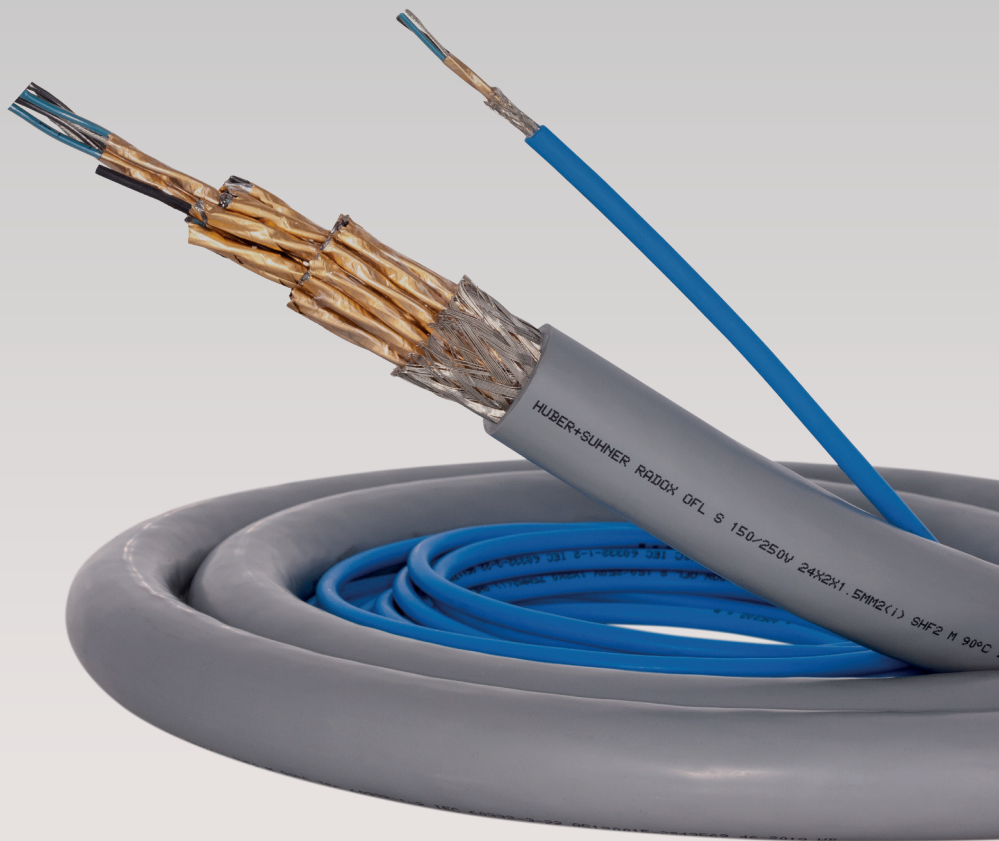


RADOX[®] OFL
Instrumentation cables
**Oil&Gas, flexible and
lightweight**



A safe way to save weight

RADOX OFL cables apply to all offshore topside applications with outstanding low Total Cost of Ownership (TCO) in terms of weight, space, lifetime, installation and handling of harsh environmental conditions compared to standard RFOU/BFOU.

Application areas:

- For fixed and moving application
- Dry, damp or wet locations
- Inside and outside ships, offshore platforms, FPSOs and other industrial equipment
- Resistant against oil, mud and hydraulic oil (NEK606:2016 Cat. a-d)
- -40 °C to + 120 °C continuous operating temperature
- Flame retardant (IEC60332) and Fire resistant (IEC60331)

Highlights:

- Thin wall design to reduce weight between 33 % and 63 %
- Approved by IEC/DNVGL- CP-0400 lightweight class program
- Innovative radiation cross-linked RADOX sheath enhance lifetime by factor 8
- Pairs, triples and quadruples with cross-sections 0.75, 1.5 and 2.5 mm²
- Very flexible even with up to 48 pairs
- Ruggedised high-end PEEK cores for high temperature process applications, e.g. steam boiler.
- NEK606 compliant





A game-changing innovation in offshore cabling

A challenge to today's outdated standards

Standards like IEC 60092-350/360, which define insulation materials and cable construction, were developed in 1987 and since then haven't changed. They have defined only two insulation materials: XLPE (chemical cross-linked PE) and EPR (Ethylene Propylene Rubber), that, in turn, has also defined cable construction and insulation thickness. With many new innovations in materials in the last 30 years, it becomes viable to design cables thinner while having much better tolerance compared to IEC standards.

A solution beyond today's RFOU/BFOUs

The requirements in the offshore market are becoming increasingly demanding in the last years. Improvements are needed to run operations more efficiently and with higher safety. It affects engineering, installation and long-term operations. The lifetime of a product must contribute to a low Total Cost of Ownership (TCO). RADOX OFL cable is the advanced solution to achieve this target.

Customer type	Today's instrumentation cables	Solution - RADOX OFL
Operator – Platform Operation 	<ul style="list-style-type: none"> • Low or less oil/mud resistance • Missing heat resistance (Boiler/Turbo Machinery) • Missing cable gland tightness/ Cold flow issues • Larger dimension tolerance • Low health&safety standard • High weight (no margin anymore) • Many different cable types 	<ul style="list-style-type: none"> • High oil/mud resistance • High heat resistance • Long-term cable gland tightness • Smaller dimension tolerance • Highest health&safety standard • Weight reduction up to 63 % • One cable type (less stock)
Operator – pre-FEED 	<ul style="list-style-type: none"> • Short lifetime • Low health&safety standard • Very high TCO - CAPEX/OPEX • Few weight saving solutions with RFOU/BFOU • Many different cables for all applications 	<ul style="list-style-type: none"> • 8 times longer lifetime • Highest health&safety standard • Lowest TCO - CAPEX/OPEX • Much lower weight • One cable for all applications (less stock)
FEED/Consultant 	<ul style="list-style-type: none"> • Very high TCO - CAPEX/ OPEX • Short lifetime • Few weight and space saving options • Lack of innovation for their client • Many cable gland selections, e.g. roundness/tightness/ tolerance. 	<ul style="list-style-type: none"> • Lowest TCO – CAPEX/OPEX • 8 times longer lifetime • High weight and space saving • Present real innovations • Simple single compression cable gland selection with best tolerance, absolute roundness and no cold flow issues
EPCs 	<ul style="list-style-type: none"> • Normal installation cost • Often wrong cable glands ordered • Few weight saving options • Standard accessories 	<ul style="list-style-type: none"> • Cheapest installation cost • Less or no cable glands issues in project phase • Weight saving potential to reduce steel structure cost • Smaller/cheaper accessories

Importance of weight and space

Weight reduction will lower initial installation and construction cost

Offshore platforms and FPSO want just one type of weight on their buildings: crude oil or LNG. For all other types of weight, they need to have a better mechanical steel structure or a better buoyance, which makes it very expensive. Adding one more ton on the topside requires additional up to 50.000 USD of steel structure. This easily leads to several millions of US dollars for a new building.

RADOX OFL - save weight from the first installed meter

Thanks to its innovative lightweight design, RADOX OFL cables can save weight from 33 % to 63 %. As a consequence, the weight of accessories like cable glands, connectors and cable trays can also be reduced due to their smaller size.

Core material comparison	RFOU	Difference	RADOX OFL S	BFOU	Difference	RADOX OFL SFR
1x(2x0.75)						
Weight [kg/km]	176	-63.1 %	65	212	-59 %	87
Diameter [mm]	9.5+/-0.5	-38.4 %	5.85+/-0.3	11+/-0.8	-35 %	7.15+/-0.3
Space [mm ²]	90.25	-62.1 %	34.2	121	-57.8 %	51.1
12x(2x0.75)						
Weight [kg/km]	841	-45.5 %	458	976	-35.2 %	632
Diameter [mm]	21+/-1	-23.3 %	16.1+/-0.5	24+/-1	-11.25 %	21.3+/-0.5
Space [mm ²]	441	-41.2 %	259.2	576	-21.2 %	453.7
24x(2x1.5)						
Weight [kg/km]	2422	-39.9 %	1456	2683	-33.8 %	1776
Diameter [mm]	36+/-1.5	-20.6 %	28.6+/-0.6	40+/-2	-12.75 %	34.9+/-0.6
Space [mm ²]	1296	-36.9 %	818	1600	-23.9 %	1218

How much do we really reduce?

Below numbers show a recent instrumentation cable package where RADOX OFL was compared with standard RFOU/BFOU (total length 608km). On average RADOX OFL could have reduced the total weight by 47 % in this project and thus save more than USD 5 million in steel structure:

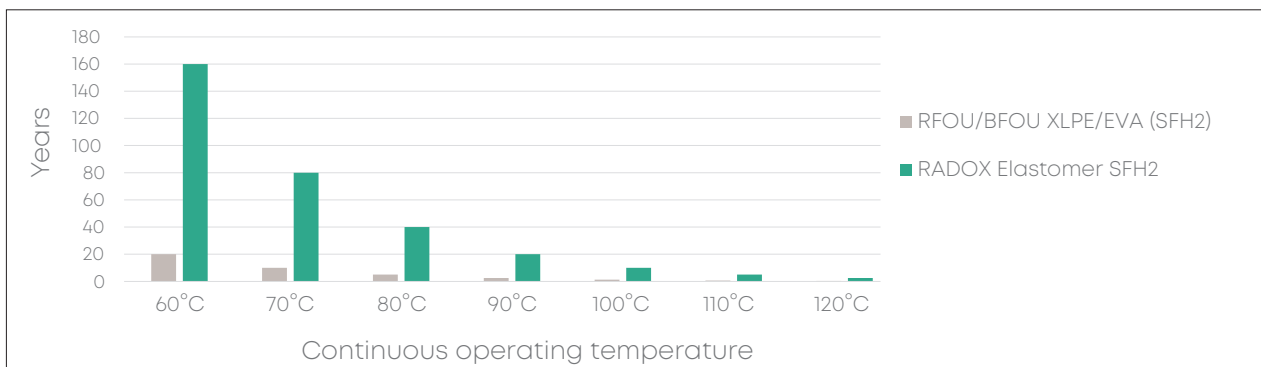
Weight RFOU/BFOU	Weight RADOX OFL	Weight saving	Weight savings in %
247.656 tons	131.181 tons	116.475 tons	47 %

New innovative materials create a world of difference

Outer sheath: RADOX OFL vs XLPE/EVA

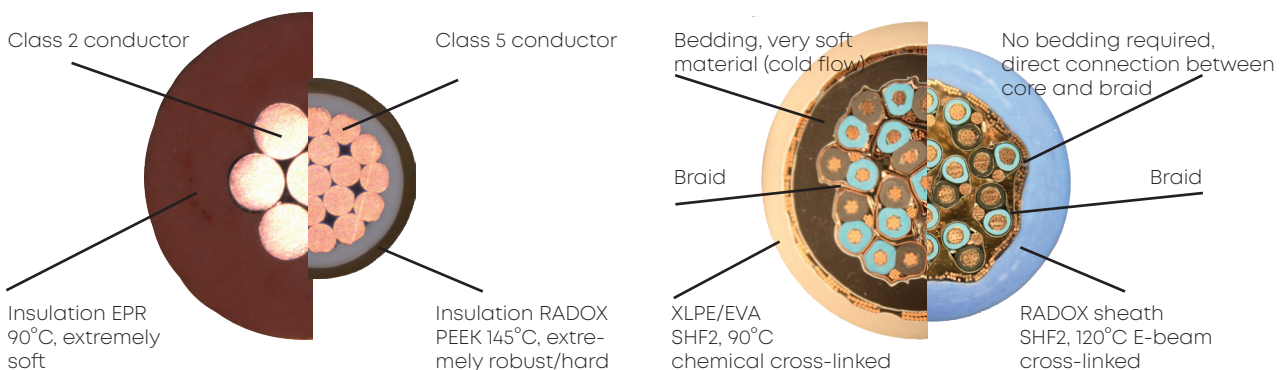
Compared to standard XLPE (chemical cross-linked Polyethylene) or EVA (Ethylene Vinyl Acetate), RADOX technology is based on Polyolefin, which makes RADOX OFL compound a dedicated material for the harsh offshore environment. It can withstand higher or lower temperatures, resist oil/mud, even hydraulic oil conditions, and ozone etc. It has a slower aging influence on the sheath material.

DNV has defined a class program DNVGL-CP-0400 to test the RADOX compound and proven that it performs mechanically and electrically the same as or better than IEC requirements, e.g. RADOX aging temperature of 120 °C can extend lifetime by factor 8.



Cores: RADOX PEEK vs EPR

PEEK (Polyetheretherketon) is the real game-changer for offshore instrumentation cables. The standard temperature is 145 °C while EPR (Ethylene Propylene Rubber) has 90°C, that extends the lifetime even in higher process temperature environment by factor 32. Furthermore, PEEK is harder than EPR and has perfect mechanical values in terms of abrasiveness, elongation at break and tensile strength.



If the core must be fire resistant (IEC60331-1/2), then a layer of Mica tape is needed to ensure a 120-minute operational functionality at 830 °C.

New innovative materials create a world of difference

Cable construction

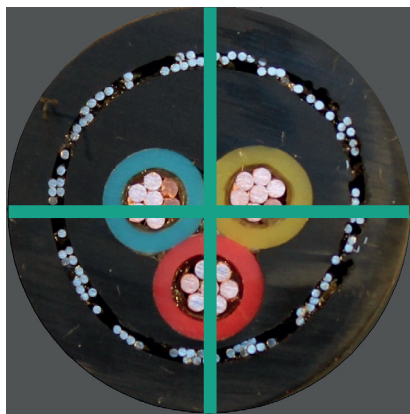
IEC 60092-350/360 defines the exact cable construction and the cable materials to be used for offshore topside cables. This includes insulation thickness for cores and sheath, bedding requirements, braiding etc., RADOX OFL cable has an advanced design in construction and uses different materials, that leads to smaller diameters. RADOX OFL is proven by and compliant with the DNVGL-CP-0400 lightweight cable program.

Why RFOU/BFOU need bedding?

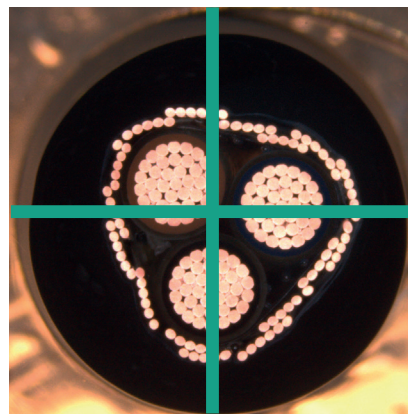
RFOU/BFOU bedding has been originally used in many cables as it has two main functions:

- Protect cores from braid
- Provide a round cable

RADOX OFL cable using the hard PEEK core material can be in direct connection with the braid and finished in any shape before the final extrusion/radiation cross-linking. A high tolerance is guaranteed.



RFOU/BFOU concentricity

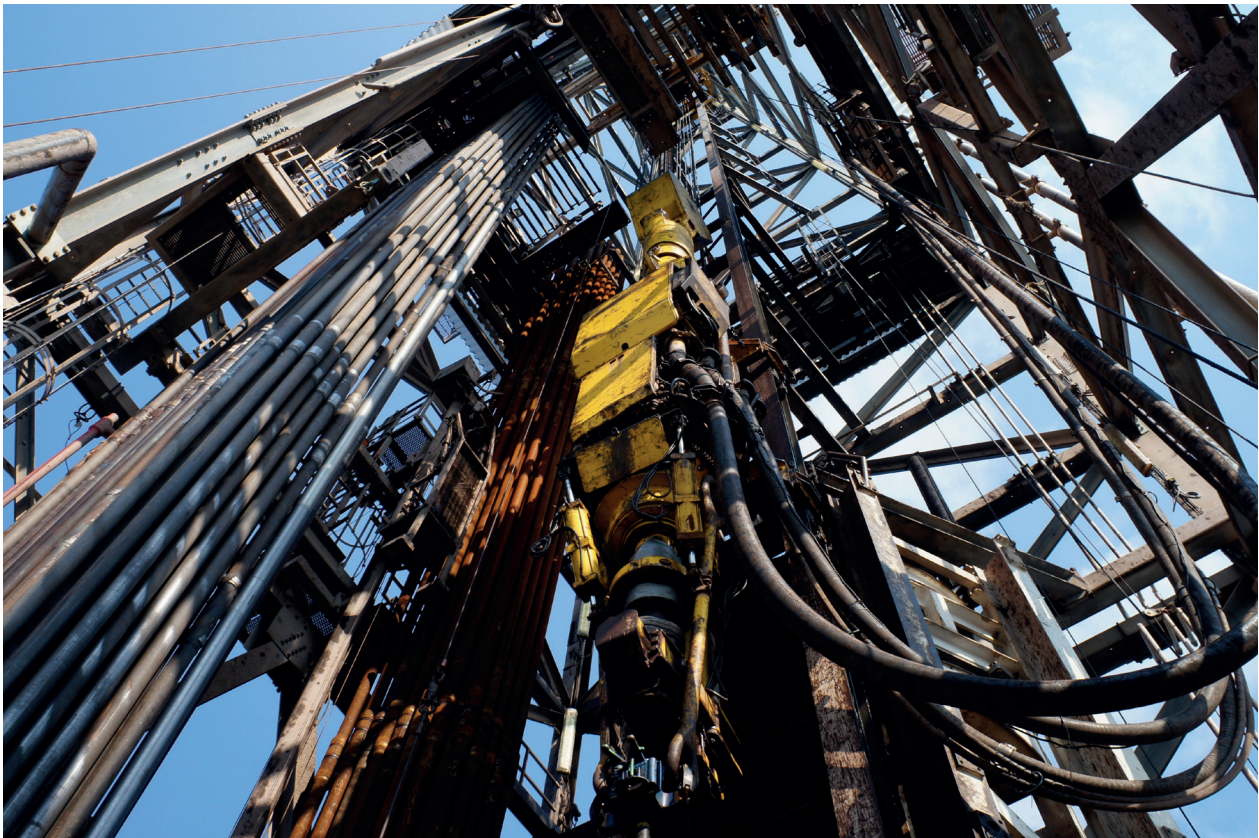


RADOX® OFL concentricity

RADOX OFL – safety by cable design

With new innovative materials and different designs, RADOX OFL cable offers huge benefits, especially safety improvement:

- No cold-flow issues as no bedding is required, thus single compression cable glands can be used with long-term tightness.
- PEEK is the ideal material for process applications like steam/hot oil heating, steam boiler etc. Instrumentation compartments often have a temperature higher than 80-90 °C, that shortens the lifetime of EPR. The consequence is that brittle insulation will lead to short-circuits or wrongly measured process values.
- Another safety risk for operators is the exposure to hydraulic/gear oil which will be swollen by the outer sheath over time and cause cracks. RADOX OFL cable can handle hydraulic/gear oil very well. In the case of cracks in the sheath material, the inside RADOX PEEK cores can withstand the hydraulic/gear oil, serving as a secondary containment to avoid any incidents.
- Safe in moving applications like offshore cranes or drag chains with up to 1.000.000 cycles



Savings on installation time and accessories costs

Cable glands – a challenge for EPCs and operators

EPCs have constantly problems with cable gland selections in engineering phase. Either the cable gland is too small or too large, or the cable dimensions are wrong due to larger tolerance.

Thanks to its outstanding design, RADOX OFL cable makes the cable gland selection as easy as possible. A simple single compression cable gland can be used, e.g. Hawke 501/421 or CMP PXSS2K-REX or equivalent. Furthermore, with the best-in-class tolerance of 0.3-0.6 mm and superior roundness, full tightness and correct cable gland selection are guaranteed. This offers several advantages, compared to existing double compression cables glands:

	Single compression cable gland for RADOX OFL	Double compression cable gland
Cost for 1x(2x0.75mm ²)	Appr. 5 USD per end	Appr. 15-20 USD per end
Parameter for cable gland selection	Outer sheath diameter	Outer sheath diameter, inner sheath diameter, number of cores
Cold flow issues	Not possible	Possible (with wrong cable glands for cheap cable gland manufacturer)

Cable running – go flexible and lightweight

Today, specially installing multi-pair cables e.g. 36x(2x1.5) is very challenging as these home-run cables are often several-hundred meters long. They are extremely stiff and heavy. Therefore, these cables are often split into three off 12x(2x1.5), resulting in more Ex housings and more cable gland connections. RADOX OFL cable offers much more options with its extreme flexibility and lower weight with up to 48 pairs.



Cable stripping – an efficient way to save time

RADOX OFL cable offers a safe way to save time from the first stripped cable end. In a full oil platform with thousands of cable runs, it can easily reduce installation time by hundreds of hours. RADOX PEEK cores are harder compared to soft rubber material, which can minimise mistakes and injuries during cable cutting.

Reference value from experienced installation company

	RADOX OFL	RFOU
12x(2x0.75) braided	7.56 minutes per end	20.4 minutes per end

Other accessories

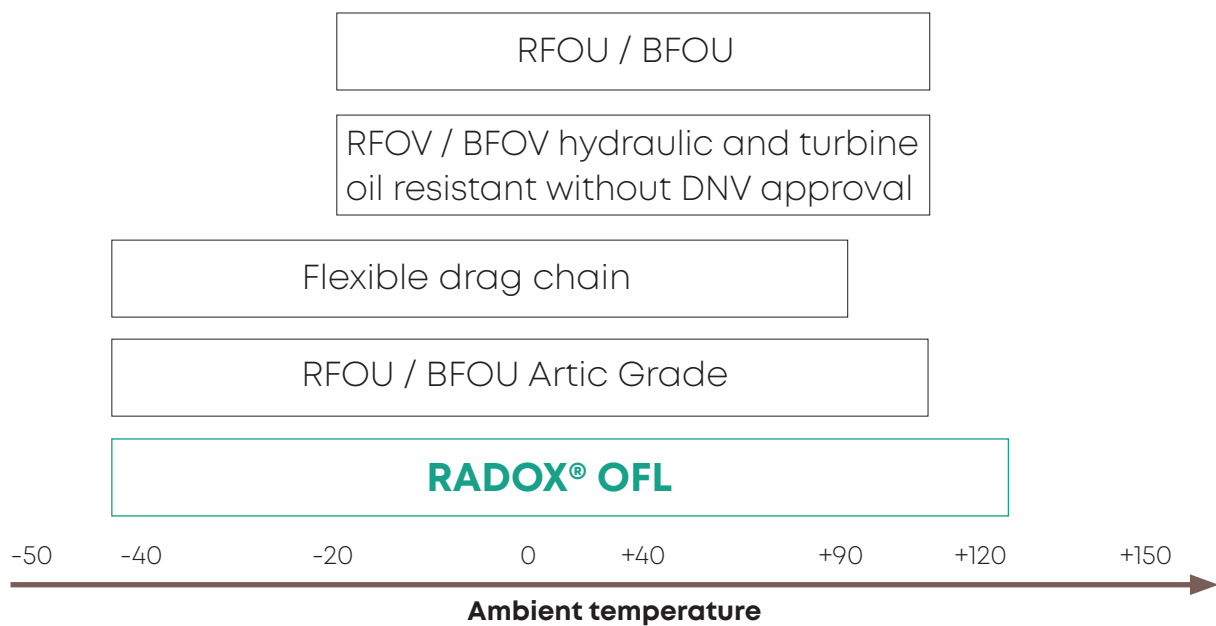
Besides cable glands, RADOX OFL cable gives more opportunities with cable trays. Thanks to smaller cable diameter, a smaller cable tray can be selected or the same cable tray is prepared for further extensions with empty space,

Cable sealings through walls or sections can handle a certain number of RFOU/BFOU. With RADOX OFL cable, the number of sealings can be reduced appr. by 40 %.



Widest range of applications with the same cable

RADOX OFL cable combines four different types of cables into one to save inventory:



Specification overview

- RADOX OFL S 150/250V (following RFOU), Flame retardant (IEC 60332-4, -2, 3-22 Cat A) or
- RADOX OFL SFR 150/250V (following BFOU), Fire resistant (IEC 60331-1, -2)
- Pair, triples or quadruples
- Cross-sections 0.75, 1.5 and 2.5 mm²
- Up to 48 pairs
- Either individually screened (i) or collectively screened (c)
- sheath colours: blue (for Ex i) or grey (safe area or Ex d)
- Oil, mud and hydraulic/gear oil resistant according to NEK606:2016 4.4.1, Cat. a-d (e.g. Shell Tellus T4, please ask for detailed tested manufacturer list)

Technical data according to IEC 60092- 376 and - 350

- Rated voltage a.c. U0/U: 150/250 V
- Max. voltage a.c. U0m/Um: 180/300 V
- Max. voltage d.c. conductor to earth: 250 V
- Max. voltage d.c. conductor to conductor: 500 V

Installation recommendations:

- Temperature index of core insulation TI/20kh: > +145 °C
- Temperature index of sheath TI/20kh: > +120 °C
- Min. operation, installation and handling temperature: - 40 °C
- Min. bending radius - fixed installation
 - D < 12 mm: 3 x D
 - D > 12 mm: 4 x D
 - free movement
 - D < 12 mm: 5 x D
 - D > 12 mm: 6 x D

Approved and compliant with:



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