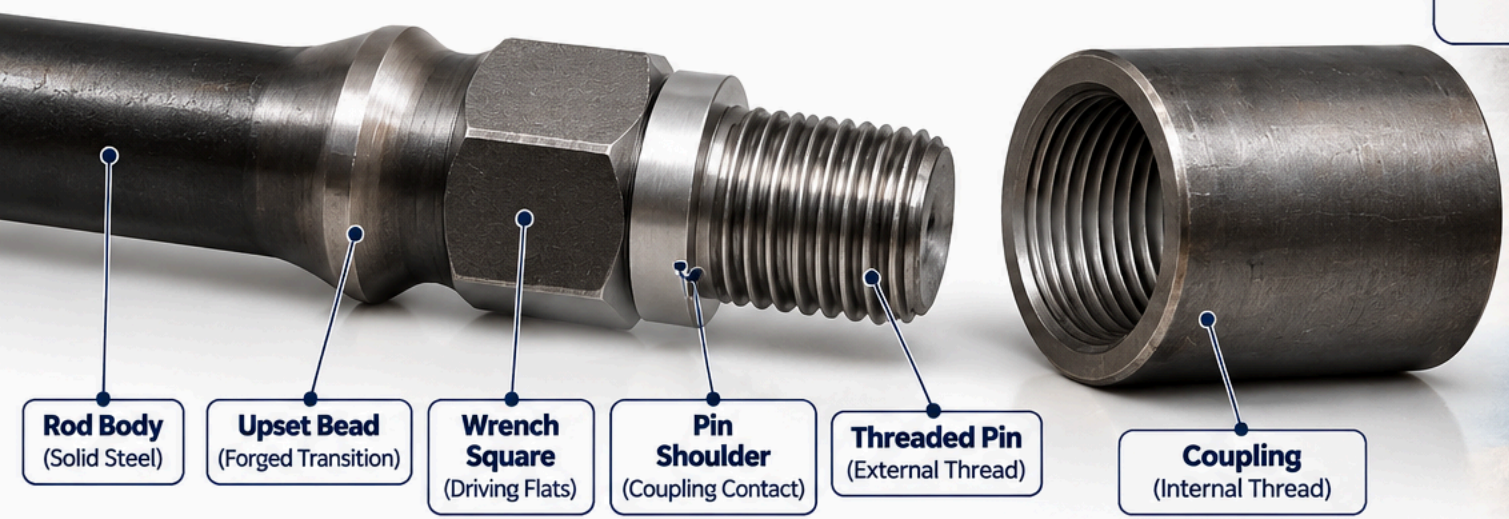
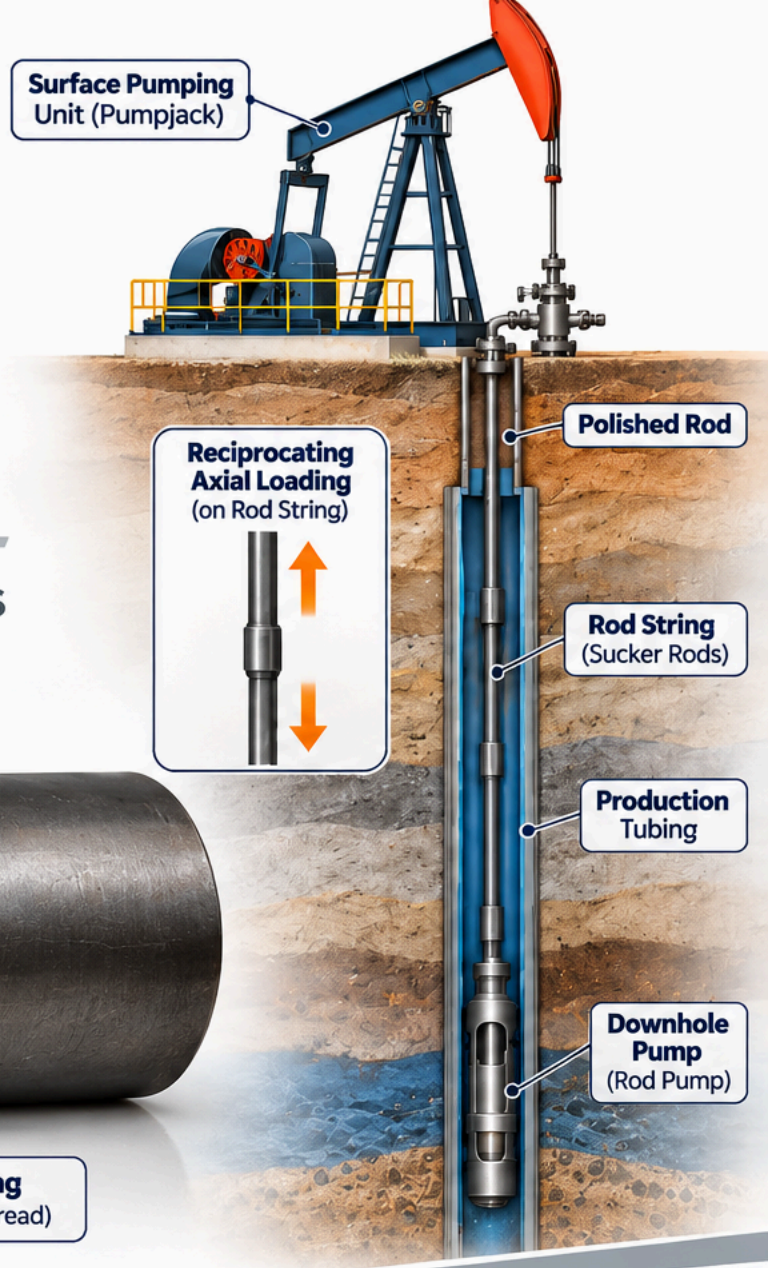
Sucker Rod Corrosion: Mechanisms, Damage and Control

Engineering Technical Guide for Rod Pumping Systems

OCTAL
SUCKER ROD





Sucker Rod Corrosion Mechanisms

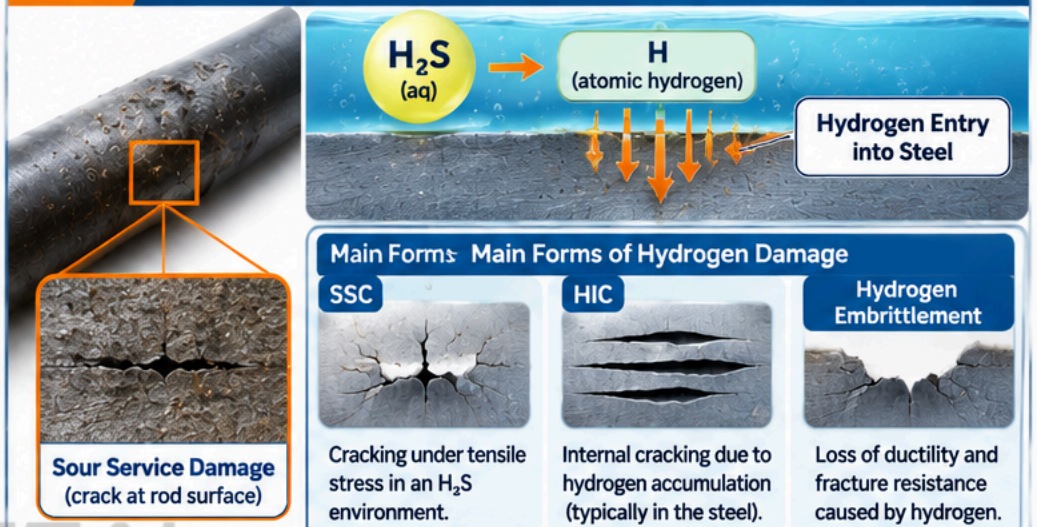
Key Environments and Damage Forms

CO_2 CO_2 Corrosion (Sweet Corrosion)



- CO_2 dissolves in water to form carbonic acid, which promotes steel dissolution.
- An $FeCO_3$ film may form under suitable conditions and reduce corrosion, but its protection depends on film stability.

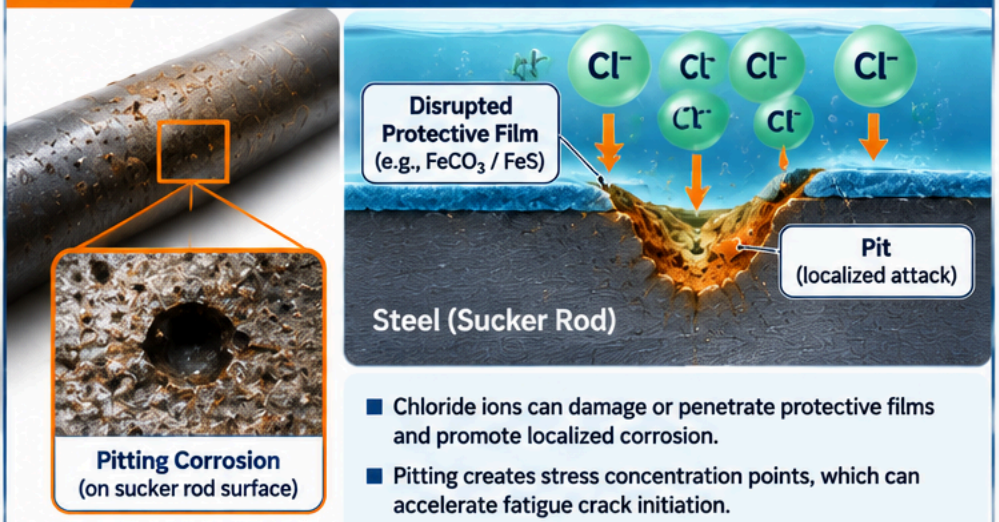
H_2S H_2S-Related Corrosion and Hydrogen Damage



Main Forms of Hydrogen Damage

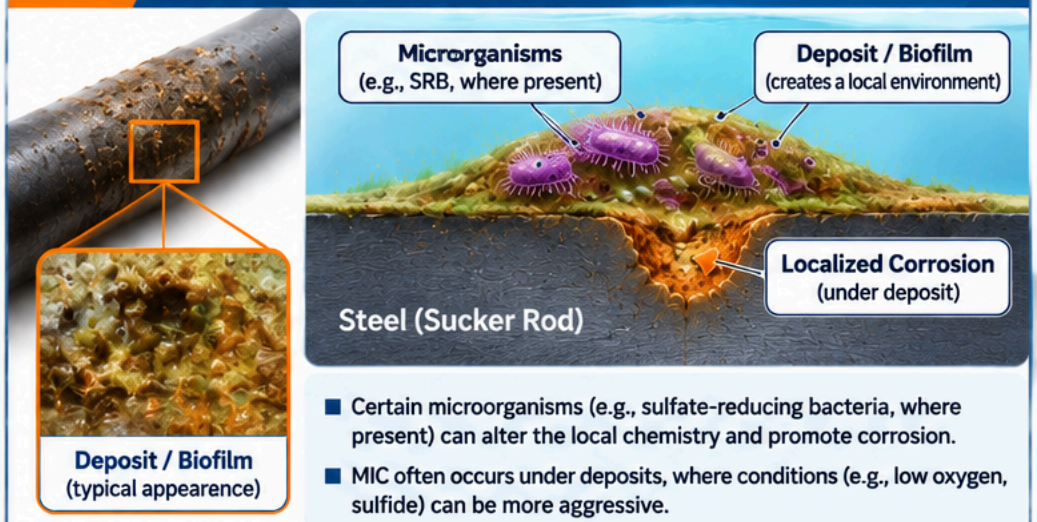
SSC	HIC	Hydrogen Embrittlement
Cracking under tensile stress in an H_2S environment.	Internal cracking due to hydrogen accumulation (typically in the steel).	Loss of ductility and fracture resistance caused by hydrogen.

Cl^- Chloride Effects (Localized Corrosion)



- Chloride ions can damage or penetrate protective films and promote localized corrosion.
- Pitting creates stress concentration points, which can accelerate fatigue crack initiation.

MIC Microbiologically Influenced Corrosion



- Certain microorganisms (e.g., sulfate-reducing bacteria, where present) can alter the local chemistry and promote corrosion.
- MIC often occurs under deposits, where conditions (e.g., low oxygen, sulfide) can be more aggressive.

Corrosion Forms and Fatigue Failure of Sucker Rods

Damage Features and Failure Evolution

Typical Corrosion Damage on Sucker Rods

Intact Surface



- **Intact Surface:** Sound surface with no corrosion damage.

General Corrosion



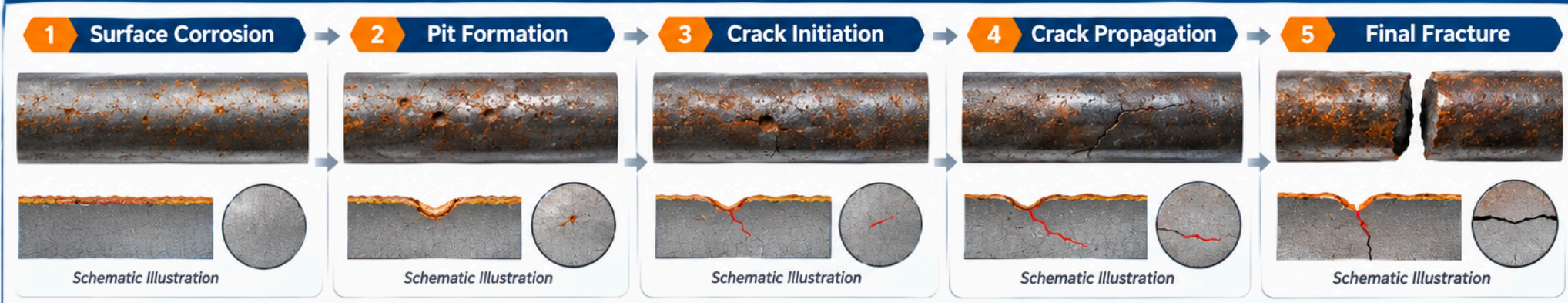
- **General Corrosion:** Relatively uniform metal loss over a large area, reducing the effective cross-sectional area.

Localized Pitting

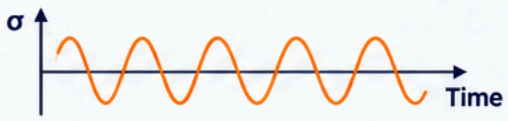


- **Localized Pitting:** Discrete and deeper corrosion cavities, causing local stress concentration and a higher risk of fatigue crack initiation.

From Corrosion Pits to Fatigue Fracture: A Five-Stage Process



Cyclic Axial Loading (on Rod)



- Corrosion pits act as stress concentration sites, where fatigue cracks can initiate.
- Under cyclic axial loading, the crack grows progressively, reducing the remaining load-bearing section, and ultimately leads to rod fracture.

Laboratory Results: Corrosion and Fatigue of Sucker Rod Steel

Controlled Tests under Specified Laboratory Conditions

Study 1: CO_2 Corrosion Behavior of Sucker Rod Steel

Laboratory Study



High-Pressure Corrosion Test Setup (CO_2 Environment)

Experimental Conditions

Temperature	60 – 120 °C
CO_2 Partial Pressure	0.1 – 0.3 MPa
Chloride Concentration	1 – 3 g/L
Test Medium	Aqueous solution with CO_2 (simulated produced water)

Key Result

Maximum reported corrosion rate:

0.9391 mm/year

at 90 °C



Corrosion Surface of Test Specimen (After Exposure, Laboratory Condition)

OCTAL SUCKER ROD

Study 2: Fatigue Life of 4330 Steel in Chloride Environment

Laboratory Study

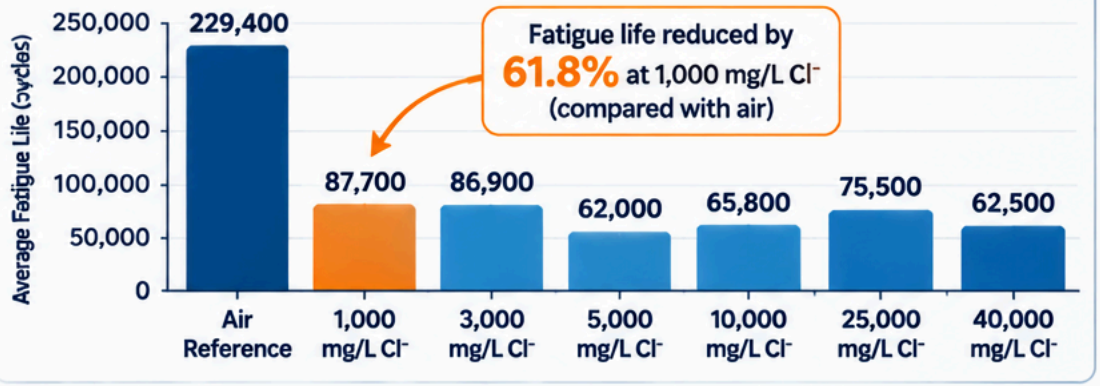


Axial Fatigue Test Setup (Sucker Rod Specimen)

Test Conditions

Maximum Stress (σ_{max})	750 MPa
Minimum Stress (σ_{min})	450 MPa
Stress Ratio (R)	0.6
Frequency	0.05 Hz
Repetitions	Three per condition

Average Fatigue Life of 4330 Steel under Different Cl^- Concentrations



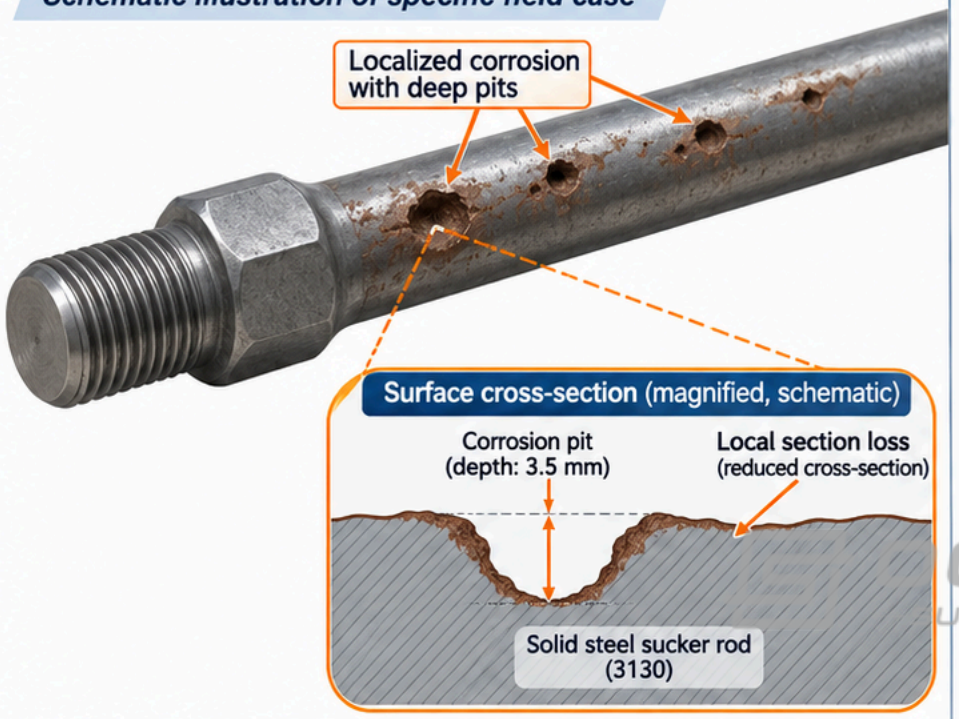
Note:

- Both studies were conducted under controlled laboratory conditions.
- Results show that the corrosive environment, especially chloride, can significantly reduce the fatigue life of sucker rod steel.

Field Failure Case and Material Factors in Sucker Rod Corrosion

Field Failure Case: 3130 Sucker Rod Corrosion

Schematic illustration of specific field case



Confirmed 3130 Field-Case Data

Material	3130 Alloy Steel
Approximate Service Period	1 Year
Average Corrosion Rate	1.6986 mm/year
Maximum Pitting Depth	3.5 mm
Corrosion Products	$FeCO_3$, Fe_7S_8, $CaCO_3$
Environment	High-Salinity, Sulfur-Containing Produced Water

Study-Specific Material Ranking

4330A > 25CrMoA > 3130

Note: This ranking applies only to the specific comparative study conditions.

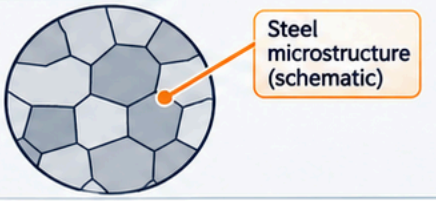
Material/Manufacturing Factors Affecting Corrosion

1 Heat Treatment



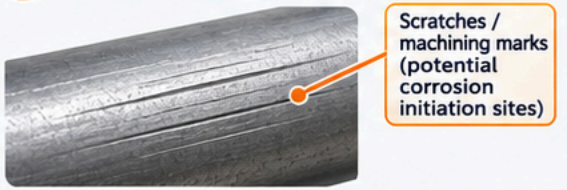
- Final properties depend on controlled heat treatment (e.g., heating, soaking and cooling) to obtain the desired strength and toughness.

2 Microstructure



- The steel microstructure (e.g., grain structure and phase distribution) affects corrosion behavior, such as corrosion rate and pitting susceptibility.

3 Surface Defects



- Surface defects, such as scratches or machining marks, can act as preferential corrosion initiation sites, facilitating localized corrosion (e.g., pitting).

Corrosion Control and Engineering Selection for Sucker Rods

Practical Corrosion-Control Modules

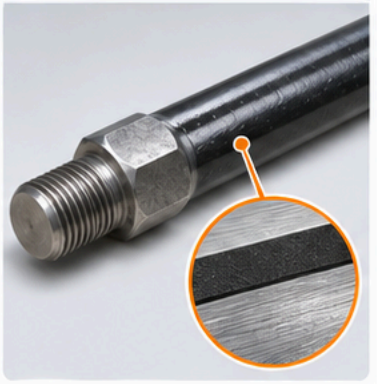
1 Corrosion Inhibitors



Function: Reduce corrosion by forming a protective film or reducing corrosive attack.

Limitation: Performance depends on well chemistry, application conditions and compatibility.

2 Protective Coatings



Function: Reduce direct contact between steel and corrosive fluids.

Limitation: Wear, damage or rod/tubing contact can reduce protection.

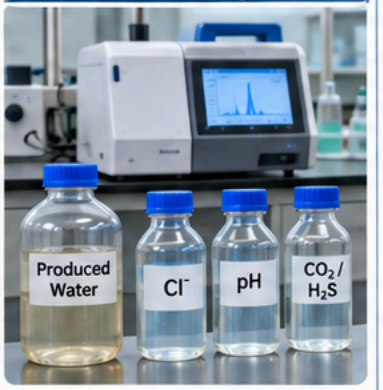
3 Material Selection



Function: Choose suitable material and properties for the actual corrosive environment.

Limitation: No single grade is universally best and selection depends on environment and mechanical loading.

4 Produced-Water Monitoring



Function: Track chloride, pH, CO_2/H_2S-related conditions and changing water chemistry.

Limitation: Periodic data still require correct interpretation and may vary over time.

5 Inspection and Maintenance



Function: Identify corrosion, pits and deterioration before major failure.

Limitation: Inspection findings must be linked to engineering judgment and follow-up action.

Selection and Qualification Workflow

Well Chemistry
chloride, pH, CO_2, H_2S, produced-water composition.

→

Mechanical Loading
tensile load, cyclic loading, fatigue risk.

→

Material Qualification
chemistry, mechanical properties, heat treatment, dimensional requirements.

→

Quality Records
dimensional records, traceability, heat/lot identification, inspection records.

→

Corrosion Control
inhibitors, coatings, monitoring, maintenance.

Note: *Sour-service requirements must be evaluated for the specific equipment and actual well conditions.*