CLEANING AND TESTING OF USED SUBMERSIBLE PUMPS AND MOTORS TO REDUCE LIFTING COSTS: AN UPDATE TO S.P.E. PAPER 13202*

D.L. DIVINE
ELECTRIC SUBMERSIBLE PUMPS, INC.

ABSTRACT

A technique has been developed to chemically clean used submersible pumps and flush used submersible motors without the expense of tearing down the equipment and rebuilding it. After the cleaning process, the pump is tested and its performance is plotted against the manufacturer's catalog curve. Over 70% of the pumps put through this process have been rerun without being rebuilt for a substantial savings to the operator.

This paper will discuss the process used in cleaning and inspecting the pump and motor. The pump test bench will be described along with the metering accuracy and calibration techniques. The test techniques used on the motor to determine if it should be rerun will be described. Use of the actual pump curve for improving production will be covered, along with statistical data on over 2000 new and used pumps tested in the Permian Basin and on the West Coast.

INTRODUCTION

This paper is an update to S.P.E. paper 13202 CLEANING AND TESTING OF USED SUBMERSIBLE PUMPS TO REDUCE LIFTING COSTS. This paper is included as an attachment to this update. Since the original publication of the paper, many additional new and used pumps have been tested in the Long Beach, California area as well as the Permian Basin area. Due to the higher incidence of sand abrasion, the percentage of pumps which are candidates for testing is slightly smaller on the West Coast. However, it can be shown that the statistical data which has been accumulated in West Texas is applicable to the West Coast pumps and vice-versa.

Additionally, a motor testing service has been added which allows the oil operator to rerun used motors with a higher degree of confidence. This motor service is a step above any service performed in the field and is without the expense of a shop tear-down and dryout.

PUMP CURVE DATA

After a pump has been cleaned and tested, the problem of determining whether or not to rerun the pump arises. As described in the attached paper, it is not unusual for a submersible pump not to meet curve whether new or used. This means that the manufacturer's curve is not a good guideline for pass/fail criteria. Actually, the only good guideline is a data base of new and used pumps by impeller type against which to compare.

Several operators on the West Coast decided to test their new pumps before installation. This data is now used to determine if used equipment should be rerun. In figure 1, the percentage deviation from the manufacturer's curve is plotted against number of units for brake horsepower required for all pumps tested on the West Coast. Several trends are evident from this data. The statistical curve has two highs. This corresponds to high volume and low volume pumps. As pointed out in figures 9 and 10 of the attached paper, lower volume pumps generally tend to deviate further from the curve than higher volume pumps. Also, in figure 7 of the attached paper, the same two peaks can be seen at approximately the same location. The higher deviation peak is not as pronounced due to more higher volume pumps being tested in West Texas than on the West Coast. It can also be seen from the curve that newer pumps average a slightly higher horsepower than the used pumps tested. New pumps do appear to go through a break-in period during which the pump's performance often improves. Several new pumps have been run on the pump test bench for several hours to determine performance improvement. In most all cases, the pump's performance improved with run time. The head and efficiency curves of the California tests were also very similar to the Texas tests.

In figure 2, the tests on a 750 BPD impeller are compared. The Texas tests are lower in efficiency than the California tests. The horsepower required was very similar between the two areas. The cause of the lower efficiency can be seen in the poorer head performance of the Texas pumps.

USED MOTOR TESTING

Just as with pumps, operators must decide if a used motor should be rerun if it was running when it was pulled. Field service technicians can check for water or other contaminants in the motor oil and check the motor electrically with a volt/ohm meter and a megohm meter. With this data many operators will decide to run the motor or send it in for a dryout or repair.

An intermediate service is now being offered to help determine the quality of the motor's insulation system before returning it to service. In addition to the service that may be performed in the field, the motor is re-oiled and the dielectric strength of the new oil is checked. The motor is also hypoted at the appropriate DC voltage and the data recorded. The polarization index is then calculated to determine the quality of the motor's insulating system. This is all done in accordance with the IEEE RECOMMENDED PRACTICE FOR TESTING INSULATION RESISTANCE OF ROTATING MACHINERY (see reference 1).

MOTOR TEST PROCEDURE

1. The motor is received and physically inspected for any obvious damage that might require the motor to be repaired. The motor is then checked electrically for any condition that might indicate that the motor would need to be rewound. The motor housing is then cleaned.

2. The motor oil is drained and checked for any contaminants which might indicate a possible problem. The motor then has new motor oil circulated through it until the oil leaving the motor has an appropriately high dielectric strength.

3. A hypot test is then run on the motor according to ANSI/IEEE STANDARDS 43-1974 AND 95-1977 (see reference 1 and 2). At the completion of the hypot test, the motor's insulation resistance and polarization index are calculated. Figure 3 is an example of a motor inspection sheet that is kept during the procedure.

TEST EVALUATION

The data during the hypot test is plotted in figure 4 as insulation resistance versus time on log-log paper. The polarization index is calculated by dividing the 10 minute resistance reading by the 1 minute resistance reading. This ratio is useful for detecting moisture or contamination in the windings. If the winding is wet or dirty, the steady value of insulation resistance will be reached in one or two minutes. For this case, the ratio of the one to ten minute reading will be small. The recommended minimum value of polarization index for class F insulated motors is 2.0 (see reference 1).

The stabilized megohm reading is considered the insulation resistance reading at the temperature of the test. The example motor was considered good and rerun by the operator.

CONCLUSIONS

Motor testing can be a very economical alternative for the oil operator. Of the first 28 motors tested, four failed the initial inspection, seven failed the final hypot testing and 17 were considered good. Neglecting the four that failed initial inspection since their problems should have been found in the field, the acceptance rate on used motors was 71%. More important than that, however, is the remaining 29% which failed during hypot test or re-oiling where contaminants were found. These were motors which passed field inspection readings and may have been rerun if the additional shop tests had not been applied. In figure 5 final megohm and polarization index readings are plotted against number of passed units.

The cost of the motor testing service is only 8% of the cost to exchange and dryout the motor. It can be seen that the monies saved by catching one used motor that may have a short run will pay for the testing of many motors without the full expense of a dryout.

REFERENCES

1. ANSI/IEEE STANDARD 43-1974, IEEE RECOMMENDED PRACTICE FOR TESTING INSULATION RESISTANCE OF ROTATING MACHINERY.

2. ANSI/IEEE STANDARD 95-1977, IEEE RECOMMENDED PRACTICE FOR INSULATION TESTING OF LARGE AC ROTATING MACHINERY WITH HIGH DIRECT VOLTAGE.

*This paper is an update of SPE 13202, "Cleaning and Testing of Used Submersible Pumps to Reduce Lifting Costs" by D.L. Divine. SPE 13202 was presented at the 59th Annual Technical Conference and Exhibition, Houston, Texas, September 16-19, 1984. Copyright for 13202 is held by SPE-AIME.

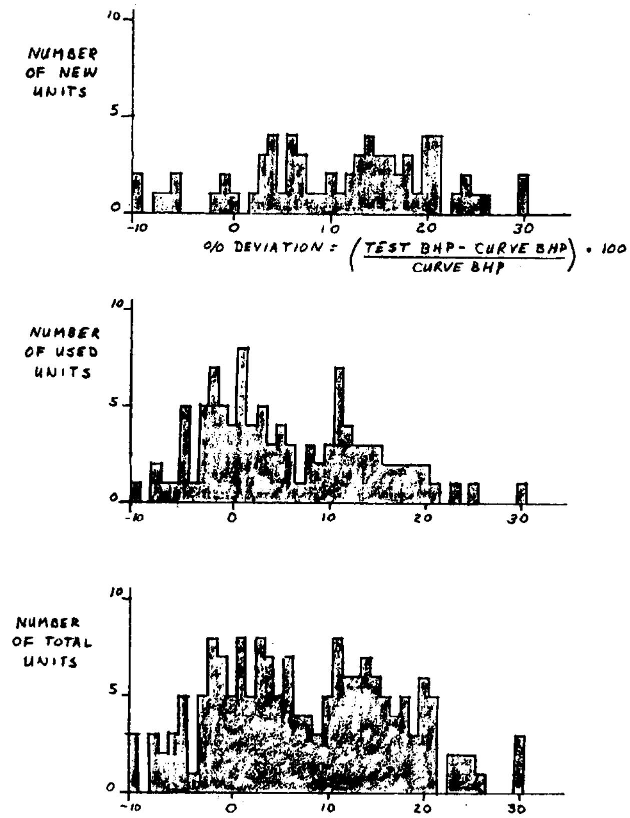

Figure 1 - Percent deviation of horsepower (West Coast tests)

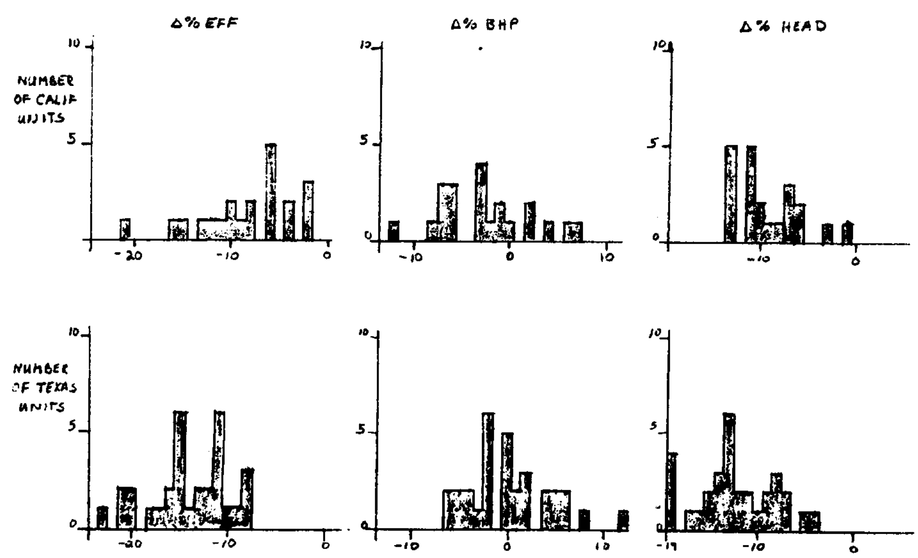

Figure 2 - 750 BPD impeller

CUSTOMER: ______ WELL # C-4

INVOICE DATE 10-26-84 INV # 1270-C

RECEIVER NUMBER 25966 TEST DATE 10-25-84

BILL OF LADING NUMBER 47451 PO # ______

VERBAL

MAKE REDA MODEL ______ S/N 4560441269

Hp 35 VOLTS 800 AMPS 27.5

CAP 1 COUPLING YES DAYS RUN 1050 RACK # ______

** INITIAL READINGS **

	1-2	1-3	2-3		1-GRD	2-GRD	3-GRD
VOM	1	1	1	MEGGER	300	300	300

ORIG OIL: Smell NONE Color DIRTY BROWN H20 YES - 1/4 CUP

Shavings NO Epoxy NO Quantity 1/2 GAL Rotation SMOOTH

BOLT HOLES: Head OK Pothead OK Rub Buttons N/A Fill Valves OK

COMMENTS: OIL DIRTY WITH WATER. SMALL AMOUNT OF EMULSIFIED OIL

*** FINAL READINGS ***

	1-2	1-3	2-3		1-GRD	2-GRD	3-GRD
VOM	1	1	1	MEGGER	inf.	inf.	inf.

OIL FLUSH: Color CLEAR Foreign Matter N/A Rotation SMOOTH

HYPOT: MAX VOLTS = (1.5 NpV + 1000) X 1.7 = 3440

VOLTS	MICRO AMPS	TIME MIN.	
3440	4	0	
3440	2	1	*
3440	1.0	2	
3440	.9	4	
3440	.9	6	
3440	.8	8	
3440	.7	10	*
3440	.7	12	

CALCULATED POLARIZATION INDEX

2.86

CALCULATED MEG OHMS PHASE TO GROUND

4914 Meg Ohms

COMMENTS: Motor came clean during oil flush with no further signs of water. Meg Ohm reading phase to ground greatly improved (from 300 to infinity). Polarization index from Hypot test shows insulation is in good condition.

Figure 3

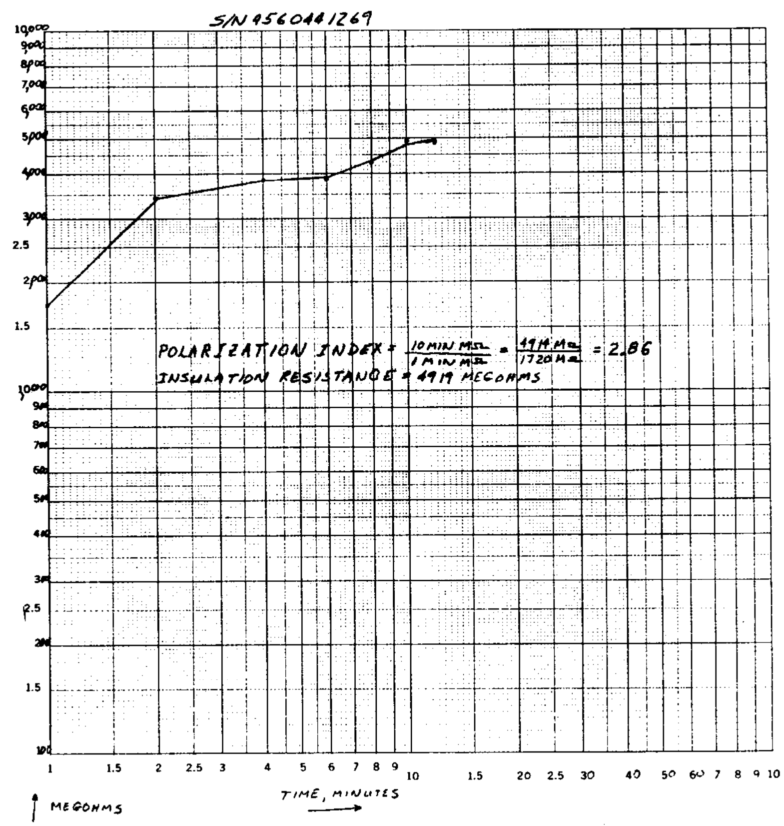

Figure 4