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PumpAction.....

ISSUE 45 OCTOBER 07

Welcome to the 45th edition of Pump Action

Kelair has been the manufacturer of the Kelair-Blivet™ Packaged Sewage Treatment Plant for some years now and those of you who have been reading Pump Action regularly will no doubt recall past case studies showing Blivets installed in camping grounds, housing estates and golf courses.

In this issue, as a departure from the usual pump application stories we offer some insight into the differences between the Blivet and Rotating Biological Contactors.

So as not to lose sight completely of pumps however the Pump Clinic article in this issue addresses NPSH. We talk about what it is and how to work it out.

We would also like to take this opportunity to advise the relocation of our Brisbane office from Springwood to:

50 Nestor Drive Meadowbrook 4131
PO Box 3780 Loganholme 4129
Ph: 1300 789 466
Fax: 07 3805 7309

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FEATURE

Blivet versus Rotating Biological Contactor

Sales Engineer Mark Butterfield (NSW)

The Kelair-Blivet™ is a stand-alone packaged sewage treatment plant comprising primary settlement, aerobic zone, final settlement (humus tank) and sludge storage. The plant is designed to accept raw (unsettled) sewage and produce a high quality final effluent without the need for ancillary tankage or equipment. The system may be buried up to lid level, significantly reducing the visual impact on the environment.



DESIGN PARAMETERS

Parameter	Influent	Effluent
BOD	250 mg/l	20/10* mg/l
Suspended Solids	250 mg/l	30/15* mg/l

*10/15 effluent standard is applicable when the Blivet is fitted with Saran filter. Please note that other final effluent standards can be achieved. The Blivet is a modular, completely self-contained unit, which lends itself to future expansion or relocation. The Blivet consists of the following four components.

PRIMARY SETTLEMENT

Raw sewage enters the Blivet and hits a full-width baffle which intercepts any plastic bags and floatables. The rest of the raw sewage is directed downwards into the primary settlement tank. Primary settlement is enhanced by upwards flow through parallel or lamella plates. The inclusion of parallel plates results in a much smaller primary settlement tank as well as 25% removal of BOD. This increase in efficiency over a standard open tank allows a corresponding reduction in the size of the aerobic section. The end result is that the Kelair-Blivet is a very compact all-in-one packaged plant; probably the smallest available worldwide.

After flowing upwards through the parallel plates, the sewage flows over a notched weir and enters the first section of the Aerobic Treatment Unit, the Kelair-BMS Aerotor. This patented Aerotor process is where the most significant improvements and differences occur in comparison to standard Rotating Biological Contactor (RBC) systems.

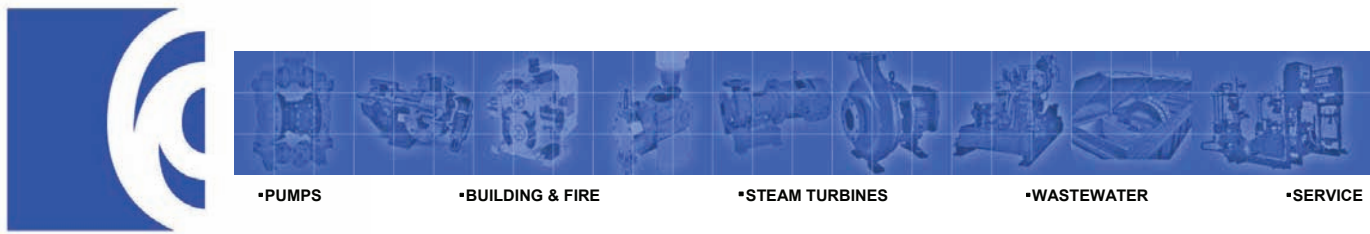
BIOLOGICAL TREATMENT (AEROTOR)

A common misconception is that the Aerotor is in fact a rotating biological contactor (RBC). An Aerotor can-

not be defined as an RBC. The Aerotor is a unique combination of two tried and tested methods of aerobic biological treatment systems: RBC-style fixed film reaction; and activated sludge. The key points of difference between an Aerotor and an RBC are:

- An RBC turns much more slowly than a Blivet. If the RBC is overloaded, an overgrowth of biomass can accumulate. The Biozone's speed of rotation (approximately 6 rpm) is such that the biomass keeps stripping off leaving a healthy layer that can not get too thick and anaerobic. The constant stripping of biomass avoids a problem seen in conventional RBCs, where the biomass bridges across the discs, effectively reducing the RBC surface area by preventing the sewage from getting between the individual discs.
- An RBC generally has open discs. The Biozone is an enclosed rotor. Encasing the biomass inside a rotor facilitates forcing the sewage through a set path inside the Biozone, ensuring that the influent is exposed to as much of the biomass as possible.
- An RBC only has passive aeration, from oxygen being entrained in the biomass as the RBC turns. The Biozone is designed to actively aerate the sewage, by sucking in air through a series of holes located along the perimeter of each Biozone and mixing it thoroughly with the influent.
- The flow path for sewage passing through the RBC is much more inconsistent than through a Blivet Aerotor. Influent could flow through the tank of an RBC and never come in contact with the discs or the biomass. In the Blivet, the influent is directed to each Biozone - and through the passageways inside

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(Feature cont.)

- to get to the next stage, so it must make contact with the biomass for a considerable period.

The Biozones are all a standard diameter of Ø1500mm, to allow Blivets to be shipped to overseas markets in a standard container. Therefore, Biozone size increases by length only.

The rotating motion of the rotor, which in mechanical terms is a pump, provides a nett head gain of 375mm. This head gain provides the following advantages:

- Automatic recirculation of any proportion of treated effluent under gravity back to the primary settlement tank. Recirculation helps keep the primary settlement tank from going septic (anaerobic). One of the major causes of odour in STPs is septicity in the primary settlement tank.
- Gravity recirculation increases at times of increased flow, thereby providing a buffer against irregular surges.

The rate of recirculation can be adjusted by the use of adjustable weirs in the final compartment splitter box to suit periods of peak loads and surge conditions. For example an amenity facility can have minimal usage during weekdays and maximum usage at weekends. Going on total recycle during the week will allow the biomass to be maintained at the level required during peak periods.

FINAL SETTLEMENT

The final settlement tank, commonly known as the Humus tank, is a discrete compartment separate from untreated or partially treated liquor. The design is similar to the primary settlement tank in that the treated liquor flows upwards through parallel plates. The normal design effluent quality is 20mg/l BOD5, 30 mg/l suspended solids. A membrane (Saran) filter or equivalent may be fitted just below top-water level, to further improve the effluent quality to 10 mg/l BOD5, 15 mg/l suspended solids.

The filter is a static design, ie; not powered and set in frames that are easily removable for cleaning. Settled humus is automatically removed to the primary settlement tank via a timed submersible pump (0.48kW, 2-4 min/hour maximum loading).

SLUDGE STORAGE

Sludge storage is provided in the base of the units. Depending on the load applied, there is approximately

12 weeks capacity provided. Normally, desludging is carried out by suction tanker.

RUNNING COST COMPARISON

The Kelair Pumps-BMS Blivet packaged sewage treatment plant requires an operator attendance of fifteen minutes per week for a visual inspection and one hour per month for greasing of the bearings, bringing the total labour requirement to two hours per month. Based on a labour rate of \$60.00 per hour this equates to \$840.00 per year. This labour requirement is constant, even when the plant experiences fluctuating loads.

Extended aeration plants require, under normal conditions, approximately fifteen minutes per day operator attendance for equipment checks and two hours per weekend for testing of effluent pH levels, oxygen level and solids settlement. Based on a labour rate of \$60.00 per hour, this equates to \$5915.00 per year. This labour requirement can increase substantially when the plant experiences periods of fluctuating or intermittent loading (a fact of life for most treatment plant).

The electrical requirements of the two plants are typically 10 kW hrs for the Blivet per day and 55 kW hrs per day for the extended aeration plant. Based on an electricity cost of \$0.10 per kW/hr, this equates to \$365.00 for the Blivet and \$2007.50 for the extended aeration plant. If we sum up the running costs per year for both types of the treatment plant, the figures come to:

Expense	Blivet Plant	Extended Aeration Plant
Labour costs per year	\$840.00	\$5915.00
Power costs per year	\$365.00	\$2007.00
Total per year	\$1200.00	\$7922.00
Total cost for 5 years	\$6025.00	\$39612.00

From the above it becomes quite clear that the initial outlay for a treatment plant can be only one cost of the overall operation, especially when one considers that the design life of the Blivet treatment plant is twenty years.

PUMP CLINIC 19

ABOUT NET POSITIVE SUCTION HEAD (NPSH)

In past Pump Clinic Articles we have talked about cavitation which most people who have any involvement with pumps will come across at some stage. In this article however we want to talk only about NPSH and what it means as it is a term that is misunderstood by many people.

We do not want bubbles in our process fluid for a lot of reasons:

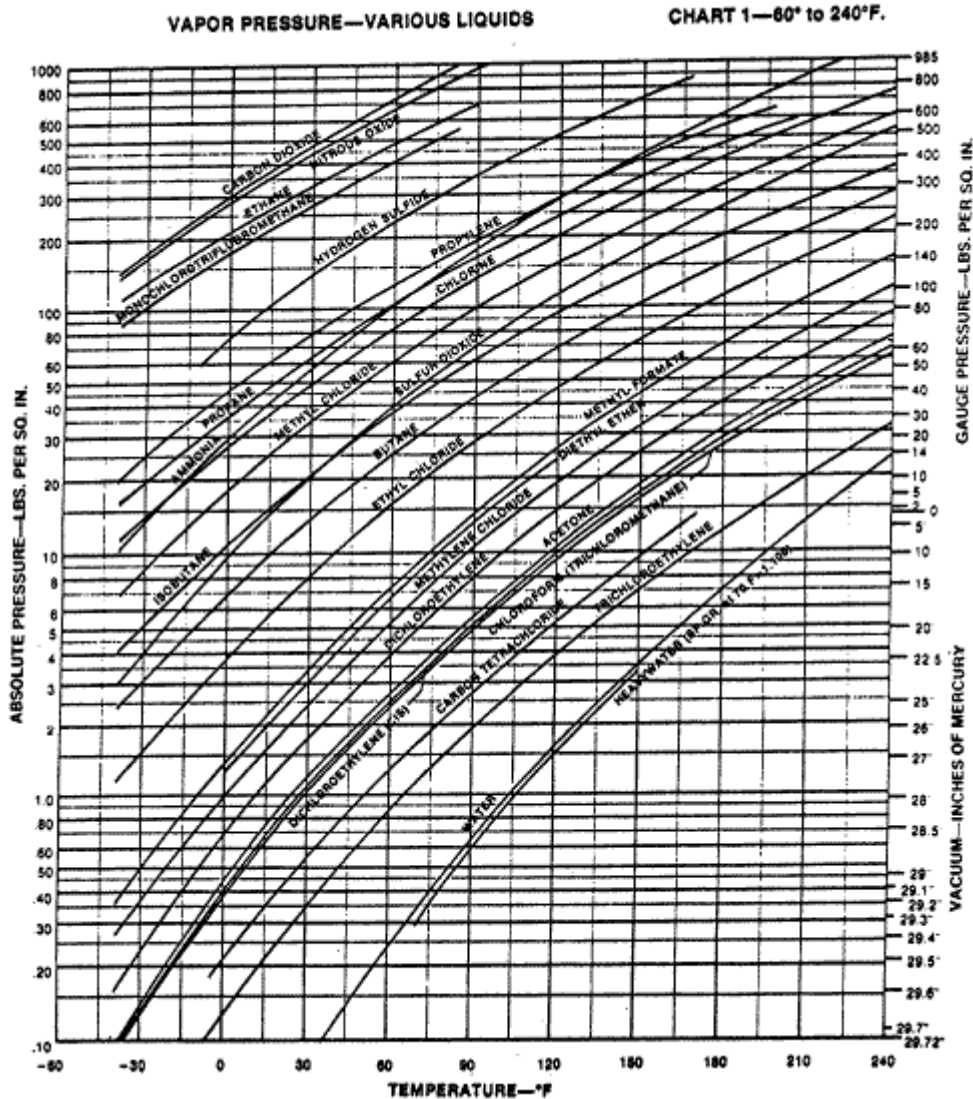
- Bubbles take up space, causing the pumping capacity to diminish. The head also reduces because energy has to be expended to increase the velocity of the liquid used to fill up the cavities, as the bubbles collapse. As the velocity goes up, the head or pressure goes down.
- Excessive vibration can occur when part of the impeller is handling a liquid and another part is handling a vapour. This vibration can lead to pump failure.
- Air is a poor heat transfer medium, meaning that the fluid we are pumping will get hotter and in almost no cases is there any advantage in heating up the process fluid.
- A bubble is a hole or cavity in the liquid. It is these cavities that are going to cause a cavitation problem that will damage both the impeller and volute.

Bubbles or cavities form in a liquid when the fluid temperature gets too high, or the fluid pressure gets too low. This is called vapourisation, or sometimes boiling although the word boiling tends to imply that the liquid is hot which need not be the case. We all know that if you throw dry ice into cold water it will bubble and vapourise, but it is not hot.

For the purpose of this article we will use *vapourise* and further state that a fluid will vapourise any time the pressure falls below its vapourisation point.

Since temperature is a variable with different fluids, there are charts that will give you the vapour pressure for any fluid at its various temperatures.

Take a look at the following chart. For the purpose of this article we will use a chart in imperial units. You will note that the vapour pressure for 60°F chlorine is 80 psi (540kPa), and the vapour pressure for 68°F fresh water is about 0.3 psi (2kPa). These numbers are required to calculate our NPSH available.



A fluid pressure can be lowered in several ways:

- Put the fluid in a container, and then pull a vacuum on the container. This happens in the hot well of condensers. This can be referred to as a loss of "pressure head"
- Lift the liquid out of a hole. This will diminish the position of the liquid level in respect to the pump centre line. This can be referred to as a loss of "static head"
- Accelerate the fluid. As its velocity increases its pressure will decrease. This is referred to as "velocity head"
- As the fluid moves through piping, fittings, restrictions and valving, some friction losses occur that will drop the fluid pressure. This is referred to as an increase in friction head, resulting in some loss of "positive suction head."



Heating of the incoming fluid is not usually a problem, but it can occur several ways:

- Internal recirculation in the pump because of worn wear rings or failure to make an impeller adjustment.
- Piping, exposed to the elements, can heat up the liquid on hot and sunny days.

We do not know how much pressure a centrifugal pump will develop, but we do know the head it can produce. The head is a function of the shaft speed and the impeller diameter. The faster the speed the higher the head.

The larger the diameter, the bigger the head. To determine the pressure we have to know the weight or "specific gravity" of the fluid we are pumping, and since any given centrifugal pump can move a lot of different fluids, with different specific gravities, it is simpler to discuss the pump's head and forget about the pressure.

Here are the formulas you can use to convert from one to the other:

$$\text{Head} = \frac{\text{Pressure} \times 0.1}{\text{Specific gravity}}$$

$$\text{Pressure} = \frac{\text{Head} \times \text{specific gravity}}{0.1}$$

In the above formula:

- Head is measured in metres (m)
- Pressure is measured in kilopascals (kPa)

The pump manufacturer has decided how much head the pump needs to prevent cold water from vapourising at different capacities and these values are published on his pump curve. The values have been obtained by testing the pump at different capacities, throttling the suction side and waiting for the first signs of cavitation. The pressure was noted, converted to head, and transferred to the pump curve.

This observed number is called the "Net Positive Suction Head Required (NPSHR).

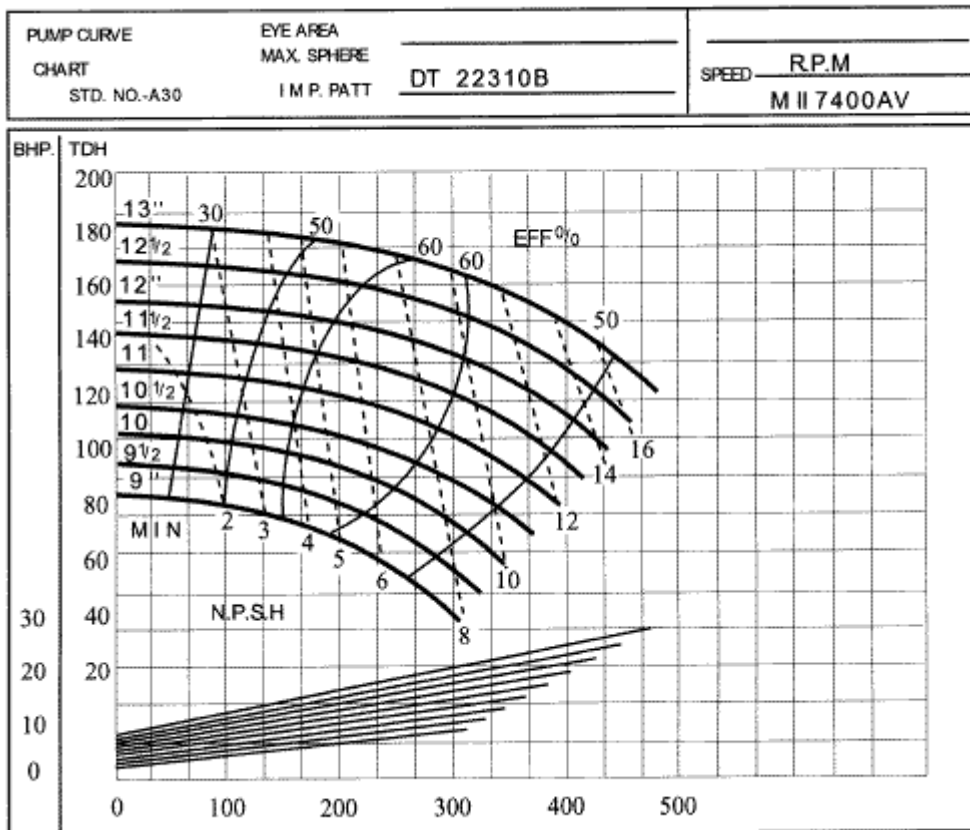
The attached pump curve shows the numbers. On the chart they are located at the bottom of the dotted lines and they run from 2 to 16. According to this graph a 13-inch impeller, running at its best efficiency point (60+%), would need a NPSH required of 9 feet. An 11-inch impeller running at its best efficiency point would need 7 feet of NPSH required. Remember this requirement is for cold water only.



KelairPumps

Kelair Pumps Australia Pty Ltd ABN 28 001 308 381 215 Walters Road Arndell Park NSW 2148
Ph: 1300 789 466 Fax: 02 9678 9455 Email: kelair@kelairpumps.com.au www.kelairpumps.com.au
QLD Fax: 07 3805 7309 VIC Fax: 03 9569 7866 TAS Fax: 03 6331 9102 WA Fax: 08 9248 2255

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Be sure to keep in mind that any discussion of NPSH or cavitation is only concerned about the suction side of the pump. There is almost always plenty of pressure on the discharge side of the pump to prevent the fluid from vapourising.

- If we go back to our formula and put the 0.3 psi/ 2kPa vapour pressure for 68° water into the numbers, it comes out to 0.7 feet or 0.2 metres of head is required to stop the water from vapourising and forming cavities. So why does the NPSH required increase as the capacity is increasing? It's because the velocity of the liquid is increasing, and anytime the velocity of a liquid goes up, the pressure or head comes down.

Now that we know what head is required, we can calculate the head we have available, and remember we are only interested in the suction side of the pump. Generally we will be looking at three kinds of head.

- The static head measured from the liquid level to the centre line of the pump. If the liquid level is above the pump centre line you will have a positive number. If the level is below the centre line you will have a negative number.
- The pressure head. Here we will be using only absolute numbers. In other words atmospheric pressure is 101kPa at sea level so you will add that number (converted to metres, using the above formula) to the static head if you have an open tank. If the fluid is under vacuum we will convert the absolute pressure reading to head and use that number, instead of atmospheric pressure. The friction loss in the piping will be a minus number. You get the number from charts showing pipes size vs flow, and flow through fittings and valves.



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Ph: 1300 789 466 Fax: 02 9678 9455 Email: kelair@kelairpumps.com.au www.kelairpumps.com.au
QLD Fax: 07 3805 7309 VIC Fax: 03 9569 7866 TAS Fax: 03 6331 9102 WA Fax: 08 9248 2255

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- The next thing we have to do is subtract the vapour pressure of our fluid (converted to feet of liquid) using the first formula I gave you. All of the above, added together is the NPSH available. If this number is equal to, or more than the NPSH required by the pump manufacturer, the liquid will not form bubbles or cavities on the suction side and the pump will not cavitate.

In summary, NPSH available is defined as:

$NPSHA = \text{Atmospheric pressure} + \text{static head} + \text{pressure head} - \text{the vapor pressure of your product} - \text{loss in the piping, valves and fittings.}$

NPSHA will always need to be greater than the NPSHR for the pump to operate without cavitation. Most people involved in pumping system design demand an additional safety factor of 1m.