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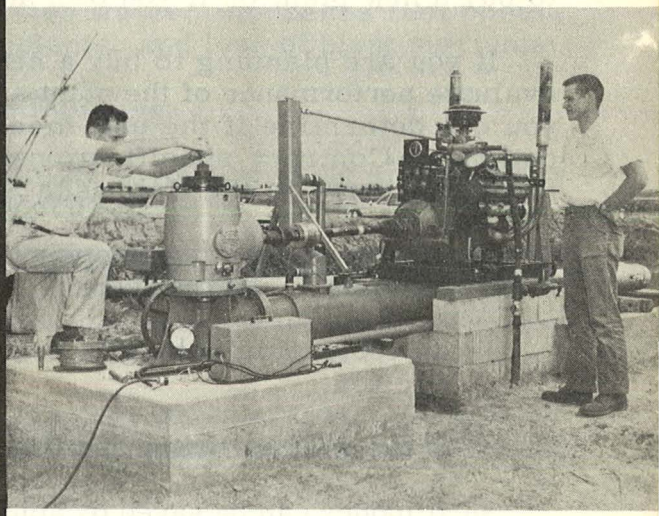
It Pays to Test Your Irrigation Pumping Plant



EXTENSION SERVICE
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE
AND U. S. DEPARTMENT OF AGRICULTURE
COOPERATING
E. F. FROLIK, DEAN E. W. JANIKE, DIRECTOR

IT PAYS TO TEST YOUR IRRIGATION PUMPING PLANT

By
John Sulek and Deon Axthelm

A pumping plant test can be made by a trained individual using accurate testing equipment. Such service may be offered by engineers or well drillers. Certain deep-well irrigation associations have equipment and a trained technician who can perform a pumping plant test. See your County Extension Agent for information on locations of these associations.

INTRODUCTION

A pumping plant test can be of great value if you plan to buy a new plant or if you own an older unit.

If you are planning to buy a new plant the test will evaluate performance of the plant after it is installed so you can determine if the unit meets contract specifications. Contract specifications may call for performance equal to the Nebraska Standards (Table I).

If you own an existing pumping plant you can use test measurements to determine:

-- an irrigation schedule for optimum crop production.

-- if the well is being operated in a danger zone.

-- if money can be saved by adjusting, reconditioning or replacing an old pump or power unit.

BENEFITS YOU OBTAIN FROM TEST MEASUREMENTS

Information you will get from a test includes the pumping rate, water levels while pumping, discharge pressure, pump and engine speed, and fuel or energy used per hour. These are necessary for establishing a performance rating on your unit. You also obtain these additional benefits.

Knowing the Pumping Rate:

-- can tell you if it is possible to extend your irrigated crop acreage. Pumping rate is one of the essential factors in determining proper water application and irrigation schedules.

-- can help you avoid wasting water. Soils require certain amounts of water to fill the profile to capacity. Over-irrigation wastes water, increases fuel costs, causes drainage problems, and loss of plant nutrients.

Water Levels While Pumping:

-- can help determine if you are using all the water your well will safely produce.

-- can help determine if you are overpumping your well, causing air or sand pumping. This information can help to establish a practical pumping rate that will relieve the problem.

-- can indicate if pump bowls are deep enough for efficient operation at the present pumping rate or at an increased rate.

Knowing the Discharge Pressure:

-- can help determine if you are wasting money by using a poorly designed discharge system. Adding a poorly designed piping system will increase pressures and reduce pumping rate.

Knowing the Pump and Engine Speed:

-- can tell you if you are operating your pump and

engine at the most efficient point for your pumping conditions.

Knowing the Fuel Used per Hour:

-- can give you accurate information on irrigation costs. It is a key factor in evaluating the performance of a pumping plant.

HOW TO EVALUATE PUMPING PLANT PERFORMANCE

Accurate test measurements are necessary to evaluate the performance of your pumping unit. They are used as follows:

The measurements of lift, discharge pressure, and gallons per minute are used to determine water horsepower (whp) - the rate work is done by the plant.

The whp and gallons of fuel used per hour are combined to establish a level of performance in terms of whp-hrs per gallon. This is similar to measurements of miles per gallon of gas you get with your car.

The measured whp-hrs per gallon are compared with the Nebraska Standards, Table I, to obtain a performance rating. The standards are obtained from averages of Nebraska Tractor Tests and from manufacturers' performance data for pumps, drives, and power units. They represent a performance level that can be obtained by pumps, engines or motors, and drives that have average or above efficiency. These must be properly selected, installed, adjusted and operated, to obtain the Nebraska Performance Standards. If the components are all above average in efficiency, it is possible to have a plant that will exceed the standards. A unit that obtains less whp-hrs per gallon or unit energy or used more fuel than calculated from the Performance Standard is termed "sub-standard".

Here is how whp and a performance rating, % of Standard, are calculated. They can be used with tables 2 3 4 5 6 & 7 to determine your potential fuel saving as shown in this example:

Example of Test Measurements and Use of Tables

Field Test Data -- Pumping rate, gpm - 1000
Lift in feet ---------- 77
Discharge pressure in lbs. per sq. inch -- 10 (1 lb. per sq. in. = 2.3')
Fuel used in gallons per hour ---------- 4.9 (Propane)

1. Determine water horsepower.

$$\text{whp} = \frac{\text{gpm x total lift in ft*}}{3960}$$

*Total lift (100') = lift from well (77') + discharge pressure in ft. (23')

$$\text{whp} = \frac{1000 \times 100}{3960}$$

whp = 25.3

2. Determine measured whp-hrs per gallon.

$$\text{whp-hrs per gallon} = \frac{\text{whp}}{\text{Gallons fuel used per hour}}$$

$$\text{whp-hrs/gal} = \frac{25.3}{4.9}$$

whp-hrs/gal = 5.16

3. Determine the performance rating.

$$\text{Rating} = \frac{\text{measured whp-hrs/gal}}{\text{Nebraska Standards whp-hrs/gal}} \times 100\%$$

$$\text{Rating} = \frac{5.16}{6.89} \times 100\%$$

(Nebr. Standards for propane from Table I)

Performance rating, % of Standard = 75%

4. Determine fuel waste -- refer to Table 3 page 7.

Find whp (25) on top line.

Find performance rating (75%) on side of chart.

Chart shows approximately 121 gallons of propane will be wasted during 100 hours of operation.

Table I. Nebraska Performance Standards for Deep Well Pumping Plants:*

Fuel	whp-hrs per unit of fuel
Diesel	10.94
Gasoline	8.66
Tractor Fuel	7.86
Propane	6.89
Natural Gas	66.7 per 1000 cu. ft.
Electric	0.885 per kw-hr

*Criteria for Appraising the Performance of Pumping Plants, P.F. Schleusener and John Sulek, Agricultural Engineering, Sept. 1959, p 550.

Table 2. Gallons of Diesel Fuel you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Plant Whp 10	15	20	25	30	35	40	45	50
95	5	7	10	12	14	17	19	22	24
90	10	15	20	25	30	36	41	46	51
85	16	24	32	40	48	56	65	73	81
80	23	34	46	57	69	80	91	103	114
75	30	46	61	76	91	107	122	137	152
70	39	59	78	98	118	137	157	176	196
65	49	74	98	123	148	172	197	221	246
60	61	91	122	152	183	213	244	274	305
55	75	112	150	187	224	262	299	337	374
50	91	137	183	229	274	320	366	411	457

Table 3. Gallons of Propane you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Plant Whp 10	15	20	25	30	35	40	45	50
95	8	11	15	19	23	27	31	34	38
90	16	24	32	40	48	56	64	73	81
85	26	38	51	64	77	90	102	115	128
80	36	54	73	91	109	127	145	163	181
75	48	73	97	121	145	169	193	218	242
70	62	93	124	155	187	218	249	280	311
65	78	117	156	195	234	273	313	352	391
60	97	145	193	242	290	339	387	435	484
55	119	178	237	297	356	416	475	534	594
50	145	218	290	363	435	508	580	653	726

Table 4. Gallons of Tractor Fuel you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Whp 10	15	20	25	30	35	40	45	50
95	7	10	13	17	20	23	27	30	33
90	14	21	28	35	42	49	57	64	71
85	22	34	45	56	67	79	90	101	112
80	32	48	64	80	95	111	127	143	159
75	42	64	85	106	127	148	170	191	212
70	55	82	109	136	164	191	218	245	273
65	69	103	137	171	206	240	274	308	343
60	85	127	170	212	254	297	339	382	424
55	104	156	208	260	312	364	416	468	521
50	127	191	254	318	382	445	509	573	636

Table 5. Gallons of Gasoline you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Whp 10	15	20	25	30	35	40	45	50
95	6	9	12	15	18	21	24	27	30
90	13	19	26	32	38	45	51	58	64
85	20	31	41	51	61	71	82	92	102
80	29	43	58	72	87	101	116	130	144
75	38	58	77	96	115	135	154	173	192
70	50	74	99	124	149	173	198	223	248
65	62	93	124	156	187	218	249	280	311
60	77	115	154	193	231	270	308	347	385
55	95	142	189	236	284	331	378	425	473
50	116	173	231	289	347	404	462	520	578

Table 6. 1000 cu. ft. of Natural Gas you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Whp 10	15	20	25	30	35	40	45	50
95	1	1	2	2	2	3	3	4	4
90	2	3	3	4	5	6	7	7	8
85	3	4	5	7	8	9	11	12	13
80	4	6	8	9	11	13	15	17	18
75	5	8	10	12	15	17	20	22	25
70	6	10	13	16	19	22	26	29	32
65	8	12	16	20	24	28	32	36	40
60	10	15	20	25	30	35	40	45	50
55	12	18	25	31	37	43	49	55	60
50	15	22	30	37	45	52	60	67	75

Table 7. Kw-hrs. of Electricity you could save in 100 hrs. of operation.

Performance Rating - % of Standard	Whp 10	15	20	25	30	35	40	45	50
95	59	89	119	149	178	208	238	267	297
90	126	188	251	314	377	439	502	565	628
85	199	300	399	499	598	698	798	898	997
80	283	424	565	706	848	989	1130	1271	1413
75	377	565	753	942	1130	1318	1507	1695	1883
70	484	726	969	1211	1453	1695	1937	2179	2422
65	609	913	1217	1521	1826	2130	2434	2738	3043
60	753	1130	1506	1883	2260	2637	3013	3390	3767
55	925	1387	1849	2311	2774	3236	3698	4161	4629
50	1130	1695	2260	2825	3390	3955	4520	5085	5650

CAUSES FOR SUBSTANDARD PERFORMANCE

The Pump

Turbine impellers are selected to lift efficiently a particular amount of water to a certain height (including pressure), at a specified speed. If pumping conditions have changed or if impellers are not matched to existing conditions the pump will be inefficient. Piping systems not considered in original pump design will cause changes in pumping conditions and plant efficiency. Qualified persons schooled to read manufacturers' impeller curves can tell if the impellers are operating properly or are matched to operating conditions.

The pump impellers may be out of adjustment. This results in higher than normal pump and engine speeds to deliver the required amount of water. Qualified pump manufacturers' representatives can adjust the impeller clearance to obtain the optimum capacity. However, if impellers are worn or corroded, adjustment will not bring them back to original capacity or efficiency.

The pump may be operating below or above the design speed. This will cause inefficient operation. A tachometer will enable the operator to hold the pump at the speed designated by design specifications.

The Engine

The engine may be under or overloaded. Engines work efficiently when operated at 75-100% of their continuous rated horsepower at a reasonable speed. A technician can advise if drive ratios need to be changed to obtain correct loading at a reasonable engine speed.

The engine may need adjustment. The ignition, timing, and carburetion should be adjusted on spark ignition engines. Diesel units may need fuel injection timing. These adjustments should be made by competent engine specialists.

The parts may be excessively worn. Loss of compression due to worn parts may result in poor fuel econo-

my. Compression tests can be run to assist in determining parts to be replaced.

The engine may not be matched to the fuel used. Compression ratio and carburetion equipment should be designed for the fuel used. Engine manufacturers' kits are available to convert gasoline engines to operate efficiently on propane or natural gas when change of fuel is desired.

Efficiency of electric motors will seldom change during use. It is important to know if a motor has become overloaded. Continuous overloading may not seriously affect the efficiency of an electric motor but will change its useful life.

The Drive

The drive ratio may be incorrect for matching pump engine speeds. This causes inefficient operation of the pump or engine or both. Qualified technicians who understand both pump and engine characteristics can recommend proper drive ratios.

Drive misalignment decreases efficiency. It also reduces drive life. Nebraska Extension Circular 57-701, "Irrigation Turbine Pump Drives", gives belt and shaft alignment recommendations.