



# Tubing Encapsulated Cable

HARSH ENVIRONMENT DOWNHOLE SOLUTIONS



Artwork courtesy of Roxar

LINKING THE OIL AND GAS INDUSTRY FROM END TO END

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Group

# Tubing Encapsulated Cable (TEC) - As tough as the people who use it

**Tubing Encapsulated Cable (TEC) is the answer to the challenges of harsh environmental conditions associated with recovery of oil and gas through reservoir management.**

TEC uses welded stainless steel and nickel alloy tubing to protect electrical and optical components from the pressure and corrosive effects of the downhole environment. Polymeric encapsulation provides additional mechanical protection. And Draka is the only manufacturer that produces and controls all TEC components including fiber / copper cores, hydraulic control / chemical injection lines and in-house encapsulation.

Draka's wide selection of copper and fiber components allow production of the industry's most sophisticated instrumentation cables.

Since first introducing TEC for the oil and gas industry in 1985, Draka has continually improved and optimized this product for new generations of downhole gauges and tools for increasingly hotter and deeper wells.

TEC configurations are available with an almost infinite combination of components in splice-free custom lengths.

Standard encapsulation sizes (11 mm x 11 mm square and 0.41 inch round with flatpack and multiple tube construction) are available to meet almost any downhole requirements.

Composite cables utilizing various combinations of electrical and optical components are available to match specific downhole needs. Please contact a Draka sales engineer to learn more.

## Sample constructions

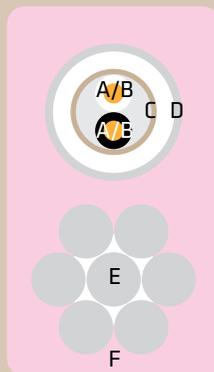
### 18 AWG single conductor Incoloy tube Square encapsulated

- A) 18 AWG (7 x 0.39 mm) tinned copper  
O.D. 0.046 in (1.16 mm) nom.
- B) Natural T-01 (FEP) insulation  
O.D. 0.098 in (2.49 mm) nom.
- C) Red P-06 (polypropylene) filler  
O.D. 0.180 in (4.57 mm) nom.
- D) Alloy 825 tube  
Wall thickness 0.035 in (0.89 mm) nom.  
O.D. 0.250 in (6.35 mm) nom.
- E) Yellow square profile CP-1 (polypropylene)  
0.433 in (11 mm) square



### 16 AWG twisted pair Incoloy tube, galvanized steel bumper Flatpack encapsulated

- A) 16 AWG solid bare copper  
O.D. 0.510 (1.29 mm) nom.
- B) Black and white T-01 (FEP) insulation  
O.D. 0.079 in (2.01 mm) nom.
- C) Natural T-17 (ETFE) filler  
0.181 in (4.60 mm) nom.
- D) Alloy 825 tube  
Wall thickness 0.035 in (0.89 mm) nom.  
O.D. 0.250 in (6.35 mm) nom.
- E) Stranded galvanized steel rope  
O.D. 0.313 in (7.9 mm) nom.  
(7 x 2.64 mm) construction
- F) Rectangular profile CP-1 (polypropylene)  
0.906 x 0.472 in (23 x 12 mm)



# Tubing options

TEC is selected based on well conditions such as pressure, temperature and corrosiveness of the well fluid. The tubing is composed of an alloy matched to the application. It is then longitudinally welded, eddy current tested and drawn to finished size. Complete test data is available for every tube.

Draka has over 25 years of downhole cable design experience coupled with extensive metallurgy expertise. Please consult with Draka's engineers to discuss the correct tubing alloys for specific applications.

## Mechanical Characteristics for Cold-worked 316L and A825 Alloy TEC

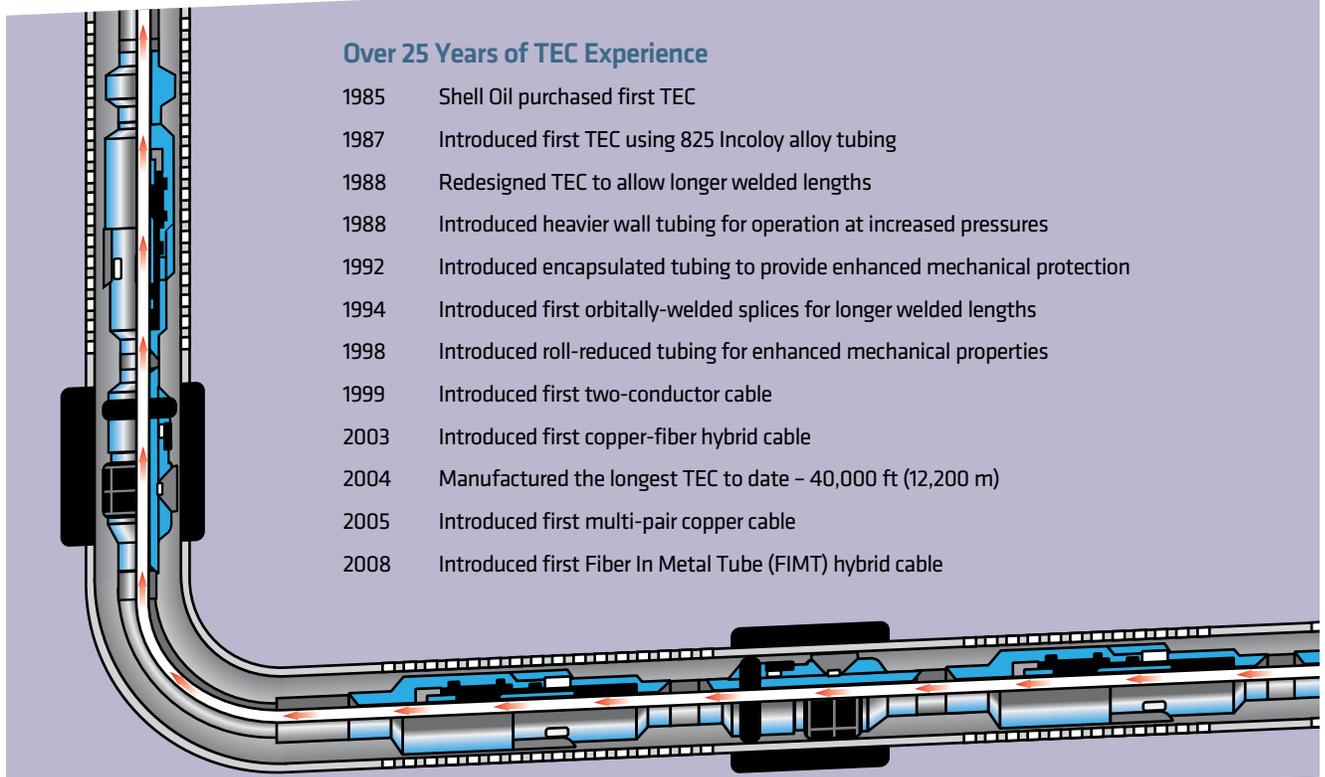
| Diameter Inches | Wall Thickness Inches | 316L Minimum Collapse PSI | A825 Minimum Collapse PSI | Minimum Bend Radius* inches |
|-----------------|-----------------------|---------------------------|---------------------------|-----------------------------|
| .125 (1/8)      | 0.022                 | 23,882                    | 25,209                    | 0.75                        |
| .250 (1/4)      | 0.028                 | 16,371                    | 17,281                    | 1.50                        |
| .250 (1/4)      | 0.035                 | 19,688                    | 20,781                    | 1.50                        |
| .250 (1/4)      | 0.049                 | 26,173                    | 27,627                    | 1.50                        |
| .375 (3/8)      | 0.035                 | 13,783                    | 14,549                    | 2.25                        |
| .375 (3/8)      | 0.049                 | 18,739                    | 19,780                    | 2.25                        |

Calculations based on minimum yield strength of 120,000 psi.

All TEC tubing is oversized welded and drawn.

Tubing can be custom printed with a variety of data including part number, serial number, sequential length and purchase order number.

\*The bending radius indicated is in a static condition after final training at the termination. All bending must be performed using a tubing bender to ensure that the bending radius is uniform. While deploying into or out of the well, the minimum bending radius should be as large as possible.



**Over 25 Years of TEC Experience**

- 1985 Shell Oil purchased first TEC
- 1987 Introduced first TEC using 825 Incoloy alloy tubing
- 1988 Redesigned TEC to allow longer welded lengths
- 1988 Introduced heavier wall tubing for operation at increased pressures
- 1992 Introduced encapsulated tubing to provide enhanced mechanical protection
- 1994 Introduced first orbitally-welded splices for longer welded lengths
- 1998 Introduced roll-reduced tubing for enhanced mechanical properties
- 1999 Introduced first two-conductor cable
- 2003 Introduced first copper-fiber hybrid cable
- 2004 Manufactured the longest TEC to date - 40,000 ft (12,200 m)
- 2005 Introduced first multi-pair copper cable
- 2008 Introduced first Fiber In Metal Tube (FIMT) hybrid cable

# Electrical and Fiber Options

## Electrical Components

| TEC Style         | TEC 100       | TEC 150       | TEC 175        | TEC 200        | TEC 250        | TEC 300                   |
|-------------------|---------------|---------------|----------------|----------------|----------------|---------------------------|
| Temperature range | -10 to +100°C | -10 to +150°C | -100 to +175°C | -100 to +200°C | -100 to +250°C | -100 to +300°C            |
| Filler*           | PP            | PP            | FEP            | FEP            | PFA            | Proprietary Fluoropolymer |
| Insulation*       | PP            | FEP           | FEP            | FEP            | PFA            | Proprietary Fluoropolymer |

\* See the Encapsulation, Insulation and Filling Materials chart on the next page for abbreviations

Copper conductors can be specified from a wide selection of configurations:

- 8 - 28 AWG conductors
- Up to 32 conductors
- Single, pair, triad and quad configurations
- Solid or stranded conductors
- Bare or tinned, silvered or nickled copper

## Maximum Electrical Conductor Resistance @ 68 °F (20°C)

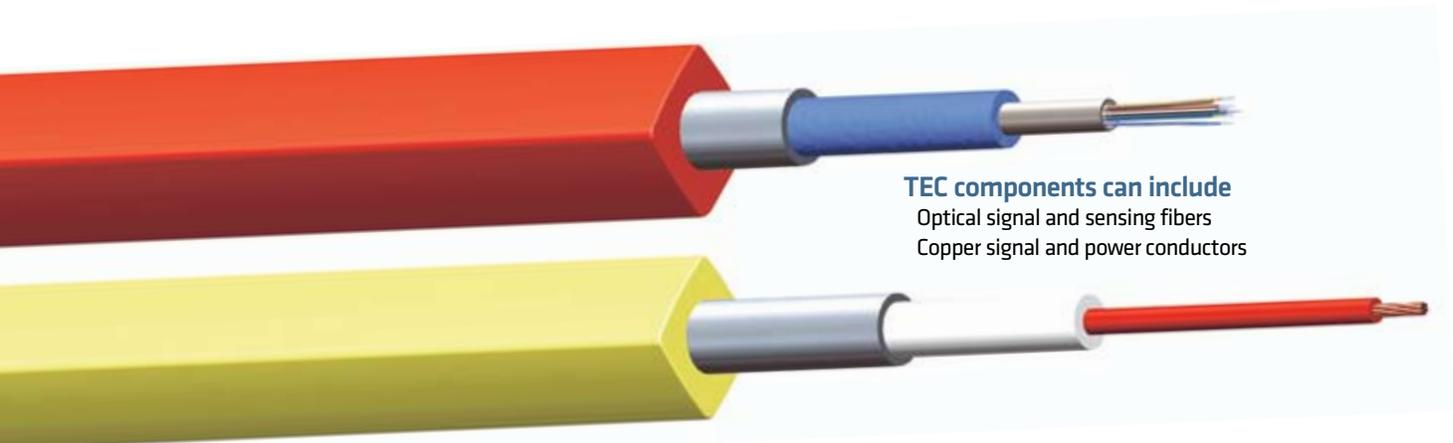
| Conductor AWG | Conductor Outside Diameter inches | Conductor Outside Diameter mm | Solid Bare Copper |          | Stranded (7 strands) Bare Copper |          |
|---------------|-----------------------------------|-------------------------------|-------------------|----------|----------------------------------|----------|
|               |                                   |                               | Ohms / kft        | Ohms / m | Ohms / kft                       | Ohms / m |
| 18            | 0.0403                            | 1.02                          | 6.52              | 21.4     | 6.66                             | 21.8     |
| 17            | 0.0453                            | 1.15                          | 5.15              | 16.9     | 5.27                             | 17.3     |
| 16            | 0.0508                            | 1.29                          | 4.10              | 13.5     | 4.18                             | 13.7     |
| 15            | 0.0571                            | 1.45                          | 3.24              | 10.6     | 3.31                             | 10.9     |
| 14            | 0.0641                            | 1.63                          | 2.57              | 8.45     | 2.62                             | 8.62     |
| 13            | 0.0720                            | 1.83                          | 2.04              | 6.69     | 2.08                             | 6.82     |
| 12            | 0.0808                            | 2.05                          | 1.62              | 5.31     | 1.65                             | 5.43     |
| 11            | 0.0907                            | 2.30                          | 1.29              | 4.22     | 1.32                             | 4.30     |
| 10            | 0.102                             | 2.59                          | 1.019             | 3.34     | 1.039                            | 3.41     |
| 9             | 0.114                             | 2.90                          | 0.808             | 2.65     | 0.825                            | 2.71     |
| 8             | 0.128                             | 3.25                          | 0.641             | 2.10     | 0.654                            | 2.14     |

## Optical Components

| TEC Style      | TEC 100              | TEC 150              | TEC 175  | TEC 200  | TEC 250  | TEC 300  |
|----------------|----------------------|----------------------|--|--|--|--|
| Fiber Coating* | Acrylate             | Mid-temp Acrylate    | Silicone-coated or Polyimide                     | Silicone Coated or Polyimide                     | Polyimide  | Polyimide  |
| Fiber Types    | SM, 50 or 62.5 MM    | SM, 50 or 62.5 MM    | SM, 50 or 62.5 MM                                | SM, 50 or 62.5 MM                                | SM, 50 or 62.5 MM                                | SM 50 or 62.5 MM                                 |
| Buffer Type    | Polymeric loose tube | Polymeric loose tube | 304 stainless steel FIMT 316L and A825 available | 304 stainless steel FIMT 316L and A825 available | 304 stainless steel FIMT 316L and A825 available | 304 stainless steel FIMT 316L and A825 available |

Optical fibers can be specified in configurations of up to 12 fibers

\*Carbon-coated fiber available upon request



**TEC components can include**  
 Optical signal and sensing fibers  
 Copper signal and power conductors

# Encapsulation Options

## Flatpacks

Flatpacks can include copper and fiber components, hydraulic control and chemical injection lines as well as mechanical components for crush resistance and additional longitudinal strength. Individual components and tubes can be color-coded and custom printed to ease installation. Draka TEC production is entirely vertically integrated to provide fast delivery, tight quality control, and the widest variety of configurations.

Draka helps take the guesswork out of well completions. Our engineers will work with you to optimize the selection of tubing alloys and wall thicknesses, crush-resistant bumpers and flatpack encapsulation materials to meet the exact requirement of your wells.

## Completion Fluid Environment

| TEC Style              | TEC 100          | TEC 150          | TEC 175               | TEC 200 | TEC 250 | TEC 300                      |
|------------------------|------------------|------------------|-----------------------|---------|---------|------------------------------|
| Brine                  | HDPE<br>PE       | PP<br>TPO-PP     | FEP, ETFE or<br>ECTFE | FEP     | PFA     | Proprietary<br>Fluoropolymer |
| Petroleum-based        | Nylon            | Nylon            | FEP, ETFE or<br>ECTFE | FEP     | PFA     | Proprietary<br>Fluoropolymer |
| Petroleum<br>and brine | ETFE or<br>ECTFE | ETFE or<br>ECTFE | FEP, ETFE or<br>ECTFE | FEP     | PFA     | Proprietary<br>Fluoropolymer |

## Encapsulation, Insulation and Filler Materials

| Abbreviation | Generic Name                     | Trade Name  | Minimum installation temperature of encapsulation materials |
|--------------|----------------------------------|-------------|---|
| ECTFE        | Ethylene Chlorotrifluoroethylene | Halar®      | -60°C   |
| ETFE         | Ethylene Tetrafluoroethylene     | Tefzel®     | -60°C   |
| FEP          | Fluoronated Ethylene Propylene   | Teflon® FEP | -100°C  |
| HDPE         | High Density Polyethylene        | - -         | -40°C   |
| PFA          | Perfluoroalkoxy                  | Teflon® PFA | -100°C  |
| PA           | Polyamide                        | Nylon       | -40°C   |
| PP           | Polypropylene                    | - -         | -10°C   |
| PVDF         | Polyvinylidene Fluoride          | Kynar®      | -20°C   |
| TPO-PP       | Thermoplastic polyolefin         | Santoprene® | -20°C   |



### Flatpack components can include

- TEC with fiber and electrical conductors
- Hydraulic control lines for controlling of downhole valves
- Fluid injection lines for enhanced oil / gas recovery or corrosion / scaling inhibition
- Bumpers of stranded galvanized steel cable for crush protection

# Linking the oil and gas industry from end to end

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