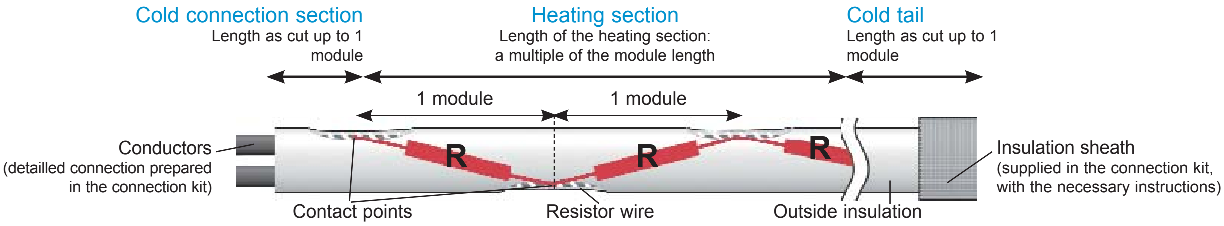
OPERATING PRINCIPLES

CONSTANT POWER CABLES

A constant power cable is a succession of identical resistors R connected in parallel, which makes it possible to have the same power dissipation on each of these sections.

These resistors are made up of a heating wire coiled around insulated conductor cables, with which it comes into contact at each contact point. These sections, between 2 consecutive contact points, are known as modules.

This is why the cable can only heat between 2 contact points, as shown in the following diagram:

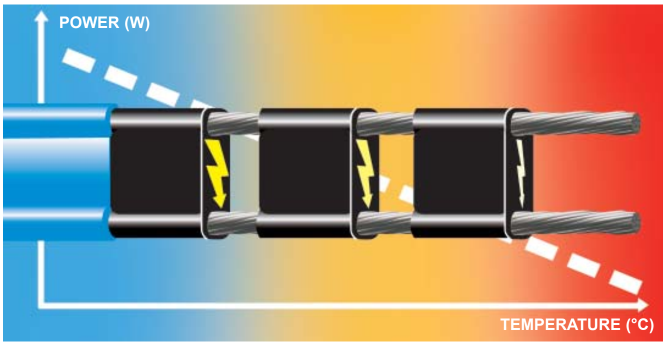


SELF-REGULATING CABLES

Between the conductors, the dark material which makes up the heating element is a polymer enriched with carbon as a conductor. The resistivity of this material varies with temperature because of the dilation of the internal structures which reduce the space available for the current to pass.

Consequently, when the temperature rises, the power dissipated by the cable decreases. This is the phenomenon referred to as self-regulation. This prevents overheating which could damage the cable and allows the part of the cable placed in a colder environment to produce more energy in that zone.

When in operation, the cable will therefore always reach a balance between the power it dissipates and the losses due to the outside environment. However, it is impossible to accurately determine at what temperature the surface of the cable will stabilise, because of the complexity and variability of its environment . Similarly, in order to keep control over the installation and to make significant energy savings, it is always recommended to adjust these cables by means of a thermostat.



NB : unlike the other heating elements, it is impossible to check that a self-regulating cable is operating correctly by measuring resistance with an ohmmeter. This can be done instead by measuring the voltage/current.

SERIES RESISTORS

A series resistor is an element with an electric current running between its two ends. It dissipates an amount of power governed by Ohm's law (cf. formula). As a result, any change in length, voltage or current is extremely tricky and means that we have to perform a new, in-depth study.

For series resistors sold by their Ohm/m rating (semi-finished products ordered by the metre or kilometre), a prior study is absolutely essential to at least be sure that the final cut length will produce a maximum power level that is in keeping with the recommendations of our technical documentation.

For finished products sold by their wattage (ordered individually), the power supply voltage must be strictly respected and the length never modified

TECHHNICAL FORMULAE

OHM'S LAW :

The formulae linking the electrical variables of a purely resistive element are as follows:

$$U = R \times I = P/I = \sqrt{P \times R}$$
$$I = U/R = \sqrt{P/R} = P/U$$
$$R = U/I = P/I^2 = U^2/P$$
$$P = U \times I = I^2 \times R = U^2/R$$

Where :
U : voltage in Volt (V)
I : current in Amps (A)
R : resistance in Ohm (Ω)
P : power in Watt (W)

WINDING PITCH:

The winding pitch is the distance between two successive turns of a cable wound round a cylindrical support. This winding should be used when the linear power obtained by straight tracing is insufficient or when very uniform heating is required.

$$P = \frac{\pi \times D \times L}{\sqrt{T^2 - L^2}} \qquad T = \sqrt{\frac{(\pi \times D \times L)^2}{P^2} + L^2}$$

All measurement in mm :
P : winding pitch in mm
D : outside diameter of the support
L : Total length of the piping
T : Total length of the cable

USUAL METAL PIPE DIAMETERS

Nominal diameter DN (inches)	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5	6	8	10	12
Outside diameter D (mm)	13.71	17.14	21.34	26.67	33.4	42.16	48.26	60.32	73.02	88.9	101.6	114.3	141.3	168.27	219.07	273.05	323.85

LOSSES PER m OF PIPING: HEAT LOSSES TO BE COMPENSATED FOR IN ORDER TO MAINTAIN A TEMPERATURE

$$Q = \frac{\pi \times (Tm - Ta)}{\frac{1}{2 \times \lambda} \times Ln\left(\frac{D + 2 \times e}{D}\right)}$$

Where :

Ambient temperature	Ta	°C
Maintenance temperature	Tm	°C
Outside dia. of piping	D	mm
Thickness of heat lagging	e	mm
Heat lagging lambda	l	W/m.K
Theoretical losses	Q	W/m

IMPORTANT : this is a theoretical calculation and must be weighted using a safety coefficient which depends on how the installation will be used. Please consult us to evaluate this coefficient.

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LOSSES in W/m FOR INSULATED PIPING

Thermal insulation thickness (mm)	dT in °C	Dimension of the piping																			
		ND (mm)	8	15	20	25	32	40	50	65	80	100	150	200	250	300	350	400	450	500	600
		Out.D (mm	14	21	27	34	42	48	60	76	89	114	168	219	273	324	356	406	457	508	610
10	20		6.2	7.2	8.5	10	12	14	16	19	23	28.8	41.1	52.6	64.7	76.1	83.3	94.6	106	117	140
	30		9.4	11	13	15	19	21	25	29	35	43.8	62.5	80	98.5	116	127	144	161	178	213
	40		13	15	18	21	25	28	34	40	47.3	59.2	84.5	108	133	157	171	195	218	241	287
20	20		4	4.6	5.3	6.2	7.3	8	9.5	11	13	16	22.5	28.5	34.9	40.9	44.7	50.7	56.7	62.6	74.6
	30		6.2	7	8.1	9.4	11	12	15	17	19.8	24.4	34.2	43.4	53.2	62.3	68	77.1	86.2	95.3	113
	40		8.3	9.5	11	13	15	17	20	23	26.7	33	46.3	58.7	71.9	84.2	92	104	117	129	153
	60		13	15	17	20	23	26	30	35	41.2	50.9	71.4	90.5	111	130	142	161	180	199	237
25	20		3.6	4.1	4.6	5.3	6.2	6.9	8.1	9.3	10.9	13.4	18.6	23.5	28.7	33.5	36.5	41.4	46.2	51.1	60.7
	30		5.4	6.2	7.1	8.1	9.5	10	12	14	16.6	20.3	28.3	35.7	43.6	51	55.6	63	70.3	77.7	92.4
	40		7.4	8.4	9.5	11	13	14	17	19	22.4	27.5	38.2	48.3	59	69	75.2	85.2	95.1	105	125
	60		11	13	15	17	20	22	26	30	34.5	42.4	59	74.5	90.9	106	116	131	147	162	193
	80		16	18	20	23	27	30	35	41	47.4	58.2	81	102	125	146	159	180	201	222	265
	100		20	23	26	32	30	39	45	53	61.2	75.2	105	132	161	189	206	233	260	287	342
30	20		3.3	3.7	4.2	4.8	5.5	6.1	7.1	8.1	9.5	11.6	15.9	20.1	24.4	28.5	31	35.1	39.2	43.2	51.3
	30		5	5.6	6.3	7.3	8.4	9.2	11	12	14.4	17.6	24.3	30.5	37.1	43.3	47.2	53.4	59.6	65.8	78.1
	40		6.7	7.6	8.6	9.8	11	13	15	17	19.5	23.8	32.8	41.3	50.2	58.6	63.8	72.2	80.6	88.9	106
	60		10	12	13	15	18	19	23	26	30	36.6	50.6	63.6	77.4	90.4	98.4	111	124	137	163
	80		14	16	18	21	24	26	31	36	41.2	50.3	69.4	87.3	106	124	135	153	171	188	224
	100		18	21	23	27	31	34	40	46	53.2	65	89.7	113	137	160	175	197	220	243	289
	120		23	26	29	33	39	42	49	57	65.9	80.4	111	140	170	198	216	244	273	301	358
	140		27	31	35	40	46	51	59	68	79.3	96.8	134	168	204	239	260	294	328	362	430
	160		32	36	41	47	55	60	70	80	93.3	114	157	198	241	281	306	346	386	426	506
	180		37	42	48	55	63	69	81	93	108	132	182	229	279	325	354	401	447	494	586
40	20		2.8	3.2	3.6	4	4.6	5	5.8	6.6	7.6	9.2	12.6	15.7	19	22.1	24	27.1	30.2	33.3	39.4
	30		4.3	4.8	5.4	6.1	7	7.7	8.9	10	11.6	14.1	19.1	23.9	28.9	33.6	36.6	41.3	45.9	50.6	60
	40		5.8	6.5	7.3	8.3	9.5	10	12	14	15.7	19	25.9	32.3	39.1	45.5	49.4	55.8	62.1	68.5	81.1
	60		9	10	11	13	15	16	19	21	24.3	29.3	39.9	49.8	60.3	70.1	76.2	86	95.8	106	125
	80		12	14	16	18	20	22	25	29	33.3	40.2	54.8	68.4	82.7	96.2	105	118	132	145	172
	100		16	18	20	23	26	28	33	37	43	52	70.8	88.3	107	124	135	152	170	187	222
	120		20	22	25	28	32	35	41	46	53.3	64.4	87.6	109	132	154	167	189	210	232	275
	140		24	27	30	34	39	42	49	56	64.1	77.4	105	132	159	185	201	227	253	279	330
	160		28	31	35	40	46	50	57	66	75.4	91.1	124	155	187	218	237	267	298	328	339
	180		32	36	41	46	53	58	67	76	87.3	106	144	179	217	252	274	310	345	380	450
50	20		2.6	2.8	3.2	3.6	4.1	4.4	5	5.7	6.5	7.8	10.5	13.1	15.7	18.2	19.8	22.3	24.7	27.2	32.2
	30		3.9	4.3	4.8	5.4	6.2	6.7	7.7	8.7	9.9	11.9	16	19.9	23.9	27.7	30.1	33.9	37.6	41.4	48.9
	40		5.3	5.9	6.5	7.3	8.4	9.1	10	12	13.4	16.1	21.7	26.9	32.3	37.5	40.7	45.8	50.9	56	66.2
	60		8.1	9	10	11	13	14	16	18	20.7	24.8	33.4	41.4	49.9	57.8	62.7	70.6	78.5	86.3	102
	80		11	12	14	16	18	19	22	25	28.5	34.1	45.9	56.8	68.4	79.3	86.1	96.9	108	119	140
	100		14	16	18	20	23	25	28	32	36.7	44	59.2	73.4	88.3	102	111	125	139	153	181
	120		18	20	22	25	28	31	35	40	45.5	54.5	73.3	90.9	109	127	138	155	172	190	224
	140		22	24	27	30	34	37	42	48	54.7	65.6	88.2	109	132	153	166	186	207	228	269
	160		25	28	31	35	40	43	50	56	64.4	77.2	104	129	155	180	195	220	244	268	317
	180		29	33	36	41	46	50	58	65	74.6	89.4	120	149	179	208	226	254	282	311	367
80	20		2.1	2.3	2.6	2.8	3.2	3.4	3.8	4.3	4.8	5.7	7.4	9	10.7	12.3	13.3	14.9	16.4	18	21.1
	30		3.2	3.5	3.9	4.3	4.8	5.2	5.8	6.5	7.3	8.6	11.3	13.7	16.3	18.7	20.2	22.6	25	27.4	32.1
	40		4.4	4.8	5.2	5.8	6.5	7	7.9	8.8	9.9	11.6	15.2	18.5	22	25.3	27.3	30.6	33.8	37	43.5
	60		6.7	7.4	8.1	9	10	11	12	14	15.3	17.9	23.5	28.6	34	39	42.1	47.1	52.1	57.1	67
	80		9.2	10	11	12	14	15	17	19	20.9	24.6	32.2	39.2	46.6	53.5	57.8	64.7	71.5	78.3	92
	100		12	13	14	16	18	19	22	24	27	31.8	41.6	50.6	60.2	69.1	74.6	83.5	92.3	101	119
	120		15	16	18	20	22	24	27	30	33.5	39.3	51.5	62.7	74.5	85.5	92.4	103	114	125	147
	140		18	19	21	24	27	28	32	36	40.3	47.3	61.9	75.4	89.6	103	111	124	138	151	177
	160		21	23	25	28	31	33	38	42	47.4	55.7	72.9	88.8	106	121	131	146	162	177	208
	180		24	27	29	32	36	39	44	49	54.9	64.5	84.4	103	122	140	152	170	188	205	241

CONVERTING BETWEEN THE METRIC SYSTEM AND THE IMPERIAL SYSTEM

Multiply		by		to obtain
Unit	x	Coefficient	=	Unit
millimetres	x	0.03937	=	inches
millimetres	x	39.37	=	mils
metres	x	39.37	=	inches
metres	x	3.28	=	feet
inches	x	25.4	=	millimetres
feet	x	0.3048	=	metres
mils	x	0.0254	=	millimetres
kilograms	x	2.205	=	pounds
pounds	x	0.4536	=	kilograms

Multiply		by		to obtain
Unit	x	Coefficient	=	Unit
Ω / km	x	0.3048	=	Ω / 1000 feet
Ω / 1000 feet	x	3.281	=	Ω / km
pounds / 1000 feet	x	1.488	=	kilograms/km
square inches	x	645.2	=	square millimetres
square millimetres	x	1.273	=	circular mms
square millimetres	x	1973.5	=	circular mils
square mils	x	1.273	=	circular mils
circular mms	x	1550	=	circular mils
circular mils	x	0.7854	=	square millimetres