Sucker Rods
Catalogue

Tenaris

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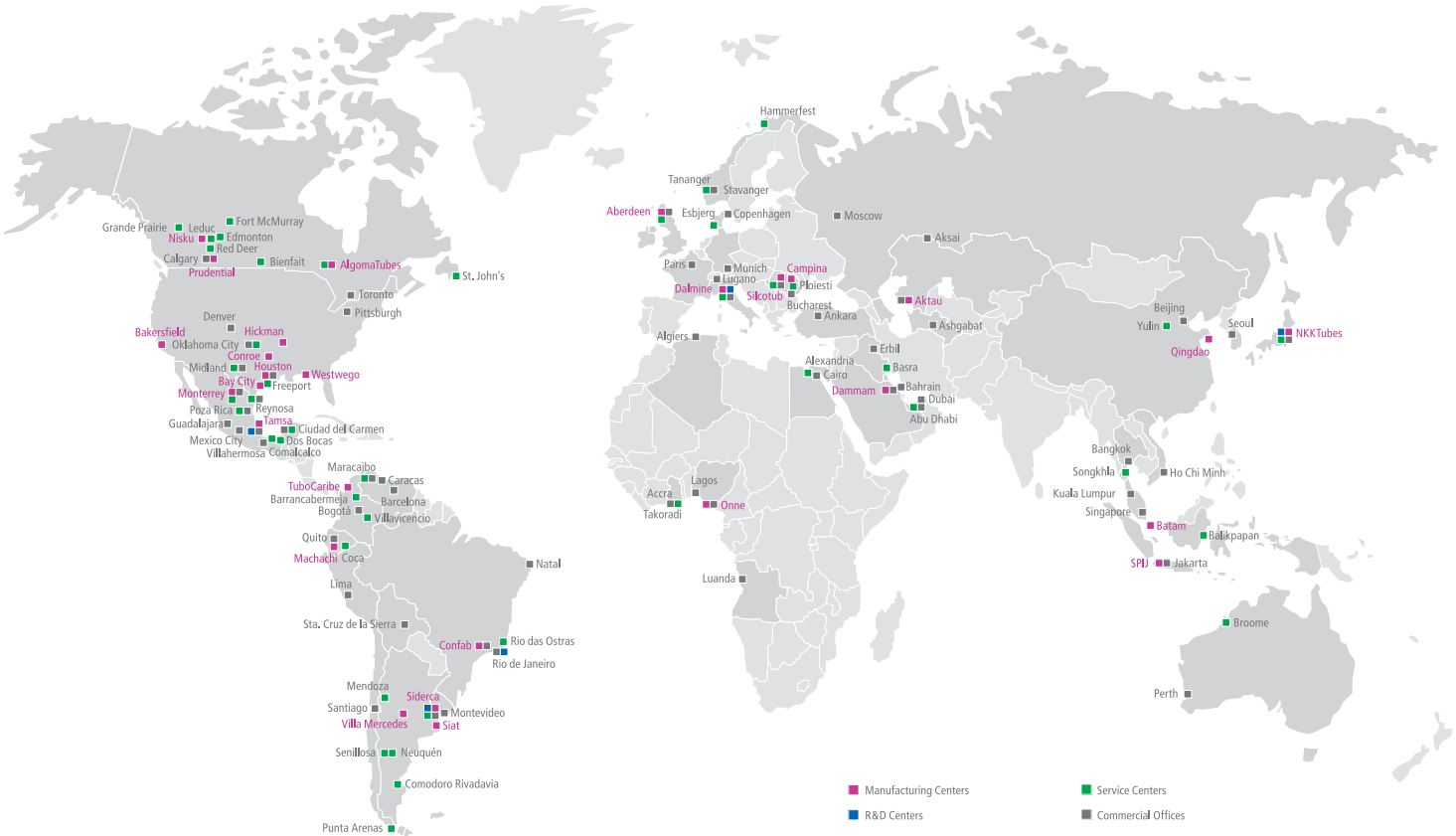
Tenaris

Tenaris is a leading supplier of tubes and related services for the world's energy industry and certain other industrial applications. Our mission is to deliver value to our customers through product development, manufacturing excellence and supply chain management. We seek to minimize risk for our customers and help them reduce costs, increase flexibility and improve time-to-market.

Tenaris employees around the world are committed to continuous improvement by sharing knowledge across a single global organization.

Through our integrated global network of manufacturing, R&D and service facilities, we work with our customers to meet their needs for the timely supply of high-performance products in increasingly complex operating environments.



Fully Integrated Manufacturing Process

Tenaris manufactures sucker rods in a fully integrated industrial process. With production centers strategically located in three regions, we meet the growing demand of our customers all over the world.

From the production of steel as a raw material to the threading of each sucker rod, the entire process takes place in our own manufacturing centers. Located in Villa Mercedes (Argentina), Pindamonhangaba (Brazil), Veracruz (Mexico), Campina (Romania) and Conroe (USA), these state-of-the-art plants are equipped to manufacture Tenaris's full line AlphaRod® Series, HolloRod™ Series, BlueRod®, X-Torque, High Strength and API sucker rods.

Tenaris's sucker rods and accessories are designed to efficiently respond to challenging operating conditions, including high loads, corrosive environments and applications where control of tubing/rod friction is required.

Manufactured to the most stringent quality standards, all product lines comply with ISO 9001 and API Q1 specifications. A single quality policy and the enforcement of a rigorous quality management system ensure homogeneous quality across all facilities. Quality control procedures include statistical process controls, daily process/product audits and sucker rods traceability systems.

Each individual rod is straightened, while its entire surface is inspected by Non Destructive Testing (NDT) equipment that can detect any potential transversal or longitudinal defects in accordance with API criteria. Internal ultrasonic tests are also performed. Additionally, all Tenaris sucker rods undergo a shot peening process that compresses their external surface to improve fatigue resistance.

VERACRUZ
In October 2011 Tenaris began producing rods in Mexico, becoming the only local manufacturer of this type of products.

Delivering Value for Customers

Building on its global reach and vast field experience, Tenaris offers a wide range of services that add value through customized supply, operational, administrative and technical solutions for your operations.

Tenaris's experienced field service specialists are always on hand to assess our customers' operational needs. The services they provide include:

STRING DESIGN OPTIMIZATION

With vast experience in even the most challenging oil well operational environments, Tenaris is able to provide full assistance in identifying the optimum string design for each particular application. Using advanced simulation software, our experts can help you with both beam and progressive cavity pumping rod string designs.

JUST-IN-TIME DELIVERY AND INVENTORY MANAGEMENT

Thanks to our global network of customer service centers, combined with our logistics expertise, we can offer just in-time delivery of materials and work closely with our customers to provide full inventory management services.

RUNNING SUPERVISION

One of the main causes behind sucker rod failures is poorly performed running. Hydraulic tongs used at the well site are not equipped to monitor that the required torque values are applied to each connection. Therefore, pressure losses, inadequate calibration and operational mistakes can lead to premature failures.

To respond to these needs, Tenaris offers a specialized running service that includes:

- Trained personnel for the supervision of handling, thread cleaning, make-up and torque control activities, ensuring compliance with best practices.
- Deployment of advanced hydraulic power tongs for optimal make-up operation and torque control analysis.
- Torque control in problematic wells with high failure rates.

PARTNERS IN THE FIELD
Tenaris offers specialized running services.

TECHNICAL ASSISTANCE

During installation, Tenaris's field engineers are trained to assist customers and address any technical doubts that could arise in the field.

TRAINING

Tenaris provides training services on product selection, string design, material handling and other aspects of the installation and operation of sucker rods. Classroom or in-field training sessions are customized to match the level of experience, knowledge and specific needs of each team.

FAILURE ANALYSIS

In our state-of-the-art laboratories, we analyze the mechanical and dimensional properties of materials, as well as the corrosion effects on them. The resulting data is used to effectively diagnose the cause of failure.

MATERIAL OPTIMIZATION SERVICE (MOS)

Designed to improve sucker rod performance and to reduce well interventions, our MOS is based on an integral analysis of the problematic field or area. This service includes a fully integrated application of all the services described above.

Following the completion of field surveys, interviewing of key customers and statistical analysis of well intervention history, our experts will propose detailed technical recommendations, covering material selection, string design and operational practices, and assist with their implementation.

Customized Services

Design & Technology

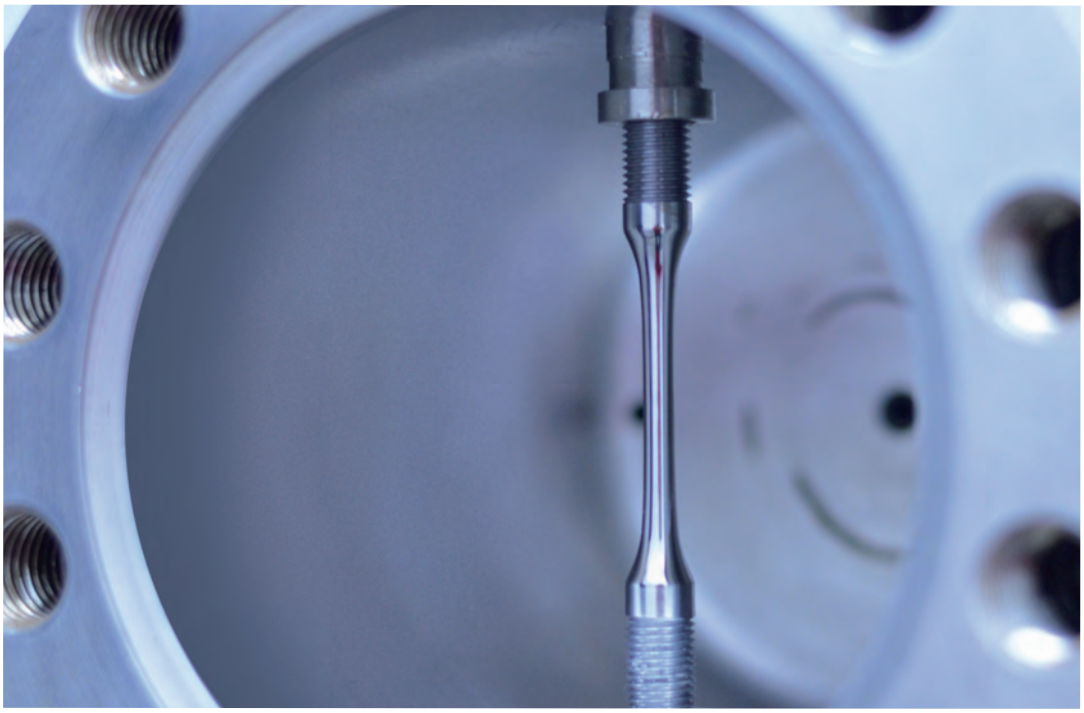
Tenaris offers field-proven products designed for the most challenging oil & gas applications.

At Tenaris, our goal is to make sure that our customers can take full advantage of the latest product technology to address their needs in the field. By sharing knowledge and resources across a global organization and leveraging our specialized R&D centers in Italy, Japan, Mexico, Brazil and Argentina, we are able to expand our range of product solutions to meet today's increasingly demanding well conditions.

Through the work carried out at the Structural Integrity, Metallurgy, Non Destructive Testing and other key departments of Tenaris's R&D network, new technologies are created for product design, manufacturing processes, surface treatment and quality control. This integrated approach has allowed Tenaris to maintain its leading position in product design and process innovation.

Any new technology developed by Tenaris is extensively tested. Over 45 years of field experience endorse the performance of Tenaris's products and provide the basis for future R&D initiatives.

AlphaRod® Series, HolloRod™ Series and BlueRod® sucker rods are an example of our continuous efforts in R&D and the high-end solutions that derive from them.



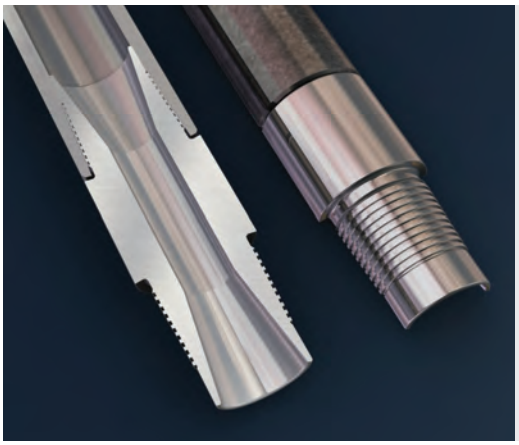
TECHNOLOGICAL BREAKTHROUGHS

ALPHAROD® SERIES

The AlphaRod® Series was created to overcome more demanding requirements and offer a solution to fatigue and corrosion fatigue problems.
The new steel grades of the AlphaRod® generation were specially designed to widely exceed the performance of API and HS steel grades under critical conditions.

BLUEROD® PREMIUM SUCKER ROD

The total capacity of the sucker rod string depends mostly on the connection capacity. Up to now, a high percentage of conventional pumping failures were traceable to this part of the rods. BlueRod® design, with a tapered trapezium thread profile and flank-to-flank contact, offers remarkable resistance for high loads, opening up a new frontier for oil pumping operations.



HOLLOROD™ SERIES

Tenaris R&D team developed the HolloRod™ Series, a technological breakthrough especially designed to resist high-torsion loads. The HolloRod™ reduce connection failure, tubing wear, and backspin effect, and enables injection of chemical corrosion inhibitors or viscosity-reduction fluids down the inside of the rod. In the last years, the use of HolloRod™ was expanded to other applications like RP, deliquification, gas lift applications, heavy oil production, paraffin control and special operations.

Full Product Range

Tenaris manufactures the industry's most comprehensive range of sucker rods for demanding well conditions.

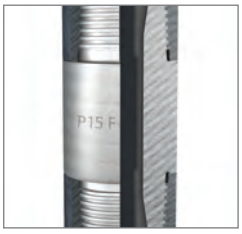
AlphaRod® Series

MAIN FEATURES					
THREAD TYPE	API				
APPLICATION	BEAM PUMPING - PROGRESSIVE CAVITY PUMPING				
ROD BODY DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
PIN DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
LENGHT (**) [ft (m)]	2 TO 12 (0.61 TO 3.66) - 25 (7.62)				
GRADE	ALPHAROD® SERIES				

BlueRod® Premium Sucker Rod

MAIN FEATURES			
THREAD TYPE	PREMIUM CONNECTION		
APPLICATION	BEAM PUMPING - PROGRESSIVE CAVITY PUMPING		
ROD BODY DIAMETER [in (mm)]	3/4 (19.1)	7/8 (22.2)	1 (25.4)
PIN DIAMETER [in (mm)]	7/8 (22.2) (*)	7/8 (22.2) (*)	1 (25.4)
LENGHT (**) [ft (m)]	2 TO 8 (0.61 TO 2.44) - 25 (7.62) - 30 (9.14)		
GRADE	D BLUEROD® - KD BLUEROD® - ALPHAROD® CS		

HolloRod™ Series



MAIN FEATURES			
THREAD TYPE	PREMIUM CONNECTION		
APPLICATION	PROGRESSIVE CAVITY PUMPING - BEAM PUMPING - SPECIAL APPLICATIONS		
ROD BODY DIAMETER [in (mm)]	1.92 (48.8)	1.66 (42.2)	2.24 (57.0)
PIN DIAMETER [in (mm)]	1.92 (48.8)	1.66 (42.2)	2.24 (57.0)
LENGHT (**) [ft (m)]	0.5 TO 10 (0.15 TO 3.05) - 28 TO 32 (8.53 TO 9.75)		
GRADE	HOLLOROD™ SERIES		

X-Torque Rod

MAIN FEATURES				
THREAD TYPE	API MODIFIED			
APPLICATION	PROGRESSIVE CAVITY PUMPING			
ROD BODY DIAMETER [in (mm)]	1 (25.4)	1 1/4 (31.8)	1 1/4 (31.8)	1 1/2 (38.1)
PIN DIAMETER [in (mm)]	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)	1 1/8 (28.6)
LENGHT (**) [ft (m)]	2 TO 12 (0.61 TO 3.66) - 25 (7.62)			
GRADE	D ALLOY - KD - D SPECIAL - MMS - UHS			

High Strength Rod

MAIN FEATURES					
THREAD TYPE	API				
APPLICATION	BEAM PUMPING - PROGRESSIVE CAVITY PUMPING				
ROD BODY DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
PIN DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
LENGHT (**) [ft]	2 TO 12 (0.61 TO 3.66) - 25 (7.62) - 30 (9.14)				
GRADE	MMS - UHS				

Conventional Rod

MAIN FEATURES					
THREAD TYPE	API				
APPLICATION	BEAM PUMPING - PROGRESSIVE CAVITY PUMPING				
ROD BODY DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
PIN DIAMETER [in (mm)]	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)
LENGHT (**) [ft (m)]	2 TO 12 (0.61 TO 3.66) - 25 (7.62) - 30 (9.14)				
GRADE	C - K - D CARBON - D ALLOY - KD - D SPECIAL				

(*) 7/8" BlueRod® has a reinforced wrench square with dimensions larger than API.
(**) Special lenght pony rods are only available upon request.

Proprietary Steel Grades

Tenaris has developed different proprietary product lines that offer a wide range of solutions both for conventional and non-conventional wells.

ALPHAROD® SERIES

- Manufactured in different steel grades (low alloy carbon steels with special addition of chromium and molybdenum, or micro alloy addition of niobium and boron) and dedicated heat treatment.

ULTRA HIGH STRENGTH SPECIAL (MMS)

- Manufactured in AISI 4138 Mod. steel to provide high mechanical strength. Produced from a chromium-molybdenum alloy steel with no nickel.
- Heat treatment: normalized and tempered.
- Recommended for deep well applications with high loads. Non-corrrosive wells.

ULTRA HIGH STRENGTH (UHS)

- Manufactured in AISI 4330 Mod. alloy steel, with nickel-chrome and molybdenum.
- Heat treatment: normalized and tempered.
- Recommended for non-corrosive wells with very high loads.

TENARIS GRADES FOR PREMIUM PRODUCTS

For BlueRod® products, three grade options are available to suit different service conditions: D BlueRod®, KD BlueRod® and AlphaRod® CS.
HolloRod™ Series products are manufactured from seamless pipes with different steel grades (low alloy carbon steels with special addition of chromium and molybdenum, or micro alloy addition of niobium and boron) and dedicated heat treatment.

PROPRIETARY STEEL GRADES
Developed to meet demanding requirements.

API Steel Grades

Tenaris supplies API sucker rods manufactured in standard steel grades suiting varying load types and corrosion levels.

GRADE C
Designed for wells with low and medium loads, non-corrosive or effectively inhibited. Manufactured in AISI 1530 Mod. steel(*).

GRADE K
Designed for low and medium loads in corrosive wells where inhibition is recommended. Manufactured in AISI 4621 Mod. steel.

GRADE D CARBON
Designed for non-corrosive or effectively inhibited wells with moderate loads. Manufactured in AISI 1530 Mod. steel(*).

GRADE D ALLOY
Designed for moderate to high loads in non-corrosive or effectively inhibited wells. Manufactured in AISI 4142 steel.

GRADE KD
Designed for corrosive wells where inhibition is recommended, with moderate loads. Manufactured in AISI 4320 Mod. steel.

GRADE D SPECIAL
Designed for moderate to high loads in non-corrosive or effectively inhibited wells. Manufactured in AISI 4330 Mod. steel.

(*) Only under special request.

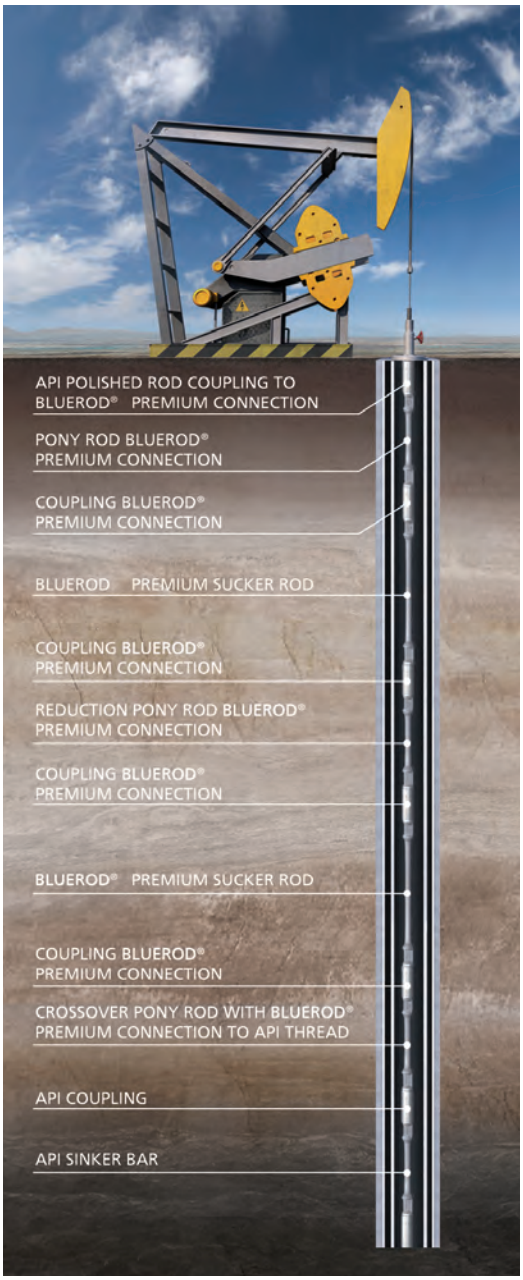
Chemical Composition and Mechanical Properties

CHEMICAL COMPOSITION	API STEEL GRADES						HIGH STRENGTH STEEL GRADES BY TENARIS	
	C 1530M	K 4621M	D CARBON 1530M	D ALLOY 4142M	KD 4320M	D SPECIAL 4330M	UHS 4330M	MMS 4138M
C	0.30-0.36	0.18-0.25	0.30-0.36	0.40-0.45	0.20-0.25	0.29-0.37	0.29-0.37	0.36-0.43
Mn	1.30-1.60	0.70-0.90	1.40-1.60	0.75-1.00	0.80-1.00	0.70-0.95	0.70-0.95	1.10-1.40
S	0.035 MAX	0.035 MAX	0.025 MAX	0.025 MAX	0.015 MAX	0.025 MAX	0.025 MAX	0.025 MAX
P	0.035 MAX	0.035 MAX	0.025 MAX	0.025 MAX	0.025 MAX	0.025 MAX	0.025 MAX	0.025 MAX
Si	0.25-0.40	0.15-0.35	0.25-0.40	0.15-0.35	0.15-0.35	0.15-0.35	0.15-0.35	0.20-0.40
Ni	0.15 MAX	1.65-2.00	0.15 MAX	0.25 MAX	1.15-1.50	1.65-2.00	1.65-2.00	0.30 MAX
Cr	0.10 MAX	0.30 MAX	0.10 MAX	0.80-1.10	0.70-0.90	0.80-1.10	0.80-1.10	0.50-1.00
Mo	0.05 MAX	0.20-0.30	0.05 MAX	0.15-0.25	0.25-0.30	0.20-0.30	0.20-0.30	0.25-0.50
V	0.15 MAX	-	0.15 MAX	-	0.03-0.07	0.04-0.08	0.04-0.08	0.04-0.08
Nb	-	-	-	-	-	-	-	0.05 MAX
Al	0.01-0.04	0.01-0.04	0.01-0.04	0.01-0.04	0.01-0.05	0.01-0.06	0.01-0.06	0.01-0.07
Cu	0.25 MAX	0.25 MAX	0.25 MAX	0.25 MAX	0.25 MAX	0.25 MAX	0.25 MAX	0.25 MAX
MECHANICAL PROPERTIES								
YS (ksi)	60 MIN	60 MIN	85 MIN	95*	85 MIN	100*	115 MIN	115 MIN
UTS (ksi)	90-115	90-115	115-140	120-140	115-140	125-140	140-160	138-155
HEAT TREATMENT								
		NORMALIZED	NORMALIZED	NORMALIZED	NORMALIZED	NORMALIZED	NORMALIZED	NORMALIZED
	NORMALIZED	TEMPERED	FORCED COOLING	TEMPERED	TEMPERED	TEMPERED	TEMPERED	TEMPERED

The values appearing in this brochure are reference values and Tenaris reserves the right to modify them according to internal specifications without prior notice.
(*) Typical value. Tenaris guarantees an 85 ksi minimum yield strength as specified in API 11B specifications.

Application Guide

Beam Pumping Solutions



STRING CONFIGURATION FOR BEAM PUMPING APPLICATIONS

In beam pumping systems, the mechanical energy of the prime mover on the surface is transmitted through the sucker rod string to the down-hole pump assembly. The produced fluid (generally an emulsion of crude oil and water) is lifted by the pump and channeled to the surface through the production tubing.

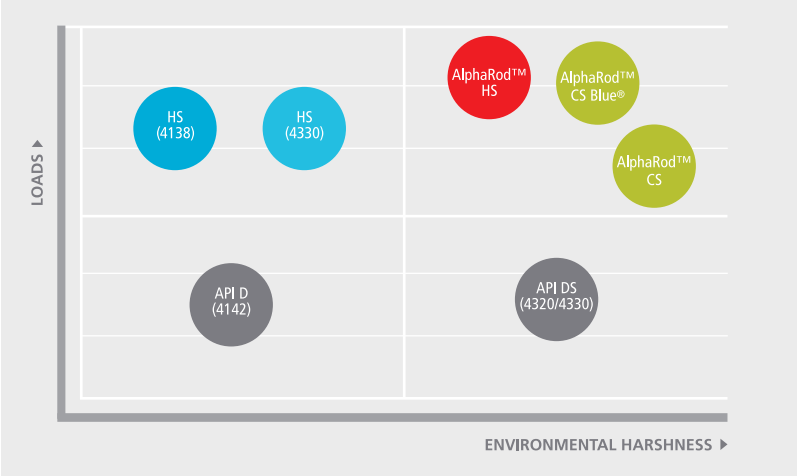
As operators move forward with the development of increasingly demanding fields requiring deeper wells and higher production flows, artificial lifting systems fitted with conventional sucker rods are being pushed to their operational limits.

Responding to this demand, Tenaris developed the BlueRod® premium sucker rod. Specially designed for high loads, its advanced technology improves fatigue life while providing excellent performance in the field.

Beam Pumping Products

PRODUCT	THREAD TYPE	STEEL GRADE	
BLUEROD® PREMIUM SUCKER RODS	PREMIUM CONNECTION	PROPRIETARY GRADES BY TENARIS	D BLUEROD® - KD BLUEROD® - ALPHAROD® CS
CONVENTIONAL SUCKER RODS	API	API STEEL GRADES	C - K - D CARBON - D ALLOY - KD - D SPECIAL
		PROPRIETARY GRADES BY TENARIS	UHS - MMS - ALPHAROD® SERIES

Beam Pumping Rod Selection Guide



Progressive Cavity Pumping (PCP) Solutions

In PCP systems, an electric motor on the surface is used to rotate a sucker rod string, which in turn transmits this rotational motion to a screw-type pump – causing the fluid contained in a cavity to flow upwards.
The performance and durability of the rod string is heavily dependant on its ability to withstand the ensuing torque stresses. The API 11B standard, which is used in the design of conventional sucker rods, only provides specification for axial loads.

Often conventional sucker rods were being subjected to greater loads than they had been designed to withstand. Having detected the need for a technological breakthrough, Tenaris introduced the HolloRod™ Series, a product specifically designed to resist the high-torque loads typical of modern PCP systems.

Other Tenaris solutions for PCP applications include the X-Torque rods (featuring a modified pin that increases torque capacity) and the BlueRod® premium sucker rod, whose innovative connection design reduces the risk of over-torque during make-up.

Progressive Cavity Pumping Products

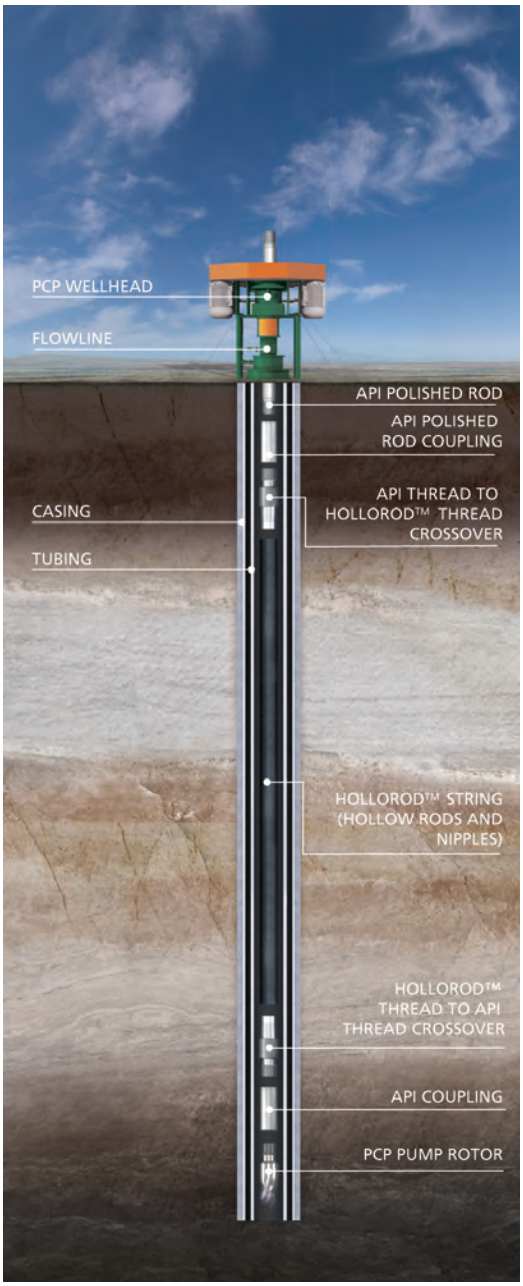
PRODUCT	THREAD TYPE	STEEL GRADE	
BLUEROD® PREMIUM SUCKER RODS	PREMIUM CONNECTION	PROPRIETARY GRADES BY TENARIS	D BLUEROD® - KD BLUEROD® - ALPHAROD® CS
HOLLOROD™ SERIES	PREMIUM CONNECTION	PROPRIETARY GRADES BY TENARIS	HOLLOROD™ SERIES
X-TORQUE RODS	API MODIFIED	API STEEL GRADES	K- D ALLOY - KD - D SPECIAL
		PROPRIETARY GRADES BY TENARIS	UHS - MMS
CONVENTIONAL SUCKER RODS	API	API STEEL GRADES	K- D ALLOY - KD - D SPECIAL
		PROPRIETARY GRADES BY TENARIS	UHS - MMS - ALPHAROD® SERIES

Progressive Cavity Pumping Rod Selection Guide

TUBING OD	RECOMMENDED TORQUE SF=0.8 FOR CONVENTIONAL & X-TORQUE RODS	BLUEROD® PREMIUM SUCKER RODS	HOLLOROD™ SERIES	X-TORQUE RODS	CONVENTIONAL RODS
[INCH]	[lb.ft]				
2 3/8	300-650	•		•	•
2 7/8	650-1000	•	•	•	•
	1000-2000		•	•	
3 1/2	1000-1500		•	•	•
	1500-2000		•	•	
	2000-3000		•	•	
BACKSPIN EFFECT RISK		MEDIUM	LOW	HIGH	HIGH
STICK -SLIP EFFECT RISK		MEDIUM	LOW	HIGH	HIGH
MAKE-UP OVERTORQUE RISK		LOW	LOW	HIGH	HIGH
TUBING AND ROD WEAR RATE		HIGH	LOW	HIGH	HIGH
THREAD RECOVERY		NO	YES	NO	NO

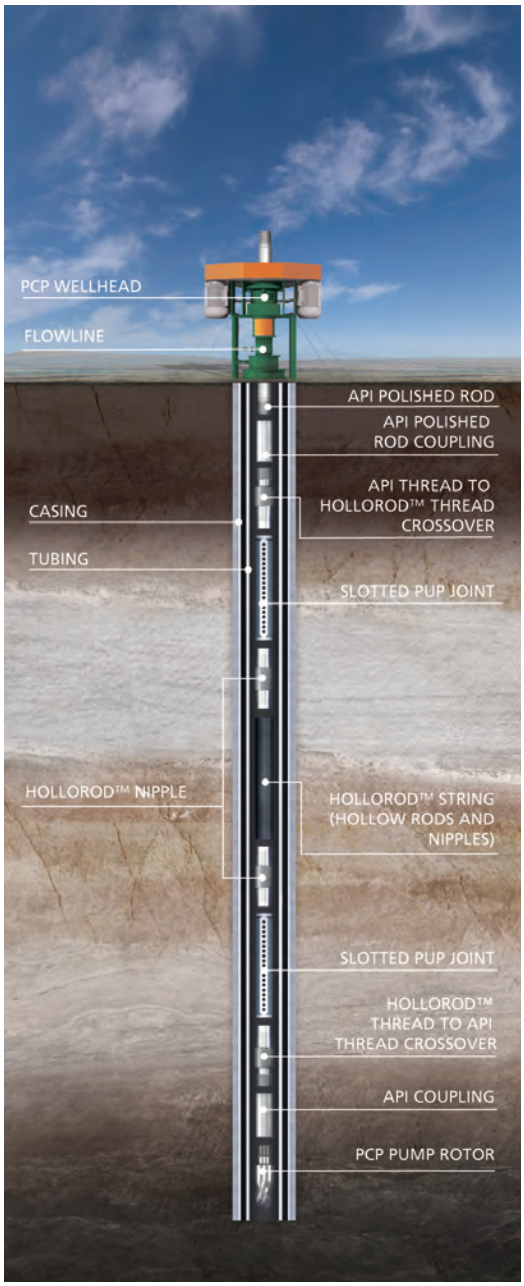
These values are for general reference only. Detailed rod selection should always be based on specific well conditions.

String configurations with HolloRod™ Series



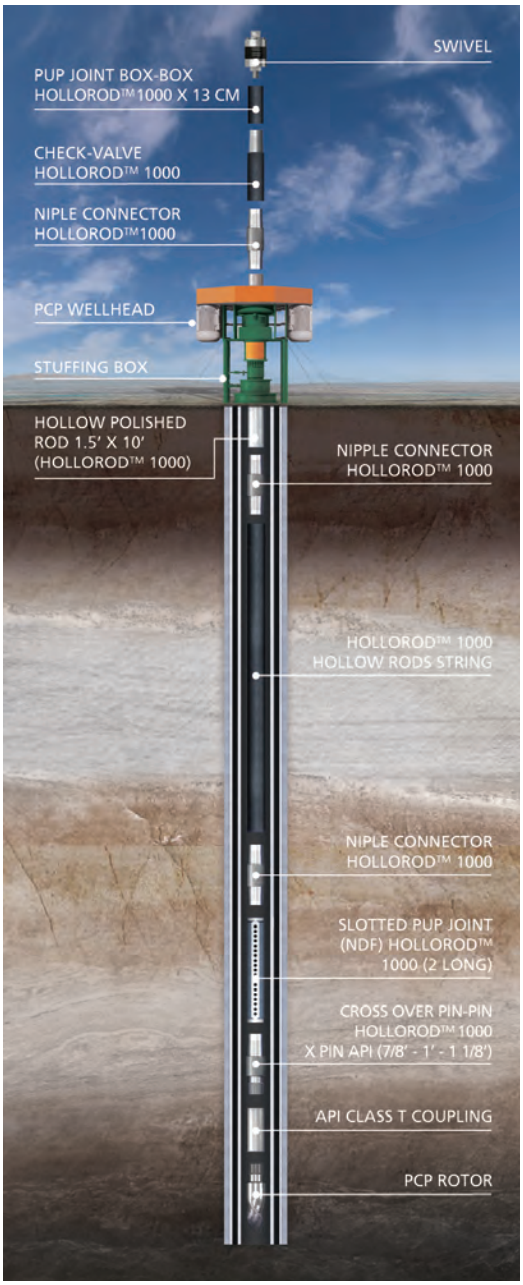
OIL PRODUCTION THROUGH THE TUBING / HOLLOW ROD ANNULUS

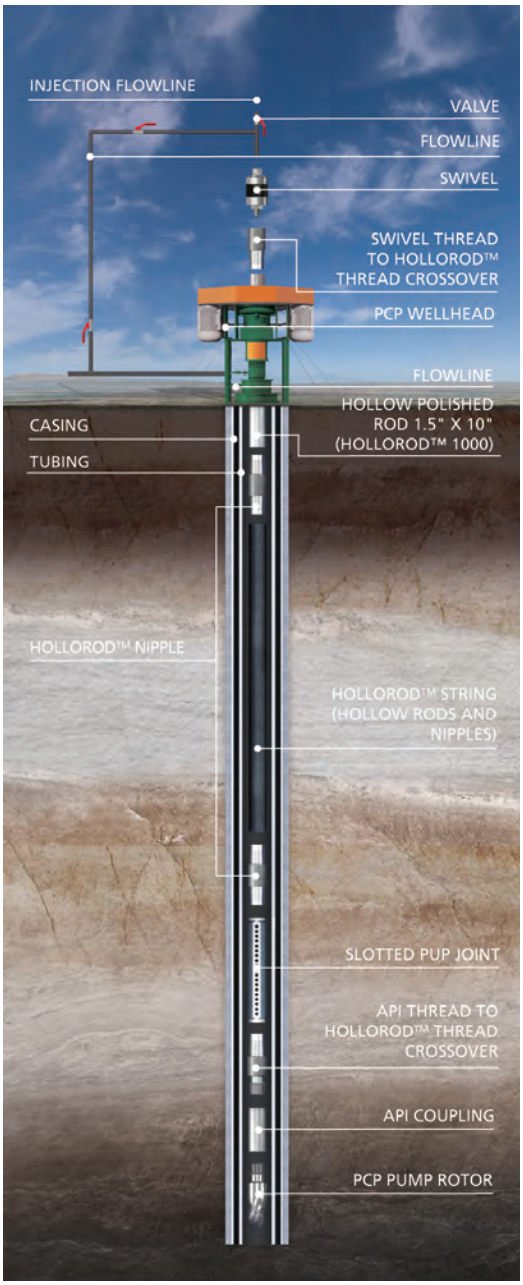
HolloRod™ Series rods make operations more reliable and safer. Thanks to their unique design, rods can withstand higher torque loads. Being more rigid than conventional products, hollow rods accumulate less energy in the string and significantly reduce the probability of backspin effects, enhancing safety at the rig.



OIL PRODUCTION THROUGH BOTH THE TUBING / HOLLOW ROD ANNULUS AND THE ROD STRING INTERIOR

This configuration increases production flow area. It is mainly recommended with HolloRod™ 486 up to 1500 lb.ft installed in 2 7/8" (73 mm) tubing, and should not be used for viscous oil pumping.





OIL PRODUCTION THROUGH THE TUBING / HOLLOW ROD ANNULUS AND INJECTION OF FLUIDS THROUGH THE ROD STRING INTERIOR

One of the alternatives that HolloRod™ technology enables is the injection of fluids into the rod string. This improves injection efficiency, since fluids come into direct contact with the flowing oil – making injection pipes and capillaries unnecessary.

FLUID INJECTION IN BATCHES THROUGH THE HOLLOW ROD

This is a modification of the previous option that allows the injection of fluids through the hollow rod string in batches. When the injection program is not being used, produced oil can be lifted through both the hollow rod string and the annular space between the tubing and the rod string, increasing flow area.

Rods
by Technology

AlphaRod®
Series

This new generation of sucker rods has been specially designed to replace conventional (API) grades

The AlphaRod® series was created to overcome critical working conditions, proving an enhanced performance under fatigue and corrosion fatigue problems.

Until now, the industry has been producing sucker rods using only standard steels commonly used for mechanical and automotive applications. Although these products have been used for years, they have reached their technical limit under harsh operating conditions.

Under harsh environment, steel performance is not only related to its mechanical properties (yield and tensile strength). Parameters like alloying and residual elements, steel cleanliness, microstructure, toughness, among others play an important role.

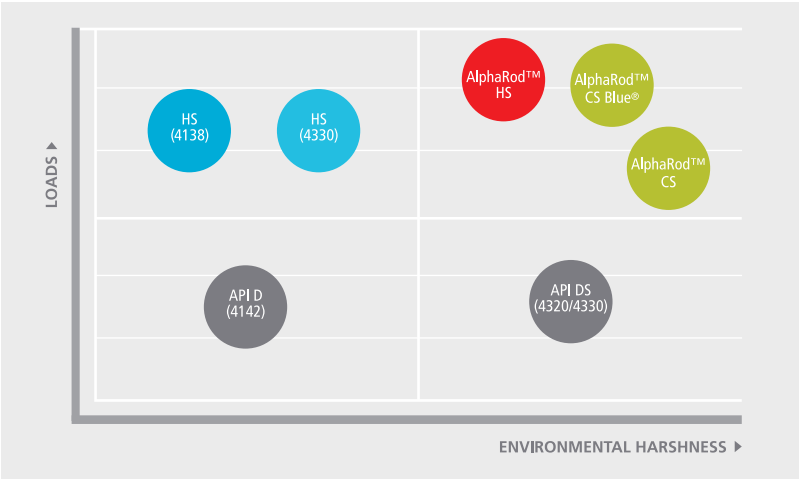
Tenaris's expertise in the development of steel and the optimization of manufacturing processes for Oil & Gas critical applications enabled the development of two steel grades that satisfy new operative requirements:

- AlphaRod® CS (Critical Service): Designed for corrosive environments, able to withstand higher loads than traditional (API) sucker rods.
- AlphaRod® HS (High Strength): Designed for very high loads in medium corrosive environment, offering improved performance than the conventional high strength sucker rods.

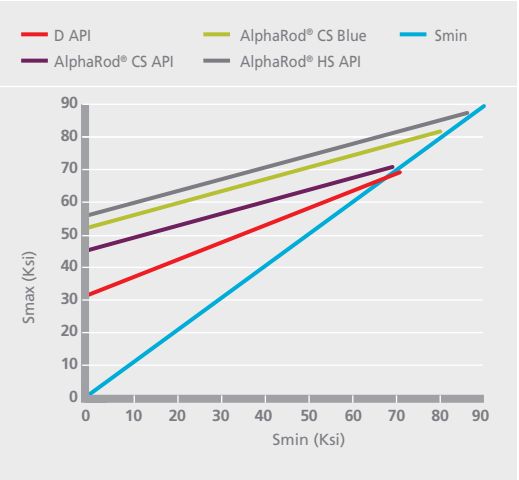
While comparing standard API and HS sucker rods, the AlphaRod® CS and AlphaRod® HS offer the following advantages:

- Superior toughness.
- Extended lifespan.
- Enhanced fatigue resistance under harsh environments.
- Increased reliability due to strict controls during the manufacturing process.
- Increased service loads.

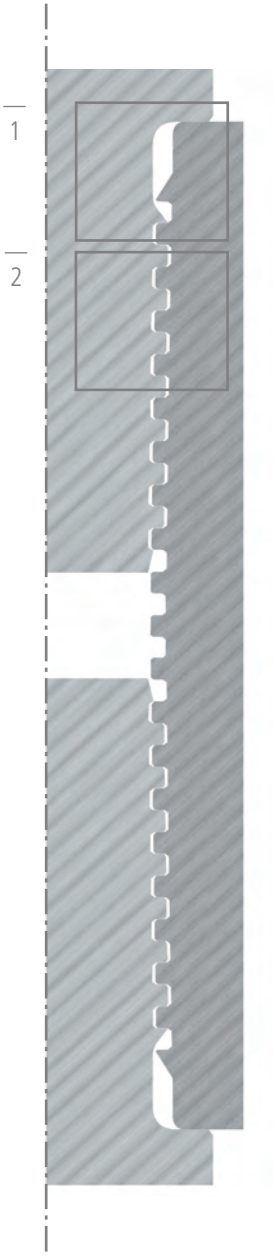
APPLICATION FIELD



ALPHAROD®



BlueRod®
Premium Sucker Rod



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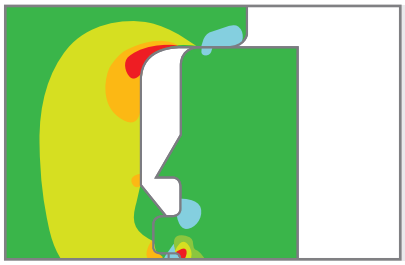
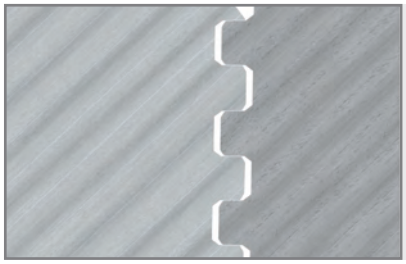


- Improved stress distribution.
- Fewer stress concentration points.

2



- Tapered trapezium thread profile.
- Diametrical interference increases the working capacity.
- Flank-to-flank contact reduces the loosening tendency.

- FEATURES

Designed to withstand very high fatigue loads.
Diametrical interference that creates a better stress distribution, reducing stress concentration areas.
No gap between threads that reduces the connection loosening tendency.
Reduction of plastic deformation during both make-up and operation.
Fast and easy make-up with no cross-threading risk.

- APPLICATIONS

Deep wells with high flows (replacing electro submersible pumps).
Wells requiring small-diameter rods.
Applications limited by rod string weight.
Progressive Cavity Pumping applications.

Technical Characteristics

Tenaris's BlueRod® premium sucker rod overcomes the limitations of conventional rod connection design, offering an increased string working capacity. The premium connection improves the fatigue life of sucker rods while providing excellent field performance.

Up to now, a large number of beam pumping failures were traceable to the connection of the sucker rod. Tenaris's new rod offers 100% connection efficiency, opening up a new frontier for oil pumping operations.

Tenaris's BlueRod® technology is produced from three special grades of low-alloy steel: D BlueRod® (chromium-molybdenum low-alloy steel), KD BlueRod® (nickel-chromium-molybdenum alloy steel) and AlphaRod® CS.

IMPROVED PERFORMANCE

The ability of BlueRod® technology to increase string capacity is fundamentally driven by the adoption of new design technologies, supported by results obtained from:

- Thread design through Finite Element Analysis.
- Full scale laboratory tests.
- Customer field trials.
- Laboratory failure analysis.

HANDLING AND OPERATIONS

No special tools are necessary for handling or make-up operations when installing BlueRod® products. Conventional power sucker rod tongs and elevators can be used with this product.

ACCESSORIES

As part of its integrated manufacturing process, Tenaris produces all accessories needed for the setting up of BlueRod® premium sucker rods, including crossovers, pony rods and couplings.

Premium Connection Technical Specifications

ROD SIZE	AVAILABLE LENGTH		COUPLING OD	THREAD PITCH	WRENCH SQUARE
[INCH]	[ft]	[m]		[tpi]	
3/4	25 / 30	7.62 / 9.15	FULL SIZE / SLIM HOLE	6	REINFORCED
7/8	25 / 30	7.62 / 9.15	FULL SIZE / SLIM HOLE	6	REINFORCED
1	25 / 30	7.62 / 9.15	SLIM HOLE	6	API

Advantages

INCREASED OPERATIONAL RANGE

As BlueRod® premium sucker rods are able to withstand higher stress levels than conventional sucker rods, their use expands the working capacity of conventional beam pumping systems to include operations normally only possible with the aid of electro submersible pumps.

INCREASED PRODUCTION FLOWS

By combining a larger pump, larger stroke length and higher pumping speed, customers can increase production flows.

MANUFACTURING & QUALITY CONTROL

- Tenaris uses state-of-the-art numerical control lathes and control gauges in order to ensure the highest quality in its connections.
- Strict measurement equipment permanently monitors compliance with the design variables of the thread in order to ensure the uniformity and reliability of the product.

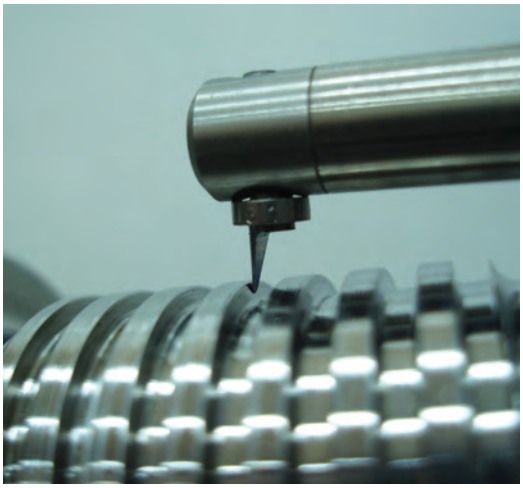
REDUCED OPERATIONAL COSTS

The deployment of BlueRod® technology has a direct impact on operational costs, as workover operations caused by sucker rod connection failures are drastically reduced. The pump jack's energy consumption and stress levels can also be lowered by installing a lighter rod string.

INCREASED CONNECTION RELIABILITY IN PCP APPLICATIONS

Combining the diametrical interference of the thread, and its stronger profile, BlueRod® technology offers higher torque resistance than conventional products.

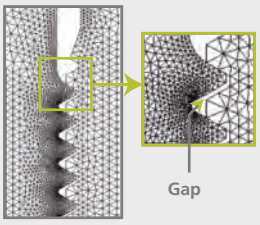
The connection make-up torque requirements are up to 10% higher than conventional products. This reduces the probability of the backspin effect, since a higher torque is required to break out the connection.

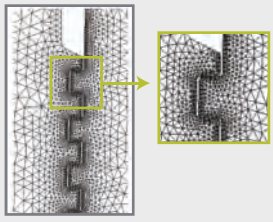


PREMIUM CONNECTION
BlueRod® premium sucker rods undergo strict quality controls.

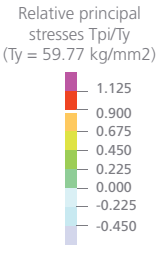
BlueRod® Design Advantages

API ROD	BLUEROD® PREMIUM SUCKER ROD

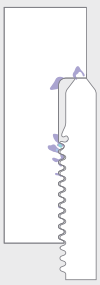


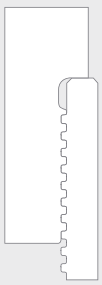


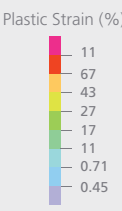
FLANK-TO-FLANK CONTACT
Reduction of the loosening tendency.



IMPROVED STRESS DISTRIBUTION
Stress distribution diagram at 100% Goodman.







PLASTIC DEFORMATIONS REDUCTION
Plastic deformations at 100% Goodman.

PREMIUM CONNECTION DESIGN IMPROVEMENTS

- Flank-to-flank contact eliminates the gap that exists in API thread profiles, reducing the loosening tendency.
- Cut-tapered trapezium thread profile with diametrical interference improves stress distribution after make-up and during operation.
- API design limitations have been overcome by the significant reduction of critical stress areas afforded by the BlueRod® premium rod.

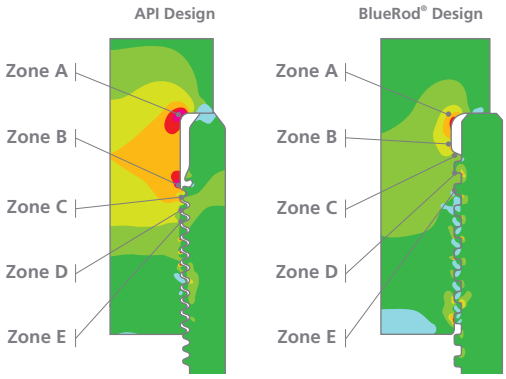
STRESS CALCULATION

Based on the results obtained through Finite Element Analysis (FEA), lab tests and field trials, a new Goodman diagram showing a higher working capacity for the D BlueRod® rods was generated.

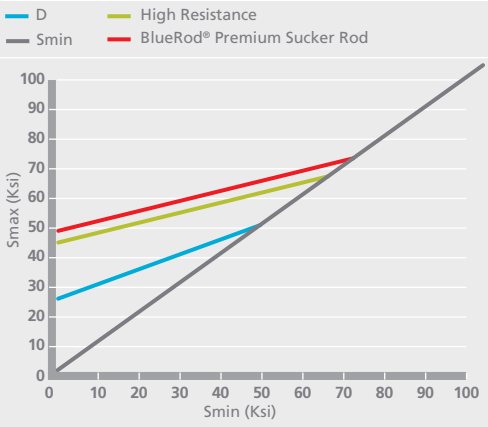
The diagram shows the BlueRod® premium rod has a higher working capacity and higher fatigue resistance than regular high-strength rods.

MULTIAXIAL STRESS FATIGUE ANALYSIS

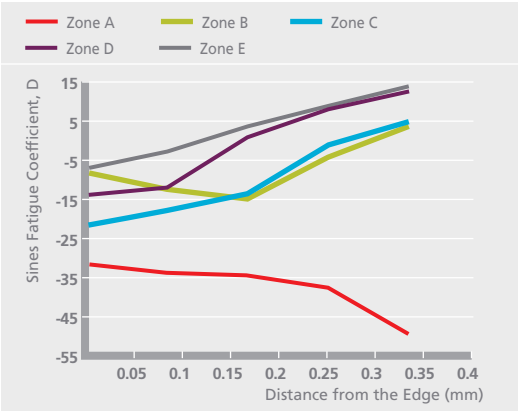
The Sines method was employed to evaluate fatigue behavior. The Sines coefficient predicts a better fatigue behavior the higher its value. The charts show that the new premium connection exhibits higher and more uniform values than those of conventional rod connections.



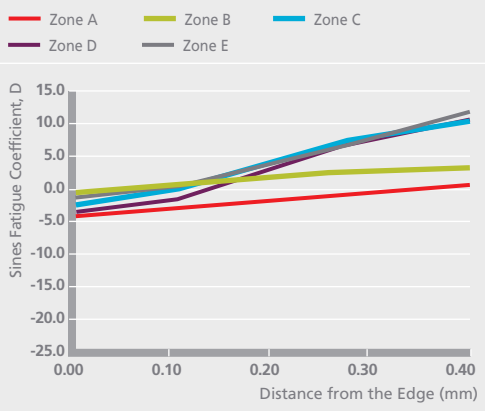
NEW MODIFIED GOODMAN DIAGRAM



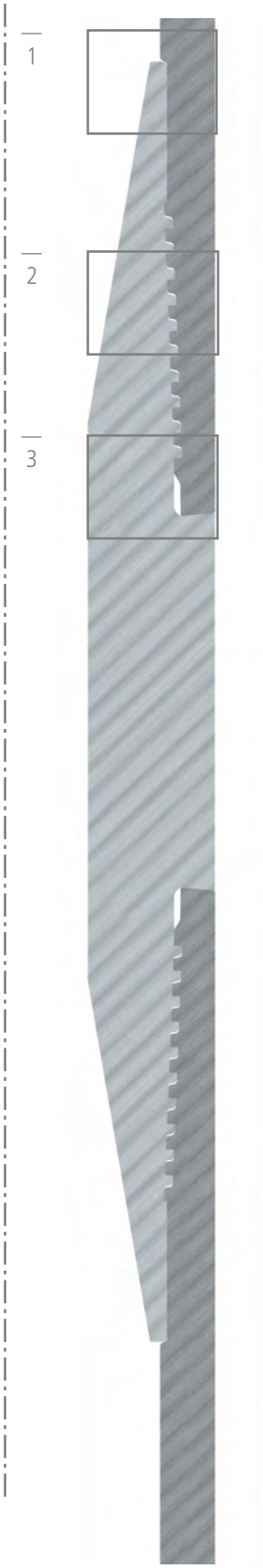
API DESIGN



BLUEROD® DESIGN



HolloRod™ Series



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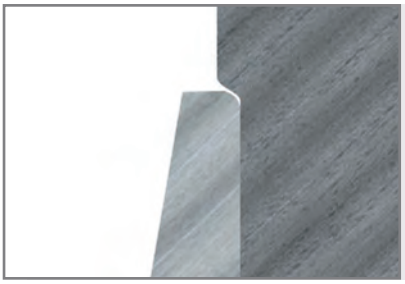
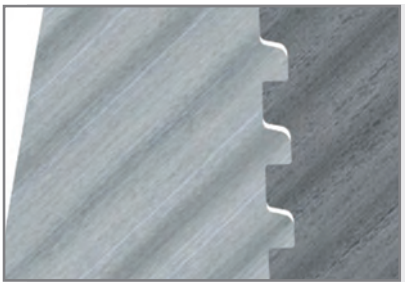


- Internal Near Flush connection to reduce fluid turbulence.
- Internal conical bore on nipple.

2



- Tapered thread profile with flank / valley contact.
- Differential taper in nipple & rod thread.

3

- Angled torque shoulder provides high torque capacity for rotating applications.

FEATURES

- External Flush connection to minimize rod/tubing wear, extending tubing life.
- Internal Near Flush connection to reduce fluid turbulence.
- Fast and easy make-up with no cross-threading risk.
- Low make-up pin stress.

APPLICATIONS

- Deep wells.
- Deviated / directional wells.
- Offshore platforms.
- Thermal wells.
- Injection / production through the hollow rod.
- Velocity string.
- Sand cleaning.

Technical Characteristics

The HolloRod™ family was originally developed to maximize well performance in Progressive Cavity Pumping applications, as a result of the high torque capacity, offering more fatigue resistance than conventional rods. The HolloRod™ reduces connection failure, tubing wear, and backspin effect, and enables injection of chemical corrosion inhibitors or viscosity-reduction fluids down the inside of the rod. Reciprocating pumping, deliquification, gas lift applications, heavy oil production, paraffin control and special operations, are other applications were the HolloRod™ series has been successfully used.

HANDLING AND OPERATIONS

As HolloRod™ Series rods are manufactured from seamless steel pipes, they can be run in a similar way and using the same type of equipment as regular tubing. No special elevator or rig specifications are required.

For further details on running recommendations for this product, please refer to the Running Operations chapter on page 53.

HolloRod™ Series Technical Specifications

PRODUCT	PIPE OUTER Ø		PIPE THICKNESS		MAX. WORKING TORQUE (*)		METRIC WEIGHT WITHOUT NIPPLE		JOINT MIN INT. Ø		MINIMUM TUBING SIZE		GRADE
	[mm	(in)]	[mm	(in)]	[N.m	(lb.ft)]	[kg/m	(lb/ft)]	[mm	(in)]	[mm	(in)]	
486 SEC NU LI-20 HS147	48.8	(1.92)	6.7	(0.264)	1356	(1000)	7	(4.7)	20	(0.79)	73	(2 7/8)	HS147
486 SEC NU LI-22 HS147	48.8	(1.92)	6.7	(0.264)	1220	(900)	7	(4.7)	22	(0.87)	73	(2 7/8)	HS147
486 SEC NU HI-18 HS147	48.8	(1.92)	6.7	(0.264)	2034	(1500)	7	(4.7)	18	(0.71)	73	(2 7/8)	HS147
486 SEC NU LI-20 CS105	48.8	(1.92)	6.7	(0.264)	1085	(800)	7	(4.7)	20	(0.79)	73	(2 7/8)	CS105
486 SEC NU LI-22 CS105	48.8	(1.92)	6.7	(0.264)	949	(700)	7	(4.7)	22	(0.87)	73	(2 7/8)	CS105
486 SEC NU HI-18 CS105	48.8	(1.92)	6.7	(0.264)	1763	(1300)	7	(4.7)	18	(0.71)	73	(2 7/8)	CS105
576 SEC NU LI-31 GR125	57	(2.24)	6.5	(0.256)	1898	(1400)	8.1	(5.4)	30.9	(1.22)	73	(2 7/8)	GR125
425 SEC NU LI-26 GR75	42.7	(1.68)	5	(0.197)		-	4.6	(3.1)	25.8	(1.01)	60.3	(2 3/8)	GR75

(*) Tenaris recommends using a 0.9 safety factor to maximize fatigue resistance.

Advantages

INCREASED TORQUE RESISTANCE

Due to a series of design innovations on their thread profile and torque shoulder elements, HolloRod™ Series products are able to work under both high and very high torque loads. This makes them ideally suited for applications where reduced flow area is an issue.

REDUCED BACKSPIN EFFECT

The rotation force used to drive Progressive Cavity Pumping systems generates an accumulation of elastic energy in the sucker rod string. Whenever the system needs to be stopped for workover operations, this energy is suddenly released. Known as “backspin effect”, such phenomenon can lead to potential accidents at the wellhead. It can also cause connections to loosen, making them more prone to failure.

Since HolloRod™ Series rods have higher torsional stiffness than conventional products, they accumulate less energy in the string, significantly reducing backspin effects. For instance, while a 1,000 m string made up with 1 1/8” sucker rods will accumulate 41 turns of elastic deformation, a string of equal length assembled with HolloRod™ will only accumulate eight turns.

REDUCED STICK-SLIP EFFECT

The higher body torsional stiffness obtained by the rod’s hollow structure also translates into a more effective and constant torque transmission, with a consequent reduction of the stick-slip effect.

LOW OVER-TORQUE RISK

Unlike the make-up operation of API rods, whose control is based on monitoring circumferential displacement, HolloRod™ Series rods are made up by monitoring torque. This ensures that consistent make-up torque values are achieved, reducing the possibility of over-torque or the need of adjustments during string operation.

INCREASED PRODUCTION FLOW RATE

Thanks to the hollow structure of the rod, fluids can be lifted through both the rod interior and the annular space between the tubing and the rod string, increasing the flow area.

REDUCED ROD/TUBING WEAR

A frequent problem associated with conventional rods is that, since their couplings have a bigger OD than rod body, rod string/tubing friction is concentrated in certain areas close to rod couplings. This produces localized wear in the tubing wall, which can ultimately lead to holes.

HolloRod™ series have been designed with a flush connection that distributes side loads much more evenly throughout the length of the tubing. This design decreases wear concentration damages, maximizing tubing lifespan.

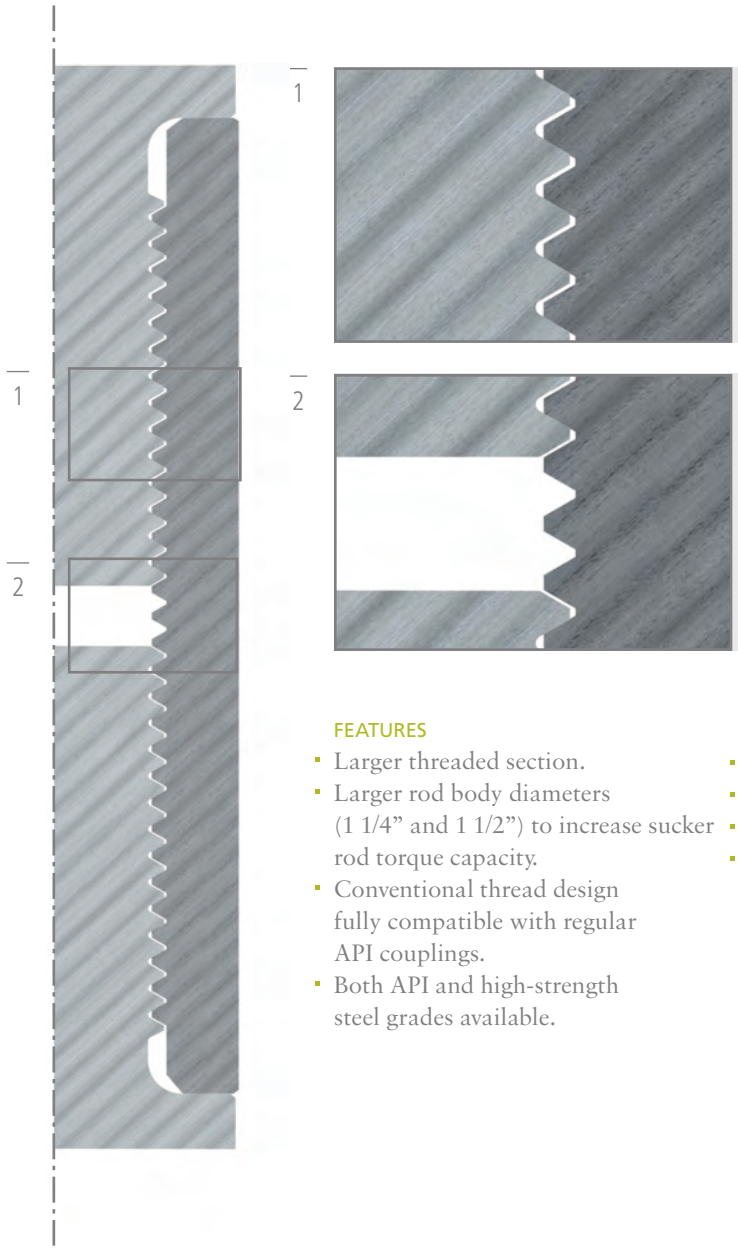
FLUIDS INJECTION

The interior of HolloRod™ Series rods can be used to inject fluids to any desired depth. Taking advantage of this unique feature allows operators to eliminate injection pipes and capillaries, reducing operational complexity and costs. Tenaris provides all the required accessories for this application.

MATERIAL RECOVERY

Should cross-threading, over-torque or any other incident damage the thread of a HolloRod™, the connection can be cut out and the rod re-threaded.

X-Torque Rod



- Pin end featuring larger threaded section than conventional rod connections to increase torque resistance.
- Non-phosphatized coupling shoulder.

- Reduced connection OD to increase flowing area.

FEATURES

- Larger threaded section.
- Larger rod body diameters (1 1/4" and 1 1/2") to increase sucker rod torque capacity.
- Conventional thread design fully compatible with regular API couplings.
- Both API and high-strength steel grades available.

APPLICATIONS

- Progressive Cavity Pumping systems.
- High torque applications.
- Deep wells with high flow.
- Slightly deviated wells.

Technical Characteristics

X-Torque rods offer increased torque capacity by incorporating a modified pin end with a larger threaded section than conventional rods.

X-Torque rods are full-length normalized, air-quenched and tempered – producing a high-quality, refined and homogenized steel grain structure as a result. They are available in API and high-strength steel grades.

Tenaris recommends the use of slim-hole couplings with non-phosphatized contact faces in order to maximize flow area and increase the torque capacity of the connection.

Make-up procedures do not differ from those followed in standard sucker rod running jobs.

INCREASED CONNECTION TORQUE CAPACITY

The modified pin with its larger threaded section increases the connection's torque capacity over conventional API rods.

INCREASED OVERALL ROD TORQUE CAPACITY

As the X-Torque connection offers higher torque capacity than the rod body, overall torque resistance of the rod can be increased by selecting a larger-diameter body.

IMPROVED TUBING FLOW AREA FOR 1" RODS

In X-Torque rods, the external diameter of the pin is always smaller than that of the rod body. Instead of producing a well with 1" conventional rods, operators can choose to produce with 1" X-Torque rods – which come equipped with 7/8" pin ends. Two main benefits can be derived from this:

- The possibility of running 1" rods in 2 3/8" tubing.
- A flow loss reduction in the rod's connection area.

Minimum Flow Area Comparison (*)

PRODUCT	[mm²]	[in²]
1" CONVENTIONAL API ROD	1,000	1.551
1" X-TORQUE ROD (PIN 7/8")	1,686	2.613

(*) Reference values for 2 7/8" tubing with 62 mm Internal Diameter.

Accessories

Rod Guides

Each year, oil field operators using Beam Pumping (BP) and Progressive Cavity Pumping (PCP) systems increase operational costs associated with rod/tubing friction and paraffin deposition in production tubing.

Tenaris has developed a series of rod guides that are molded directly onto the rod body to control this threat. Our rod guides for BP and PCP applications come in a wide range of materials.

Combined with the use of rotators, rod guides provide effective paraffin and wear control. All Tenaris's rod guides incorporate design features that help maximize their contact area against the tubing while providing maximum fluid flow.

GUIDES CHARACTERISTICS

Our rod guides are manufactured from different types of materials specifically selected to ensure their optimum performance and long lifespan: Polyamide 66, Poliphenylene Sulfide (PPS) and Polyphthalamide (PPA).

ADVANTAGES

Rod/tubing wear protection

Inevitably, frictions between individual sucker rods and the production tubing produce severe wear of both strings. This problem is magnified in deviated wells (particularly those exhibiting high dogleg severity) and in sections where the string is exposed to high compression loads.

Tenaris's rod guides center the rod string and guide it smoothly through the tubing, avoiding metal-to-metal contact and absorbing the lateral loads that cause premature wear of couplings, rods and tubing. As a result, operators can expect a longer lifespan for both their sucker rod and tubing installations.

ROD GUIDES
Molded directly on the rod body, guides offer true protection for the tubing.

Displacement resistance

Given that our rod guides are molded directly onto the rod body, they are highly resistant to axial displacement.

Paraffin control

Paraffin concentration on tubing walls is a problem that pushes up costs in two ways – it carries production losses and it requires well interventions. Tenaris's rod guides control paraffin by:

- Combining rod guides for beam pumping with rod rotators so that each tubing joint is fully swept with each pump stroke.
- Using PCP rod guides with their helical blades effectively acting as scrappers in beam pumping systems.

Improved corrosion control

The use of our rod guides provides great help in operators' efforts to protect their wells from corrosion by improving the effectiveness of film protectors applied in friction areas.

Reduced operational costs

Significant cost savings are achieved as a direct result of the above-mentioned operational advantages:

- Longer installation lifecycles;
- Lower intervention rates;
- Lower production losses.

Rod Guide Properties

PROPERTY	POLYAMIDE 66 (PA 66)	POLIPHENYLENE SULFIDE (PPS)	POLYPHTHALAMIDE (PPA)
COLOR	BLACK	WHITE	BLACK
MAXIMUM SERVICE TEMPERATURE	80°C	200°C	165°C
DYNAMIC FRICTION COEFFICIENT	0.2	0.3	0.25
FIBERGLASS COMPONENT	0%	40%	33%

Recommended Applications

WELL CONDITIONS	POLYAMIDE 66 (PA 66)	POLIPHENYLENE SULFIDE (PPS)	POLYPHTHALAMIDE (PPA)
"HOT OIL"	NO	YES	YES
SAND	YES	YES	YES
SWEET ENVIRONMENT	YES	YES	YES
ACID ENVIRONMENT	NO	YES	YES
AQUEOUS ENVIRONMENT	NO	YES	YES
BACTERIAL ENVIRONMENT	YES	YES	YES

Couplings

We provide a complete line of couplings and sub-couplings for sucker rods and polished rods. They are available in reduced slim-hole (SH) diameters and normal full size (FS) diameters for both API and high-strength (UHS) versions.

The new AlphaRod® couplings incorporate the CS, SM and HS grades with a specially designed steel to be the best partner of the AlphaRod® series.

Tenaris's couplings are manufactured from quenched and tempered seamless steel pipes produced at our mills. The quality of Tenaris steel – combined with a cold-rolled threading process performed by computerized numeric control lathes – ensures our couplings enhanced fatigue resistance.

For Progressive Cavity Pumping applications, our couplings can be produced without phosphatized shoulders.

CHEMICAL COMPOSITION AND MECHANICAL PROPERTIES

Each coupling class can be produced from a choice of different steel grades, as follows:

CHEMICAL COMPOSITION	T	SM	UHS
	ALLOY STEEL	CARBON STEEL	ALLOY STEEL
C	0.28-0.33	0.26-0.350	0.28-0.33
P	0.020 MAX	0.025 MAX	0.020 MAX
Cr	0.400-0.65	0.55 MAX	0.400-0.600
Mo	0.150-0.250	0.25 MAX	0.150-0.250
Si	0.150-0.350	0.15-0.35	0.150-0.350
Mn	0.700-0.95	1.25-1.550	0.700-0.900
S	0.020 MAX	0.025 MAX	0.020 MAX
Ni	0.400-0.700	-	0.400-0.700
MECHANICAL PROPERTIES			
HARDNESS (HRA)	56-62	56-62	64-68
SURFACE HARDNESS	-	595 HV200 MIN	-

T COUPLINGS

Manufactured under API specifications. Their material hardness is between 56 and 62 HRA.

SPRAY METAL (SM) COUPLINGS

Spray Metal is a superficial hardening process in which a powder mix of nickel, chrome, boron and silicon is applied to the base metal and is then melted. This results in a hard, dense and uniform surface with a low friction coefficient and high corrosion resistance.

The superficial coating has a minimum hardness of 595 HV200, a thickness of between 0.01" and 0.02" (0.254 to 0.508mm), and covers the full external diameter of the coupling.

SM couplings are manufactured under API specifications. Under special customer request, Tenaris can guarantee a minimal surface roughness value (8 µinch Ra) to help reduce coupling/tubing wear.

UHS COUPLINGS

Following the development of high-strength-grade sucker rods, the next step was the introduction of couplings offering higher mechanical strength. Tenaris responded to this industry need by developing the UHS special couplings.

Manufactured from quenched and tempered microalloyed steel, they have been designed to be used in effectively inhibited corrosive wells under very high loads – either with grade D or high-strength sucker rods.

ALPHAROD® COUPLINGS

Manufactured from quenched and tempered seamless pipes in a low alloyed steel with special addition of chromium and molybdenum, available in CS, HS and SM grades.

COUPLINGS
Manufactured from seamless steel pipes produced by Tenaris.

Pony Rods

Pony rods are used to space out the sucker rod installation. Complying with the same strict quality requirements that we apply to our line of sucker rods, we provide pony rods measuring 2, 4, 6, 8, 10 and 12 feet, available in a variety of steel grades, rod body diameters and threads. Other lengths can also be manufactured in accordance with customer specifications.

—

PONY RODS
Available in a variety of steel grades and rod body diameters.

Sinker Bars

Sinkers bars are an important accessory in the optimization of sucker rod string design, as they help reduce compressive loads.

Generated during the downstroke, compressive loads produce a buckling effect on the sucker rods, which causes connections to loosen and may lead to premature fatigue failure of pins and couplings. To mitigate such effect, sinker bars are placed in sections of the string where compressive loads tend to appear (usually at the bottom of the string). This ensures that sucker rods are maintained under tensile load during the pumping cycle, compensating for the compression forces.

SINKER BARS
Used to reduce compressive loads.

PRODUCT RANGE

Manufactured under API specifications, Tenaris offers standard sinker bars with diameters of 1 1/4" to 1 3/4". Their ends are fully machined and their threads laminated to increase fatigue resistance.

Tenaris has also developed a special 1 1/8" sinker bar, manufactured under general API specifications. For this product, a 1 1/8" head is forged but a 7/8" pin with laminated thread is machined. As a result, these special sinker bars can be installed in 2 7/8" tubing. Their greater metric weight and passage area characteristics make them ideally suited for viscous oil recovery.

Sinker Bar Technical Specifications

REQUIREMENTS	RECOMMENDED GRADE	CHEMICAL COMPOSITION	MINIMUM UTS
LOW LOADS IN NON-CORROSIVE OR EFFECTIVELY INHIBITED ENVIRONMENTS	GRADE I	AISI 10XX	90 ksi
MODERATE LOADS IN NON-CORROSIVE OR EFFECTIVELY INHIBITED ENVIRONMENTS	GRADE II	AISI 43XX / 46XX	90 ksi
HIGH LOADS IN NON-CORROSIVE OR EFFECTIVELY INHIBITED ENVIRONMENTS	GRADE III	AISI 41XX	115 ksi

ADVANTAGES

- Reduces compressive loads on the sucker rod string.
- Mitigates buckling effects, reducing rod/tubing wear, connection loosening problems and premature fatigue failure of pins and couplings.
- Increases the effectiveness of piston stroke, which in turn increases flow production.

Guided Couplings

Friction between rod couplings and tubing gradually wears both elements until one of them eventually fails. To protect installations, Tenaris has developed a line of guided couplings for beam pumping and progressive cavity pumping systems that can be injected with special polymers.

BEAM PUMPING

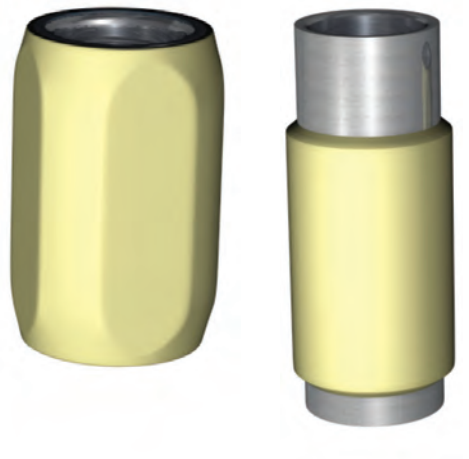
Specially designed for beam pumping applications, Tenaris manufactures couplings with a molded-on guide that reduces metal-to-metal contact.

We recommend the use of this product in combination with guided sucker rods (a deviation survey is also recommended in all cases).

PROGRESSIVE CAVITY PUMPING

Specially designed for PCP applications, couplings are produced in 6” length with an injected guide measuring 4.4”.

This design leaves a space to handle the coupling in case it needs to be freed from the rod. The polymer used in guided couplings is the same material used for rod guides.



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GUIDED COUPLINGS
Available for both BP and PCP applications.

Accessories for HolloRod™ Series

Tenaris offers a wide range of high-quality accessories to complement its line of HolloRod™ Series rods.

HOLLOROD™ NIPPLE
Specially designed to support a Flush external connection, the HolloRod™ nipple can withstand a larger amount of torque than standard sucker rod connections.

HOLLOROD™ / API THREAD CROSSOVER
A crossover that allows standard API-threaded accessories to be attached to hollow rods.

HOLLOROD™ / HOLLOROD™ CROSSOVER
This other crossover allows different models of hollow rods to be connected between each other.

SLOTTED PUP JOINTS
Allow the injection of fluids into the tubing.

INJECTION SWIVEL
The injection swivel allows fluids to be injected into the well through the hollow rod string.

CHECK VALVE
Installed either down-hole or at the wellhead, check valves are used to prevent production/injection fluids from entering/returning into the hollow rod string. This improves safety at the rig.

POLISHED HOLLOW ROD
The polished hollow rod provides an effective seal between the environment and the production fluids at the uppermost section of the hollow rod string.

SLOTTED PUP JOINT
Along with a check valve, the slotted pup joint allows fluids to be injected into the tubing at varying depths. This is used to flush away sand, control corrosion, control paraffin deposition, reduce scale build-up or reduce heavy oil viscosity.

The device also makes it possible for production fluids to be simultaneously lifted through both the inside of the hollow rod string and the tubing rod string annulus.

Running Operations

BlueRod®
Premium Sucker Rod

CLEANING

Follow the same cleaning recommendations as for conventional sucker rods.

THREAD COMPOUND

To avoid galling, Tenaris recommends the use of API 5A3 running compound. Before using any other compound, be sure to check with Tenaris's technical staff.

- To apply the running compound, use a new brush with clean, soft bristle (never use metallic brushes or spatulas).
- Thread compound should be applied as a continuous film, starting from the thread root and covering the entire pin. The outline of the thread form should remain clearly visible. It is very important to keep both the rod and coupling shoulders free of running compound.
- Keep the running compound container covered in order to avoid contamination from dust, water, sand or other contaminants.

MAKE-UP

1. The initial torque should be applied using the hand tong, making sure that the right tool size is used for each diameter.
2. Upon reaching the hand–tight position, the threads have diametric interference. So, instead of making contact, coupling and sucker rod shoulders should briefly remain in a standoff.
3. The torque to make shoulder contact should be applied gently and gradually with the power tong. A 0.05 mm (0.002 inch) gauge must be used to check the proper shoulder contact.
4. When shoulders make contact, a vertical line should be marked on the pin and coupling shoulders.
5. Gradually apply torque until reaching the final circumferential displacement indicated in the displacement card.
6. Repeat steps 1 to 5 every ten joints.

Recommended Make-up Circumferential Displacement

CIRCUMFERENTIAL DISPLACEMENT		MINIMUM		MAXIMUM	
		mm	in	mm	in
BLUEROD®	3/4"	7	0.28	9	0.35
	7/8"	7	0.28	9	0.35
	1"	8	0.31	10	0.39

POWER TONG CALIBRATION

1. It is recommended to start setting a low pressure value on the power tong hydraulic circuit (i.e.300psi) and then gradually increase it (i.e. +50psi) until shoulders make contact (contact pressure).

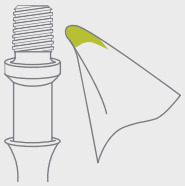
2. After that, the circuit pressure must be gradually increased until the final circumferential displacement is obtained (final pressure).

3. Steps 1 and 2 must be followed for the first few joints at the beginning of the operation, or immediately after a change of diameter. Thereafter, the final pressure should be applied to the rest of the rods.

4. Every ten joints, repeat steps 1 and 2 in order to adjust any potential deviation from the original power tong calibration.

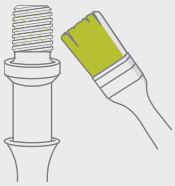
Make-up Sequence for BlueRod® Premium Sucker Rods

Step 1



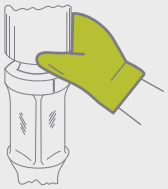
Clean pins before make-up with solvents or biodegradable detergents and dry with compressed air.

Step 2



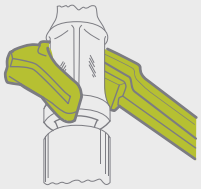
Apply API 5A3 dope on the pin, using a clean brush, and remove dope excess on flanks.

Step 3



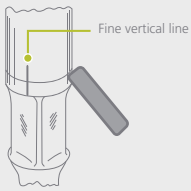
On the pipe racks, manually **buck the coupling on** until the first threads are engaged.

Step 4



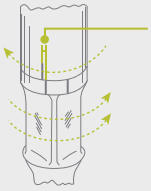
Hoist up to the wellhead and **make up the connection** with a duckbill wrench, until the hand-tight position is reached.

Step 5



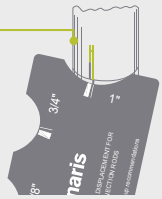
Apply pressure with the power tongs until flank-to-flank contact is reached. Check flank-to-flank contact with a 0.05 mm gauge.

Step 6



Apply torque until the maximum required in the displacement card is reached.

Step 7



Check circumferential displacement, as required in the displacement card.

HolloRod™ Series

CLEANING

Follow the same cleaning recommendations as for conventional sucker rods.

LENGTH MEASUREMENT

As HolloRod™ rods come in varying lengths, it is particularly important to measure the exact length of the string during make-up, in order to meet well design requirements. For each hollow rod, 2" should be added to account for the nipple connector.

HANGING

There are two main ways of hanging HolloRod™ rods:

- Using conventional rod elevators in combination with a crossover connected to a 2 ft long conventional pony rod.
- Using tubing elevators in combination with a pin-box accessory featuring a box with a similar external diameter to that of a tubing coupling.

MAKE-UP

Make-up is performed with conventional casing or tubing tongs adapted to the hollow rod's external diameter (see 'Required tools' below for more details).

The power tong used must be equipped with a direct reading gauge so that applied torque can be controlled. Space-out is done with standard-length pup joints (hollow pony rods) in the same way as with conventional sucker rods.

REQUIRED TOOLS

- Power tong: Any type or model of hydraulic power tong can be used. Casing or tubing tongs are normally used (the only modification they require is that the dies be adjusted to the hollow rod's OD). The power tong must have a hydraulic or manual backup with the same die size as the tong.
- Hanging slips (spider): Use pneumatic slips for conventional pipes adapted to 1.9" (48.8 mm) OD.
- Safety clamp (dog collar): Since HolloRod™ rods are relatively lightweight, it is recommended to use a safety clamp above the spider for the first ten rods – until the rod string gets heavy enough to ensure a correct hanging operation with the spider.

Make-up Torque for Hollow Rods

PRODUCT	MIN TORQUE lb.ft	MAX TORQUE lb.ft
486 SEC NU LI-20/22 HS147	1100	1200
486 SEC NU HI-18 HS147	1500	1600
486 SEC NU LI-20/22 CS105	900	1000
486 SEC NU HI-18 CS105	1300	1400
576 SEC NU LI-31 GR125	1450	1550

X-Torque, High Strength and Conventional Rods

CLEANING

1. Thread storage compound must be thoroughly removed from connections.

2. Clean connections using a nonmetallic brush and cleaning solvent. The use of diesel is not recommended.

3. Once cleaned, the connections should be dried with the use of compressed air; then the coupling should be hand-mounted.

4. If rods are to be left on the rack for an extended period of time, apply a suitable compound to the thread. Place dry, clean and damage-free thread protectors on all connections and repeat the cleaning process prior to running.

THREAD COMPOUND

For rods with API threads, Tenaris does not recommend the use of running compound.

HANGING

Conventional sucker rod elevators are used according to sucker rod body diameter. Once the sucker rod is in a vertical position and its coupling axis is aligned with the axis of the wellhead, lower it slowly for make-up.

MAKE-UP

The following steps are recommended:

1. The initial torque (hand-tight position) should be applied using the hand tong, making sure the right tool size is used for each diameter.

2. When shoulders make contact, a vertical line should be marked on the pin and coupling shoulders.

3. Gradually apply torque until reaching the final circumferential displacement indicated in the displacement card.

4. Steps 1 to 3 must be followed for the first ten joints run at the beginning of the operation, or immediately after a change of diameter. Thereafter, displacement values should be checked every ten joints.

POWER TONG CALIBRATION

Initial pressure should be applied according to the power tong datasheet specifications for conventional sucker rods. If that information is not available, it is recommended to start setting a low pressure value on the power tong hydraulic circuit (i.e.300psi) and then gradually increase it (i.e. +50psi) until the final circumferential displacement is obtained.

Recommended Make-up Circumferential Displacement

CIRCUMFERENTIAL DISPLACEMENT [mm (in)]		API GRADES				PROPRIETARY GRADES			
		NEW ROD		USED ROD		NEW ROD		USED ROD	
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
CONVENTIONAL SUCKER RODS (*)	5/8"	6.3	7.1	4.8	6.3	8.4	9.9	8.0	8.8
		(0.25)	(0.28)	(0.19)	(0.25)	(0.33)	(0.39)	(0.31)	(0.35)
	3/4"	7.1	8.7	5.6	6.7	10.4	11.9	9.2	9.9
		(0.28)	(0.34)	(0.22)	(0.26)	(0.41)	(0.47)	(0.36)	(0.39)
	7/8"	8.7	9.5	7.1	9.1	11.5	13.0	11.2	12.3
		(0.34)	(0.37)	(0.28)	(0.36)	(0.45)	(0.51)	(0.44)	(0.44)
	1"	11.1	12.7	9.5	11.1	14.7	17	14.3	15.9
		(0.44)	(0.50)	(0.37)	(0.44)	(0.58)	(0.67)	(0.56)	(0.63)
	1 1/8"	14.3	16.7	12.7	15.1	17.9	20.7	17.0	19.9
		(0.56)	(0.66)	(0.50)	(0.59)	(0.70)	(0.81)	(0.67)	(0.78)

(*) Recommended circumferential displacement for sinker bar make-up is similar to that of sucker rods, according to pin diameter.

CIRCUMFERENTIAL DISPLACEMENT		D GRADE FOR HIGH TORQUE APPLICATIONS				
		MINIMUM		MAXIMUM		MAKE UP TORQUE
		[mm	(in)]	[mm	(in)]	[lb.ft]
X-TORQUE	1" pin 7/8"	11	(0.43)	13	(0.51)	830 to 1070
	1 1/4" pin 1"	20	(0.79)	23	(0.91)	1390 to 1900
	1 1/2" pin 1 1/8" "	21	(0.83)	24	(0.94)	1730 to 2150

CIRCUMFERENTIAL DISPLACEMENT		D GRADE FOR INTERMEDIATE TORQUE APPLICATIONS				
		MINIMUM		MAXIMUM		MAKE UP TORQUE
		[mm	(in)]	[mm	(in)]	[lb.ft]
X-TORQUE	1" pin 7/8"	7.5	(0.30)	10	(0.37)	570 to 780
	1 1/4" pin 1"	14.0	(0.55)	17	(0.67)	970 to 1410
	1 1/2" pin 1 1/8" "	18.0	(0.71)	21	(0.83)	1480 to 1880

CIRCUMFERENTIAL DISPLACEMENT		HS GRADE FOR HIGH TORQUE APPLICATIONS				
		MINIMUM		MAXIMUM		MAKE UP TORQUE
		[mm	(in)]	[mm	(in)]	[lb.ft]
X-TORQUE	1" pin 7/8"	13	(0.51)	15	(0.59)	980 to 1230
	1 1/4" pin 1"	23	(0.91)	26	(1.02)	1600 to 2150
	1 1/2" pin 1 1/8" "	24	(0.94)	27	(1.06)	1980 to 2420

CIRCUMFERENTIAL DISPLACEMENT		HS GRADE FOR INTERMEDIATE TORQUE APPLICATIONS				
		MINIMUM		MAXIMUM		MAKE UP TORQUE
		[mm	(in)]	[mm	(in)]	[lb.ft]
X-TORQUE	1" pin 7/8"	11	(0.43)	13	(0.51)	830 to 1070
	1 1/4" pin 1"	17	(0.67)	20	(0.79)	1180 to 1650
	1 1/2" pin 1 1/8" "	21	(0.83)	24	(0.94)	1730 to 2150

Make-up Comparison Chart

MAKE-UP PROCESS	BLUEROD® PREMIUM SUCKER RODS	HOLLOROD™ SERIES	X-TORQUE RODS	HIGH STRENGTH RODS	CONVENTIONAL RODS
LENGTH MEASUREMENT	NO	TALLY	NO	NO	NO
THREAD CLEANING	YES	YES	YES	YES	YES
THREAD RUNNING COMPOUND	API 5 A3	API 5 A3	NO	NO	NO
ELEVATORS	CONVENTIONAL	CONVENTIONAL + CROSS OVER TUBING ELEVATOR	CONVENTIONAL	CONVENTIONAL	CONVENTIONAL
INITIAL TORQUE	USING HAND TONG	USING HAND TONG	USING HAND TONG	USING HAND TONG	USING HAND TONG
POWER TONG CALIBRATION	GRADUALLY INCREASE PRESSURE UNTIL REACHING DISPLACEMENT RECOMMENDED BY TENARIS	SET THE TONG PRESSURE IN ORDER TO REACH RECOMMENDED TORQUE	SET THE TONG PRESSURE IN ORDER TO REACH DISPLACEMENT RECOMMENDED BY TENARIS	SET THE TONG PRESSURE IN ORDER TO REACH DISPLACEMENT RECOMMENDED BY TENARIS	SET THE TONG PRESSURE IN ORDER TO REACH DISPLACEMENT RECOMMENDED BY TENARIS
SHOULDER CONTACT TORQUE	YES	YES	ALREADY DONE WITH HAND TONG	ALREADY DONE WITH HAND TONG	ALREADY DONE WITH HAND TONG
SHOULDER CONTACT VERIFICATION	USING A 0.05 MM GAUGE FOR EVERY ROD	NO	NO	NO	NO
APPLYING FINAL TORQUE	ACCORDING TO DISPLACEMENT RECOMMENDED BY TENARIS	ACCORDING TO DATASHEET SPECIFICATIONS	ACCORDING TO DISPLACEMENT RECOMMENDED BY TENARIS	ACCORDING TO DISPLACEMENT RECOMMENDED BY TENARIS	ACCORDING TO DISPLACEMENT RECOMMENDED BY TENARIS
MAKE-UP VERIFICATION	1 EVERY 10 RODS	1 EVERY 10 RODS	1 EVERY 10 RODS	1 EVERY 10 RODS	1 EVERY 10 RODS

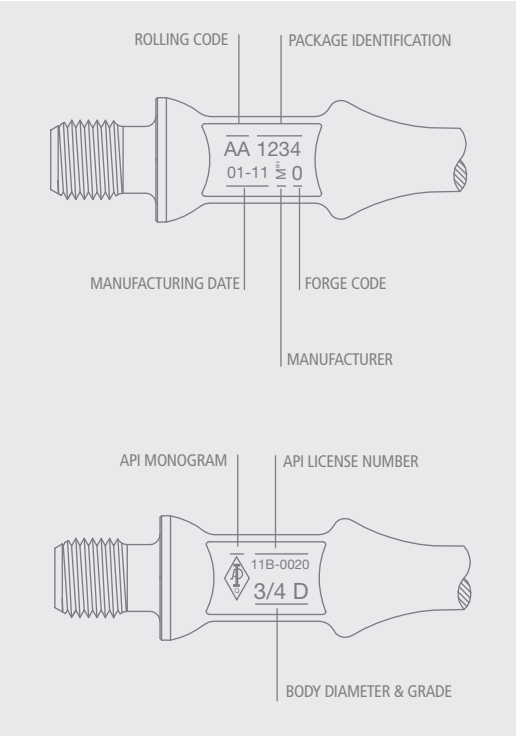
Appendix

Product Identification

SUCKER RODS

- Heat code: Identifies the raw material before the start of the manufacturing process.
- Lot identification: Identifies product and process parameters of the sucker rod during its manufacturing process.
- Manufacturing date: Identifies month and year.
- Manufacturer: M”” stands for the Tenaris sucker rods mill in Argentina, CF stands for the mill in Brazil, TM stands for the mill in Mexico and SL stands for the mill in Rumania.
- Forge code: Identifies the crew that made the forging process.
- API monogram: Identifies sucker rods manufactured under API 11B specs.
- API license number: Identifies manufacturer’s API license.
- Body diameter: 5/8”, 3/4”, 7/8”, 1”, 1 1/8”, 1 1/4” and 1 1/2”.
- Grade: Specifies the sucker rod steel and mechanical properties (C, K, D, KD, UHS, MMS, D BlueRod™, KD BlueRod®, HolloRod™ Series and AlphaRod® Series).

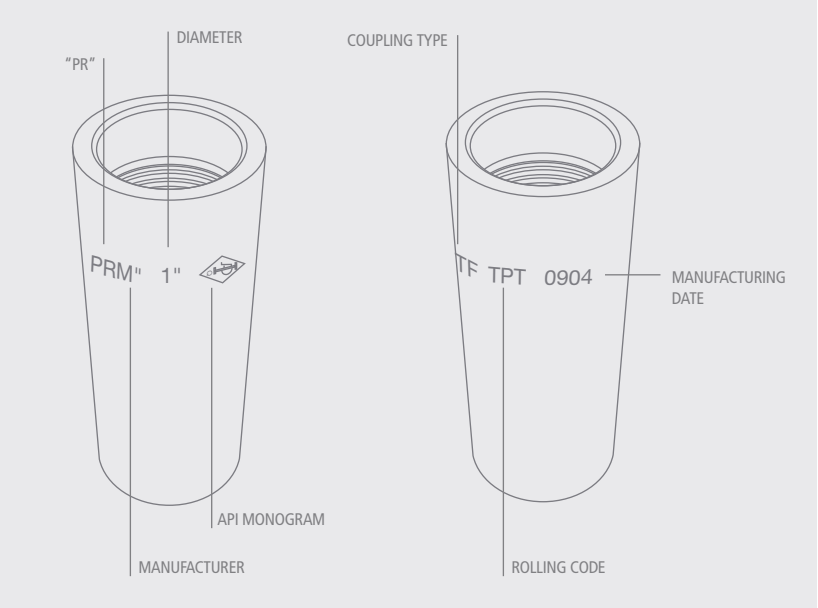
Rods identification



COUPLINGS

- PR: Only used for polished rod couplings.
- Diameter: nominal pin size coupling diameter.
- Manufacturer: M"" stands for the Tenaris sucker rods mill in Argentina, CF stands for the mill in Brazil, TM stands for the mill in Mexico and SL stands for the mill in Rumania.
- API monogram: Identifies sucker rods manufactured under API 11B specs.
- Coupling type: Specifies the material properties – T, SM or UHS (high-strength couplings).
- Manufacturing date: month and year.
- Heat code: Identifies the raw material before the start of the manufacturing process.

Couplings identification

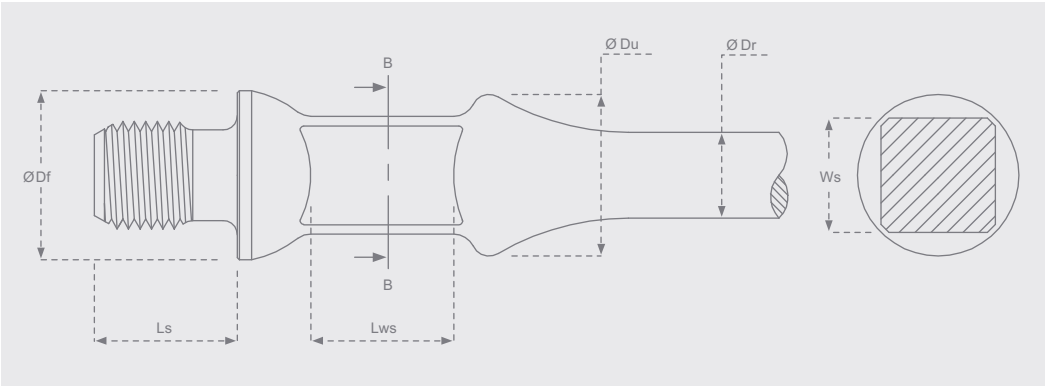


Dimensional Characteristics

BlueRod®, X-Torque and Conventional Rods

PRODUCT DIMENSIONS		Dr		Du		Ws		Lws (MIN)		Df		Ls	
		[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]
BLUEROD® RODS	3/4"	19.05	0.75	38.1	1.50	28.6	1.13	31.8	1.25	41.4	1.63	42	1.65
	7/8"	22.23	0.88	38.10	1.50	28.6	1.13	31.8	1.25	41.28	1.63	41.28	1.63
	1"	25.40	1.00	48.42	1.91	33.3	1.31	38.1	1.50	50.80	2	49.1	1.93
X-TORQUE RODS	1" PIN 7/8"	25.40	1.00	38.10	1.50	25.4	1	31.8	1.25	41.28	1.63	49	1.91
	1 1/4" PIN 1"	31.75	1.25	48.42	1.91	35.75	1.41	38.1	1.50	50.80	2	48.42	1.91
	1 1/4" PIN 1 1/8"	31.75	1.25	55.56	2.19	37.95	1.49	41.3	1.63	57.15	2.25	53.98	2.13
	1 1/2" PIN 1 1/8"	38.10	1.50	55.56	2.19	38.9	1.53	41.3	1.63	57.15	2.25	53.98	2.13
CONVENTIONAL SUCKER RODS	5/8"	15.88	0.63	30.96	1.22	22.23	0.88	31.8	1.25	31.75	1.25	31.75	1.25
	3/4"	19.05	0.75	35.72	1.41	25.4	1	31.8	1.25	38.10	1.50	36.51	1.44
	7/8"	22.23	0.88	38.10	1.50	25.4	1	31.8	1.25	41.28	1.63	41.28	1.63
	1"	25.40	1.00	48.42	1.91	33.34	1.31	38.1	1.50	50.80	2	47.63	1.88
	1 1/8"	28.58	1.13	55.56	2.19	38.1	1.50	41.3	1.62	57.15	2.25	53.98	2.13

References

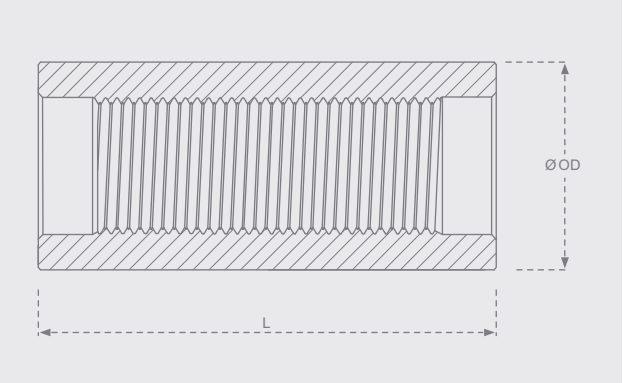


Couplings

PRODUCT DIMENSIONS		THREAD	L		FULL SIZE OD		SLIM HOLE OD	
			[mm]	[in]	[mm]	[in]	[mm]	[in]
COUPLINGS	5/8"	1 5/16 X 10	101.6	4.0	38.1	1.5	31.8	1.3
	3/4"	1 1/16 X 10	101.6	4.0	41.3	1.6	38.1	1.5
	7/8"	1 3/16 X 10	101.6	4.0	46.0	1.8	41.3	1.6
	1"	1 3/8 X 10	101.6	4.0	55.5	2.2	50.8	2.0
	1 1/8" (*)	1 9/16 X 10	114.3	4.5	60.3	2.4	57.3	2.3

(*) Couplings are manufactured according to API dimensional specifications, with the exception of 1 1/8" coupling slim hole.

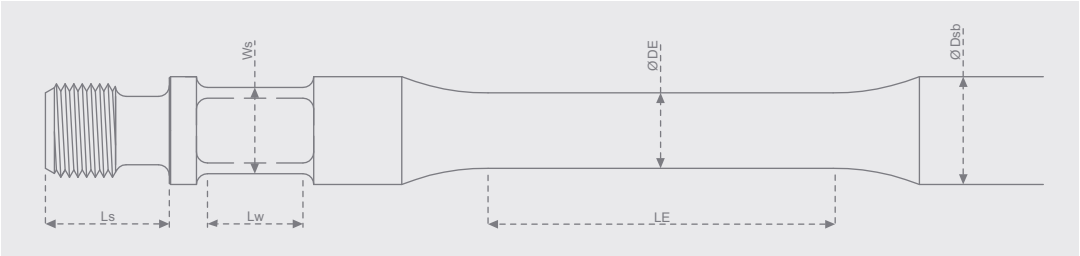
References



Sinker Bars

PRODUCT DIMENSIONS		Dsb		DE		LE (min)		Ls		Lw (min)		Ws	
		[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]
SINKER BARS	1 1/4" PIN 5/8"	31.75	1.25	22.2	0.9	101.6	4.0	31.75	1.25	31.75	1.25	25.40	1.00
	1 3/8" PIN 5/8"	34.93	1.38	25.4	1.0	101.6	4.0	31.75	1.25	31.75	1.25	25.40	1.00
	1 1/2" PIN 3/4"	38.10	1.50	25.4	1.0	101.6	4.0	36.51	1.44	38.10	1.50	33.34	1.31
	1 5/8" PIN 7/8"	41.28	1.63	25.4	1.0	101.6	4.0	41.28	1.63	38.10	1.50	33.34	1.31

References



Product Weights

BlueRod®, X-Torque and Conventional Rods

PRODUCT WEIGHT WITHOUT COUPLING [kg (lb)]		PONY RODS						SUCKER RODS	
		2 ft	4 ft	6 ft	8 ft	10 ft	12 ft	25 ft	30 ft
BLUEROD® RODS	3/4"	1.4	2.8	4.2	5.5	6.9	8.2	17.8	21.2
		(3.1)	(6.1)	(9.1)	(12.1)	(15.1)	(18.2)	(39.3)	(46.7)
	7/8"	2.0	3.8	5.7	7.5	9.4	11.3	24.0	28.5
		(4.3)	(8.4)	(12.5)	(16.6)	(20.7)	(24.8)	(52.9)	(62.9)
	1"	2.6	5.0	7.5	9.9	12.3	14.7	31.9	38.0
		(5.8)	(11.1)	(16.4)	(21.8)	(27.1)	(32.5)	(70.3)	(83.8)
X-TORQUE RODS	1" PIN 7/8"	1.9	4.3	6.7	9.2	11.6	14.0	31.2	-
		(4.2)	(9.5)	(14.9)	(20.2)	(25.6)	(30.9)	(68.7)	-
	1 1/4" PIN 1"	4.1	7.9	11.7	15.5	19.2	23.0	49.1	-
		(9.0)	(17.4)	(25.7)	(34.1)	(42.4)	(50.8)	(108.2)	-
	1 1/4" PIN 1 1/8"	4.2	8.0	11.7	15.5	19.3	23.1	49.2	-
		(9.2)	(17.5)	(25.9)	(34.2)	(42.6)	(50.9)	(108.4)	-
	1 1/2" PIN 1 1/8"	6	11.5	16.9	22.4	27.8	33.3	69.5	-
		(13.2)	(25.4)	(37.3)	(49.4)	(61.3)	(73.4)	(153.2)	-
CONVENTIONAL SUCKER RODS	5/8"	1.0	1.9	2.9	3.8	4.8	5.7	12.3	14.7
		(2.1)	(4.2)	(6.3)	(8.4)	(10.5)	(12.6)	(27.1)	(32.4)
	3/4"	1.4	2.8	4.2	5.5	6.9	8.2	17.8	21.2
		(3.1)	(6.1)	(9.1)	(12.1)	(15.1)	(18.2)	(39.3)	(46.7)
	7/8"	2.0	3.8	5.7	7.5	9.4	11.3	24.0	28.5
		(4.3)	(8.4)	(12.5)	(16.6)	(20.7)	(24.8)	(52.9)	(62.9)
	1"	2.6	5.0	7.5	9.9	12.3	14.7	31.9	38.0
		(5.8)	(11.1)	(16.4)	(21.8)	(27.1)	(32.5)	(70.3)	(83.8)
	1 1/8"	3.4	6.4	9.5	12.6	15.7	18.7	39.4	47.1
		(7.4)	(14.2)	(21.0)	(27.7)	(34.5)	(41.3)	(86.8)	(103.8)

HolloRod™ Series

PRODUCT WEIGHT WITHOUT NIPPLE [kg (lb)]		PUP JOINTS						HOLLOW RODS	
		2 ft	4 ft	6 ft	8 ft	10 ft	12 ft	MIN (28 ft)	MAX (32 ft)
HOLLOROD™ SERIES	HOLLOROD™ 486	4.2	8.5	12.7	16.9	21.2	25.4	59.3	67.8
		(9.3)	(18.7)	(28.0)	(37.4)	(46.7)	(56.0)	(130.7)	(149.5)
	HOLLOROD™ 576	4.9	9.9	14.8	19.8	24.7	29.6	69.1	79.0
		(10.8)	(21.6)	(32.4)	(43.2)	(54.0)	(64.8)	(151.2)	(172.8)
	HOLLOROD™ 425	2.8	5.6	8.4	11.2	14.0	16.8	39.3	44.8
		(6.2)	(12.4)	(18.6)	(24.8)	(31.0)	(37.2)	(86.8)	(99.2)

Couplings

PRODUCT WEIGHT [kg (lb)]		SLIM HOLE	FULL SIZE
COUPLINGS	5/8"	0.4	0.6
		(0.8)	(1.4)
	3/4"	0.5	0.7
		(1.2)	(1.5)
	7/8"	0.6	0.9
		(1.3)	(1.9)
	1"	1.0	1.1
		(2.1)	(2.5)
	1 1/8"	-	1.6
		-	(3.5)

Sinker Bars

PRODUCT WEIGHT [kg (lb)]		25 ft	30 ft
SINKER BARS	1 1/8" PIN 7/8"	38.7	46.4
		(85.3)	(102.2)
	1 1/4" PIN 5/8"	48.8	58.5
		(107.5)	(129.0)
	1 3/8" PIN 5/8"	56.8	68.1
		(125.2)	(150.2)
	1 1/2" PIN 3/4"	68.1	81.8
		(150.2)	(180.2)
	1 5/8" PIN 7/8"	79.5	95.4
		(175.2)	(210.3)
	1 3/4" PIN 7/8"	95.3	114.4
		(210.2)	(252.2)

Pulling Load Capacity

Rods

RECOMMENDED LOAD CAPACITY (SF 80%) [lb (tonnes)]							
PRODUCT		API GRADES		PROPRIETARY GRADES			
		C / K	D ALLOY / KD / D SPECIAL	UHS / MMS	D BLUEROD®	KD BLUEROD®	HOLLOROD™ SERIES
YIELD STRENGTH [ksi]		60	85	115	95	85	
BLUEROD® RODS	3/4"	-	-	-	33,500	30,039	-
		-	-	-	(15.2)	(13.6)	-
	7/8"	-	-	-	45,600	40,895	-
		-	-	-	(20.7)	(18.5)	-
	1"	-	-	-	59,700	53,438	-
		-	-	-	(27.1)	(24.2)	-
HOLLOROD™ SERIES	HOLLOROD™ 486 HS147	-	-	-	-	-	103,000
		-	-	-	-	-	(47.0)
	HOLLOROD™ 486 CS105	-	-	-	-	-	81,600
		-	-	-	-	-	(37.0)
	HOLLOROD™ 576 GR125	-	-	-	-	-	130,000
		-	-	-	-	-	(59.0)
	HOLLOROD™ 425 GR75	-	-	-	-	-	23,000
		-	-	-	-	-	(10.0)
X-TORQUE RODS	1"PIN 7/8"	28,867	40,895	55,329	-	-	-
		(13.1)	(18.5)	(25.1)	-	-	-
	1 1/4" PIN 1"	58,925	83,477	112,939	-	-	-
		(26.7)	(37.9)	(51.2)	-	-	-
	1 1/4" PIN 1 1/8"	58,925	83,477	112,939	-	-	-
		(26.7)	(37.9)	(51.2)	-	-	-
	1 1/2" PIN 1 1/8"	84,816	120,156	162,564	-	-	-
		(38.5)	(54.5)	(73.7)	-	-	-
CONVENTIONAL SUCKER RODS	5/8"	14,731	20,869	28,235	-	-	-
		(6.7)	(9.5)	(12.8)	-	-	-
	3/4"	21,204	30,039	40,641	-	-	-
		(9.6)	(13.6)	(18.4)	-	-	-
	7/8"	28,867	40,895	55,329	-	-	-
		(13.1)	(18.5)	(25.1)	-	-	-
	1"	37,721	53,438	72,298	-	-	-
		(17.1)	(24.2)	(32.8)	-	-	-
	1 1/8"	47,691	67,562	91,407	-	-	-
		(21.6)	(30.6)	(41.5)	-	-	-

Values shown refer to sucker rods only and indicate the maximum resistance to yield strength of the material.
They do not refer to pumps, polished rods, anchors or other accessories.
When pulling sucker rods, the weakest rod in the entire rod string is usually the one with the smallest diameter.

Stress Calculation

ROD STRESS CALCULATION IN BEAM PUMPING APPLICATIONS

Modified Goodman Diagram

Given that sucker rods in Beam Pumping systems are subjected to cyclic loads, the American Petroleum Institute recommends the use of the Modified Goodman diagram to determine a safe operating range.
Load solicitations should be compared using the Goodman formula:

$$\%\,Goodman = \left(\frac{TS_{max} - TS_{min}}{TS_{allow} - TS_{min}} \right) \text{x } 100$$

Where,
TS_{allow} = Allowable tensile strength
TS_{min} = Minimum tensile strength
TS_{max} = Maximum tensile strength

Maximum Allowed Stress Equations

API RP 11BR (Recommended Practice for the Care and Handling of Sucker Rods) defines the following equation as a maximum allowable tension for API sucker rod grades:

$$TS_{allow} = (UTS / 4 + 0.5625 \text{ x } TS_{min}) \text{ x } SF$$

For high-strength sucker rods, the following equation is recommended:

$$TS_{allow} = (UTS / 2.8 + 0.375 \text{ x } TS_{min}) \text{ x } SF$$

For BlueRod®, the following equation is recommended:

$$TS_{allow} = (UTS / 2.3 + 0.375 \text{ x } TS_{min}) \text{ x } SF$$

Where,
UTS = Ultimate tensile strength
SF = Service factor

Recommended Service Factors

For AlphaRod®, the following equations are recommended:

$TS_{allow} = (44.64 + 0.375 \text{ x } TS_{min}) \text{ x } SF$ *for CS grade*
$TS_{allow} = (52.08 + 0.375 \text{ x } TS_{min}) \text{ x } SF$ *for CS Blue® grade*
$TS_{allow} = (55.36 + 0.375 \text{ x } TS_{min}) \text{ x } SF$ *for HS grade*

For corrosive environments applying a variable service factor is recommended, with its ultimate value depending on the operating conditions of individual wells.

ROD STRESS CALCULATION IN PCP APPLICATIONS

Sucker rods working in Progressive Cavity Pumping systems should withstand both axial and torque loads. Therefore, they are subjected to a combined tensional state whose effective stress should not exceed the rod's elastic limit.

Most of the axial load is the result of the pressure load above the pump and the weight of the sucker rod string.

Total torque is the result of the hydraulic pump torque, pump friction torque and the resistive torque from the friction of the rod string surface against the production fluid.

The effective stress can be calculated using the von Mises equation:

$$\sigma_e = \sqrt{\frac{C_1 L^2}{\pi^2 D^4} + \frac{C_2 T^2}{\pi^2 D^6}}$$

Where,
σe = Effective stress
L = Total axial load (lb or N)
T = Total torque (lb.ft or Nm)
D = Rod string body outer diameter (in or mm)
C_1 = Constant (Imperial system 1.6×10^{-5}; International system 16)
C_2 = Constant (Imperial system: 0.1106, International system: $7.680 \times 10^{+8}$)

In order to have each sucker rod operating within a safety margin, the effective stress should be lower than the sucker rod's yield strength (whose value varies depending on the steel grade used). Additionally, a safety factor can be used to increase the rod's fatigue life.

COUPLING STRESS LOAD CALCULATION

To factor in the use of couplings in the calculation of allowable tensile strength (TSallow) for sucker rods, the equation must incorporate a depreciation factor, as shown below:

$$TS_{allow} = (UTS / 4 \times DF + 0.5625 \times TS_{min}) \times SF$$

Where,
UTS = Ultimate tensile strength
DF = Depreciation factor
SF = Service factor

The first coupling of each section of the rod string should be evaluated, applying the Modified Goodman equation.

Depreciation Factor

The depreciation factor depends on the relationship between the tensile strength of the materials that couplings and sucker rods are made of and their effective working area.

Recommended Depreciation Factor for Couplings

DIAMETER	COUPLING API SH WITH SUCKER ROD			COUPLING API SH WITH HIGH STRENGTH SUCKER ROD	COUPLING API FS WITH HIGH STRENGTH SUCKER ROD
	D	C	K		
5/8"	0.76	0.97	-	0.63	-
3/4"	0.85	-	-	0.7	0.94
7/8"	0.68	0.87	0.92	0.56	0.85
1"	0.89	-	-	0.73	-

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