The New Generation

AlphaRod® Sucker Rods

Tenaris

Steel that sets new standards

Until today, the industry had produced sucker rods only with conventional steel grades used in mechanical applications in neutral or benign environments. These materials have performed satisfactorily, but have reached their limit.

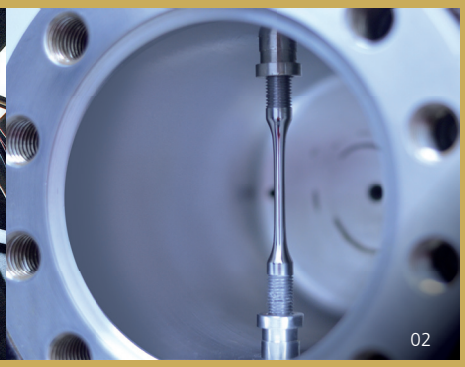
In the presence of a corrosive environment, the fatigue limit of the steel is reduced dramatically in correspondence with the following:

- **Environmental conditions:** pressure, temperature, concentrations of CO2 and H2S, water injection percentage and chemical composition, bacterial activity, chloride content, pH and dynamic fluid.
- **Mechanical conditions:** stress level, frequency, load spectrum, and overloads.
- **Metallurgical conditions:** steel cleanliness, chemical composition, residual elements, microstructure and grain size.

Tenaris's expertise in the development of steel and the optimization of manufacturing processes for Oil & Gas critical applications enabled the development of two steel grades that satisfy new operative requirements:

- **AlphaRod® HS** (High Strength)
- **AlphaRod® CS** (Critical Service)


01


02

A comprehensive program of tests –detailed below– confirmed that the new AlphaRod® series widely exceeds the performance of API and HS steel grades.

- NACE Test (National Association of Corrosion Engineers).
- Fatigue full-scale testing in neutral environments (01).
- Corrosion fatigue test in environments with CO2 y H2S. Specially designed equipment with autoclave allowed to run these tests while varying parameters such as pressure, temperature, fluid type and simulating the most extreme operative conditions in the field (02).

AlphaRod®
Exceptional solution to toughest demands

The AlphaRod® series was created to overcome more demanding requirements and offer a solution to fatigue and corrosion-fatigue problems. During oil production, sucker rods face operative conditions that get tougher by the day:

MATURE CONVENTIONAL WELL

In secondary oil recovery, with increased water injection and production volumes where the concentration of compounds such as CO2, H2S and bacteria increases due to the lack of chemical treatment or their low efficiency.

In Enhanced Oil Recovery (EOR) with chemical additives (injection of surfactants, polymers and alkaline solutions) that increase the corrosion levels of production fluids.

NON-CONVENTIONAL WELL

Greater depths, deviated, and –in most of the cases– with horizontal sections and high production volumes that increase the axial and lateral loads during the pumping cycle.

Offset frack: fracturing cycles of a well can interfere the operations of surrounding wells causing an increment of the fluid corrosiveness.

In the conditions described above, fatigue and corrosion fatigue phenomena expose sucker rods in such ways that lead to an increase in premature fails. The new steel grades of the AlphaRod® generation were specially designed to satisfy these operative conditions.

"Corrosion fatigue is defined as the sequential stages of metal damage that evolve with accumulated load cycling, in an aggressive environment compared to inert or benign surrounding, and resulting from interaction of irreversible cyclic plastic deformation with localized chemical or electrochemical reactions".

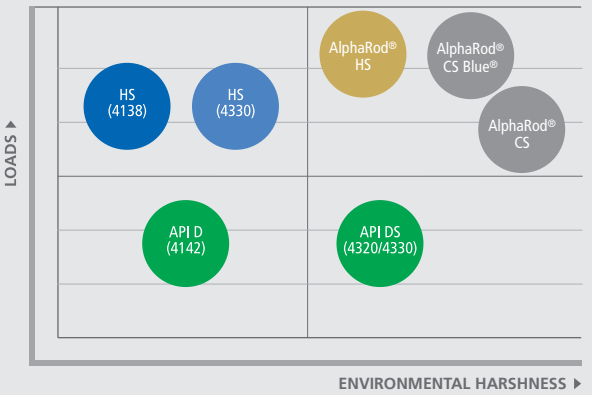
R. P. Gandloff
Environmental Cracking - Corrosion Fatigue

The promise of a new generation

While comparing standard API and HS sucker rods, the AlphaRod® HS and CS offer the following advantages:

- Superior toughness when compared to standard API sucker rods.
- Extended lifespan.
- Enhanced fatigue resistance in harsh environments.
- Increased reliability due to strict controls during the manufacturing process.
- Increased service loads.

Application field



Substitution table

A series with improved performance that substitutes standard steel grades.

Standard grades	AlphaRod® grades
API D 4142	AlphaRod® CS
API DS 4320/30	
HS 4138 - HS 4330	AlphaRod® HS

Dimensional range

Sucker rod body diameter	5/8 in.	3/4 in.		7/8 in.		1 in.	1 1/8 in.
Thread diameter	5/8 in.	3/4 in.	7/8 in.	7/8 in.	1 in.	1 in.	1 1/8 in.
Available thread type	API	API	API	API	API	API	API
			BLUE®	BLUE®		BLUE®	
Type of couplings	CS (Critical Service)			HS (High Strength)		SM (Spray Metal)	

Available thread types: API or Blue®.

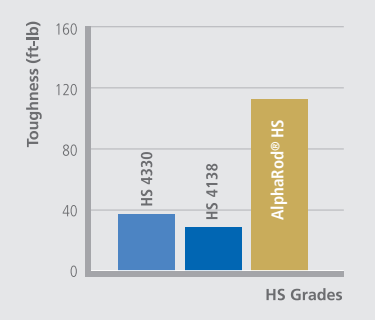
AlphaRod® HS
High Strength

The solution for very high loads in medium corrosive environment, offering improved performance than the conventional high strength sucker rods.

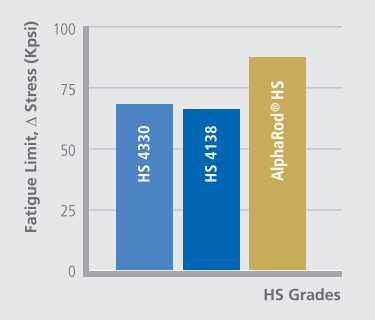
AlphaRod® HS mechanical properties

YS (0.2% offset)	135 Kpsi (930 MPa)
UTS	155 Kpsi (1068 MPa)
Elongation (8")	10% Min
Impact Toughness (CVN@20°C)	110 ft-lb (150 J)

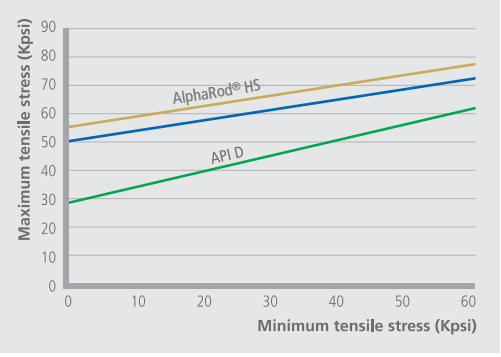
Superior toughness when compared to steel grades of similar resistance



Superior fatigue resistance



AlphaRod® HS Goodman diagram



Goodman formula for AlphaRod® HS and AlphaRod® CS

Goodman formula	$\%Goodman = \left(\frac{TSmax - TSmin}{TSallow - TSmin}\right) * 100$
AlphaRod® CS	TSallow = (44.64 + 0.375 TSmin) *SF
AlphaRod® CS Blue®	TSallow = (52.08 + 0.375 TSmin) *SF
AlphaRod® HS	TSallow = (55.36 + 0.375 TSmin) *SF

REFERENCES

SF = Service factor*
TSallow = Allowable tensile stress (Kpsi)
TSmin = Minimum tensile stress (Kpsi)
TSmax = Maximun tensile stress (Kpsi)

(*) The service factor takes into consideration the corrosivity of the environment (H2S, CO2, injection water chemical composition, etc). Its value may vary between 0.8 and 1.0.

AlphaRod® CS

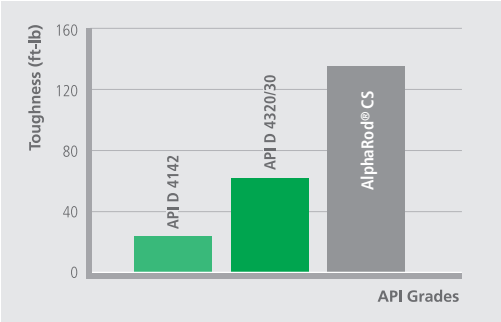
AlphaRod® CS Critical Service

Designed for corrosive environments, able to withstand higher loads than traditional (API) sucker rods.

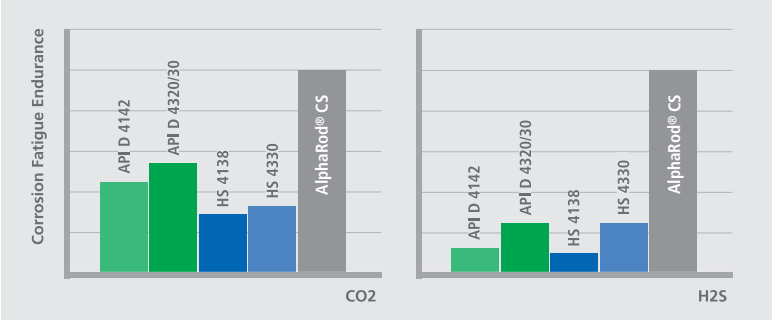
AlphaRod® CS mechanical properties

YS (0.2% offset)	110 Kpsi (758 MPa)
UTS	125 Kpsi (862 MPa)
Elongation (8")	10% Min
Impact Toughness (CVN@20°C)	133 ft-lb (180 J)

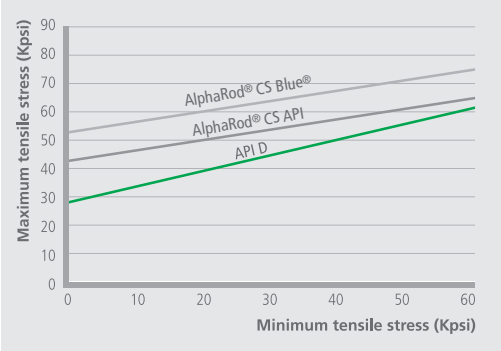
Superior toughness when compared to API steel grades



Higher Endurance in Corrosion Fatigue



AlphaRod® CS Goodman diagram



A new process brings to life what was thought impossible

A fully integrated production process –from steel production and rolling to the final heat treatment– guarantees the top performance and quality of this series.

The steel chemical composition and the heat treatment process allow obtaining a martensitic transformation higher than 90%. This prevents the formation of harmful micro-constituents affecting the toughness of the sucker rod.

During the steelmaking process, raw materials as well as the process itself undergo strict controls with the aim of reducing residual elements (mainly S and P) and oxygen content to minimize the non-metallic inclusion content offering a greater resistance in sour environments.

Throughout the production process, the austenitic grain size control is key to obtain an optimal combination between strength and toughness. Finally, the heat treatment guarantees the martensitic structure that completes the final properties of the product.

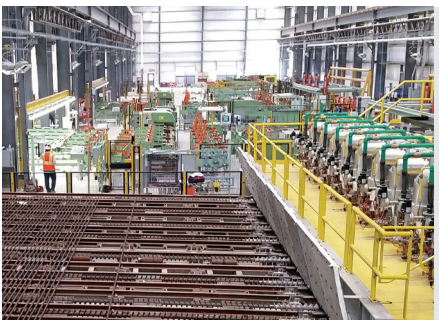
The above-mentioned conditions define altogether an excellent fatigue and corrosion fatigue resistance.

STEEL SHOP

- Ultra-clean steelmaking practice.
- Low levels of non-metallic inclusions.
- Low content of phosphorus and sulfur.
- Strict control of chemical composition.

ROLLING AND NDT

- 100% automated process.
- Rigorous control of temperature and grain size.
- Inspection of longitudinal and transversal discontinuities and internal defects (EMI - UT).
- Automatic measurement of length and diameter.



HEAT TREATMENT

- Quench & temper process specially designed for the production of the AlphaRod® series.
- Martensitic structure throughout the length and thickness of the sucker rod.
- Mechanical properties continuous assessment.

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For further information please contact:
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