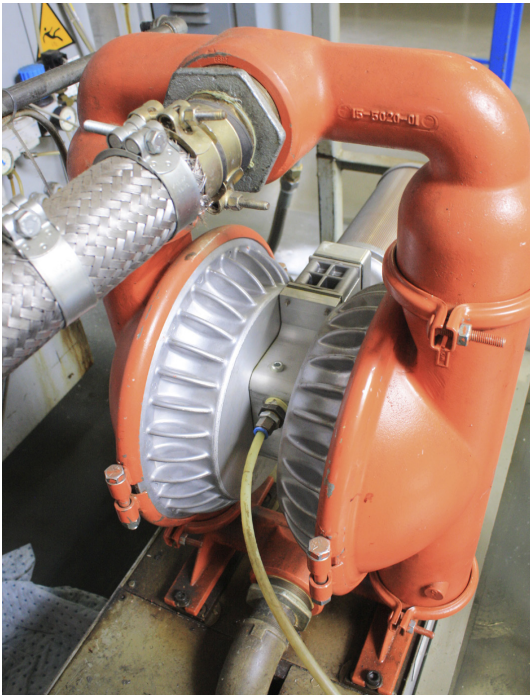


TECHNICAL WHITE PAPER / 04

Viscous Liquid Transfer: Design the Suction Line Before Increasing Air Pressure

Select a diaphragm pump for viscous fluids by assessing suction lift, true hose bore and product temperature before increasing air pressure.



Pump and hose arrangement from the Chromalloy application report. Photo: Wilden / PSG. Reference photograph, not a validated piping design.

Scope: an original engineering discussion for pump selection and operating review. Examples are illustrative; this is not a product certification or a field-test report.

Executive summary

A diaphragm pump can only discharge the liquid that reaches and fills its chambers. When a viscous product enters too slowly, increasing cycle rate may fail to produce a corresponding increase in delivery. The limiting element may be the inlet system rather than the pump's nominal outlet capacity.

Selecting a diaphragm pump for viscous fluids requires more than a maximum viscosity statement. High-viscosity diaphragm pump selection should connect the fluid data with the actual diaphragm pump suction lift and inlet losses.

This paper examines suction-side design for an AODD transfer installation. Its objective is to help engineers identify the data needed for a defensible selection and distinguish a pipework problem from an equipment-capacity problem. It does not replace a model-specific performance curve, a rheological assessment or a site hydraulic calculation.

1. Define the duty for a diaphragm pump for viscous fluids

“Thick liquid” is not a design property. Record the viscosity and its measurement temperature. For a formulation that changes behavior with shear rate or time, provide the relevant test method or rheological data rather than a single catalogue-style number. A cold first batch and a warm recirculating batch may present different inlet conditions.

Also record density, entrained gas, suspended solids and any tendency to settle or cure. Establish which cleaning fluids are used and whether a partially emptied line can remain idle between batches. These details help define the condition that must be checked, even where no complete hydraulic model is initially available.

2. Walk the complete inlet route

Start at the source vessel, not at the pump flange. Note the minimum liquid level, the outlet valve, adapters, hose internal diameter, length, fittings and strainer. A large nominal hose can still contain a restrictive coupling. A short section of reduced bore near a container valve can dominate an otherwise generous connection.

Wilden installation guidance calls for a short, direct suction route, suitable reinforced hose and independently supported piping. It also warns that air leakage at connections can reduce suction capability. Those principles establish a good starting arrangement; the final dimensions still depend on the duty and exact model. [R7]

Item to inspect	Question to resolve	Evidence to retain
Source vessel	Is approved venting adequate at the transfer rate?	Vessel arrangement and vent specification
Minimum source level	What is the vertical relationship to the pump inlet?	Measured elevations
Hose and couplings	What is the smallest actual internal bore?	Sizes, length and photographs
Strainer or screen	Can normal fouling restrict supply?	Clean and loaded condition observations
Product condition	What is the coldest or most resistant normal batch?	Temperature and viscosity data

Item to inspect	Question to resolve	Evidence to retain
Inlet pressure	Does pressure fluctuate as the pump cycles?	Suitable pressure record, not only one average

3. Separate static lift from flow-dependent losses

For a liquid surface open to atmosphere, positioning the pump above the liquid creates a static lifting requirement. As the vessel empties, that requirement can increase. Pipe friction, fittings and local restrictions add further losses when liquid moves. A pressurized or sealed vessel requires a different assessment of the surface pressure and its allowable operating conditions.

The hydrostatic pressure difference is:

Pressure difference = density × gravitational acceleration × elevation difference.

For an illustrative liquid density of 1,300 kg/m³ and an upward lift of 3 m, the static term is approximately 38,259 Pa, or 0.383 bar. This is only the elevation contribution. It is not the complete suction requirement and does not demonstrate that any selected pump will prime successfully.

The example explains why a suction figure expressed in metres of water cannot be transferred unchanged to a denser liquid. The actual inlet assessment must also consider surface pressure, vapor pressure and flow-dependent losses. Manufacturer guidance similarly notes the effect of specific gravity on suction performance. [R8]

4. Why a small bore change can matter

For steady, fully developed laminar flow of an incompressible Newtonian liquid in a straight circular pipe, the Hagen-Poiseuille relationship gives a frictional pressure drop proportional to viscosity, pipe length and flow rate, and inversely proportional to the fourth power of internal diameter. [R17]

Under those restricted assumptions, changing internal diameter from 40 mm to 50 mm at the same flow, viscosity and length changes the straight-pipe loss by a factor of (40/50)⁴, or 0.4096. That represents about 59% less loss in that idealized pipe segment.

This is a sensitivity illustration, not a prediction for an entire AODD installation. It excludes fittings, entrances, non-Newtonian behavior and the unsteady flow associated with reciprocating pumping. A system may remain limited by a container outlet or another narrow section after the hose itself is enlarged. Manufacturer piping guidance also identifies unnecessary friction as a contributor to poor pump-system performance. [R9]

5. Treat a faster cycle rate as a test variable

Observe delivered volume and inlet behavior while making controlled changes within the equipment's operating limits. If cycle rate rises substantially but liquid delivery does not, investigate supply and filling conditions before escalating pressure further. Record the observation; do not use it alone to declare cavitation or a failed diaphragm.

A useful sequence is to verify the source level and approved venting, inspect restrictions and air ingress, confirm product temperature, and then evaluate the operating setting. Isolate and depressurize equipment before physical inspection. Do not loosen an operating connection to “see whether liquid is present.”

Where pulsating inlet pressure matters, an average gauge reading can conceal short low-pressure events. Select appropriate instrumentation and seek a more detailed dynamic assessment when required by the duty. A steady-flow calculation is a screening tool, not a complete description of a reciprocating inlet system.

6. Decide what should change

A shorter route, larger true bore or lower pump position may be more useful than additional air pressure. A flooded arrangement must still remain within the model's permitted inlet-pressure conditions. Heating a product should never be assumed acceptable without evaluating process chemistry, material limits and the approved operating procedure.

If satisfactory inlet conditions cannot be achieved at the required rate, reconsider the pump configuration or transfer method with the supplier. Provide a dimensioned inlet sketch, actual fluid data and the minimum vessel level. This makes the next selection a response to a defined hydraulic requirement rather than a guess based on port size.

WILLEE can use those records to prepare a focused pump enquiry and identify where additional manufacturer review is needed.

Send your suction arrangement for review - willeepump.com/contact/

Technical references

[R7] Wilden / PSG. PS8 Plastic Engineering, Operation and Maintenance Manual.

[R8] Wilden / PSG. Air-Operated Double Diaphragm Pumps for Oil and Fuel.

[R9] Wilden / PSG. Minimizing Pumping-System Friction Losses.

[R17] OpenStax. University Physics Volume 1, Section 14.7: Viscosity and Turbulence.

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