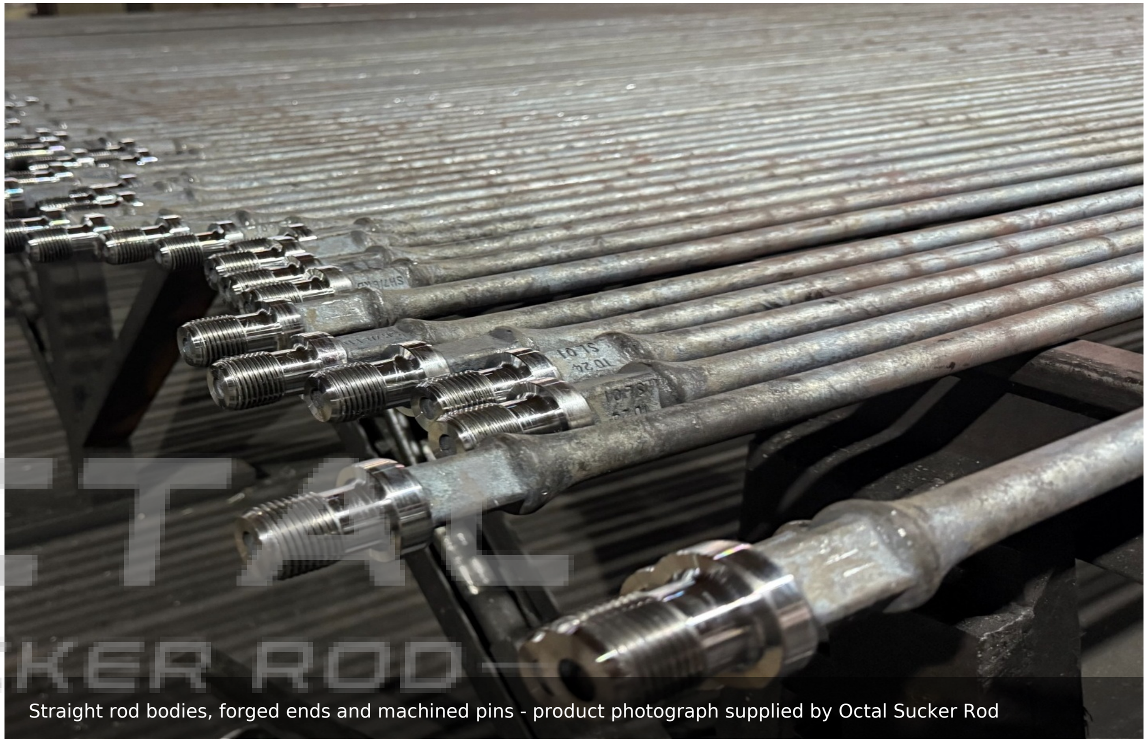
AISI 4138 Sucker Rod

Engineering Data and Load Selection Reference

4138M chemistry, finished mechanical properties, nominal rod sizes, beam-pumping and PCP stress calculations, and manufacturing-release controls.



Straight rod bodies, forged ends and machined pins - product photograph supplied by Octal Sucker Rod

MODIFIED 4138M CHEMISTRY - PROCUREMENT REFERENCE

Element	Range	
C	0.38-0.43%	mass fraction
Cr	0.50-1.00%	mass fraction
Mo	0.24-0.50%	mass fraction

Chemistry identifies the alloy route. Finished rod release still requires heat treatment, tensile, hardness, dimensional, connection and inspection evidence.

MATERIAL ROUTE

Modified AISI 4138

UNS G41380 chromium-molybdenum steel

REFERENCE FINISHED LEVEL

High-strength 4138M

115 ksi min yield; 140-155 ksi tensile

NOMINAL SUPPLY RANGE

5/8-1 1/8 in.

Common full lengths: 25 ft and 30 ft

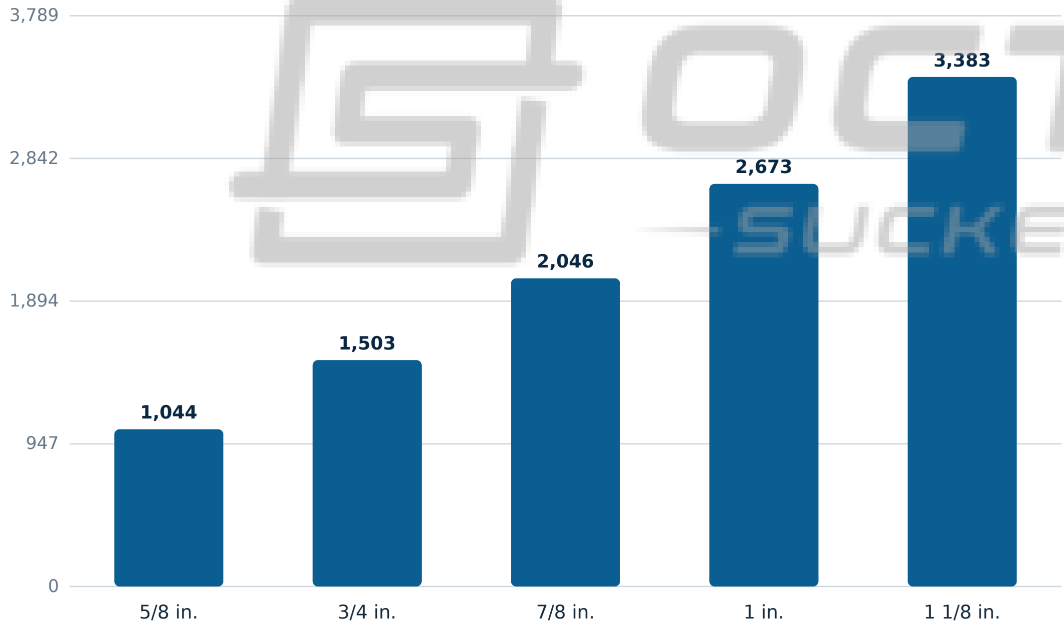
NOMINAL GEOMETRY

Rod Sizes and Section Properties

Values use the nominal round body diameter and a steel density of 7.85 g/cm3. Calculated mass excludes forged upsets, pins, couplings, coatings and manufacturing tolerances.

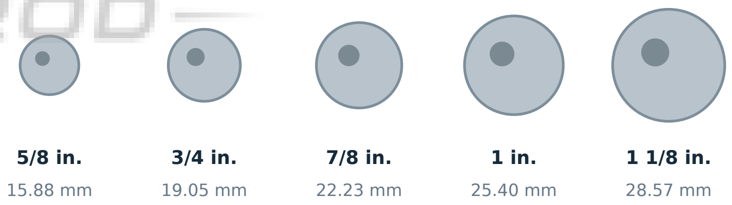
Nominal diameter	Metric	Body area	kg/m	lb/ft	25 ft body	30 ft body	1,000 ft body
5/8 in.	15.875 mm	0.3068 in2	1.554	1.044	26.1 lb	31.3 lb	1,044 lb
3/4 in.	19.050 mm	0.4418 in2	2.237	1.503	37.6 lb	45.1 lb	1,503 lb
7/8 in.	22.225 mm	0.6013 in2	3.045	2.046	51.1 lb	61.4 lb	2,046 lb
1 in.	25.400 mm	0.7854 in2	3.978	2.673	66.8 lb	80.2 lb	2,673 lb
1 1/8 in.	28.575 mm	0.9940 in2	5.034	3.383	84.6 lb	101.5 lb	3,383 lb

THEORETICAL BODY MASS PER 1,000 FT



Body-only mass, lb; excludes ends and couplings

NOMINAL BODY DIAMETER COMPARISON



Selection effect

A larger diameter increases metal area and rod-string mass while reducing nominal body stress under the same axial load.

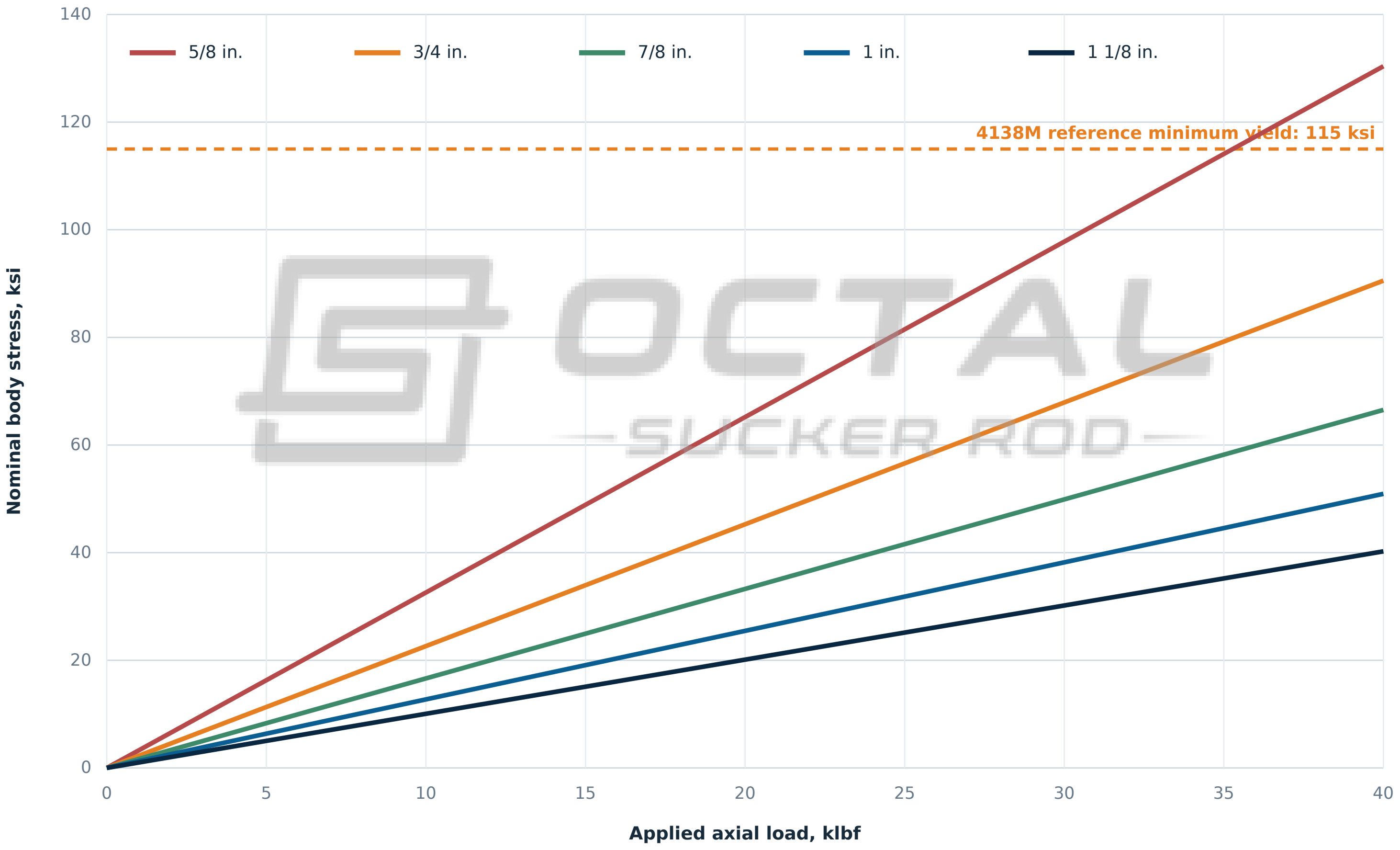
Axial Load and Nominal Body Stress

sigma = P / A

P = applied axial load
A = nominal round-body area

If P is in klbf and A is in in2, sigma is in ksi.
The result describes uniform body stress only.

LOAD-STRESS CURVES BY NOMINAL BODY DIAMETER



READING THE CURVES

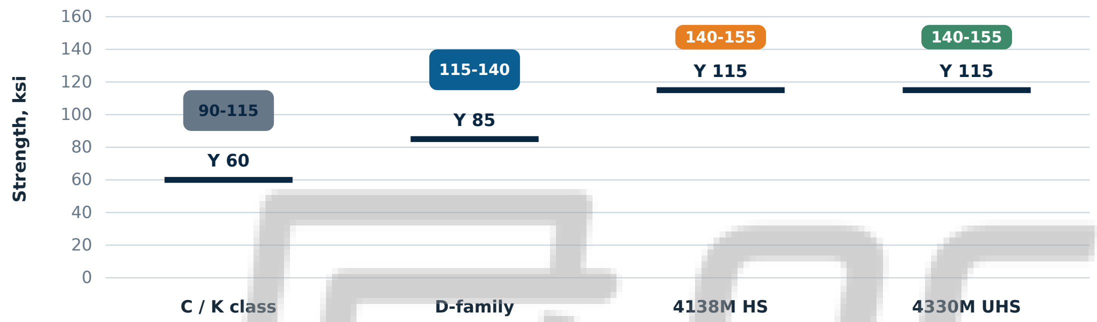
1. At the same load, a smaller body diameter carries higher nominal stress.
2. The 115 ksi line is a finished-product benchmark, not an allowable operating stress.
3. Connections, upsets, bending, wear, corrosion and fatigue can govern first.
4. Use maximum and minimum cycle loads for every taper section.

Calculated reference only. Do not publish these curves as rated capacity or safe working load.

Finished Strength and Practical Position

The comparison separates alloy route from finished-product performance. Values are reference benchmarks from the current article and must be confirmed against the ordered product specification.

REFERENCE FINISHED-STRENGTH BANDS



Horizontal marker = minimum yield; colored band = tensile range

WHERE 4138M FITS

4138M raises the reference minimum yield from the conventional D-family level of 85 ksi to 115 ksi without relying on the higher nickel content commonly associated with 4330M-type routes.

PRACTICAL GAIN

+35.3% minimum yield over an 85 ksi D-family benchmark.

SELECTION LIMIT

Strength does not qualify corrosion, H2S, deviation or fatigue life.

Best fit: loads beyond D-family without a justified nickel-rich UHS route

Route	Reference min yield	Reference tensile range	Practical position	Primary limitation
C / K class	60 ksi / 414 MPa	90-115 ksi / 621-793 MPa	Light-to-moderate load	Limited margin as cyclic stress rises
D-family / 4130 type	85 ksi / 586 MPa	115-140 ksi / 793-965 MPa	Moderate-to-high beam load	Can become restrictive in heavy strings
4138M high strength	115 ksi / 793 MPa	140-155 ksi / 965-1,069 MPa	High load with economical Cr-Mo chemistry	Qualified heat treatment; no inherent corrosion resistance
4330M-type UHS	115 ksi / 793 MPa or specified	Often 140-155 ksi / 965-1,069 MPa	Severe load where nickel-alloy response is justified	Higher alloy content and cost

INTERPRETATION Overlapping tensile ranges do not make 4138M and 4330M interchangeable. Toughness, fatigue demand, heat-treatment response, service environment and total supply cost still govern selection.

Beam-Pumping and PCP Stress Screens

Beam-pumping strings are screened with cyclic axial stress. PCP strings require axial and torsional stress to be combined. The examples below demonstrate calculation logic only.

BODY AREA

$$A = \pi d^2 / 4$$

Use actual or minimum body diameter

AXIAL STRESS

$$\sigma = F / A$$

Beam-pumping and PCP axial screen

TORSIONAL STRESS

$$\tau = 16T / (\pi d^3)$$

Required for PCP torque

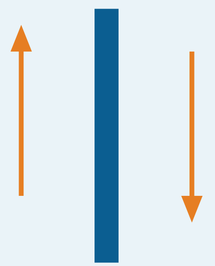
EFFECTIVE PCP STRESS

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2}$$

von Mises combined-stress screen

Example	Input	Calculated result	Engineering meaning
7/8 in. beam-pumping rod	Fmax 50,000 lbf; Fmin 10,000 lbf; area 0.601 in2	sigma max 83.2 ksi; sigma min 16.6 ksi; range 66.6 ksi; mean 49.9 ksi	Below yield does not prove acceptable fatigue life; apply the approved fatigue criterion
1 in. PCP rod	Axial load 60,000 lbf; torque 1,000 lbf-ft; area 0.785 in2	Axial 76.4 ksi; torsional 61.1 ksi; effective 130.5 ksi	Torque raises combined stress far above the axial-only result

BEAM-PUMPING CYCLE



Pmax = 50 klbf

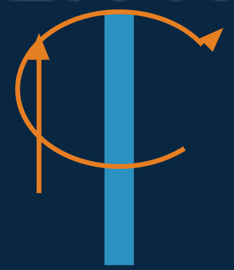
Pmin = 10 klbf

Stress range = 66.6 ksi

Mean stress = 49.9 ksi

One principal tensile-load cycle occurs during each pumping stroke. Fatigue assessment must use maximum and minimum cycle loads, not yield strength alone.

PCP COMBINED LOAD



Axial stress = 76.4 ksi

Torsional stress = 61.1 ksi

Effective stress = 130.5 ksi

Axial-only analysis understates demand

A complete PCP review also checks connection capacity, rotation speed, coupling OD, tubing clearance, deviation, wear and the qualified fatigue method.

CALCULATION BOUNDARY The examples exclude buoyancy, acceleration, pump dynamics, tubing friction, connection stress area, bending, corrosion loss and service factors. They are not rated capacities or safe working loads.

MANUFACTURING ACCEPTANCE

Heat Treatment and Finished-Product Release

Manufacturing acceptance must preserve heat and treatment-lot identity while controlling forged ends, full-length heat treatment, connection geometry and finished mechanical properties.

Incoming release

0.38-0.43% C

Heat analysis; bar NDT scope defined by the ITP

End forging

~1,200 C ref.

Procedure-qualified heating; both ends visually examined

Normalize + temper

1 chart / lot

Release by finished strength, ductility and hardness

Connection + final

10 TPI ref.

Calibrated gauges; 100% visual and marking check

The approximate forging temperature is a process reference, not a universal API acceptance limit; the qualified procedure governs actual set points and hold time.

Release item	Reference basis	Objective evidence
Material identity	Modified AISI 4138 / UNS G41380 route	Heat-numbered material certificate and chemical analysis
Minimum yield strength	115 ksi / 793 MPa	Finished-condition tensile report linked to the treatment lot
Tensile-strength range	140-155 ksi / 965-1,069 MPa	Finished-condition tensile report
Minimum elongation	8% over an 8 in. gauge length	Specified tensile specimen result
Minimum reduction of area	30%	Specified tensile specimen result
Maximum hardness	32 HRC reference	Recorded hardness results and environmental review where required

TRACEABILITY CHAIN

HEAT / MTC → FORGING LOT → FURNACE LOT → TENSILE TEST → GAUGE / NDT → MARKING / PACKING

FULL-LENGTH HEAT-TREATMENT LINE

STRAIGHTENING AND MACHINING AREA

AUTOMATED END-PROCESSING LINE