FACTORS AFFECTING MINIMUM POLISHED ROD LOAD AND MAXIMUM PUMPING SPEED IN A (WIRELINE TYPE) BEAM, AND SUCKER ROD PUMPING SYSTEM

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ABSTRACT

Since maximum pumping speed in a wireline type beam and sucker rod pumping system is closely related to maximum down stroke acceleration, and the polished rod motion pattern, this paper looks at a number of stations in the pumping spectrum where anomalies occur and generalizations may be suspicious or incorrect.

INTRODUCTION

Since both the (1) torsional load and (2) maximum pumping speed, in a beam and sucker rod system, are dependent upon the magnitude of the minimum polished rod load, it is important to both the designer and operator to understand some of the more significant factors that control the value of this important force.

The basic beam pumping cycle consists of two principal parts (1) The upstroke, when the pumping unit lifts the weight of rods and fluid, and (2) The downstroke, wherein gravity pulls the rods downward to the bottom of their travel., Thus, the pumping unit furnishes the energy to lift the rods (and fluid), but the force to return the rods is provided by gravity. Since the wirelines (or bridle) on the horsehead cannot operate satisfactorily in compression, the pumping unit does not drive the rods downward, but must simply rely on the force gravity to pull them through their downward travel. Consequently, maximum pumping speed is partially controlled by the pumping unit, and partially by the force of gravity.

Theoretically, a pumping unit may be driven at very high pumping speeds but unless the unit is capable of pushing the rods down, as well as lifting them up - nothing would be gained by this excessive speed. Since the pumping unit cannot force the rods down, because of the inability of the rods and wirelines to function in compression, maximum pumping speed is reached when the minimum polished rod load becomes zero.

In normal field practice, the minimum polished rod load becomes zero when the pumping unit is operated so fast that , during the downstroke, the rod carrier bar tends to run away from the falling rods, thus defining maximum (practical) pumping speed.

Several important factors determine the magnitude of the minimum polished rod load, and consequently maximum, practical, pumping speed. Three of the more important are:

First, and normally the most important factor, is the retarding force in the well opposing rod fall. This can be caused by many thing; a tight stuffing box, highly viscous fluid, normal buoyancy, excessive bottomhole pump friction, the rod coupling piston effect, a crooked hole causing an abnormally high rod-tubing-friction, or drag, etc., or some combination thereof.

Second, another important factor in determining minimum rod load and consequently maximum pumping speed is the maximum downward acceleration of the pumping unit's rod carrier. All else equal, stroke length, pumping speed, downhole hardware, retarding forces in the well, friction, etc., the off-top (maximum, downward) acceleration of the rod carrier is a function of the unit's geometry.

Class I lever systems like the conventional unit, start downward, off-top with a maximum acceleration lower than than of simple harmonic motion acceleration. Class III lever systems like the air balance and the Mark II, start downward with a (maximum) off-top acceleration higher than that of simple harmonic motion acceleration.

The magnitude of the off-top acceleration for a particular beam type pumping unit geometry is largely determined by the pitman-to-crank ratio. The lower the pitman-to-crank ratio on a conventional unit (i.e. the Class I lever system) the lower the maximum, off-top acceleration becomes. Just the opposite obtains on a Class III lever system like the air balance and Mark II. The higher the pitman-to-crank ratio, the lower the off-top acceleration.

If the pitman-to-crank ratio were infinitely large, both the Class I and Class III lever systems would accelerate the rod carrier downward, off-top, with the same (simple harmonic) acceleration. Since the pitman-to-crank ratio for both lever systems is finite, all else equal, the Class I lever system will always start downward, off-top, with lower acceleration.

On the other hand, the conventional, Class I system will accelerate the maximum, off-bottom load upward with acceleration greater than that of simple harmonic motion - while the Class III lever system will accelerate the maximum load of rods and fluid upward, off-bottom, with a lesser acceleration, which often reduces rod and structural load.

Third. The final important factor determining minimum polished rod load and maximum pumping speed is the pumping mode. This is a largely unrecognized and unappreciated factor in maximum pumping speed consideration.

Pumping mode is simply the particular combination of rod size and taper, pumping speed, stroke length, plunger diameter and unit geometry. In most cases, a lower off-top acceleration will permit a higher maximum pumping speed - but not in all cases. There are some pumping modes where a higher off-top acceleration actually produces a higher minimum load, and potentially at least, a greater maximum pumping speed.

Of these three dominant factors controlling minimum polished rod load and maximum pumping speed, the industry in general has recognized the influence of the MAGNITUDE OF OFF-TOP ACCELERATION; only casually considered the most important factor, RETARDING FORCES in the well opposing rod fall; and generally overlooked the influence of the PUMPING MODE.

The chief burden of this discussion is to illuminate the existence and importance of the PUMPING MODE as a factor in maximum pumping speed and the resulting maximum (possible) production. Examination of several of the following examples and comparisons will serve to illustrate the importance of considering the pumping mode, as well as off-top acceleration and well retarding forces, in determining maximum pumping speed.

The complex harmonic nature of an elastic rod string makes prediction of the minimum polished rod load, and consequently maximum pumping speeds using elementary mathematical equations, and assuming an inelastic rod mass, highly suspicious, if not often misleading and incorrect.

Although a few early students of beam pumping considered the reality of an elastic rod string, most manufacturers and operators, mainly for convenience, considered the sucker rod string as a simple, inelastic, concentrated mass. Consequently, for many years, minimum polished rod load and maximum pumping speed predictions were derived by assuming an inelastic rod string, and it was not until the mid 50's when the Sucker Rod Pumping Research Institute (SRI) began considering rod string elasticity, that a more accurate and precise predictive technique was developed.

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SOME ANOMALIES

Applications I, II, and III illustrate the fact that in some common, conventional unit pumping applications, a higher, off-top rod acceleration (downward), may not, as generally supposed, limit maximum pumping speed. These three studies show several of the many cases where the pumping mode dominates, and is more important than the influence of a higher off-top acceleration.

The following applications illustrate the possible relationship between contrasting pumping modes lifting a given amount of fluid from a certain depth.

The following, Application I, emphasizes the effect of maximum off-top polished rod acceleration, and resulting minimum polished rod load when varying only the pumping speed, stroke length, and type of load-elastic, or concentrated mass. Three different applications are shown in applications I, II, and III and several parameters are computed:

(1) Minimum polished rod load using the standard wave equation mathematics as given in API Bulletin 11L3 (Sucker Rod Pumping System Design Book);
(2) The maximum off-top (downward) acceleration of the rod carrier bar;
(3) The magnitude of the minimum polished rod load assuming an equivalent inelastic string (i.e, concentrated mass, such as an equivalent weight lead ball), instead of the regular elastic rod string predictive calculations.
(4) The difference between the two minimum polished rod load calculations, one assuming an elastic rod string and the second assuming a (traditional) concentrated, inelastic rod mass.
(5) All pumping modes produce a constant fluid volume.

APPLICATION I
(API-11L3 - Sucker Rod Pumping System Design Book - Page 299)
Conventional unit lifting 300 B/D from 5500 ft. with 1.5 in. plunger and API 66 rod string.

Pumping Mode	(1) Constant Volume Pumping -- Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-top Downward Acceleration of Carrier Bar (Ft/Sec/Sec)	(3) Minimum Polished Rod Load (Elastic Rods) lbs.	(4) Minimum Polished Rod Load (Inelastic Rods) lbs.	Difference Between (3) & (4) lbs.
1	22x42" SPM	7.74	4626	5953	1327
2	22x48" SPM	7.32	4517	6055	1538
3	20.2x54" SPM	6.84	4357	1671	1814
4	18.1x64" SPM	6.51	4203	622	2049
5	16.4x74" SPM	6.09	4028	6355	2327
6	14.8x86" SPM	5.77	3951	6434	2483

Observing pumping mode 6 (Application I), a typical conventional unit driven 14.8 - 86 inch SPM with a 1.5 inch plunger, results in a minimum polished rod load of 3951 lbs.; a maximum downward, off-top acceleration of 5.77 ft/sec/sec; and a minimum load of 6434 lbs. When the same rod mass is considered inelastic, i.e., a lead ball of the same weight, the difference between the minimum polished rod load of the elastic rod string and the inelastic (concentrated mass) is 2483 lbs.

Next, considering pumping mode 5, with nothing changed except the pumping speed and stroke length, (i.e. maintaining a constant volume) it is seen that a typical conventional unit, pumping 16.4 - 74 inch SPM with a minimum polished rod load of 4028 lbs.; a maximum off-top acceleration of carrier bar and rod string of 6.09 ft/sec/sec, and a minimum polished rod load of 6355 lbs. when the rod string is considered an inelastic mass. The difference between the minimum polished rod load of the elastic rod string and the inelastic (concentrated mass) rod string is 2327 lbs. Comparing pumping mode 6 with pumping mode 5, clearly illustrates a significant and important anomaly in sucker rod pumping.

Intuitively, it would seem that the faster the carrier bar rod string is accelerated downward, off-top, the lower the minimum load would become. Just the opposite occurs here. As the carrier bar accelerates more rapidly off-top, i.e. 6.09 ft/sec/sec vs. 5.77 ft/sec/sec, the minimum load increases from 3951 lbs. up to 4028 lbs., just opposite of what would be expected. On the other hand, considering the rod string as an inelastic concentrated mass, the minimum load drops from 6434 lbs. down to 6355 lbs., exactly as expected, based upon simplified, predictive methods and traditional thinking.

Looking next at the comparison of pumping mode 4, 18.1 - 64 inch SPM, the resulting minimum load is 4203 lbs., the maximum downward acceleration of the rod string is 6.51 ft/sec/sec and the minimum load of the equivalent concentrated mass rod string is 6252 lbs. Here again, it is seen when comparing pumping mode 4, with pumping mode 5, that as the rods are dropped faster, and with greater maximum acceleration, the minimum load of the elastic rod string increases rather than decreases; but the concentrated mass, equivalent (anomaly) also occurs, namely that, although the carrier bar is being accelerated, downward faster, the minimum load again is slightly decreased.

Comparing pumping mode 3 with pumping mode 4, the conventional unit is driven 20.2 - 54 inch SPM and the resulting minimum polished rod load is 4357 lbs., while the maximum downward acceleration of the carrier bar is 6.84 and the minimum load of the equivalent concentrated mass rod string is 6171 lbs.

Once more, as the rod carrier moves downward faster, the minimum load of the elastic rod string is elevated - just opposite of intuition, while the concentrated mass rod load is decreased as would be traditionally supposed.

Contrasting pumping mode 2 with pumping mode 3, the same mechanical anomaly obtains; and comparing pumping mode 1 with pumping mode 2, results in the same irregular behavior.

In each of these six pumping modes taken from the API 11L3 Sucker Rod Pumping System Design book, the faster the rods are dropped, the <u>higher</u> the minimum load of the elastic rod string. On the other hand, the faster the rods are dropped, the <u>lower</u> the minimum load of the <u>inelastic</u> rod string. Both elastic and inelastic sets of parameters assume a constant volume produced with a single plunger size.

APPLICATION II

(API-11L3 - Sucker Rod Pumping System Design Book - Page 363)

Conventional unit lifting 300 B/D from 6500 ft. w/1.25 in. plunger and API 76 rod string.

Pumping Mode	(1) Constant Volume Pumping -- Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-top Downward Acceleration of Carrier Bar (Ft/Sec/Sec)	(3) Minimum Polished Rod Load (Elastic Rods) lbs.	(4) Minimum Polished Rod Load (Inelastic Rods) lbs.	Difference Between (3) & (4) lbs.
7	20.7x64" SPM	8.52	5231	7495	2264
8	19x74" SPM	8.18	5118	7602	2484
9	17.5x86" SPM	8.06	4905	7640	2735
10	15.9x100" SPM	7.74	4807	7741	2934
11	14x120" SPM	7.63	4635	7776	3141

Turning to a second application with a different API rod string and different depth, it can be seen in Application II, pumping mode 11, that conventional unit pumping 14 - 120 inch SPM with an 1-1/4 inch plunger, that the minimum polished rod load, considering the elastic rod string, is 4635 lbs., the maximum downward off-top acceleration of the rod string is 7.63 ft/sec/sec and the equivalent (concentrated mass) inelastic rod string minimum is 7776 lbs.

Comparing pumping mode 11 with pumping mode 10, 15.9 - 100 inch SPM, the minimum polished rod load of the elastic rod string is 4807 lbs., maximum off-top acceleration 7.74 ft/sec/sec and the minimum polished rod load of the <u>inelastic</u> rod string 7741 lbs. Comparing pumping mode 11 with pumping mode 10, it is seen that, as the off-top, downward acceleration becomes greater, the minimum load of the <u>elastic</u> string once more becomes higher, but the <u>inelastic</u>, rod string minimum polished rod load becomes smaller - as expected.

Comparing pumping modes 10 and 9, 9 and 8, 8 and 7, the same mechanical anomaly occurs, namely that as off-top acceleration increases, the minimum polished rod load of the elastic string also increases. As before, the inelastic rod string minimum polished rod load behaves exactly the opposite. A constant volume is pumped in all cases with a single plunger diameter.

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APPLICATION III

(API-11L3 - Sucker Rod Pumping System Design Book - Page 297)

Conventional unit lifting 250 B/D from 5500 ft. w/1.25 in. plunger and API 76 rod string.

Pumping Mode	(1) Constant Volume Pumping -- Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-top Downward Acceleration of Carrier Bar (Ft/Sec/Sec)	(3) Minimum Polished Rod Load (Elastic Rods) lbs.	(4) Minimum Polished Rod Load (Inelastic Rods) lbs.	Difference Between (3) & (4) lbs.
12	23.6x48" SPM	8.30	4448	6400	1952
13	22x54" SPM	8.12	4362	6448	2086
14	20x64" SPM	7.95	4215	6494	2279
15	18.2x74" SPM	7.50	4071	6615	2544
16	16.2x86" SPM	6.91	4008	6772	2764

Observing the third application, with a different API rod taper, different pumping depth, and a different fluid volume, the same anomalistic results obtain when comparing pumping modes 16 with 15, 15 with 14, 14 with 13, and 13 with 12.

The burden of the comparisons in these three applications is to show that, although the carrier of the conventional pumping unit drops the rods with greater off-top acceleration, it does not necessarily mean that the minimum load will always be lower, and the maximum pumping speed limited to a lesser value.

Admittedly, in most applications, a higher off-top acceleration dropping the rods faster will result in a lower minimum polished rod load and a lower maximum pumping speed - but not in all cases.

It should be emphasized that in each of the applications, I, II, and III, the geometry (conventional), the plunger size, and pump displacement are held constant. The only parameters changed in these tables are stroke length vs. pumping speed.

Observing these three conventional unit applications, emphasizes the fact that the complex nature of an elastic rod string is involved enough that simply concluding, because maximum, off-top, rod acceleration is higher, the minimum load will automatically be lower, and maximum pumping speed will be reduced. In many applications, this intuitive and reasonable observation is simply not so.

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Since the reverse geometry of the air balance and Mark II pumping units have higher off-top accelerations than a similar conventional unit, (all else equal), is it logical to suppose that they will react in the same anomalistic manner.

Application IV, outlining a typical Mark II application, shows that this type of geometry like the conventional unit, may, in some cases, also have a higher minimum polished rod load, the faster the rods are dropped - again, completely opposite intuition.

APPLICATION IV
(After S. Gibbs and S. Lekia)
(Mark II unit lifting 300 B/D from 2500 ft. w/1.50 in. plunger and API 65 rods.)

Pumping Mode	(1) Constant Volume Pumping -- Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-top Downward Acceleration of Carrier Bar (Ft/Sec/Sec)	(3) Minimum Polished Rod Load (Elastic Rods) lbs.	(4) Minimum Polished Rod Load (Inelastic Rods) lbs.	Difference Between (3) & (4) lbs.
17	22.1x54" SPM	15.06	1538	1543	5
18	19.8x64" SPM	12.74	1486	1752	266
19	16.2x74" SPM	11.18	1434	1892	458
20	14.0x86" SPM	9.47	1371	2046	675
21	12.0x100" SPM	8.03	1298	1276	878
22	10.0x120" SPM	6.91	1208	2276	1068

By observing Application IV (pumping a constant volume), pumping mode 17, shows a Mark II, pumping 22.1 - 54 inch SPM, has a minimum polished rod load, assuming an elastic rod string, of 1538 lbs., while the off-top acceleration is 15.06 ft/sec/sec. Assuming the same maximum off-top acceleration, all else equal, the minimum polished rod load of the inelastic rod string is 1543 lbs.

In pumping mode 18, pumping 18.9 - 64 inch SPM, the minimum polished rod load drops to 1486 lbs., the maximum off-top acceleration drops to 12.74 ft/sec/sec, yet the inelastic rod's minimum polished rod load increases to 1752 lbs.

Here again, the same anomalistic situation occurs with the elastic rods having a lower minimum polished rod load as the maximum off-top acceleration decreases, while the inelastic rods have a minimum polished rod load which increases, as expected.

Pumping modes 19, 20, 21, and 22 of the Mark II follow this identical pattern where the lower the off-top acceleration, the lower the minimum polished rod load for the elastic string, and the higher the minimum polished rod load for the inelastic string. The results of Applications I, II, III, and IV result, again, in contrary minimum polished rod load values for an elastic rod string in both the conventional and Mark II units.

Admittedly, the reverse geometry of the air balance unit and the Mark II unit - all else equal - i.e. the same the stroke length and SPM, have higher off-top acceleration than a similar Class I, conventional unit. Thus, for a given application, the natural assumption would be that the conventional unit would , all else equal, on any application, have a higher minimum polished rod load and consequently a higher maximum pumping speed than the equivalent Class III units like the air balance unit and the Mark II.

These Three Cases Compare Minimum Polished Rod Loads Of
Two Different Geometries - Conventional Vs. Mark II
Lifting Equal Fluid Volumes From The Same Depth

APPLICATION V
(After S. Gibbs and S. Lekia)
Pumping 1500 B/D from 5500 ft. w/API 87 rod string and 2.75 in. plunger.

Pumping Mode	Type	(1) Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-Top Acceleration of Carrier Ft/Sec/Sec	(3) Minimum Rod Load Elastic Rods (lbs.)	(4) Minimum Rod Load Inelastic Rods (lbs.)	Difference Between (3) & (4)(lbs.)
23	Conv.	17.5x100 in.	9.37	5009	3242	3242
24	Mk II	18.0x100 in.	18.06	5513	5277	-236

APPLICATION VI
(After S. Gibbs and S. Lekia)
Pumping 1500 B/D from 5500 ft. w/API 86 rod string and 2.50 in. plunger.

Pumping Mode	Type	(1) Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-Top Acceleration of Carrier Ft/Sec/Sec	(3) Minimum Rod Load Elastic Rods (lbs.)	(4) Minimum Rod Load Inelastic Rods (lbs.)	Difference Between (3) & (4)(lbs.)
25	Conv.	23.2x86 in.	14.17	4716	6412	1696
26	Mk II	22.1x86 in.	23.60	4963	3059	-1904

APPLICATION VII
(After S. Gibbs and S. Lekia)
Pumping 1250 B/D from 5500 ft. w/API 86 rod string and 2.75 in. plunger.

Pumping Mode	Type	(1) Pumping Speed (spm) and Stroke Length (in.)	(2) Maximum Off-Top Acceleration of Carrier Ft/Sec/Sec	(3) Minimum Rod Load Elastic Rods (lbs.)	(4) Minimum Rod Load Inelastic Rods (lbs.)	Difference Between (3) & (4)(lbs.)
27	Conv.	16.0x100 in.	7.84	5296	9165	3869
28	Mk II	16.6x100 in.	15.36	5598	6335	737

Applications V, VI, VII illustrate comparisons between conventional and Mark II pumping unit geometries, showing that in some cases, the Mark II's higher off-top acceleration paradoxically, results in higher minimum polished rod loads than the equivalent conventional unit. This study emphasizes the complex nature of beam and sucker rod pumping.

In pumping modes 23 and 24, the two units (conventional and Mark II) are lifting 1500 barrels a day form 5500 ft. with and 87 rod string and 2.75 inch plunger. The conventional unit, pumping slightly slower, i.e., 17.5 - 100 inch SPM, with the same 2.75 inch plunger, has a minimum polished rod load of 5009 lbs. Consequently, comparing pumping modes 23 and 24, the Mark II, with the faster, off-top, downward, maximum acceleration, 18.06 vs. 9.37 ft/sec/sec, has a higher minimum polished rod load than the conventional unit - all else equal - pumping faster.

In application VI, the two units are to once again lift 1500 barrels per day from 5500 ft. with AP 86 rod string and 86 inch stroke length.

In pumping mode 25, it can be seen that the conventional unit, pumping 23.2 - 86 inch SPM with a 2.5 inch plunger and maximum off-top acceleration of 14.17 ft/sec/sec, has a minimum polished rod load of 4716 lbs.

In pumping mode 26, the Mark II, handling this same application, pumping 22.1 - 86 inch SPM with the same 2.5 inch plunger, and a maximum off-top acceleration of 23.60 ft/sec/sec has a minimum polished rod load 4963 lbs.

Once again, the pumping unit having the higher off-top maximum downward acceleration has a higher minimum polished rod load, and presumably a higher maximum pumping speed.

In application VII, lifting 1250 barrels per day from 5500 ft. with an AP 87 rod string. In pumping mode 27, the conventional unit pumping 16 - 100 inch SPM with a 2.75 inch plunger has a minimum load of 5296 lbs. The Mark II, handling the same application (pumping mode 28), pumping 16.6 - 100 inch SPM with the same 2.75 plunger has a minimum polished rod load of 5598 lbs. - presumably having a higher potential maximum pumping speed, although the Mark II maximum off-top acceleration is almost twice as high as the conventional unit.

The thrust of this discussion and comparison (Applications V, VI, and VII) is not to suggest that, in most pumping applications, the faster downstroke will result in a higher maximum pumping speed. Rather the objective is to emphasize that the complexity of sucker rod pumping makes it highly suspect to always assume that a conventional unit will, in every case, produce a higher minimum polished rod load, and a higher potential maximum pumping speed than an air balance, or Mark II unit, because of the lower off-top acceleration of the conventional unit's rod carrier.

Of the three dominant factors affecting the minimum polished rod load, and maximum pumping speed, the above applications should emphasize that, because of the complex behavior of the elastic rod system, the heretofore mostly unrecognized and unappreciated influence of the PUMPING MODE may, in many, or at least in some applications, may be as important, or perhaps even more important, than either (1) retarding forces in the well, and/or (2) maximum, off-top, rod carrier (downward) acceleration.

CONCLUSIONS

1. Three of the most important items in determining minimum polished rod load and consequently maximum pumping speed in a beam and sucker rod pumping system are: (a) retarding forces in the well; (b) the maximum, downward, off-top acceleration of the rod carrier; and (c) the pumping mode.

2. Momentarily disregarding the most important item, retarding forces in the well, in most applications - though certainly not all - minimum polished rod load and consequently maximum pumping speed is a function of maximum, off-top, downward acceleration of the carrier bar. Normally, the faster the rods are returned, the lower the minimum polished rod load.

3. A significant, off-setting factor to item 2, the faster return of the rods, is the recognition and the precise prediction of a special pumping mode, which can, in many instances, reduce the alleged "handicap" of a faster off-top rod acceleration.

4. In many applications, a heavier rod string will tend to off-set a faster off-top rod acceleration.

5. In other cases, the lower, off-top, maximum acceleration of the conventional pumping unit results in a higher minimum polished rod load than that of the air balance and Mark II pumping units. However, in some cases this factor can be off-set by judicious selection of the proper pumping mode for Class III units.

6. Both the prime mover size and prime mover type have a significant bearing on minimum polished rod load and consequently maximum pumping speed. Each individual application should be analyzed to find out which size and prime mover type will result in the highest minimum polished rod load and greatest economy.

REFERENCES

1. API, Sucker Rod Pumping System Design Book (API BUL 11L3)
2. Gibbs, S.G., Personal Correspondence
3. Lekia, S.D.L., An Improved Technique For Evaluating performance Characteristics And Economy Of The Conventional and Mark II Beam And Sucker Rod Pumping Systems. (19482); Masters Thesis, University of Tulsa.
4. Brown, Kermit; Day, John; Joe; Byrd, Joe; Technology Of Artificial Lift Methods; Vol. 2A, University of Tulsa. Petroleum Publishing Co., 1980.