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Webinar 2. Reciprocating Rod Lift
Rajan Chokshi & Bill Lane
Sep 23, 2014
Weatherford
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Webinar Series
1. Introduction to Artificial Lift Aug 27 '14
2. Reciprocating Rod Lift (RRL) Sep 23 '14
3. Gas-Lift Oct 21 '14
4. Progressing Cavity Pumping (PCP) Nov 19 '14
5. Electrical Submersible Pumping (ESP) Dec 16 '14
6. Hydraulic Lift: Jet Pump & Piston Pump Jan 13 '15
7. Plunger Lift and Capillary Deliquification Feb 10 '15
8. Production Optimization for Artificial Lift Mar 10 '15
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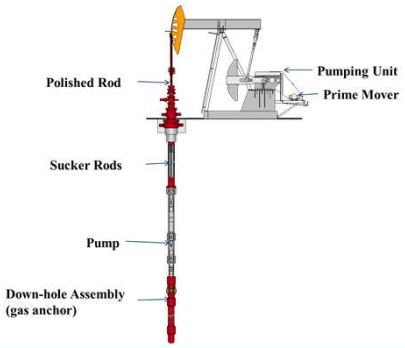
Presentation Outline

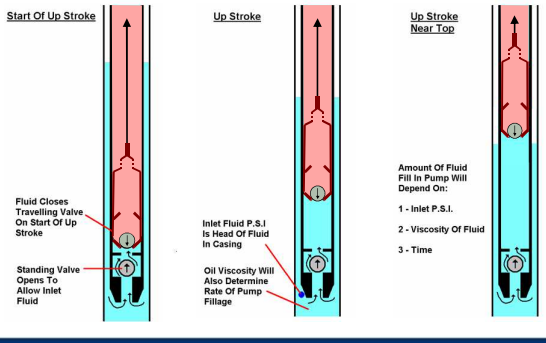
- What is rod lift?
- Why is rod lift so widely used?
- Main components
- Optimization
  - Dynamometer Cards
  - Optimization systems: hardware + software
- Special applications
  - Gassy wells
  - Sandy wells
  - Deviated wellbores
  - Heavy oil

Reciprocating Rod Lift System



The Entire Rod Lift Chain

Pumping Cycle (Ideal) - Upstroke



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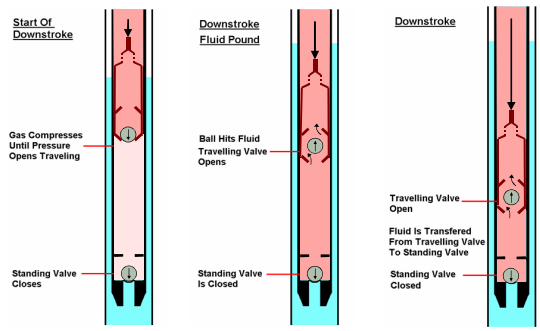
Pumping Cycle (Ideal) - Downstroke



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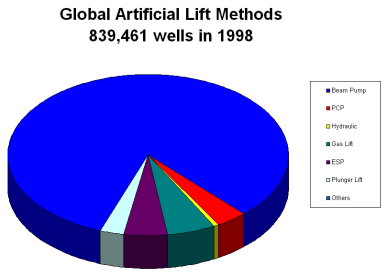
Rod Lift Installations Share



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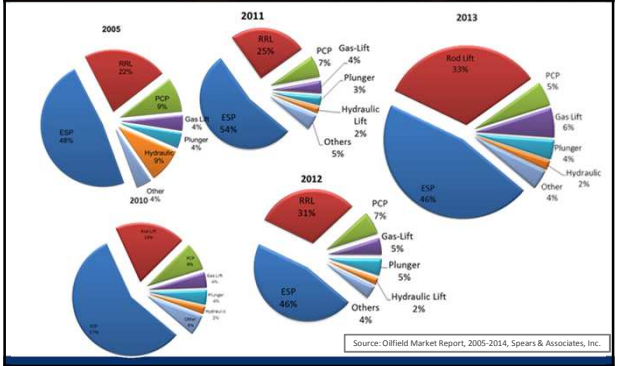
Rod Lift Market Share Growth



Source: Oilfield Market Report, 2005-2014, Spears & Associates, Inc.

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Why Rod Lift?

"Sucker rod (beam) pumping should be the standard consideration if operations are on land… Experience has shown that such choices normally result in optimum production and minimum costs... The other methods should be selected only where there are definite installation and operations advantages."

- *SPE Distinguished Author Series,* Recommendations and Comparisons for Selecting Artificial-Lift Methods. *Authors Joe Clegg, S. Mike Bucaram, and N.W. Hein, Jr.*

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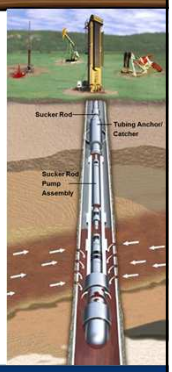
Why Rod Lift?

- Flexibility
  - Depths to 16,000 feet (4,878m)
  - Most fluid types
  - Not sensitive to temperatures
  - Low volumes to 6,000 BPD
  - Adjust production through stroke length and speed



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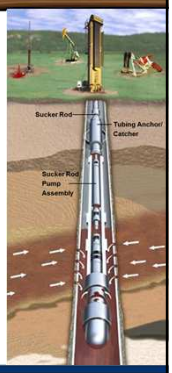
Why Rod Lift?

- Flexibility
- Positive displacement = strong drawdown



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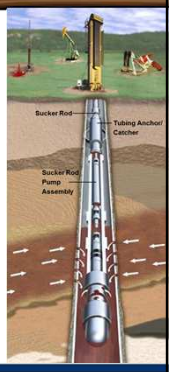
Why Rod Lift?

- Flexibility
- Positive displacement = strong drawdown
- Good economic value
  - High system efficiency, low OPEX
  - Economical to service and repair
  - High salvage value



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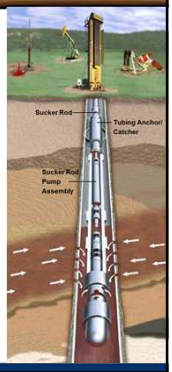
Why Rod Lift?

- Flexibility
- Positive displacement/ strong drawdown
- Good economic value
- Special configurations for tough applications
  - Gassy fluids
  - Sandy fluids
  - Heavy/viscous oil



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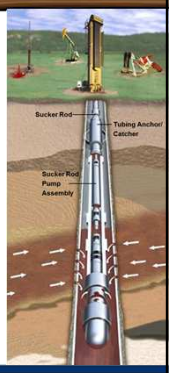
Why Rod Lift?

- Flexibility
- Positive displacement/ strong drawdown
- Good economic value
- Special configurations for tough applications
- Optimization controls



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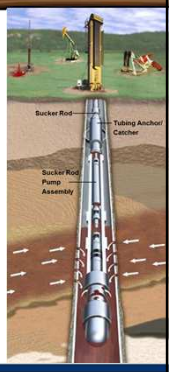
Why Rod Lift?

- Flexibility
- Positive displacement/ strong drawdown
- Good economic value
- Special configurations for tough applications
- Optimization controls
- Familiarity



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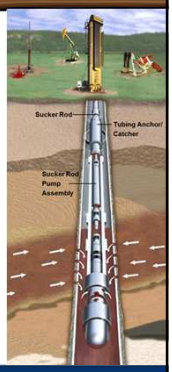
Rod Lift Limitations

- Potential for tubing and rod wear
- Land only
- Rod string load capacity
  - Pump volume decreases as depth increases.
- Performance affected by free gas
- Environmental and aesthetic concerns



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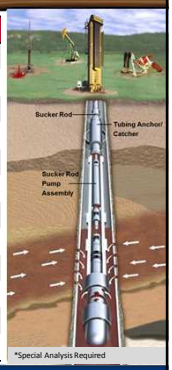
Application Considerations

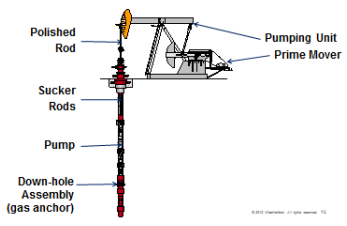
	Typical Range	Maximum*
Depth (TVD)	100 to 11,000 ft	16,000 ft
Volume	5 to 1,500 BPD	6,000 BPD
Temperature	100 to 350°F	>550°F
Well Deviation	0 to 20°	<15°/100 ft
Corrosion	Good (with Upgraded Materials)	
Gas Handling	Fair to Good	
Solids Handling	Fair to Good	
Fluid Gravity	>8° API	
Servicing	Workover or Pulling Rig	
Prime Mover	Gas or Electric	
Offshore	Limited	
Total Efficiency	45 to 60%	



*Special Analysis Required

Typical Rod Lift Applications

- Land applications
- Medium and light oil from any depth
- Lifting from low pressure reservoirs
- Hot well fluids (steam flood, CSS, SAGD)
- Wells with large changes in production volumes
- Locations with rod lift infrastructure and experience
- Locations with limited skill service resources

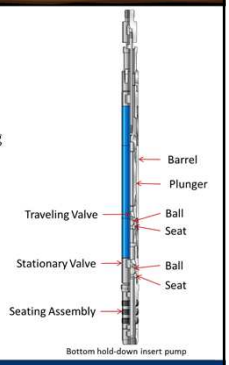


Reciprocating Rod Lift

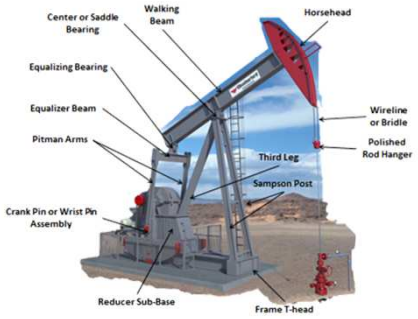
MAIN COMPONENTS

Rod Pump Components

- **Barrel** – pressure containing cylinder in which the plunger reciprocates
- **Plunger** – piston that provides the moving seal and carries the traveling valve
- **Traveling valve** – holds well pressure during upstroke, opens to allow the plunger to fall during downstroke
- **Stationary valve** – holds well pressure during downstroke, opens to allow the barrel to fill during upstroke
- **Seating assembly** – latches into a seating nipple to hold an *insert pump* at a specific tubing location



API Beam Pumping Unit Overview



Pumping Units

Conventional Unit

Front Mounted Crank Unit
(Mark II Unitorque)

Phased Crank Unit

Beam Balanced Unit

Air Balance Unit

Pumping Units

Ultra Long Stroke

Hydraulic

Low-Profile

Portable Hydraulic

Types of Rod Strings

- Jointed Sucker Rods
  - Conventional API Sucker Rod
  - Non-API sucker rods for special applications
  - Hollow sucker rods
  - Fiberglass sucker rods
  - High strength connections

Continuous Rod

- Fewer connections
- Reduced rod-tubing wear
- Lower flow resistance
- Lighter weight
- Faster service operations

API Documents on Rod Pumping

- **TR 11L**: Technical Report on Design Calculations for Sucker Rod Pumping Systems (Conventional Units)
- **RP 11AR**: Recommended Practice for Care and Use of Subsurface Pumps
- **Spec 11AX**: Specification for Subsurface Sucker Rod Pumps and Fittings
- **Spec 11B**: Specification for Sucker Rods (steel and fiberglass, couplings , polished rods, stuffing boxes, sinker bars, polished rod clamps)
- **RP 11BR**: Recommended Practice for Care and Handling of Sucker Rods
- **Spec 11E**: Specification for Pumping Units
- **RP 11G**: Recommended Practice for Installation and Lubrication of Pumping Units
- **TR 11L6**: Technical Report on Electric Motor Prime Mover for Beam Pumping Unit Service
- **Bull 11L2**: Bulletin, Catalog of Analog computer Dynamometer Cards

Reciprocating Rod Lift

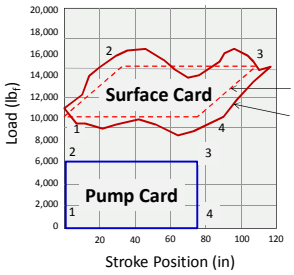
OPTIMIZATION

Optimization of Rod Pumping

- Dynamometer cards
- Wellsite automation
  - Rod pump controller
  - Variable frequency drive (VFD)
  - Sensors
- Role of software or desktop Intelligence
  - Static application in design and analysis
  - Real-time application for monitoring, surveillance and optimization

Dynamometer "Cards"

Graphs of forces at any point in the pumping cycle



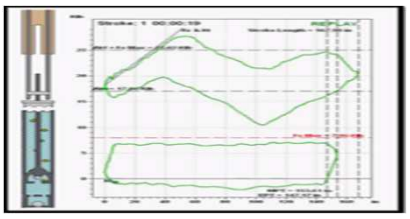
Ideal = f{static loads)

Actual = f(dynamic loads)

Reveals system performance and problems

Rod Pumping Card Visualizations[1]

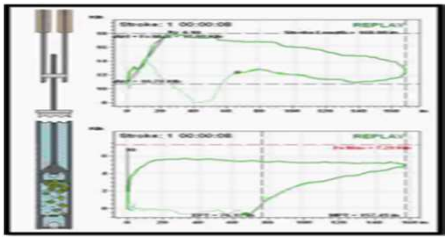
Full Pump



[1] Courtesy Echometer

Rod Pumping Card Visualizations[1]

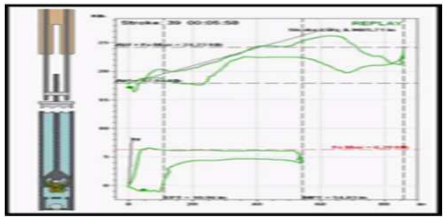
Gas Interference



[1] Courtesy Echometer

Rod Pumping Card Visualizations[1]

Pump Off



[1] Courtesy Echometer

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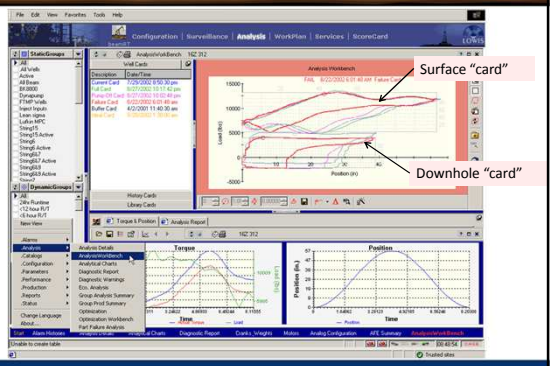
Monitor Screenshot - Dynamometer



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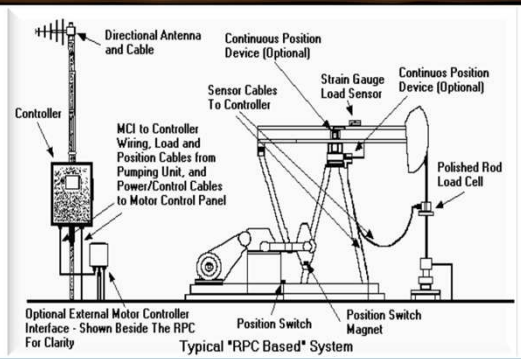
Optimization Components – Wellsite Intelligence



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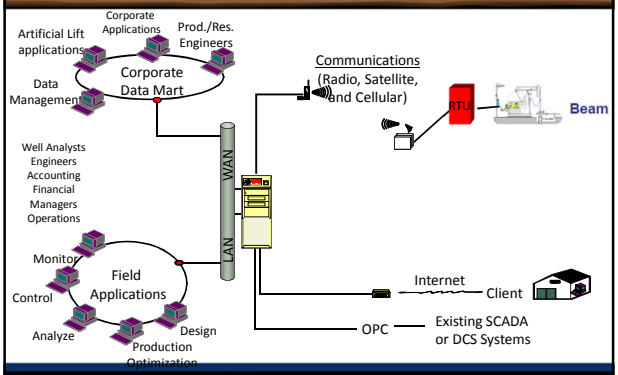
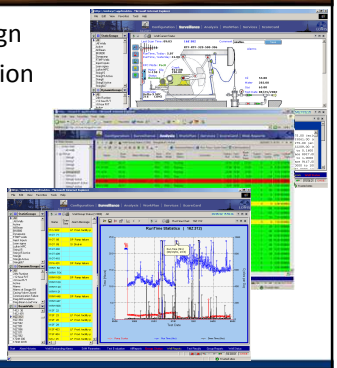
Field-wide Optimization – Wellsite to Desktop



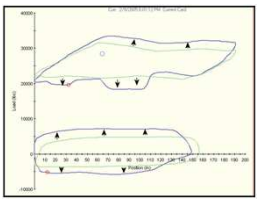
Role of Software – Desktop Intelligence

- Rod lift system design
- Real-time optimization
  - Monitoring
  - Management by exception
  - Lift analysis
  - Desktop control
- Asset optimization



Rod Pump Controllers

- Controls the pumping cycle
- Programmable logic
- Remote communication



"Sticking" *without* Rod Load Control

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"Sticking" *with* Rod Load Control

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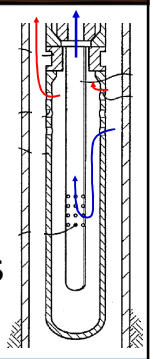
Reciprocating Rod Lift

ROD PUMPING GASSY WELLS



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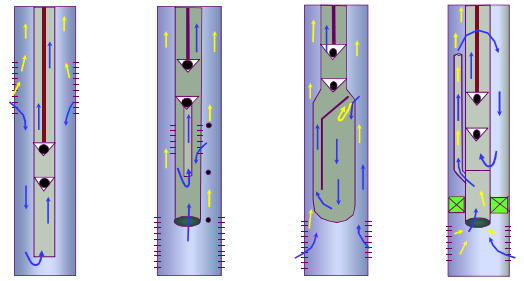
Gas Issues

When fluid pressure < oil bubble point pressure:

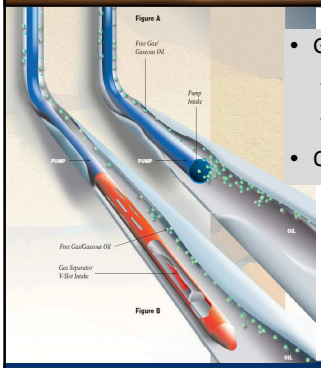
- **Gas interference** – pump stroke must compresses gas before displacing fluids
  - poor pump efficiency
  - reduced production
- **Gas pound** – on pump downstroke, plunger impacts gas-liquid interface in barrel creating system shock
- **Gas lock** – pump cycle compresses and decompresses gas without discharging fluid

Gas Separation Options

Natural Gas Anchor | Poor-Boy Gas Anchor | Modified Poor-Boy | Packer-Type Anchor



Gravity Orienting Horizontal Gas Separator

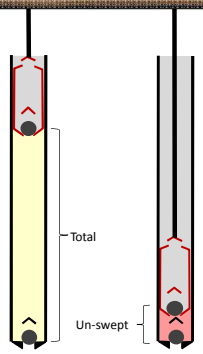


- Gravity oriented
  - Bottom intake
  - Top gas vent
- Quiet volume in separator

Compression Ratio

$$Compression\ ratio = \frac{total\ volume}{unswept\ volume}$$

Compression ratio = indicator of the pump's ability to *compress gas* and *build fluid pressure* sufficiently to open the traveling valve on the downstroke.



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Pumps for Gassy Wells

- Use longer stroke smaller diameter pumps
- RW or RX Pumps (no extensions)
- RH Pump with a zero extension on bottom
- Consider special gas handling pumps
- Reduce unswept volume in pump
  - Internal hex plugs
  - High compression cages
  - Space pump plunger < ½" off bottom

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Reciprocating Rod Lift

ROD PUMPING SANDY WELLS

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Sand Cut Plunger

As the plunger OD wears:

- Fluid slippage increases
- Pump efficiency decreases
- Solids between plunger and barrel increase
- Wear accelerates

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Producing the Sand to Surface

- Chrome barrels & spray metal plungers
- Top seating assembly
- Medium/light fluids
  - Keep fluid moving to prevent sand fallback/bridging
    - Smaller pumps & tubing to increase flow velocities
    - Faster pump speeds ≈ 12 to 14 strokes per minute
- Heavy oil with ≤ 10% of sand
  - Sand tends to stay in suspension and flows easily with the produced fluids

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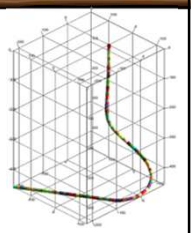

Reciprocating Rod Lift

ROD PUMPING DEVIATED WELLS

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Challenges of Deviation

- Lift equipment conveyance (run & retrieve)
- Landed position and orientation
- Rod-tubing contact and wear
- Gas separation challenges
  - Turbulent slug flow
  - Limited vertical separation length

Designing for Deviated Wells

- Land pumps in straight sections (avoid bending)
- Long slow stokes
- Rod strings
  - Continuous rods or sucker rods with rod guides
  - Spiral rod guide and stabilizer bars above pump
  - Sinker bars above the well kickoff point

Designing for Deviated Wells

Rod Pumps

- Spray-metal valve rod
- Stellite-lined rod guide
- Smallest plunger sizes
- Open plunger fit and short plunger length
- Single travelling valve assembly
  - Premium ball & seat
  - Stellite-lined or insert guided cage

Reciprocating Rod Lift

ROD PUMPING HEAVY OIL

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Cold Pumping of Heavy Oil

- Large diameter continuous rod string
  - Increased flow annulus in the tubing
  - Eliminate coupling piston effect
  - Sized to achieve desired weight to help rod fall
- Large diameter insert pumps and oversized tubing pumps
  - Generous clearances
  - Full flow high compression standing valve cage
- Slow pumping speeds = 2 – 3 SPM
- Conventional pumping units (slow downstroke)

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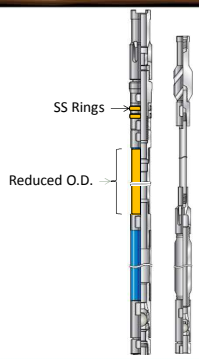
Thermal Production

Modified API rod pump

- Stainless steel friction rings in seating assembly
- Full flow high compression standing valve cage
  - Minimizes steam flashing
  - Helps prevent scale deposition
- Nitrided plunger to help prevent scale buildup
- For CSS, reduced OD allows bypass when pump is unseated from PSN



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