
INCORPORATING VARNISH MITIGATION

INTO YOUR COMPRESSORS FLUSHING ACTIVITIES

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Whitepaper

SYNOPSIS

Incorporating Varnish Mitigation into High Velocity Oil Flushing will remove varnish and oxidation contaminants left behind from normal particulate flushing. The process provides additional protection against lubrication related failures.

INTRODUCTION

Refinery and Petrochemical Facilities are subjected to extreme temperatures leading to oxidation and varnish deposits in their compressors lubrication systems. This increases when facilities are located in warm humid climates, like the Gulf Coast of the United States. Downtime is a costly proposition that has reliability and maintenance personnel consistently reviewing technology to keep their facilities running from one major turnaround to the next. (usually a 5-6 year period).

High Velocity Oil Flushing to remove mechanical wear and maintenance introduced foreign materials have been utilized by facilities for over 50 years. Over time, technology advancements have improved “Best Practices” of the flushing process to increase turbulent flow, thermal cycling, pneumatic vibration of pipes and “sparging” (introducing dry air or nitrogen into flush fluid creating turbulence). All of which are critical to keeping systems within OEM cleanliness specifications. What is missed during normal flushing activities is the mitigation of sub-micron oxidation deposits (commonly called varnish). Varnish is a soft-contaminant composed of lubricant degradation by-products that are less than 1 micron in size and is not measured by traditional particle count. Varnish deposits show as a thin-orange, brown or black insoluble film deposit occurring on internals of lubricant systems. Figure 1 shows varnish deposits plating to compressors internal components.

With a wave of young engineers and readily available information sharing we are seeing technology used in the Power Generation industry sector making its way

into other marketplaces. One of which is incorporating varnish mitigation strategies during major turnarounds.

Varnish potential can be measured by including the Membrane Patch Colorimetry (MPC) test during lubrication analysis. The Membrane Patch Colorimetry test is used to measure the color bodies of insoluble contaminants in lubricants.

MPC OPERATING PRINCIPLE

The oil sample is received by the lab and held for a specified time at a controlled temperature. Once the required time is reached a portion of the oil is mixed with a non-polar solvent and passed through a .45 micron Millipore patch. Varnish material tends to be polar in nature, and not very soluble in the oil/solvent mixture. The insoluble material is captured on the Millipore patch.



Figure 1: Varnish formation on gas compressor -gear



Figure 2: Varnish material on gas .45 micron Millipore patch

Varnish tends to color the patch and by measuring the hue and intensity of the colored material deposited on the patch a general characterization can be made about the level of varnish in the system. Figure 2, above, shows an example of an MPC Millipore patch test.

METHOD

A Varnish Mitigation and High Velocity Oil Flushing plan can be broken down into (4) steps.

1. Review Varnish analysis of current system lubrication
2. Varnish mitigation flush with Step One Cleaner
3. Purge/particle Contamination flush with virgin oil
4. Side stream filtration of final fill oil

STEP 1: LUBRICANT ANALYSIS

Prior to developing the full process and procedure the current lubricant needs to be analyzed using the MPC test. Based on the levels of varnish in the current lubricant it could be necessary to reduce varnish levels prior to flush utilizing a varnish adsorption system or a fluid change can be performed at beginning of flush for the varnish mitigation stage. If current lubricant is saturated with varnish it will not be able to carry varnish and deposits will remain plated out in system.



Figure 3. Varnish Adsorption System

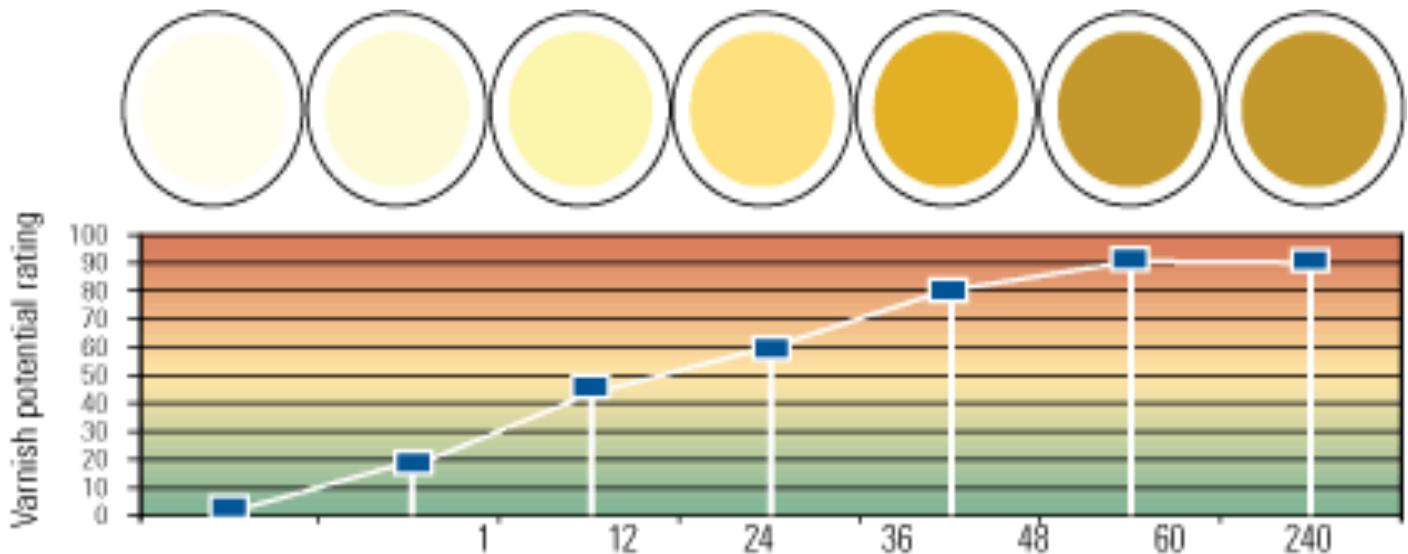


Figure 4. MPC Scale

STEP 2: VARNISH MITIGATION

Due to limited timeframe and additional work scheduled during a turnaround, execution of varnish mitigation step will take one of two possible directions.

SITUATION 1: MECHANICAL INSPECTIONS AND MAINTENANCE OCCURRING SIMULTANEOUSLY

Commonly you have multiple contractors performing work on the compressor. This can impact the lubricants flow path requiring bypass jumpers to be installed around components being serviced. During the mitigation process the goal is to incorporate as much of the lube oil system as possible. Varnish is not a material that always flows back to the reservoir and drops to the bottom. The deposits will plate out on any steel components including coolers, valves, bearings, gears and the lube oil piping itself.

SITUATION 2: WHEN THE TARGETED COMPRESSOR HAS NO ADDITIONAL WORK SCHEDULED DURING THE TURNAROUND

This is a rare occurrence that should be taken advantage of when possible. Use the system as designed, moving detergent and carrying agent mix through the normal flow path. This will solubilize varnish deposits from components not normally reached with high velocity oil flushing.

Note: Utilizing this option bypass jumpers are installed around critical components during the high velocity particulate flush phase.

With either situation the mitigation process uses an oil-soluble, solvent-free cleaner that contains emulsifiers, dispersants, and rust inhibitors. Think of it is a detergent used to get that hard ground in dirt off of your clothes. This product is utilized due to the fact that it is mineral based and compatible with common seals up to a 20% concentration. The cleaner has a high flash point to allow systems to operate normally during the cleaning process.

Using 5-10% system cleaner added to the current (or base stock) lubricant, run mix for 72-hours. The fluid needs to be kept above 120F. Side stream filtration with a 2.5Micron Beta1000 filter is recommended during the 72-hour circulation. At the end of 72-hours the system is drained while hot including reservoir, low point drains, filter vessels, coolers and even feed headers. Best practices would include entered the reservoir and a performing a cursory cleaning of any heavy drop out and residual oil. Once complete perform a filter replacement, install bypass jumpers for high velocity particulate flush.



Figure 5. Prior to cleaning and flushing

OIL RESERVOIR



Figure 6. After cleaning post varnish removal flush



Figure 7. Before the varnish removal flush

OIL SYSTEM PIPE INTERNAL



Figure 8. After the varnish removal flush

STEP 3: HIGH VELOCITY OIL FLUSH

The goal of the high velocity oil flush is to remove any particulate contamination introduced to the system from mechanical wear and foreign materials from maintenance activities. A formal procedure should be developed to incorporate process and inspection criteria. This portion of the service requires bypass jumper material to be installed around all critical components. The materials allow for achieving turbulent flow (Figure 9) and prevent contamination from being pushed into and damaging components.

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Professional flush companies will utilize "Best Practices" to meet OEM flushing specifications including stainless steel bypass materials, isolation valves, variable frequency drive pump skids, fine filtration, pneumatic vibrators and on site particle count units to name a few. In lieu of OEM specification The API 614 inspection table should be utilized.

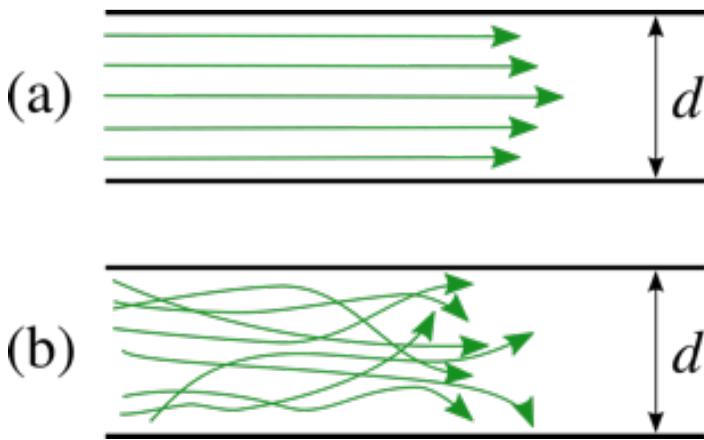


Figure 9. Laminar Flow (a) Vs. Turbulent Flow (b)

Using a 100 Mesh screen (at specified locations) run for 1 hour and view screens for:

- No magnetic particles
- No particles gritty to the touch
- A negligible dirt count per screen (see Table 1)

Nominal Pipe Size (inches)	Schedule 40 or less	Schedule 80	Schedule 160	Double Extra - Strong
<1	6	5	4	None
1 – 1.5	15	10	10	5
2	20	20	15	10
3	45	40	35	25
4	80	70	60	50
6	180	160	130	115

Table 1. 100 Mesh Screen Comparisons

STEP 4: FINAL FILL

After completing the flushing activities the reservoir should be cleaned and inspected. Virgin product does not come from the distributor at OEM cleanliness specification. Performing the flush and filling with unfiltered oil would be taking a step backwards in the process. Filter the oil to meet OEM specifications prior to filling the reservoir to operating level.

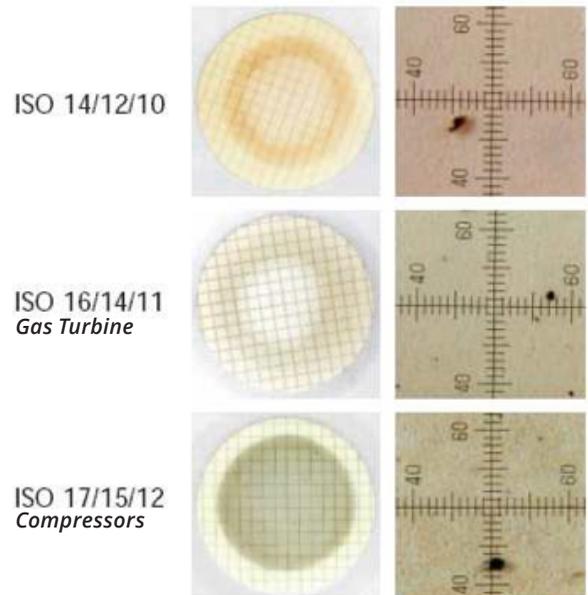
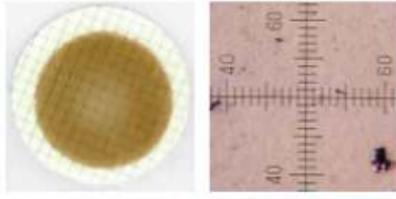


Figure 10. OEM Specifications

ISO 19/17/14
Virgin Oil



ISO 22/20/17

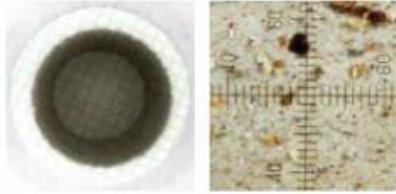


Figure 10. OEM Specifications (cont)

CONCLUSION

With today's demands on compressors to run harder and longer between turnarounds keeping your lubrication systems at recommended cleanliness levels improve reliability. It doesn't end with the flushing service, routine analysis and lubricant cleanliness handling program will keep unit within specifications.

In any service it starts with the technical knowledge and plan. Start early and use resources at hand. Professional flush companies understand the processes required to meet OEM and site requirements. Saving both time and money.



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