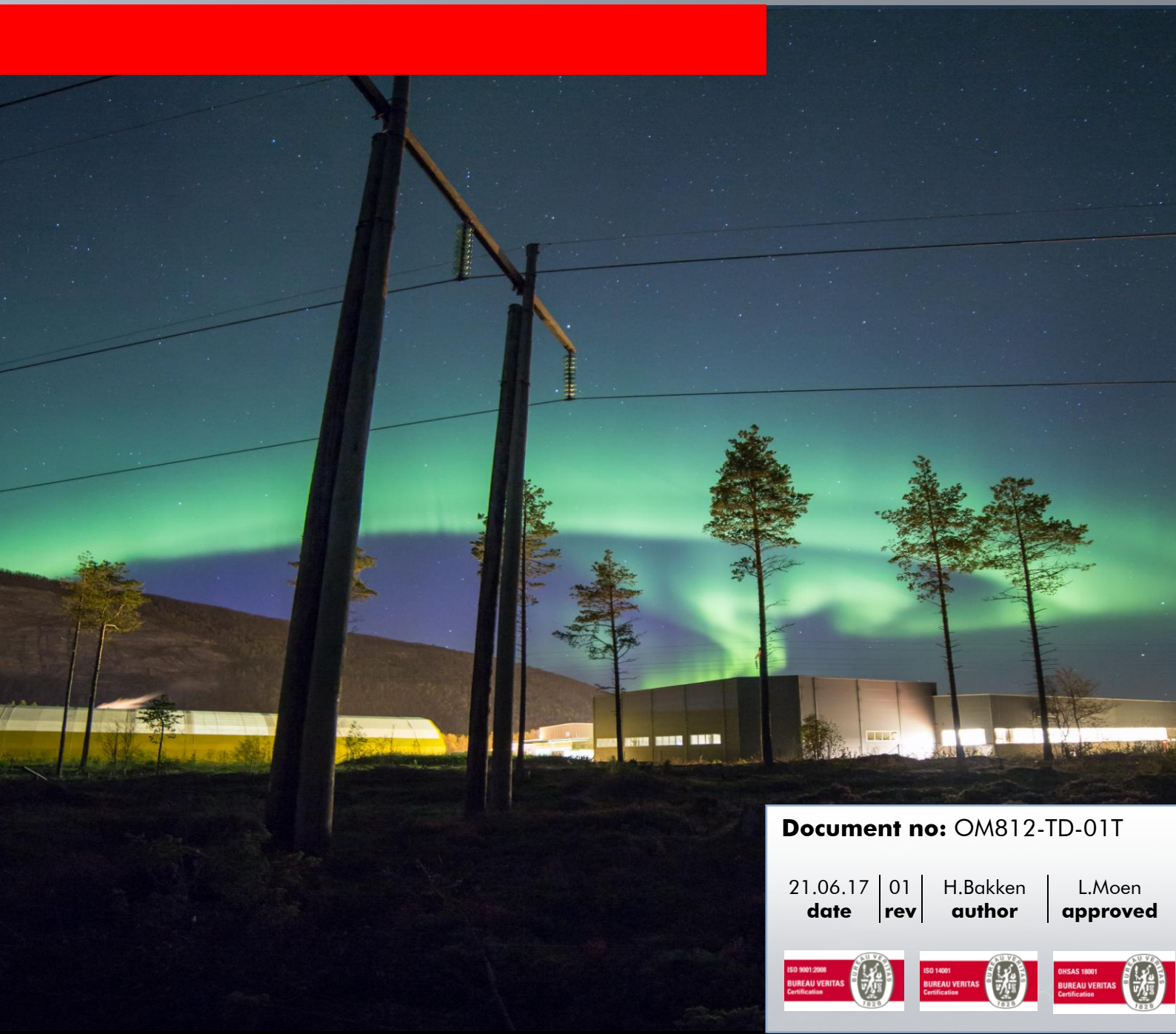
Technical Description (TD)

Medium voltage (MV) power & fibre optics
Subsea cable.



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21.06.17	01	H.Bakken	L.Moen
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ISO 9001:2008 BUREAU VERITAS Certification
ISO 14001 BUREAU VERITAS Certification
OHSAS 18001 BUREAU VERITAS Certification

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1 INTRODUCTION

This document describes a Nexans standard Medium Voltage subsea power cable. Optical fibres can be included upon request. Utilising the common nomenclature $U_0/U(U_{max})$[1], the following voltage ratings are covered in this document:

- $U_0/U(U_{max})$= 6/10(12)kV
- $U_0/U(U_{max})$= 12/20(24)kV
- $U_0/U(U_{max})$= 18/30(36)kV

NOTES:
1. Order of precedence: In the event of conflict between the content of this document and other specifications, this document takes precedence.
2. The quality is verified through a control activity plan (ref. TR-055-12) and the corresponding control activity description (ref. TR-088-12).

2 REVISION HISTORY

Rev.	Date	Amendments
01	21.06.17	Issued for Tender

3 REFERENCES

Document	Title
ISO9001	*Model for Quality Assurance in design/development, production, installation and servicing.*
ISO 13628-5:2009	Petroleum and natural gas industries-Design and operation of subsea production systems-Part 5 Subsea umbilicals.
REN spec 9302	Technical specification REN Subsea power cable. *(NO: Teknisk spesifikasjon REN sjøkabel)*
IEC 60228 (2004)	Conductors of insulated cables.
IEC 60502-2 (2014)	Power cables with extruded insulation and their accessories for rated voltages from 6 kV (U_m=7.2 kV) up to 30 kV (U_m=36kV).
IEC 60287-1-1	Calculation of continuous rating of cables.
TR-055-12	Standard inspection and test plan for cable manufacturing (Rognan factory).
TR-088-12	Standard test procedures for cable manufacturing (Rognan factory).
TR-066-16	Medium voltage standard elements.

[1] Ref IEC60502-2.

4 CABLE DESIGN

4.1 Functional elements

4.1.1 Power core

The electrical conductors are made of plain annealed Copper (Cu) as per ISO13628-5 section 7.2.5.3. The conductors are insulated with XLPE in accordance to IEC 60502-2, section 6.2.
A copper foil is bonded to an extruded sheath of semiconducting polyethylene. The foil serves as both metal screen and radial waterblocking for the power core. The sheath is in accordance to IEC 60502-2, section 14.3.

4.1.2 Fibre optical element

Multiple single mode fibres (G652) are encapsulated in a protective steel tube together with a hygroscopic filling compound. The final diameter of the element is tuned to match the primary interstice of the main assembly by extruding an outer polyolefin sheath.

4.2 Element lay up

The insulated conductors are assembled by a qualified assembly technique as per ISO13628-5 section 7.2.5.6.
In the assembly process, the interstices are filled with compatible solid PE fillers (and optical fibre elements if applicable) to achieve a consolidated arrangement, as per ISO13628-5 section 7.2.5.7.
Wrapping tape(s) are applied over the assembly.

4.3 Armouring

Protective layer(s) of galvanized steel wires is applied over the inner covering. Interstices are filled by bitumen for corrosion protection. The armour provides axial stiffness and crush resistance. Steel wire dimensions are according to IEC60502-2 section 13, and steel wire properties according to EN10257-2 and EN10244-2.
A number of steel wires can be replaced by zinc wires for additional corrosion protection.

4.4 Outer covering

An outer covering is applied over the armouring. The covering can be one of the following types (depending on the application):

- Extruded polymer (cylindrical layer)
- Bitumen filled textile tape and layer of polymer strings (helical layers)

The outer covering colour is by default black with a yellow stripe.
For unique identification, as per ISO13628-5 section 7.2.5.11, a text string is printed on the outer sheath with an interval of approximately one meter.

4.5 Cable Details

4.5.1 Assumptions for cable calculations

Maximum conductor temperature (long term): 90°C.
Short circuit temperature rating: 250°C.
Frequency: 50Hz.
Screens bonded at both ends and connected to earth.
Ambient temperature: 15°C.
Burial depth of cables: 1000mm.
Thermal resistivity of surroundings: 1.2Km/W

4.5.2 3-phase power cable, 6/10(12)kV

Conductor X-section [mm2]	16	25	35	50	70	95	120	150	185	240	300
Conductor diameter [mm]	4,8	6,0	7,0	8,2	9,9	11,5	12,9	14,3	16,0	18,4	20,5
Phase diameter [mm]	19,4	20,8	21,2	22,6	24,3	26,1	27,6	29,3	30,9	33,6	36,8
Screen cross sectional area [mm2]	12,7	13,6	13,9	14,9	16,2	17,5	18,6	19,7	21	22,9	24,5
Lay up diameter (3xUNIT-P) [mm]	42,6	45,7	46,5	49,5	53,2	57,1	60,3	64	67,4	73,3	80,1
Armour steel wires diameter [mm]	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Diameter over armour [mm]	51,0	54,1	54,9	57,9	61,6	65,5	68,7	72,4	75,8	81,7	88,6
Nominal outer diameter [mm]	57,0	60,1	60,9	63,9	67,6	71,5	74,7	78,4	81,8	87,7	94,6
Outer diameter tolerance [mm]	± 1.9	± 2.0	± 2.0	± 2.1	± 2.2	± 2.4	± 2.5	± 2.6	± 2.7	± 2.9	± 3.1
Conductor DC resistance [Ω/km]	1,15	0,727	0,524	0,387	0,268	0,193	0,153	0,124	0,099	0,075	0,06
Screen DC resistance [Ω/km]	1,354	1,265	1,237	1,154	1,062	0,983	0,925	0,873	0,819	0,751	0,702
Armour DC resistance [Ω/km]	0,37	0,35	0,35	0,32	0,30	0,28	0,27	0,26	0,24	0,23	0,21
Max current rating [A]	104	135	162	192	235	279	316	352	394	451	501
Short circuit current for 1s, conductor [kA]	2,5	3,9	5,4	7,6	10,5	14,2	17,8	22,2	27,3	35,3	44
Short circuit current for 1s, screen [kA]	2,0	2,1	2,2	2,3	2,5	2,7	2,8	3,0	3,2	3,5	3,7
Capacitance per phase [µF/km]	0,205	0,231	0,240	0,265	0,302	0,336	0,366	0,396	0,432	0,483	0,527
Dielectrical loss [W/m]	0,01	0,01	0,011	0,012	0,014	0,015	0,017	0,018	0,020	0,022	0,024
Charging current [A/km]	0,39	0,44	0,45	0,50	0,57	0,63	0,69	0,75	0,81	0,91	0,99
AC resistance [Ω/km]	1,46	0,923	0,665	0,492	0,341	0,246	0,195	0,158	0,127	0,097	0,078
Inductance per phase [mH/km]	0,468	0,437	0,41	0,391	0,368	0,353	0,341	0,332	0,32	0,309	0,306
Reactance [Ω/km]	0,147	0,137	0,129	0,123	0,116	0,111	0,107	0,104	0,101	0,097	0,096
Impedance [Ω/km]	1.47+0.147i	0.934+0.137i	0.676+0.129i	0.503+0.123i	0.353+0.116i	0.259+0.111i	0.209+0.107i	0.173+0.104i	0.142+0.101i	0.113+0.097i	0.095+0.096i
Cable weight in air [kg/m]	5,8	6,5	6,8	7,6	8,6	9,9	11,0	12,2	13,8	16,1	18,8
Cable weight in water [kg/m]	3,8	4,1	4,4	4,9	5,6	6,5	7,2	8,0	9,1	10,7	12,5
Min bending diameter [m]	1,5	1,6	1,6	1,7	1,8	2,0	2,1	2,2	2,3	2,5	2,7
Safe handling load [kN]	123	135	140	157	174	198	217	239	267	306	354

4.5.3 3-phase power cable, 12/20(24)kV

Conductor X-section [mm2]	16	25	35	50	70	95	120	150	185	240	300
Conductor diameter [mm]	4,8	6,0	7,0	8,2	9,9	11,5	12,9	14,3	16,0	18,4	20,5
Phase diameter [mm]	23,7	24,9	25,5	26,7	28,6	30,2	31,9	33,4	35,0	37,7	40,9
Screen cross sectional area [mm2]	15,7	16,7	17,0	17,9	19,3	20,5	21,6	22,7	24,1	26,0	27,6
Lay up diameter (3xUNIT-P) [mm]	51,9	54,5	55,8	58,4	62,5	65,9	69,6	72,8	76,3	82,1	89,0
Armour steel wires diameter [mm]	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Diameter over armour [mm]	60,3	62,9	64,2	66,8	70,9	74,3	78,0	81,2	84,7	90,5	97,4
Nominal outer diameter [mm]	66,3	68,9	70,2	72,8	76,9	80,3	84,0	87,2	90,7	96,5	103,4
Outer diameter tolerance [mm]	± 2.2	± 2.3	± 2.3	± 2.4	± 2.5	± 2.6	± 2.8	± 2.9	± 3.0	± 3.2	± 3.4
Conductor DC resistance [Ω/km]	1,15	0,727	0,524	0,387	0,268	0,193	0,153	0,124	0,099	0,075	0,060
Screen DC resistance [Ω/km]	1,096	1,030	1,012	0,961	0,891	0,839	0,796	0,758	0,714	0,662	0,623
Armour DC resistance [Ω/km]	0,31	0,30	0,29	0,28	0,26	0,25	0,24	0,23	0,22	0,21	0,19
Max current rating [A]	101	131	158	188	231	275	311	348	390	446	496
Short circuit current for 1s, conductor [kA]	2,5	3,9	5,4	7,6	10,5	14,2	17,8	22,2	27,3	35,3	44
Short circuit current for 1s, screen [kA]	2,5	2,7	2,7	2,8	3,0	3,2	3,3	3,5	3,7	4,0	4,2
Capacitance per phase [µF/km]	0,149	0,166	0,171	0,188	0,211	0,233	0,252	0,271	0,294	0,326	0,355
Dielectrical loss [W/m]	0,027	0,030	0,031	0,034	0,038	0,042	0,046	0,049	0,053	0,059	0,064
Charging current [A/km]	0,56	0,62	0,65	0,71	0,80	0,88	0,95	1,02	1,11	1,23	1,34
AC resistance [Ω/km]	1,46	0,923	0,665	0,492	0,341	0,246	0,195	0,158	0,127	0,097	0,078
Inductance per phase [mH/km]	0,508	0,473	0,447	0,425	0,401	0,382	0,370	0,358	0,345	0,332	0,327
Reactance [Ω/km]	0,160	0,149	0,140	0,133	0,126	0,120	0,116	0,113	0,108	0,104	0,103
Impedance [Ω/km]	1.472+0.16i	0.936+0.149i	0.678+0.14i	0.505+0.133i	0.355+0.126i	0.26+0.12i	0.21+0.116i	0.174+0.113i	0.143+0.108i	0.115+0.104i	0.097+0.103i
Cable weight in air [kg/m]	7,2	7,9	8,3	8,9	10,1	11,4	12,6	13,8	15,3	17,8	20,6
Cable weight in water [kg/m]	4,3	4,7	5,0	5,3	6,1	7,0	7,7	8,5	9,5	11,2	13,0
Min bending diameter [m]	1,8	1,9	1,9	2,0	2,1	2,2	2,3	2,4	2,5	2,7	2,9
Safe handling load [kN]	145	157	165	175	196	220	239	260	285	328	376

4.5.4 3-phase power cable, 18/30(36)kV

Conductor X-section [mm2]	50	70	95	120	150	185	240	300
Conductor diameter [mm]	8,2	9,9	11,5	12,9	14,3	16,0	18,4	20,5
Phase diameter [mm]	31,8	33,5	35,3	36,8	38,5	40,1	42,8	46,0
Screen cross sectional area [mm2]	21,6	23,0	24,2	25,3	26,4	27,8	29,6	31,3
Lay up diameter (3xUNIT-P) [mm]	69,4	73,0	76,9	80,1	83,8	87,3	93,1	100,0
Armour steel wires diameter [mm]	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Diameter over armour [mm]	77,8	81,4	85,3	88,6	92,2	95,7	101,5	108,4
Nominal outer diameter [mm]	83,8	87,4	91,3	94,6	98,2	101,7	107,5	114,4
Outer diameter tolerance [mm]	± 2.8	± 2.9	± 3,0	± 3.1	± 3.2	± 3.4	± 3.5	± 3.8
Conductor DC resistance [Ω/km]	0,387	0,268	0,193	0,153	0,124	0,099	0,075	0,060
Screen DC resistance [Ω/km]	0,796	0,748	0,711	0,680	0,652	0,619	0,581	0,550
Armour DC resistance [Ω/km]	0,24	0,23	0,22	0,21	0,20	0,19	0,18	0,17
Max current rating [A]	183	226	270	306	342	384	440	491
Short circuit current for 1s, conductor [kA]	7,6	10,5	14,2	17,8	22,2	27,3	35,3	44
Short circuit current for 1s, screen [kA]	3,4	3,6	3,8	4,0	4,1	4,3	4,6	4,8
Capacitance per phase [µF/km]	0,146	0,163	0,178	0,192	0,205	0,221	0,244	0,263
Dielectrical loss [W/m]	0,060	0,066	0,073	0,078	0,084	0,09	0,099	0,107
Charging current [A/km]	0,83	0,92	1,01	1,08	1,16	1,25	1,38	1,49
AC resistance [Ω/km]	0,492	0,341	0,246	0,195	0,158	0,127	0,097	0,078
Inductance per phase [mH/km]	0,460	0,432	0,413	0,398	0,387	0,372	0,357	0,350
Reactance [Ω/km]	0,144	0,136	0,130	0,125	0,121	0,117	0,112	0,110
Impedance [Ω/km]	0.507+0.144i	0.357+0.136i	0.262+0.13i	0.212+0.125i	0.176+0.121i	0.145+0.117i	0.116+0.112i	0.098+0.11i
Cable weight in air [kg/m]	10,9	12,0	13,4	14,6	16,0	17,5	20,1	22,9
Cable weight in water [kg/m]	6,0	6,7	7,5	8,2	9,1	10,1	11,8	13,4
Min bending diameter [m]	2,3	2,4	2,6	2,7	2,8	2,9	3,0	3,3
Safe handling load [kN]	204	221	245	264	289	314	357	401

4.6 Drawing of cable (conceptual)