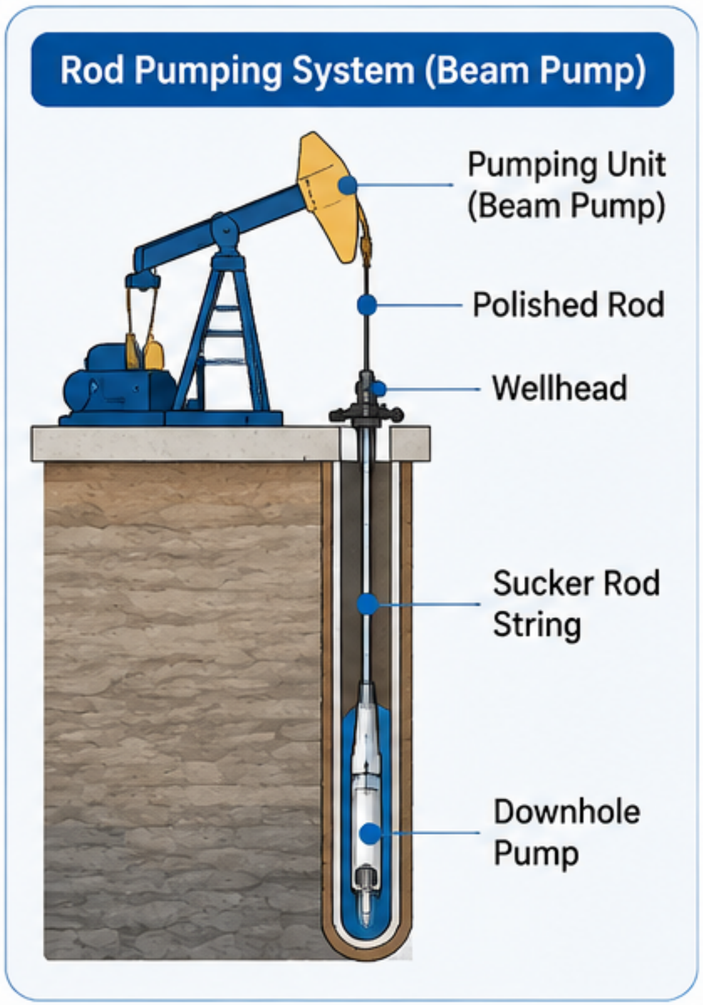
STEEL VS. FIBERGLASS SUCKER RODS

Engineering Comparison of Materials, Mechanical Performance and Oilfield Applications



Steel Sucker Rods

Fiberglass Sucker Rods



What Are Sucker Rods?

Sucker rods connect the surface pumping unit to the downhole pump, transmitting reciprocating motion to lift oil and other fluids from the well.

Steel Sucker Rods

- Made from carbon or alloy steel.
- Solid rod body with forged or upset ends, threaded for coupling.
- High axial stiffness and tensile strength.
- Suitable for conventional pumping systems and wells with higher mechanical loads.

Fiberglass Sucker Rods

- Made from glass fiber–reinforced polymer (GFRP) with metallic end fittings.
- Lower density and greater elastic elongation.
- Resistant to many corrosive well fluids.
- Often used in deep or corrosive wells to reduce rod-string weight and polished rod loads.

CONSTRUCTION AND MATERIAL PROPERTIES

Steel Sucker Rod vs. Fiberglass Sucker Rod

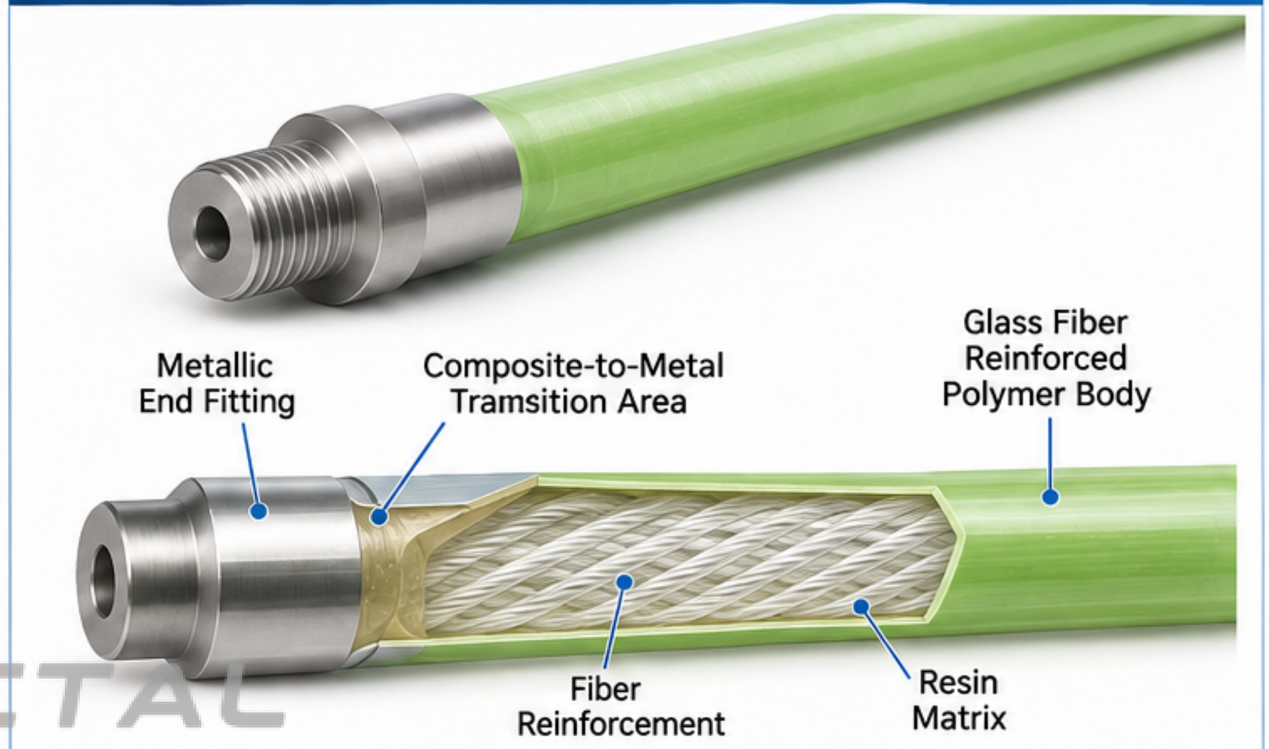
Steel Sucker Rod: Construction and Structure



About Steel Sucker Rods

- Steel sucker rods are made from carbon steel or alloy steel and use forged/upset ends with threaded pin-and-coupling connections.

Fiberglass Sucker Rod: Construction and Structure



About Fiberglass Sucker Rods

- Fiberglass sucker rods use composite rod bodies with metallic end fittings, and their properties depend on fiber orientation, resin formulation, and product construction.

Reference Material Properties (Typical)

Property	Steel Sucker Rod	Fiberglass Sucker Rod
Density	Approximately 7.85 g/cm³	Approximately 1.8–2.1 g/cm³ *(Depends on fiber orientation, resin formulation, and product construction.)*
Elastic Modulus	Approximately 200–210 GPa	Manufacturer-specific *(Depends on fiber orientation, resin formulation, and product construction.)*

MECHANICAL PERFORMANCE COMPARISON

Steel Sucker Rod vs. Fiberglass Sucker Rod

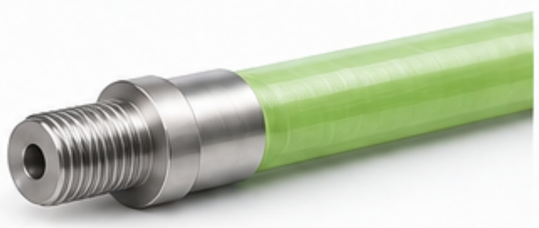
Steel Sucker Rod: Mechanical Behavior



Suitable for applications requiring greater mechanical stability.

- **Tensile performance:** Reliable tensile capacity for rod-string loading.
- **Axial stiffness:** High axial stiffness.
- **Elastic modulus:** Approximately 200–210 GPa.
- **Elastic elongation:** Lower elongation under the same loading and geometry.
- **Compression limitations:** Compression can be tolerated within structural limits.
- **Fatigue behavior:** Fatigue risk concentrates at stress-sensitive areas, especially threaded regions and connection transitions.

Fiberglass Sucker Rod: Mechanical Behavior



Lighter rod string behavior with greater elastic elongation.

- **Tensile performance:** Provides tensile capacity for rod-string loading (application-dependent).
- **Axial stiffness:** Lower axial stiffness.
- **Elastic modulus:** Manufacturer-specific and generally lower than steel.
- **Elastic elongation:** Greater elongation under equivalent loading.
- **Compression limitations:** Compression must be controlled more carefully.
- **Fatigue behavior:** Involves progressive composite degradation and connection-area sensitivity (e.g., end fitting and transition regions).

Axial Tensile Loading and Elastic Elongation



Elastic Elongation Formula

$$\Delta L = \frac{FL}{AE}$$

Variable Definitions (SI Units)	
ΔL	axial elongation (m)
F	applied tensile force (N)
L	rod length (m)
A	cross-sectional area (m^2)
E	axial elastic modulus (Pa)

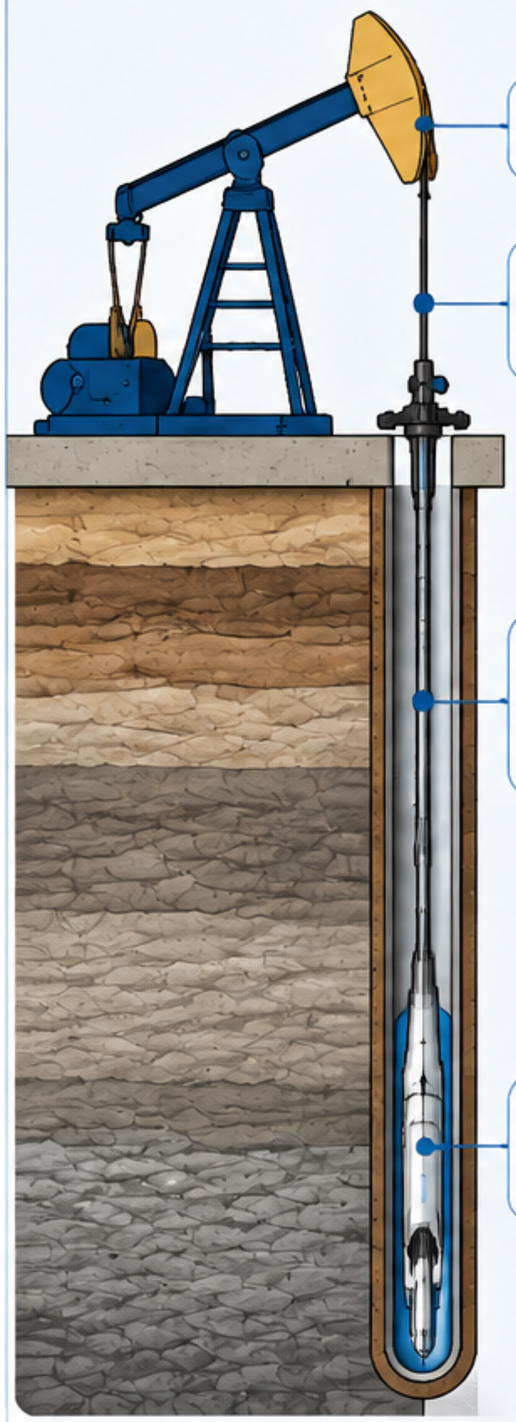
Why fiberglass generally has greater elastic elongation: From $\Delta L = FL / AE$, for the same tensile force, length, and cross-sectional area, the material with the lower elastic modulus (E) will have a larger axial elongation. Because fiberglass has a lower axial elastic modulus than steel, it generally exhibits greater elastic elongation.

Mechanical Performance Comparison

Comparison Item	Steel Sucker Rod	Fiberglass Sucker Rod
Tensile Performance	Reliable tensile capacity for rod-string loading.	Provides tensile capacity for rod-string loading (application-dependent).
Axial Stiffness	High axial stiffness.	Lower axial stiffness.
Elastic Modulus	Approximately 200–210 GPa.	Manufacturer-specific and generally lower than steel.
Elastic Elongation	Lower elongation under the same loading and geometry.	Greater elongation under equivalent loading.
Compression Behavior	Compression can be tolerated within structural limits.	Compression must be controlled more carefully.
Fatigue Behavior	Fatigue risk concentrates at stress-sensitive areas, especially threaded regions and connection transitions.	Involves progressive composite degradation and connection-area sensitivity (e.g., end fitting and transition regions).

Rod String Weight and Pumping Loads

Rod Pumping System and Load Components



Single Rod Weight Comparison (Illustrative Example)



Steel Sucker Rod

Diameter	1 in (25.4 mm)
Length	30 ft (9.144 m)
Density	7.85 g/cm³
Approx. Body Weight	**16.0 lb (7.26 kg)**



Fiberglass Sucker Rods

Diameter	1 in (25.4 mm)
Length	30 ft (9.144 m)
Density	1.9 g/cm³
Approx. Body Weight	**3.9 lb (1.77 kg)**

Weight Calculation

$$W = \rho \times A \times L$$

- **W** = rod body weight (kg)
- **ρ** = material density (kg/m³)
- **A** = cross-sectional area (m²), $A = \pi d^2/4$
- **L** = rod length (m)

Rod String Weight (Example with 100 Rods)



Steel Rod String (100 rods) ≈ 1,600 lb (726 kg)

Fiberglass Rod String (100 rods) ≈ 390 lb (177 kg)

Key Takeaways

- Fiberglass sucker rods have a much lower density, resulting in a significantly lighter rod string.
- A lighter rod string can help reduce the polished rod load and the mechanical demand on surface equipment.
- Rod weight is only one contributor to the maximum and minimum polished rod loads. Other factors also include fluid load, pump setting depth, pumping speed, stroke length, and system dynamics.

Sucker Rod Failure Modes and Engineering Considerations

Steel Sucker Rods – Typical Failure Modes



General Corrosion

Uniform material loss caused by corrosive well fluids.



Localized Pitting

Local corrosion that forms small pits and can act as crack initiation sites.



Corrosion Fatigue

Crack growth under combined corrosion and cyclic loading.



Thread-Root Fatigue

Fatigue cracks typically initiating at thread roots due to stress concentration.



Forged-End Transition Fatigue

Fatigue cracking at the upset/forged-end area under repeated tensile loading.

Fiberglass Sucker Rods – Typical Failure Modes



Matrix Cracking

Cracks in the resin matrix due to cyclic stress, impact, or chemical exposure.



Fiber Damage

Breakage or delamination of glass fibers, which reduces tensile capacity.



Localized Compression Damage

Damage caused by excessive compressive load or contact with tubing or other components.



End-Fitting Debonding

Loss of bond between the composite rod and metallic end fitting due to cyclic loading, temperature or chemical effects.

Temperature Limitation

Steel Sucker Rods

- Service temperature depends on the steel grade, heat treatment and well conditions.
- Higher-temperature service is generally achievable with appropriate material selection.

Fiberglass Sucker Rods

- Limited by the resin system, bonding technology and end fitting.
- Long-term performance can be affected by elevated temperature, which may reduce resin strength and bond integrity.

Key Differences in Failure and Inspection

Item	Steel Sucker Rods	Fiberglass Sucker Rods
Main Failure Mechanism	Corrosion, fatigue, thread and transition area failure	Matrix cracking, fiber damage, compression damage, end-fitting debonding
Inspection Focus	Corrosion, pitting, thread wear, crack detection (e.g., MPI/UT)	Surface condition, cracks, impact damage, end-fitting bond and straightness
Typical Influencing Factors	Corrosive fluids, cyclic load, stress concentration, material condition	Axial and compressive load, chemical exposure, temperature, resin aging

Engineering Takeaways

- Steel and fiberglass sucker rods have different failure mechanisms and require different inspection methods and acceptance criteria.
- Both materials can be affected by the well environment, including corrosive fluids, temperature and cyclic loading.
- Proper load control, compatible materials and regular inspection help reduce the risk of rod failure and maintain reliable pumping operation.

Sucker Rod Material Selection Guide

Steel, Fiberglass and Combination Rod Strings

Rod String Options and Typical Applications



Steel Rod String

- Conventional and general wells
- Higher axial stiffness
- Higher mechanical load capability



Fiberglass Rod String

- Deep wells or high rod weight
- Corrosive fluid environments
- Lower suspended weight, greater elasticity



Combination Rod String

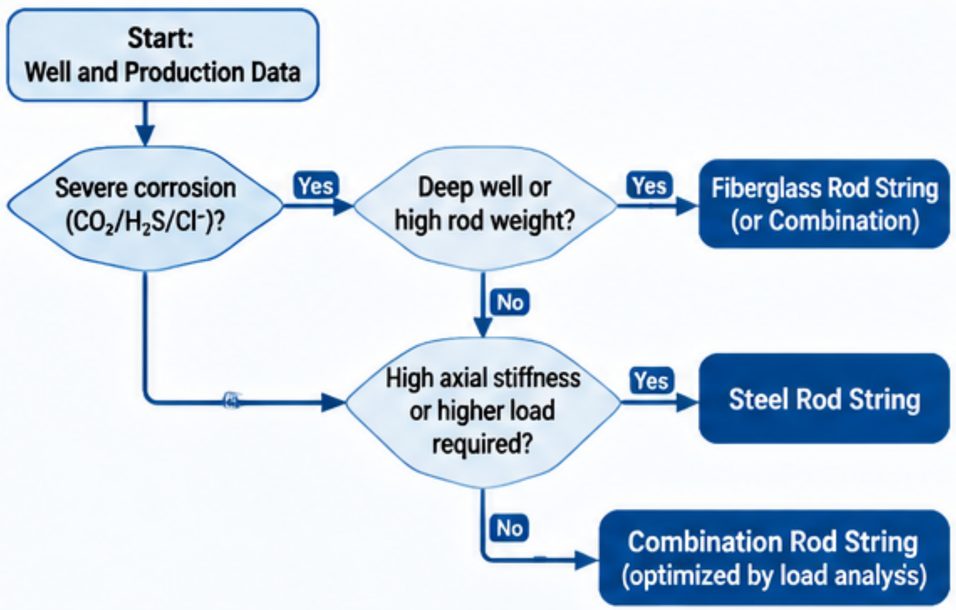
- Balance between weight, stiffness and load
- Often used in deep and corrosive wells
- Section lengths and transition position determined by engineering analysis

Comparison of Key Selection Factors

Selection Factor	Steel Rod String	Fiberglass Rod String	Combination Rod String
Pump setting depth	Widely applied	Advantageous in deeper wells	Suitable for deep or complex wells
Suspended rod weight	Higher	Siginficantly lower	Medium (reduced vs. all-steel)
Maximum rod load (tension)	Higher capacity	Lower, product-specific	Matched by section design
Minimum rod load / compression	Better tolerance	More sensitive, needs control	Managed by proper design
Corrosive fluid conditions (CO_2 / H_2S / chlorides)	Material and coating selection required	Composite body resists many corrosive fluids	Improved corrosion resistance with steel strength at lower section
Downhole temperature	Depends on steel grade	Limited by resin system and end fittings	Limited by fiberglass section
Axial stiffness	High	Lower	Moderate (between the two)
Connection compatibility	Standard threaded (pin and coupling)	Manufacturer-specific end fitting	Requires confirmed transition connection

OCTAL SUCKER ROD

Material Selection Flowchart



Key Engineering Considerations

- Pump setting depth and anticipated rod load range.
- Suspended rod weight and its impact on polished rod load.
- Fluid properties and corrosion risk (CO_2, H_2S, chlorides, etc.).
- Downhole temperature and material service limits.
- Required axial stiffness and allowable elastic elongation.
- Compression risk during the pumping cycle (e.g.. downstroke).
- Connection type, compatibility and field assembly requirements.

Procurement and Design Data Checklist

- [ ] Well information (depth, formation, produced-fluid properties).
- [ ] Pumping parameters (stroke length, pumping speed, cycle).
- [ ] Calculated maximum and minimum rod loads.
- [ ] Material selection (steel, fiberglass or combination) and rationale.
- [ ] Rod size (diameter, length) and expected section lengths (for combination strings).
- [ ] Temperature range and chemical environment (CO_2, H_2S, Cl^-, etc.).
- [ ] Connection type and compatibility (threaded or manufacturer-specific).
- [ ] Required standards and inspection (e.g., dimensional, MPI/UT, etc.).

Note: Final material selection and rod string design should be based on actual well conditions, rod load analysis and verified product data.