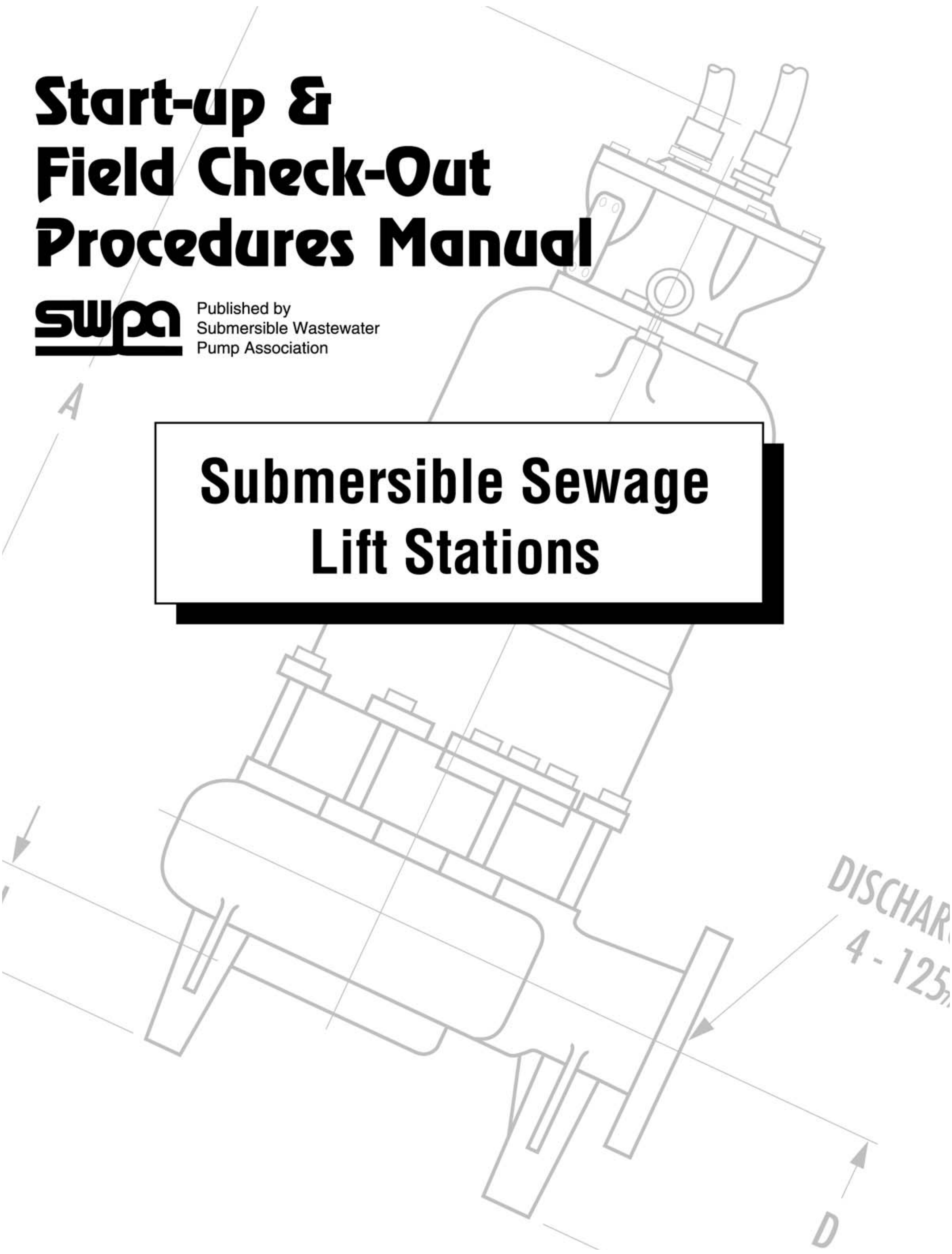
Start-up & Field Check-Out Procedures Manual

Published by
Submersible Wastewater
Pump Association

Submersible Sewage Lift Stations



SUBMERSIBLE WASTEWATER PUMP ASSOCIATION

WHO WE ARE...

The Submersible Wastewater Pump Association (SWPA) was founded in 1976 to represent and serve a growing industry. One of its initial goals -- and still one of its primary goals today -- is to increase the acceptance and sales of the industry's products which are defined as *"submersible wastewater pumps that can efficiently handle solids."*

SWPA represents its members and the industry with numerous groups involved in the selection, installation, and use of industry products.

SWPA is the focal point of the industry's communications network. The association acts as a data center for the industry.

As an essential part of its services, the association provides for a pooling of skills and know-how of submersible wastewater pump manufacturers and the manufacturers of component parts and accessory items for those pumps and pumping systems.

AND WHAT WE DO...

SWPA HAS THREE MAJOR ACTIVITY AREAS:

GUIDELINES -- SWPA works with standards and code development organizations to encourage wider acceptance of submersible pumps in wastewater applications. These efforts are aimed at developing voluntary product guidelines for effective product use.

EDUCATION -- SWPA informs specifiers and users about the workings and benefits of submersible wastewater pumps, thereby representing the interests of its members in the public interest.

PROMOTION -- SWPA encourages the use of submersible wastewater pumps in municipal and industrial applications to increase their acceptance and build the industry.

FOR ADDITIONAL INFORMATION ABOUT THE ASSOCIATION AND IT'S SERVICES, CONTACT:
SUBMERSIBLE WASTEWATER PUMP ASSOCIATION
1866 SHERIDAN ROAD, SUITE 201 ● HIGHLAND PARK, IL 60035-2545
PHONE: 847.681-1868 ● FAX: 847.681.1869
E-MAIL: SWPAEXDIR@TDS.NET ● WEB SITE: WWW.SWPA.ORG

Start-up & Field Check-Out Procedures Manual

Published by
Submersible Wastewater
Pump Association

Submersible Sewage Lift Stations

Submersible Wastewater Pump Assocation

Disclaimer

All ideas, recommendations, methods, techniques, training, or subjects mentioned in this publication are for information and educational purposes only. Because of the intangible and external influences that may bear on the use of these ideas and suggestions in any application and the absolute necessity for a totally integrated planning effort, the authors and publishers make no promises and accept no responsibility for the manner in which any of the information provided or contained herein may be applied, nor for the adverse effects that may result therefrom.

Printed in the United States of America

TABLE OF CONTENTS

Warnings, Cautions, and Symbols

The products and procedures described in this document, like all products using electrical current, can result in harm if not used with EXTREME CAUTION and in strict accordance with manufacturers' instructions. Seek professional assistance if in doubt.

Although every effort has been made to present comprehensive information, the Submersible Wastewater Pump Association is not responsible for and expressly disclaims all liability for the negligence and damages of any kind, whether direct, indirect or consequential arising out of use, reference to, or reliance on this publication.

No Guarantees or Warranties, Including any Expressed or Implied Warranties of Quality, Merchantability or Fitness, are made by the Submersible Wastewater Pump Association with respect to this document.

Safety Signs, Labels and Symbols

A*NSI Z535.4-1991, "Product Safety Signs and Labels,"* and *ANSI Z535.3-1991, "Criteria for Safety Symbols"* published by the National Electrical Manufacturers Association (NEMA)*, include these appropriate definitions which are followed in this publication:

DANGER: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

** For information on ANSI, NEMA and other standards setting organizations, see page 30.*

Note: **DANGER** or **WARNING** should not be considered for property damage accidents unless personal injury risk appropriate to these levels is also involved. **CAUTION** is permitted for property-damage-only accidents.

Symbol/Pictorial: A graphic representation intended to convey a message without the use of a word or words. It may represent a hazard, a hazardous situation, a precaution to avoid hazard, a result of not avoiding a hazard, or any combination of these messages. *(See ANSI Z535.3-1991, Criteria for Safety Symbols.)*

Introduction

The Technical Committee of the Submersible Wastewater Pump Association (SWPA) began developing a formalized *Start-Up and Field Check-Out Procedure* document for use in the field during 1995. Committee members did not feel that a simple form was necessary because pump manufacturers represented on the committee already had their own checkoff documents. What they did feel was needed in the field was a *"how to"* training guide with an explanation of *"here's why you're doing it"* for use when starting up a lift station.

The committee's intent was to establish a procedure, not to publish a fill-in-the-blank form. The goal was to develop different levels of procedures, based on equipment available, to be used in conjunction with the manufacturers start-up check-out document and *Pump Instruction and Operation Manual (IOM),* **not in place of it.**

As the initial phase in the project, a basic outline of the step-by-step procedures to put a lift station into service was developed. That outline was then expanded into this book which lists start-up and check-out procedures at three separate levels, based on test equipment available.

Procedure A1 -- *Using a Multimeter*

Procedure A2 -- *Using a Multimeter and a Clamp-On Ammeter*

Procedure A3 -- *Using a Voltmeter, a Clamp-On Ammeter, and a Megohmmeter*

In addition, procedures for flow and performance (flow and head) evaluations were developed and are included in this publication:

Procedure B1 -- *Flow Evaluation Using a Watch Displaying Seconds*

Procedure B2 -- *Performance (Flow and Head) Using a Watch Displaying Seconds and a Pressure Gauge*

This Manual also includes a listing of periodic station checks and inspections, notes on operation and maintenance, a sample Start-Up Report Form, simple guidelines concerning a Station Log Book and Log Book Forms, information about standards setting organizations and a glossary of commonly used terms.

Finally as a reference tool, this Manual includes a drawing and SWPA's *Common Terminology for the Components of a Typical Submersible Pump Station.*

Originally printed in 1998, this publication was updated in 2001.

<u>PROCEDURE A1</u>

Start-Up and Check-Out Procedures Using a Multimeter

Inspect the pump(s) for external damage prior to installation in the wet well.

Follow steps 1 through 8. Corrective action must be taken <u>before</u> energizing the pump(s) if any deficiencies are identified.

When a multimeter is available for start-up and check-out, follow these steps:

Perform steps 1 through 5 with the pump power cables disconnected from the control panel.

STEP 1. Check every inch of the power and sensor cables for damage which could allow short circuits or water intrusion. Repeat this inspection for all level switch cables.

STEP 2. Check the pump for external damage. Inspect the hardware for tightness and for damage related to rough handling.

STEP 3. **The motor power cables should not be connected to the control panel when this step is performed.** Check the impeller manually for free rotation. Use **extreme caution** when checking free rotation on grinder pumps. Always wear heavy gloves to help prevent injuries from cutter blades on grinder pumps.

STEP 4. ***<u>ON THE CONTROL PANEL</u>:*** Prior to connecting the panel to the incoming service power, check each wire termination to verify that transportation vibration has not loosened any wiring screws. Verify incoming power for proper voltage and phase. Follow the schematic diagram in the manufacturer's *Pump Instruction and Operation Manual* to verify proper wiring and to become familiar with the control logic of the system. Check the electrical rating of the panel and compare it to the pump for proper voltage and phase prior to connecting the motor leads to the panel. Check the amperage rating of the overloads to insure that they are compatible with the horsepower and current draw characteristics of the pump.

STEP 5. ***<u>ON THE PUMP (S)</u>:*** Using a **multimeter**, check the winding resistance and compare it to information in the *Pump Instruction and Operation Manual*. Check the continuity and resistance to the ground lead and to exposed metal surfaces on the pump. The reading should show a closed or continuous circuit to ground and an open circuit through the windings. Check the panel supply voltage (before the panel) and at the motor lead terminal blocks. Check each level switch with the multimeter for continuity when manually activated.

With a pump(s) that is (are) provided with a moisture sensor(s), check the continuity from the sensor(s) to ground. *This should be an open circuit*.

NOTE: Some pumps have resistor(s) built into the moisture sensor probes. Resistance checks should be made using the leads in the control cables. Refer to the manufacturer's *Pump Instruction and Operations Manual* for specific resistance readings. With a pump(s) provided with internal thermal switches embedded in the stator windings, check the continuity between the sensor leads. *This should be a closed circuit*. Check the continuity between the temperature sensor lead(s) and the pump motor ground wire. *This should be an open circuit.*

Perform Steps 6 through 9 with the pump power cables connected to the control panel.

STEP 6. Terminate leads in the control panel according to the schematic diagram and verify the connections when completed. Check each termination for loose screws. On three-phase pumps, verify the proper rotation of the impeller by momentarily jogging the start circuit and *OBSERVING* the direction of rotation. *Do not touch or approach the pump until the impeller has stopped rotating and the motor disconnect (breaker) is switched to the off and locked out position.*

- If the pump is rotating in the wrong direction, swap any two power leads of a three-phase motor at the terminal board of the panel. Do not swap the ground lead.

- To change the rotation of a single-phase pump motor, contact the manufacturer.

If questions arise, contact the pump manufacturer for *specific* instructions. With only the control circuitry energized, verify proper level switch operation and logic prior to lowering the switches into the wet well. Observe that the pump contactor actuates properly on simulated rising levels and shuts off on simulated falling levels.

STEP 7. Install the pump(s) and level switches in the wet well. Never pick the pump up or lower it into the wet well by the power or sensor cables. This could cause damage, loosen internal connections and/or cause leakage. Verify that all connections to the piping are tight and that the pump(s) is (are) positioned properly. Verify that the level switches are properly positioned (off is the lowest, the first on, then lag on [if provided], then high level alarm [if provided]).

STEP 8. If all checks are satisfactory, install the conduit seal around the cables in the conduit entering control panels and junction boxes to prevent wet well gases from migrating up the conduit and damaging the control panel.

STEP 9. Place the station into automatic operation and observe for several pump down cycles to verify proper function. Lock the access cover and control panel closed.

<u>PROCEDURE A2</u>

Start-Up and Check-Out Procedures Using a Multimeter and a Clamp-On Ammeter

Extreme caution should be exercised when checking motor loads with a clamp-on ammeter*. All leads should be securely fastened. The meter should be clamped in place with the circuit “dead”. The circuit should then be energized and the reading taken. The circuit should then be de-energized prior to removing the meter from the wire. The use of a clamp-on ammeter requires familiarity with high voltage equipment and operation must be in strict compliance with the device manufacturers' instructions to operate the equipment in a safe and consistent manner.*

When a multimeter and clamp-on ammeter are available for start-up and check-out, follow these steps:

First, complete steps 1 through 9 in *Procedure A1 -- Start-Up and Check-Out Procedures Using a Multimeter.* Then, using a clamp-on ammeter, perform these additional steps:

STEP 1. With the pump running and the ammeter clamped on the black wire in the circuit, take a reading with the discharge valve fully opened and the wet well at its highest normal level. At this point, the amperage reading should not exceed the pump nameplate data for full load amperage. If the reading is above the nameplate full load amperage, investigate the cause and correct any problem prior to leaving the station in automatic operation. Record the readings in the station log book and on the start-up form from the manufacturer. For a three-phase pump, repeat step 1 for each lead.

STEP 2. On three-phase pumps, check to determine that the amperage imbalance is satisfactory. If the amperage imbalance exceeds the manufacturer’s specifications, trace and locate the cause of the problem, starting with the incoming power source. Operation with excessively unbalanced loading on the motor leads will shorten the life of the pump's motor.

STEP 3. When the pump(s) is equipped with a Variable Speed Drive (VSD), the use of a digital ammeter will result in erroneous readings because the output of the drive is not compatible with the meter display. Therefore, on VSD controlled pumps, only analog (dial type) ammeters should be used. An analog voltmeter is to be used to read the output voltage of the drive. Load readings can also be read on the drive input.

PROCEDURE A3

Start-Up and Check-Out Procedures Using a Voltmeter, a Clamp-On Ammeter, and a Megohmmeter

In addition to Procedure A1 and A2 checks, the use of a megohmmeter (either hand crank or electronic) will aid in the detection of weakened insulation in the pump and/or the attached power cable.

Prior to taking any of the steps listed in Procedures A1 and A2, a megohmmeter should be used to verify the winding insulation of the stator and the power cable connected to the stator.

It is critical that the cable and stator be checked with the pump motor leads disconnected from the control panel. This reduces the possibility of including components inside the panel which would affect the reading given by the megohmmeter.

Caution*: Using an electronic megohmmeter requires familiarity with high voltage equipment and operation must be in strict compliance with the device manufacturer's instructions to perform readings in a safe and consistent manner.*

When a voltmeter, ammeter, and megohmmeter are available for start-up and check-out, follow these steps:

STEP 1. Use a megohmmeter to measure the resistance between each pump power lead and the ground conductor. Record both the winding resistance and the winding temperature each time this measurement is performed using a multimeter. Use the temperature value to obtain a compensated megohmmeter value. Refer to the most recent version of IEEE-43 (published by the Institute of Electrical and Electronic Engineers) to calculate the temperature compensated megohmmeter values. These readings should be recorded in the station log book for future comparison for changes which would indicate that the windings/cables are deteriorating.

STEP 2. Record the readings on the start-up form provided by the pump manufacturer. Compare them to the readings given in the *Pump Instruction and Operation Manual*. The readings and date should also be recorded in the Station Log Book (See Table C, page 19).

STEP 3. Some control panel manufacturers offer an automatic pump meg-ohming function built into the panel to automatically megohmmeter check the motor after each pumping cycle. Should the reading fall below the preset trip limit, an alarm function is tripped which keeps the pump from trying to start again until the problem is corrected.

STEP 4. Follow steps outlined in procedures A1 and A2.

PROCEDURE B1

Flow Evaluation Using a Watch Displaying Seconds

General: *This procedure provides an approximate wet well inflow rate and pump flow rate calculation. Wet Well infow and pump flow can be monitored initially, recorded on the Start Up Report Form and Station Log Book for comparison at later dates to help determine changes in both station inflow or decreased pump flow.*

Note: *In order to obtain accurate readings on the flow of the pump(s), it is necessary to confirm that the discharge piping and force main are completely filled prior to the start of flow measurements.*

When using a watch displaying seconds, follow these steps to obtain a flow evaluation:

STEP 1. In order to make computations on the wet well inflow and the pump flow, it is necessary to determine the number of gallons per foot of depth of liquid held by the wet well. Table A provides approximate values for gallons per foot for standard diameter wet wells without guide rail(s) or other equipment installed. Therefore, these calculations should be made at sections of the wet well where this equipment stays submerged or is never submerged during the timing phase.

Table A
Volume Per Foot of Standard Direction Wet Wells

Wet Well Diameter FT	(mm)	Gallons/Foot of Depth of Liquid	(Liters/M)
2	(600)	24	(300)
3	(900)	53	(700)
4	(1,200)	94	(1,200)
5	(1,500)	147	(1,800)
6	(1,800)	212	(2,600)
8	(2,400)	376	(4,700)
10	(3,000)	588	(7,300)
12	(3,600)	846	(10,500)

STEP 2. Using the values for volume per foot shown in Table A, use a watch displaying seconds to record the time required to fill the wet well one foot *(no pumps*

should be running during this process). On fast filling stations, it may be necessary to record the fill rate at increments greater than one (1) foot (300mm). This will make the calculation more accurate on incoming flow rate. The ideal fill time should be in the range of 1/2 to 1 minute to make calculation simple. *An example is shown in Table B, below.*

The pumping rate should not change over time, except where it varies with the number of stations connected to the force main. It is not the purpose of this test to calculate multiple station interaction.

This calculation assumes a steady flow rate on influent and gives an average pump flow rate over the depth used.

Table B
Calculation Example of Time Required to Fill the Station

A five foot (1500 millimeters) diameter wet well has duplex pumps installed, with 4 feet (1200 millimeters) free volume above the pumps. It takes 5 minutes to fill this 4 foot (1200 millimeters) volume, and 3 minutes to pump down the same 4 feet (1200 millimeters) along with the inflow during that period (one pump runs). *What is the inflow rate into the station? What is the pumping rate?*

Since the station is five (5) feet (1500 millimeters) in diameter, the volume per foot (millimeters) (from Table A) is 147 gallons per foot (1800 liters per meter).

4 feet (1200 millimeters / 1000 millimeters per meter) x 147 gallons per foot (1800 liters per meter) = 588 gallons (2160 liters)

Inflow Rate Calculation:

588 gallons (2160 liters) in 5 minutes gives:

588/5 (2160/5) = 118 gallons per minute (432 liters per minute or 7.2 liters per second)

Pumping Rate Calculation:

First calculate the number of gallons (liters) that came in during the time required to pump the station down.

3 minutes x 118 gallons per minute (432 liters per minute) = 354 gallons (1296 liters)

Then:

Pump Output = Total inflow for given time period + Total volume pumped down

Pump Output = 354 gallons (1296 liters) + 588 gallons (2160 liters) completed in 3 minutes

Pumping Rate = 942 gallons (3456 liters) / 3 minutes

Pumping Rate = 314 gallons per minute (1152 liters per minute or 19.2 liters per second)

PROCEDURE B2

Performance (Flow and Head) Evaluation Using a Watch Displaying Seconds and a Pressure Gauge

WARNING: *CAUTION should be exercised when closing the isolation valve because some types of pumps cannot operate against a closed discharge.* *Do not operate pumps that contain warnings regarding operation with closed discharge valves because damage and/or injury could result.* *Closely review the* **Manufacturer's Pump Instruction and Operation Manual** *for warnings regarding operation with closed discharge valves.*

Should the pump not be suitable to operate with a closed discharge valve, the steps in this procedure should be skipped and the pump manufacturer contacted to provide a factory test curve for the pump(s) installed. In such cases, proceed to **Periodic Station Checks and Inspections** *(page 18).*

A pressure gauge can assist in the field trial and start-up of a typical submersible pumping or lift station. In its most simple application, the gauge can be used to determine the "shutoff head" or zero flow point produced by the pump(s) which can be used to check that the pump(s) is operating according to its published performance curve.

When using a watch displaying seconds and a pressure gauge, follow these steps to obtain a performance evaluation:

STEP 1. To determine the shutoff head of the pump, the pressure gauge should be connected at Pressure Tap "A" (see Figure 1, page 17) between the pump and the check valve, while being accessible to the free liquid level of the wet well for ease of evaluation.

First, operate the pump with the isolation valve fully open to establish flow. *Then,* slowly close the valve to the zero flow position. Quickly read the gauge, record the reading as raw data, and reopen the valve. Convert the pressure reading from PSI to Feet of water. Use the formula:

Feet of water = PSI x 2.307

STEP 2. Determine the discharge elevation head (Z_d) once the shutoff data reading has been taken in the wet well. The discharge elevation head (Z_d) is the distance from the gauge centerline to the free liquid level (See Figure 1). This value is calculated using the formula below:

Z_d = (head on manufacturer's curve for zero flow rate)
— (shut off data reading on the pressure gauge)

To complete a Pump Performance Evaluation, follow the steps outlined in Procedures A1, B1 and B2. Following the steps below will create a set of points which will make up the pump head vs. capacity curve and electrical performance vs. capacity curve.

STEP 3. Open the isolation valve to the fully open position in a number of incremental steps as required to develop a curve. At each position, document the flow rate as outlined in Procedure B1.

STEP 4. To obtain the Total Head (TH) of the pump, the gauge head (h_g), the velocity head (h_v) and the discharge elevation head (Z_d) are added as follows:

$$TH = h_g + h_v + Z_d$$

where: h_g = Gauge Reading
$h_v = 0.00259\ (GPM^2/D^4)$
Z_d = Elevation from Figure 1

Calculate and record TH at each position of the isolation valve.

NOTES: 1) D equals pipe inside diameter at the pressure gauge tap in inches.
2) TH, $h_{g,}$ $h_{v,\ and}$ Z_d are expressed in units of feet

STEP 5. The accumulated data can now be plotted against the manufacturer's performance curve.

NOTES: 1) Procedure B1 is intended to give the user an approximation of pump performance. Field conditions should not be expected to duplicate factory test results. Variations in flow measurement accuracy, RPM, voltage, and friction losses can cause varying test results.

2) The readings taken should be recorded on the Station Start-Up Report Form and the Station Log Book referred to from time to time to determine if changes have occurred with the pump which would warrant service.

***WARNING:* Gauges can become damaged if left connected to the piping system.**

TROUBLESHOOTING

A. *If there is little or no flow:*

With the pump off, remove the gauge from the valve (Pressure Tap A, Figure 1) and place it behind the isolation valve (Pressure Tap B, Figure 1). If the reading is higher than the pump shutoff head (zero flow rate), as shown on the pump manufacturer's performance curve, this means that the static head of the system exceeds the pump shutoff head, and the pump will not deliver any flow. Consult the system designer if this occurs.

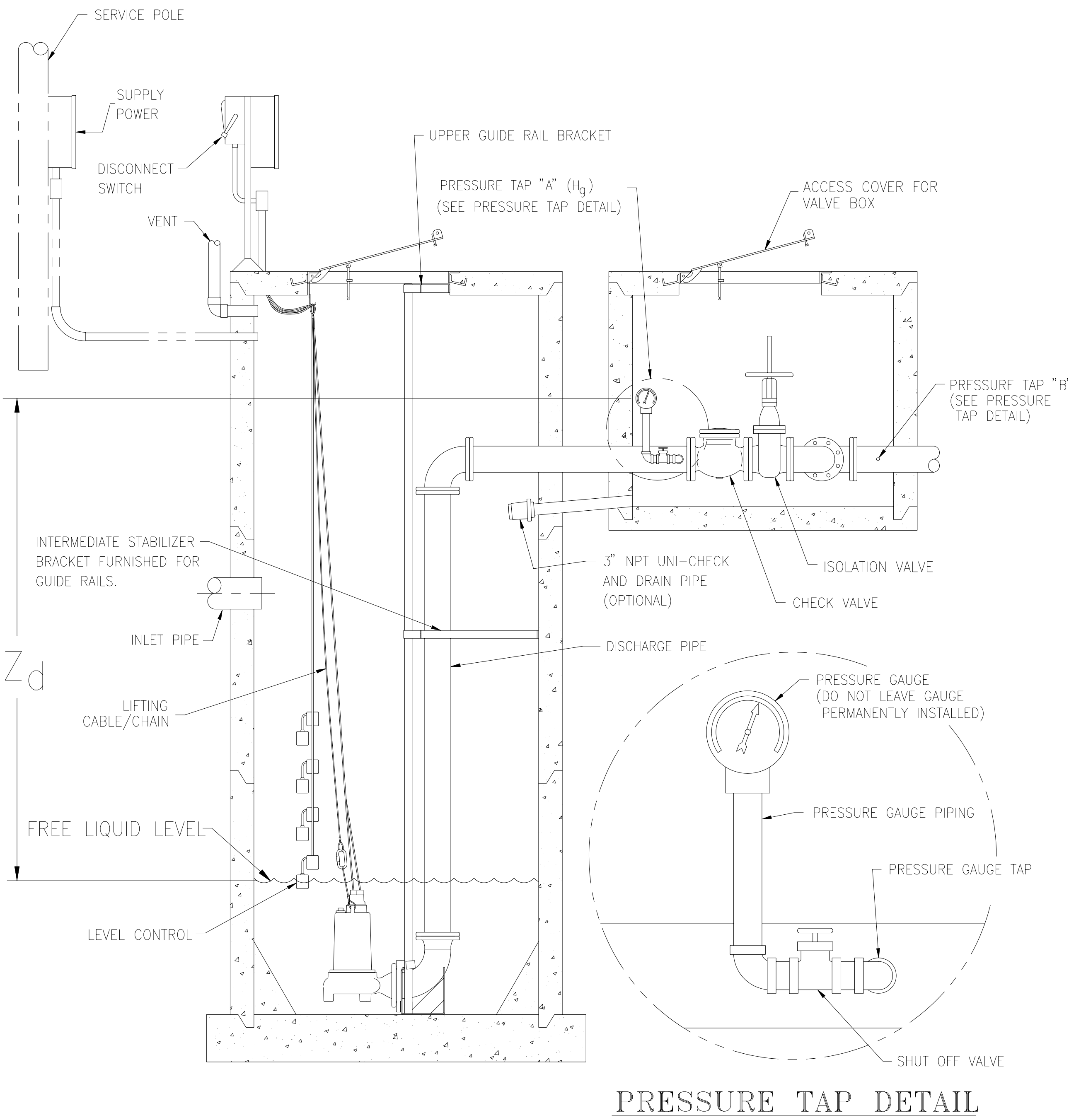
B. *If head and/or flow rate is off by 10% or more:*

1) Look for leaks in the connections between the discharge elbow and Pressure Tap A, Figure 1.

2) Check the direction of rotation. Submersible pumps will produce some head even when rotating backwards. The pump also may make additional noise and amps will be higher than usual. To determine if the pump is rotating backwards, refer to Procedure A1, Step 6. The pump must be out of the wet well and on a level surface when this check is performed.

3) Review the installation and start-up section of the *Manufacturer's Pump Instruction and Operation Manual* to determine other potential solutions.

Figure 1
Typical Submersible Pump Station



Courtesy: Zoeller Engineered Products

PERIODIC STATION CHECKS AND INSPECTIONS

Weekly station checks should be performed and data recorded in the Station Log Book (see page 24). Certain visual inspections should be made, amperage readings should be taken and recorded, and megohmmeter checks should be made.

In making station checks and visual inspections, when taking amperage readings, and in making megohmmeter checks, follow these steps:

STEP 1. **Conduct weekly performance checks by recording the running time of each pump in the Log Book (if hour meters are provided).** This will allow analysis comparing relative time of operation and possible increased pump wear or station inflow changes. In a station with multiple pumps designed for all pumps to be run evenly, pump hour meters can be used to detect system problems specifically when uneven run times are recorded. Time to pump down should be measured and recorded for each pump. All pump down times should be equal, at equal amperage loads. If not, determine the cause and correct the deficiency. If the impeller and pump housing are not excessively worn, the reason could be as simple as a partially clogged impeller or rotation in the wrong direction. Worn parts cause the run time per cycle to increase from month to month. Once wear starts affecting performance, the operating cost increases.

STEP 2. **Making Visual Inspections:** If the pump connection is worn or is not sealing properly, leakage at the discharge connection will cause the wet well to become agitated each time the pump runs. When this happens, the pump causing the agitation should be removed and inspected. If the pump checks out satisfactorily, then the discharge connection could be the problem. *Correcting a problem with the discharge connection should never be done with the station in service*. The station should be removed from service, bypassed, and entered only by qualified individuals following all confined space entry requirements and regulations. (*See* ***Occupational Safety and Health Standards for General Industry*** 29 CFR PART 1910.120(b)(4)(ii)(i)(c)(3), Confined Spaces, Hazardous Work).

STEP 3. **Taking amperage readings:** Weekly amperage readings recorded in the Station Log Book can identify changes in pump performance due to clogging and wear. The amperage readings could go down or up with a partially clogged impeller. The readings could increase if a restriction is wedged between the impeller and casing components causing drag on the impeller. The readings could decrease due to a restriction of full flow through the pump, which does not drag on the casing or impeller. As the flow is reduced, the work that the motor must do is reduced which, in turn, lowers the amperage reading.

STEP 4. **Making megohmmeter checks**: In general, the temperature compensated megohmmeter values should not change very much from month to month (See Table C). These can easily be compared when recorded in the Station Log Book. Meg values vary with design characteristics and among motor manufacturers. The values shown in Table C represent one manufacturer's suggested values. Contact your manufacturer for acceptable megohmmeter values. If moisture gains access to the inside of a pump motor or pump power leads, the readings will start declining and then fall drastically with a totally damp interior. The pump motor will continue to run with very low readings. Time until failure will be very short. If the pump motor is removed and serviced prior to total failure of the windings, it is likely that the situation can be corrected by baking the stator and replacing the components which allowed the water to gain access to the inside of the pump. If the pump continues to operate until total failure, then a complete rebuild will be necessary. For service information, contact the pump manufacturer for specific recommendations.

Table C
Insulation Resistance Readings

CONDITION OF MOTOR LEADS	OHM VALUE	MEGOHM VALUE
A new motor (without drop cable).	20,000,000 (or more)	20.0
A used motor which can be reinstalled in the well.	10,000,000 (or more)	10.0
MOTOR IN WELL. Ohm readings are for drop cable plus motor.		
A new motor in the well.	2,000,000 (or more)	2.0
A motor in the well in reasonable good condition.	500,000 - 2,000,000	0.5 - 2.0
A motor which may have been damaged by lightening or with damaged leads. Do not pull the pump for this reason.	20,000 - 500,000	0.02 - 0.5
A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will not fail for this reason alone, but it will probably not operate for long.	10,000 - 20,000	0.01 - 0.02
A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced.	less than 10,000	0 - 0.01

Courtesy: Franklin Electric Company, Inc.

Notes on Operation and Maintenance

Regular inspection and preventive maintenance will insure continued, reliable operation of the entire submersible pump station. All stations, pumps, and operating equipment should be inspected at least once a year, and more frequently under severe operating conditions. All equipment in the station should be backed by manufacturers' service manuals. This material should be carefully read and filed and should be consulted whenever servicing is required.

In conducting regular inspections and preventative maintenance, be sure to follow the manufacturer's recommendations (pump, control panels, valves, etc.) as well as appropriate safety precautions to minimize the risk of accidents.

Before starting work, make sure the pump and the control panel are isolated from the power supply and that neither can be energized.

For additional information on Operation and Maintenance, including a "Trouble Checklist" of common problems and their probable causes, consult ***Submersible Sewage Pumping Systems (SWPA) Handbook*** *(See pages 30-31).*

START-UP REPORT FORM

Most pump and panel manufacturers have special forms that can be used during the start-up of a lift station.

A sample pump manufacturer's Start-Up Report is shown on the following pages.*

Some manufacturers require that these forms be filled out and returned to ensure warranty on the pumps, control panel, and station components. This type of form provides a detailed description of the procedures and tests to be performed.

**Submersible Sewage Pumping Systems (SWPA) Handbook.*

Sample Start-Up Report Form

This report is designed to assure the customer that customer service and a quality product are the number one priority.

Please answer the following questions completely and as accurately as possible. Please mail this form to:

Manufacturer's Name
Manufacturer's Address

1) Pump Owner's Name____
Address ____
Location of Installation____
Person in Charge______________________________ Phone ______________
Purchased From____

2) Model______________________________Serial No.____________________
Voltage ______Phase_________Hertz____________Horsepower____________
Rotation: Direction of Impeller Rotation (Use C/W for clockwise, CC/W for counterclockwise) ____
Method Used to Check Rotation (viewed from bottom)______________________
Does Impeller Turn Freely by Hand _____Yes _____No

3) Condition of Equipment _____Good _____Fair _____Poor
Condition of Cable Jacket _____Good _____Fair _____Poor
Resistance of Cable and Pump Motor (measured at pump control)
Red-Black______Ohms Red-White______Ohms White-Black______Ohms
Resistance of Ground Circuit Between Control Panel and Outside of Pump______Ohms
Resistance of moisture sensor ______Ohms
Motor Heat Sensor connected and circuit enabled____Yes ____ No
MEG Ohm Check of Insulation:
Winding temperature _____ ^{o} F or ______ ^{o} C.
Red to Ground_____Ohms White to Ground_____Ohms Black to Ground_____Ohms

4) Condition of Equipment at Start-Up: Dry_______ Wet_______ Muddy________
Was Equipment Stored: ___ Yes ___ No. If YES, length of Storage: _______________
Describe Station Layout____

5) Liquid Being Pumped ____
Debris in Bottom of Station? ___ Yes ___ No
Was Debris Removed in Your Presence? ___ Yes ___ No
Are Guide Rails Exactly Vertical (plumb)? ___ Yes ___ No
Is Base Elbow Installed Level? ___ Yes ___ No

6) Liquid Level Controls: Model ____
Is Control Installed Away from Turbulence? ___ Yes ___ No
Operation Checks:
Tip lowest float (stop float), all pumps should remain off.
Tip second float (and stop float), one pump comes on.
Tip third float (and stop float), both pumps on (alarm on simplex).
Tip fourth float (and stop float), high level alarm on (omit on simplex).
If not our level controls, describe type of controls______________________________
Does liquid level ever drop below volute top? ___ Yes ___No

7) Control Panel Model No. ____
Number of Pumps Operated by Control Panel _______
NOTE: At no time should hole be made in top of control panel, unless proper sealing devices are utilized.
Control Panel Manufactured By Others: ____ Yes ____ No
Company Name____
Model No.____
Short Circuit Protection____________________________________Type ________________
Number and Size of Short Circuit Device(s)_____________________ Amp Rating _________
Overload Type ______________________ Size_________________ Amp Rating _________
Do Protective Devices Comply With Pump Motor Amp Rating? ___ Yes ___ No
Are All Connections Tight? ___ Yes ___ No
Is the Interior of the Panel Dry? ___ Yes ___ No. *If "No," correct the moisture problem.*

8) Electrical Readings:
Single Phase:
Voltage Supply at Panel Line Connection, Pump Off, LI, L2 ___________________________
Voltage Supply at Panel Line Connection, Pump On, LI, L2 ___________________________
Amperage: Load Connection, Pump On, LI __________ L2 __________
Three Phase:
Voltage Supply at Panel Line Connection, Pump Off, LI-L2 __ L2-L3 __ L3-LI __
Voltage Supply at Panel Line Connection, Pump On, LI-L2 __ L2-L3 __ L3-LI __
Amperage, Load Connection, Pump On, LI_____ L2 _____ L3 _____

9) Final Checks:
Is Pump Seated on Discharge Properly? ___ Yes ___ No
Was Pump Checked for Leaks? ___ Yes ___No
Was System Piping Checked for Leaks? ___Yes No
Do Check Valves Operate Properly? ___ Yes ___ No
Flow: Does Station Appear to Operate at Proper Rate? ___ Yes ___ No
Noise Level: ___ Acceptable ___ Unacceptable
Comments: ____

10) Describe any Equipment Difficulties During Start-Up:
____
____
____

11) Manuals:
Has Operator Received Pump Instruction and Operations Manual? ___ Yes ___ No
Has Operator Received Electrical Control Panel Diagram? ___ Yes ___ No
Has Operator Been Briefed On Warranty? ___ Yes ___ No
Name/Address of Local Representative/Distributor ___________________________________
____
____

I Certify This Report To Be Accurate. Signed By (Start-Up Person)_________________________
Employed By: ____ Date_____________
Date and Time of Start-Up____
Present at Start-Up:
( ) Engineer's Name__________________ ( ) Operator's Name ________________
( ) Contractor's Name__________________ ( ) Others _________________________

STATION LOG BOOK AND LOG BOOK FORMS

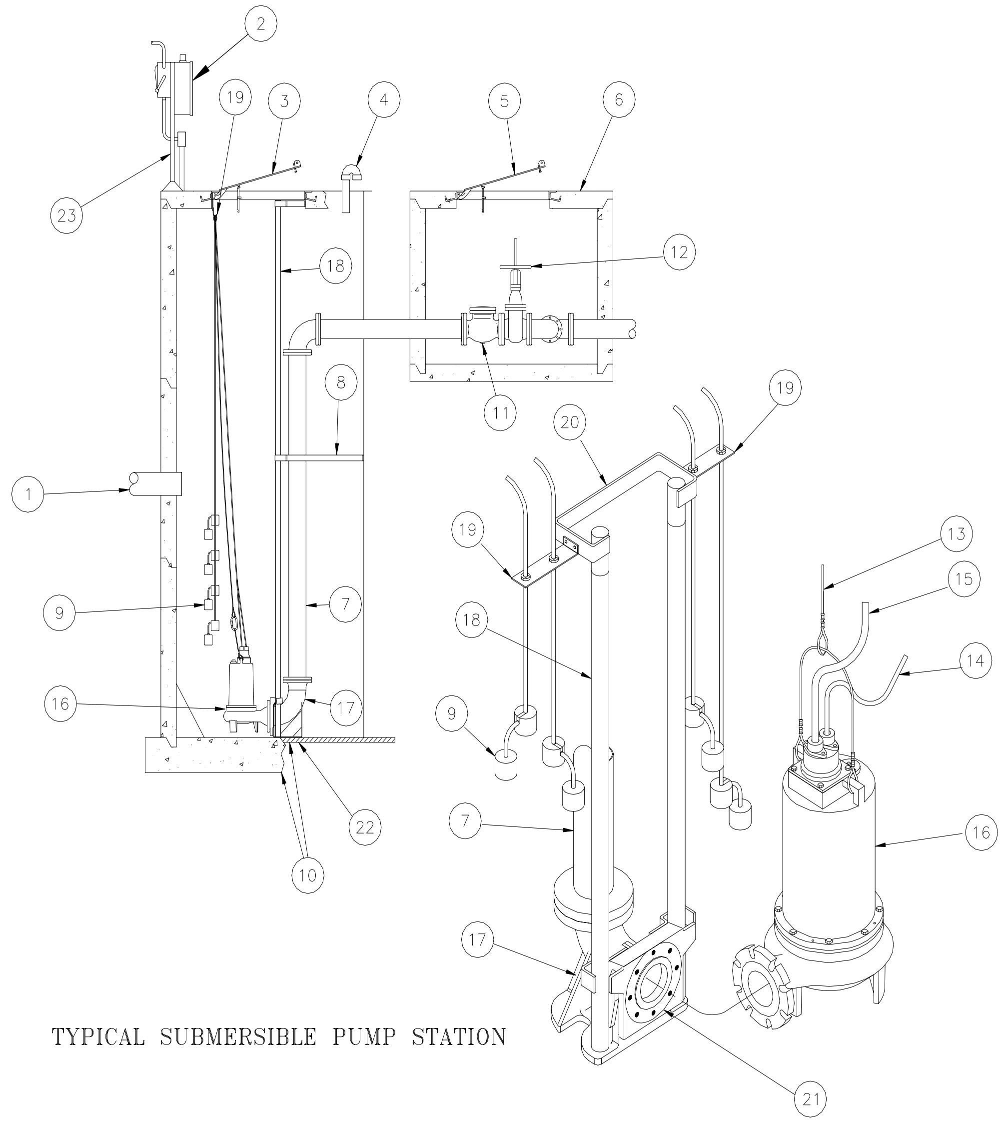
It is recommended that a Station Log Book be created based on the needs and specifics of the individual station. There is no universally accepted format for a Station Log Book and no pre-formatted forms for recording station data.

Whatever format is used, it is recommended that the Station Log Book be kept at the station in the control panel.

A daily planner type book, available in most office supply stores, offers an ideal format for a **Station Log Book**. For most stations, a standard, wirebound book, 4-7/8" x 8" page size, dated for a full year, with one weekday per page, Saturday and Sunday combined, is sufficient.

This format and size is ideal to use for recording station information and maintaining a record of periodic maintenance done on the station. The lined format allows space for comments about the station's operation which need to be noted. This might not be easily accomplished on a pre-formatted form.

The value of the Station Log is in consistently utilizing the book and noting all important information so it can be used for analysis and comparison.



TYPICAL SUBMERSIBLE PUMP STATION

COMMON TERMINOLOGY OF THE COMPONENTS OF A TYPICAL SUBMERSIBLE PUMP STATION

ITEM#	DESCRIPTION
1	INLET PIPE
2	CONTROL PANEL
3	ACCESS COVER
4	VENT
5	ACCESS COVER
6	VALVE BOX
7	DISCHARGE PIPE
8	INTERMEDIATE GUIDE RAIL BRACKET
9	LEVEL CONTROL
10	WET WELL
11	CHECK VALVE
12	ISOLATION VALVE
13	LIFTING CABLE/CHAIN
14	CONTROL CABLE/CORD
15	POWER CABLE
16	SUBMERSIBLE PUMP
17	DISCHARGE BASE ELBOW
18	GUIDE RAIL(S)
19	CABLE HOLDER
20	UPPER GUIDE RAIL BRACKET
21	SLIDE BRACKET
22	ANCHOR BOLTS
23	CONDUIT SEAL

GLOSSARY OF TERMS

Following are definitions of some of the more common systems and electrical terms used when referring to submersible sewage lift stations.
For a more complete glossary of systems and electrical terms, consult *Submersible Sewage Pumping Systems (SWPA) Handbook.*
(See pages 30-31).

SYSTEM TERMS

CAPACITY — The quantity of liquid that can be contained, or the rate of liquid flow that can be carried.

DISCHARGE — The flow or rate of flow from a pump or pumping system.

DISCHARGE DIAMETER -- The inside diameter of the discharge port of the pump as measured at the integrally cast discharge flange to the pump casting (volute).

DISCHARGE PIPE — The pipe that exits the wet well or valve box.

DRY WELL — A dry compartment in a pumping station, near or below pumping level, where the pumps are located.

DUPLEX — A pumping station containing two pumps.

DYNAMIC HEAD — The head (or pressure) against which a pump works.

EDDIES — Circular movements occurring in flowing liquid, caused by currents set up in the water by obstructions or other flows.

FORCE MAIN — A pressure pipe joining the pump discharge at a water or wastewater pumping station with a point of gravity flow.

FREE BOARD — The vertical distance between the normal maximum level of liquid in a tank and the top of the tank.

FRICTION LOSS — The head loss of liquid flowing in a piping system as the result of the disturbances set up by the contact between the moving liquid and the system components. It is a function of pipe diameter, length, surface roughness, and flow rate.

GALLONS PER MINUTE (GPM) — The volume delivered at the pump discharge flange expressed in gallons per minute (GPM). Expressed on the X axis of a pump curve.

GRINDER PUMPS — Specialized submersible pumps which mechanically disintegrate sewage.

HEAD — The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

IMPELLER — A rotating set of vanes designed to impel rotation of a mass of fluid.

INFLOW — The extraneous flow which enters a sanitary sewer from sources other than infiltration.

LIFT STATION — A system that includes pumps, tanks, appurtenant piping, valves, and other mechanical and electrical equipment for pumping water or wastewater.

LIQUID LEVEL CONTROLS — In-station devices which start or stop the pump(s) in response to the liquid level within the well when connected to a control panel.

LAG PUMP — A succeeding or backup pump in a pump system. Control systems usually alternate pump operation.

LEAD PUMP — The first pump to start in a pump cycle.

RPM — Revolutions per minute of the motor/pump rotating assembly.

STATIC ELEVATION (STATIC HEAD) — The vertical distance between the level of the source of supply and the high point in the force main or the level of the discharge to the atmosphere.

SUBMERSIBLE PUMPS — Submersible wastewater pumps are vertical, close-coupled, extra-heavy duty pump-motor units which are designed to operate under the liquid they are pumping. They are non-clogging, usually have a 3-in. or larger discharge, and are also called submersible sewage pumps. Also see Grinder Pumps.

SYSTEM HEAD CURVE — A graph showing the relationship of static head and friction head at various flow rates through a given piping system.

TOTAL DYNAMIC HEAD (TDH) — The difference between the elevation corresponding to the pressure at the discharge flange of a pump and the elevation corresponding to the vacuum or pressure at the suction inlet of the pump, corrected to the same datum plane, plus the velocity head at the discharge flange on the pump, minus the velocity head at the suction inlet of the pump. The value or quantity used to express the energy content of the liquid per unit height. Expressed on the Y axis of a pump curve.

VALVE BOX — A metallic, non-metallic or concrete box or vault containing valving, to allow access for service and maintenance without having to enter the wet well.

VOLUTE — The casing of a centrifugal pump made in the form of a spiral or volute as an aid to the partial conversion of the velocity energy into pressure head as the water leaves the impeller.

WATER HAMMER — A series of shocks within a piping system when the flow of liquid is stopped suddenly or reversed, causing a sound like hammer blows.

WET WELL — A tank or pit which receives drainage, stores it temporarily, and from which the discharge is pumped.

ELECTRICAL TERMS

AMMETER — Meter for measuring the current in an electrical circuit, measured in amperes.

AMPERE — The unit of electric current flow. One ampere will flow when one volt is applied across a resistance of one ohm.

CIRCUIT BREAKER — A mechanical switching device capable of making, carrying, and breaking currents under normal conditions. Also making, carrying for a specific time, and automatically breaking currents under specified abnormal circuit conditions, such as those of short circuit. Circuit breakers have an ampere trip rating for normal overload protection and a maximum magnetic ampere interrupting capacity (AIC) for short circuit protection.

CONDUCTOR — A wire, cable or bus bar designed for the passage of electrical current.

CURRENT — The amount of electricity measured in amperes (amperage) which is flowing in a circuit.

CYCLE — A given length of time (See Alternating Current). In the U.S., most electric current is 60 cycle (60 Hz).

DISCONNECTING MEANS (DISCONNECT) — A device or group of devices, or other means whereby all the ungrounded conductors of a circuit can be disconnected simultaneously from their source of supply.

FREQUENCY — The number of complete cycles of an alternating voltage or current per unit of time and usually expressed in cycles per second or Hertz (Hz).

FULL LOAD AMPS (FULL LOAD CURRENT) — The current flowing through a line terminal of a winding when rated voltage is applied at rated frequency with rated horsepower.

FUSE — An over-current protective device which consists of a conductor that melts and breaks when current exceeds rated value beyond a predetermined time.

GROUND — A connection, either intentional or accidental, between an electric circuit and the earth or some conducting body serving in place of the earth.

HERTZ (Hz) — A unit of frequency equal to one cycle per second.

HORSEPOWER -- A system of rating motors whereby horsepower values are determined, for various synchronous speeds, from the minimum value of breakdown torque that the motor design will provide.

MEGOHMMETER OR MEGOHMETER — A high resistance range ohmmeter utilizing a power source for measuring insulation resistance.

NEC — The National Electrical Code (NEC) is the standard of the National Board of Fire Underwriters for electric wiring and apparatus, as recommended by the National Fire Protection Association.

NFPA — National Fire Protection Association. Sponsors and publishes the National Electrical Code (NEC).

NEUTRAL — The point common to all phases of a polyphase circuit, a conductor to that point, or the return conductor in a single phase circuit. The neutral in most systems is grounded at or near the point of service entrance only and becomes the grounded neutral.

OHM — Unit of electrical resistance. One volt will cause a current of one ampere to flow through a resistance of one ohm.

OHMMETER — A device for measuring electrical resistance expressed in ohms.

PHASE (THREE PHASE CIRCUIT) — A combination of circuits energized by alternating electromotive forces which differ in phase by one-third of a cycle (120 degrees). In practice, the phases may vary several degrees from the specified angle.

RPM — Revolutions per minute of the motor/pump rotating assembly.

RESISTANCE — The non-reactive opposition which a device or material offers to the flow of direct or alternating current. Usually measured in ohms.

SERVICE FACTOR — A safety factor designed and built into some motors which allows the motor, when necessary, to deliver greater than its rated horsepower.

SINGLE PHASE — A circuit that differs in phase by 180 degrees. Single phase circuits have two conductors, one of which may be a neutral, or three conductors, one of which is neutral.

STARTING AMPS (LOCKED ROTOR AMPS) — The maximum current drawn by the motor during the starting period.

SWITCH — A device for making, breaking, or changing connections in a circuit.

TELEMETERING — The transmitting of alarm and control signals to and from remote lift station controls and a central monitoring location via phone lines.

TERMINAL BLOCK — An insulating base equipped with terminals for connecting wires.

UNDERWRITERS LABORATORIES, INC. (UL) — An independent, non-profit U.S. organization that tests products for safety.

VSD — Variable speed drive.

VOLTAGE (NOMINAL A) — A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 240/480, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

VOLTMETER — An instrument for measuring voltage.

STANDARDS SETTING ORGANIZATIONS

Listed below are the major standards setting organizations whose work impacts on submersible sewage lift stations and their components. For additional information on applicable standards, contact these organizations directly.

ANSI -- AMERICAN NATIONAL STANDARDS INSTITUTE
25 W. 43rd Street, 4th Floor
New York, NY 10036-9002
Phone: 212/642-4900
FAX: 212/398-0023
Web Site: www.ansi.org

CSA -- CANADIAN STANDARDS ASSOCIATION
178 Rexdale Boulevard
Toronto, Ontario, Canada M9W 1R3
Phone: 416/747-4000
FAX: 416/747-4149
Web Site: www.csa-intl.org

FM -- FACTORY MUTUAL RESEARCH CORPORATION
1151 Boston-Providence Turnpike
P. 0. Box 9102
Norwood, MA 02062
Phone: 781/762-4300
FAX: 781/762-9375
Web Site: www.fmglobal.com

HI -- HYDRAULIC INSTITUTE
9 Sylvan Way
Parsippany, NJ 07054-3802
Phone: 973/267-9700
FAX: 973/267-9055
Web Site: www.pumps.org

IEEE -- INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS, INC.
445 Hoes Lane P.O. Box 1331
Piscataway, NJ 08855-1331
Phone: 800/678-IEEE (4333)
FAX: 732/981-9667
Web Site: www.ieee.org

NEMA -- NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
1300 North 17th Street, Suite 184
Rosslyn, VA 22209
Phone: 703/841-3200
FAX: 703/841-5900
Web Site: www.nema.org

NEC -- NATIONAL ELECTRICAL CODE
NFPA -- NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
P. 0. Box 9101
1 Batterymarch Park
Qunicy, MA 02269-9101
Phone: 617/770-3000
FAX: 617/770-0700
Subscription Department:
Phone: 800/344-3555
FAX: 800/593-6372
508/895-8301
Web Site: www.nfpa.org

NSF INTERNATIONAL
P. O. Box 130140
NSF Building
789 N. Dixboro
Ann Arbor, MI 48105
Phone: 734/769-8010
FAX: 734/769-0109
Web Site: www.nfs.org

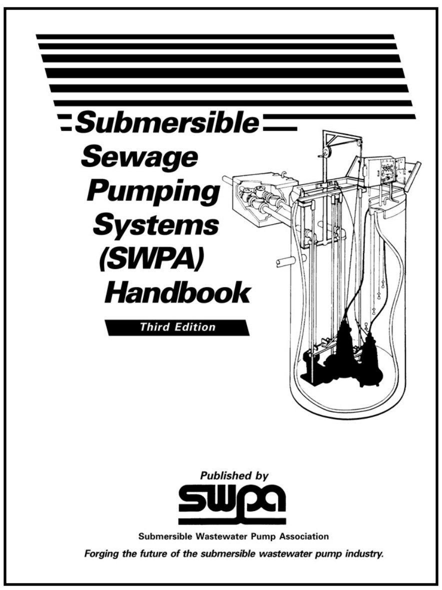
UL -- UNDERWRITERS LABORATORIES
333 Pfingsten Road
Northbrook, IL 60062
Phone: 847/272-8800
FAX: 847/272-8129
Web Site: www.ul.com

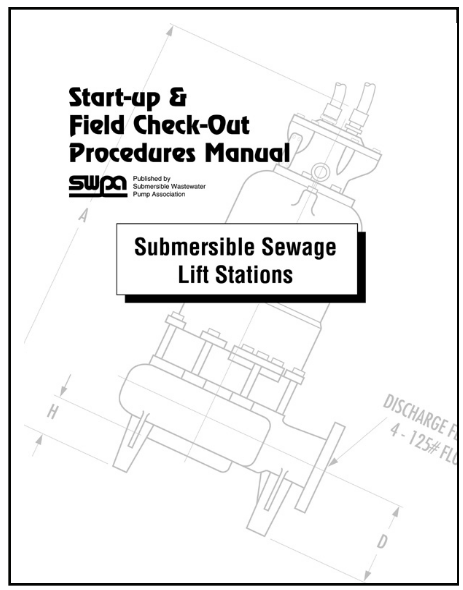
ADDITIONAL TECHNICAL RESOURCES AND INFORMATION

There are a number of additional Technical Resources and informational items you can use to learn more about submersible wastewater pumps and the submersible pump industry, obtain essential information for specifying submersible wastewater pumps, and assist you with the design, installation and proper operation of submersible wastewater pumping systems.

The most significant of these Technical Resources are published by the Submersible Wastewater Pump Association (SWPA) and the Hydraulic Institute (HI).

SWPA'S TECHNICAL RESOURCES





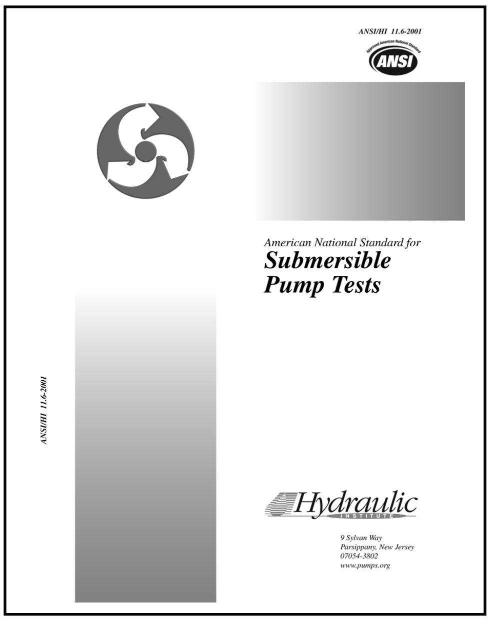
SWPA's current Technical Resources include the following:

- Submersible Sewage Pumping Systems (SWPA) Handbook, 3rd Edition
- Submersible Sewage Pumping Systems (SWPA) Handbook
- Grinder Pumps in Pressure Sewers
- Start-Up & Field Check-Out Procedures Manual for Submersible Sewage Lift Stations
- The Very Versatile Submersible Training Video
- Common Terminology and Definitions for a Typical Submersible Lift Station
- Common Terminology and Definitions for a Grinder Pump Station
- Standardized Presentation Format for Pump and Motor Characteristics
- Submersible Wastewater Pumping Systems Users and Specifiers Guide

For additional information, including how to order these Technical Resources, visit the SWPA Web Site at www.swpa.org or contact SWPA at 847-681-1868.

ANSI/HI SUBMERSIBLE PUMP TEST STANDARDS (ANSI/HI 116.2001)

The landmark ANSI/HI Submersible Pump Tests provides valuable information on procedures for centrifugal submersible pump performance testing. Developed through collaboration between the Hydraulic Institute (HI) and the Submersible Wastewater Pumps Association (SWPA), this 40+ page Standard meets one of the long-standing, major challenges in the wastewater pump industry: the development and acceptance of a test standard written specifically for submersible pumps.



ANSI/HI Submersible Pump Tests primarily applies to tests of centrifugal submersible pumps driven by induction motors. A centrifugal submersible pump is defined as a close-coupled impeller pump/motor unit designed to operate submerged in liquid, including wet-pit and dry-pit environments. This Standard does not apply to submersible vertical turbine pumps or to accessory items, such as discharge elbows, suction fittings, or sliding connections.

Fundamentally based on the ANSI/HI Centrifugal Pump Test Standard (ANSI/HI 1.6), this Standard was initiated by a SWPA Test Standards Subcommittee. This Standard was processed and approved for submittal to ANSI by the Hydraulic Institute, and is now accepted and utilized by all segments of the pump industry.

The ANSI/HI *Submersible Pump Tests*, HI product code M126, is available from the Hydraulic Institute in three formats:

- **Individual Hardcopy**
- **Complete Hardcopy Set of ANSI/HI Standards**
- **CD-ROM of Complete ANSI/HI Standards**:

For additional information, including how to order ANSI/HI Submersible Pump Test Standards, visit the HI Web Site at www.pumps.org or contact HI at 973-267-9700.

START-UP & FIELD CHECK-OUT PROCEDURES MANUAL FOR SUBMERSIBLE SEWAGE LIFT STATIONS

This Manual was created as one of the Submersible Wastewater Pump Association's (SWPA) educational activities to inform specifiers and users about the workings and benefits of submersible wastewater pumps, thereby representing the interests of the association's members in the public interest.

Based on field research, the SWPA's Technical Committee determined that a *"how to"* training guid with an explanation of *"here's why you're doing it"* for use when starting up a submersible sewage lift station was needed for personnel in the field. This Manual was developed in response to that need.

The committee's goal was to develop different levels of procedures, based on equipment typically available to start-up personnel in the field, to be used in conjunction with the pump manufacturers start-up and check-out document and *Pump Instruction and Operation Manual -- not in place of it.*

Step-by-step procedures to put a lift station into service were developed and then expanded into this Manual which lists start-up and check-out procedures at three separate levels, based on equipment available. These procedures are:

⇒ *Using a Multimeter*

⇒ *Using a Multimeter and a Clamp-On Ammeter*

⇒ *Using a Voltmeter, a Clamp-On Ammeter, and a Megohmmeter*

Procedures for flow and performance evaluations were also developed based on equipment available. These procedures are:

⇒ *Flow Evaluation Using a Watch Displaying Seconds*

⇒ *Performance (Flow and Head) Evaluation Using a Watch Displaying Seconds and a Pressure Gauge*

In addition to the step-by-step procedures to put a lift station into service, this Manual also includes a listing of periodic station checks and inspections; notes on operation and maintenance, a sample Start-Up Report Form, a drawing showing SWPA's *Common Terminology for the Components of a Typical Submersible Pump Station;* Glossaries of System and Electrical Terms; and a listing of selected standards setting organizations.

1866 SHERIDAN ROAD, SUITE 201 ● HIGHLAND PARK, IL 60035-2545
PHONE: 847.681.1868 ● FAX: 847.681.1869 ● E-MAIL: SWPAEXDIR@TDS.NET