

White Paper

**Selection & Operation of
Positive Air Displacement
Pumps**

for

**Landfill Leachate &
Condensate Pumping**



INTRODUCTION

**This white paper is offered by Geotechnical Instruments UK Ltd.,
with compliments.**

**The white paper aims to provide information on the selection and
operation of positive air displacement pumps for landfill leachate and
condensate pumping, as a guide.**

We hope it is of interest and of use.

**The scope includes pumps and their environments to the top of
borehole and connected piping for airlines and removal of pumped
liquid.**

**The information presented is accurate at time of publication however,
Geotechnical Instruments UK Ltd. recommends that before making any
decisions or taking action, readers consult their supplier for site-specific and
borehole-specific pump selection and system planning.**

**The broader subject of systems to supply compressed air to pumps, remove
leachate or condensate to holding areas and the management and use of
pumped liquids are for another white paper and outside the scope of this one.**

Abbreviations

EA	-	Environment Agency
ATEX	-	Explosive Atmospheres
DSEAR	-	Dangerous Substances and Explosive Atmospheres Regulations

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1. Background

In the UK landfill sites must be managed to comply with Environment Agency (EA) standards and guidelines. While opinions vary on the number of years available for future landfill, they concur that the UK will ultimately run out of landfill space.

The UK has been using landfill for waste for decades with increasing EA control of operators of open sites and site recently closed. Some of the EA's control is now being applied to sites closed many years ago. As on active or recently closed sites, this requires site investigation and management by means e.g., of drilling boreholes or wells. The basic requirement with leachate is to maintain it at required levels to stop it contaminating watercourses and water sources and to remove it for treatment. With landfill gas, mostly methane (CH₄) operators aim to minimise migration to site edges and maximise gas collection from the centre of a site for flaring or generating electric power to sell. Operators may manage leachate levels to optimize methane production and spray extracted leachate on the site surface. This has two effects. As the leachate sinks under gravity through the site it assists methane production. It also forms a temporary additional gas-trapping membrane. This can increase gas yield by reducing gas loss. In the UK there are more than 2000 operational and closed, household and industrial waste sites and hazardous waste sites. All operate under EA licences.

Landfill around the world presents many similar challenges with management of them most advanced in the USA, Canada and Western Europe. Landfill management in the third world is least developed. Inevitably managing landfill sites creates operational costs for which site operators seek the most economic solutions. Since landfill site operation is a long-term task, durable, long-life leachate pumps which work and continue to work in aggressive conditions have been adopted on most sites in most countries, especially in the UK where EA compliance is closely monitored and EA compliance failure may be fined, sometimes heavily.

2. Information from the UK Environment Agency, www.environment-agency.gov.uk

“The UK produces around 330 million tonnes of waste annually - a quarter of which is from households and business. The rest comes from construction and demolition, sewage sludge, farm waste and spoils from mines and dredging of rivers.”

“Waste management industry

The waste management industry is central to delivering the necessary changes in the way we manage waste and in protecting the environment and safeguarding human health. There is a lot of common ground between our aims of meeting Government's strategy 2000 targets and managing waste in a more sustainable, integrated fashion and industry's need to meet its customer and business expectations. We, [the EA] regulate waste management activities including the collection, treatment and disposal of wastes. We work closely on the interpretation and development of guidance.

“Services we provide

Our main regulatory role in the sustainable management of waste is to protect the environment and human health through a system of waste permitting (waste management licensing and pollution prevention and control permits); compliance assessment and monitoring and enforcement. We provide advice on applications for permits and guidance on regulatory compliance and good practice. We also provide up to date information, data on waste and trends in our strategic waste management assessments. This allows industry to plan for the future, and provide information on alternative technologies and life assessments.”

3. Defining the Task – Pumping Landfill Leachate and Gas Condensate

3.a. Leachate - What Is Leachate And What Does It Contain?

The word 'leachate' describes the liquid that leaches from landfill material and drains to the bottom of sites. It leaches out of decomposing matter as it breaks down. It is added to by rainwater and by gas condensate. Leachate varies at each landfill site and can change as a site ages. Common characteristics of leachate are corrosive liquids, solids, solvents and viscous fluids making a challenging pumping environment. Compliance with Environment Agency means a maximum depth of leachate of one meter from the bottom of the landfill site. The risk of underground landfill fires mean ATEX Zone 0 certified equipment is highly desirable.

3.b. Typical Leachate Characteristics

The amount of leachate is variable. It contains water, organics, in-organics and solids, often at high temperatures. It may be foaming due to gas bubbling out of the liquid. It may contain silt or sand or fibrous materials, hydrocarbons, solvents, suspended solids, corrosives and viscous fluids.

These difficult conditions require pumps which can withstand the environment, work reliable and be serviced easily.

3.c. Condensate - What Is Condensate and What Does Condensate Contain?

Condensate is the liquid that results from landfill gas removal or the gas cooling within a gas collection system. Landfill sites produce combustible gases, mainly methane so explosion hazards trigger DSEAR rating.

3.d. Typical Condensate Characteristics

Condensate liquid volumes vary. It mostly contains water and organics and in some condensates the pH can be very low. The environment is for less severe pump duty however, totally reliable operational performance is essential to maintain condensate levels so they do not rinse and adversely affect gas flow to engine for electricity generation or flaring.

3.e. Combined Wells

Gas wells that have combined leachate and condensate are where the well is used as a 'knock-out pot' to remove moisture from gas extraction.

3.f. Sampling Wells

This is mainly monitoring around the perimeter of a landfill site to check on any unwanted migration of landfill gas or leachate.

3.g. Leachate Borehole or Well design and Other Considerations.

The casing may be of made of steel, plastic or concrete. Some wells are constructed from vertical concrete 1000mm diameter pipe sections as the site is filled. Others are drilled as boreholes of 100mm diameter after filling and capping. In practice, useable diameters vary from 1000mm down to 50mm. Depths vary from 30-100m.

The top of each borehole or well will have one of many possible combinations of wellhead assemblies; open, vented, sealed or flanged. Airline wellhead equipment is discussed later.

Movement of unstable landfill and machinery impact can damage wells and boreholes. This can reduce an original diameter to 50mm or less. Indeed, boreholes may become too compressed, fractured or unaligned to recover and service pumps which can be lost.

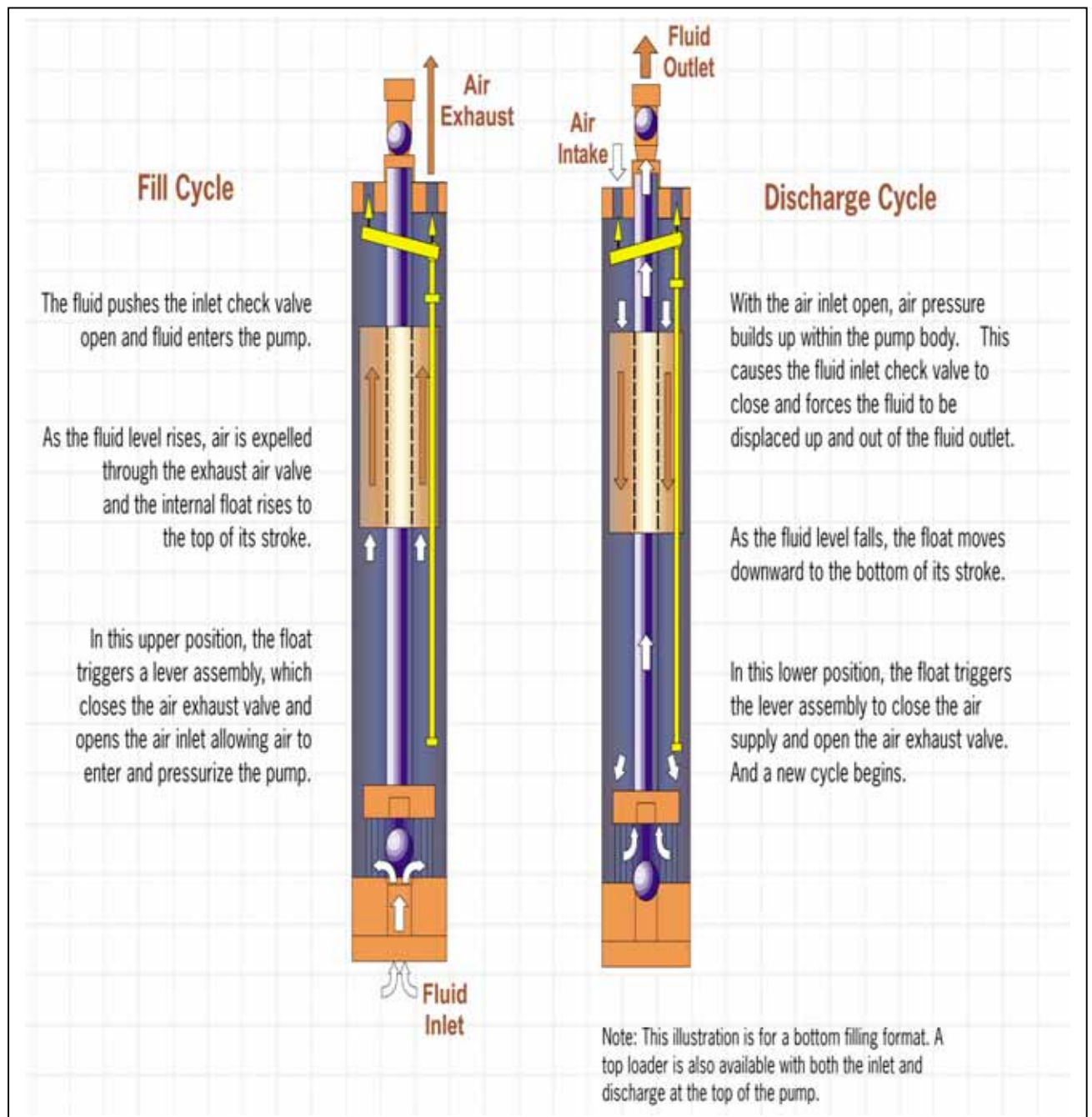
4. Landfill and Remediation Pump Comparisons

Electric Pumps	Hydraulic Pumps	Eductor Pumps	Pneumatic Pumps	Surface Control Pneumatic
<p>Advantages</p> <ul style="list-style-type: none"> - Easy availability - High flow 3750 Rpm 	<p>Advantages</p> <ul style="list-style-type: none"> - Simple operation - High flow rates 	<p>Advantages</p> <ul style="list-style-type: none"> - Relatively Inexpensive - Low draw down - No moving components 	<p>Advantages</p> <ul style="list-style-type: none"> - Simple design - Large clearances - Automatic matching of pumping to flow needs - Designed for stop / start. - Self-cleaning action - Few moving parts = reliable - Low maintenance - Inherently / Intrinsically safe 	<p>Advantages</p> <ul style="list-style-type: none"> - Simple down-well pump design - Only 2 moving Teflon balls with high clearance - Auto matching to flow needs (with level control) - Self-cleaning action - More material options
<p>Disadvantages</p> <ul style="list-style-type: none"> - Mostly designed for clear water pumping - Often not designed for stop / start use - Many moving bearings and seals - Corrosion - Power grid required - high spark, shock hazard - Hard to control flow rates - Can accelerate silting - Failure tends to be expensive (motor burnout) - Overall higher system installation cost 	<p>Disadvantages</p> <ul style="list-style-type: none"> - Must be designed in (can not retrofit for new problem areas) - Encourages silt deposition - High maintenance / daily - Heavy wheeled plant to drive the pump - Potential well / sample point oil - Prone to damage & seal problems (deep location) Hard to fix. - Labour intensive as powered by remote generators 	<p>Disadvantages</p> <ul style="list-style-type: none"> - Requires constant positive head of liquid - Requires constant pressure to enable flow - Systems failure prone to leaks - Very high maintenance 	<p>Disadvantages</p> <ul style="list-style-type: none"> - Air liquid contact - The control mechanism is down the well - Higher initial cost 	<p>Disadvantages</p> <ul style="list-style-type: none"> - Surface adjustments required - Requires operator education
<p>Notes</p> <p>Since June 2006 DSEAR Regs. require pumps, when serviced to be ATEX certified. Electricians must be IEEE certified,</p>	<p>Notes</p> <p>Usually to provide high flow rate pumping for short-term stand-alone application and not as part of a system.</p>	<p>Notes</p> <p>Eductor pumps use the Venturi effect to operate.</p>	<p>Notes</p> <p>Simple operating design was purposely developed to pump landfill leachate. Easy to: Clean, maintain, service and repair</p>	<p>Notes</p> <p>Simple operating design,</p>

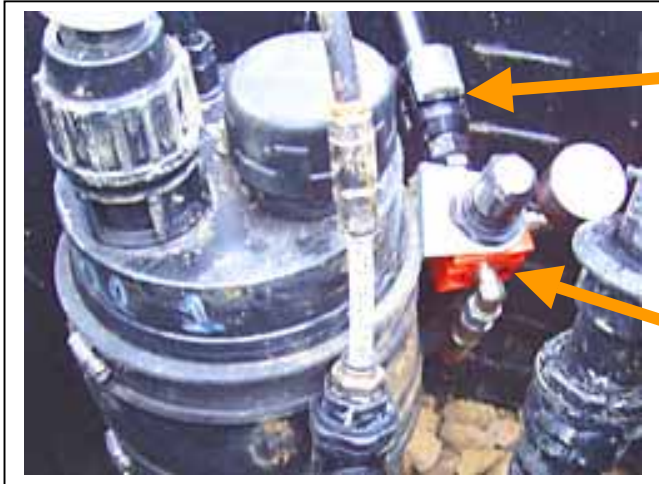
5. Pneumatic Pumps (GI's are called AutoPumps)

These pneumatic pumps known as 'positive air displacement pumps' are controller-less as they self-regulate and pump only when needed. An airline runs to each pump from an air compressor and a second pipe carries pumped leachate to a collection tank or lagoon. The pump works in continuous cycle when submerged. When level falls so that it does not raise the float the pump stops. As liquid in the well rises it again raises the pump's float. That restarts the pump's pumping cycle. It then restarts and stops in response to the level of the liquid.

At the top of the wellhead the airline supply passes into a pressure regulator and flow counter before being attached to the pump and lowered into the well. (See next page)



6. Wellhead Airline Connections for a Positive Air Displacement Pump.



Flow Counter is operated by air as it enters pump against a sprung, magnetic piston. It counts number of pump cycles. For each the pump volume is known so total volume pumped can be calculated.

Pressure Regulator allows operator to inspect and set optimum operating pressure.



7. Considerations - Successful operation of positive air displacement pump depends on selecting the right pump (below), appropriate checking, cleaning and pump maintenance and ensuring the system is working properly.

7a. Pump Selection for Application

This is a quick guide to pump selection. As a general guideline, pump model selection is usually based on the following primary application criteria. They are presented in the common sequence of consideration, but special site needs may alter the priority.

- **Maximum flow and depth** - pump model, depth, submergence and drive pressure determine the maximum flow rate that can be achieved.
- **Pump Diameter** - to fit the well internal diameter. Larger diameter pumps deliver higher flow rates, all other factors being equal.
- **Inlet Position** - top or bottom inlet; a top inlet can assist in a with gaseous or foaming leachate while bottom inlets provide the highest flow rates and greatest solids-handling capacity_With bottom inlet, actuation level is typically 700mm allowing a margin of 300mm below the 1 meter EA compliance level. This also avoids the pump being in silt at the bottom of the borehole. With top inlet with a similar 700mm actuation level, the top inlet can be close to the 1-meter maximum level which is less satisfactory as pumping may only be down to that level and not below it.
- **Actuation Level** - minimum height of liquid needed to actuate the pump, also equal to the minimum drawdown level; low-drawdown models are optimized for maximum drawdown. With GI's AutoPumps can pump from a liquid depth of as little as 29cm. Low drawdown models are optimised for maximum drawdown.
- **Materials of construction** - special applications, such as extremes of pH, suspended solids, high temperatures and aggressive solvents may require upgraded construction materials.

7b. Intrinsic Pump Performance depends on its specification

Bottom Fill Pump Diameter	Pump Type	Length in/cm	Max Flow gpm / lpm	Max Depth ft / m	Actuation Level in / cm
8.9cm	Long	53 / 135	14 / 53	425 / 130	35 / 89
8.9cm	Short	41 / 104	13 / 49	425 / 130	27 / 69
8.9cm	Low Draw	28 / 71	7 / 26.5	250 / 76	13 / 33
6.68 cm	Long	57 / 145	7.3 / 27.6	220 / 67	31 / 79
6.68 cm	Short	42 / 107	6 / 22.7	175 / 53.3	22 / 56
4.45cm	Long	55 / 139	2.3 / 8.82	300 / 91.4	35 / 88.9
4.45cm	Short	33 / 85	2 / 7.57	300 / 91.4	20 / 51
Top Fill Pump Diameter					
8.9cm	Long	57 / 145	10 / 38	425 / 130	52 / 132
8.9cm	Short	42 / 107	9 / 34	425 / 130	37 / 94
8.9cm	Low Draw	29 / 74	6.4 / 24	250 / 76	24 / 62
6.68 cm	Long	57 / 145	5.4 / 20	220 / 67	53 / 135
6.68 cm	Short	47 / 119	4.8 / 18.1	175 / 53.3	42 / 107
4.45cm	Long	57 / 144	1.9 / 7.2	300 / 91.4	52 / 132
4.45cm	Short	35 / 89	1.6 / 6.0	300 / 91.4	31 / 77.2

Application Excellence

Landfill fluids pumping is challenging. Geotechnical Instruments is dedicated to providing a comprehensive approach to meet the specific needs of each site and well, taking into account many factors beyond just flow rate and depth, such as:

- Preferred inlet position- top or bottom
- Pump length to match water column and meet drawdown requirements
- A broad range of materials of construction to match fluid properties and temperature
- A wide variety of standard and custom wellhead completions to fit site needs

Pumped in litres per minute and produced in tonnes per day

The continuous pumping maximum flows shown in the table can be affected by severely adverse leachate and in-site air pressure characteristics.

However, 60 lpm gives 3600 lph and 86,400 litres per day which is 86.4 tonnes (metric tons) a day. Even 15 lpm is 21.6 tonnes a day.

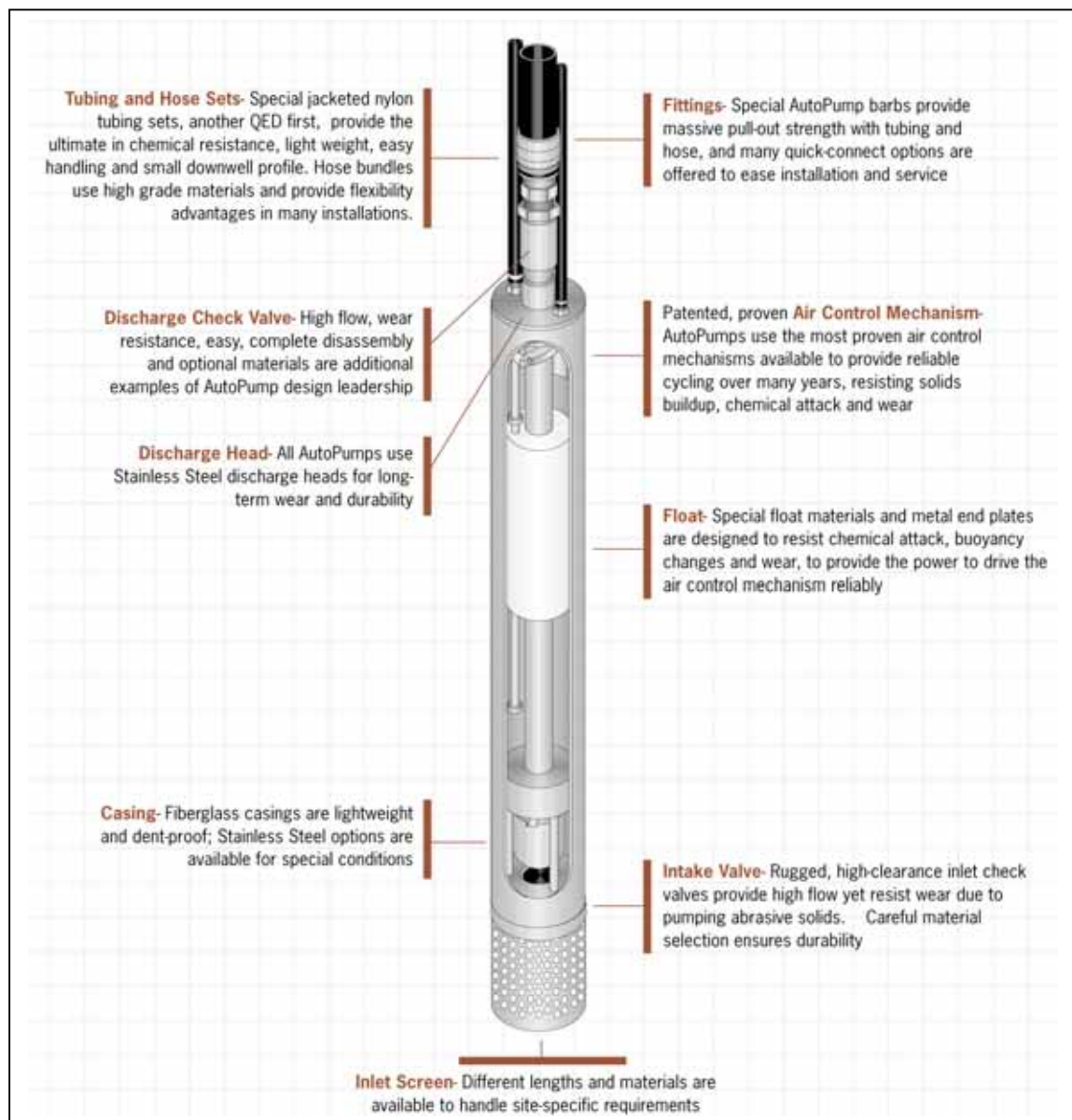
Product	Flow - lpm maximum	Depth - metres maximum	Drawdown- metres maximum
4" AP4 - Bottom Inlet, 1" OD Discharge - Long	60.0	90	0.9
3" AP3 - Bottom Inlet, 1" OD Discharge - Long	27.0	60.0	0.8
3" AP3 - Bottom Inlet, 1" OD Discharge - Short	22.0	60.0	0.6
4" AP4 LDD - Bottom Inlet, 1" OD Discharge	15.0	76.0	0.3

The other factors affecting pump performance include the total system of pressurized air supply and leachate removal. These are not covered here.

7c. Component Material Selection

Materials of Construction Many models are available in upgraded materials for special applications such as extremes of pH, suspended solids, high temperatures and aggressive solids. Manufacturers now have available and offer a wide range of materials for pump construction to meet site-specific conditions. Some of these materials include stainless steel, Acetyl, Nylon, Teflon, epoxy, fibreglass and broad variety of alloys and engineering plastics to meet the site-specific requirements of the most demanding landfill applications. These material choices allow for higher operating temperatures and higher resistance in corrosive conditions.

In identical environments, the more appropriately pumps are made, the longer they last - giving best value after just a few years. Pump customisation includes selecting site-appropriate materials for interchangeable components. For landfill leachate this may be by trial and experience. For remediation, analysis of the liquid phase informs selection of pump type, fabrication and operation. With landfill leachate and condensate and with remediation, positive air displacement pumping depends on the performance and reliability of key components, especially the float. Each component and the material from which it is made are relied on even more if maintenance checks are missed or intervals lengthen. That is attractive to those operators who only inspect if there is a problem.



7d. Pump Checking and Maintenance

Regular checking and maintenance is essential. This means pulling a borehole pump to the surface, pressure hosing it clean, washing out sand or silt, cleaning off deposits. When checking for damage or wear and tear, replacing parts is easily done as and when necessary.

Pump maintenance operatives can clean, strip, service and reassemble a positive air displacement pump with very little training. Working with compressed air of 40-100psi is safe and carries no unusual H&S requirements

With new pumps in new wells GI recommends, for its pumps, checking every three months for the first year. Thereafter inspection intervals can vary depending on the first-year's experience and a pump's continuing performance.



7e. User experience

Shrigley Builders install and service turnkey landfill and remediation leachate control systems throughout the entire country for gas generation and landfill operators. They have been supplying and fitting the Geotechnical Instruments' Auto Pumps range for more than five years. Michael Shrigley, said, "They are easy to strip and clean, and have proven to be extremely reliable. They comply with all the current legislation; ATEX and DSEAR for landfill sites. They stand up well in difficult sites. For any pump, sand can cause heavy wear but replacing worn parts is easily done during routine maintenance and cleaning." One of the worst environments in Shrigley Builders' experience is in industrial waste with a build up of iron deposits. According to Michael Shrigley, "It is not a problem. We just dismantle the pump, clean off the deposits and it runs as well as ever."

Shrigley Builders installed top-loading AP3s for a 50-pump leachate control system on a site in Wiltshire and confirmed, from the routine first-year 3-month service checks, each pump has performed perfectly."

Margaret Wilson at Veolia manages landfill gas at seven sites which have 40-45 AP3 Autopumps. Commenting on reliability and performance she said, "They are excellent. We never have a problem. We know when we get a new AutoPump we don't have to worry about it for years. We clean and check our pumps every two months.

Based on this reliability experience, Margaret Wilson installed an AP2 AutoPump for the very important job removing condensate from a knock-out pot on gas-to-electricity generation plant. In this methane-rich environment the ATEX Zone 0 rating and DSEAR compliance of the pump ensured its appropriateness. Ms Wilson confirmed, "This pump has completely solved our condensate level problem."

7f. Operational Features of Geotechnical Instruments's Positive Air Displacement Pumps

- ATEX Zone 0 Certified
- Flow rates up to 60lt/m
- Positive air displacement
- Simple yet rugged operating mechanism
- Low maintenance / longer life
- High temperature fluids up to boiling (rated up to 65 degrees C)
- Aggressive solids up to 4mm
- Run dry / automatic stop start
- Low air consumption – of 35cfm at 40-100psi
- Lightweight and no heavier than 7.3kg
- Achieve EA compliance in UK (1metre head of water)

8. Troubleshooting – The System

- Air pumps are normally part of a system with a central compressed air supply and a discharge holding area for leachate and condensate. For pumps to work properly the system must also be maintained and routinely checked. Most system problems are above-ground and mainly due to installation or maintenance and may include: -
 - o Pipes with sharp bends or damaged from onsite machinery
 - o Discharge tank full - automatically shutting the systems down temporarily
 - o The a pump or several pumps may not be adequately submerged
 - o A well could be dry which, as designed, automatically stops the pump working
 - o Excessive gas pressure overcomes hydrostatic pressure and forces leachate - out of well back into surrounding landfill, so pumping ceases.
 - o UV deterioration (pipe colours)
 - o Leaks in system (air /liquid)
 - o Low air pressure at wellhead regulator
 - o Poor fitting choice – i.e. reduction in apertures / scaling
 - o Closed valves
 - o Liquid main blocked
 - o Liquid and/or grit in the airline requiring better airline filtration and maintenance

Further information on these and other other pumps and total pumping systems is available from Geotechnical Instruments (UK) Ltd www.geotech.co.uk
Tel: +44(0)1926 338111