

Engineering Overview

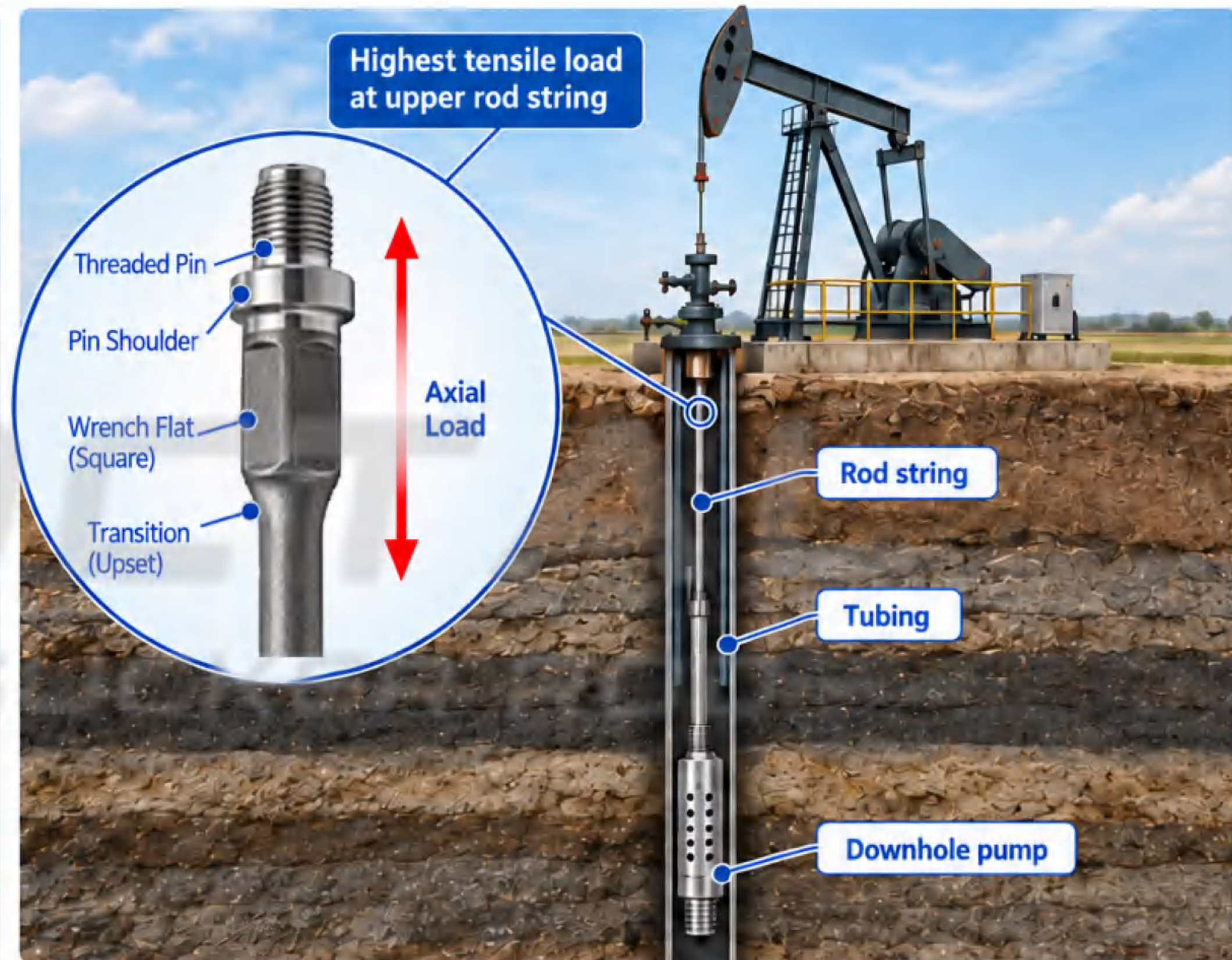
How Load Capacity Is Determined

The load capacity of a sucker rod is not defined by grade alone. It depends on the combination of nominal diameter, cross-sectional area, steel grade, rod string arrangement and the actual operating load in the well. These factors together determine the allowable tensile load and the safety margin for reliable service.

The same grade of rod will have different load capacity when the rod diameter changes, because the cross-sectional area changes. Conversely, for the same diameter, different grades provide different strength levels and therefore different safety margins.

Core Engineering Variables

- 1 Nominal diameter
- 2 Cross-sectional area
- 3 Rod grade
- 4 Axial load
- 5 Rod string position



Size

Diameter controls section area



Area

Area governs nominal stress



Grade

Grade sets strength window



Load

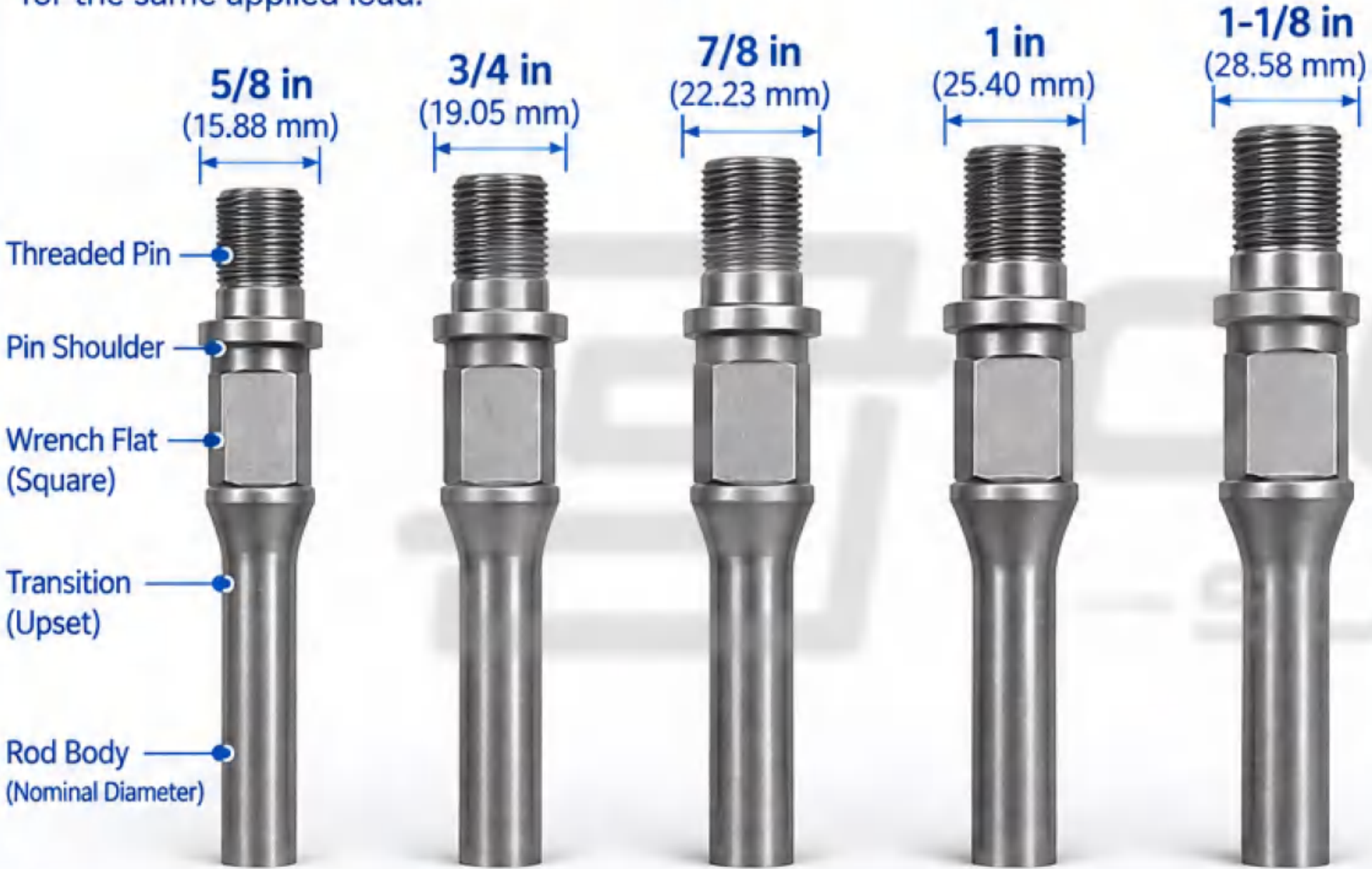
Load determines service demand

Load capacity must be evaluated from rod size, section area, grade and actual operating load rather than from diameter or grade alone.

Rod Sizes and Section Area

Common Sucker Rod Sizes

Sucker rods are manufactured in standard nominal diameters. A larger diameter provides a greater cross-sectional area, which reduces the nominal tensile stress for the same applied load.



Section Area Formula

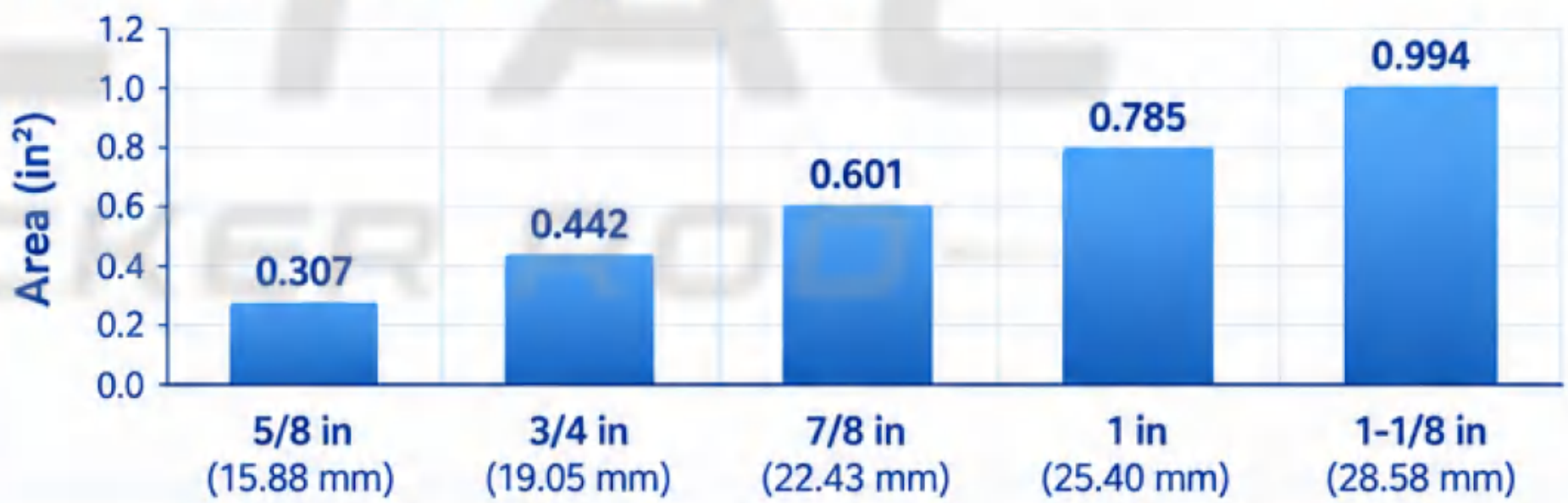
$$A = \frac{\pi d^2}{4}$$

As rod diameter increases, the cross-sectional area increases, which reduces the nominal tensile stress under the same axial load.

Nominal Diameter and Section Area

Nominal Size	Diameter (mm)	Area (in²)	Area (mm²)
5/8 in	15.88	0.307	198
3/4 in	19.05	0.442	285
7/8 in	22.23	0.601	388
1 in	25.40	0.785	507
1-1/8 in	28.58	0.994	641

Cross-Sectional Area by Rod Size



Engineering Meaning

- 1 Larger section area lowers nominal tensile stress.
- 2 Rod size must match load demand and tubing clearance.
- 3 Nominal diameter is one of the first inputs in rod string design.

Rod diameter influences load capacity primarily through its effect on cross-sectional area, not through size alone as a visual dimension.

Axial Load and Nominal Stress

Nominal Stress Calculation

Nominal stress is the average axial stress calculated from the applied axial load divided by the rod cross-sectional area.

Nominal stress (σ) = $\frac{\text{Axial load (F)}}{\text{Section area (A)}}$



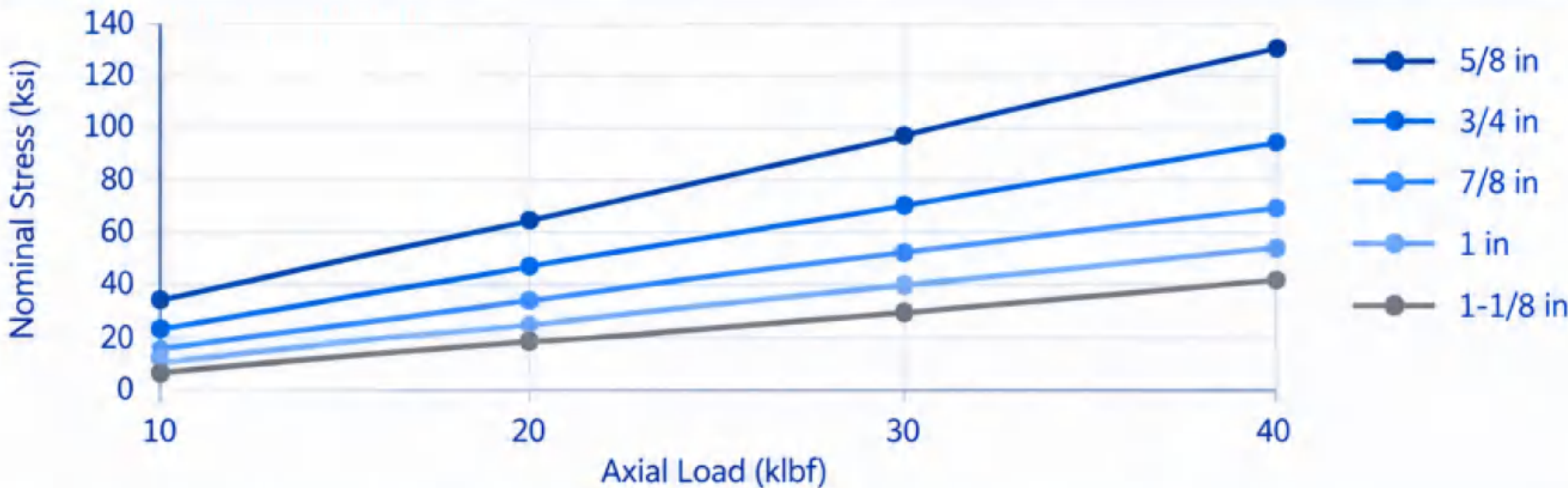
i For the same axial load, a smaller rod carries higher nominal stress because the load is distributed across a smaller section area.

d Nominal stress is a screening value and should be checked together with grade and service condition.

Stress Under Different Axial Loads

Rod Size	Nominal Stress (ksi)			
	10 klbf	20 klbf	30 klbf	40 klbf
5/8 in	32.6	65.2	97.7	130.3
3/4 in	22.6	45.3	67.9	90.5
7/8 in	16.6	33.3	49.9	66.6
1 in	12.7	25.5	38.2	50.9
1-1/8 in	10.1	20.1	30.2	40.2

Stress Trend by Rod Size



Interpretation

- 1 Smaller rods reach high stress faster**
For the same axial load, smaller diameter rods develop higher nominal stress due to the reduced section area.
- 2 Grade selection determines the available strength margin**
Nominal stress must be compared with the grade minimum tensile strength to confirm adequate safety margin.
- 3 Deep wells often require a combination of larger upper rods and higher grades**
Increasing either the rod size or the grade, or both, can help manage the higher stresses encountered in deep well applications.

Axial load must always be converted into nominal stress before diameter and grade decisions can be compared on an engineering basis.

Rod Grade and Strength Margin

Why Grade Matters

Rod diameter determines the cross-sectional area and therefore the nominal stress for a given load. Grade determines the strength window (yield and tensile strength) and the allowable load margin.

The same rod diameter can have different service capability when made to different grades, because a higher grade provides a higher strength window and greater margin to carry the same operating load reliably.

Common Strength Grades

Grade	Minimum Yield Strength	Tensile Strength	Typical Use
D	85 ksi (586 MPa)	115 – 140 ksi (793 – 965 MPa)	Conventional rod pumping loads.
HL	115 ksi (795 MPa)	140 – 173 ksi (965 – 1195 MPa)	Higher load and deeper wells.
HY	High-strength application grade	Service-specific high-strength range	Demanding applications with higher strength margin and wear-focused service.

Same Diameter, Different Grade

Example: 1 in rod under a 30 klbf load



30 klbf
(axial load)

Nominal diameter:
1.00 in

Nominal stress (σ) = Load / Area

For 1 in rod (area = 0.785 in²) under 30 klbf:
 $\sigma = 30,000 \text{ lbf} / 0.785 \text{ in}^2 = 38.2 \text{ ksi}$

Grade D

Minimum yield strength
85 ksi
(586 MPa)

Nominal stress ratio
45% of yield

45%

Nominal stress = 38.2 ksi

Grade HL

Minimum yield strength
115 ksi
(795 MPa)

Nominal stress ratio
33% of yield

33%

Nominal stress = 38.2 ksi

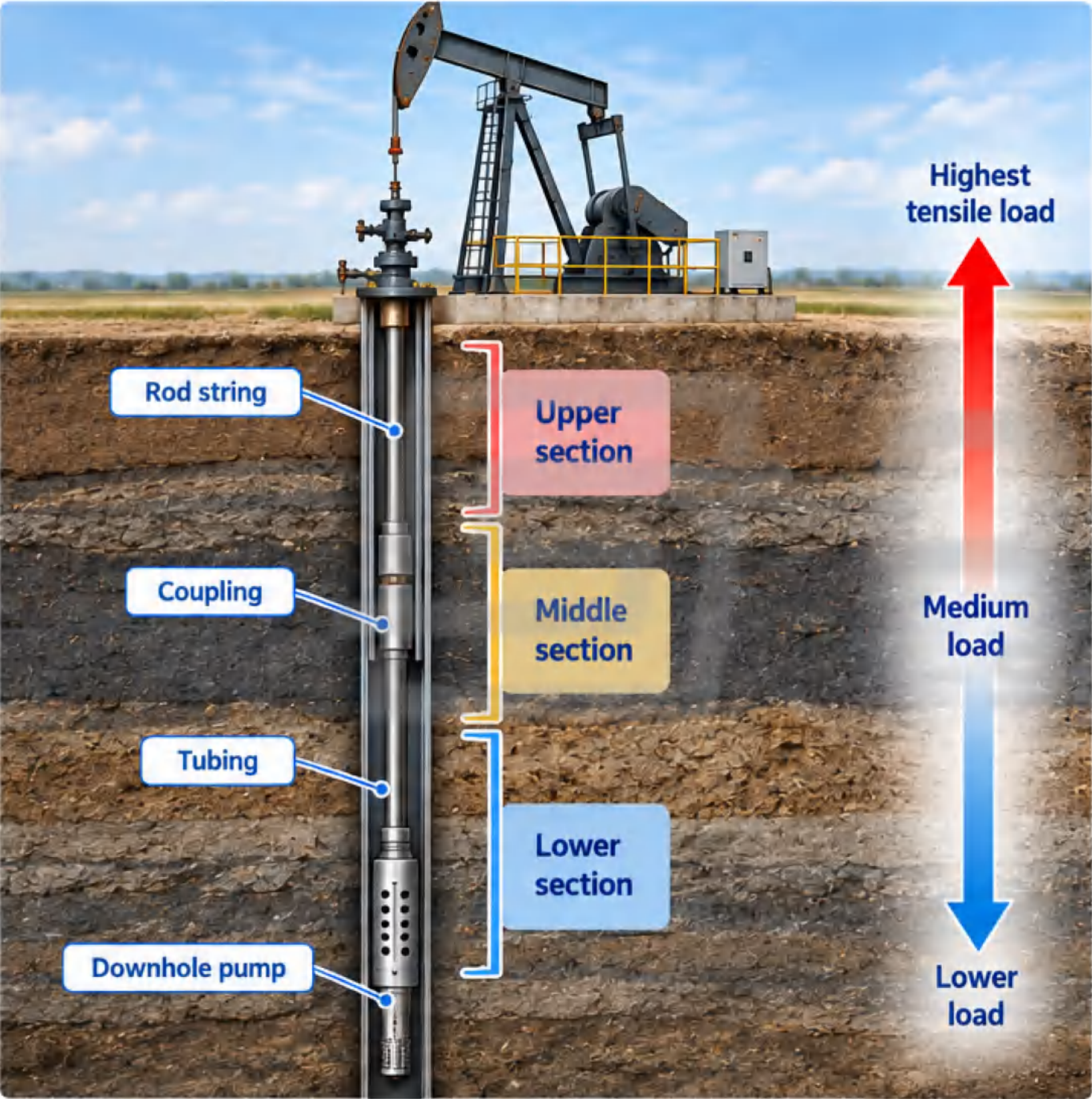
Illustrative nominal stress comparison only.

Minimum Yield Strength Comparison



Diameter controls stress level, while grade determines the strength margin available to carry that stress reliably.

Rod String Load Distribution



Load Characteristic by String Position

Rod String Position	Load Characteristic	Engineering Meaning
Upper section	Highest tensile load	Carries the weight of the rod string below and transmitted production load.
Middle section	Transitional load zone	Used to balance load capacity and string weight.
Lower section	Lower tensile load, high motion near pump	Requires compatibility with pump stroke and lower-section dynamics.

Illustrative Tapered Rod String Example



Illustrative example only — actual configuration depends on well depth, load and pumping conditions.

Why Tapered Strings Are Used

- Improves load distribution**
Larger, higher-grade rods are used where the tensile load is highest.
- Reduces unnecessary string weight**
Smaller rods are used in lower-load zones to minimize weight and cost.
- Matches rod size and grade to section demand**
Optimizes strength, fatigue life and overall string performance.

The highest tensile load is usually carried by the upper rod string, which is why rod size and grade are often selected by string position rather than by a single uniform rod design.

Engineering Selection Guide

Selection Workflow



A complete selection should verify both rod body capacity and connection compatibility.

Key Input Data Before Selection

Input Item	Why It Matters
Well depth	Determines string weight and load distribution.
Pump size and plunger load	Influences transmitted axial load.
Stroke length and pumping speed	Affect cyclic loading and fatigue demand.
Tubing size	Limits rod and coupling clearance.
Service environment	Influences material and surface requirements.

Data Required for Quotation or Engineering Review

Item	Required Information / Notes
Rod size	Nominal diameter(s) for uniform or tapered string.
Rod grade	Specified grade (e.g., C, D, K, etc.).
Standard length	Single rod length or mixed lengths (e.g., 25 ft, 30 ft).
Connection type	Thread type and standard (e.g., API, proprietary).
Coupling requirement	Coupling type, material grade and make-up standard.
Service condition	Well depth, fluid type, temperature, corrosive conditions and expected service life.



Use higher diameter when nominal stress is too high.



Use higher grade when strength margin is insufficient.



Use tapered string when load varies significantly by string position.

A reliable high strength sucker rod selection combines load analysis, diameter choice, grade verification and rod string configuration rather than relying on a single parameter.