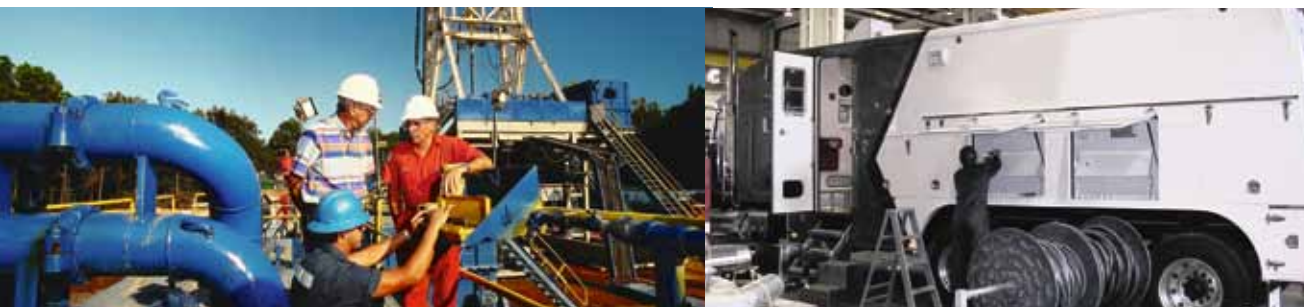


Sandvik slicklines **for the oil & gas industry**





When you put your expensive equipment on the line, make sure it's a reliable one!

The demand for reliable and cost-effective slicklines increases as the oil and gas industry explores finds at even greater depths.

Sandvik is a leading manufacturer and supplier of alloyed stainless steel wire, capable of withstanding severe corrosive environments as well as high pressures and high temperatures.

A strong alternative for increased productivity

Slicklines are used in tough environments, where wire material is exposed to great risks such as fatigue, overloading, mechanical damage, corrosion and high-temperature embrittlement.

To cope with aggressive well conditions, Sandvik offers steel grades that combine strength with a chemical composition maximized to provide the best possible anti-corrosion properties.

Sandvik's innovative material development focuses on improving our customers' efficiency and productivity through

longer-lasting and more secure lines. The user will benefit from purchase of fewer lines, minimized downtime, reduced re-spooling costs and reduced risk of failure.

Tried and tested

All Sandvik lines are fully non-destructive tested during manufacture. Destructive testing after manufacture includes tensile strength (breaking load), micrographic (surface and microstructure), ductility (wrap testing) and Positive Material Identification (analysis).

Slicklines with a bright future

Beginning in 2009, Sandvik offers slicklines in a bright, lustrous finish, created by using a bright-drawing process. Through the complete elimination of polishing marks, fatigue testing of Sandvik bright-drawn lines has shown an increase of completed cycles before failure of up to 25%. Corrosion testing has shown that the smooth bright-drawn finish provides additional corrosion

resistance due to the significant reduction in cavities where pitting corrosion could start.

The smooth, bright finish reduces friction and wear in all slickline equipment, from the drum to the stuffing box, thereby prolonging the lifetime of both the slickline and the equipment.





Sandvik slicklines come with all the technical support you need

As a Sandvik slickline customer, you have direct access to Sandvik's steelmaking expertise, materials knowledge and worldwide applications experience. We'll assist you with trouble-shooting and problem solving, as well as advising on material selection, properties and material handling.

Sandvik controls the entire steelmaking process – from the melt to the finished product. In our R&D center, 250 engineers are developing new materials and making improvements to existing products in order to satisfy new and future market needs. This includes better fatigue strengths, greater breaking loads and enhanced corrosion properties.

Our strategically localized stocks ensure quick product deliveries.

The Sandvik Group

The Sandvik Group is a global high technology enterprise with 50,000 employees in 130 countries. Sandvik's operations are concentrated on three core businesses: Sandvik Tooling, Sandvik Mining and Construction and Sandvik Materials Technology – areas in which the group holds leading global positions in selected niches.

Sandvik Materials Technology

Sandvik Materials Technology is a world-leading manufacturer of high value-added products in advanced stainless steels, special alloys, metallic and ceramic resistance materials, as well as medical implants and process plants.

Quality Assurance

Sandvik Materials Technology has Quality Management Systems approved by internationally recognized organizations. We hold, for example, the ASME Quality Systems Certificate as a Materials Organization, approval to ISO 9001, ISO/TS 16949, ISO 17025, and PED 97/23/EC, as well as product approvals from TÜV, JIS and Lloyd's Register.

Environment, Health & Safety

Environmental awareness, health and safety are integral parts of our business and are at the forefront of all activities within our operation. We hold ISO 14001 and OHSAS 18001 approvals.



Grade selection guide

When choosing material grade for slicklines, please take the following into consideration:

- **Mechanical properties required**
- **Local concentrations of chlorides, carbon dioxide and hydrogen sulphide**
- **Downhole pressure and temperature**
- **Manufactured according to API-9A, in applicable parts**



Sandvik grade						Minimum tensile strength ksi	Diameter inch	Minimum breaking load lbf	Weight lb/1000 ft	Maximum length ft (approx)
Sanicro® 36Mo						276	0.092	1 831	22.95	55000
C	Cr	Ni	Mo	N			0.105	2 524	29.89	43000
≤ 0.020	27	34	5.5	0.4			0.108	2 457	31.63	40000
UNS N08936							0.125	3 381	42.37	35000
Austenitic alloy										
PRE ¹⁾ = ≥50										
Sanicro® 26Mo						230	0.082	1 214	18.31	70000
C	Cr	Ni	Mo	Cu	N		0.092	1 530	23.95	55000
≤ 0.020	20.5	25	6.3	0.8	0.2		0.105	1 990	30.02	43000
UNS N08926							0.108	2 105	31.76	40000
Austenitic alloy							0.125	2 820	42.55	35000
PRE ¹⁾ = ≥43							0.150	4 061	61.27	25000
Sanicro® 28						220	0.082	1 149	18.31	70000
C	Cr	Ni	Mo	Cu			0.092	1 446	23.95	55000
≤ 0.020	27	31	3.5	1.0			0.105	1 883	30.02	43000
UNS N08028							0.108	1 992	31.76	40000
Austenitic alloy							0.125	2 669	42.55	35000
PRE ¹⁾ = ≥38							0.150	3 843	61.27	25000
SAF 2707 HD®						268	0.108	2 457	31.00	40000
C	Cr	Ni	Mo	N			0.125	3 292	41.50	35000
≤ 0.030	27	6.5	4.8	0.4						
UNS S32707										
Duplex stainless										
PRE ¹⁾ = ≥48										
SAF 2205®						250	0.082	1 302	17.81	70000
C	Cr	Ni	Mo	N			0.092	1 639	22.42	55000
≤ 0.030	22	5.5	3.2	0.18			0.105	2 134	29.21	43000
UNS S31803							0.108	2 258	30.90	40000
Duplex stainless							0.125	3 025	41.39	35000
PRE ¹⁾ = ≥35							0.150	4 356	59	25000
5R60						220	0.082	1 149	17.99	70000
C	Cr	Ni	Mo				0.092	1 446	22.64	55000
0.04	17	11	2.6			203	0.105	1 758	29.49	43000
AISI 316, UNS S31600							0.108	1 860	31.20	40000
Austenitic stainless							0.125	2 491	41.80	35000
PRE ¹⁾ = ≥25							0.150	3 587	60.19	25000

Typical elastic modulus: 26 800 ksi (185 000 MPa) for the austenitic grades. Approx. 200 000 MPa for Sandvik SAF 2205.

Typical yield strength: 90% of tensile strength for Sandvik Sanicro 28 and Sandvik SAF 2205, 85% for the other steel grades.

¹⁾ PRE, Pitting Resistance Equivalent = %Cr + 3.3x%Mo + 16x%N.

Product features

Sandvik Sanicro® 36Mo

- High strength for sour wells.
- Also suitable for multi-strand logging cables.
- Very good corrosion resistance in H₂S, chloride and CO₂ environments.
- Very good resistance to pitting and general corrosion.

See datasheet S-2807-ENG for more details.

Sandvik Sanicro® 26Mo

- For sour wells. Also suitable for multi-strand logging cables.
- Very good corrosion resistance in H₂S, chloride and CO₂ environments.
- Very good resistance to pitting and general corrosion.

See datasheet S-2801-ENG for more details.

Sandvik Sanicro® 28

- For sour wells. Also suitable for multi-strand logging cables.
- Very good corrosion resistance in H₂S, chloride and CO₂ environments.
- Very good resistance to pitting and general corrosion.

See datasheet S-2805-ENG for more details.

Sandvik SAF 2205®

- For heavy demands on tensile strength in medium sour wells with a hydrogen sulphide partial pressure of max. 3 psi.
- Very good corrosion resistance in chloride environments.
- Good resistance to pitting and general corrosion.

See datasheet S-2806-ENG for more details.

Sandvik SAF 2707 HD®

- Super-high tensile strength for medium sour wells with a hydrogen sulphide partial pressure of maximum 3 psi.
- Extremely good corrosion resistance in chloride environments.
- Very good resistance to pitting and general corrosion.

See datasheet S-2815-ENG for more details.

5R60

- A cost-effective choice in less severe corrosive conditions.
- Good resistance to general corrosion.

See datasheet S-2809-ENG for more details.

Grade selection software

Sandvik's Grade Selection Guide (GSG) software provides recommendations based on extensive corrosion testing carried out on all grades over many years. Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when the actual service conditions are known. The Grade Selection Guide can be obtained by contacting your local Sandvik office.

Cut costs and save time

- Improve the accuracy of your grade selection
- Reduce downtime
- Improve your performance

The widest product range suitable for sweet, medium and sour wells.



Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice. Sandvik, Sanicro, Sandvik SAF 2205 and Sandvik SAF 2707 HD, are trademarks owned by Sandvik Intellectual Property AB..

How to maximize slickline life

Correct handling will prolong the life of the line and reduce your costs.

Stretch

Under load, a wireline will elongate (stretch) elastically. The following formula can be used to calculate slickline elongation.

Imperial and metric units

$$S = F \times L (T + 0.5W)$$

Example

Stretch (inches) for a 0.125" Sanicro 26Mo line working at 8,000 ft, with a 200 lb tool.

F (stretch factor):	3.6439×10^{-5}
L (read-off length, ft):	8,000
T (tool weight, lb):	200
W (weight of line in well, lb):	154

$$S = 3.6439 \times 10^{-5} \times 8,000 \times (200 + (0.5 \times 154))$$

$$S = 0.2195 \times (200 + 77)$$

$$S = 0.2195 \times 277 = \mathbf{81(\text{inches})}$$

What slickline length is needed, i.e. read off length at spool, to reach a desired depth in the well?

Imperial units

$$L = 12 \times \frac{R}{12 + F (T + 0.5W)}$$

Metric units

$$L = \frac{R}{1 + 0.001 \times F (T + 0.5W)}$$

where

- S = stretch in inch or mm
- F = stretch factor, see table at right
- L = read off length, feet or m
- T = tool weight, lb or kg
- W = weight of wire in well, lb or kg (see table at page 5)
- R = desired depth
(read off line length + stretch) feet or m.

Stretch factor, F

Wire diameter inch	Stretch factor inch/feet/lb
0.092	6.7×10^{-5}
0.105	5.2×10^{-5}
0.108	4.9×10^{-5}
0.125	3.6×10^{-5}
0.150	2.5×10^{-5}

For Sandvik SAF 2205 and SAF 2707 HD, the stretch factor will be 8% lower

Fishing

When a line failure occurs, the lost part will take the form of a spiral. The height per 1000 ft of lost line length can be estimated using the following figures:

Tube diameter inch	Spiral height, feet Line diameter, inch		
	0.092	0.105/0.108	0.125
7	820	910	955
5 1/2	920	960	980
4 1/2	950	975	988
3 1/2	970	985	993

Recommended safe load

Sandvik recommends a safe load of 75% of the effective breaking load.

$$\text{Breaking load} = \text{Certified tensile strength} \times \text{diameter}^2 \times 0.7854$$



Minimum sheave diameter

Wire diameter inch	0.092	0.105	0.108	0.125	0.14	0.15	0.16
Min. sheave diameter inch	13	15	15	17	20	21	22



Conversion table

1 inch = 25.4 mm

1 ft = 0.305 m

1 inch² = 645.2 mm²

1 lb = 0.454 kg

1 lbf = 0.454 kp = 4.45 N

°C = (°F - 32) x 0.555

°F = 32 + (°C x 1.80)

1 atm = 1.013 bar

1 atm = 14.70 psi

1 atm = 0.1013 N/mm²

1 atm = 1.033 at

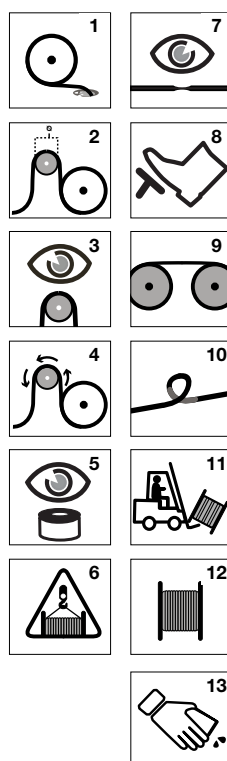
= 1.033 kp/cm²

1 MPa = 1 N/mm² = 145 psi

1 ksi = 1 000 psi

1 psi = 0.069 bar

1 kp/cm² = 14.22 psi



Recommendations for line usage

1. Avoid abrasion between the line and the ground or other equipment
2. Ensure that sheave grooves are of the correct diameter
3. Check sheaves for wear
4. Check that sheaves are able to rotate freely
5. Check the rubber seal in the stuffing box for wear
6. Use caution during jarring operations
7. Inspect lines for diameter reduction after heavy jarring
8. Brake carefully when lowering tools into the well
9. When re-spooling, always spool from top to top
10. Avoid kinking the line
11. Avoid damage to shipping spools
12. Store wireline spools vertically
13. Clean lines after use

Ductility testing

Testing lines for ductility is usually carried out by a torsion test or a wrap test. Torsion testing is the recommended method for testing ductility in carbon steel wirelines and wrap testing is the recommended method for stainless steel wirelines. The reason for using two different methods for testing ductility is purely technical: Carbon steel has the same ductility properties in all directions. This means it will tolerate being twisted. Stainless steel is vastly more complex in structure and will not tolerate being twisted. Instead, wrapping of the wire around its own diameter is recommended.

Wrap testing

The wrap test stretches the outer skin of the wire, exposing tendencies to cracking, but without causing stresses in the horizontal direction. Any tendency to cracking caused by embrittlement will be observed in the surface of the wire. A full explanation for these recommendations is provided in the document "Differences in structure, carbon and stainless steels" which can be obtained by contacting your local Sandvik office.



Torsion testing equipment

The Wraptor is a Sandvik-developed wrap and torsion tester, which can be ordered from your local Sandvik office.

Sales and service around the world

www.smt.sandvik.com/worldwide



Sandvik Materials Technology
SE 811 81 Sandviken, Sweden, Phone +46 26 26 30 00, Fax +46 26 27 47 20
www.smt.sandvik.com