Reducing the Carbon Footprint of Sewage Pumping Stations

This paper describes the vastly improved use of energy, and hence reduced carbon production, when Gorman-Rupp self priming pumps are used instead of submersible pumps at sewage pumping stations.

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Topics:

1. Carbon production “drivers” at a sewage pumping station.
2. Energy efficiency – not just “wire to water”.
3. The impact of losses in efficiency.
4. The impact of “choking inefficiency”
5. The impact of additional personnel

1. Carbon Production Drivers

Carbon is “produced” whenever a crew jumps into the truck to go to site, whenever the pumps are energised and running, whenever personnel or additional personnel are required to perform functions at the stations. Whenever anything is consumed, energy is required to replace the items consumed.

“Additional” carbon is produced if efficiencies are lost or if more activity is necessary at pumping stations than should otherwise be the case. This paper describes the vastly improved use of energy, and hence reduced carbon production, when Gorman-Rupp self priming pumps are used instead of submersible pumps at sewage pumping stations.

The paper looks at just the major “measurable” areas of efficiency loss, the effect of “excess choking” and the impact larger crews have on the amount of carbon produced by a hypothetical municipality having 100 pumping stations. We could take it further by examining the carbon “cost” of consumables, the various choices of vehicles used, the cost of crane usage and more, but if estimates arrived at can be considered a minimum, then “drilling deeper” can only improve the results achieved. It is generally considered that the operational life of a pump station should be about 30 years, so we have used this time period for our calculations.

2. Energy Efficiency – not just “wire to water”

There have been several good papers written about selecting the right sewage pump. One message that is almost universal in them is that if you selected your pumps just on efficiency, a full time operator would be needed at each just to remove the chokes. Clearly, a good sewage pump must be selected based on its capacity to handle unscreened sewage and the ease of un-blocking when occasional chokes do occur. “Wire to water” efficiency comes somewhere way after that for importance.

Having said that, if you could combine good non-choking ability, good un-choking ability, and be able to provide a reasonably high efficiency, you save on energy costs, reduce maintenance costs and improve your carbon efficiency.

At this point, let’s introduce the Gorman-Rupp ‘Ultra V’ Series of self priming centrifugal sewage pump. As you’ll see, it is the most advanced design of its type anywhere in the world, and brings all the elements of a good sewage pump together. We will be comparing a “fleet” of these versus the use of submersible pumps in our hypothetical town of 100 pumping stations.

Gorman-Rupp’s ‘Ultra V’ is 20-25% more efficient than any other pump of its type. The Ultra V is at least as efficient as comparable size (head and flow) submersible pumps. So for the sake of this exercise we will consider the starting efficiency of submersible pumps to be equal of that of the Gorman-Rupp Ultra V.

3. The Impact of Losses in Efficiency

Using available "carbon footprint calculators", the author has calculated that a pump station drawing 22kW of energy at the duty point, pumping 2 hours per day, will produce 14.85 tonnes of CO_2 per annum if running at "starting efficiency" for the full year.

Here is where the case for using Gorman-Rupp self priming Ultra V series pumps starts.

The use of replaceable wear-rings in submersibles

Most submersible pumps use replaceable wear-rings to maintain efficiency within the pump. The problem with this is that **they are not adjustable**. The wear-rings need to be replaced to bring the pump back to starting efficiency. In the mean time, pumps are gradually losing efficiency until choking becomes so bad that operators are forced to make the change.

It is not surprising that wear ring changes are not done regularly, because in order to do so, the following needs to happen:-

- A team of at least 2 needs to attend (possibly more depending on the confined spaces regulations of that area and whether an electrician is needed to disconnect the pump).
- The wet-well lids need to be opened and the safety screen needs to be drawn away.
- Safety barricades will probably be needed.

- A lifting device will need to be brought to the site unless a permanent one has been installed.
- The pump needs to be lifted out of the well.
- It probably needs to be cleaned down because of the hazards of working on something covered in raw sewage.
- The pump may need to be sent back to the workshop if heating the casing (oxy torch) or cooling the wear-ring (nitrogen) is needed to separate the 2 items.

The author has collected anecdotal evidence from numerous operators that this practice (changing wear-rings) needs to be done about every 4 years per pump. Submersible pump operations manuals state that wear-rings need to be changed after clearances have opened up to about 2.0mm. (Bear in mind that the pumps start with a clearance of about 0.5mm).

Now **compare this with keeping clearances at peak efficiency** on a Gorman-Rupp Ultra V:-

1. Only one operator is needed.
2. The pump is high and dry above the wet well, so no lids or safety screen need to be opened.
3. The operator takes a gauge reading and notices that performance is down slightly.
4. With 2 small spanners, the operator adjusts the clearances without disconnecting piping or driver and without opening the pump. It is all done in less than 5 minutes from the outside of the pump - without a drop of sewage in sight.

Because the task can be done in minutes, and so easily and cleanly, this work has a very high probability of being done, and keeps the pump at its starting efficiency.

The Gorman-Rupp self priming pump can therefore be estimated to produce the calculated 14.85 tonnes of carbon per year, but because wear-rings of the submersible is constantly being worn away, we can make some estimates on what this efficiency may cost in extra carbon produced.

It is estimated that a pump's efficiency could be down by as much as 5-6% if left too long before the wear-rings are changed, but for the sake of this argument, we will assume that it loses no more than 4% between when it is new and the time wear rings are replaced (after 4 years). This table illustrates the amount of "carbon cost" this inefficiency produces:-

		Additional Carbon (Tonnes)
Year 1	Submersibles with "as new" clearances	0
Year 2	As new minus 1.33%	0.2
Year 3	As new minus 2.66%	0.4
Year 4	As new minus 4%	0.6
	Additional carbon produced over 4 years	1.2 Tonnes
	Additional carbon produced over 30 years	7.2 Tonnes

Now take this over 100 pump stations and this equates to a **staggering 720 tonnes** of additional carbon produced because of "slight" losses in efficiency.

Even if the average size of station were smaller than this, the amount of additional carbon produced would be in proportion (eg if the average size was only 15kW, the additional carbon produced by the 100 pump stations because of efficiency losses would still be 491 tonnes).

4. The impact of "choking inefficiency"

The impact of efficiency loss on carbon production is not just the additional cost of energy, but also the fact that pumps will choke more often when their clearances open up.

Once again, the author will draw on collected anecdotal evidence to attempt to put some numbers to this situation. It has been reported that when choking is to a stage where they are occurring fortnightly, it is time for a wear-ring change to bring the pump back to its best. We then made the following assumptions:-

- Pumps at their best tolerances will choke only once per quarter.
- It will take 4 years for submersibles to get to the stage when the wear-rings need replacing.
- The increase in occurrence of choking for the submersibles will be linear until they reach "condition critical".
- Because Gorman-Rupp Ultra V pumps can be kept at their most efficient for the life of the installation, choking rates are estimated to remain the same.

	Gorman-Rupp - chokes	Submersible pumps – chokes

	per year	per year
Year 1	4	4
Year 2	4	8
Year 3	4	12
Year 4	4	16
Total	16	40

The impact of this additional service: additional operator time, additional mileage on vehicles. Once again, assumptions need to be made to estimate the additional carbon produced. We have assumed that a round trip to a station would be about 30km.

Using available information, a 6 cylinder “ute type” vehicle will produce about 10kg of carbon per 30km of travel (based on 6.62 tonnes per 20,000km travelled).

Therefore, 24 extra trips “to site” for the submersible option, represent 240kg of extra carbon produced every 4 years. That is, over and above that which the Gorman-Rupp Ultra V would produce. Or 1.56 tonnes over the 30 year life of one station. **A massive 156 Tonnes** for 100 pump stations.

5. The impact of additional personnel

Calculating the impact of personnel also takes some assumptions. We’ve used accurate information gained from web sites devoted to carbon reduction. The average person creates a carbon footprint of some 7.6 tonnes in a home using lighting, air conditioning and power in a conservative manner. Assuming the same conditions would apply to a place of employment, and a person spent 8 hours per day and 250 days per year on the job, then each employee would produce 1.74 Tonnes of carbon per year.

Now go back to our premise (in item 4) that operators will attend a single pump station an average of 10 times per year **and a Gorman-Rupp station only 4 times** per year.

This indicates 2.5 times more personnel are required to maintain a submersible station compared with a Gorman-Rupp station. And even this comparison does not take into account the following:-

- The additional personnel required at each service for a submersible compared to a Gorman-Rupp self primer site.
- That general service type activity (oil changes, pump repairs etc) takes much longer with submersible pumps.
- That guide rails and “duck-foot” bends in the submersible pumps (not used for self primers) will also need replacing during the life of the station, again not factored into our personnel needs.
- Spare parts inventory for Gorman-Rupp stations is only a fraction of that needed to support a submersible pump station “fleet”.

This equates to an additional 10.44 tonnes per year, or **a huge 313.2 Tonnes** over the 30 year life of 100 submersible stations compared to the more robust Gorman-Rupp stations.

Adding the additional energy, vehicular travel and personnel contributes an **additional 1189 tonnes of carbon**. This makes the Gorman-Rupp choice a substantially greener one.

We trust this paper has been thought provoking and of value to you.

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