm	mm	mm	mm	kg/km
Single core	0.75	7/0.37	0.55	0.5	4.1	22	0.5	0.9	1.4	8.9	155
	1	7/0.44	0.55	0.5	4.3	26	0.5	0.9	1.4	9.1	165
	1.5	7/0.53	0.55	0.5	4.6	32	0.5	0.9	1.4	9.4	180
	2.5	7/0.67	0.55	0.5	5.0	43	0.5	0.9	1.4	9.8	200
	4	7/0.85	0.55	0.5	5.6	60	0.5	0.9	1.4	10.4	240
Two cores	0.75	7/0.37	0.55	0.5	7.0	64	0.5	0.9	1.4	11.8	285
	1	7/0.44	0.55	0.5	7.4	74	0.5	0.9	1.4	12.2	310
	1.5	7/0.53	0.55	0.5	8.0	92	0.5	0.9	1.4	12.8	345
	2.5	7/0.67	0.55	0.5	8.8	120	0.5	0.9	1.4	13.6	400
	4	7/0.85	0.55	0.5	9.9	165	0.5	0.9	1.4	14.7	475
Three cores	0.75	7/0.37	0.55	0.5	7.5	75	0.5	0.9	1.4	12.3	310
	1	7/0.44	0.55	0.5	7.9	88	0.5	0.9	1.4	12.7	355
	1.5	7/0.53	0.55	0.5	8.5	110	0.5	0.9	1.4	13.3	375
	2.5	7/0.67	0.55	0.5	9.4	150	0.5	0.9	1.4	14.2	445
	4	7/0.85	0.55	0.5	10.6	205	0.5	0.9	1.4	15.4	535
Four cores	0.75	7/0.37	0.55	0.5	8.3	90	0.5	0.9	1.4	13.1	360
	1	7/0.44	0.55	0.5	8.7	105	0.5	0.9	1.4	13.5	380
	1.5	7/0.53	0.55	0.5	9.4	135	0.5	0.9	1.4	14.2	430
	2.5	7/0.67	0.55	0.5	10.4	180	0.5	0.9	1.4	15.2	500
	4	7/0.85	0.55	0.5	11.7	255	0.5	0.9	1.5	16.7	620

E Unarmoured fire resistant cables
F Armoured fire resistant cables
* Multicore unarmoured and armoured fire resistant cables are available upon request



300/500V, Unarmoured and Armoured Shielded Fire Resistant Cables

Table 4

	(E) Unarmoured Cables						(F) Armoured Cables				
	Nominal area of conductor	No. & Diameter of wires	Insulation Thickness	Sheath Thickness	Approx. diameter overall	Approx. weight	Bedding Thickness	Armour wire diameter	Sheath Thickness	Approx. diameter overall	Approx. weight
	mm^2	No./mm	mm	mm	mm	kg/km	mm	mm	mm	mm	kg/km
Single pair	0.75	7/0.37	0.5	0.8	7.9	65	0.8	0.9	1.4	12.7	300
	1	7/0.43	0.6	0.8	8.5	75	0.8	0.9	1.4	13.3	340
	1.5	7/0.53	0.6	0.8	9.1	90	0.8	0.9	1.4	13.9	370
	2.5	7/0.67	0.6	0.8	9.9	110	0.8	0.9	1.4	14.7	420
Two pairs	0.75	7/0.37	0.5	0.8	10.0	100	0.8	0.9	1.4	14.8	410
	1	7/0.43	0.6	0.9	11.0	125	0.9	0.9	1.4	15.8	460
	1.5	7/0.53	0.6	0.9	11.8	150	0.9	0.9	1.5	16.8	520
	2.5	7/0.67	0.6	1.0	13.1	205	1.0	0.9	1.5	18.1	605
Three pairs	0.75	7/0.37	0.5	1.0	12.2	145	1.0	0.9	1.5	17.2	565
	1	7/0.43	0.6	1.0	13.1	170	1.0	0.9	1.5	18.1	600
	1.5	7/0.53	0.6	1.0	14.1	215	1.0	0.9	1.6	19.3	655
	2.5	7/0.67	0.6	1.1	15.7	290	1.1	1.25	1.6	21.6	920
Four pairs	0.75	7/0.37	0.5	1.0	13.7	180	1.0	0.9	1.5	18.7	600
	1	7/0.43	0.6	1.0	14.7	215	1.0	1.25	1.6	20.6	820
	1.5	7/0.53	0.6	1.1	16.1	280	1.1	1.25	1.6	22.0	920
	2.5	7/0.67	0.6	1.1	17.7	370	1.1	1.25	1.6	23.8	1090

G Unarmoured fire resistant cables
H Armoured fire resistant cables
* Multipairs unarmoured and armoured shielded fire resistant cables are available upon request

SELECTION OF CROSS-SECTIONAL AREA OF CONDUCTOR

In order to choose the right power cable, one has to consider:

- the current
- the voltage drop
- the short circuit rating
- the installation methods
- the ambient temperature
- the frequency and harmonic current
- maximum safe length at short circuit

Current Rating

When electric current flows through the conductor of a cable, the electrical resistance of the conductor generates heat. When a temperature greater than that allowed is reached by the cable due to heat generation, a larger conductor size (with lower electrical resistance) has to be selected. Other important considerations are methods of installation of the cable and ambient temperature. Calculation which takes into account all criteria are described in IEC 60287 and are rather complex. In general, preferences is given to standard current rating tables which are issued by national standardization bureaus.

The current rating given in Table 4 to 14 are based on the following standard conditions of the installation.

1. Maximum operating temperature of conductor = 90°C
2. Ambient air temperature = 30°C
3. Ground temperature = 15°C
4. Soil thermal resistivity = 1.2°C m/w
5. Depth of laying (For cable laid direct in the ground) = 0.5m

Voltage Drop

Another important factor for the determination of the conductor size is the voltage drop. The voltage drop of the cable at a given current is caused by losses in the cable. In case of a too high voltage drop, it is necessary to choose a bigger conductor size. The voltage drop in a cable demotes the difference in voltage at the beginning and at the end of the cable. It depends on:

- the current carried
- the power factor
- the length of the cable
- the resistance of the cable
- reactance of the cable

The permissible voltage drop is usually stated as a percentage of the circuit voltage.

According to CP5:1998 regulation 525-01-01, it is stipulated that the total voltage drop for any particular cable run must be such that the voltage drop in the circuit of which the cable forms a part does not exceed 4% of the nominal voltage of the supply.

Selection of Cable based on Voltage Drop and Current using Tables

Since the actual power factor of the load is usually not known, the most practical approach to the question of the voltage drop is to assume the worst conditions, i.e. power factor equal to one and the conductor is at maximum operating temperature. The voltage drop values given in the tables are based on these assumptions.

The values of the voltage drop (Vd) are tabulated for a current of one Ampere for a 1 metre run, the value of voltage drop needs to be multiplied by the length of the run, in metre, and by the current, in Ampere that the cables are to carry.

V=Vd x I x L

Where V = Voltage
Vd = Approximate Voltage drop/Ampere/metre
I = Current in Ampere per phase
L = Route length in metres

Example:
Given that the supply voltage is 415V, 3 phase 50Hz and that the cable used is a 4C Cu/mica/XLPE/SWA/PVC fire resistant cable. Required cable is to be installed in ground and to carry a 250 Amp load per phase over a route length of 100m. Cable installation is to be in compliance with CP5: 1998 Regulation 522.08 regulation.

V=Vd x I x L

Maximum permissible voltage drop
Vmax = 4% of 415V
Vmax = 16.6V

Voltage drop/ampere/metre

$$Vd = \frac{Vmax}{I \times L} = \frac{16.6V}{250 \times 100} = \mathbf{0.66mV}$$

Select from Table 10 (pg 32) such that the Vd value is equal to, or less than the calculated 0.66mV, at the same time ensuring that it will carry the current. It will be seen that this value is 0.61 giving a cable size of 70mm^2.

Handling and installation of FR cable

Minimum bending radius

Type of cable	Unarmoured		Armoured
Number of cores	Single core	Multicore	
300/500V and 600/1000V cable	8D	6D	10D

where D: diameter of cable

Side wall pressure to cable

Permissable maximum side wall pressure to the cable at bending point during installattion is 500kgf/m.

$$\text{Side wall pressure to cable} = \frac{\text{Pulling tension (kgf)}}{\text{Bending radius (m)}}$$

$$= \frac{T}{R}$$

Permissable maximum pulling tension (T)

Conductor	(Tension kgf)
Copper	7 x (No. of cores) x (cross-sectional area of conductor)

Drum handling

Handle the drums with care! It is always recommended and a must with heavy drums - to lift drums with a fork-lift truck or a crane when removing them from the vehicle. Always take care to lower the drums into an upright position on their flanges.