Draka

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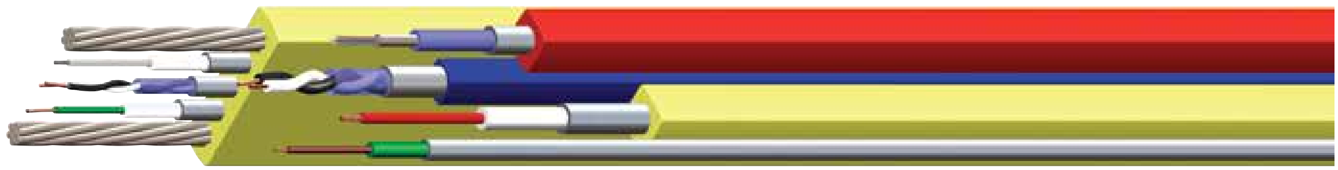
Alloy 316L Seam Welded Sheathed Tubing

COLD WORKED / 90 KSI MINIMUM YIELD STRENGTH / UNS S31603



Application

Alloy 316L seam welded sheathed tubing, which is commonly referred to as TEC, is typically used in oil, natural gas and geothermal wells to provide power and communication to downhole gauges. TEC contains a core consisting of insulated electrical conductor(s) and/or optical fiber(s). The tubing is generally deployed by strapping it to the outside of the production casing. However, it may also be free hanging (self-supporting) inside the production casing. It may be encapsulated and can be included along with pressure tubing and mechanical components, such as bumpers, within a flatpack. The tubing is frequently supplied as 5,000 to 35,000 ft. coils on a wooden or steel reel, depending on size.

Description

Alloy 316L is a chromium - nickel austenitic stainless steel with an addition of molybdenum and reduced carbon content. The addition of molybdenum provides improved resistance to pitting and crevice corrosion in environments containing halides such as chlorides when compared to so-called conventional 18 chromium 8 nickel austenitic stainless steels such as 304L. The reduced carbon content minimizes harmful chromium carbide precipitation during welding and thereby improves resistance to intergranular corrosion. Austenitic stainless steels such as 316L are susceptible to stress corrosion cracking (SCC) in environments containing chlorides and other halides. Alloy 316L is generally used in oil and gas production environments which do not contain oxygen and have limited amounts of chlorides and hydrogen sulfide. Consult ISO 15156-3, Table A.7 for the limits regarding alloy 316L in hydrogen sulfide containing environments for oil and gas production. Draka uses expert system software to assist customers in their selection of alloys for oil and gas environments.

Manufacturing Process and Resultant Properties

Strip splice welds, which are used to join lengths of cold rolled strip, enable long continuous lengths of tubing to be manufactured. The strip is formed into a tubular cross section around the core and longitudinally seam welded using the gas tungsten arc welding (GTAW) process. The tubing is seam welded at a larger outside diameter to protect the core and then sunk to final size. The final material condition of the tubing is cold worked. Mechanical properties, permissible variation in tubing dimensions and size dependant characteristics / properties are listed in Tables 3, 4, and 5 on reverse respectively.

Nondestructive Testing (NDT)

In-process eddy current testing (ECT) is performed on the as-welded tubing and final ECT is performed on the as-sunk tubing. Visual examination is performed on all ECT indications. Performance of additional NDT is dependent upon both the type of core and specific customer requirements, and may include: electrical continuity, high voltage/bending; insulation resistance, optical time domain reflectometer, and high pressure nitrogen underwater.

Standards and Specifications

Tubing Specification PTM-TS-001, Alloy 316L Sheathed Insulated Electrical Conductors and Optical Fibers

ASTM A554, Standard Specification for Welded Stainless Steel Mechanical Tubing

Meets the material limits for austenitic stainless steel listed in ISO 15156-3, Table A.7

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Table 1 - Chemical Composition

UNS S31603 with further restrictions by Draka Strip Specifications PTM-SS-002 or PTM-SS-006, (%)

C	Mn	P	S	Si	Cr	Ni	Mo	N	Cu	Fe
0.030 max	2.00 max	0.040 max	0.017 max	0.75 max	16.0 - 18.0	10.0 - 14.0	2.00 - 3.00	0.10 max	0.50 max	Bal

Table 2 - Typical Physical Constants and Thermal Properties

Density (lbs/in^3)	0.290
Modulus of tension elasticity (x 10^6 psi)	29.0 at 70°F
Mean coefficient of thermal expansion from 70°F to temperature shown (in/in/°F x 10^{-6})	9.2 to 200°F

Table 3 - Mechanical Properties

Property	Minimum	Typical
Ultimate Tensile Strength UTS, (psi)	100,000	140,000 to 160,000
0.2% Offset Yield Strength, YS (psi)	90,000	115,000 to 130,000
Elongation in 2 inches, E (%)	–	5 to 15
Vickers Hardness, HV5 (5 kg load)	–	300 to 340

Note: Typical properties vary with the amount of cold work. Vickers Hardness testing was performed in weld metal and base metal regions on mounted cross sections

Table 4 - Permissible Variation in Tubing Dimensions

Dimension	Permissible Variation
Nominal Outside Diameter (in)	± 0.002
Nominal Wall Thickness 0.022-in.	0.0200 to 0.0225
Nominal Wall Thickness 0.028-in.	0.0255 to 0.0285
Nominal Wall Thickness 0.035-in.	0.0315 to 0.0355
Nominal Wall Thickness 0.049-in.	0.0445 to 0.0495

Table 5 - Size Dependant Characteristics / Properties (based upon nominal tubing dimensions)

Nominal Outside Diameter in	Nominal Wall Thickness in	Minimum Burst Pressure psi	Minimum Collapse Pressure psi	Metal Cross Section in^2	Weight per unit Length lbs/1000 ft	Load at Minimum 0.2% YS lbs	Load at Typical UTS lbs
0.125	0.022	31,496	23,882	0.0071	24.8	641	1,068
0.125	0.028	40,157	28,885	0.0085	29.7	768	1,280
0.1875	0.035	33,245	24,947	0.0168	58.4	1,509	2,515
0.250	0.028	20,238	16,371	0.0195	68.0	1,758	2,929
0.250	0.035	25,000	19,688	0.0236	82.3	2,128	3,546
0.250	0.049	35,317	26,173	0.0309	107.7	2,785	4,641
0.3125	0.049	28,299	21,865	0.0406	141.2	3,651	6,084
0.375	0.035	16,711	13,783	0.0374	130.1	3,365	5,608
0.375	0.049	23,607	18,739	0.0502	174.6	4,517	7,528

Notes Regarding Burst and Collapse Pressure

Minimum internal burst pressure and external collapse pressure calculations were based upon:

Minimum ultimate tensile strength, UTS_{min} and minimum 0.2% offset yield strength, YS_{min} per above table.

Maximum outside diameter, OD_{max} per above table

Minimum wall thickness, t_{min} per above table

Minimum burst pressure = (2 x t_{min} x UTS_{min}) / OD_{max}; assumes no axial or other loading except internal pressure.

Collapse pressure based on API 5C3; assumes no ovality, internal pressure or other loading except external pressure.

Notes Regarding Load at 0.2% YS & UTS

The load at minimum 0.2% YS represents the load at which 0.002 in/in of plastic (permanent) axial strain deformation has occurred.
The load at typical UTS represents the load to cause failure. The UTS used in the calculation of the load at typical UTS was 150,000 psi.
Decisions regarding the pull out load to be applied to tubing should consider these two loads.

The data herein is approximate and subject to normal manufacturing tolerances. These specifications are subject to change without notice.

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