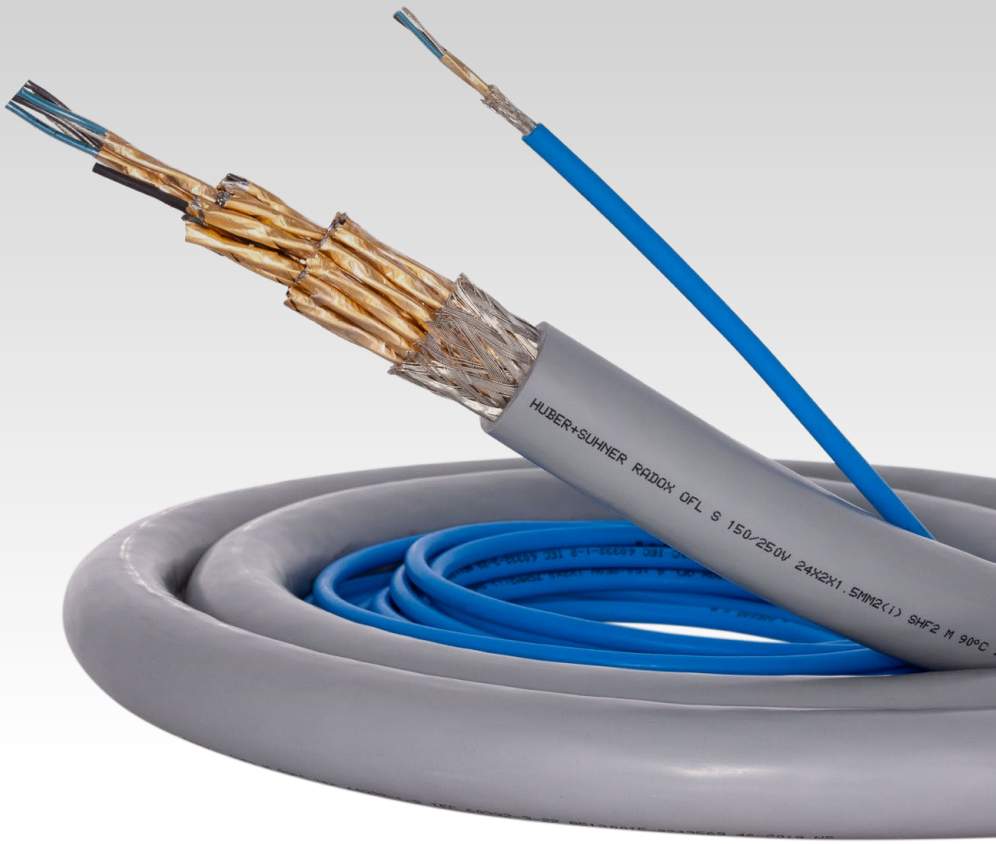
RADOX® OFL™
Instrumentation cables
Oil & Gas, Flexible and Lightweight



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A safe way to save weight

RADOX® OFL™ instrumentation cables are part of the RADOX® OFL™ family and offer 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, and other industrial cables.

Application areas:

- Instrumentation, sensor and control cabling
- For fixed and moving application (e. g. drag chains, cranes)
- Dry, damp or wet locations
- Inside and outside ships, offshore platforms, FPSOs and other industrial onshore constructions (e. g. refineries)
- Resistant against oil, mud, hydraulic oil and chemicals
- –40 °C to +125 °C continuous operating temperature
- Flame retardant (IEC60332) and Fire resistant (IEC60331)

Highlights:

- Thin wall design to reduce weight between 30 % and 65 % (average 45%)
- Approved by IEC/DNV CP-0400 lightweight class programme
- Innovative radiation cross-linked RADOX® sheath enhances lifetime by factor 10
- Pairs, triples and quadruples with cross-sections 0.5, 0.75, 1.0, 1.5 and 2.5 mm^2
- Very flexible even with up to 32 pairs
- Ruggedised high-end RADOX® cores for high temperature process applications, e. g. steam boiler, thermal oil
- Fully NEK606: 2016 compliant, Cat. a – c (Cat. d on request)
- Highest smoke and halogen-free standard (SHF2)

A game-changing innovation in oil & gas 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A challenge to today's outdated standards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 is now possible to design thinner cables with much better tolerance compared to IEC standards.

A solution beyond today's RFOU/BFOUs and other industrial cables

The requirements in the oil & gas market have become increasingly stringent over the last several years. In order to run operations more efficiently and increase safety, improved cabling solutions are needed. The lifetime of a product also contributes to a low Total Cost of Ownership (TCO). RADOX® OFL™ cables are the advanced solution to achieve this target.

Customer type	Today's instrumentation cables	Solution - RADOX® OFL™
Operator 	· Low or less oil/mud resistance · Missing heat resistance (Boiler/Turbo Machinery) · Cable gland selection/Coldflow issues · Larger dimension tolerance · Low health&safety standard · High weight · Many different cable types	· High oil/mud resistance · High heat resistance · Long-term cable gland tightness · Smaller dimension tolerance · Highest health&safety standard · Weight reduction up to 65% · One cable type (less stock) · Massive CO_2 footprint reduction
Operator – pre-FEED 	· Short lifetime · Low health&safety standard · Very high TCO – CAPEX/OPEX · Few weight saving solutions · Many different cables for all applications	· 10 times longer lifetime · Highest health&safety standard · Lowest TCO – CAPEX/OPEX · Much lower weight · One cable for all applications (less stock)
FEED/Consultant 	· Very high TCO – CAPEX/OPEX · Short lifetime · Few weight and space saving options · Lack of innovation for their client · Cable gland selection is affected by cable construction, e.g. roundness/compactness/tolerance.	· Lowest TCO – CAPEX/OPEX · 10 times longer lifetime · High weight and space saving · Present real innovations · Single choice of cable gland thanks to close tolerance, absolute roundness and no Coldflow issues. · Help to reduce CO_2 footprint
EPCs 	· Normal installation cost · Often wrong cable glands ordered · Few weight saving options · Standard accessories	· Lowest installation cost · Fewer or no cable glands issues in project phase (no re-work needed) · 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
An ideal offshore platform or FPSO, for example, would have all of its weight made up of crude oil or LNG. All of the other necessary weight involved in the steel structure or to help buoyancy just adds cost. Typically, every ton added to the steel structure of the topside costs between 30,000 and 50,000 USD. This can easily end up as several millions of US dollars for a new offshore platform or FPSO.

RADOX® OFL™ - save weight from the first installed metre
Thanks to its innovative lightweight design, RADOX® OFL™ cables can save weight from 30 % to 65 %. As a consequence, the weight of accessories like cable glands, connectors and cable trays can also be reduced due to their smaller size.

Weight and diameter comparison	RFOU	RADOX® OFL™ S	Difference	BFOU	RADOX® OFL™ SFR	Difference
1×2×0.75 (i)						
Weight [kg/km]	180	64	**–64 %**	228	99	**–57 %**
Diameter [mm]	9.5 ±0.5	5.8 ±0.3	**–39 %**	11 ±0.8	7.6 ±0.3	**–28 %**
12×2×0.75 (i)						
Weight [kg/km]	850	463	**–46 %**	995	719	**–28 %**
Diameter [mm]	21 ±1	16.2 ±0.5	**–23 %**	24 ±1	23.3 ±0.5	**–3 %**
24×2×1.5 (c)						
Weight [kg/km]	1940	1169	**–40 %**	2290	1611	**–30 %**
Diameter [mm]	33 ±1.5	26.2 ±0.6	**–21 %**	36.5 ±1.5	34 ±0.6	**–7 %**

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 an average of 43 % in this project, saving up to USD 5.5 million in steel structure:

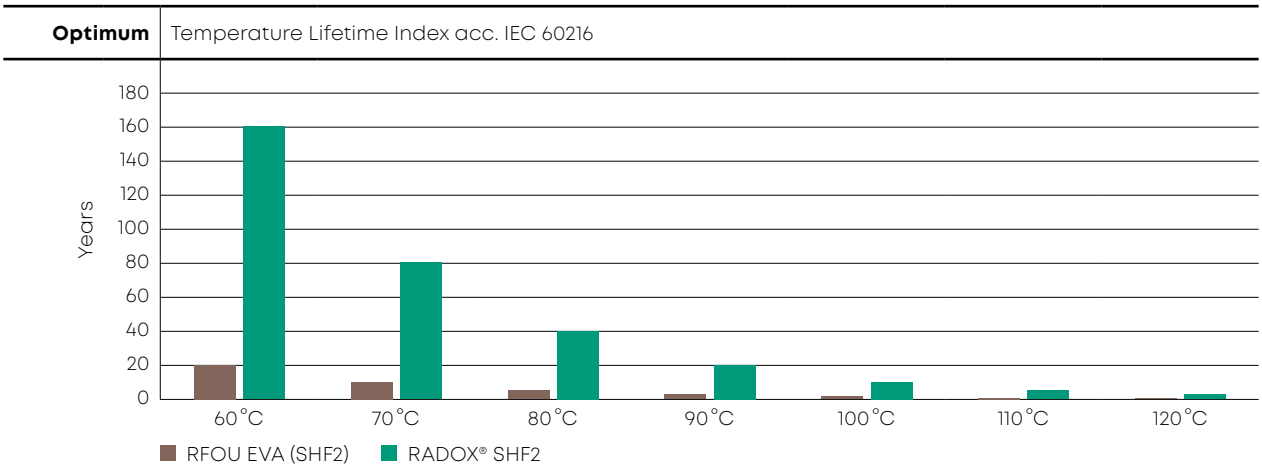
Weight RFOU/BFOU	Weight RADOX® OFL™	Weight saving	Weight savings in %
253,279 tons	143,745 tons	109,534 tons	average 43 %

New innovative materials create a world of difference

Outer sheath: RADOX® OFL™ vs XLPE/EVA or PVC/ PU

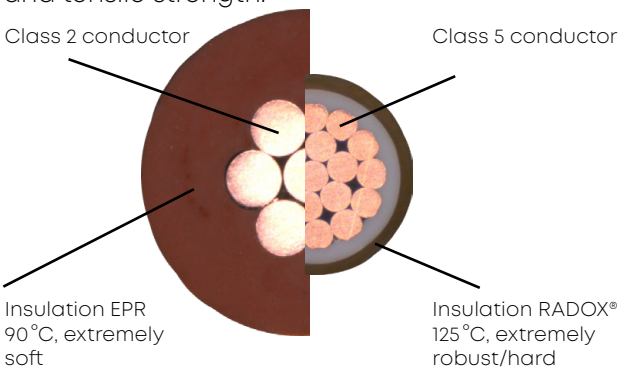
Unlike standard XLPE (chemical cross-linked Polyethylene) or EVA (Ethylene Vinyl Acetate) or PVC/PU, RADOX® technology is based on Polyolefin, which makes RADOX® OFL™ compound a a material better suited to the harsh offshore environment. It can withstand higher or lower temperatures, resist oil/mud, and can even resist oil conditions, chemicals and ozone etc. This means the sheath material does not age as quickly. Furthermore, RADOX® materials are E-beam crosslinked which increases the resistance and further reduces the aging.

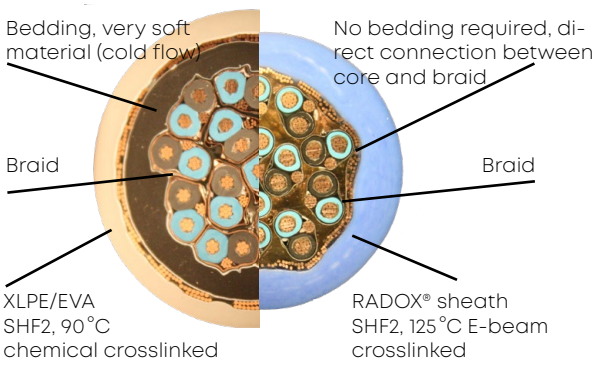
DNV has defined a class program DNV-CP-0400 to test the RADOX® compound and prove that it performs mechanically and electrically the same as or better than IEC requirements. For example, the RADOX® aging temperature of 125 °C can extend lifetime by factor 10.



RADOX® OFL™ Cores vs EPR/PE

RADOX® OFL™ cores are the real game-changer for oil & gas instrumentation cables. The standard temperature is >125 °C while EPR/PE has 90 °C. This extends the lifetime even in a higher process temperature environment by factor 10. Furthermore, RADOX® is harder than EPR/PE 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 minimum 120-minute operational functionality at 830 °C. Furthermore, RADOX® materials are E-beam crosslinked which increases the resistance and reduces the aging.

New innovative materials create a world of difference

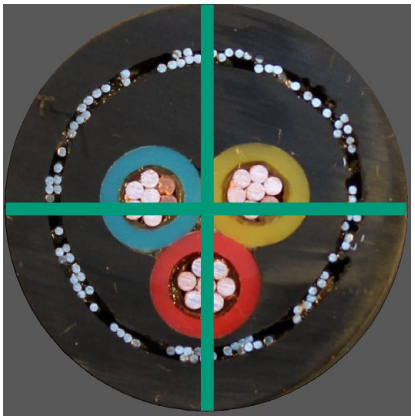
Cable construction
IEC 60092-350/360 defines the exact cable construction and the cable materials to be used for offshore topside cables. This includes insulation thickness for cores and sheath, bedding requirements, braiding etc. RADOX® OFL™ cables have an advanced design in construction and use different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

Why do RFOU/BFOU need bedding?

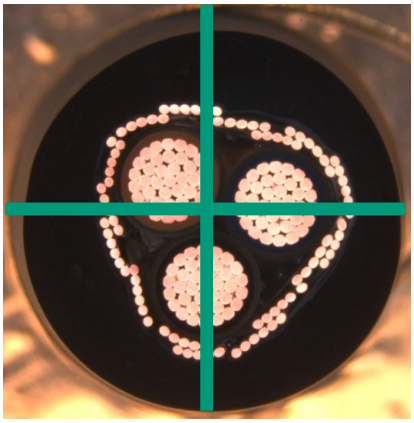
RFOU/ BFOU and PVC/ PU bedding has traditionally been used in many cables as it has two main functions:

- Protects cores from braid (strands can stick into soft rubber core insulation)
- Provides a round cable before final extrusion and chemical crosslinking

RADOX® OFL™ cables using the hard RADOX® 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.



Concentricity in other industrial cables

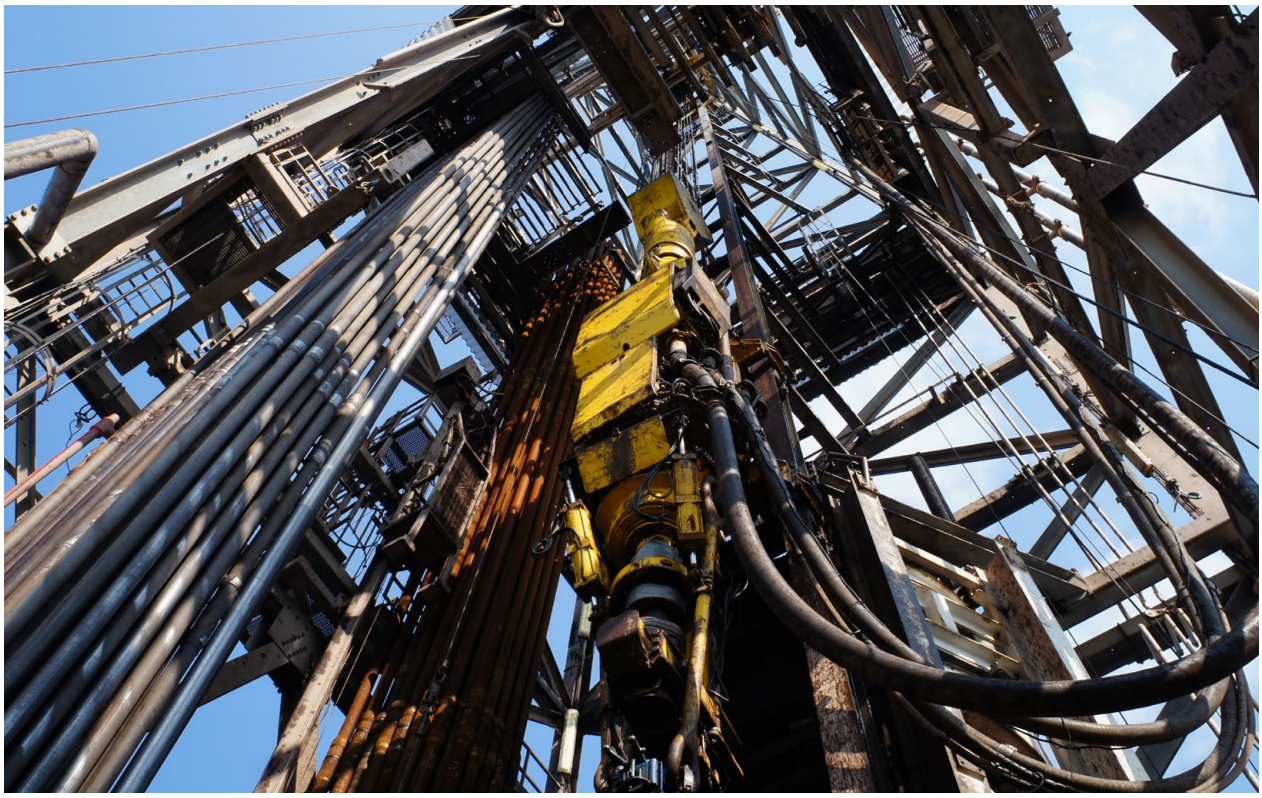


RADOX® OFL™ concentricity

RADOX® OFL™ – safety by cable design

With new innovative materials and different designs, RADOX® OFL™ cables offer huge benefits, especially in relation to improving safety:

- No Coldflow issues.
- Only one cable gland size per cable making gland selection simple.
- RADOX® 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™ cables can handle hydraulic/gear oil very well. In the case of cracks in the sheath material, the inside RADOX® 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 constantly have problems with cable gland selections during the engineering phase. Either the cable gland is too small or too large, or the cable dimensions are wrong due to larger tolerance.

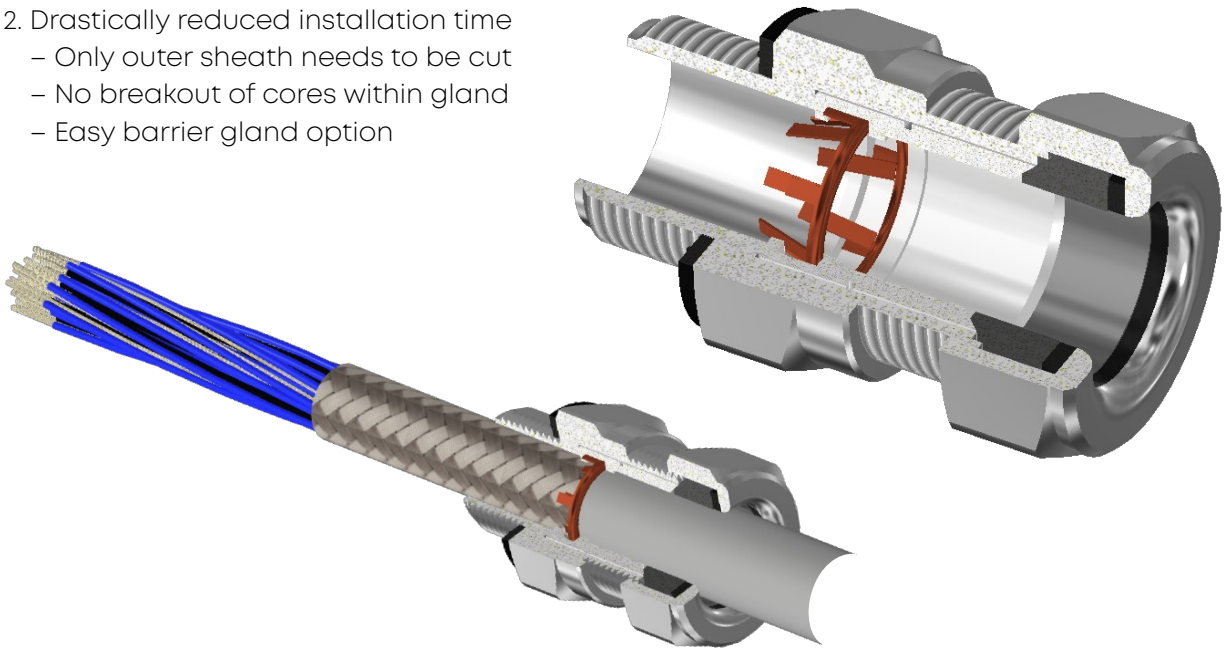
Thanks to its outstanding design, RADOX® OFL™ cables make the cable gland selection as easy as possible. A simple single compression cable gland can be used. Furthermore, with the best-in-class tolerance of 0.3 – 0.6 mm and superior roundness, full tightness and correct cable gland selection are guaranteed. This offers several advantages, compared to existing double compression cable glands:

	Single compression cable gland for RADOX® OFL™	**Double compression cable gland**
Cost for 1×(2×0.75 mm²)	Appr. 10 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, braid diameter
Cold flow issues	Not possible	Possible (with wrong cable glands from cheap cable gland manufacturer)

RADOFLEx™ – the new oil & gas cable gland standard

HUBER+SUHNER introduces the first true Ex d/e/i single compression gland with EMC function for all offshore and onshore applications.

1. Reduced engineering mistakes and enhanced safety
   – Dedicated gland for each cable article, guaranteeing the perfect fit
   – Ex approval for cable + cable gland
2. Drastically reduced installation time
   – Only outer sheath needs to be cut
   – No breakout of cores within gland
   – Easy barrier gland option



Cable stripping – an efficient way to save time

The 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® OFL™ cores are harder compared to soft rubber material, which can minimise mistakes and injuries during cable cutting.

Reference value from experienced installation company

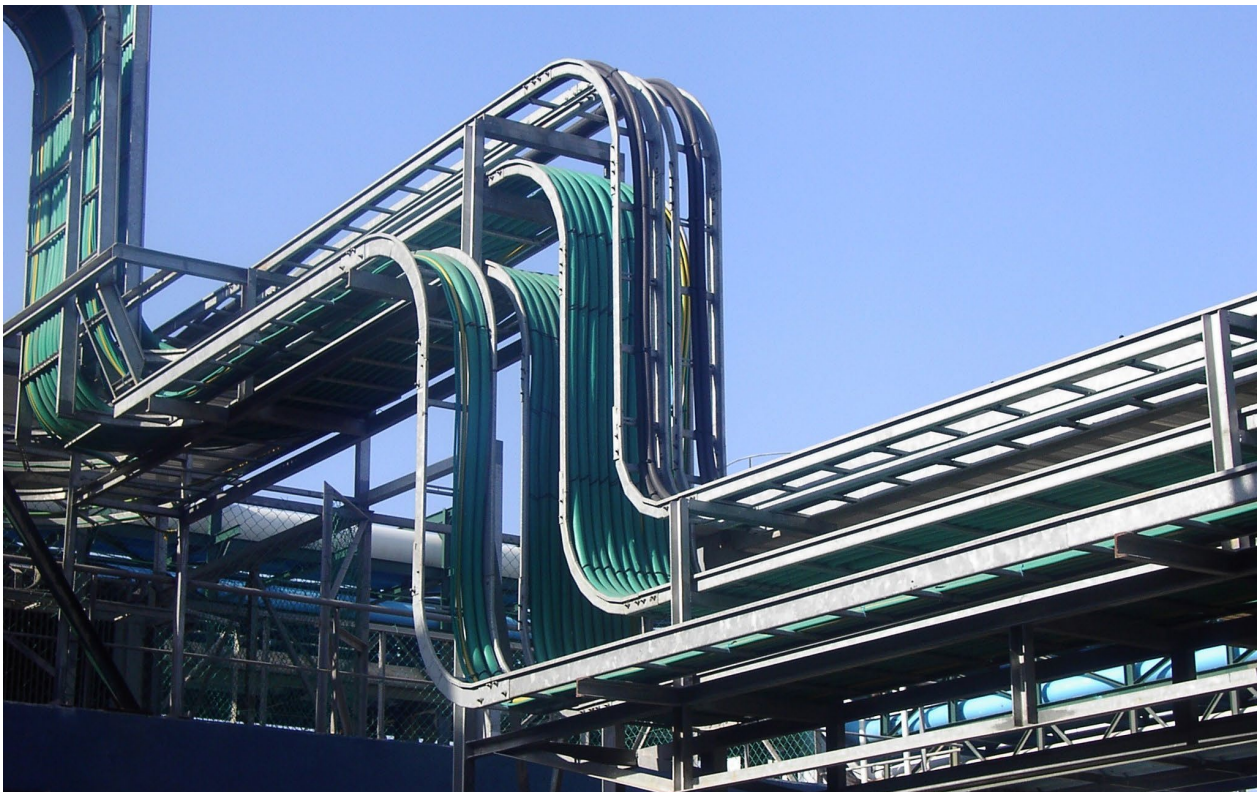
	RADOX® OFL™	RFOU
12×(2×0.75) braided	7.56 minutes per end	20.4 minutes per end

Other accessories

Besides cable glands, the RADOX® OFL™ cable gives more opportunities with cable trays. Thanks to the smaller cable diameter, a smaller cable tray can be selected or a standard cable tray can have space left for additional cables to be added later.

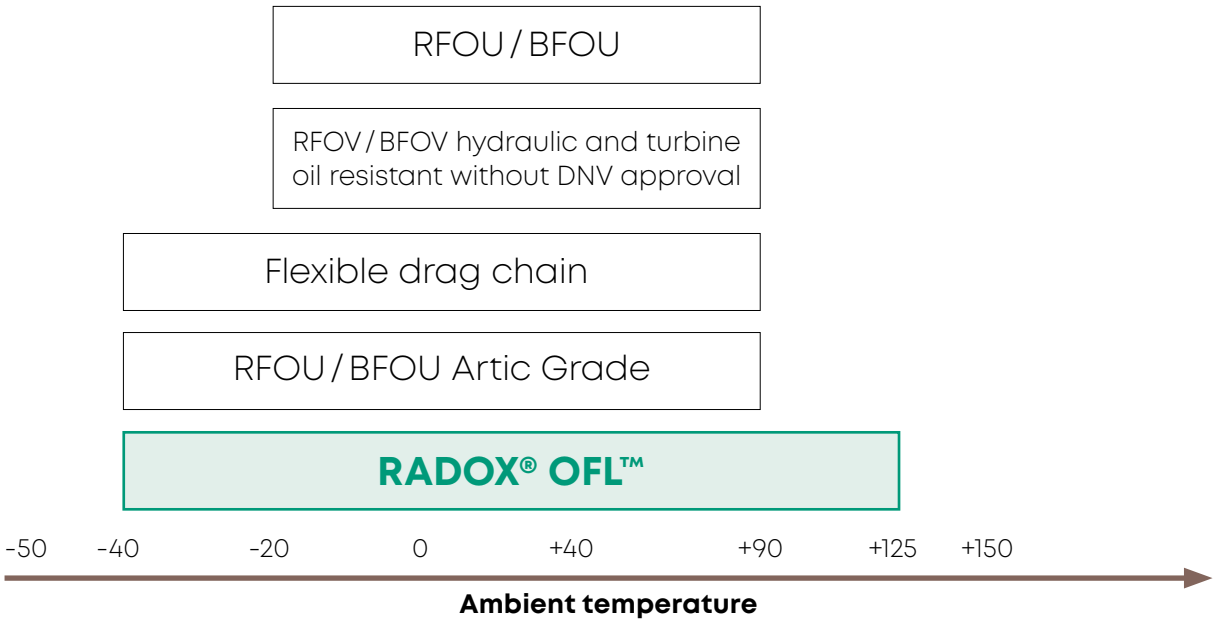
Cable running – go flexible and lightweight

Today, installing multi-pair cables, for example, 24×(2×1.5), is very challenging as these home-run cables are often several-hundred meters long, and extremely stiff and heavy. Therefore, these cables are often split into two of 12×(2×1.5), resulting in more Ex housings and more cable gland connections. The extreme flexibility of the RADOX® OFL™ cable means that a single cable with up to 32 pairs can be easily installed, so reducing the installation complexity.



Widest range of applications with the same cable

RADOX® OFL™ cables combine four different types of cables into one to save inventory:



Specification overview

- RADOX® OFL™ S 150/250V (300/500V) (following RFOU), Flame retardant (IEC 60332-4, -2, 3-22 Cat A) or
- RADOX® OFL™ SFR 150/250V (300/500V) (following BFOU), Fire resistant (IEC 60331-1, -2)
- Pair, triples or quadruples
- Cross-sections 0.5, 0.75, 1.0, 1.5 and 2.5 mm^2
- Up to 32 pairs
- Either individually screened (i), collectively screened (c) or individual/collective (ic)
- Sheath colours: blue, grey, black
- Oil, mud and hydraulic/gear oil resistant according to NEK606:2016, Cat. a – c (Cat d on request, 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 (300/500 V)
- Max. voltage d.c. conductor to earth: 250 V (450 V)
- Max. voltage d.c. conductor to conductor: 500 V (900 V)

Installation recommendations:

- Temperature index of core insulation TI/20kh: > +125 °C
- Temperature index of sheath TI/20kh: > +125 °C
- Min. operation, installation and handling temperature: –40 °C
- Min. bending radius – fixed installation D < 12 mm: 3 × D
  D > 12 mm: 4 × D
  free movement D < 12 mm: 5 × D
  D > 12 mm: 6 × D

Approved and compliant with:

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