Pumping With Submergible Pumping Equipment

By HOWARD F. SCHULTZ
Reda Pump Co.

INTRODUCTION

A submergible pump is essentially a multistage centrifugal pump, the shaft of which is, through a protector section, directly connected to an electric motor. The entire assembly, as a unit, is of such outside diameter that it can be installed in wells completed with standard sizes of casing. The unit is suspended on tubing, submerged in well fluid, which a cable from the surface supplying electricity to the motor (Fig. 1). The unit may be installed at any desired depth since it is designed to function under any submergence pressures encountered in wells.

A complete submergible pumping unit is composed of five basic components: (1) multistage centrifugal pump, (2) protector, (3) submergible electric motor, (4) electric cable, and (5) a switchboard. In addition to these basic components, various auxiliary items are needed to complete an installation. Some of these auxiliary items are: flat cable guards, cable clamps, check valve, bleeder valve, swage nipple, well head adapter, ground rod and clamp, shipping boxes, cable reel, reel supports, shock absorber and, when necessary, an autotransformer or power transformer.

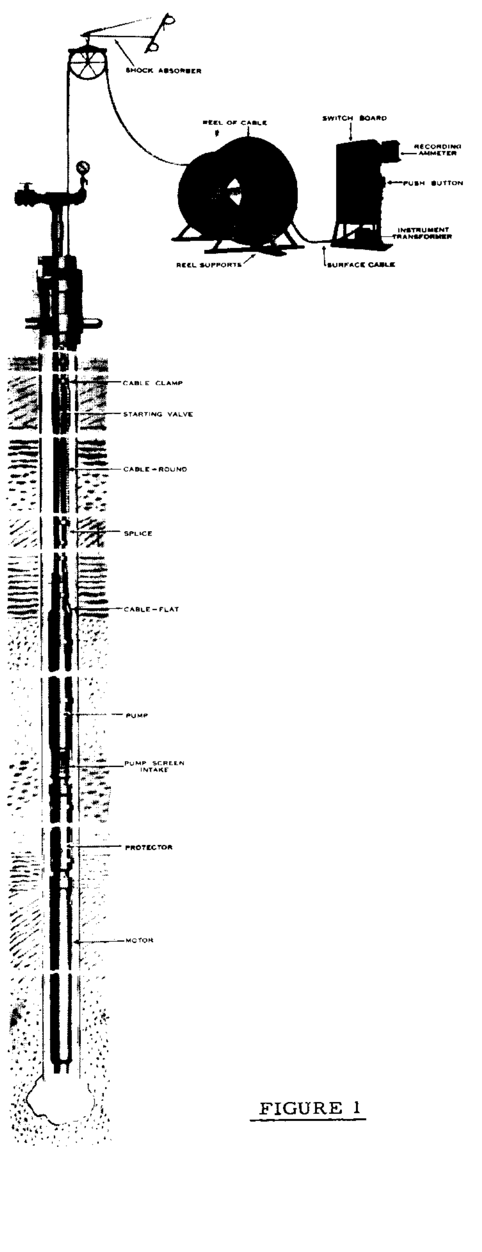

FIGURE 1

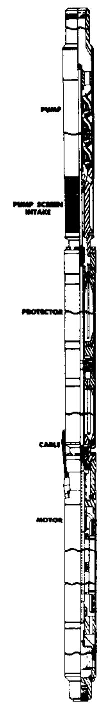

FIGURE 2

PARTS AND APPLICATION

Pump

To provide the desired results in each particular application the multistage centrifugal pump is manufactured in a wide range of capacities. In the application of pumps of centrifugal type for great pressures and relatively small capacity by extreme multistaging, manufacturers have as a matter of regular production items pumps in single housing of as many as 266 stages and 417 stages in tandem arrangements. The pump section consists of a series of stages keyed to a pump shaft, and each stage includes an impeller and diffuser. The pump shaft is directly connected through the protector section to the motor. (Fig. 2).

Protector

The protector section, which is located between the pump and motor, serves to equalize internal pressure in the motor with submergence pressure in the well, and to isolate the pump thrust from the motor bearings. A tandem arrangement of two oil chambers, each containing a mechanical seal, serves to exclude water from the motor while it permits expansion and contraction of the motor oil as the unit heats and cools on starting and stopping. In water well or industrial pumping equipment, expansion and contraction of the motor oil is provided for by an elastic diaphragm located in the lower end of the motor.

Motor

The submergible motor is of the squirrel cage induction type. The motor is filled with oil to insure lubrication and proper cooling. The horsepower ranges available are from 1/3 to over 240 hp, or larger when built in tandem.

CABLE

Electric cable supplies power to the pump-motor assembly. The cable, in various sizes, is oil and water resistant and capable of operating under the most severe conditions encountered in wells. A flat cable is attached at the bottom end to provide sufficient clearance to extend past the pump and protector to the motor, while mechanical protection is provided by interlocking armor of steel, bronze, or monel as dictated by corrosive aspects of particular well fluid. The cable is clamped to the tubing at intervals during installation. Special cable is available for temperatures up to ambient 280° F.

SWITCHBOARDS AND CONTROLS

Among great variety of accessories and miscellaneous equipment, there is available a large selection of various size switchboards from simple pushbutton magnetic contactors with overload protection to switchboard assemblies with devices such as fused disconnects, recording ammeters, undervoltage and overload protection, signal lights, timers for intermittent pumping and instruments for automatic remote control operation.

GENERAL RECOMMENDATIONS

Sandy Wells

Submergible pumps are capable of handling large amounts of sand, although wear, of course, is more rapid than when pumping abrasive-free fluid. Past experience has proven the addition of special rubber stage bearings and has proven Ni-Resist impellers to be the most abrasive-resistant type of contruction and well worth the slight extra cost if the well is expected to produce sand. Also, excellent results have been obtained in some supply wells where the loose formation had been consolidated with the use of special plastics.

Corrosive Wells

Submergible pumps have good corrosion resistance when constructed of proper materials, namely, bronze impellers, Ni-Resist diffusers, seamless steel housings and K-Monel shafts. Where severe corrosion is encountered, it is recommended that Ni-Resist impellers along with protective, corrosion-resistant coating on the pump housing be used. Also, available are various corrosion-resistant coatings which are of Plasite, zinc coat, and other special coatings. Too, Monel-armored cable is available to replace the commonly used galganized steel-armored cable for use in wells with a severe corrosion problem. Monel housings for motors,

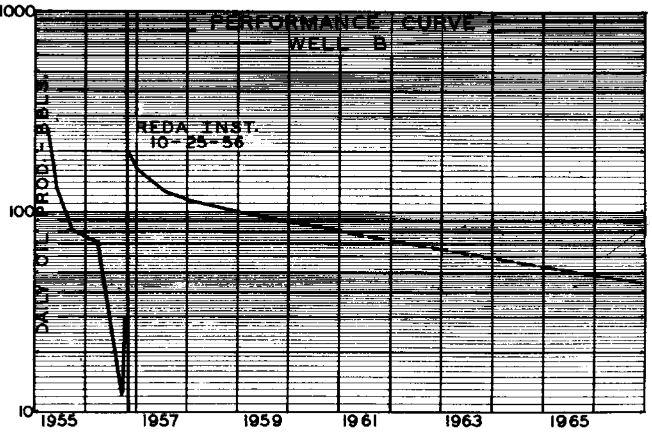

FIG. 3

pumps and protectors are available for extremely corrosive wells, along with Monel-armored cable.

Gassy Wells

Many submergible pumps operate successfully in gassy wells. There gas is encountered, a small amount of volumetric efficiency will be lost. For gassy wells the use of a gas separator, along with greater depths of submergence, is recommended. In fact to insure against possible gas interference of "gas-lock" conditions, it is recommended that a gas separator be used for all applications.

High Temperature Wells

Submergible pumps and cable of standard construction have operated satisfactorily in well temperatures up to 180 ° F, while using special high temperature cable and standard pump construction, they are operating satisfactorily in well temperatures up to 240°F. By using special high temperature cable and specially wound high temperature motors, the pumps are being operated satisfactorily in well temperatures up to 280° F.

Paraffin Conditions

Paraffin depositions usually cause less trouble with submergible equipment than they do with conventional pumping equipment, because the motor, to some extent, acts as a "down-hole heater." The motor imparts heat to the produced fluid; the amount of temperature rise provided by the motor depends on the volume of fluid being pumped. As paraffin accumulates in the upper portion of the tubing, paraffin heat-insulates the tubing and causes the produced fluid to reach the surface at such high temperature that no additional deposition forms to block the passage.

Crooked or Deviated Wells

Submergible pump performance is as good in crooked wells as in "straight" wells, as long as the unit is set at a point where it is not in a bind. These pumps are operating successfully in directionally drilled wells which were drilled on the shoreline to reach reservoirs beneath the ocean floor and directional wells drilled to reach reservoirs beneath populated areas.

Pumping Viscous Crudes

Submergible pump installations throughout the world

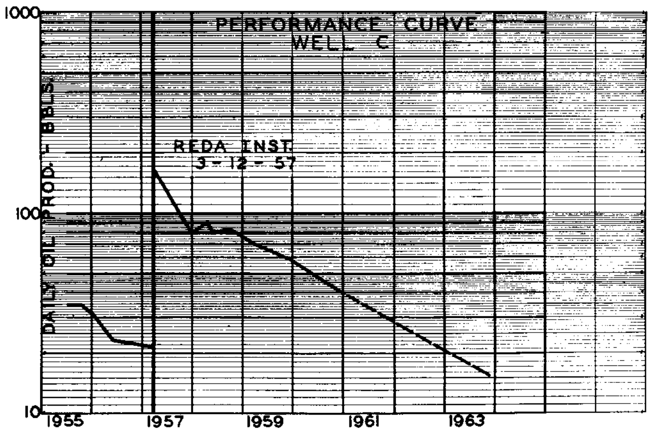

FIG. 4

are pumping crudes of various viscosities, although, naturally, viscous crudes do effect the performance of the pump. The pump efficiency and effective lift are reduced, and the horsepower requirements are increased as the viscosity increases. However, submergible pumps operate more efficiently pumping viscous crude than do any other type of well equipment.

REDA PUMP PERFORMANCE IN OREGON BASIN FIELD OF WYOMING

WELL NO.		A	B	C	D	E	F
Date of Initial REDA Installation		9-19-55	10-25-56	3-12-57	9-9-58	9-11-58	2-11-59
PRODUCTION							
Previous to REDA (B P D.)	Oil	80	30	22	97	18	39
	Water	459	470	711	1116	882	742
	Gross	539	500	733	1213	900	781
Initial On REDA (B P D)	Oil	521	161	165	421	122	411
	Water	3062	1628	4615	5219	5198	5382
	Gross	3583	1789	4780	5640	5320	5790
REDA as of 1-1-61 (B P D)	Oil	40	81	39	156	50	175
	Water	4502	1477	5186	5377	6283	6075
	Gross	4542	1558	5225	5533	6333	6250
Estimated TOTAL with REDA (Bbl x 1000)	Oil	470	165	125	220	65	180
	Water	6800	2220	6450	4250	4600	3750
	Gross	7270	2385	6575	4470	4665	3930
*Estimated Lifting Cost per 1000 Bbl of Oil		$139	$173	$363	$123	$407	$136
Estimated Lifting Cost per 1000 Bbl /Fluid		$8.97	$11.95	$6.90	$6.05	$5.67	$6.23
Lifting Cost per 1000 Bbl /Fluid per 1000 of Lift		$3.52	$5.28	$3.09	$3.23	$3.39	$5.15

* Estimated Lifting Costs include: Repairs, pull and run costs, electric power (8.5 Mills per KW/Hr.), labor (based on $2.00 per day per well) and amortization (based on 8 Years)

FIG. 5

Water Supply Wells

Submergible pumping equipment of one type or another is used almost universally to pump water from supply wells for waterfloods or pressure maintenance programs. In some pilot floods, the submergible pumping unit is being used as the supply pump with enough additional head to reinject the water in the injection wells. Pump sizes in single units vary from small horsepower, low capacity pumps to 240 hp, 14,000 to 15,000 BPD capacity units.

Performance by Two 240 hp Pumping Units in Water Supply Wells For Waterflood Projects in Oklahoma

Well No.	BWPD	Lift	Average Cost per 1000 Bbl*	Cost per Bbl per 1000' in Mills
A	14,200	1000'	$3.80	3.8
B	14,000	1100'	$3.70	3.7

*Costs include repairs, run and pull expense, and cost of electric power.

Brine and Chemical Wells

In the chemical and salt industry, hundreds of submergible pumps are used to produce the salt water from which salt or various chemicals are recovered. In some places fresh water is injected into the salt beds to dissolve the salt and is then pumped to the surface with submergible equipment. Submergible pumps are also used extensively in producing wells with natural brine.

Operating Results of High Volume Pumping

In conclusion, Figures 3, 4 and 5 show that high-volume pumping can increase profits by increasing the economic life of wells or fields and reducing the lifting cost per barrel of fluid. These results were obtained from a total of over 7,200 operating days in six wells equipped with Reda pumping equipment in the Oregon Basin Field of Wyoming. (See "High-Volume Pumping Can Up Profits" by R. W. Parker, Ohio Oil Company, Cody, Wyoming. Presented at the spring meeting of the Rocky Mountain District Division of Production, A.P.I., Casper, Wyoming.)