

FILTRATION FOR ROTARY PUMPS

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Filtration used to protect rotary, positive displacement pumps is an important element for maximizing pump life and minimizing maintenance expense. Many systems using rotary pumps require a level of liquid cleanliness far

and between adjacent rotating pump components, figure 1. Single screw pumps literally have zero running clearances due to a slight, deliberate interference fit between the metallic rotor and the elastomeric stator. The clearance

erosion of clearance components. Jamming or breakage is catastrophic in nature and will normally cause immediate system shutdown with its attendant outage costs as well as extensive repair time and cost. Scoring and abrasion of

FILTRATION

Filtration refers to the deliberate addition of components to the liquid system to remove undesirable solids. The term "filter" is more frequently applied to a component in the discharge side of the pump system and intended to protect downstream equipment. At least one installation of a 400 gpm (91 m³/h) high speed rotary lube oil pump was inspected after 60,000 hours operation and required only new gaskets, shaft seal and ball bearing during reassembly. This provides ample evidence that systems that stay clean can provide extraordinarily long pump life. Some recirculating liquid systems will have a return line filter that removes contaminants as the liquid is returned to its source before being pumped again back into the system. Return line filters are relatively inexpensive and very effective but limited to systems that can accommodate the back

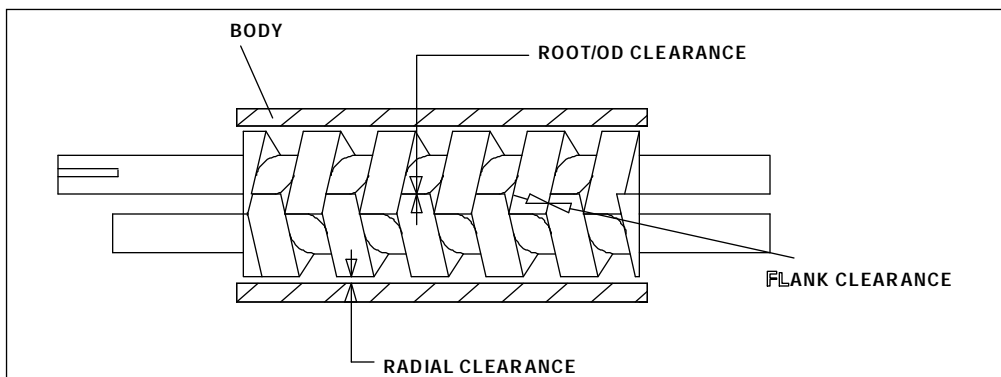


Figure 1 Rotary Pump Running Clearances

different than the pump itself. For example, the loading of crude oil and fuel oils aboard tankers has virtually no solids limitations while turbomachinery lubrication or servo hydraulic systems may mandate system filtration in the 2 to 10 micron (millionths of a meter) range. This article will address filtration provisions intended to protect the rotary, positive displacement pump rather than the variety of systems these pumps serve.

CLEARANCES

Rotary, positive displacement pumps include a great variety of designs, chief among which are gear, vane and screw pumps. Running clearances within these pumps can range from less than 0.001 inches (0.025 mm) to perhaps as much as 0.010 inches (0.254 mm) depending on pump size and pressure rating. Running clearances are those necessary gaps or spaces between stationary and rotating parts

regions of rotary pumps are the most susceptible to damage and abrasion from solids, contaminants and foreign material. Internal slip flow (volumetric inefficiency) carries the liquid borne debris towards pump running clear-

clearance surfaces will usually reduce the pump output flow by allowing increased slip through increased clearances. This is usually detected as a loss in system discharge pressure due to the loss of pump flow rate. While

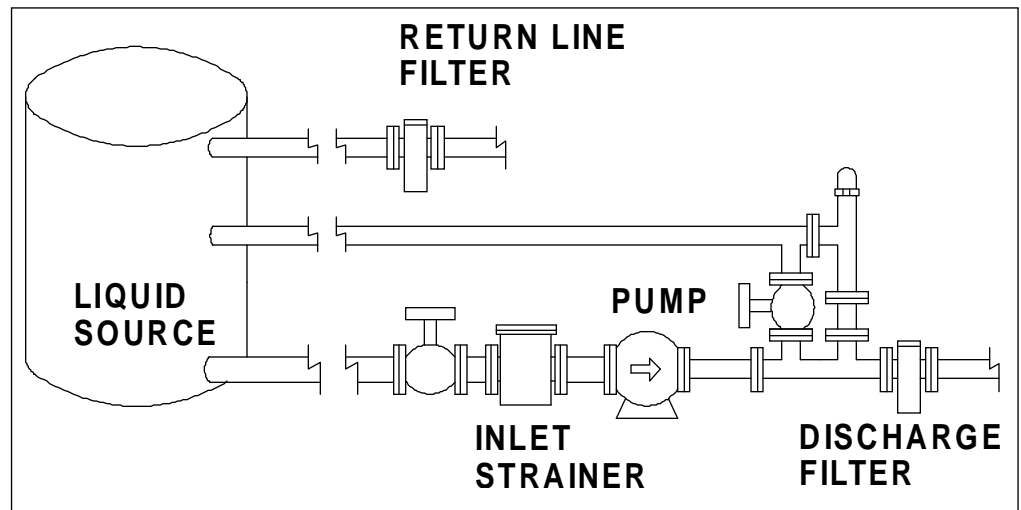


Figure 2 Pump System Strainer and Filters

ances. This debris can cause jamming or breaking of pumping elements, scoring of clearance surfaces and abrasive

more gradual, it still requires shutdown, albeit planned, and the expense to overhaul the pump.

pressure imposed by the presence of such a device (see figure 2). Lubrication systems with gravity oil return to the

reservoir normally do not provide enough pressure to effectively use a return line filter. On the inlet side of the pump, filtration devices are usually called "strainers". The name implies a coarser degree of contaminant removal, far poorer than a system filter. It is this inlet or suction strainer that provides the most immediate short term protection for the pump.

Strainer elements are most often manufactured from woven wire cloth. The "mesh" rating of the cloth (number of wires per linear inch of cloth) provides an approximate correlation to the size of the openings in the cloth. Actual opening size will depend upon both the cloth mesh and the diameter of the wire used to make it as well as the weave pattern. The table below gives the approximate opening sizes for selected mesh ratings:

Sq. Mesh (per inch)	Wire Diameter		Opening Size		Percent (%) Open Area
	inch	mm	inch	mm	
20	0.028	0.711	0.022	0.56	19.4
40	0.010	0.254	0.015	0.38	36.0
60	0.0085	0.216	0.0082	0.21	24.2
80	0.006	0.152	0.0065	0.17	27.0
100	0.005	0.127	0.0050	0.13	25.0

For the same mesh size, larger diameter wire will decrease the open area and opening size. Conversely, smaller diameter wire will increase the open area and opening size. Opening size, pressure drop and contaminant holding capacity must all be considered together as none can be separated from the others. Fine strainers will clog faster and need more frequent cleaning unless they are very large (and expensive). On the other hand, neglecting pressure drop, they provide the maximum protection for the pump.

CONTAMINANT

System contamination has many forms, comes in many sizes and can range from cata-

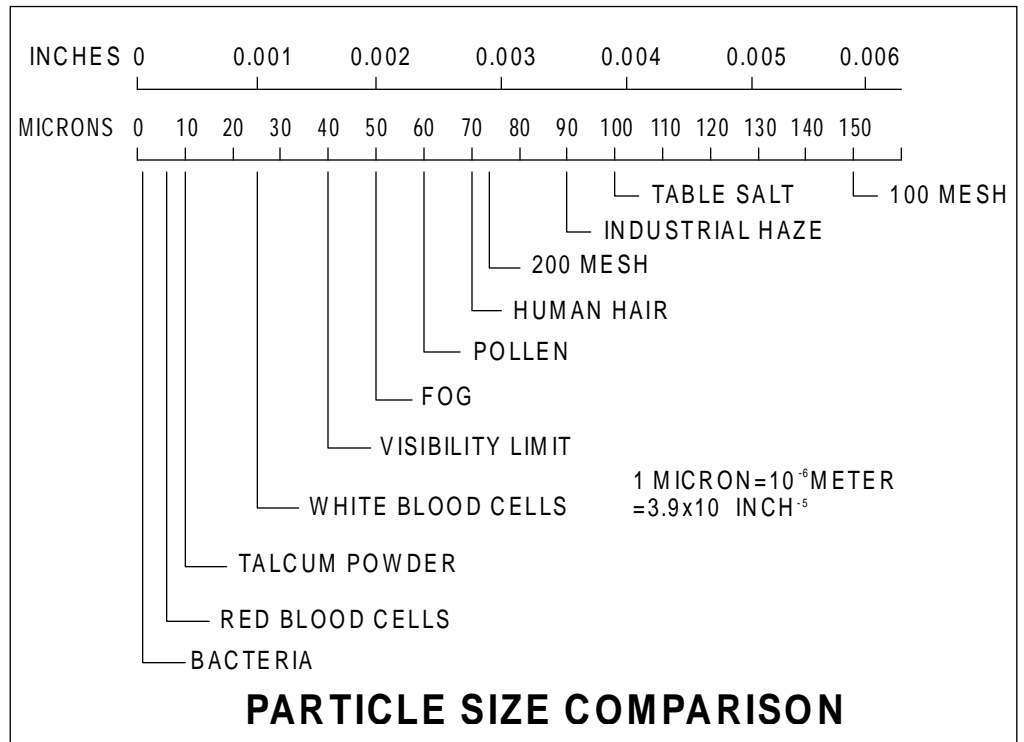


Figure 3 Particle Size Comparison

strophic to negligible in its impact. Fabrication debris is ing crude oil, highly abrasive dust ingress in hydraulic and

STRAINER TYPES

There are numerous strainer designs available from many vendors. They range from a simple cone strainer, made from wire mesh cloth, that is trapped between flanges, to duplex, self cleaning, automated strainers. Many can be equipped with magnetic devices to attract and retain ferrous particles. The cone strainer shown in figure 4 is intended as a temporary device used to catch fabrication debris. It will not retain much quantity of contaminant, is awkward to service but is quite inexpensive. Cone strainers must be removed after initial system cleaning to prevent later plugging and collapse.

Submerged and simplex strainers, figure 5, and "Y" type strainers are intended for permanent installation. They are designed to allow ready access to the strainer element

frequently the most serious source of contamination in new systems. Weld bead, slag and spatter, pipe scale, rust, machining chips, etc. all provide opportunities for pump failures or rapid wear outs. Other debris left from inattentive workmanship can be a danger to pumps as well such as extra flange fasteners (nuts, bolts, washers), weld rod stubs, unremoved port dust guards, lacing wire, rags, tools, lunch pails and a nearly endless list of things that would never be expected in a pumping system. In addition to such initial contaminant, many systems must accommodate ongoing levels of contaminant such as sand and carbonates found in transport-

lubrication systems associated with mining and ore handling machinery, not to mention sewage pumping, a subject requiring its own unique solutions to solids handling. Figure 3 illustrates particle size comparison with common items. The table below provides some hardness comparisons for common materials and gives a feel for how destructive some contaminants can be:

Material	Knoop Hardness Number
Copper	163
Heat Treated Steel	360
Nickel	537
Sand	710
Chromium	935
Tungsten Carbide	1880
Diamond	7000

(Photo courtesy of Royal Guard Corporation, Longview, TX, USA)

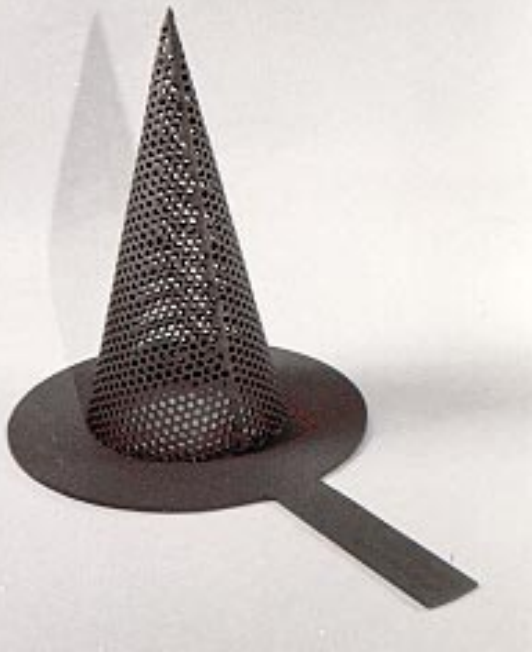


Figure 4 Cone Strainer for Temporary Use

for cleaning or replacement. They do, however, require that the pumping system be shut down while the strainer is serviced. Their cost is moderate and they should be considered the minimum pump protection required for a reasonably well designed system. Some simplex strainers are available with manual or motor driven scraper blades allowing a degree of strainer cleaning to be provided without interrupting pump operations. This self cleaning feature can be automated via timers or pressure switches such that minimal human intervention is needed.

Duplex strainers, figure 6, are more versatile, if more expensive, in that they allow transfer of flow from one strainer element to another without interruption of pump operations. One element can be cleaned or replaced while the system continues to operate. This strainer type is especially appropriate for systems whose operation is critical to a process or service and pump system outages must be minimized.

STRAINER PRESSURE DROP

As with any strainer, the pressure loss across it should be measured and monitored or, preferably, alarmed. This is due to the fact that as a strainer

does its job, contaminants accumulate in the strainer and gradually close off the open flow area. This area reduction leads to increasing pressure drop across the strainer.

reaching a pump. Unfortunately, there is also no realistic strainer size that can be relied upon to prevent all pump wear from taking place. The practical nature of pump inlet



(Photo courtesy of Mueller Steam Specialty, St. Pauls, NC, USA)

Figure 6 Duplex Strainer

Excessive pressure loss in this area will reduce the pressure available to the pump (NPSHA) and cause cavita-

side strainer protection dictates a compromise between what is affordable and practical vs what would be ideal.

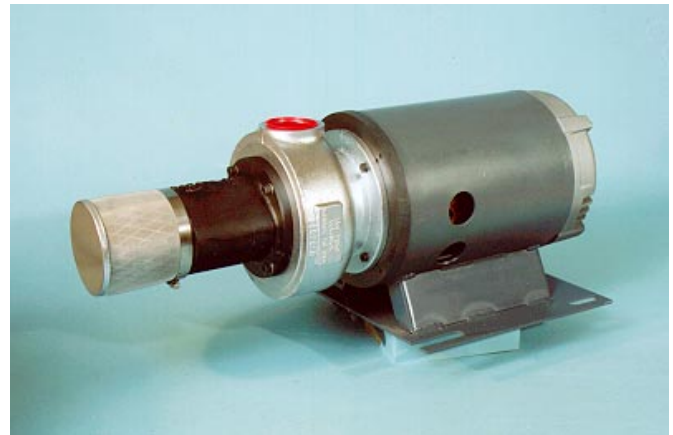


Figure 7 Submersible Pump/Motor With Built-On Strainer

tion with its attendant damage. In the worst case, the pressure difference across the strainer will cause the strainer element to collapse and be carried into the pump. This inevitably causes a complete and extensive failure of the pump. Always monitor or alarm the pressure loss across suction (inlet) side strainers.

STRAINER RECOMMENDATIONS

If not impossible, it is at least economically impractical to prevent ALL contaminant from

For example, high viscosity liquids such as bunker fuels or asphalts will inherently cause more pressure loss through any strainer. This, in turn, reduces the pressure available to the pump inlet, itself a problem if allowed to fall too low. Consequently, viscous liquids will dictate relatively large strainer element openings for economic reasons. There is always the risk that one or more particles small enough to pass through such a strainer will cause damage. It is currently a risk that



Figure 5 Single Type, Permanent Strainers

most pump users will have to live with as no practical alternatives exist. By the same token, low viscosity liquids allow the use of much finer strainer elements and thus

used as a check sheet for the principle parameters regarding strainers:

1. Type (Cone, Simplex, "Y", Duplex, etc.)



Figure 8 Hydraulic Pump With Right Angle Inlet Strainer

better protection for the pump. Aside from contaminant large enough to do immediate damage, a high viscosity pump can generally afford more wear (increase in running clearances) before significant flow reduction occurs. On the other hand, the same degree of wear in a low viscosity pump will cause significant flow loss. Fortunately, these factors work in the general favor of the pump user.

Strainers should be selected in consultation with the pump supplier recognizing that no strainer system will be perfect. The list below can be

2. Materials of construction
3. Flow rating (at maximum liquid viscosity)

Photo courtesy of Winn Czerny, Imo Industries Inc.



Figure 10 Running Clearance Increase Caused By Very Fine Contaminant



Figure 9 Pump Rotor Damage Caused By Hard Contaminant

4. Port sizes and ratings (if applicable)
5. Strainer pressure rating (overall)
6. Strainer element opening size
7. Strainer element open area
8. Pressure drop, clean (at maximum liquid viscosity)
9. Maximum allowable pressure drop
10. Applicable codes

11. Optional features
12. Cost

Particle sizes smaller than pump running clearances will still cause wear due to impact erosion of these solids on pumping components, figure 10. The objective of using an inlet strainer is to provide the pump with reasonable protection against likely contaminant hazards at an affordable cost while sizing and instrumenting such strainers so they provide their protection in a reliable manner over the long term.

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