2.2 Submarine Cable Design Sheet – 1,000 MW

DC Voltage	±320 kV	
Conductor		
Type / material	profiled strands / copper	
Cross-section	2,500 mm^2	
Water blocking	compound	
Diameter	2.27 inches	(57.6 mm)
Conductor binder		
Material	semi-conductive swelling tape	
Thickness	24 mils	(0.6 mm)
Conductor shield		
Material	semi-conductive polymer	
Thickness	59 mils	(1.5 mm)
Insulation		
Material	cross-linked DC polymer	
Thickness	709 mils	(20 mm)
Insulation shield		
Material	semi-conductive polymer	
Thickness	55 mils	(1.4 mm)
Longitudinal water barrier		
Material	semi-conducting swell-able tape	
Thickness	24 mils	(0.6 mm)
Metallic sheath		
Type / material	extruded / lead alloy	
Thickness	114 mils	(2.9 mm)
Inner sheath		
Material	high-density polyethylene	
Thickness	98 mils	(2.5 mm)
Tensile armour		
Type / material	wire / steel	
Thickness	197 mils	(5 mm)
Outer serving		
Material	polypropylene yarn, 2 layers	
Thickness	157 mils	(4 mm)
Complete cable		
Diameter	5.31 inches	(135 mm)
Weight in air	35.2 lbs./ft.	(52.4 kg/m)
Weight in water	25.6 lbs./ft.	(38.1 kg/m)

Note: All data shall be considered nominal

2.3 Electrical Cable Properties

The submarine cable has the following electrical properties:

Rated continuous DC voltage, U_0	320 kV
Switching impulse withstand level (SIWL) started from U_0	698 kV
Subtractive SIWL started from U_0 to voltage at opposite polarity	378 kV
Rated continuous current under the installation conditions set out in Sections 2.5 and 2.6 below	1,638 A
Maximum conductor temperature in normal operation	70 °C
DC resistance at 20 °C	0.0022 ohm/1,000 ft. (0.0072 ohm/km)
DC resistance at maximum conductor temperature	0.0027 ohm/1,000 ft. (0.0087 ohm/km)
Losses at rated current	7.1 W/ft. and cable (23.3 W/m)
Capacitance	0.085 μF/1,000 ft. (0.28 μF/km)
Inductance (between conductor and metallic sheath)	0.039 mH/1,000 ft. (0.127 mH/km)
Surge impedance	21.4 ohm
Maximum permissible short-circuit current in the conductor during 0.2 s for 70 °C initial conductor temperature	24 kA
Maximum permissible short-circuit current in the metallic sheath during 0.2 s for 70 °C initial conductor temperature	12 kA

2.4 Mechanical Cable Properties

Weight of cable	
- in air	≈ 35.2 lbs./ft. (52.4 kg/m)
- in water	≈ 25.6 lbs./ft. (38.1 kg/m)
Maximum water depth	380 feet (116 m) near MP 54
Minimum bending radius	
- at laying (high tension)	6.4 feet (2.0 m)
- at handling (low tension)	5.1 feet (1.6 m)
Minimum coiling diameter	40.0 feet (12.2 m)
Maximum pulling force	47,200 lbs. (210 kN)
Maximum side wall pressure[1)]	6,000 lbs./ft. (90 kN/m)
[1)] $SWP = \frac{Pulling\ Force}{Bending\ Radius}$	

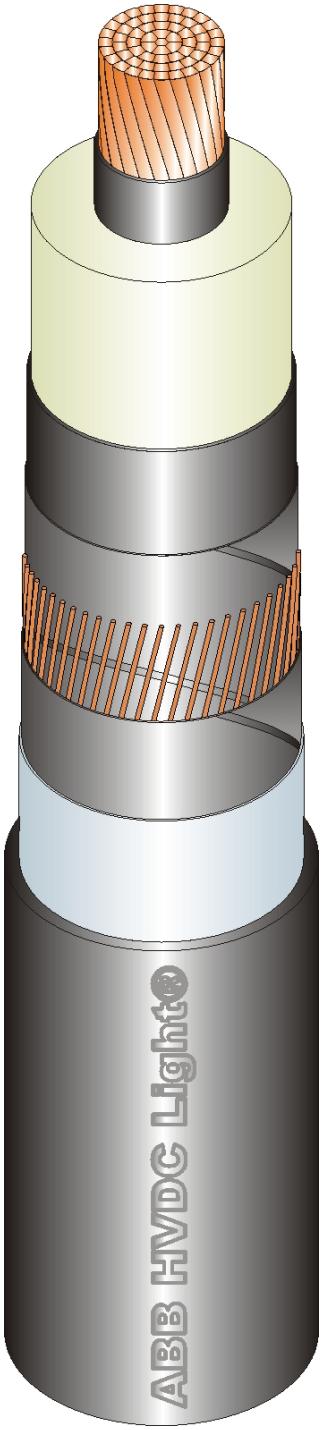
2.5 Installation Conditions

The submarine cables will either be surface laid at water depths equal to or greater than 150 ft., buried in the lake bed at water depths less than 150 feet, or installed in HDDs at the landing site. Table 1 summarizes the assumed design conditions for the submarine cable segment in Lake Champlain:

Type of Installation	Burial Depth (Top of Cable)	Cable Separation at Maximum Burial Depth (C-C)	Temp (°C)	Thermal Resistivity (K.cm./W)
Underwater trench	5 ft. (1533 mm)	Zero (0)	20	154
HDD, PE 12", grouted	15 ft. (4,572 mm)	30 ft. (9,144 mm)	20	154

Table 1: Assumed ambient design conditions for submarine cable in Lake Champlain

2.2 Underground Cable Design Sheet – 1,000 MW



DC Voltage	±320 kV	
Conductor		
Type / material	profiled stands / copper	
Cross-section	2,500 mm^2	
Water blocking	compound or swelling tape	
Diameter	2.27 inches	(57.6 mm)
Conductor binder		
Material	semi-conductive swelling tape	
Thickness	24 mils	(0.6 mm)
Conductor shield		
Material	semi-conductive polymer	
Thickness	59 mils	(1.5 mm)
Insulation		
Material	cross-linked DC polymer	
Thickness	709 mils	(18 mm)
Insulation shield		
Material	semi-conductive polymer	
Thickness	55 mils	(1.4 mm)
Longitudinal water barrier		
Material	semi-conducting swell-able tape	
Thickness	24 mils	(0.6 mm)
Metallic screen		
Type / material	round wires / copper	
Thickness	39.4 mils	(1.0 mm)
Total cross-section	35 mm^2	
Longitudinal water barrier		
Material	semi-conducting swell-able tape	
Thickness	24 mils	(0.6 mm)
Radial moisture/water barrier		
Type / material	longitudinal applied foil / Aluminium	
Thickness	7.9 mils	(0.2 mm)
Outer jacket		
Material	high-density polyethylene	
Thickness	189 mils	(4.8 mm)
Complete cable		
Diameter	4.6 inches	(117 mm)
Weight	20.2 lbs./ft.	(30.1 kg/m)

Note: All data shall be considered nominal

2.3 Electrical Cable Properties

The underground cable has the following electrical properties:

Rated continuous DC voltage, U_0	320 kV
Switching impulse withstand level (SIWL) started from U_0	698 kV
Subtractive SIWL started from U_0 to voltage at opposite polarity	378 kV
Rated continuous current under the installation conditions set out in Sections 2.5 - 2.11 below	1,638 A
Maximum conductor temperature in normal operation	70 °C
DC resistance at 20 °C	0.0022 ohm/1,000 ft. (0.0072 ohm/km)
DC resistance at maximum conductor temperature	0.0027 ohm/1,000 ft. (0.0087 ohm/km)
Losses at rated current	7.09 W/ft. per cable (23.3 W/m)
Capacitance	0.091 μF/1,000 ft. (0.30 μF/km)
Inductance (between conductor and metallic screen)	0.036 mH/1,000 ft. (0.117 mH/km)
Surge impedance	19.6 ohm
Maximum permissible short-circuit current in the conductor during 0.2 s for 70 °C initial conductor temperature	24 kA
Maximum permissible short-circuit current in the metallic sheath during 0.2 s for 70 °C initial conductor temperature	12 kA

2.4 Mechanical Cable Properties

Weight of cable	
- in air	≈ 20.2 lbs./ft. (30.1 kg/m)
Minimum bending radius	
- at laying	6.9 feet (2.1 m)
- at handling (low tension)	4.6 feet (1.4 m)
- installed	4.6 feet (1.4 m)
Maximum pulling force	39,300 lbs. (175 kN)
Maximum side wall pressure[1)]	514 lbs./ft. (7.5 kN/m)
[1)] $SWP = \frac{Pulling\ Force}{Bending\ Radius}$	