Common Problems and Operational Tips - Submersible Sewage Pumps

Tricks of the Trade
## Outline

1. Brief Introduction
   - Parts of a Submersible Pump

2. Recommended Maintenance
   - Fluids and Lubricants
   - Mechanical Components
   - Electrical Components

3. Common Operational Issues
   - Inlet to Wet Well
   - Spacing
   - Grease
   - Submergence
   - Clogging
   - Variable Speed Applications
   - Grit

4. Summary and Questions
Common Problems and Operational Tips

Part 1 – Parts of Submersible Sewage Pump
Parts of a Submersible Pump

- Terminal Board
- Motor Casing
- Name Plate
- Shaft and Rotor
- Motor Chamber Oil-Filled
- Seal Oil Chamber
- Gauge Port
- Discharge Connection
- Clean-out Port
- Wear Rings
- Suction Connection
- Cable
- Sealed Cable Entry
- Upper Bearing
- Oil Return Pipe
- Stator Pack
- Winding
- Lower Bearing
- Heat Exchanger
- Enclosed Block Seal
- Volute or Casing
- Impeller
- Discharge Connection
- Clean-out Port
- Wear Rings
- Suction Connection
**Rules of Thumb – Velocities**

Remember that if you have a maximum flow design requirement (pumping into an overloaded or shared treatment system), that the maximum flow will occur with a near full wet well (minimum static)

<table>
<thead>
<tr>
<th></th>
<th>Dry Pit Suction Piping</th>
<th>Discharge Piping</th>
<th>Pump Inlet Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal Range</strong></td>
<td>2 to 4 fps</td>
<td>3 to 7 fps</td>
<td>5 to 15 fps</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>7 to 8 fps</td>
<td>8 to 10 fps</td>
<td>Check NPSH if over 15 to 20 fps; (25+ too fast)</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>Below 2 fps must have settling</td>
<td>Below 2 fps may have settling</td>
<td>Below 1.5 to 2 fps may have recirculation</td>
</tr>
</tbody>
</table>
Part 2 – Recommended Maintenance

Each model has their own requirements, these are meant as general information; severe duty applications will require more maintenance than listed (usually double)
Recommended Maintenance

Fluids and Lubricants
**Recommended Maintenance: Fluids and Lubricants**

**Fluids and Lubricants**

- **Bearings:** Grease bearings if pumps have fittings once per year (pretty rare on newer pumps; most bearings are sealed for life now)

- **Coolant:** FK motors have mineral oil coolant, change every 3 years. For HC or FKT model motors have water/glycol coolant, change every 3 years. Check levels and fluid quality every year and top up if required.

- **Seal Chamber:** Non-conductive oil Change annually or every 8000 hours.
Coolant
Air-filled motor with internal cooling system; change coolant every 3 years. Check every year.

Wilo FKT27.1 motor
Seal Chamber for smaller pump with air-filled motor (drain and fill plug are same)
Separate plugs for fill and draw in larger motors.

Must always wait for motors to cool to room temperature and must be disconnected from electrical power before beginning service. Oil or coolant might be pressurized.
## Fluids and Lubricants - Summary

<table>
<thead>
<tr>
<th>Application</th>
<th>Fluid or Lubricant</th>
<th>Recommended Fluid Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearings</td>
<td>Most are sealed and do not require re-greasing</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Larger pumps still require use external grease</td>
<td>Once per year</td>
</tr>
</tbody>
</table>
| Coolant or Motor Filling | - White Medical Oil  
|                       | - Transformer Oil (models prior to year 2001?)         | Once every 3 years; check every year |
| Seal Chamber          | - White Medical Oil                                      | Once per year                        |
|                       | Or other non-conducting oil                            | Check every year                     |
Recommended Maintenance

Mechanical Components
Recommended Maintenance – Mechanical Components

Annual Inspection (Disconnect power):

- Visually inspect power cable and cable holders, especially where cable flexes
- Visually inspect external pump components
- Visually inspect wear ring clearance if pump has wear rings
- Visually inspect impeller for wear
- Check and adjust clearances for all grinder pumps (MTS and MTC models)
Mechanical Components - Cables

- Make sure cables are free of strain, well supported and in conduit where possible. Keep power cables away from control wiring (especially 4-20 mA circuits)

- Cables should not hang from a sharp bend
Inspect for the obvious first: corroded metal, lost coatings, etc.

If it is a wet pit submersible, watch how it comes up the rails and then re-seats on elbow when re-installed. Check for “blow by” by running level down to a foot above the volute.

If it is a dry pit submersible, watch for any patterns of leakage between the volute and motor and the volute and suction elbow.
- Wear ring clearance for our pumps is .040 when new and they are to be changed when that distance becomes .080

- Wear rings ensure maximum flow through the impeller
Inspect impeller for wear: pitting, holes and missing material (cavitation)

Damaged water pump impeller

Consider a ceramic coating at first signs of wear
Mechanical Components - Impeller

Whenever you disconnect power, make a record of wire numbers for re-connection.

If you forget, you will need to check impeller rotation. Remember that sewage pump impellers “fling” water and the vanes bend backwards in direction of rotation.
Summary – Mechanical Components

Examine the exterior of the pump, the cables and the wet end once per year.

Consider dropping the volute and inspecting the impeller more closely once the pump is 3 or more years old.
Recommended Maintenance

Electrical Components
Electrical Components – Monthly Checks

Record the running amps and voltage (A to B, B to C, C to A) every month. Keep these on file and review.

1. Amps give an indication of possible hydraulic issues—as wear increases, amperage will change.

2. Voltage gives an indication of the quality of power and possible phase imbalance.

-Voltage must be +/-10% rated voltage or warranty invalid for most (5% for Flygt and others)

-Voltage phase to phase should be 1% top to bottom or motor life compromised. For example, am imbalance of only +/- 2% causes a power loss of 5%
Consider running your level control system through a brief test on a monthly basis

- Make sure pumps come on and turn off at correct level

- Make sure alternation works
Electrical Components-Annual Checks

Once per year, check the following:

1. Motor insulation value (some O and M manuals recommend twice per year)

1. Moisture sensor circuit

2. Over-temperature sensor circuit

3. Full test of level control system
Annual Electrical Checks – Moisture Sensors

For our electrode type, measure resistance.

- For single probe type (Wilo EMU standard), value should approach infinity

- For dual probe option, value across probes should be very high (300,000 + ohms)

You need to know if seal failure alarm shuts down pump or only lights indicator light. Either is acceptable with electrode type sensor
Annual Electrical Checks – Temperature Sensors

**Temperature Sensors – Measure Resistance across them**

1. Bi-Metallic (most common: FK, T42 and smaller) which gives “ON/OFF” – reading should be near zero

2. PTC type (cold type thermistors: HC, FKT and T49 and larger) which gives “ON/OFF” – reading should be 20 -100 Ω (3 in series would be 60-300 Ω).

3. PT 100 (Platinum resistance type: optional) which can give a varying signal indicative of temperature – reading should be 100 Ω at 0 degrees C (32 degrees F) and increased by 0.385 Ω/degree C (108 Ω at 68 degrees F).
Vibration switches can shut down equipment that experience abnormal vibration on a temporary basis

Active vibration sensors can quantify and record vibration history and show trends prior to a catastrophic mechanical failure
Electrical Components – Level Control System

1. Full operational system test
   - Verify that alarms will activate
   - Verify pumps will turn ON and OFF
   - Verify alternation schemes work including the ones not normally used
   - Check calibration on all elements producing varying (analog or 4-20 mA) signals like flow meters—especially if used for billing purposes

2. Level Sensor test
   - Measure resistance across discrete sensors (floats)—should approach infinity if normally open
   - Measure amperage for any varying (analog) sensors like level transducers while in operation (break circuit and put meter in series with instrument)
Conclusion of Recommended Maintenance

1. Maintenance for submersible pumps is dependent on the manufacturer and impeller type. Non-clogs have least maintenance.

2. Replace seal oil and do a visual inspection once per year. Perform a system check on each station once per year.
Part 3 - Most Common Operational Problems
Common Problems and Operational Tips

Inlet to the wet well
Most Common Operational Problems – inlet on top of pump

You must avoid dumping sewage via free fall; especially on top of a pump

- Free fall will entrain air
- Pumping on pump also causes unstable flow pattern into pump
- Problems worst at low water levels
- Common indicator is if the one pump being dumped on gives more trouble than the other(s)

Most common problem we see
Larger Example – High slope, aimed at pump
Inlet on top of pump (cont’d)

Add a baffle (or other solution like piping) instead

- Prevents air entrainment
- Reduces possibility of swirling flow into the pump
- Controls high approach velocity
- Still allows line to be cleared if jammed

Preferred approach is along the floor at low velocity (1-2 fps) to the pump
Common Problems and Operational Tips

Pump Spacing
Most Common Operational Problems – Pump Spacing

Pump spacing too tight

In this example, the middle pump will have low flow and more mechanical issues (especially vibration)

Possible Fixes

1. Change the control sequence to avoid running the center pump in combination with the others.

2. Add anti-vortexing devices, like knee walls between the pumps or a vertical plate on the pump inlet.

3. Best: Move the center pump to the other side of the wet well.
Pump Spacing (cont’d)

- For a submersible pump, the “D” distance from Hydraulic Institute is the volute diameter.

- Spacing is one “D” from the edge of one pump to the edge of the next pump (2D from centerline to centerline).

- Spacing to the wall is 1/2“D” (one D from centerline to wall). You need a pump to be close enough to the wall to prevent vortexing.

- Resist the temptation to use a single manufacturer’s design criteria if it conflicts with Hydraulic Institute – limits the Owner’s future options.

General spacing for wet pit pumps with both pumps in the control sequence.
Pump Spacing (cont’d)

- Do not forget about vertical spacing

- Many pumps, especially larger ones at 1800 RPM, may need to be elevated to reduce the influence of the floor—otherwise flow will be lower than expected and more “noise” will be heard.
Grease
Most Common Operational Problems – Grease

This is a major way that grease ends up in wet wells:

1. Restaurants use water for dish washing that is hotter than allowed by code. When they wash dishes, that water melts the grease in the grease trap (even if it was working correctly), and this grease-laden sewage ends up in your lift station.

2. They wash the majority of dishes later in the evening when there is lower flow coming into the station—fewer pump cycles. Also, liquid grease is lighter than water anyway.

3. The grease re-forms on the top of liquid with the lower temperature sewage in the pump station.
Grease (cont’d)

3 common solutions for grease:

**Mix/Flush Valve**
- Uses entire pump HP for mixing/can cavitate pump
- Does not operate at night when pumps are OFF
- Does not need another starter or much control logic

**Wet well mixer**
- Most efficient and low HP
- Operates in low flow when pumps are OFF
- Requires another starter and 3 relays

**Aerating the wet well**
- Usually a blower/coarse bubble diffuser(s)
- Can help keep fresh/can increase odor problem if septic
- Requires starter and a little more in the control realm
Common Problems and Operational Tips

Submergence
Most Common Operational Problems – Submergence

Low Submergence

- Keeps odor down (more cycles)
- Can cause vortexing – devices can help
- Easier to entrain air
- NPSH considerations (especially for dry pit pumps)

High Submergence

- Prevents vortexing
- Keeps motor cool
- Better hydraulically-increasing submergence can cover up for many deficiencies

*Must cover the top of the volute!*
Submergence (cont’d)

Whenever you are trying to diagnose a pump problem, increase the level in the wet well prior to starting the pump—higher submergence will lessen any sump design problems and pump application problems, but not greatly improve a broken pump.

Also, consider plugging the inlet to the station if there is a visible swirl (vortex) or other problems which are caused by the station inlet
Submergence (cont’d)

Motor cooling becomes an issue with low submergence. Submersible motors keep water out and heat in.

Internal closed loop cooling system
Motors without cooling systems rely on short cycle times and submergence for cooling.

Watch out for low submergence at lowest speed on VFD applications—slows down the coolant. Consider closed loop cooling system especially for VFD applications.
Common Problems and Operational Tips

Clogging
Clogging

Avoid VFDs for stations that are prone to clogging—**must keep inlet velocity up**.

If you have VFDs, set min. speed higher

Sewage pumps are clog resistant, not clog proof
Clogging (cont’d)

Check clearances for non-clogs:

Where is it clogging?

- 3” sphere passage
- Wear ring clearance
- Above the impeller
Check tolerances between the cutting surfaces for cutting impellers
Clogging (cont’d)

Pick the correct impeller—might not be the most efficient (vortex or single vane).

Vortex also called recessed impeller
Common Problems and Operational Tips

Variable Speed Applications
Vast majority of variable speed systems are set up with a linear ramp and a single PID loop, based on level, with the intention of matching the flow exiting the station with the station influent flow.

**PID:** proportional-integral-derivative: hunts and seeks the correct level by calculating and correcting
VFD Applications – General Rules of Thumb

- Lowest minimum speed is 30 Hz (50%)
- Lowest flow should be 25% or more of BEP full speed flow (some pumps can go lower) to prevent impeller recirculation
- Pump motors are less efficient at lower speeds than their design speed.
- Select pumps right of BEP to slow down to better efficiency
- Consider a minimum flow that equates to 2 fps or have controls speed up to full speed to achieve scouring
- Minimum speed must be high enough to allow the pumps to shut off if the inlet flow is at or near zero
Sample Selection #1 - 500 at 40 feet; 28’ static

Pump selection for VFD

500 gpm: 66%
250 gpm: 70%

Selection most efficient at slower speed
Sample Selection #2-500 at 40 feet; 28’ static

Pump selection for a constant speed station

500 gpm: 70%
250 gpm: 60%

Allows run out to the right if head is lowers than expected
Tips for Variable Speed Service

- Be very careful if you are using an air-filled submersible motor without auxiliary cooling on a VFD application.

- Worst scenario is to expose the top of the motor and simultaneously achieve equilibrium with the pump flow matching the station influent flow. There will be no cooling for the upper bearing, etc.

  Keep minimum speed up to minimize that time of exposure
We have had multiple applications that, due to the hydraulics of pumping into an old system, were designed such that the lead pump can only operate up to 45 hertz (approximate) before a second pump is brought on at reduced speed.

In other words, a single pump cannot operate at full speed.

Guess what happened after the pump station was started up?
Variable Speed Applications (cont’d)

- The VFD controls (furnished by others) gave problems, so the operator ran the pumps across the line (full speed)

- The pumps experienced extreme cavitation while pumping 1100-1200 gpm and were repaired under “warranty”

- The operator did not understand why the system was designed as it was (it was a retrofit, but the controls were changed completely)
Common Problems and Operational Tips

Grit (Raw Sewage)
Grit in sewage pump stations

Grit is in excess of 600 BHN

- Cast irons are 100 to 200 BHN and are industry standard
- Cast stainless steels are 130 to 450 BHN and are expensive
- High chrome irons are 600 to 700 BHN, but are hard to cast (brittle and hard to machine) and are very expensive
- Ceramic coatings can be an inexpensive solution
Grit - Ceramic Coatings

Other ceramic coatings:

- **Solids by weight:** up to 100%
- **Minimum Adhesion:** up to 15.9 Newtons per square millimeter (2,300 psi) per ISO 4624.
- **Resistance:** Level 1 (continuous duty) for sewage with pH of 6-11, Level 1 for saltwater, Level 1 for 10% hydrochloric acid and Level 1 for 50% sodium hydroxide.
- **Hardness:** 87-91 Shore D (550 to 620 BHN)

*From Marks’ Handbook*
Impellers

Flow Inducer Head
(Grit Pumps)
Consider selecting where the girt will settle out
Common Problems and Operational Tips

Part 3 - Summary and Questions
Conclusion

1. If you have a problem installation, consider the possibility that there is a inherent problem – a pump is only a tool.

2. When looking at a design, use a competent independent third party for design advice (Hydraulic Institute, for example).

3. Communicate—design to operations and vice versa
   - Design decisions
   - Operational needs
   - Potential problems
   - Preferences
Any Questions?

Thank you very much!