TECHNICAL REPORT

HANDLING/INSTALLATION GUIDELINES FOR DYNAMIC CABLES			**Date:** 20.05.2005 **Issue no:** 08 **Case no:**
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Summary:

This document describes handling and installation guidelines for dynamic cables manufactured by Nexans Norway AS Building and Telecom Cables Division. Nexans recommend using these guidelines in order to prevent injuries to equipment and personnel, and to provide efficient service and prolong the cable lifetime.

The following topics are covered in this document:

- GENERAL
  - Definitions
  - Cleaning and chemical restrictions
  - Handling storage and transportation
  - Cable heating and temperature monitoring
  - Incidents
  - Recycling of cables
- TERMINATION OF FIBRE OPTIC STEEL TUBES
- SPOOLING
- STEEL ARMOURED CABLES
- ARAMID ARMOURED CABLES
- FREE SWIMMING / NON-LIFTING OPERATIONS

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1 GENERAL

1.1 INTRODUCTION

This document describes handling and installation guidelines for dynamic cables manufactured by Nexans Norway AS Building and Telecom Cables Division.

1.2 DEFINITIONS

1.2.1 Safe Working Load (SWL)

Safe working load or SWL, is the maximum load that the cable shall be exposed to. The SWL is specified in the cable technical description.

Handling within the specified SWL prevents injuries to personnel and equipment, and provides efficient service and prolongs the cable lifetime.

1.2.2 Breaking strength

Calculated breaking strength of a new undamaged cable. The breaking strength is specified in the cable technical description.

A cable must never be stressed anywhere near its breaking strength. Throughout the cable lifetime, the braking strength will continually be reduced due to fatigue, shock loads, bending, corrosion, etc.

1.2.3 Minimum bending diameter

A cable must never be bent below minimum bending diameter. The minimum bending diameter is specified in the cable technical description.

Handling within the specified minimum bending diameter prevents injuries to personnel and equipment, and provides efficient service and prolongs the cable lifetime.

1.2.4 Fleet angle

The fleet angle is defined as in Figure 1-1: Fleet angle. It should be noted that handling at large fleet angles in combination with small bending diameters over the level wind decrease the fatigue lifetime of the cable.

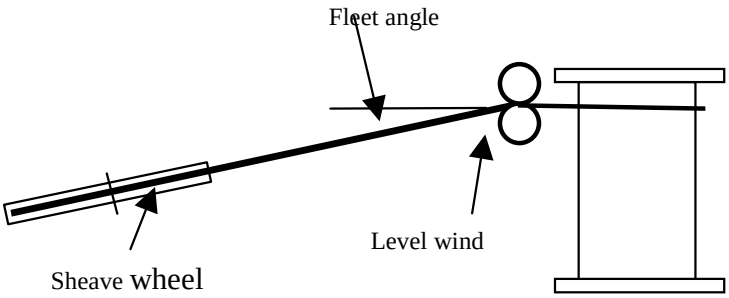


Figure 1-1: Fleet angle

1.2.5 Lay direction

Figure 1-2: Left hand lay

Figure 1-3: Right hand lay

1.2.6 Spooling direction

The spooling direction depends on the outer armouring lay direction as follows:

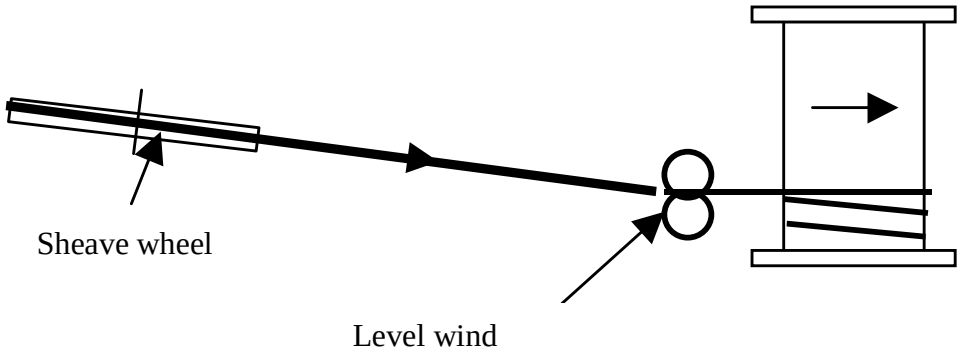


Figure 1-4: Right hand lay

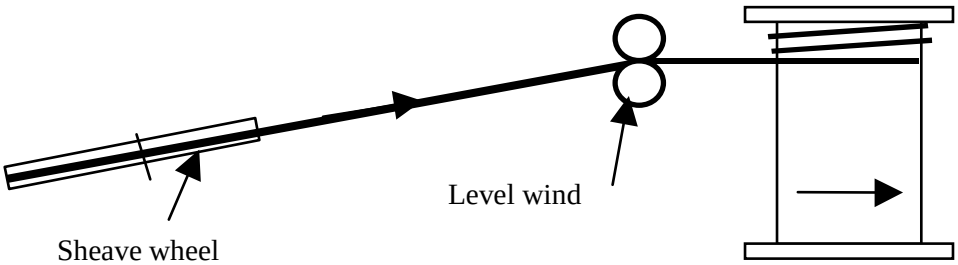


Figure 1-5: Left hand lay

1.3 CLEANING AND CHEMICAL RESTRICTIONS

1.3.1 Solvents

Polymer materials should only be exposed to solvents for short periods, for instance during termination work. Maximum exposure time is 0.5 hours at elevated temperatures and 1 hour at room temperature. Other safety measures, such as breathing precautions and flammability must be adhered to when using solvents.

The following solvents that can be regarded as safe at the given temperatures:

Solvent:	Comments:	Description:
White spirit	Low aromatic 15-20% Best at max 40°C	Coarse removal of: - RBFC - Petroleum jelly - ROV Shell grease
Refined lamp oil White spirit Dedicated TCD[1]	Best at 20°C Best at 40°C -	Coarse removal of: - Thermo-elastic filling compound ("soft adhesive filling compound")
Isopropanol Alcohol Genklene Triclorethane		Finish: - RBFC - Petroleum jelly - ROV Shell grease - Thermo-elastic filling compound ("soft adhesive filling compound")

1.3.2 Oil filled termination boxes

NOTE: TPR (typically used as tether outer sheath material) is non-compatible to oil products. Thus the outer sheath may extend to, but not into the oil filled junction box. The cable must penetrate into the junction box on an inner sheath level. This prevents oil from penetrating the aramid armouring and water penetrating along the aramid armouring into the termination box.

[1] Subsea Supplies Ltd, Aberdeen, e-mail: info@subsea-supplies.co.uk

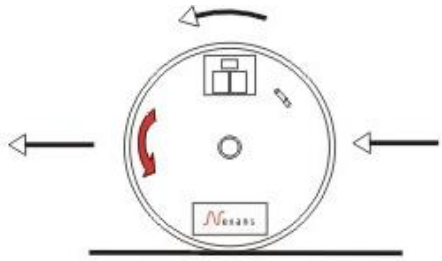
1.4 HANDLING, STORAGE AND TRANSPORTATION

All drums must stored with vertical flanges on a base that can resist the pressure from the flanges. Wooden drums must not be stored on a wet base for long periods (e.g. on soil).

1.4.1 Rolling direction

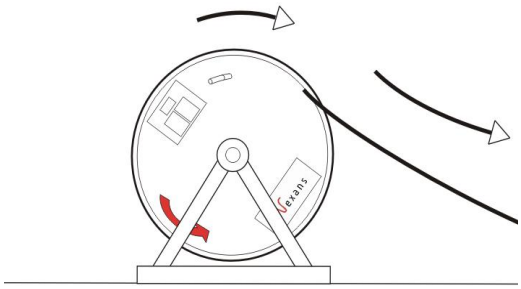
All cable drums shall be rolled in the direction indicated by the arrow on the drum flange.

Rolling in the opposite direction can loosen the cable wraps, complicating further cable handling.



1.4.2 Spooling direction

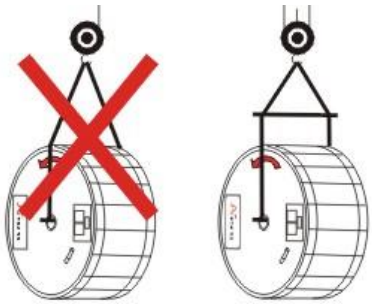
All cable spooling from the drum shall be performed in the opposite direction of the arrow on the drum flange.



1.4.3 Drum lifting

When lifting a drum with wires, separator rods shall be used to avoid damaging stressing of the drum flanges.

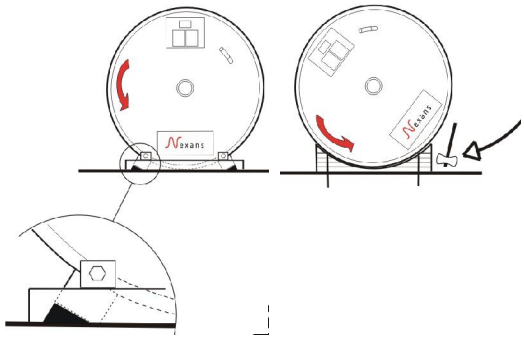
The inner cable end can be fixed on the outside of the drum flange. Loads in this area must be avoided.



Fork lifting of drums shall be performed as indicated in the shown instructions.

Large drums can be fitted with cradles especially equipped for fork lifting.

1.4.4 Securing drums



Drums shall be secured from unintended rolling by use of wooden stoppers or steel cradles.

During transport wooden stopper and cradles must be fixed to the base. Additionally, the drum itself must be secured using other fixtures (e.g. chains) according to good workmanship and legislation.

1.4.5 Storage requirements

Storage within the following requirements prevents cable degradation and prolongs the cable lifetime:

Item	Description
Temperature range	-20°C to +50°C
Sun radiation	Long term storage in direct sunlight must be avoided.
Petroleum products	Outer sheath: Remove any oil remains with a degreaser prior to storage.
Corrosion	Steel armouring: Remove any salt remains using fresh water, drying and reapply grease prior to storage.

1.5 CABLE HEATING AND TEMPERATURE MONITORING

1.5.1 General

Electrical powering of cables always induces cable heating. The heat generally increases with the increasing current and conductor resistance. Additionally the resistance increases with temperature, leading to further cable heating.

The cable temperature must never exceed the specified temperature range. In most cases the polymer materials dictate the temperature range of a cable. Typically the rate of degradation of polymers is doubled every 8-10°C. Note also that excess heating can cause total melting of the polymers, leading to cable failure. The temperature range for some typical insulation materials is as follows:

Polyethylene (PE):	<70°C
Polypropylene (PP):	<90°C
Fluorinated Ethylene Propylene (FEP):	<205°C

1.5.2 Temperature monitoring

The heat dissipation of a cable system depends on a wide range of parameters (cable and winch design, water temperature, weather conditions, etc…) thus it is hard to specify accurate cooling requirements. Generally steel armoured cables have higher heat conductivity than aramid armoured cables, and are thus easier to cool down.

To avoid cable degradation due to excess heating, it is recommended to monitor the cable temperature during operation. This can be done by using a fibre Bragg grating temperature-monitoring system, or by measuring the loop resistance of two conductors.

Nexans can provide a fibre Bragg grating temperature-monitoring system upon request. This system comprises of discrete sensor points (fibre Bragg gratings) being monitored using a FOS&S interrogation unit. The accuracy is better than ±1°C.

Nexans can also provide software (VinsjMot.exe) calculating the cable temperature from the loop resistance in a pair. This calculates the average temperature along the cable length, and can not detect any local overheated areas (e.g. on the winch). The accuracy is approximately ±10°C.

1.6 CABLE MARKING

Element	**Marking**		
UNIT-P	First conductor: Blue Alternating: White, green, red, white,… Last conductor: Orange		
UNIT-SP	Conductor #1-#2: Blue, red Each pair identified with longitudinal numbering tape.		
UNIT-SQ	Pair #1: Blue, red Pair #2: White, green Each quad identified with longitudinal numbering tape.		
UNIT-FO	Natural	6MM fibres: 6SM fibres:	**With no rings:** Red, green, blue, yellow, white, natural **With two rings every 25mm:** Red, green, blue, yellow, white, natural
UNIT-FO	Natural	12SM fibres:	**With two rings every 25mm:** Red, green, blue, yellow, white, natural **With two rings every 50mm:** Red, green, blue, yellow, white, natural

Element	Marking				
UNIT-FO	**Fibre numbering code, 48 fibres[2]**				
Fibre colour	**0/0**	**1/50**	**1/25**	**2/50**	**2/25**
Red	1	13	22	31	40
Green	2	14	23	32	41
Blue	3	15	24	33	42
Yellow	4	16	25	34	43
White	5	17	26	35	44
Grey	6	NA	NA	NA	NA
Brown	7	NA	NA	NA	NA
Violet	8	NA	NA	NA	NA
Aqua	9	18	27	36	45
Black	10	NA	NA	NA	NA
Orange	11	19	28	37	46
Pink	12	20	29	38	47
Natural	NA	21	30	39	48
UNIT-FO	**Fibre numbering code, 96 fibres[2]**				
Fibre colour	**0/0**	**1/50**	**1/25**	**2/50**	**2/25**	**1/100**	**2/200**	**3/50**	**3/300**	**4/50**	**4/100**
Red	1	13	22	31	40	49	58	67	76	85	94
Green	2	14	23	32	41	50	59	68	77	86	95
Blue	3	15	24	33	42	51	60	69	78	87	96
Yellow	4	16	25	34	43	52	61	70	79	88	NA
White	5	17	26	35	44	53	62	71	80	89	NA
Grey	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Brown	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Violet	8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aqua	9	18	27	36	45	54	63	72	81	90	NA
Black	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Orange	11	19	28	37	46	55	64	73	82	91	NA
Pink	12	20	29	38	47	56	65	74	83	92	NA
Natural	NA	21	30	39	48	57	66	75	84	93	NA
SHEATHS	<Production order no.> Nexans Norway High Voltage <year>, <meter>				

NOTE:
Black coloured conductors are normally drain wires that should be connected to ground.

[2] The ring marking, A/B, is defined as follows:
A = number of rings
B = spacing between rings

1.7 INCIDENTS

Any incidents or damages on cable and accessories delivered by Nexans Norway shall be reported on separate Incident Report Form included in Appendix 1.

1.8 RECYCLING OF CABLES

In Norway, a separate company "Renas" has been established to recycle all used cable in the Norwegian market. The company is operating in accordance with all national relevant rules and regulations. Contact Renas at phone +47 22 13 52 00 or http://www.renas.no.

In other countries, Nexans recommend contact with national environmental authorities for the safe and responsible deposit/recycling of used cable products. Please ensure the end receiver of such products is operating under relevant national rules and regulations.

2 TERMINATION OF FIBRE OPTIC STEEL TUBES

This procedure describes the termination procedure for 2.3mm fibre optic steel tube elements. The procedure is applicable for both surface terminations (dry) and oil filled pressure compensated termination boxes. Note that individual length adjustment might be needed, depending on the termination design.

Tooling and termination kit, and a CD-ROM with an animated termination procedure (in English, Portuguese and French) are available upon request.

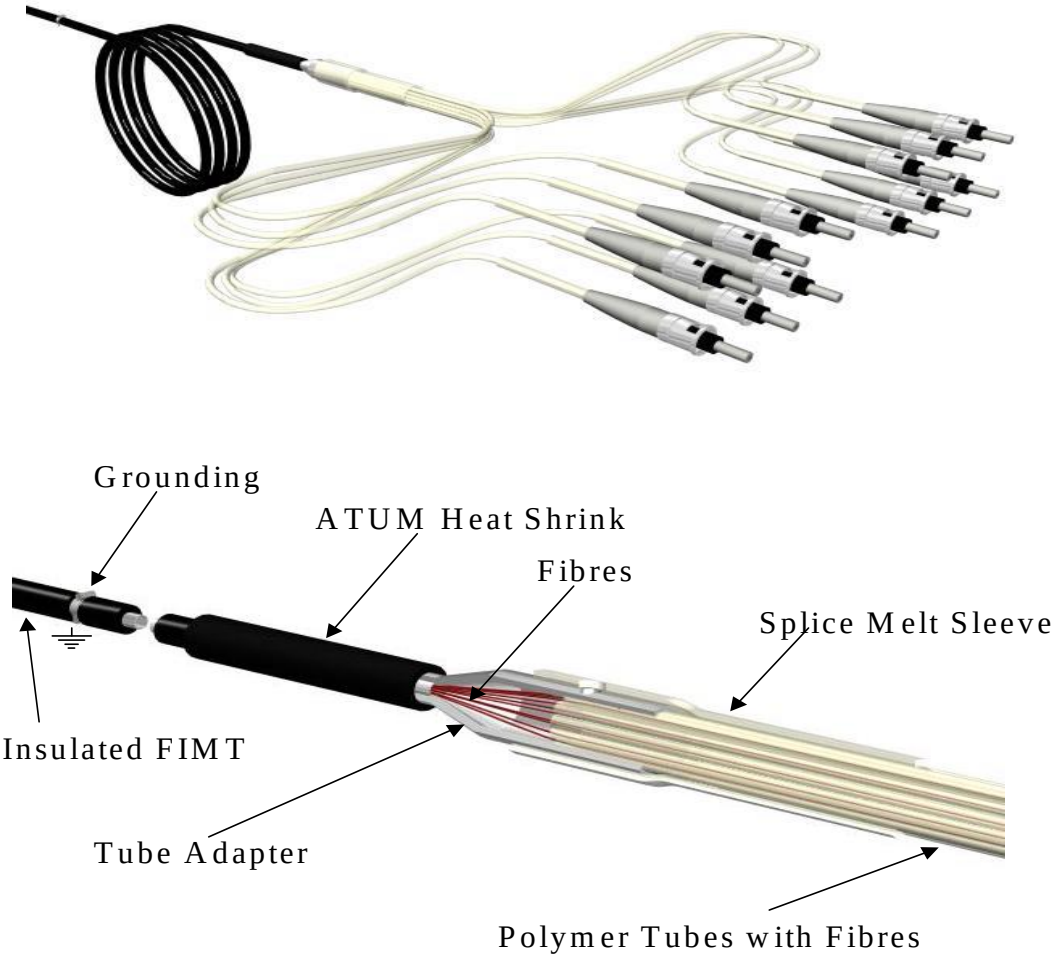


Figure 2-1: Termination of fibre optic steel tube

2.1 TERMINATION PREPARATION

1. Carefully remove the fibre steel tube from the core.
2. Straighten the tube, removing the pre-formed twist from manufacturing.
3. Remove 85mm (3 3/8") of the steel tube sheath where the tube will be cut.
4. Straighten the unsheathed part of the tube to allow the tube cutter to make a clean score on the tube.
5. Make a crack initiation with a tube cutter approx. 10mm from the sheath end. Do not tighten the cutter too deep, as this may cause the deburring tool not to fit the tube.
6. Work the cutter around the tube until the cutter moves freely. Do not tighten any more and remove the tube cutter.
7. Bend the tube at the score point slowly in one direction until it snaps. Do not break the steel tube completely by moving it further in the same direction, as this will damage the fibres. Bend the tube back and forth until it breaks. Avoid moving the two pieces too much, as it might damage the fibres. Pull the steel tube slowly off the fibre bundle, while holding the bundle to avoid fibre stress.
8. Slide the deburring tool over the fibre bundle and deburr the tube end. Turn the tool back and forth (± 90°). Further rotation of the tool can damage the fibres.
9. Clean the fibres and steel tube with WD-40 then with isopropanol/alcohol. This will make it easier to insert the fibres into the individual tubes.

2.2 TERMINATION OF STEEL CASE ADAPTER

1. Make sure that the steel tube and fibres are clean before sliding the 50mm (2") long heat shrink sleeve, ATUM 8/2, and the Steel Case Adapter over the fibres and the steel tube. Glue steel case to the steel tube with Locktite 415.
2. Use a heat gun to shrink down the ATUM 8/2 to fit over the end of the steel case and on to the sheathed steel tube.

2.3 PREPARATION AND TERMINATION OF "PIGTAILS"

1. Cut the loose polymer tubes to correct lengths, depending on splice box layout.
2. Insert four tubes into the IAKT 3/1 heat-shrink tube. The IAKT 3/1 heat-shrink tube shall be 30mm (1 3/16") long.
3. Let the polymer tube protrude 20mm (3/4") outside the IAKT. Shrink down the IAKT.
4. Distribute the other eight polymer tubes around the shrunk IAKT. Then slide IAKT 8/2 outside all twelve tubes. Let the IAKT 8/2 protrude 5mm (1/4") outside the IAKT 3/1 on each end.
5. Shrink the IAKT 8/2.
6. Cut the end of all polymer tubes 8mm (5/16") from the IAKT 8/2 with a scalpel.
7. Straighten out the tubes and tape them to a straight piece of flat stock, this will allow the fibre bundle to be advanced toward the steel tube in a uniform manner, while also keeping the tubes straight.

8. Insert one fibre into each of the loose tubes, in the “bundle”.
9. Once all fibres are inserted, carefully stretch the fibres while the “bundle” enters the steel case. Push the fibre “bundle” into the steel case adapter, not more than 8mm (5/16").
10. Slide the 50mm (2") long heat-shrink sleeve over the bundle and over the steel case and shrink.
11. To allow liquid passing through during ambient pressure changes, cut a small hole in the shrunk sleeve where the sleeve covers the hole in the steel case.
12. Finalise the final fibre and tube end connector work in accordance to the procedure from the connector manufacturer.

2.4 STEEL TUBE GROUNDING

To avoid charging up of the steel tube due to its electromagnetic and static interaction with the power transmission, it is recommended to ground the steel tube to the protective earth bar or local earth. The grounding clamp shall be connected to the steel tube on a suitable spot by means of a grounding clamp and an extension grounding wire.

Tighten the grounding clamp until finger tight, and then use two spanners to tighten the screw one (1) turn.

2.5 TERMINATION BOX LAY-OUT

It is recommended to coil 1.0-1.5m (40”-60”) of the sheathed steel tube into the termination box, for future re-terminations and to absorb potential fibre length variations.

Minimum bending diameters of the fibre is 60mm (2 1/4").

2.6 PART LIST

The following tables summarise the items necessary for termination of both ends of one 2.3mm fibre optic steel tube element.

2.6.1 Tool kit for 2.3mm steel tube element

Item	Quantity
Tube deburrer (for smoothing the internal edges of tube end)	1pc
Steel tube cutter	1pc

2.6.2 Termination kit for 2.3mm steel tube element

Item	Quantity
Steel case adapter, 2.3 mm tube OD	2
Splice melt sleeve	4x50mm
IAKT Heat Shrink 8/2	4x50mm
IAKT Heat shrink 8/2	4x40mm
IAKT Heat shrink 3/1	4x30mm
Locktite 415	1 bottle
El. steel tube grounding clamps	2pcs
Polymer Sleeve / tube 3M	25m

2.6.3 Related items (not included)

Item	SM or MM	Quantity
HOT MELT CONNECTORS FROM 3M		
ST 6100	MM	2 per fibre
FC 6200	MM	2 per fibre
ST 8100-Y-S	SM	2 per fibre
STANDARD CONNECTORS [3]		
Molex: FC 86053-5500	SM	2 per fibre
Molex: ST 86013-0500	MM	2 per fibre
Amphenol: FC 944-601-5006F39U	SM	2 per fibre
Amphenol: FC 944-601-5010F39U	MM	2 per fibre
Amphenol: ST 953-101-5306	SM	2 per fibre
Amphenol: ST 953-101-5310	MM	2 per fibre
RAPID GLUE FOR MOLEX AND AMPHENOL		
FTC-ADH 101	-	-
Accelerator (optional), FTC-ACC 101	-	-
1.5mm^2 GROUND WIRE AND CABLE SHOE	-	1 in each end

[3] Standard connectors are not hot melt nor pre-filled with glue. These connectors are normally stock items and allow also use common tools etc.

3 SPOOLING

Cable spooling must always be performed under controlled conditions. Handling within the specified spooling requirements prevents injuries to personnel and equipment, and provides efficient service and prolongs the cable lifetime.

The following general requirements apply for cable spooling:

1. There must be no gaps between adjacent cable windings on the winch. Undesired gaps should be filled to enable satisfactory spooling of the remaining cable length.
2. The cable inner end must be secured with "Kellum grips" or clamps.
3. For operation below 2000m depth, the winch drum should be furnished with a grooved core (e.g. from "LeBus ®" [4]). Note that the cable OD tolerances must comply with recommendation of the drum shell manufacturer.

3.1 UMBILICAL INSTALLATION SPOOLING

Installation spooling is defined as spooling from transportation drum to winch system:

Description	Requirement and comments
Temperature range	-5°C to +50°C
Spooling tension	60 to 90% of cable tension at actual working depth.
Spooling direction	See section 1.2.6
Fleet angle	Maximum 10°
Distance to winch	Minimum 5m distance between delivery drum to winch drum

3.2 UMBILICAL OPERATIONAL SPOOLING

Description	Requirement and comments
Temperature range	0°C to +40°C
Spooling tension	Tension at actual working depth during operation.
Spooling direction	See section 1.2.6
Fleet angle	Maximum 4°. A suitable array of two or more rollers ("gooseneck") will increase cable lifetime.

[4] http://www.lebus-intl.com/

3.3 TETHER INSTALLATION SPOOLING

Installation spooling is defined as spooling from transportation drum to winch system:

Description	Requirement and comments
Temperature range	-5°C to +50°C
Spooling tension	1% to 5% of breaking load.
Bending diameter	The minimum bending diameter is specified in the cable technical description.

3.4 TETHER OPERATIONAL SPOOLING

During tethering in and out, relative movements between the outer sheath and the armouring may accumulate and show as "milking" of the outer sheath. See Figure 3-1.

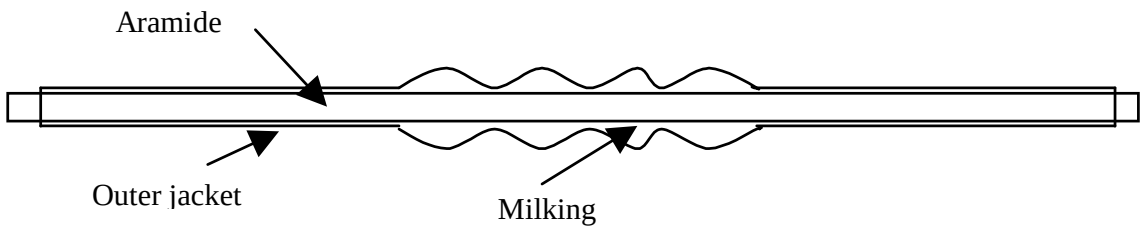


Figure 3-1: Outer sheath "milking".

If "milking" occurs even to a small extent the back tension should be monitored and adjusted accordingly.

When tethering out (Figure 3-2), braking force is applied to the drum as the powered sheaves pull out the cable. As a result, "milking" can occur.

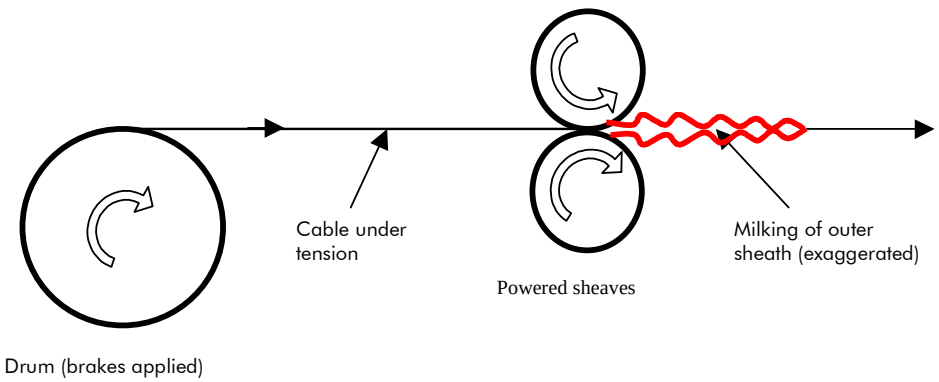


Figure 3-2: Tethering out.

When tethering in (Figure 3-3), braking force is applied to the powered sheaves as the drum spools in the cable. As a result, "milking" can occur.

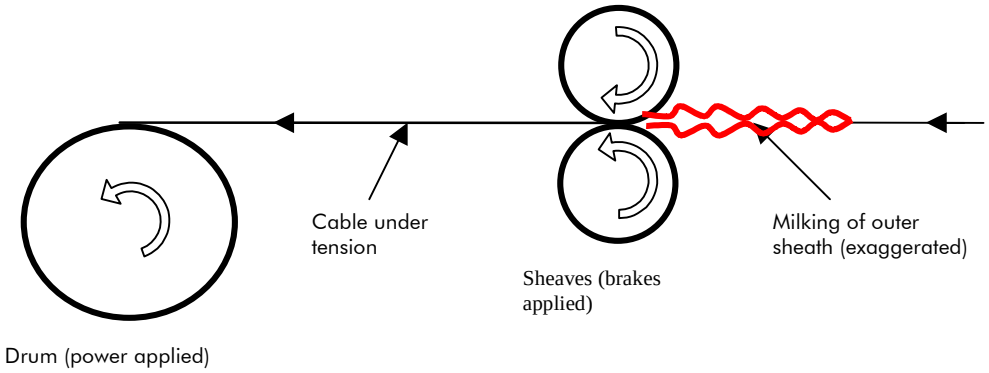


Figure 3-3: Tethering in.

4 STEEL ARMOURED CABLES

4.1 CORROSION PROTECTION

Outer steel armouring wires must be kept lubricated at all times. This prevents wire corrosion, and provides efficient service and prolongs the cable lifetime. It is also recommended to always clean/spray the cable with fresh water prior to storage.

The maintenance implies regularly saturating the armouring wires with an anti-corrosion lubricant. The first treatment should be performed during initial spooling onto winch.

Rust, water and oxidised compounds must be removed prior to lubrication. Depending on climate and use, cable lubrication is likely to be required several times a year. Salt water and tropical climate will accelerate the corrosion.

The lubricant must be applied in moderate quantities. If applied at low cable loads, excess lubricant will be squeezed out increasing the load. In addition to the general inconvenience this will cause, it might complicate cable handling (e.g. using traction winch). Excess lubricant should be removed by fixing a regular rope around the cable behind the lubricator. Alternatively, the cable can be pulled through the lubricator once more without the supply of lubricant.

The lubricant must be renewed if white powder spots or brown spots appear on the steel wire surface. White powder indicates Zinc layer corrosion. Brown spots indicate steel corrosion, implying increased consumption of zinc and reduction of steel cross section. The remaining steel will also gradually become more brittle.

Some lubricants have been claimed to accelerate the corrosion process. Nexans recommend the following lubricants:

1. Shell ROV cable grease [5]
2. "Tuff coat" (Dynacon USA) [6]
3. "Tufshield" (Rocol) [7]

Masto Wire-Service A/S[8] provides lubrication equipment designed for multi-layer steel ropes. This equipment removes old lubricant, dirt and water and applies new lubricant in one operation. The application pressure should be low, as a too high pressure may have a detrimental effect on the armouring.

4.2 MECHANICAL TERMINATION

Steel armoured cables are usually mechanically terminated using cone systems or moulding. Nexans recommend using cone terminations due to the good repeatability and quality of terminations performed in the field. The following general guidelines apply in order to avoid armouring "bird-caging" and to evenly distribute the load between all armouring wires. See Figure 4-1:

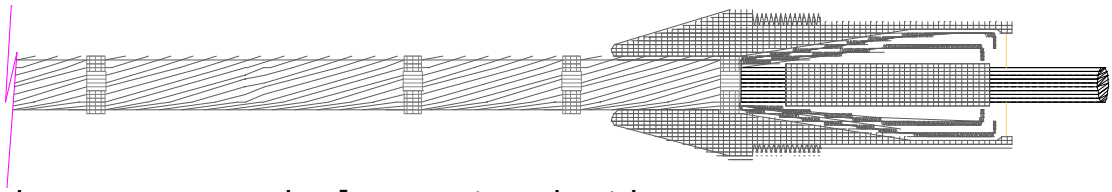


Figure 4-1: Typical cone termination.

1. Before the termination work starts, lay out approx. 10m of cable in a straight line.
2. Clamp the outer armouring with at least 5 steel bands ("Band-it") over a 0.5m cable length. Start from the left, and work towards the cable end. The last steel tape inside the termination unit shall never be released.
3. Tighten the steel bands forcing the armouring to the inner sheath. If "bird-caging" occurs, force the "birdcage" towards the cable end using additional glass fibre tape.
4. Ensure that the armouring lay length has not changed in section containing the steel bands. Cut off more of the cable if the lay length varies over the section.
5. Clean the armouring wires.
6. Cut the cable end. Seal the cable end with heat shrink caps or adhesive tape[9] until further connection work shall be performed.

[5] AS Norske Shell Kundesenter, attn: Tor Grymyr, Postboks 1154, Sentrum, N-0107 Oslo, Norway, Ph +47 22 66 53 00, Fax: +4722665541, E-mail address for orders: sksi-1@ope.shell.com
[6] http://dynacom.com
[7] http://www.rocol.com
[8] Masto Wire Service AS, http://www.masto.no, N-4632 Kristiansand, Norway, Ph +47 38 09 70 50, fax +47 38 09 70 53
[9] El-Technic AS, P.O. Box 116, N-1471 Lørenskog, tel. +47 67 97 81 20, fax + 47 67 90 18 80

5 ARAMID ARMOURED CABLES

5.1 MECHANICAL TERMINATION

5.1.1 Kellum grips

Aramid armoured cables must be terminated using "Kellum grips"[10] (also referred to as "Chinese finger"). Moulded terminations can reduce the aramid breaking strength, and are thus not recommended.

1. Total grips length must be more than 20 times the cable OD for cables with SWL above 8kN. For cables with SWL below 8kN, the minimum ratio shall be 17.
2. The Kellum grips inner diameter must only be slightly larger than the cable OD.
3. The Kellum grips hose must be graded having a 3:1 or 4:1 cross-section ratio for the first and last sector. Each sector should have the same length.

To avoid unpredictable mechanical strain relief and following aramid fatigue, it is important to follow this termination procedure.

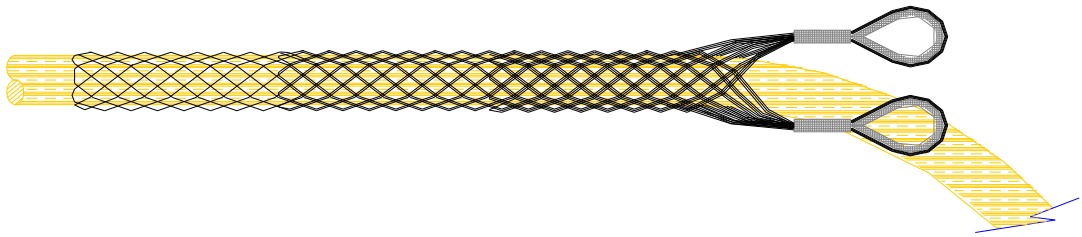


Figure 5-1: "Kellum Grips" ("Chinese finger").

[10] Kellum grips can be supplied by:
Henriksens Efterf., N-1684 Vesterøy, Norway, tel. +47 69 37 72 26
info@subsea-supplies.co.uk

5.1.2 Preparation of cable end

Always make sure that used cables are undamaged before re-termination:

1. Cut back at least 20m of cable.
2. Remove 1m of the outer sheath (including offset yarns if any).
3. Pull at least 5 yarns from each armouring layer to approx. 200N (20kg, 45lbf).
4. If any of the yarns breaks cut back another 10m of cable and repeat point 2 to 4.
5. If no yarns break, terminate the cable (ref. section 5.1.3 or 5.1.4).

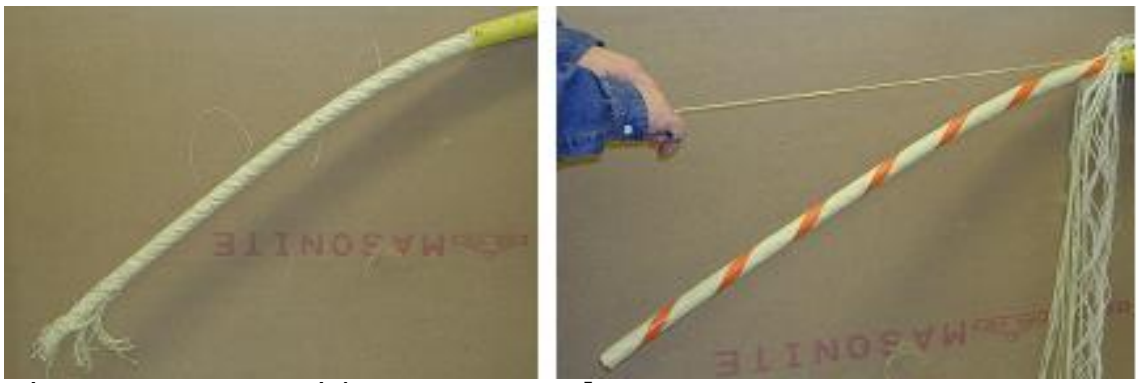
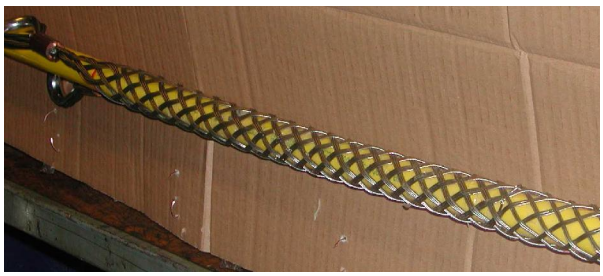


Figure 5-2: Aramid yarn control

5.1.3 Cables with rubber (TPR) outer sheath

Cables (typically tethers) with a TPR outer sheath shall be terminated as follows:

1. Expand and slide the Kellum grips over the cable end. At least 25cm of the outer sheath must extend beyond the eye-end of the Kellum grips. Tighten Kellum grips from the lowest grading by pulling it towards the eye-end of the grips.



2. Lock and protect the lowest grading of the Kellum grips with glass fibre tape and an overall heat shrink sleeve (e.g. MSRTK). Let the tape extend approx. 5cm onto the outer sheath.

NOTE: TPR is non-compatible to oil products. See section 1.3.2 for further information.

5.1.4 Cables with thermoplastic polyester (TPE) outer sheath

Cables with a TPE outer sheath shall be terminated as follows:

1. Clean the outer sheath with Isopropanol or similar to a length corresponding to the length of the Kellum grips.

2. Wrap pressure sensitive double-sided adhesive tape (3M, Scotch type 9080) over the outer sheath. The tape shall be applied under the whole length of the Kellum grips, and a double layer shall be applied under the first grading of the Kellum grips (approx. 15cm or 6").

3. Expand and slide the Kellum grips over the cable end without damaging the tape. At least 25cm of the outer sheath must extend beyond the eye-end of the Kellum grips. Tighten Kellum grips from the lowest grading by pulling it towards the eye-end of the grips.

4. Secure the Kellum grips with 2 hose clamps. One 20mm from the end of the lowest grading and on at the next lowest grading. Protect the hose clamps with heat shrink sleeves.

6 FREE SWIMMING / NON-LIFTING OPERATIONS

There is a high risk of forming harmful cable loops, bends, kinks or bird caging during cable handling at low cable tension (i.e. free-swimming/non-lifting operations). The following precautions are thus required:

1. Keep a minimum cable tension of 5kN.
2. Keep the maximum cable rotation below 10° per meter.
3. Keep the distance across a "U-shaped" catenary wider than 5m (Figure 6-1).
4. Keep the cable at the bottom of a "U-shaped" catenary close to neutral (Figure 6-1). Around the bottom point of the "U-shape", approx. 5m of cable should be equipped with buoyancy elements every 1m.
5. Gradually reduce buoyancy in transition from horizontal to vertical cable (Figure 6-2).
6. Distribute and gradually decrease buoyancy between buoyant and neutral section, by reducing point buoyancy and increase spacing. This applies specifically to ploughing operations (Figure 6-1).

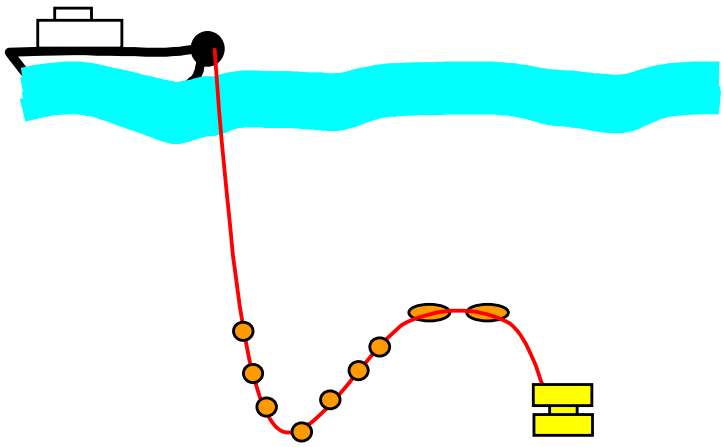


Figure 6-1: Non-lifting operation.

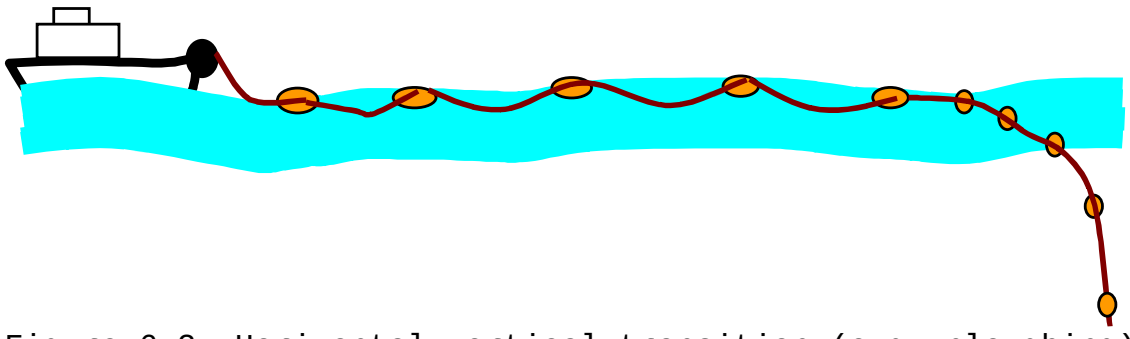


Figure 6-2: Horizontal-vertical transition (e.g. ploughing)

7 AMENDMENT LIST

Issue No.	Date	Amendments
08	20.05.05	- Included section with definitions. - Included section regarding re-cycling. - Included section with cut-back procedure for termination of aramid armoured cables.
07	12.11.03	Included revised termination procedure for tethers with TPR outer sheath. Incident Report Form included.
06	04.09.03	Typical high tension spooling arrangement to ROV winch added. Grooved winch drum recommendations added. Storage and transportation details updated. ID tape added under colour coding. Added details regarding FiMT termination. Added simplified tether termination for tethers with TPE outer sheath. Added termination of HV conductors with outer semiconducting insulation screen.
05	20.03.02	Scope/name changed to include dynamic cables in general. Recommendations related to roller gaps. Increased length of Kellum grips and advise against hose clip fixed end for work class tethers. Armouring lay direction vs. drum configuration changed.
04	29.10.01	Document restructured. Misc. clarifications. Section C.1.1 ("Overboard cable spooling" omitted. Section C6 ("Free swimming ROV") expanded.
03	16.08.01	Changes in section A3, Heat Dissipation. Colour coding of electrical conductors included in A.5.2 FC and ST connectors part no. specified for FiMT terminations. Minor changes page 21.
02	02.04.01	Printing errors (steel tube OD). Spooling guidelines (sect. B.1.1). Tube length reduced to 25 m (sect. A.4.7).
01	03.01.01	New document, replacing ID010 rev 2.

APPENDIX 1

See incident report sheet on next page.

Incident Report

Date of incident:	**Place of incident:**
Reported by:	**Sent to:**
Product code:	**Product document no.:**
Cable delivery date:	**Cable delivery length:**
Track record:	
Hours in operation:	Previous incidents:
Max operational depth:	Operational tension:
Total cable length:	Damaged length:
Other (minimum bending diameter, temperature voltage, re-terminations etc):	

Incident description:

Attachments: