Roscommon Equipment Center Program

Project No. 50

EVALUATION

OF THE

AQUA-DUK PUMP

Published March 1986

Reviewed and Reprinted March 1987

Reformatted for Web Page November 1998

Northeast Forest Fire Supervisors

In Cooperation with

Michigan's Forest Fire Experiment Station

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ACKNOWLEDGEMENTS

Paul and Pat Wilson of the Automatic Aqua-Duk[1] Corporation, were extremely helpful and kindly provided a pump for our testing purposes.

Several agencies provided endurance information and comments about the pump. We thank Michael Long and J. P. Greene, Florida Division of Forestry; Dennis Gardner, Minnesota Department of Natural Resources; and John Bitzer, Pennsylvania Bureau of Forestry, for their help.

Pump tests were conducted by staff at the Forest Fire Experiment Station: John Macon, Frank O'Neil, and Donald Duggar; manuscript and photo work by Lois Jones and Richard Greenlaw.

Brian Hutchins
Michigan Forest Fire Experiment Station

DISCLAIMER

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[1] Aqua-Duk is a registered trademark of the Automatic Aqua-Duk Corporation.

INTRODUCTION

Wildfire agencies have long used small pumps in the 10 gpm class for use on pickup and jeep type pumpers. Most of these have been powered by gasoline engines; some by belts or other ingenuous methods. The Aqua-Duk, produced by the Automatic Aqua-Duk Corporation, is a 12-volt DC powered pump which provides agencies with another option.

This project results from requests by several northeast states for an independent evaluation of the Aqua-Duk. Because of the multitude of pumps in this class, it was decided not to run comparative tests, but to provide agencies with data that they can use to compare against similar size pumps in their system.

A primary concern was that of electric power consumption and battery drain. Many of the tests and user comments emphasize this point.

MANUFACTURER'S SPECIFICATIONS

The Aqua-Duk pump assembly is a 12-volt DC electric motor coupled to a Hypro[2] Model 4001N roller pump. The electric motor provides adequate startup torque as well as endurance. Baldor Electric produces the motor through agreement with the Automatic Aqua-Duk Corporation.

The complete assembly includes a pressure switch that shuts off the motor when reaching a pre-set pressure. This shuts down the system when the nozzle is turned off. Opening the nozzle relieves the pressure, turning the pump on again. Draining the pump system can be quickly accomplished by the petcocks provided. All the plumbing connections are ¾-inch IPT. The electrical connections provided are #4 welding cable. The manufacturer's electric motor specifications are 1 hp, 12 volt DC, 80 amperes at 2600 rpm.

[2] Hypro is a registered trademark of Lear-Siegler, Inc.

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TEST PROCEDURES

Tests were conducted to evaluate pump performance, power consumption, continuous pumping performance and suction lift. The methodology for each test is discussed below.

Pump Performance and Power Consumption

The Aqua-Duk pump was mounted on a 200 gallon slip-on tank so that the suction lift was approximately zero. A 5 foot hose discharged into a 55 gallon drum. The drum rested on a 1000 pound Toledo scale. For given pressures measured at the pump, the weight of the water pumped was measured for a one minute period and converted to volume in gallons. The electrical supply consisted of two parallel 12 volt batteries connected to a 40 amp battery charger. During each trial the voltage was checked to make sure the batteries were fully charged. Three trials were conducted for each pressure from 0 to 160 psi, in 20 psi increments, with amperage into the motor and water volume measured as noted. The data provided in Figures 1, 2, and 3, are based on averages of the three trials.

Continuous Pumping Performance

To determine the effects of continuous pumping on electric consumption and battery drainage, the Aqua-Duk pumped for 20 continuous minutes at various pressures. The pump was mounted on an REC M-715 200 gallon slip-on tanker (Project #33).

A marine deep cycle battery powered the Aqua-Duk. The marine battery was isolated from the rest of the electrical system and engine starting batteries. The pump battery was charged from a 12 volt alternator which we added on. The engine operated from the original 24 volt system. During each minute the battery voltage and pump pressure were measured, as well as the amperage input to the pump and output from the alternator.

Suction Lift

The anticipated use of the Aqua-Duk is in conjunction with a pumper unit. As such, its capability to lift water is most valuable for drafting water to refill the tank. Lift trials were conducted to a height of 12 feet.

PERFORMANCE DATA

A series of graphs shows the results of the tests with the Aqua-Duk. Figure 1 shows the performance curve generated from the tests. The maximum discharge was 13.0 gpm at free flow. The maximum pressure was about 165 psi. This was the pressure at which the factory set the pump shut-off switch. A 3.8 gpm discharge was found at 160 psi.

Figures 2 and 3 show the relationship between the input amperage and pressure. The amperage draw of the pump can be closely estimated by the pumping pressure. High pressures will result in high current draw from the battery.

A series of graphs show the results of the 20 minute endurance tests. During 20 minutes of continuous pumping, no significant performance declines occurred at pressures less than 100 psi. This is not to say that the battery condition remained unchanged. For example, voltage declined to 11 volts during the 80 psi test (Figures 4A and 4B) where the current draw of the pump was about 75 amps and the alternator was producing about 45 amps. About 150 gallons was pumped during this 20 minute trial.

For pressures of 100 psi to 150 psi, performance declined midway through the 20 minute trials (Figures 5A through 8B). The amperage input averaged about 40 during these tests. Despite these slight drops in pressure due to minor battery drain, the pump performance was adequate throughout the trials. The approximate volumes pumped during these trials were 125, 110, 90, and 85 gallons at 100, 120, 140, and 150 psi, respectively.

At 160 psi, the performance decline began in the 6th minute. By the 20th minute, the pressure dropped to about 140 psi. The battery voltage dropped below 11 volts. Approximately 80 gallons had been pumped. The average current needed to produce this pressure was about 100 amps.

Suction lift trials were conducted up to 12 feet in height. The Aqua-Duk showed little problem pumping at this height at free flow. The manufacturer indicates that it will lift up to 14 feet.

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FIG. 1 PUMP PERFORMANCE...AQUA–DUK

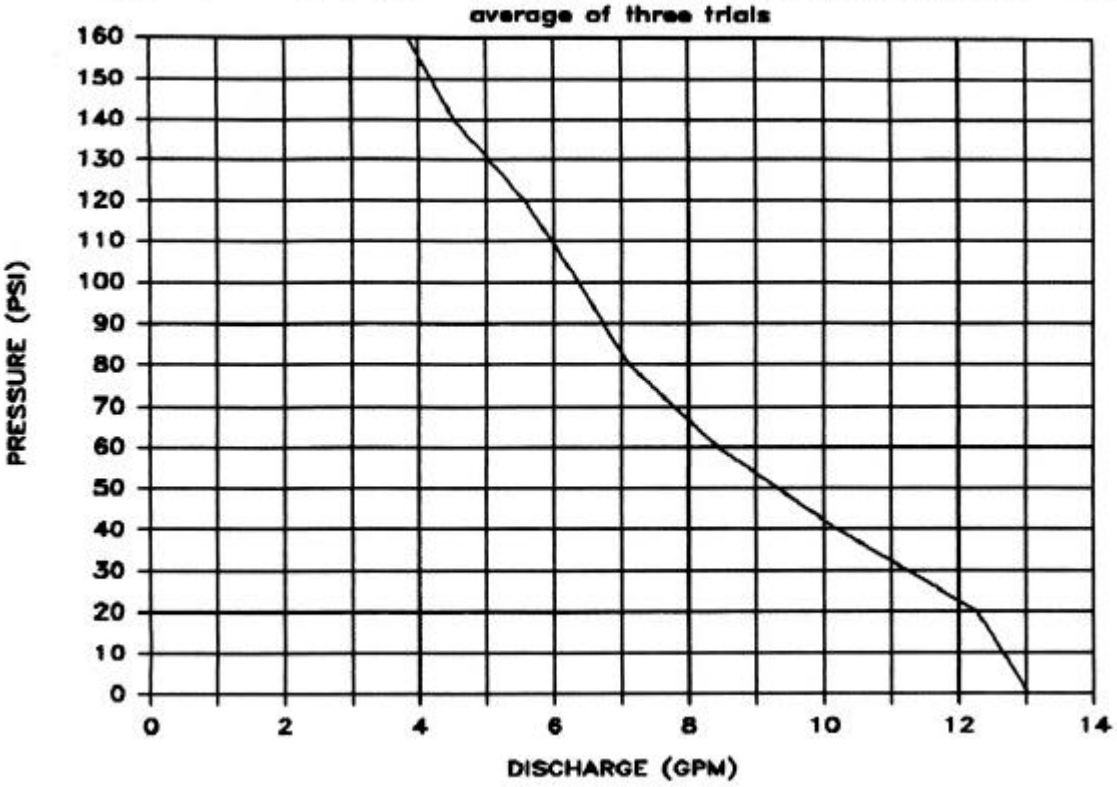

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FIG. 2 GPM vs. AMPERAGE AND PRESSURE

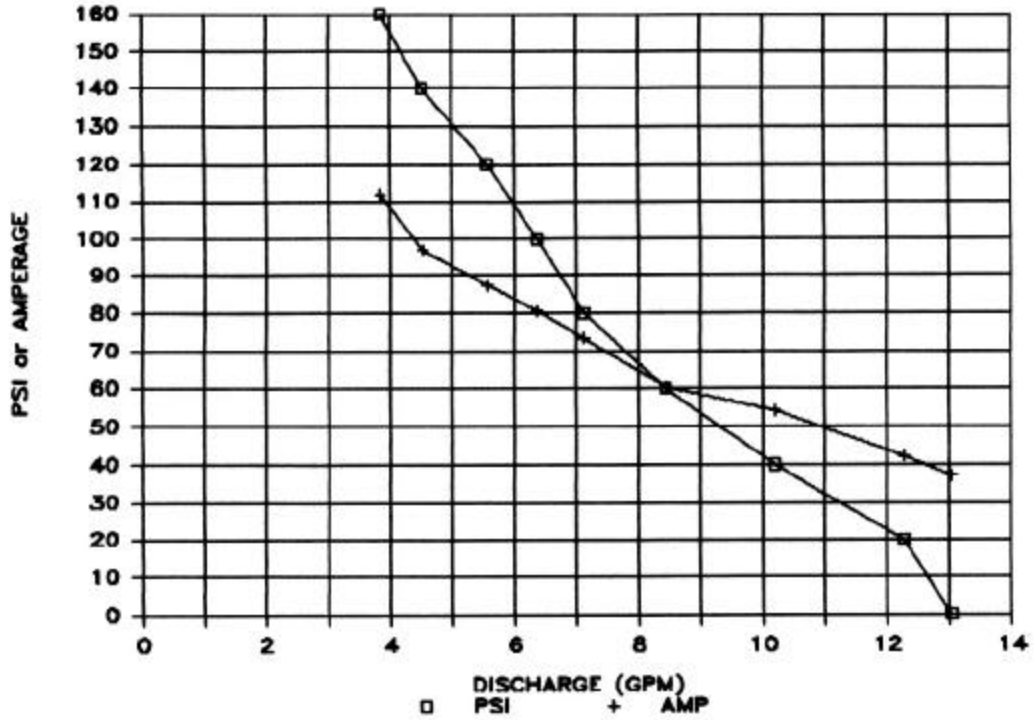

FIG 3. AMPERAGE vs PRESSURE

VOLTAGE HELD NEARLY CONSTANT

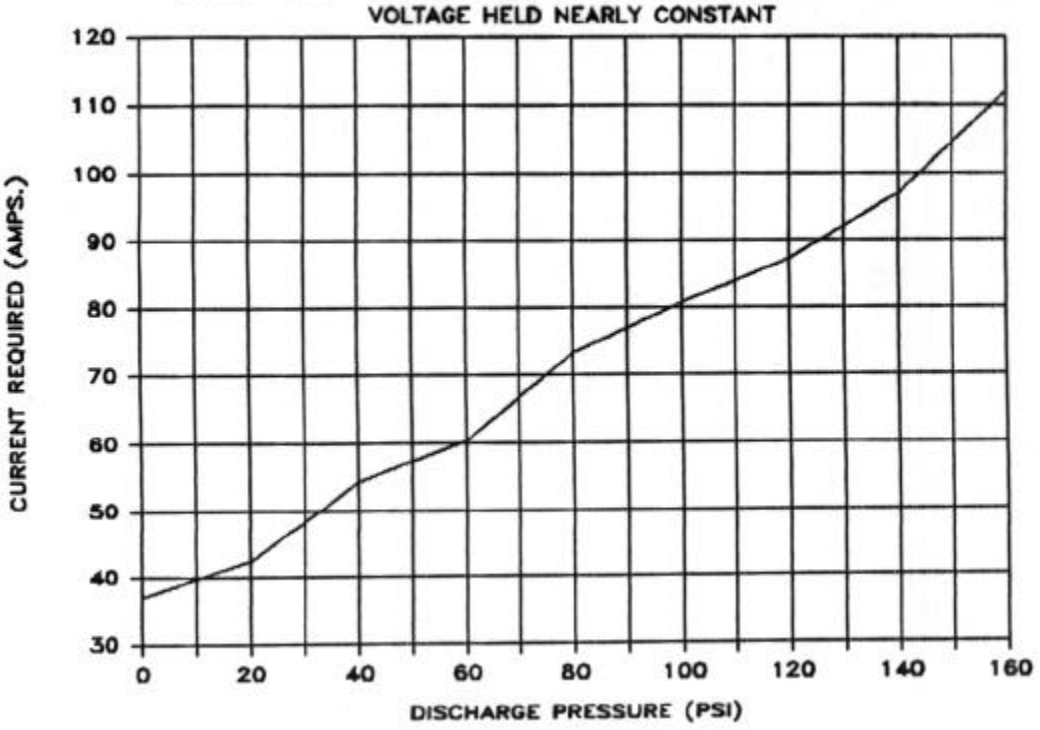

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FIG. 4A 20 MIN. CONTINUOUS PUMPING

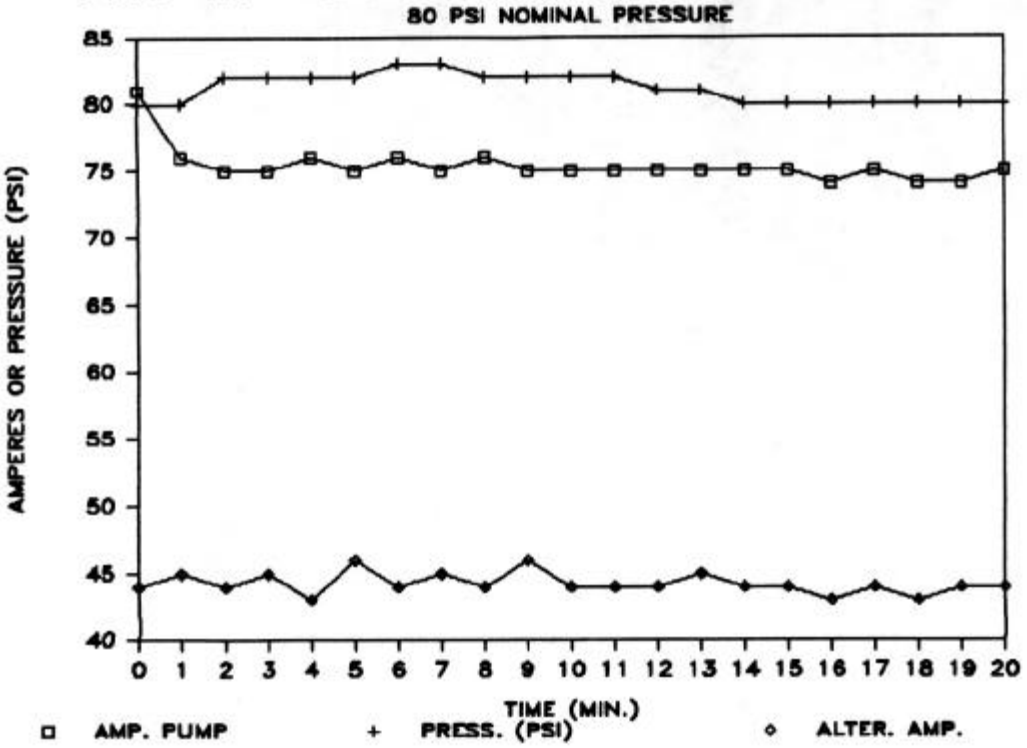

FIG. 4B 20 MIN. CONTINUOUS PUMPING

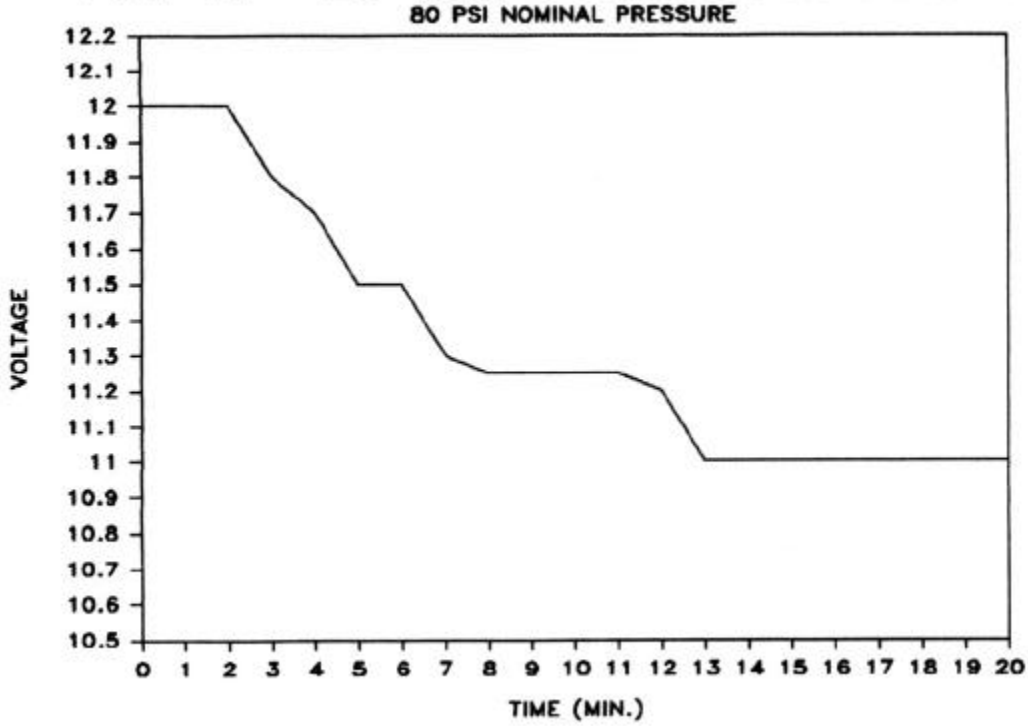

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FIG. 5A 20 MIN. CONTINUOUS PUMPING

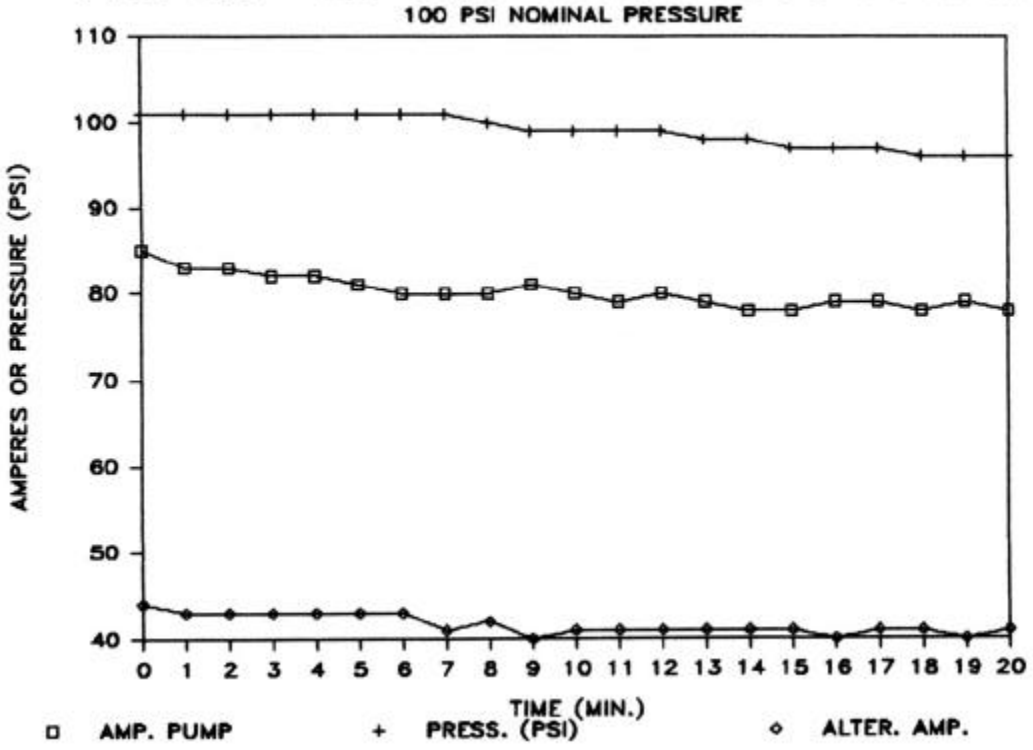

FIG. 5B 20 MIN. CONTINUOUS PUMPING

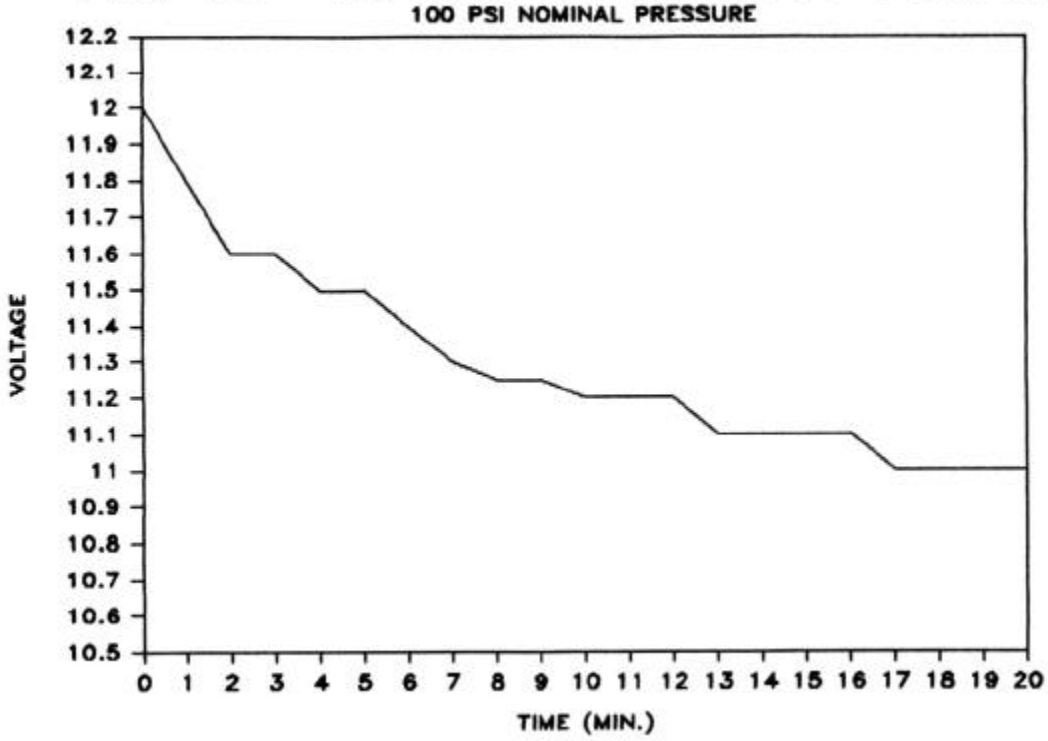

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FIG. 6A 20 MIN. CONTINUOUS PUMPING

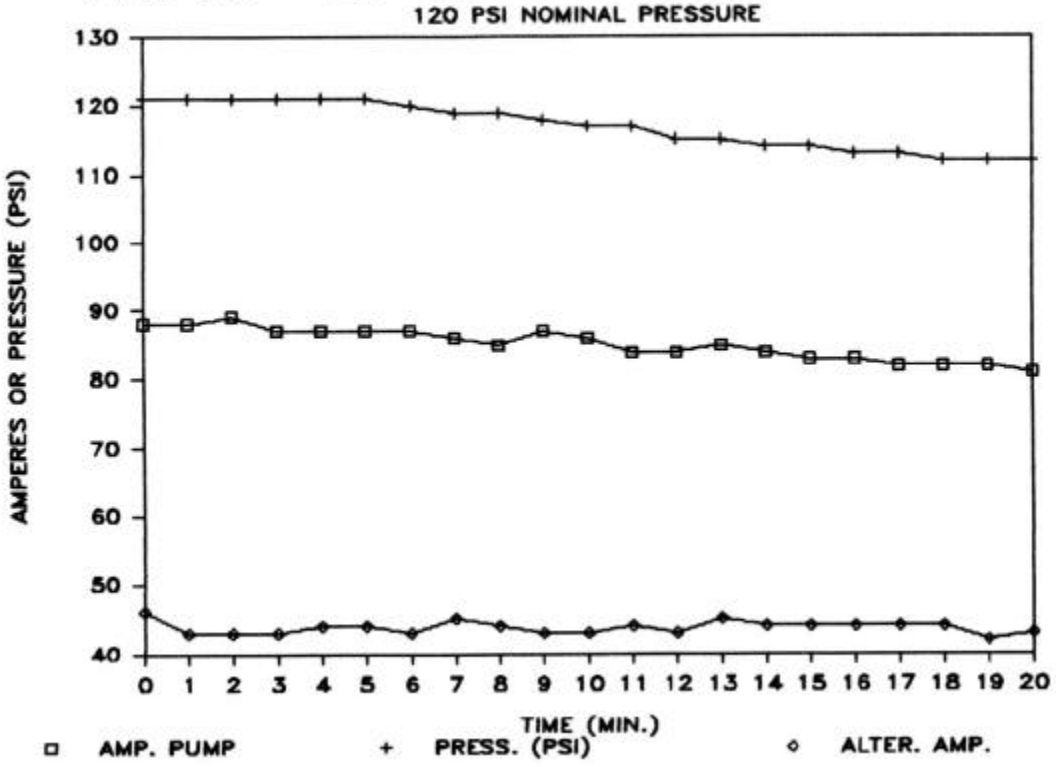

FIG. 6B 20 MIN. CONTINUOUS PUMPING

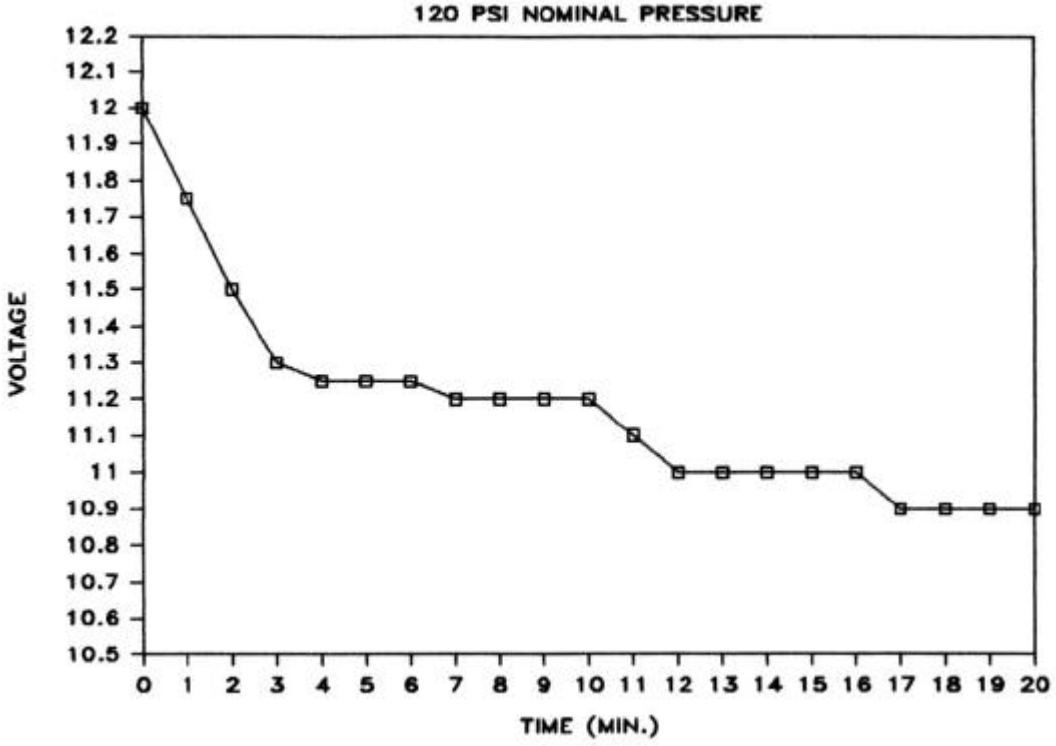

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FIG. 7A 20 MIN. CONTINUOUS PUMPING

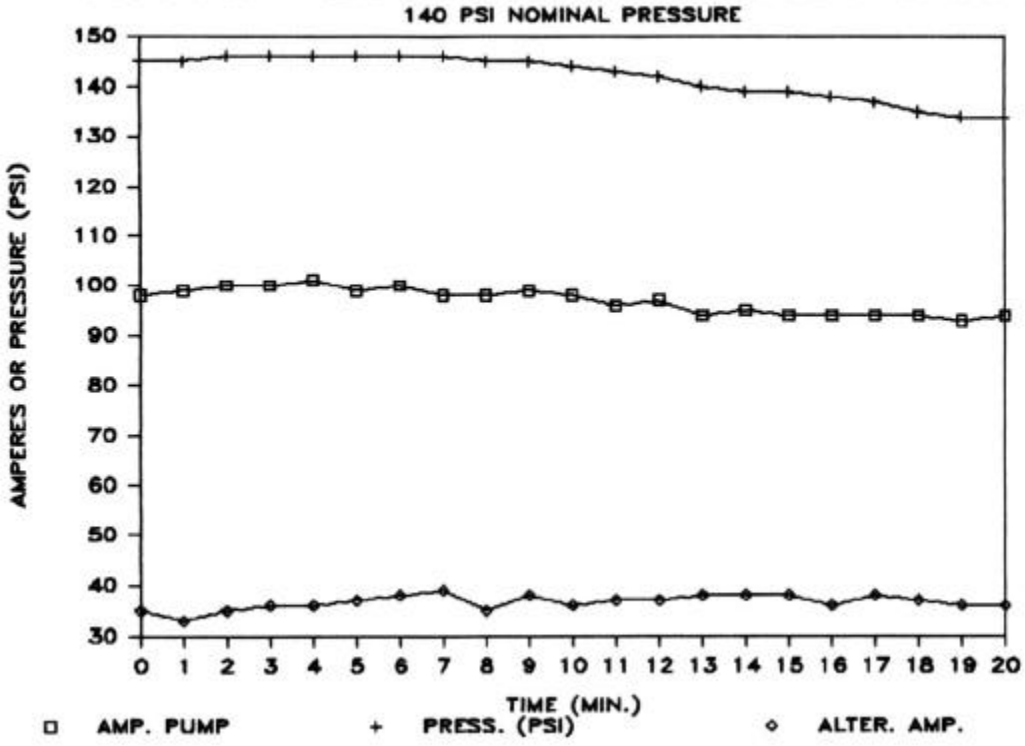

FIG. 7B 20 MIN. CONTINUOUS PUMPING

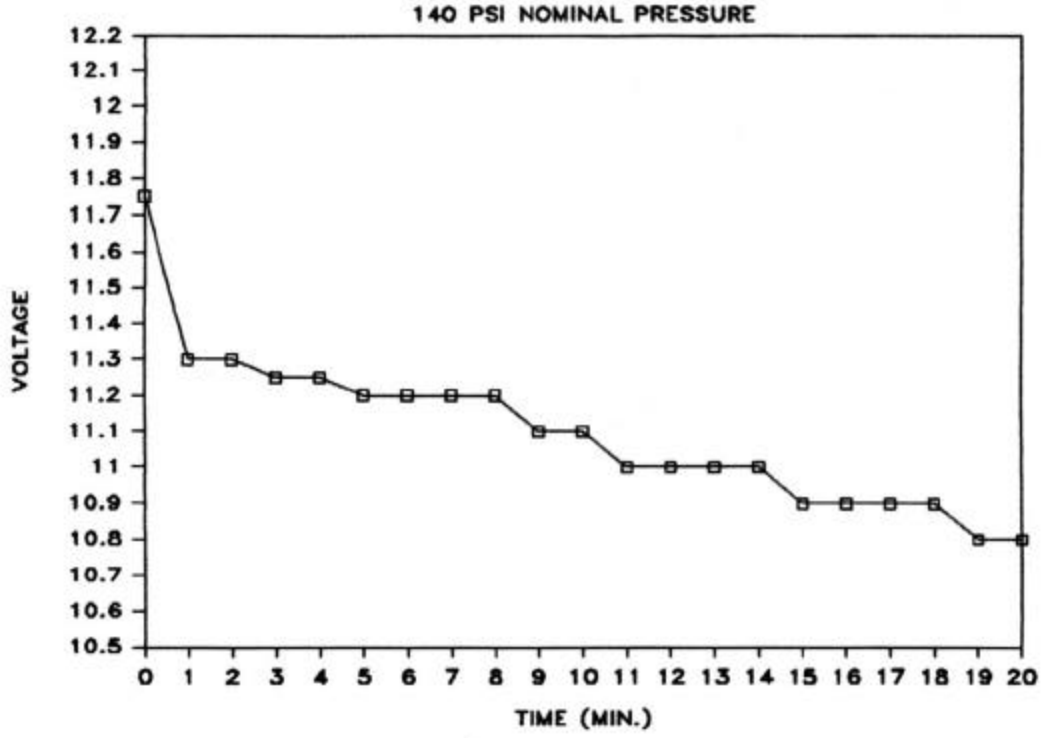

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FIG. 8A 20 MIN. CONTINUOUS PUMPING

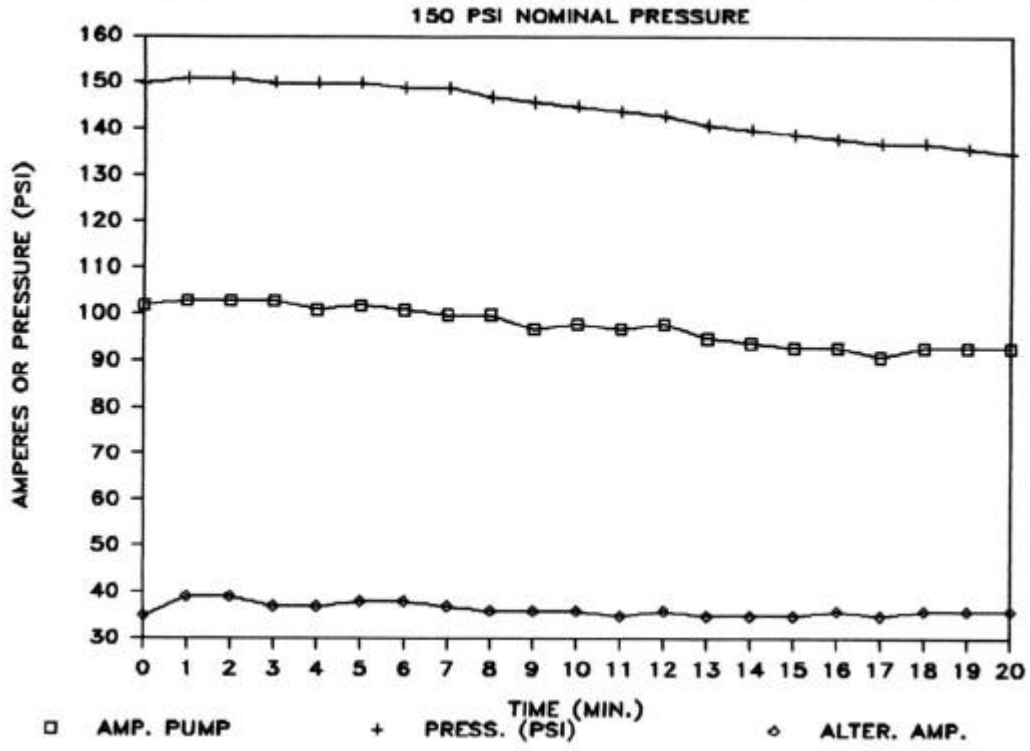

FIG. 8B 20 MIN. CONTINUOUS PUMPING

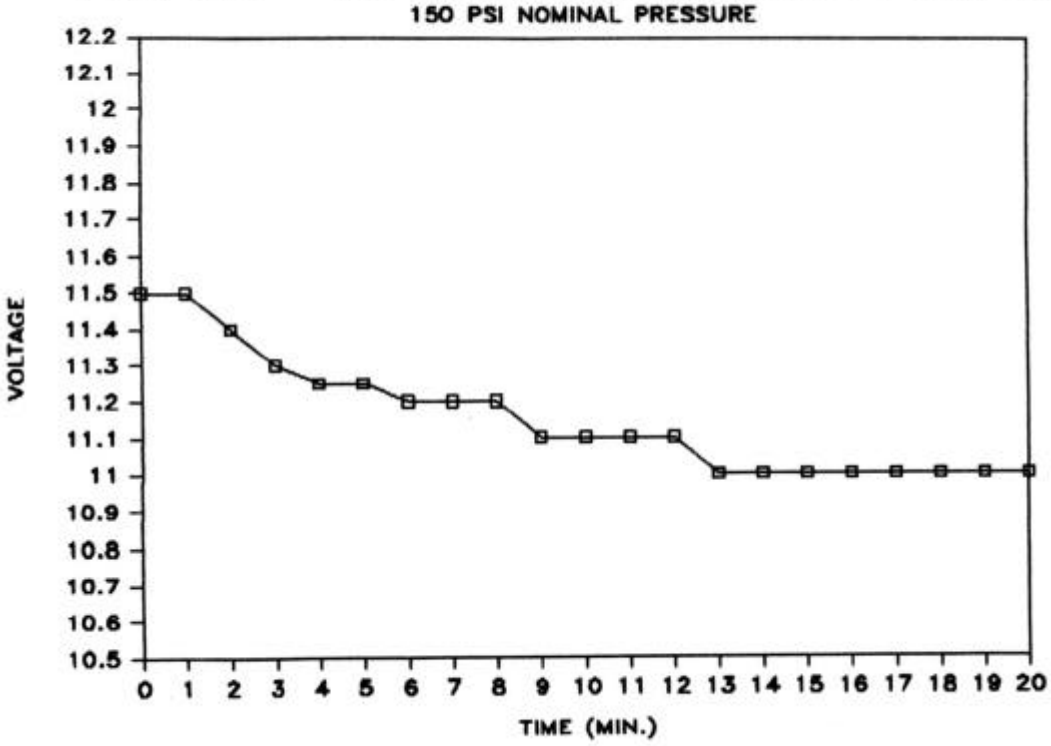

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FIG. 9A 20 MIN. CONTINUOUS PUMPING

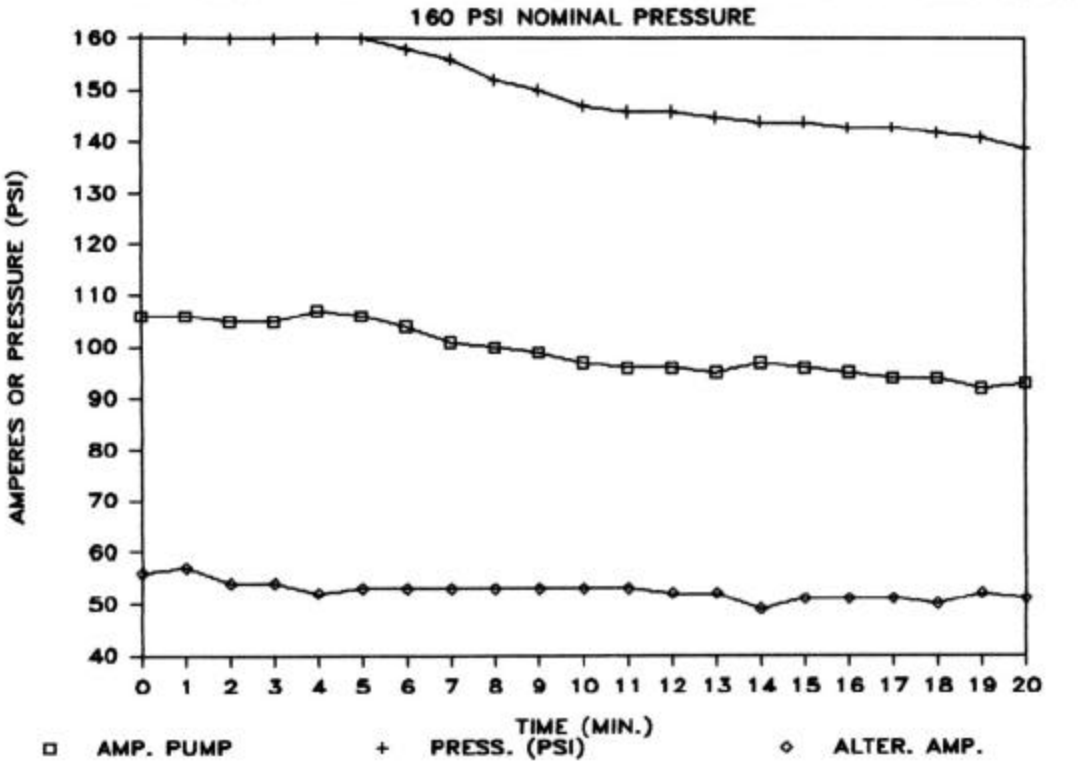
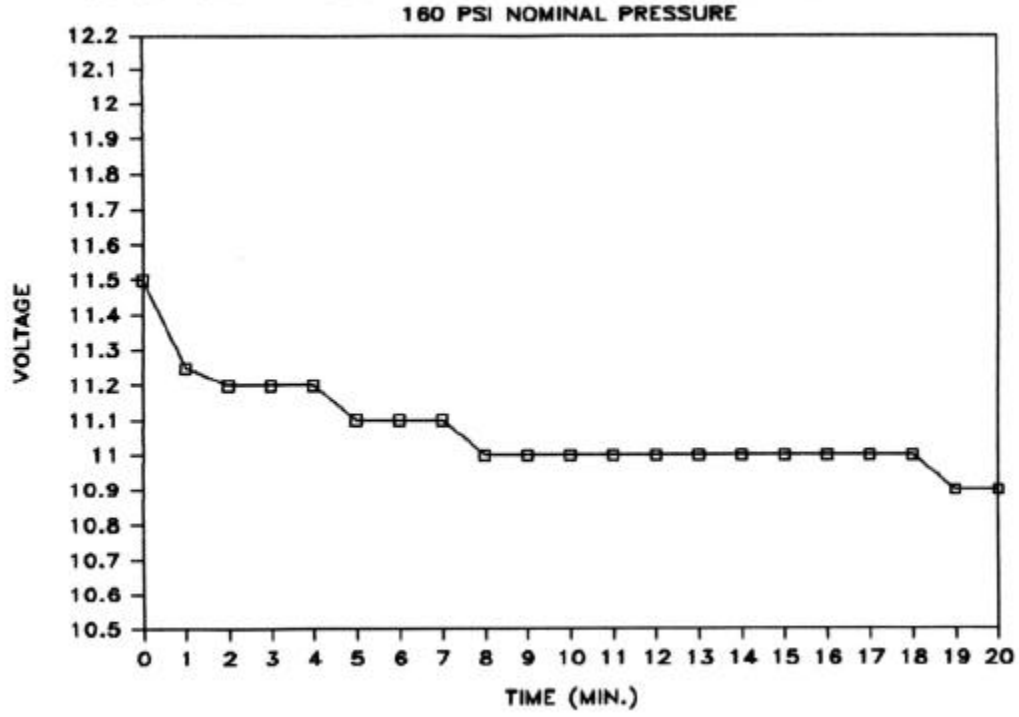


FIG. 9B 20 MIN. CONTINUOUS PUMPING



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USER'S EXPERIENCE

The laboratory could not totally answer questions about life expectancy, maintenance needs and problems associated with field use. The Florida, Minnesota, and Pennsylvania Forestry agencies provided information by their field users.

Three comments surfaced most often:

1. The nylon rollers of the Hypro pump wear due to abrasives in dirty water.

2. At times the impellers would "freeze up" after periods of nonuse, but they are relatively easy to free.

3. The other problem related to the electric power consumption of the pump. Remarks included some battery drain problems and the need to install larger alternators, engine throttle controls, and deep cycle batteries. Further discussion concerning the design of an adequate electrical system for this pump follows in the conclusion.

The durability of the electric motor seems very adequate. Motor maintenance was not a problem according to users.

The pressure switch did not give us any significant problems during the tests. Users have reported a need to replace the switch every few years. It does not cost much and can be obtained locally.

CONCLUSIONS

The Aqua-Duk will perform adequately for light wildfire situations. Each agency will need to evaluate the performance data and user's comments contained within this report versus data from other small pumping systems to determine whether the 12-volt Aqua-Duk meets their needs. The primary use of this pump will be in conjunction with automotive type vehicles where 12-volt electric systems are in place.

The Aqua-Duk can adequately draft to heights of at least 12 feet for filling small tanks. The manufacturer says the pump will lift up to 14 feet. We anticipate that it will be used in conjunction with tanks of about 100 gallons average size. Fill time will be about 8 minutes. The user may find that in line strainers and periodic cleaning of the inside of tanks may help prevent roller wear associated with roller pumps.

Most of the pump parts are readily available and inexpensive. The electric motors could be an expensive repair, but it appears reliable according to user experience.

The Hypro 4001N pump is rated for a maximum 1800 rpm, according to the manufacturer. The electric motor is rated at 2600 rpm. In the Aqua-Duk system, the pump is being run over speed. Hypro indicated that this may cause cavitation erosion or increased wear. Since the wildfire situation calls for intermittent use, this may not be a problem. Users reported no repair problems related to cavitation.

The continuous pumping trials were conducted to give the potential user some frame of reference about battery drain. Variations will occur during use depending upon the alternator's output, the pressure needed, and the frequency of use that the situation demands.

Some comments need to be made to complete the analysis of this pump. A primary concern of the user must be the electric power consumption. Figures 10 and 11 show the horsepower and efficiency curves for the total motor-pump assembly. The information was calculated from the pump performance trials. The maximum efficiency reached about 30 percent at 60 psi. This is quite low. We recommend that several changes be made to the automotive electric system when using this pump.

FIG. 10 HORSEPOWER VS. PRESSURE

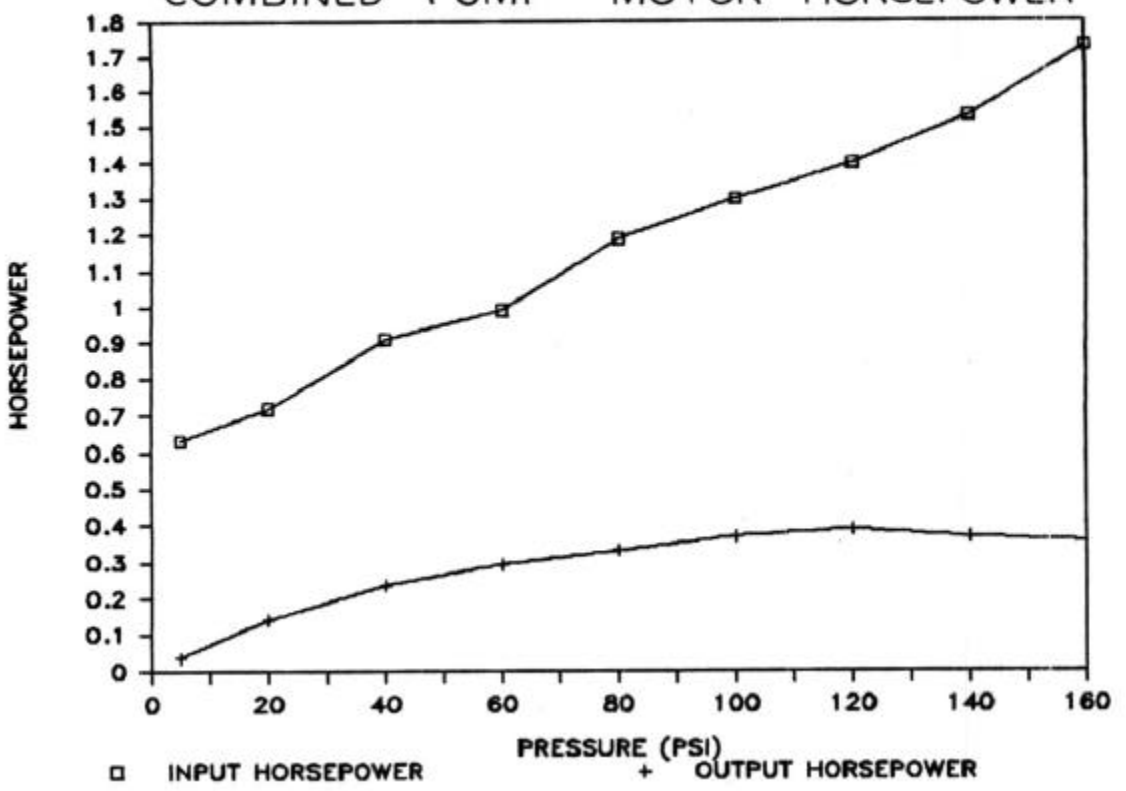

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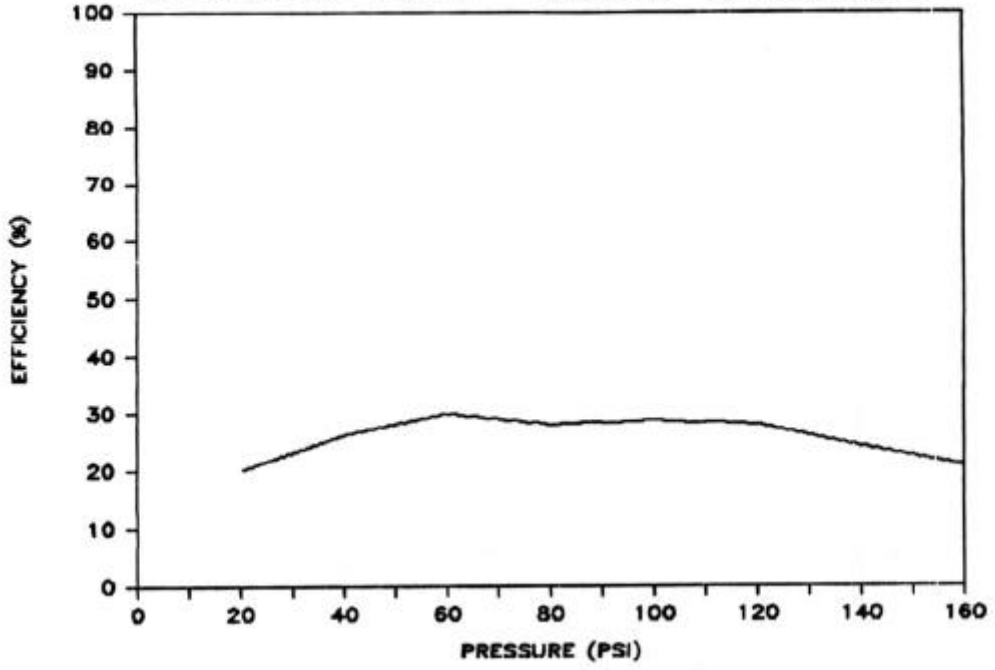
FIG. 11 EFFICIENCY VS. PRESSURE



First, the pump should operate on its own 12-volt battery. This battery will discharge quickly under some operating conditions and should be isolated from the vehicle's starting battery. In short, an auxiliary battery will be necessary and a battery isolator should be used to prevent discharge of the starting battery if the engine is not operating. Battery isolators are available at auto parts or recreation vehicle dealers. Battery isolators may not be suitable for positive ground electrical systems.

Secondly, the auxiliary battery should be of the marine deep-cycle type. Deep-cycle batteries have thicker plates than ordinary starting batteries. The thicker plates allow for many more recharging cycles before the plates deteriorate and the battery fails. Because of the high current draw of the Aqua-Duk, the battery will be drawn down during use and will need to be recharged by the alternator. The slight additional cost of the deep-cycle battery will more than be recovered.

Thirdly, an alternator of at least 60 amps would seem advisable. In order to get maximum charging from the alternator, a hand throttle for the vehicle's engine would be useful. Using the pump without the vehicle's motor operating is not advisable unless an emergency warrants it.

The user will need to consider the additional cost of these additional electrical components. We expect that the need for only minimal maintenance to the pump and motor will offset the extra cost of installing an adequate electrical system.

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