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TECHNICAL NOTE

PLUGGED PUMP DISCHARGE FILTER ELEMENTS

BACKGROUND: Filter elements are designed to trap solid particles so that they can be removed from the working fluid before they can cause binding, wear and/or deposits where there are close clearances and before they can contribute to fluid degradation. As such filter elements have a life that depends on the particle ingestion rate from external and particle generation rate from internal sources. Typically those on the pump discharge locations last at least a year before the pressure drops reach the 100 psid limit used by both GE and Siemens Westinghouse. Some achieve longer lives but too long carries with it a greater risk of media migration, more fines going downstream as the beta ratio drops and actual filter element collapse. The rating of disposable filter elements on the pump discharge might be 3 microns with a beta ratio of 200 on older GE systems and 6 microns on newer GE systems. The cleanable metal mesh filter elements on Siemens Westinghouse systems is rated at 10 microns absolute.

CONSEQUENCES: Also note that if a filter element is plugging, it is doing its job. The action should be taken to determine if the life is too short and if so, what action should be taken. The intention being to ensure that the function of the servo-valves is not compromised and that the steam valves will work as required.

Rapid blocking can arise for a variety of reasons including the following; material generated or ingested upstream of the pump discharge filters, breakdown of the fluid on the filter element because of electrochemical and/or electrostatics and deposition of fluid degradation byproducts. Examples of the latter can be the result of overheating, metal salts arising from the purification media and carbon particles from dieseling.

1. MATERIAL GENERATED OR INGESTED DOWNSTREAM OF THE PUMP DISCHARGE FILTERS.

This could be the result of contamination through any piping or components that had been opened, weld repairs or hot spots on piping. The later can be a result of heat shields or lagging being removed and not replaced or the result of lagging hydraulic supply lines in with a steam line. The lines should be walked to determine if there are any hot spots and action taken to make corrections.

Material in the lines can also be deposited over a long period of time or left from previous work but was loosened by a trip or other repairs. This might reduce in time because it should be trapped by filters or screens and/or be deposited in the reservoir. However, if considerable amounts are present corrective action would likely require a real system flush. The servo-valves should be replaced with flushing blocks. It only takes a few seconds to contaminate a system for months so it is generally much better to take extra

effort to keep particles out than to try to remove them later.

2. BUILD-UP OF PARTICULATES.

Most filter elements do not have an absolute rating but instead the performance is characterised by a parameter called the beta ratio. This is the ratio at a set size of the number of particles counted in the fluid before a filter to the number after the filter. Even so this ratio can vary with the size of the particles, with the type of fluid, with the pressure drop and with pressure pulsations.

For a particular size rating a beta ratio of 200 is usually adequate. While good this does mean that many particles are getting downstream which might then be caught by the servo-valves screen or trapped in the very tight clearances between the spool and the valve body.

For example, the recommended maximum fluid cleanliness for GE turbines in the 5-10 micron size range is 24,000 particles per 100 ml. Consequently, even with a beta ratio of 200 this means that 120 particles in this size range per 100 ml is in the fluid going to the servo-valves. Assuming a servo-valve leakage flow of just 1 gpm this is 24,000,000 particles per year! While this might be the worst case and this size particle may not be the most damaging, it does indicate what can accumulate.

3. OVERLOADING OF THE PUMP DISCHARGE FILTER ELEMENTS.

Situations can also arise because of system or reservoir maintenance, fluid additions or even just changing of the purification media that can mean a large number of particles are added to the system. While the pump discharge filter will try to handle as many as it can, because of the beta ratio, some will end up going to the servo-valves. This can be controlled by ensuring that the fluid is clean after any maintenance and before the main pumps are started, that only 1 micron filtered fluid is added as make-up and that the trap filters (back-up filter) after the purification media, such as the fuller's earth and Selexsorb, are good enough.

The trap filter can be of particular concern if the filter element media is the type in which the beta ratio (efficiency) gets better with time. The reason being that the maximum number of fines can be expected when new fuller's earth is first valved in and that is when you need the best beta ratio. Not the worse. Options might be to leave the old filter element in for a week or so after the purification media is changed, to run the fuller's earth system in a re-circulation mode to 'cake' the trap filter, or to use a better trap filter.

4. FAILURE OF PUMP DISCHARGE FILTER ELEMENT.

Filter elements are manufactured constructions of various materials. While generally very good, there can be variations. It is for this reason that 100% bubble point testing is recommended.

In addition, many filter element suppliers have been making changes to the media and to the design so that these have to be considered. For some turbines the performance can be monitored by observing the differential pressure across the filter to ensure that

it is not too low, too high or rising too fast.

Too low a pressure drop is of concern because it can mean that the fluid is not being filtered. The reason can be because of the filter element itself, missing housing internals or improper replacement of the filter element. The result can be very rapid plugging of servo-valve screens. Unfortunately, many systems do not have differential pressure gauges but these can usually be fitted to the housings or to supply lines. Fluid samples for particle counts can also often be taken upstream and downstream of the filter elements to determine if the filter is working. In addition, when the servo-valve screens are changed they should be examined for material such as fibres. These can be from the filter elements and/or from rags and wipes.

5. FLUID DEGRADATION BYPRODUCTS.

As well as solid material that can plug the open areas in filter elements or plate out on the media, the media support mesh or the metal endcaps and core.

For example, in normal use the fluid will be stressed and this is controlled by purification.

However, if the temperature has been excessive, the water content too high for too long or the acid number too high at any time, it can mean that the fluid has degraded. This can lead to the formation of higher molecular weight fluid byproducts or to the reaction of fluid byproducts with metals from the purification media. These can then form gums, gels, soaps, black scum and the like.

The solubility of these in the fluid can be temperature dependent so that they can get through the pump discharge filter to form on downstream surfaces or screens. This material may also come out when a unit is shutdown or when the acid number drops.

Further, there can possible be reactions of the fluid degradation byproducts with material previously trapped on the servo-valve screens.

ANALYSIS

If the life of a filter element is too short, one of the first steps should be to identify the material on the screens. Care is required that the appropriate tests are performed so that erroneous conclusions are not reached. A variety of testing is often required.

Generally there is too little material for extensive testing but the following are suggested;

Optical examination of the filter element media before cleaning. Typically 40x is sufficient and photos can be very useful.

Testing both the fluid and deposits by FTIR (Fourier transform infrared) analysis and in particular look for oxidation and nitration. FTIR on the deposit might require a special microprobe version.

Consider also trying to remove the deposit material in a controlled manner and examining after each step. First use hot water to get lower molecular weight materials as might be caused by hydrolysis. It can also remove some water soluble sodium compounds. Then alcohol to remove phenols, heptane to remove residual fluid and lastly, toluene or acetone to get any remaining phosphate ester material. Confirm with optical examination that the majority of the material debris has been removed.

Filter the fluid and/or the material removed with the above solvents using a patch of 0.8_ or better and both phosphate ester and solvent compatible. Optically examine the debris. Analyse each solvent by ICP for metals. Consider analysing the material on the patches by acid digestion and ashing followed by ICP or X-ray fluorescence. EDAX in an SEM can be useful to determine the elemental composition of particles but any volatile organic phase might be lost. If sufficient material is present, molecular weight determination by LC/MS (liquid chromatography/mass spectroscopy) can be very valuable to determine the source of any metal soaps or gels.

In addition, to get a handle on the past fluid maintenance consider;

Full fluid analysis and trace metals by ICP.

Examination of historical fluid test data.

Determination of pump discharge filter changes, differential pressures and actual beta ratios by upstream and downstream sampling.

Confirmation of the filter elements being used.

It is important to keep in mind that the reason the analysis is being done is to identify the reason for the blockage so that there are no further unplanned shutdowns or deratings.

This normally requires being able to achieve the turbine manufacturers recommended change out intervals.

