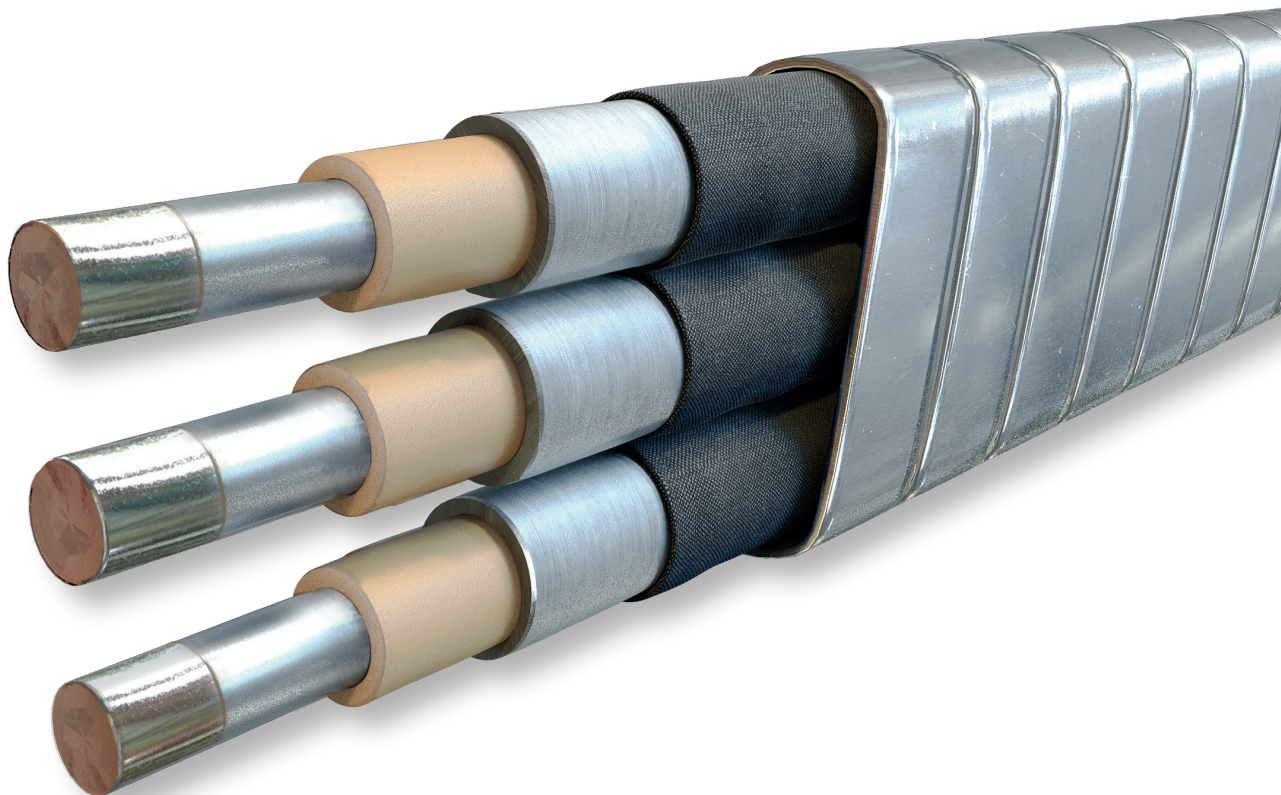


HIGH-TEMPERATURE ESP CABLE



30+ YEARS OF EXPERIENCE
DEVELOPING, MANUFACTURING
AND SERVICING DOWNHOLE
EQUIPMENT



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ABOUT NOVOMET

The Company was established in 1991 as a submersible pump stage manufacturer. We were the first to use space-grade powder metallurgy manufacturing technology in the oil and gas industry. Powder metallurgy components have demonstrated superior performance over the years under extreme conditions, delivering exceptional pump runlife.

Throughout the Company's history, we have continued to develop technologically superior products for in artificial lift. We offer ESP cable as a complement to our superior downhole pumping systems. We also offer custom components for various industries using 3D printing, traditional casting, and powder metallurgy manufacturing technologies.



30 years of experience in petroleum engineering



Manufacturing up to 700 complete ESP systems per month



More than 4 000 employees in 16 countries



100 000 m² of manufacturing facilities



Manufacturing up to 360 km of cable per month



Producing up to 230 000 pump stages per month



NOVOMET

- Exporting products and services to 30 countries
- Offering reliable service and repair in 16 service centers



ESP CABLE OVERVIEW

SUPERIOR STANDARDS AND QUALITY





Manufacturing details

- Production according to individual customer requirements
- Tinning lines (Italian)
- Extruder for applying rubber insulation (German)
- Extruder for applying the lead sheath (Swedish)
- Braid winding line
- Cable armouring line, including armouring with capillary tube
- Cable test benches of own production
- Quality control at every stage



Superior packaging materials and technologies, providing reliable protection and convenience for transportation and acceptance

- Free cable end has the length of 3 m or even more, it is attached to the internal wall of the reel, which provides the possibility to perform tests with no unwinding
- Application of halogen-free, non-flammable, flexible packaging material for protection against corrosion, mechanical damage, and weather impact



Novomet service centers located worldwide offer quick and easy access for cable delivery and maintenance

- Cable requirements and selection
- Armour repairs
- Cable splicing, heat plug piston, and motor lead extensions
- Comprehensive testing
- RIH/POOH services for ESP, PCP and RDCP systems
- Solving problems and performing non-standard tasks

FEATURES

- Stepped, interlocked profile reduces the risk of mechanical damage to the armour
- High dielectric strength EPDM rubber insulation provides at least 500 megaohms per km at 20°C (500 megaohms per 3,280 ft at 68°F)
- Materials offer reliable cable operation at temperatures -40 to 232°C (-40 to 450°F)
- In accordance with GOST 51777-2001, the entire length of cable is labeled with Cable type, brand, month and year of manufacture

Components

- Tin-coated copper solid conductor (class 1)
- High dielectric strength EPDM rubber insulation
- Lead casing for best protection against gas and corrosive fluids
- Synthetic braid applied over full length of lead sheath to ensure mechanical strength
- Armour with interlocked profile galvanized or corrosion-resistant, or with a MONEL alloy option for extreme pressures
- Stainless steel chemical injection capillary tube for supplying scale and corrosion inhibitor to the production zone

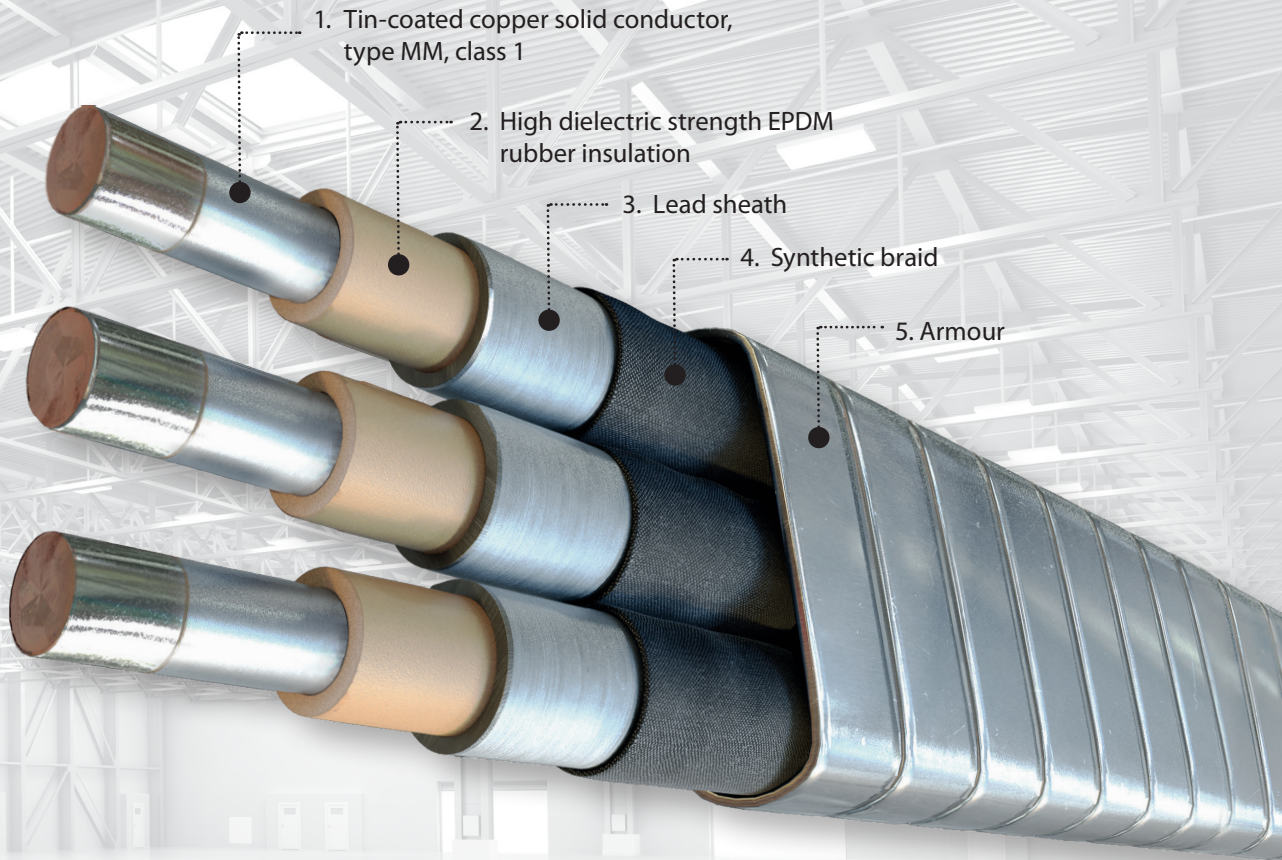
Three types of armour

- Galvanized steel for basic corrosion resistance
- Stainless steel for high-corrosion-resistance
- Monel alloy for sulfide-stress-cracking resistance

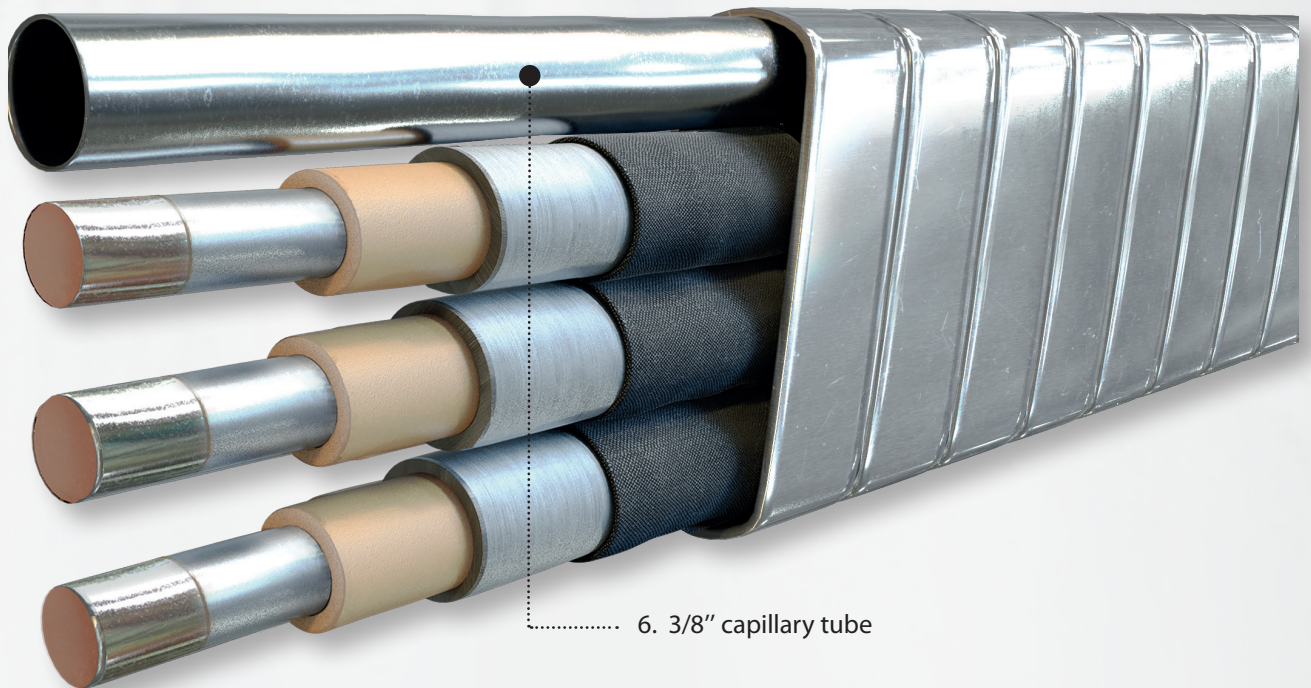
EPDM rubber insulation

Ethylene propylene copolymer (EPDM) has high dielectric properties enabling reliable operation at downhole temperatures up to 232°C (450°F).

Three-core ESP cable



Three-core ESP cable with capillary tube

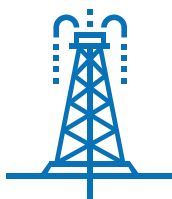


APPLICATION

Novomet ESP cable delivers up to 5000 V to downhole submersible motors at frequencies ranging from 50 to 400 Hz. A wide range of motor lead extension (MLE) sizes enables use with ESP systems with an outside diameter (OD) ranging from 69 – 229 mm (2.72" - 9.00").

The cable can also be manufactured for MLE purposes and intended for operation in deep wells or harsh well conditions including high gas-to-oil ratios, high temperatures, abrasive and corrosive fluids, heavy oil, wells with minimum drift, and highly deviated wells.

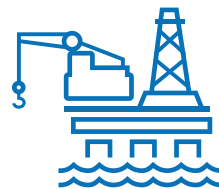
Application



Artificial lift



Water injection
and downhole
pumping



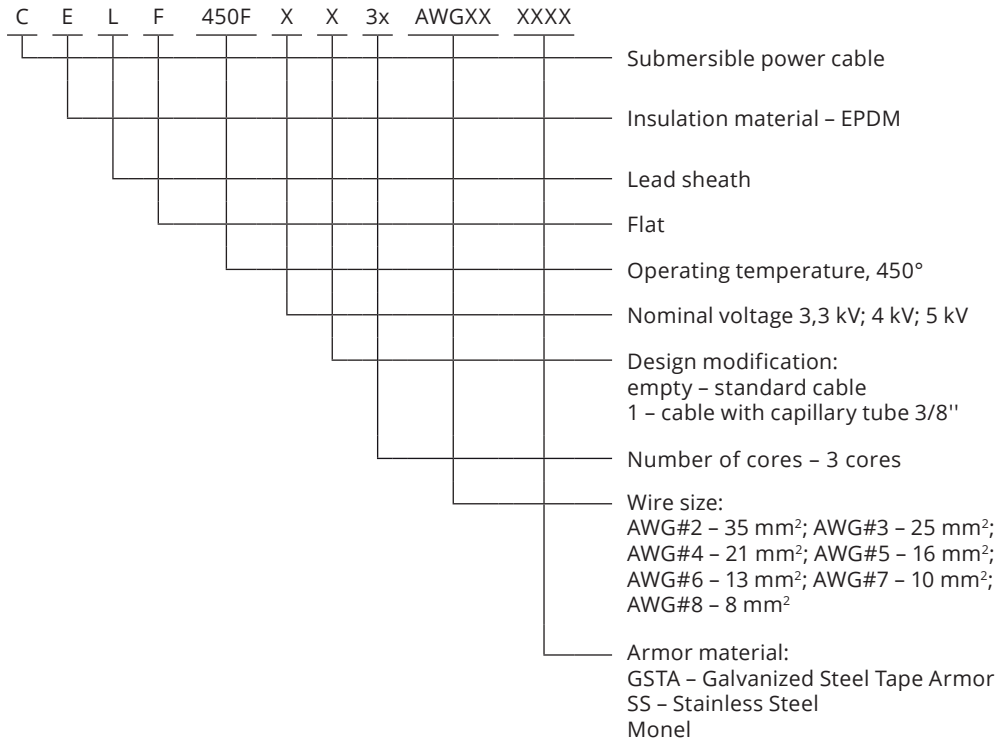
Offshore
operations



Geothermal
and water wells



Cable Glossary



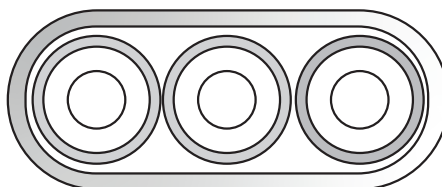
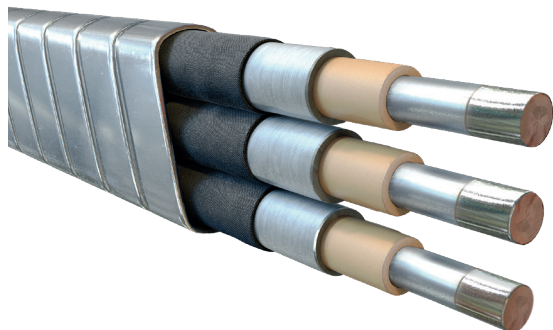
An example of recording an oil-submersible cable "C" (POWER CABLE), with rubber insulation based on ethylene-propylene rubber "E", with lead sheaths of the cores "L", flat version "F" (FLAT), with a long-term permissible heating temperature of the cores of 230 °C (450F), for a rated operating voltage of 5.0 kV (5 kV), with three wires with a nominal cross section of wires "8" (AWG # 8), armored with steel galvanized tape "GSTA", manufactured by Novomet when ordering and in other documentation

POWER CABLE CELF 450F 5KV AWG#8 GSTA FLAT



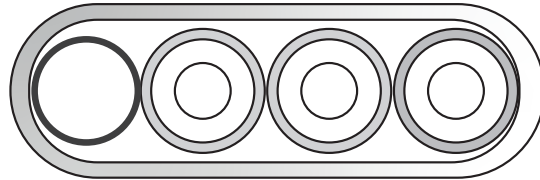
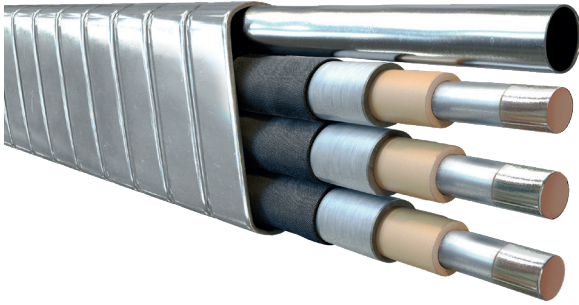
SPECIFICATION

Three-core ESP cable



Type	Nominal cross-section and number of cores, pcs x mm ²	Compliance with American wire gauge	Tinned wire diameter		Diameter over insulation in.	Overall dimensions in.	Length per reel type ft
			in.	mm			
CELF 450F 4 kV	3 x 0.012	-	0.13	3,194	0.24	0,457 x 1,151	35926
	3 x 0.013	AWG8	0.13	3,264	0.24	0,460 x 1,159	35365
	3 x 0.016	-	0.14	3,574	0.26	0,472 x 1,196	33026
	3 x 0.016	AWG7	0.14	3,664	0.26	0,475 x 1,207	32393
	3 x 0.021	AWG6	0.16	4,124	0.28	0,494 x 1,261	29415
	3 x 0.025	-	0.18	4,514	0.29	0,509 x 1,307	27201
	3 x 0.026	AWG5	0.18	4,624	0.30	0,513 x 1,320	26624
	3 x 0.033	AWG4	0.20	5,204	0.32	0,536 x 1,388	23852
	3 x 0.039	-	0.22	5,644	0.34	0,560 x 1,459	21422
	3 x 0.041	AWG3	0.23	5,834	0.35	0,567 x 1,482	20726
	3 x 0.052	AWG2	0.26	6,544	0.38	0,595 x 1,565	18414
	3 x 0.054	-	0.26	6,684	0.39	0,601 x 1,582	18004
	3 x 0.065	-	0.29	7,314	0.41	0,625 x 1,656	16318
	3 x 0.066	-	0.29	7,354	0.41	0,627 x 1,661	16216
	3 x 0.078	AWG8	0.31	7,984	0.44	0,652 x 1,735	14770
3 x 0.083	-	0.32	8,254	0.45	0,662 x 1,767	14209	
CELF 450F 5 kV	3 x 0.012	AWG7	0.13	3,194	0.27	0,499 x 1,276	28195
	3 x 0.013	AWG6	0.13	3,264	0.27	0,501 x 1,284	27785
	3 x 0.016	-	0.14	3,574	0.28	0,514 x 1,321	26069
	3 x 0.016	AWG5	0.14	3,664	0.29	0,517 x 1,332	25600
	3 x 0.021	AWG4	0.16	4,124	0.30	0,535 x 1,386	23393
	3 x 0.025	-	0.18	4,514	0.32	0,551 x 1,432	21740
	3 x 0.026	AWG3	0.18	4,624	0.32	0,555 x 1,445	21304
	3 x 0.033	AWG2	0.20	5,204	0.35	0,578 x 1,513	19211
	3 x 0.039	-	0.22	5,644	0.36	0,595 x 1,565	17824
	3 x 0.041	-	0.23	5,834	0.37	0,603 x 1,588	17269
	3 x 0.052	AWG1	0.26	6,544	0.40	0,630 x 1,671	15416
	3 x 0.054	-	0.26	6,684	0.40	0,636 x 1,688	15085
	3 x 0.065	AWG0	0.29	7,314	0.43	0,661 x 1,762	13724
	3 x 0.066	-	0.29	7,354	0.43	0,662 x 1,767	13642
	3 x 0.078	-	0.31	7,984	0.46	0,687 x 1,841	12467
3 x 0.083	-	0.33	8,254	0.47	0,698 x 1,873	12008	

Three-core ESP cable with 3/8" capillary tube



Type	Nominal cross-section and number of cores, pcs x mm ²	Compliance with American wire gauge	Tinned wire diameter		Core diameter, in	Capillary tube diameter	Overall dimensions in.	Length per reel type ft
			in.	mm				
CELF 450F 4 kV 3/8"	3 x 0.026	AWG5	0.18	4,624	0.30	3/8"	0,513 x 1,320	16407
	3 x 0.032	AWG4	0.20	5,204	0.32		0,536 x 1,388	14973
	3 x 0.052	AWG2	0.26	6,544	0.38		0,595 x 1,565	12303
	3 x 0.066	AWG1	0.29	7,354	0.41		0,627 x 1,661	11024
	3 x 0.078	-	0.31	7,984	0.44		0,652 x 1,735	10161
	3 x 0.083	AWG0	0.32	8,254	0.45		0,662 x 1,767	9824
CELF 450F 5 kV 3/8"	3 x 0.026	AWG5	0.18	4,624	0.32	3/8"	0,555 x 1,820	16407
	3 x 0.033	AWG4	0.20	5,204	0.35		0,578 x 1,888	14973
	3 x 0.052	AWG2	0.26	6,544	0.40		0,630 x 2,046	12303
	3 x 0.066	AWG1	0.29	7,354	0.43		0,662 x 2,142	11024
	3 x 0.078	-	0.31	7,984	0.46		0,687 x 2,216	10161
	3 x 0.083	AWG0	0.32	8,254	0.47		0,698 x 2,248	9824

All ESP cable can be customized on request

Cable modifications by corrosion resistance for reservoir fluid parameters and operating conditions

Parameter	Value				
	Cable armour material				
	GSTA Galvanized Steel Tape Armour	SS Stainless Steel	Monel - Monel Alloy		
Cable conductor continuous heating temperature, °F (°C) at least	450 (232)				
PH factor of production water	From 5.0 to 8.5 inclusive	From 3.0 to 9.0 inclusive	From 3.0 to 9.0 inclusive		
H ₂ S concentration, % (volumetrically)	≤ 0.075	≤ 0.075	≤ 0.075	> 0.075	
Partial pressure H ₂ S, Pa	≤ 345	≤ 345	> 345	**	
Amount of aggressive components, g/l, less than	H ₂ S	0,01	1.25	1.25	
	CO ₂	1.15	1.45	1.45	
	Cl ⁻	20	200	200	
	HCO ₃	1.0	1.25	more than 1.25	
	Ca ²⁺	2.00	9.00	2.00	
	(Na ⁺⁺ K ⁺)	-	40	-	
Absolute pressure, Pa, not less than	1.83•10 ⁶				
Gas content, nm ³ /m ³ , no more than	No restrictions				
Maximum content of associated water, %	100				
Density, g/m ³ , no more than	1400				
Maximum allowable pressure***, MPa	40				
<p>* PH = 0 is allowed for 6 hours or less</p> <p>** Parameters are not regulated</p> <p>*** By agreement on individual contracts with a maximum working pressure up to 60 MPa</p>					

Testing voltage and insulation current

Rated cable voltage, kV	Test voltage, kV	Insulation leakage current for test voltage, A, no more than
3.3	18.0	5 · 10 ⁻⁵
4.0	22.0	
5.0	24.0	

Requirements of resistance to mechanical impact

- Cable is resistant to bending when wound on a cylinder with a diameter equal to 15 times the maximum cable diameter. The diameter of the cable is taken as a value equal to the ratio of the maximum outer perimeter to pi.
- Cable with a core cross section of 8 mm² will withstand a crushing load of at least 98 kN (10 ton-force). Cable with a core cross section of 10 mm² or more will withstand a crushing load of 158 kN (16 ton-force).
- Insulated conductors are longitudinally sealed against a fluid pressure drop of 0.02 MPa per meter.

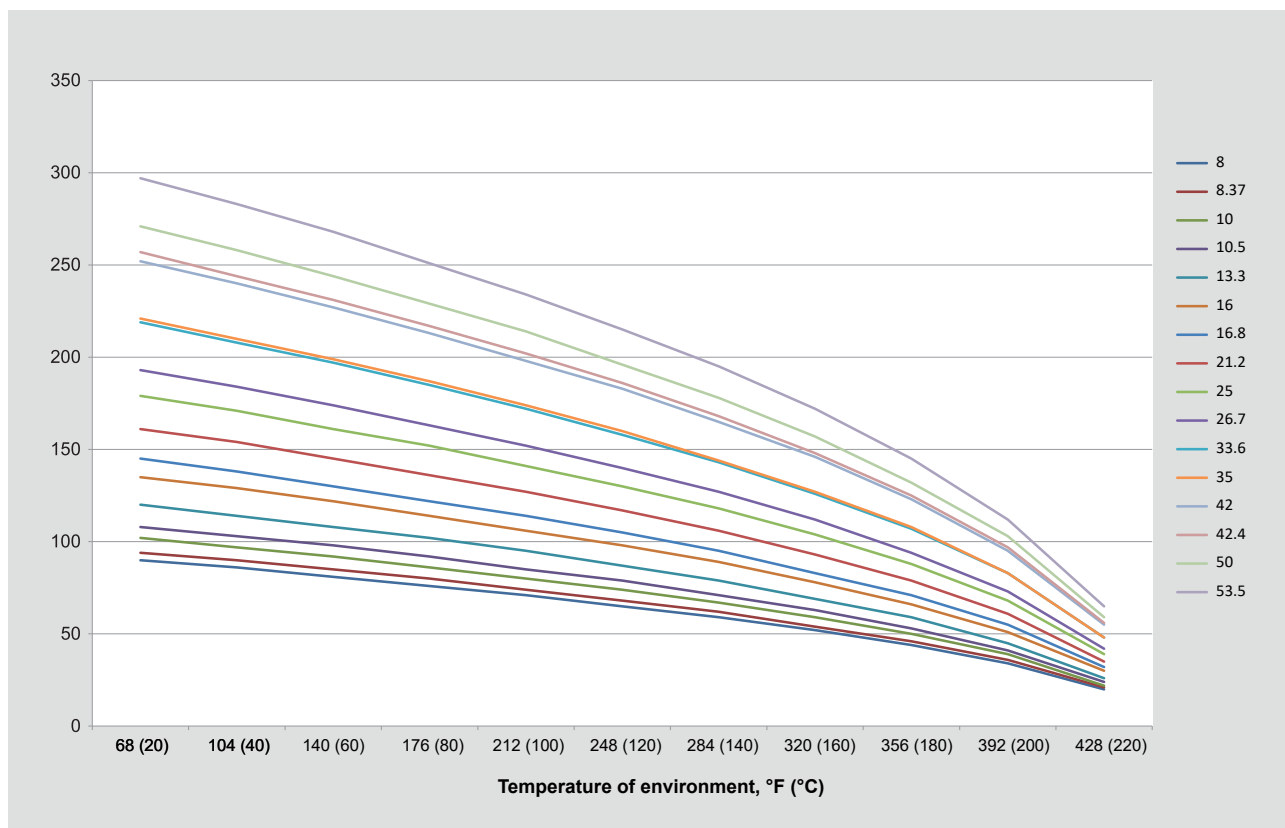
Requirements for resistance to environmental conditions

- During transportation and storage, cable is resistant to temperatures as low as -60°C (-76°F) and as high as 232°C (450°F).
- While being deployed, the cable can withstand winding around a reel with a diameter equal to 15 times the maximum cable diameter, at temperatures above -40°C (-40°F) and below 90°C (194°F).

Continuous current depending on core cross section

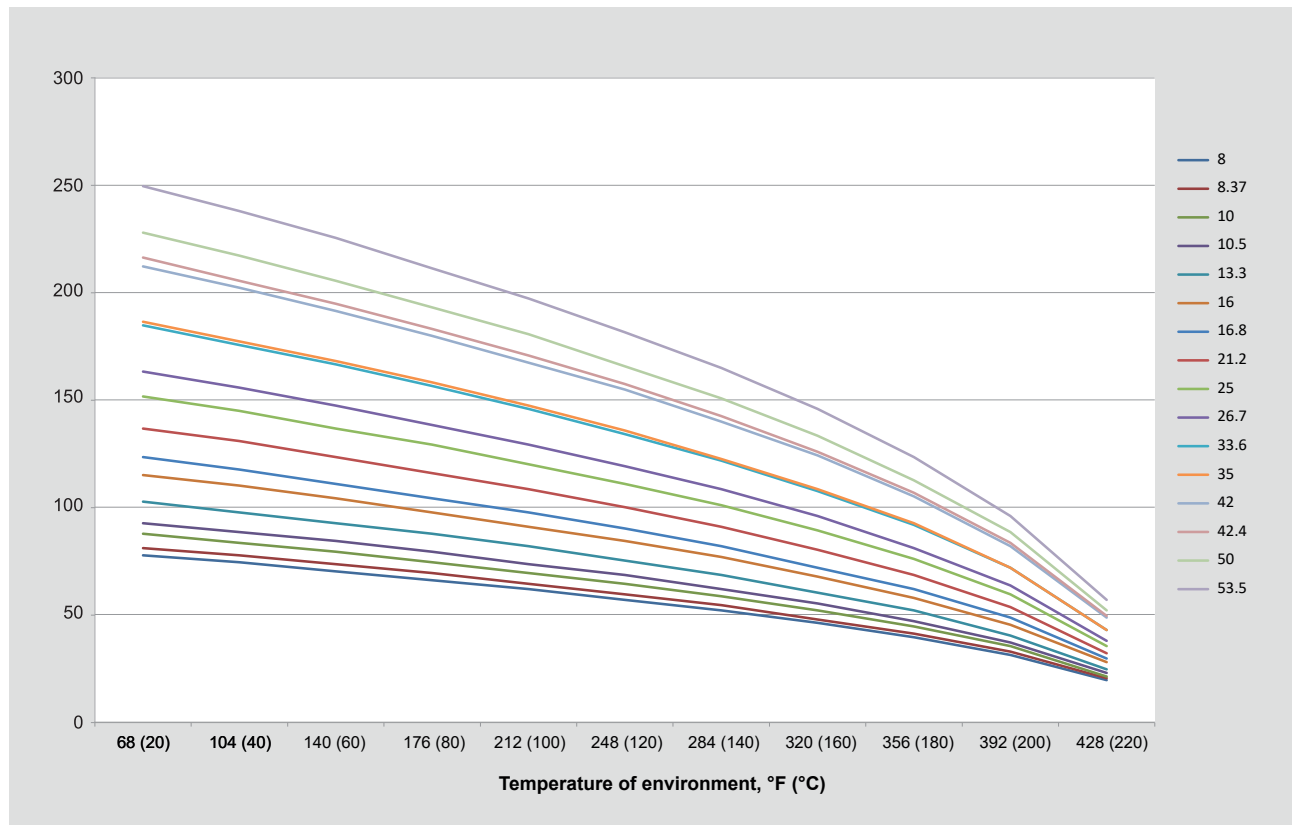
in reservoir fluid

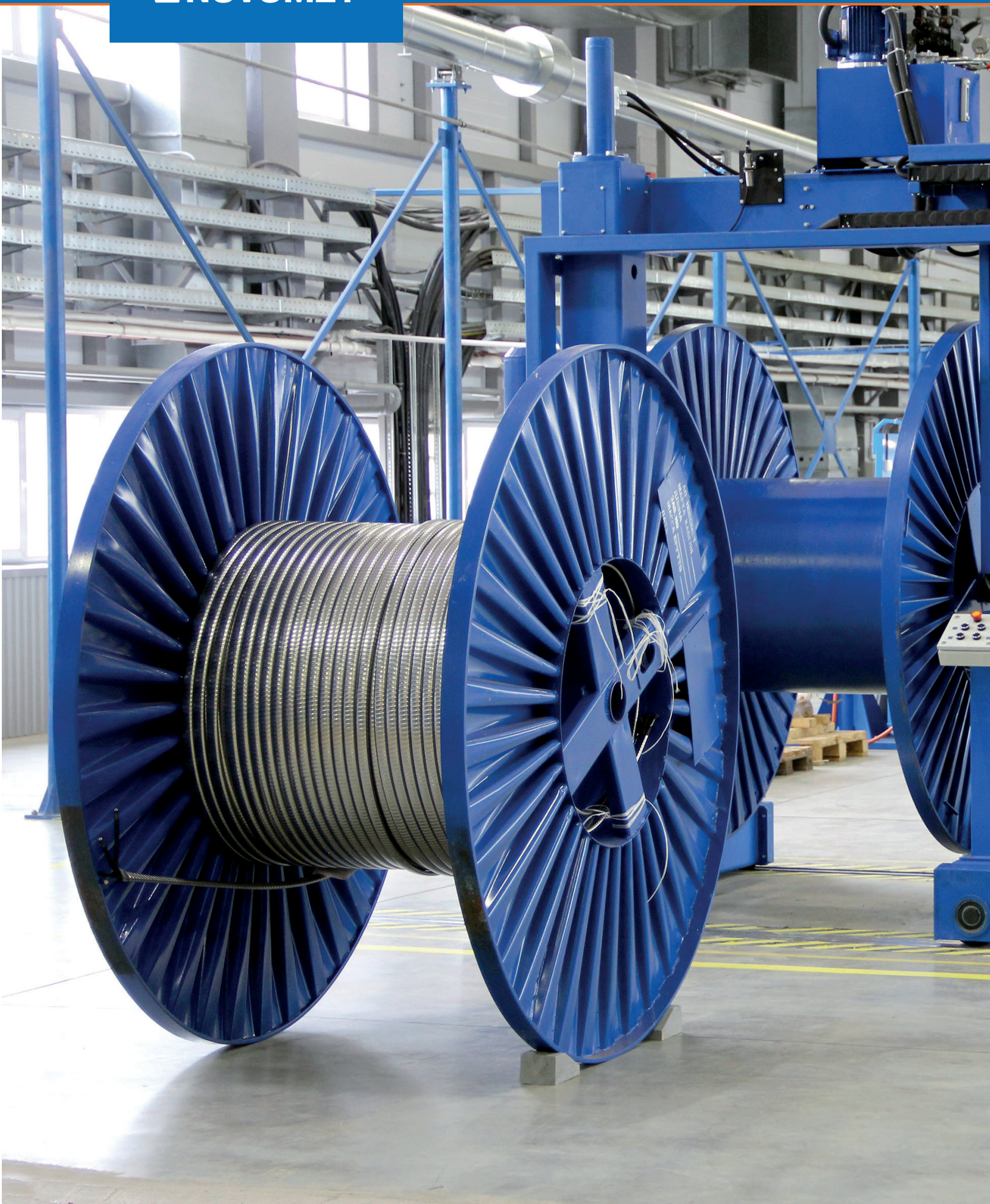
Temperature °F (°C)	Continuous load current (A, not less than) depending on the cross-section of the conductive core (mm ² in reservoir fluid)															
	8.00	8.37 AWG8	10.00	10.50 AWG7	13.30 AWG6	16.00	16.80 AWG5	21.20 AWG4	25.00	26.70 AWG3	33.60 AWG2	35.00	42.00	42.40 AWG1	50.00	53.50 AWG0
68 (20)	90	94	102	108	120	135	145	161	179	193	219	221	252	257	271	297
104 (40)	86	90	97	103	114	129	138	154	171	184	208	210	240	244	258	283
140 (60)	81	85	92	98	108	122	130	145	161	174	197	199	227	231	244	268
176 (80)	76	80	86	92	102	114	122	136	152	163	185	187	213	217	229	251
212 (100)	71	74	80	85	95	106	114	127	141	152	172	174	198	202	214	234
248 (120)	65	68	74	79	87	98	105	117	130	140	158	160	183	186	196	215
284 (140)	59	62	67	71	79	89	95	106	118	127	143	144	165	168	178	195
320 (160)	52	54	59	63	69	78	83	93	104	112	126	127	146	148	157	172
356 (180)	44	46	50	53	59	66	71	79	88	94	107	108	123	125	132	145
392 (200)	34	36	39	41	45	51	55	61	68	73	83	83	95	97	103	112
428 (220)	20	21	22	24	26	30	32	35	39	42	48	48	55	56	59	65



in gassy environments

Temperature °F (°C)	Continuous load current (A, not less than) depending on the cross-section of the conductive core (mm ² in gassy environments)															
	8.00	8.37 AWG8	10.00	10.50 AWG7	13.30 AWG6	16.00	16.80 AWG5	21.20 AWG4	25.00	26.70 AWG3	33.60 AWG2	35.00	42.00	42.40 AWG1	50.00	53.50 AWG0
68 (20)	77	81	87	93	103	115	123	137	152	164	185	186	212	216	228	249
104 (40)	74	77	83	88	98	110	117	131	145	156	176	177	202	205	217	237
140 (60)	70	73	79	84	92	104	111	123	137	147	166	168	191	194	205	224
176 (80)	65	68	74	79	87	98	104	116	129	138	156	157	179	182	192	211
212 (100)	61	64	69	73	81	91	97	108	120	129	145	146	167	170	179	196
248 (120)	56	59	63	67	74	84	89	99	110	118	134	135	154	156	165	180
284 (140)	51	53	57	61	67	76	81	90	100	107	121	122	139	141	149	163
320 (160)	45	47	50	54	59	67	71	79	88	94	107	107	123	125	131	144
356 (180)	38	40	43	45	50	56	60	67	74	80	90	91	104	105	111	122
392 (200)	29	31	33	35	39	44	47	52	58	62	70	70	80	82	86	94
428 (220)	17	18	19	20	22	25	27	30	33	36	40	41	46	47	50	54





Estimated cable weight

4kV cable

	Nominal core cross-section		Estimated weight of 1 km of cable	
	mm ²	in ²	kg	lb
CELF 450F 4 kV	8.00	0.0124	989	2563,98
	8.37	0,0130	1005	2605,86
	10.00	0.0155	1079	2797,67
	10.50	0.0163	1101	2854,99
	13.30	0.0206	1218	3159,22
	16.00	0.0248	1323	3432,6
	16.80	0.0260	1354	3511,96
	21.20	0,0329	1522	3948,48
	25.00	0.0388	1681	4360,74
	26.70	0.0414	1743	4519,48
	33.60	0.0521	1982	5141,18
	35.00	0.0543	2032	5269,05
	42.00	0.0651	2262	5866,50
	42.40	0.0657	2277	5906,18
	50.00	0.0775	2523	6543,32
	53.50	0.0830	2632	6827,72
	CELF 450F 4 kV 3/8"	16.8 x 3	0.0260 x 3	4947
21.2 x 3		0.0329 x 3	5454	3948,48 x 3
33.6 x 3		0.0521 x 3	6831	5141,18 x 3
42.4 x 3		0.0657 x 3	7716	5906,18 x 3
50.0 x 3		0.0775 x 3	8454	6543,32 x 3
53.5 x 3		0.0830 x 3	8781	6827,72 x 3

5 kV cable

	Nominal core cross-section		Estimated weight of 1 km of cable	
	mm ²	in ²	kg	lb
CELF 450F 5 kV	8.00	0.0124	2239	2764,6
	8.37	0.0130	2287	2808,69
	10.00	0.0155	2396	3002,7
	10.50	0.0163	2428	3060,02
	13.30	0,0206	2598	3366,46
	16.00	0.0248	2747	3644,24
	16.80	0.0260	2790	3723,61
	21.20	0.0329	3024	4166,74
	25.00	0.0388	3210	4523,89
	26.70	0.0414	3292	4682,62
	33.60	0.0521	3612	5308,73
	35.00	0.0543	3676	5436,6
	42.00	0.0651	3977	6038,46
	42.40	0,0657	3998	6078,14
	50.00	0.0775	4314	6719,69
	53.50	0,0830	4453	7006,29
	CELF 450F 5 kV 3/8"	16.8 x 3	0.0260 x 3	9832
21.2 x 3		0.0329 x 3	10524	4166,74 x 3
33.6 x 3		0.0521 x 3	13443	5308,73 x 3
42.4 x 3		0.0657 x 3	13491	6078,14 x 3
50.0 x 3		0.0775 x 3	14391	6719,69 x 3
53.5 x 3		0.0829 x 3	14811	7006,29 x 3



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