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Special Edition

New Sucker-Rod Pumping System Design Calculator Provides Free, Convenient Analysis On-Line

Unico has developed a convenient design tool for analyzing sucker-rod pumping (SRP) system performance. The [SRP Calculator™](#) is available on-line free of charge and provides a quick, easy analysis for many systems.



Sucker-rod pumping systems involve complex dynamic relationships between production rates and stresses at various points within the unit. As a result, numerous calculations are required to optimize the effectiveness of these types of systems. The popularity of rod-pump systems has led to a variety of methods for analyzing their performance.

In 1954, a group of users and manufacturers undertook a study of sucker-rod pumping systems. Their results eventually led to the publication of *Recommended Practice for Design Calculations for Sucker Rod Pumping Systems* (RP 11L) in 1988 by the American Petroleum Institute (API). This publication set the standard for analyzing rod pumps until recently, when personal computer calculation programs, such as Theta Enterprises' *Rodstar* and others, became available.

These PC-based analysis programs generally include an extensive database of pumping units and rod-string components. They are capable

of analysis that correlates to actual field measurements with amazing precision. In many situations, however, this precision is unnecessary, and often it greatly exceeds what can be measured at the well site.

Unico's SRP Calculator™ satisfies the need for simple well analysis. It can be used to quickly analyze well performance to determine if a more detailed analysis is necessary.

Input and output variables generally follow those provided for the API publication and commercial analysis programs. The API method suffers from the fact that it does not account for performance differences between Class I (conventional) and Class III (Mark II) geometries. While rod loads may be similar between the two types of pumping units, there is a significant reduction in Class III gearbox torque relative to the Class I geometry.

Several parameters were added to the API method that improve the agreement between the SRP Calculator™ and commercially available analysis programs. A comparison of the features of the various rod-pump analysis tools is given below.

Analysis Tool Feature Comparison

Parameter	API Method RP 11L	Unico SRP Calculator™	Theta Rodstar
Pumping Speed	Constant speed	Constant speed	Allows variation
Fluid Level	Zero	Selectable	Selectable
Water Cut	None	Selectable	Selectable
Water Specific Gravity	None	Selectable	Selectable
Oil API Specific Gravity	Fixed	Selectable	Selectable
Fluid Inertia Effects	None	None	Selectable
Tubing Pressure	Zero	Selectable	Selectable
Casing Pressure	Zero	Selectable	Selectable
Pump Depth	Selectable	Selectable	Selectable
Plunger Diameter	Selectable	Selectable	Selectable
Pump Efficiency	100%	Selectable	Selectable
Pump Fill	100%	Selectable	Selectable
Tubing Size	Selectable	Selectable	Selectable
Tubing Anchor	Fixed	Selectable	Selectable
Stuffing Box Friction	Zero	Selectable	Selectable
Pump Friction	Zero	Selectable	Selectable
Pumping Unit Type	Class I	Class I or III	Class I or III
Rotation Direction	Fixed	Fixed	CW or CCW
Pumping Unit Stroke	Selectable	Selectable	Unit database
Unbalanced Force	Zero	Selectable	Unit database
Articulating Inertia	Zero	Zero	Unit database
Balance Moment	Ideal	Selectable	Selectable
Prime Mover Type	None	AC Motor	Selectable
Rod String Sections	Four	Three	Eight
Rod String Material	Steel	Steel	Steel or Fiberglass
Rod String Type	Continuous	Coupled or Corod	Rod database
Sinker Bars	None	None	Selectable

Buoyant Rod Load	Calculated	Calculated	Calculated
Fluid Column Load	Calculated	Calculated	Calculated
Maximum Rod Load	Calculated	Calculated	Calculated
Minimum Rod Load	Calculated	Calculated	Calculated
Required Balance	Calculated	Calculated	Calculated
Max. Gearbox Torque	Calculated	Calculated	Calculated
Polished Rod Power	Calculated	Calculated	Calculated
Fluid Production	Calculated	Calculated	Calculated
Dynamometer Card	None	None	Displayed
Gearbox Torque Plot	None	None	Displayed

The results of the SRP Calculator™, the Rodstar program, and the API RP 11L method are compared below for both Class I and Class III well examples. The relative error of most of the SRP Calculator™ calculations, which use some simplifying assumptions, is 10% or less, with many being within 5%. The only significant difference between the SRP Calculator™ and the Rodstar program occurs with the minimum motor size, for which the Unico program was able to select a smaller motor on the Class III pump. A number of results fall between those estimated by the Rodstar program and the API method. Additional care should be taken with values that fall to one side or another of both other methods. Generally, the SRP Calculator™ provides somewhat better results for Class I than Class III pumping units.

Analysis Comparison (Class I Example)

Calculation	Unico SRP Calculator	Theta Rodstar	Unico/ Rodstar	API	Unico/ API
Fluid Production Rate (bpd)	323	331	-2%	331	-2%
Oil Production Rate (bpd)	65	66	-2%	66	-2%
Polished Rod Power (hp)	26.1	27.7	-6%	21.4	+22%
Minimum Motor Size (hp)	60.0	60.0	0%	—	—
Required Balance (in-lb)	1,878,714	1,920,570	-2%	—	—
Existing Balance Effect (lb)	23,557	23,407	+1%	—	—
Required Balance Effect (lb)	22,129	22,418	-1%	21,706	+2%
Max. Gearbox Torque (in-lb)	977,751	1,007,000	-3%	753,406	+30%
Buoyant Rod Load (lb)	15,696	15,942	-2%	15,636	0%
Maximum Rod Load (lb)	30,716	31,266	-2%	28,007	+10%
Minimum Rod Load (lb)	10,541	10,446	+1%	10,389	+1%
Tubing Stretch (in)	1.07	1.10	-3%	1.10	-3%
Pump Stroke (in)	126.46	129.00	-2%	128.30	-1%

Analysis Comparison (Class III Example)

Calculation	Unico SRP Calculator	Theta Rodstar	Unico/ Rodstar	API	Unico/ API
Fluid Production Rate (bpd)	318	331	-4%	331	-4%
Oil Production Rate (bpd)	64	66	-4%	66	-4%
Polished Rod Power (hp)	25.6	27.9	-8%	21.4	+20%
Minimum Motor Size (hp)	50.0	60.0	-20%	—	—
Required Balance (in-lb)	2,087,616	2,175,160	-4%	—	—

Existing Balance Effect (lb)	21,958	21,197	+4%	—	—
Required Balance Effect (lb)	22,920	23,525	-3%	21,706	+6%
Max. Gearbox Torque (in-lb)	763,923	801,000	-5%	753,406	+1%
Buoyant Rod Load (lb)	15,695	15,941	-2%	15,636	0%
Maximum Rod Load (lb)	30,299	30,713	-1%	28,007	+8%
Minimum Rod Load (lb)	10,209	9,336	+9%	10,389	-2%
Tubing Stretch (in)	1.07	1.10	-3%	1.10	-3%
Pump Stroke (in)	124.53	129.00	-3%	128.30	-3%

Give the SRP Calculator™ a try at www.unicous.com/oilgas/srpcalc.php and let us know what you think. We would appreciate any [feedback](#) that can make this tool more useful for you. Check future issues of *Solutions* or our Web site for enhancements to the SRP Calculator™ as well as other new artificial-lift design tools. You may also want to inquire about our artificial-lift drive systems that incorporate complete dynamic analysis, including dynamometer cards and gearbox torque plots.

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What's Coming Up

In Future Issues...

Look for the following articles in upcoming issues of *Oil & Gas Automation Solutions*:

- Taking advantage of utility rate structures to reduce artificial-lift energy costs
- Unico drives plot and control pump fill using inferred downhole dynamometer graphs
- Power loss components in a typical rod pumping system
- A novel way of conceptualizing the effectiveness of artificial lifts
- Reducing power consumption and improving power factor of beam pumps
- Detecting PCP stick/slip oscillations that fatigue rod-string couplings and reduce energy efficiency
- Embedded well control is engineered for compatibility with Rotaflex® units

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Since 1967

SRP Calculator™

Sucker-Rod Pumping System Design Tool

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Well

Pump Speed (spm)	<input type="text" value="6.5"/>	Fluid Production Rate (bpd)	318
Fluid Depth (ft)	<input type="text" value="7000"/>	Oil Production Rate (bpd)	64
Tubing Pressure (psi)	<input type="text" value="75"/>	Polished Rod Power (hp)	25.6
Casing Pressure (psi)	<input type="text" value="75"/>	Minimum Motor Size (hp)	50.0

Pumping Unit

Class	<input type="text" value="Class III"/>	Max. Gearbox Torque (M in-lb)	764
Stroke Length (in)	<input type="text" value="168.00"/>	Existing CB Effect (lb)	21958
Structured Unbalance (lb)	<input type="text" value="-5380"/>	Required CB Effect (lb)	22920
CB Moment (M in-lb)	<input type="text" value="2000.00"/>	Required CB Moment (M in-lb)	2087.62

Fluid

Water Cut (%)	<input type="text" value="80.0"/>	Oil Specific Gravity	0.887
Water Specific Gravity	<input type="text" value="1.050"/>	Fluid Specific Gravity	1.017
Oil API Specific Gravity	<input type="text" value="28.0"/>	Fluid Column Load (lb)	9865

Rod String

Type	<input type="text" value="Coupled"/>	Buoyant Rod Load (lb)	15695
Upper Rod Diameter (in)	<input type="text" value="1.000"/>	Maximum Rod Load (lb)	30299
Lower Rod Diameter (in)	<input type="text" value="0.750"/>	Minimum Rod Load (lb)	10209
Upper Rod Fraction (%)	<input type="text" value="32.8"/>		
Lower Rod Fraction (%)	<input type="text" value="33.9"/>		
Stuffing Box Friction (lb)	<input type="text" value="100"/>		

Tubing

Tubing Diameter (in)	<input type="text" value="2.875"/>	Tube Stretch (in)	1.07
Tubing Anchor Depth (ft)	<input type="text" value="7500"/>		

Pump

Plunger Diameter (in)	<input type="text" value="2.000"/>	Pump Stroke (in)	124.53
Pump Depth (ft)	<input type="text" value="8000"/>		
Pump Efficiency (%)	<input type="text" value="85.0"/>		
Pump Fill Ratio (%)	<input type="text" value="100.0"/>		
Pump Friction (lb)	<input type="text" value="200"/>		