Strategies for Optimum Filter Location

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Abstract
Having determined the optimum target cleanliness level for a contamination control programme, many engineers are then challenged by the process of optimising the location of the filter.

To ensure effective solid particle ingression balance, the engineer must consider various elements such as whether the filter will be for protection or for contamination control, ease of access for maintenance, and the performance of the unit being considered to meet the challenges of the target set.

Introduction

Firstly, the author assumes the user is aware of the benefits of proactive maintenance, since these are clearly documented elsewhere by many authors. Secondly, it is also assumed that the reader is familiar with setting specific optimised cleanliness targets.

To summarise the process of achieving ‘Proactive Maintenance in three easy steps’, the first is to set cleanliness targets, the second is to take specific actions to achieve the targets, and the third step is to measure contaminant levels frequently. The paper describes a process to strategise the methodology of achieving the optimum filter location based on the second step of taking specific actions to achieve target cleanliness levels.

Achieving the Second Step

The first decision to be made is whether the system is a complex unit requiring protection of sensitive components. In the main, hydraulic units operating with sensitive servo valves would be typical of such a requirement. In which case, one should consider a protection filter to minimise damage to components, particularly those with minimal working clearances between components.

Protection Filters considerations:

- Located upstream of sensitive components typically providing protection from particles entering the circuit from the tank or pump wear debris.
- Typically located downstream of the pump, thus mounted in a high-pressure zone. This will mean the need for a stronger element and housing, thus increasing cost.
- Because of the role of protection, the units are typically not fitted with a by-pass option. This will mean that the system will shutdown if a sudden rise in ingression occurs which prematurely blocks the element.

Protection filters are not intended as a means of balancing system ingression, merely as a protection device. Given the high cost of these elements, their use as contaminant control filters is not advised.

Filtration for the purposes of contamination control is where the location issue becomes a little more complex.

The first stage in the process of location selection for contamination control is to map the solid particle ingression to determine the balance required. The aim is to optimise a filter specification suitable to balance the ingression and a location that optimises this process.

Consider the following ingression points in the system:

1. Ingression from Manufacturing and Service work
2. Ingested contamination from the environment via the
    a. Breathers or vents
    b. Hatches or filler ports
    c. Seals or gaskets
3. Generated contaminants from the working surfaces or lubricant itself.

Therefore, if we consider that the filter must achieve a balance, then the particle removal rate is as follows:

Removal Rate $\geq$ Sum of Contaminants (1+2+3)

High performance filters are expensive. So, to optimise the cost of filter maintenance, it is necessary to look at ways of reducing the cost of performance to a point that is acceptable. Therefore, it is imperative to look at possible alternatives to reduce the

ingression level, thus minimising the performance/cost of the filtration required to balance this.

Firstly, the ingression associated with manufacturing can be controlled through specifying agreed standards of cleanliness with the manufacturer, and can be tackled through the use of flushing prior to commissioning. Service ingression can also be controlled to an extent through the application of clean working procedures and the use of portable filtration, or fixed inlet/filler filter units to ensure clean fluid delivery to the system. This would ensure that the filter being specified is not over-engineered for the task merely to meet the challenge of intermittent contaminant ingress as a result of service work.

Therefore, the focus of the balance is on points 2 & 3. Considering point 3, the generation of contaminants from within the machinery, then an active root-cause condition-monitoring programme with frequent inspection would ensure that the level of balance required would be minimised. Such tasks as regular alignment and balancing, condition based or optimised periodic oil drains, and regular inspection of machinery would limit the risk.

Remember that wear is a factor of the sum of points 1 and 2. Which further leads to minimising point 2, ingestion of solid particles from the environment. Again, depending on the quality of the ingestion point components, this will further reduce the overall ingression, and minimise point 3. Therefore, the emphasis of expenditure should not be on the filtration alone, but on the upgrading of the breather, vents, seals and fill points. To highlight this, as stated by James Fitch, the cost of excluding a gramme of dirt is typically about 10% of what it will cost to remove it from the system. This allows funding to be applied more proactively across the system and thus minimising expenditure and time spent maintaining the filtration.

Having considered these issues, then the next step is to consider the system itself. In the main, the complexity and type of the system will determine the ease with which a location is selected. Figure 1 describes a typical dry sump circulating system such as a bearing feed circuit or a hydraulic system.

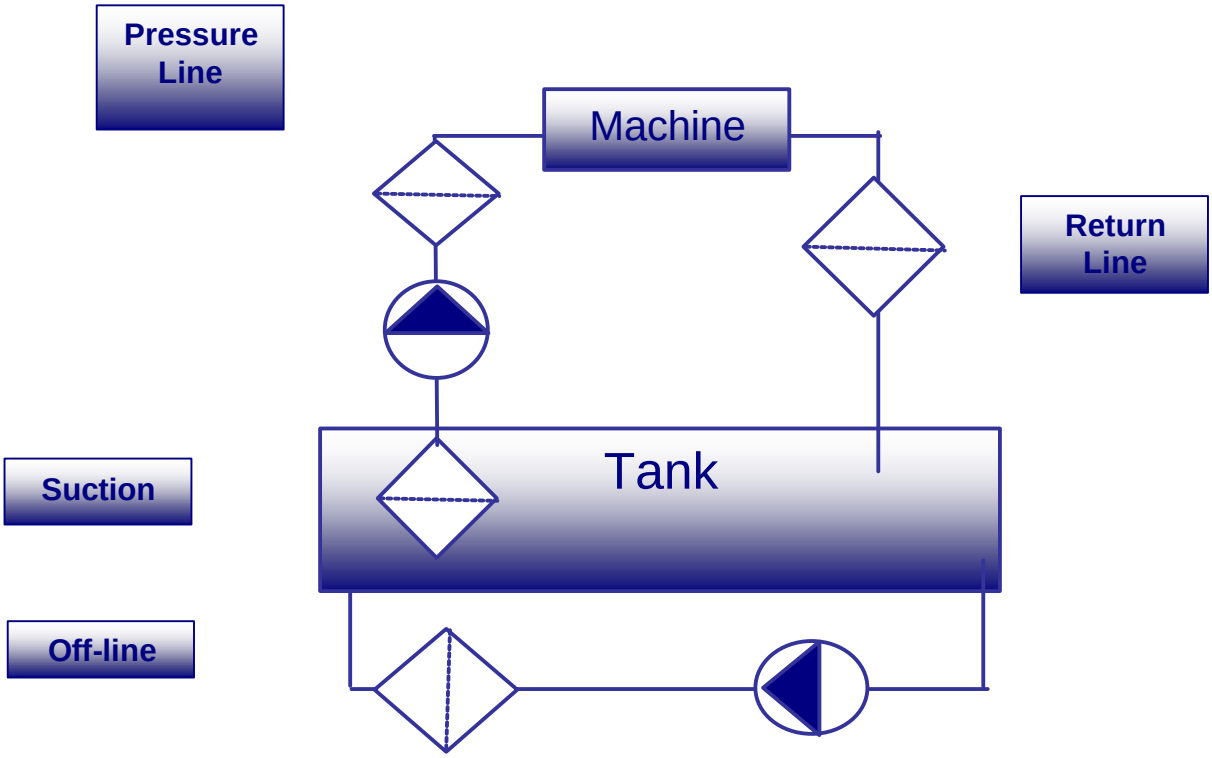

Figure 1 – Filter Location Options.

Each of the locations will be discussed.

Suction Line Devices

- All units should be fitted with a strainer, typically of 100µm rating, to minimise the risks of large foreign objects entering the system and potentially causing catastrophic damage. It is essential that these are accessible for regular inspection and cleaning if necessary.
- Not generally recommended except as a strainer device to avoid large debris that may have accidentally entered the tank.
- Generally an inexpensive option.
- Poses a risk of cavitation to the pump if too fine a filter is fitted.
- No downstream protection of sensitive components.
- Filter must be large to avoid excessive pressure drop, avoid compromising on coarse rather than bigger element.
- Access can prove difficult for replacement or monitoring inside the tank
- Always consult the pump manufacturer before fitting any device upstream of the pump.

Pressure Line Devices

- Provides effective protection to sensitive components and sub-systems.
- Protects systems from pump failure.
- Filter must be able to withstand full system pressure.
- Pressure drop across filter is less of an issue than on return or off-line filters.
- Potential harm from vibration or transient pressure and flow peaks.
- System must be stopped for element change unless duplex filters or service by-pass valves are fitted.
- Filter must withstand any cyclic pulses produced by variations in pump or system pressure.
- Has a perceived high unit cost.

Return Line Devices

- Provides effective control over system fluid cleanliness levels.
- Prevents ingested or generated debris reaching the reservoir.
- Filter may be subjected to high flow surges when system is operating.
- System must be interrupted for maintenance unless duplex filters or service by-pass valves are employed.
- Return line filters may be mounted on the reservoir or fitted in-line.
- Generally less expensive, less complex design.
- No direct protection of sensitive components.
- Care should be taken to avoid excessive backpressure against upstream components.

Offline, Side Stream or Kidney Loop Devices

- Provides effective control over system fluid cleanliness levels when permanently mounted with no concern on pressure drop.
- Filtration is still possible when system is in shutdown mode.
- Filter not subjected to systems conditions of flow/pressure peaks or vibration.
- Filter can be positioned for ease of access.
- Does not require system interruption for element replacement.
- Off-line circuit can be utilised for system re-fills or top-ups.
- Introduces a higher cost of set-up owing to extra pump, piping and valves.
- Not suitable for in-line protection of sensitive components.
- Does not alone filter 100% of the fluid in the system.

Other Contaminants and Multiple Locations

Multiple objectives may lead to the consideration of several possible locations. For example, in extreme environmental conditions, an off-line circuit may prove to be an invaluable addition to the return line set up.

Filtration is not merely limited to solid particles. In addition, other contaminants may ingress into the system such as water. The consideration may be to include the option for connection of vacuum dehydration units on an off-line circuit to remove an accidental ingress of water.

In addition, it is becoming more common to incorporate electro-static separation units on the offline circuit, particularly on hydraulic machinery that has experienced varnishing problems in the past.

On crankcase units, bypass filtration is also becoming a considered option to support pressure line filtration and better improve the filtration performance. The benefit is to allow finer filtration without affecting the flow or pressure delivered to the working components.

Conclusion

The goal of the solid particle filter is to balance the ingression rate on the system. In order to minimise cost, the issues of built in debris and generated particles should be controlled through proactive maintenance strategies thus reducing the ingression rate and maximising the life of the filter and its required location. The impact of the maintenance of the filter on production can be further minimised by the right location and choice of housing. Above all, ensure that the housing is easily accessible for regular inspection and that the ease of servicing is considered.