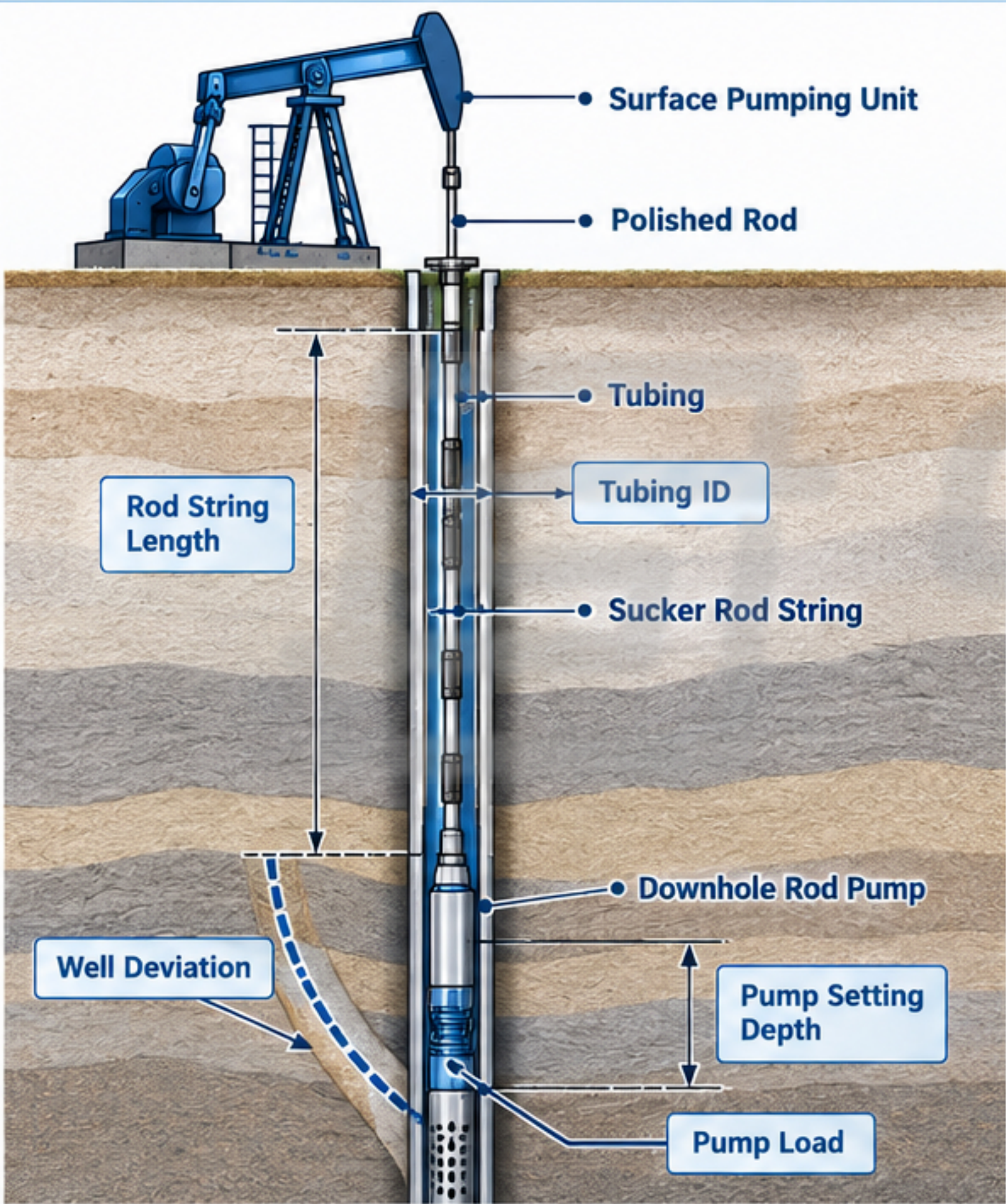


## Design Inputs for Sucker Rod String Selection

Engineering starting point for rod-string sizing, load review and connection clearance check



### Engineering Input Panel



#### Well Geometry

- Pump setting depth
- Tubing size / tubing ID
- Deviation profile

##### Engineering Effect:

Controls rod travel path and available clearance.



#### Pump Operation

- Pump load
- Stroke length
- Pumping speed

##### Engineering Effect:

Defines the axial demand transmitted through the string.



#### Rod String

- Candidate rod diameter
- Rod grade
- Existing string configuration

##### Engineering Effect:

Determines load capacity, weight and design compatibility.



#### Service Condition

- Produced fluid
- Corrosion condition
- Wear / contact risk

##### Engineering Effect:

Affects material selection and service suitability.



#### Tubing ID

Controls available rod and coupling clearance.



#### Pump Load

Determines the axial demand transferred through the string.

### Design Workflow (Page 1)

Well Data

Load Demand

Rod Diameter

Grade

String Configuration

Connection & Clearance Check

Rod Diameter and Axial Stress Calculation

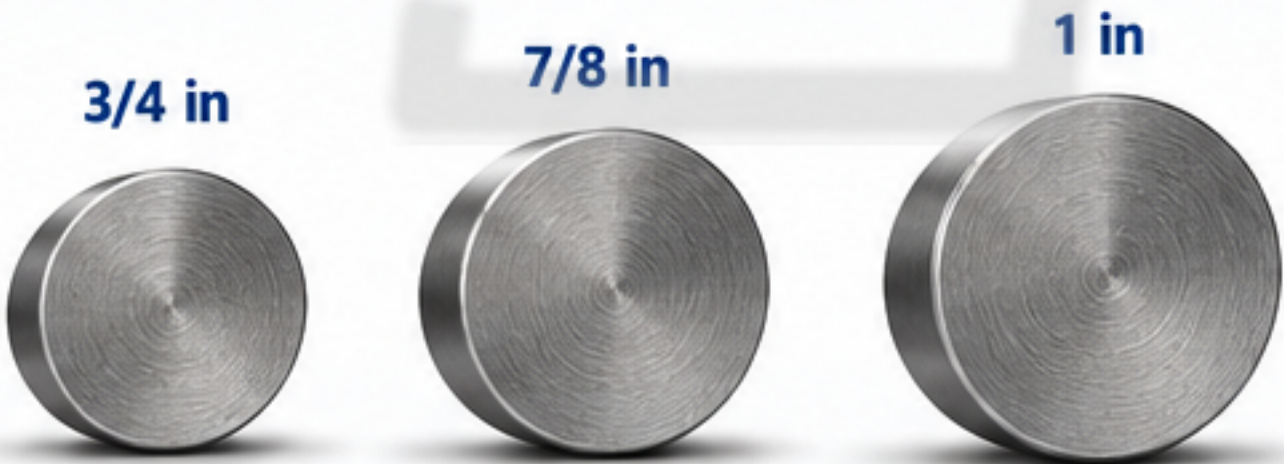
Basic calculation page for rod diameter, rod-body area and nominal axial stress

Basic Relationships

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

A = rod-body cross-sectional area  
d = nominal rod-body diameter  
F = applied axial load  
σ = nominal axial stress

Solid Rod Section Comparison

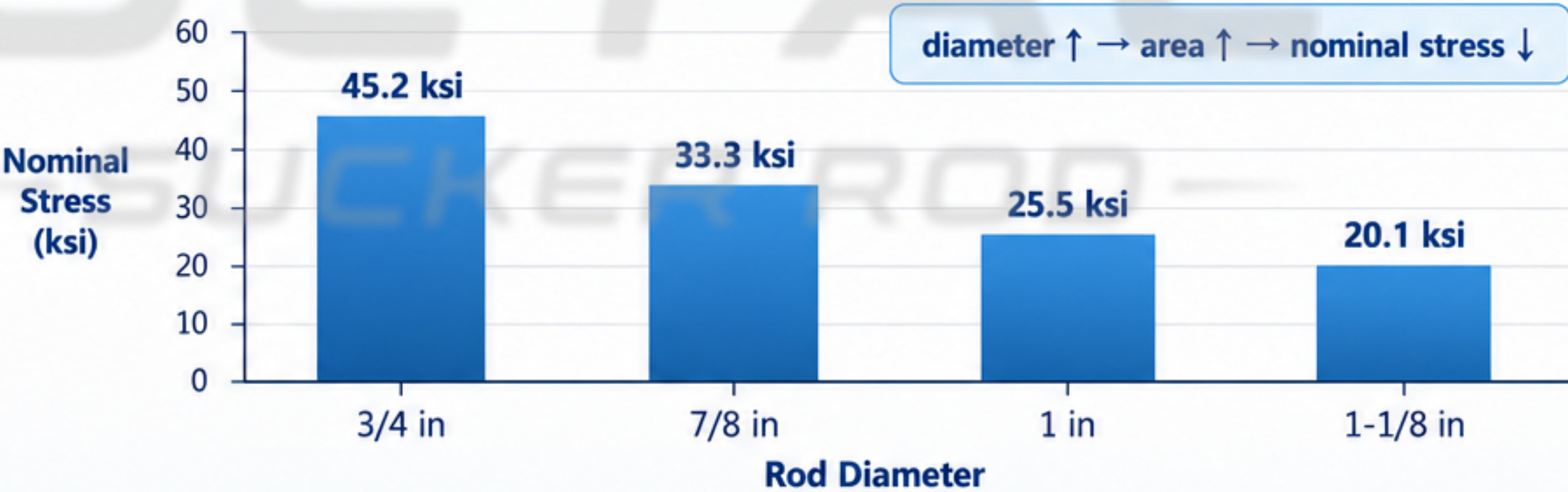


Solid rod section, not hollow tube.

Illustrative Axial Load: 20,000 lbf

| Rod Diameter | Section Area | Nominal Stress at 20,000 lbf |
|--------------|--------------|------------------------------|
| 3/4 in       | 0.442 in²    | 45.2 ksi                     |
| 7/8 in       | 0.601 in²    | 33.3 ksi                     |
| 1 in         | 0.785 in²    | 25.5 ksi                     |
| 1-1/8 in     | 0.994 in²    | 20.1 ksi                     |

Nominal Stress vs Rod Diameter



Key Engineering Takeaway

Increasing rod diameter reduces nominal axial stress under the same load, but it also increases rod-string weight and reduces available tubing clearance. Diameter therefore cannot be increased independently of the complete string design.

Design Workflow (Page 2)

Well Data

Load Demand

Rod Diameter

Grade

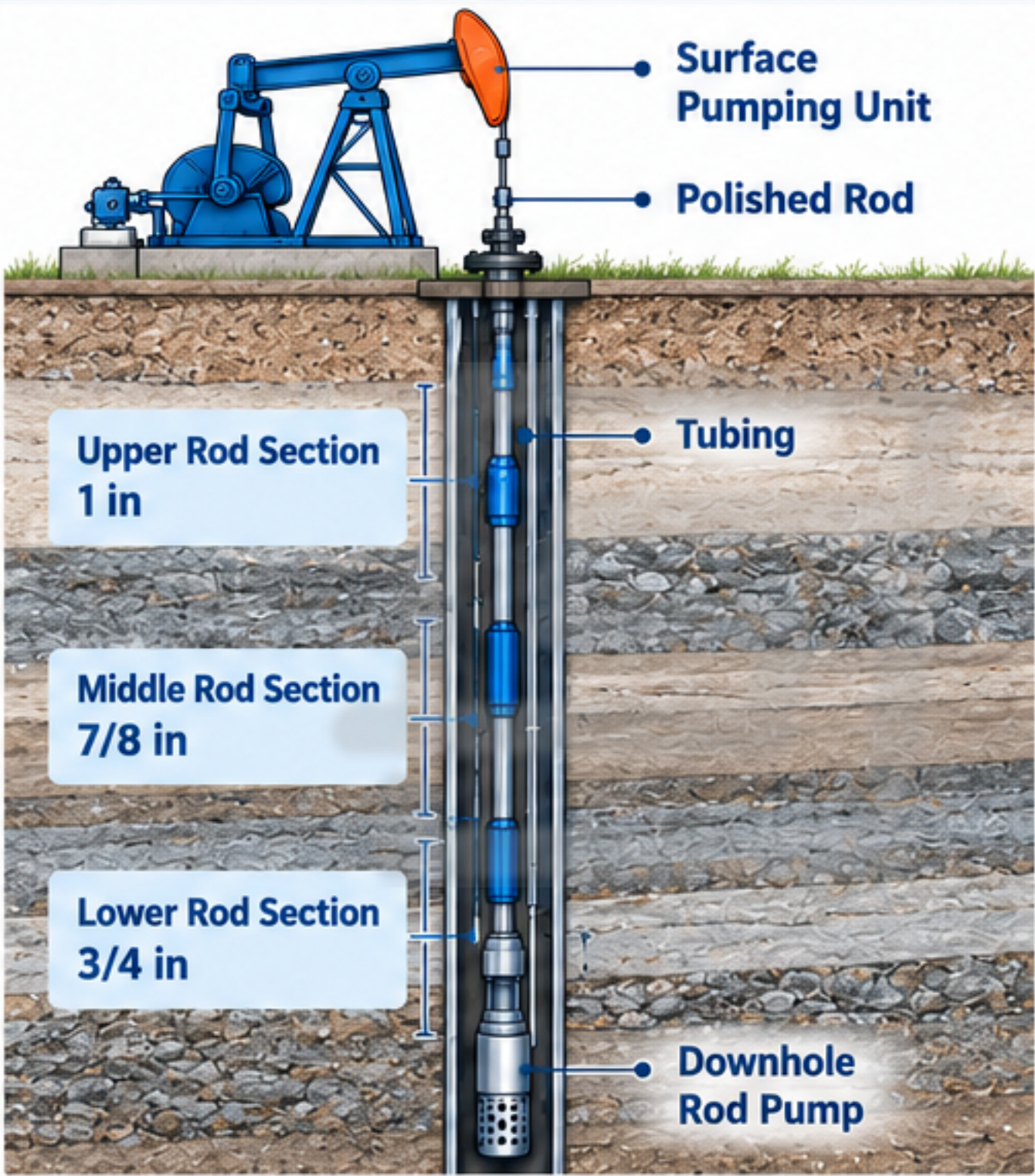
String Configuration

Connection & Clearance Check

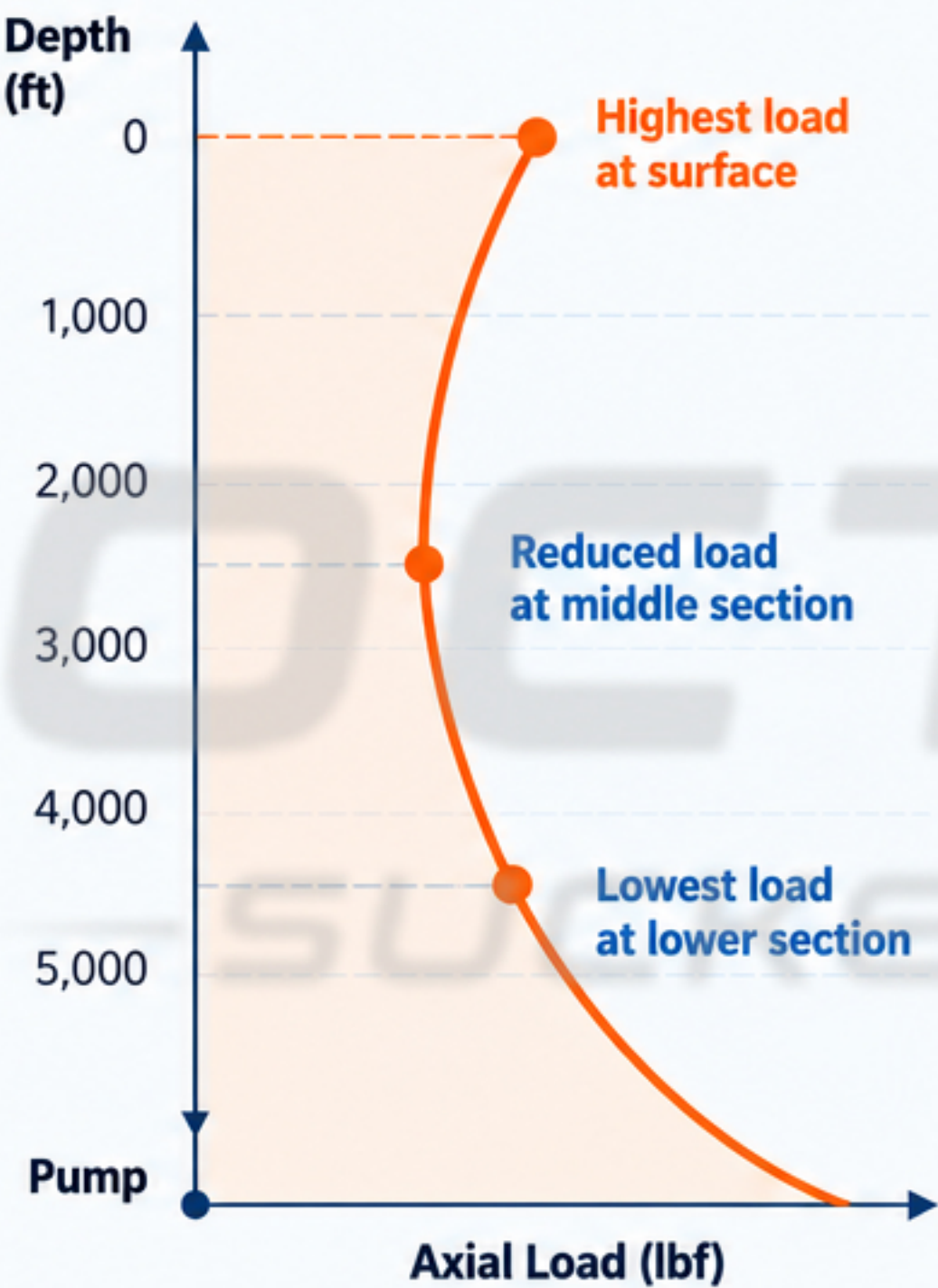
## Load Distribution Along the Rod String

How load changes from upper to lower rod-string sections

### Wellbore and Rod String Configuration



### Accumulated Load Along the Rod String



### Section Load Explanation

|  |                                                                                                      |                               |
|--|------------------------------------------------------------------------------------------------------|-------------------------------|
|  | <b>Upper Section</b><br>Carries pump-related load and the weight of rods below.                      | Rod Diameter<br><b>1 in</b>   |
|  | <b>Middle Section</b><br>Carries reduced accumulated rod weight.                                     | Rod Diameter<br><b>7/8 in</b> |
|  | <b>Lower Section</b><br>Carries less suspended rod weight but remains part of the pumping load path. | Rod Diameter<br><b>3/4 in</b> |

### Load Components

Pump-related load

+

Rod weight below the section

+

Dynamic effects

=

**Section load demand**



**A tapered string is useful when the required rod capacity changes significantly with depth.** The objective is not simply to use smaller rods at the bottom, but to match rod area, material strength and rod weight to the load carried by each section.

### Design Workflow (Page 3)

Surface Section

Middle Section

Lower Section

Load Curve

Tapered String Logic

Uniform vs Tapered Rod String: Worked Selection Case

Illustrative configuration comparison for rod-string selection

Illustrative Well Condition

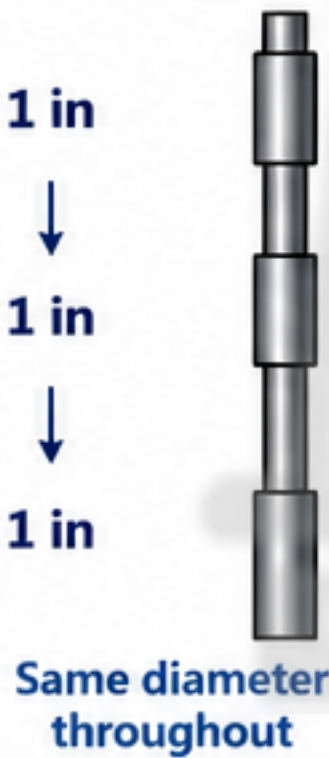


- Pump setting depth: **6,000 ft**
  - Rod pumping system
  - Higher accumulated string load
- Tubing clearance available for multiple rod sizes
  - Candidate sizes: **1 in / 7/8 in / 3/4 in**



**Illustrative engineering example — not a final well design.**  
This example uses representative data and should not be considered a general design conclusion.

Option A — Uniform Rod String



Advantages

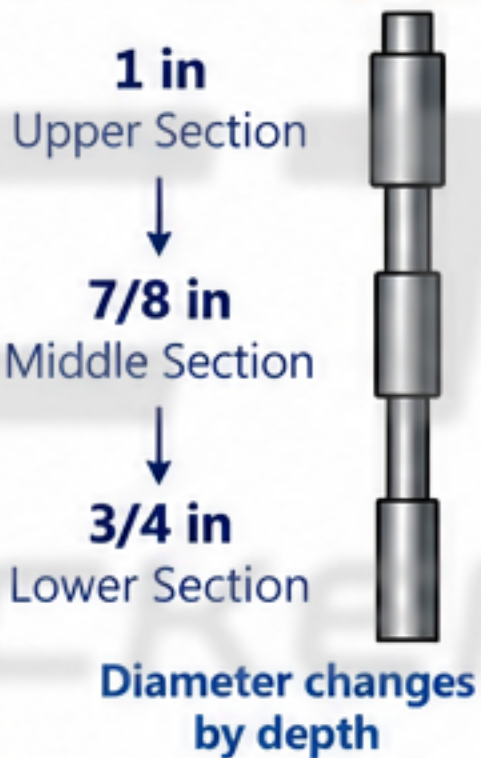
- Simple configuration
- Fewer size transitions
- Easier replacement standardization



Trade-offs

- Higher total rod weight
- Large rod section used where full area may not be required

Option B — Tapered Rod String



Advantages

- Reduces unnecessary lower-string rod mass
- Matches rod section more closely to load distribution



Checks Required

- Section transition
- Coupling compatibility
- Connection capacity
- Tubing clearance

Engineering Comparison

| Design Factor            | Uniform String | Tapered String |
|--------------------------|----------------|----------------|
| Configuration complexity | Lower          | Higher         |
| Rod weight optimization  | Limited        | Better         |
| Section transitions      | Few            | Multiple       |
| Connection checks        | Simpler        | More critical  |
| Load matching by depth   | Limited        | Better         |



**The objective is not to prove that tapered strings are always better.**  
The engineering task is to match rod area, rod weight and connection requirements to the load carried by each section.

Sucker Rod Selection Decision Matrix

Quick engineering matrix for adjusting rod diameter, grade and string configuration

| Design Condition            | Increase Rod Diameter | Increase Rod Grade         | Use Tapered String                   | Check Coupling / Clearance |
|-----------------------------|-----------------------|----------------------------|--------------------------------------|----------------------------|
| High nominal axial stress   | Primary option        | Possible                   | Possible                             | Required                   |
| High accumulated rod weight | May increase weight   | Possible                   | Strong option                        | Required                   |
| Limited tubing ID           | Restricted            | Useful if strength permits | Possible                             | Critical                   |
| Deep well                   | Possible by section   | Common consideration       | Strong option                        | Required                   |
| High cyclic loading         | Check stress range    | Important                  | Depends on load distribution         | Important                  |
| Deviated well               | May worsen clearance  | Does not solve contact     | Depends                              | Critical                   |
| Existing replacement string | Match existing design | Match required grade       | Maintain existing layout if verified | Critical                   |

Selection Errors to Avoid

- 1

Higher grade does not compensate for inadequate section area in every case.
- 2

Larger rod diameter may reduce stress but increase rod-string weight and reduce tubing clearance.
- 3

A tapered string must be checked at every size and connection transition.

## Final Rod-String Design Verification

Final Sucker Rod String Design Check

### 01 Load



Is the expected sectional load defined?

#### Check:

- pump load
- rod weight
- operating condition

### 02 Rod Area



Is nominal stress acceptable for the selected diameter?

#### Check:

- rod diameter
- section area
- calculated stress

### 03 Grade



Does the selected grade provide sufficient mechanical margin?

#### Check:

- yield strength
- tensile strength
- fatigue demand
- environment

### 04 String Configuration



Is the load distribution compatible with the selected uniform or tapered design?

#### Check:

- section length
- rod size changes
- rod weight

### 05 Connection



Can the pin and coupling carry the required load?

#### Check:

- thread compatibility
- coupling type
- connection capacity

### 06 Clearance



Will the rod and coupling operate with sufficient tubing clearance?

#### Check:

- tubing ID
- coupling OD
- deviation
- guides / wear control



### Final Configuration

Rod Diameter + Rod Grade + Section Length + Coupling + Tubing Clearance

**A sucker rod string should be accepted only after load capacity, connection compatibility and operating clearance are confirmed together.**