

PETROLEUM REFINERY

CENTRIFUGAL GAS COMPRESSOR VARNISH REMOVAL & HVOF

By Larry B. Jordan, Sr. Technical Advisor, RIG

Case Study

SYNOPSIS

RIG successfully removed varnish from a refinery's centrifugal compressor lube oil system, achieving changing the MPC from >40 to 1. High velocity flushing combined with side streaming filtration and chemical cleaning.

GLOBAL LEADERS IN PRECOMMISSION & PLANT MAINTENANCE

INTRODUCTION

In addition to a high level of wear metal contamination the refinery's centrifugal compressors lubricant was showing MPC values >40 which put it in a critical level for varnish potential.

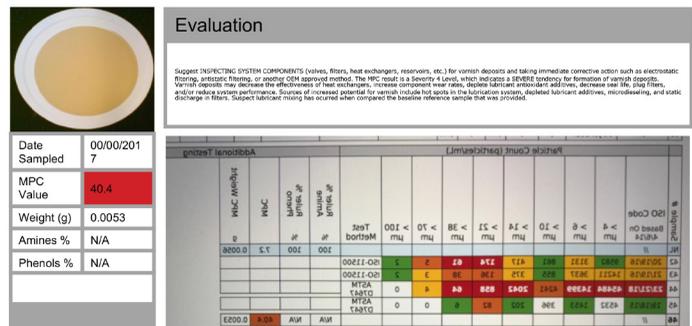


Figure 1. Evaluation

RIG was contracted to provide services on the compressor lube oil system during the turnaround. The services performed included:

- Varnish mitigation flush with Step One Cleaner
- Purge / particle contamination flush with virgin oil
- Side stream filtration of final fill oil

OPERATIONS

Prior to arriving on site RIG personnel completed all site specific safety training requirements. RIG personnel and equipment arrived onsite on the scheduled date to start. Once checked-in with contact, permitting requirements were completed and the flushing equipment was staged in the dedicated location near the lube oil reservoir.

The system spools were removed in preparation of installation of the RIG supplied flushing jumpers. Additionally RIG personnel made connections from the flushing equipment to the compressor lube oil system.



3" 150# Suction on The Reservoir Prior to Flushing

Supply to the flushing skid was pulled from the lube oil reservoir. Figures 2, 3, & 4 show various items from the lube oil system prior to flushing and cleaning.



Figure 2. Interior of the Oil Reservoir Prior to Cleaning and Flushing



Figure 3. 3"150# Suction On the Reservoir Prior to Flushing



Figure 4. Sight Glass Removed for Hand Cleaning

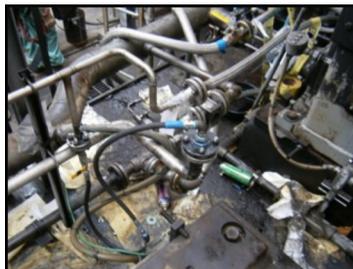


Figure 5. Gearbox and Compressor Jumpers

The varnish removal flush began by circulating and heating the existing oil using the RIG flushing pump and heater. Once the oil reached 150°F the system cleaner was added at %5 blend to the system. This started the 72-hour varnish mitigation flush. RIG technicians cycled all the bypass circuits and alternated flow between the oil coolers and filter housings during the flush.

At the end of the 72 hours, RIG immediately drained the reservoir and all low point drains as quickly as possible. The system was thoroughly blown down with plant nitrogen.

The door on the oil reservoir was removed to gain access to the interior for cleaning. Large amounts of debris ranging from paint chips to varnish and sludge were found in the reservoir. Confined space entry was



Figure 6. Debris in the Oil Reservoir After the Varnish Mitigation Flush



Figure 7. Oil Reservoir After Cleaning Post Varnish Mitigation Flush

not allowed at this facility, so the reservoir was cleaned from the outside with squeegees and shop vacuums. The final reservoir cleanliness was inspected and approved by the customer representative.

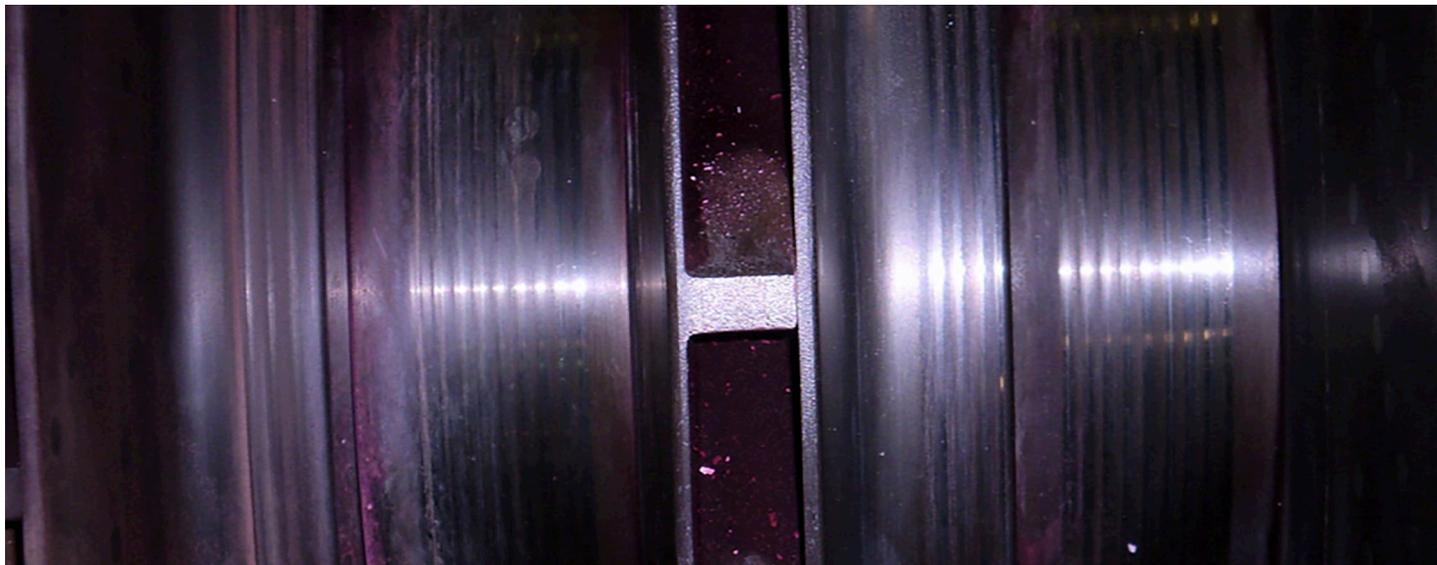
After the reservoir was inspected and covers reinstated, the system was filled with virgin oil. The purge and particulate flush was started. This stage removed any residual system cleaner from the oil system and was used for inspections for particulate contamination. Initial inspection screens became plugged with debris after an hour of flushing. (See Figure 8)



Figure 8. Initial Inspection Screens Check After 1-Hour Flushing

A course flush was executed without inspection screens installed for 12 hours. After 12 hours, a subsequent one-hour screening run showed improvement. The flush continued with RIG technicians alternating flow through the oil coolers and filter housings every hour.

During the flushing sequence, the final fill oil was being filtered in a storage tote with a 1-micron filter. This insured the final fill oil met the ISO code specifications when the purge/particulate flush was completed.



Inspection screen runs were performed until a one-hour run produced clean screens. A confirmation screen one-hour run was performed to confirm the pipe cleanliness. Final inspection screens are shown in Figure 8. The purge oil was field tested for particle count and returned an ISO code of 15/14/10. The final fill oil was also tested and returned an ISO code particle count of 16/14/11. The test results for the field particle counter are shown in Figures 10 & 11.

The customer approved the inspection screen and ISO cleanliness of the system. RIG shut down the flushing equipment, closed all valves, and began reinstating the system. The final fill oil was filter filled into the oil reservoir.

A sample from both the final purge oil and a from the final fill oil were sent to a third-party lab for final particle count and MPC analysis. The lab results showed final particle count for the purge oil was 16/14/11 and 15/14/10 for the final fill oil. MPC on the final oil was reported at a color value of 1. Final laboratory test reports are shown in Appendices I, II & III.

CONCLUSION

RIG safely completed the varnish mitigation flush, purge/particulate flush, and filter fill on the centrifugal compressor lube oil system. The job was able to successfully remove varnish from, and MPC >40 to 1, in the lube oil system. System cleanliness was verified by API 614 specifications by producing clean inspection screen after a 1-hour run followed by another successful confirmation run. The final fill oil had a final ISO code particle count of 16/14/11 from the field particle counter and 15/14/10 from laboratory confirmation testing.



Figure 9. Final Inspection Screen Check

ISO CODE- 350	
15/14/10	
NAS CLASS 6	
SAMPLE VOLUME 15mL	
µm(c) /100ml	
4	30624
6	1820
14	840
21	199
25	66
38	22
50	22
70	0

Figure 10. Field Particle Analysis Results for Purge Oil

ISO CODE-	
16/14/11	
NAS CLASS 7	
SAMPLE VOLUME 15mL	
µm(c) /100ml	
4	34508
6	13808
14	1548
21	597
25	309
38	110
50	0
70	0

Figure 11. Field Particle Analysis Results for Final Fill Oil

Appendix I: Purge Oil – Post Flush Analysis Results



Machine Condition **NORMAL**
 Lubricant Condition **NORMAL**
 Machine Name: Citgo Lemont - #13 GB Post Rinse

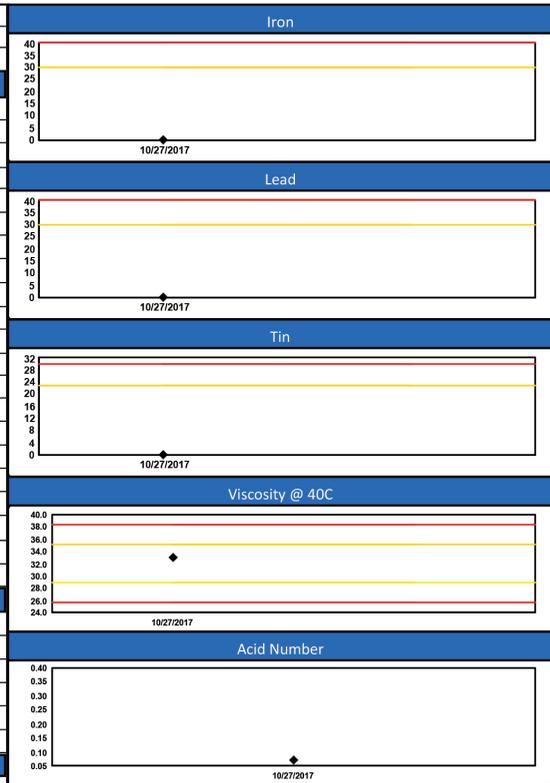
Analysis Report					
Component Information		Sample Information		Customer Information	
Machine Type:	Industrial Turbine	Sump Size:	Unknown	Received:	10/30/2017
Lubricant:	CITGO/PACEMAKER T-32	Report:	10/30/2017	PetrolinkUSA, LLC	
Machine MFG:	UNKNOWN	Sample No.:	3166 - 1 - 326 - 1	3021 E. Fourth Ave.	
Machine MOD:		Analyst/Test:	HMV / PARKF	Columbus, OH 43219	
				Contact:	Jason Bandy

PROBLEMS No problems found with current sample.

COMMENTS The results for this sample indicate normal conditions. Please continue scheduled sampling.

CUSTOMER NOTES

Date Sampled	NEW OIL	10/27/2017			
Lab No	676571	2077024			
Machine / Lube Cond.		N / N			
ELEMENTAL SPECTROSCOPY (ppm) ASTM D5185 Mod (-) indicates below detection limit					
Wear Metals	Iron	-	-		
	Copper	-	2		
	Lead	-	-		
	Aluminum	-	-		
	Tin	-	-		
	Nickel	-	-		
	Chromium	-	-		
	Titanium	-	-		
	Vanadium	-	-		
	Silver	-	-		
Additives	Calcium	-	-		
	Magnesium	-	-		
	Phosphorus	18	14		
	Zinc	2	-		
	Barium	-	-		
Contaminants	Molybdenum	-	-		
	Silicon	-	-		
	Boron	-	-		
	Lithium	-	-		
Sodium	-	-			
Potassium	-	-			
PARTICLE COUNT (particles per ml) ISO 4406:99					
ISO Code	18/16/14	15/14/10			
>4 Micron		297			
>6 Micron		115			
>14 Micron		8			
>50 Micron		0			
>100 Micron		0			
VISCOSITY (centistokes) ASTM D445 MOD					
Viscosity@40° C	30.2	33.0			
ACID NUMBER (mg KOH/g) ASTM D974 MOD					
Acid Number	0.14	0.07			
WATER (PPM) a-ASTM D6304C b-IWI-134* c-Crackle d-IWI-135* e-IWI-370*					
Water		24 (a)			



Testing performed by Insight Services *, an ISO/IEC 17025:2005 accredited laboratory L-A-B Accredited Certificate Number 2221 Testing. (*) - Not in scope of accreditation. PetrolinkUSA, LLC assumes sole responsibility for the application of and reliance upon results and recommendations reported by TestOil, whose obligation is limited to good faith performance.

Appendix II: Final Fill Oil - Post Filtering Oil Analysis Results



Machine Condition **NORMAL**
 Lubricant Condition **NORMAL**
 Machine Name: Citgo Lemont - #13 GB Final Fill

Analysis Report

Component Information		Sample Information		Customer Information	
Machine Type:	Industrial Turbine	Sump Size:	Unknown	Received:	10/30/2017
Lubricant:	CITGO/PACEMAKER T-32	Report:	10/30/2017	PetrolinkUSA, LLC	3021 E. Fourth Ave.
Machine MFG:	UNKNOWN	Sample No.:	3166 - 1 - 327 - 1	Columbus, OH 43219	
Machine MOD:		Analyst/Test:	HMV / PARKE	Contact:	Jason Bandy

PROBLEMS No problems found with current sample.

COMMENTS The results for this sample indicate normal conditions. Please continue scheduled sampling.

CUSTOMER NOTES

Date Sampled	NEW OIL	10/27/2017			
Lab No	676571	2077025			
Machine / Lube Cond.	N / N				
ELEMENTAL SPECTROSCOPY (ppm) ASTM D5185 Mod (-) indicates below detection limit					
Wear Metals	Iron	-	-		
	Copper	-	-		
	Lead	-	-		
	Aluminum	-	-		
	Tin	-	-		
	Nickel	-	-		
	Chromium	-	-		
	Titanium	-	-		
	Vanadium	-	-		
	Silver	-	-		
Additives	Calcium	-	-		
	Magnesium	-	-		
	Phosphorus	18	22		
	Zinc	2	-		
	Barium	-	-		
Contaminants	Molybdenum	-	-		
	Silicon	-	-		
	Boron	-	-		
	Lithium	-	-		
	Sodium	-	-		
Potassium	-	-			
PARTICLE COUNT (particles per ml) ISO 4406:99					
ISO Code	18/16/14	15/14/10			
>4 Micron		317			
>6 Micron		123			
>14 Micron		9			
>50 Micron		0			
>100 Micron		0			
VISCOSITY (centistokes) ASTM D445 MOD					
Viscosity@40°C	30.2	33.1			
ACID NUMBER (mg KOH/g) ASTM D974 MOD					
Acid Number	0.14	0.06			
WATER (PPM) a-ASTM D6304C b-IWI-134* c-Crackle d-IWI-135* e-IWI-370*					
Water		19 (a)			

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VARNISH STATUS

Normal

Lube Type: CITGO PACEMAKER T-32	Received: 02/01/2018	Citgo Lemont - #13 GB MPC
Machine MFG: UNKNOWN	Report: 2/5/2018 4:48:00PM	Jason Bandy
Machine MOD:	Sample No: 3166-1-388	PetrolinkUSA, LLC
Machine Type: Industrial Turbine		3021 E. Fourth Ave.
		Columbus, OH 43219

Observations/Recommendations
 The current test results indicate a low level of degradation by-products associated with varnishing. Please continue routine sampling to monitor the trend in the level.

<p>UC VALUE</p> <p>2146867 - 01/31/2018</p> <p>Lab ID - Sample Date</p>				
<p>COLOR VALUE</p> <p>2146867 - 01/31/2018</p> <p>Lab ID - Sample Date</p>				
SAMPLE DATE	01/31/2018			
LABID	2146867			
ULTRA CENTRIFUGE TEST				
UC VALUE				
MEMBRANE PATCH COLORIMETRY				
COLOR VALUE	1			
PHYSICAL PROPERTIES				
ACID NUMBER mg KOH/g				
KARL FISCHER WATER ppm				
RULER TEST				
AMINE				
PHENOLIC				
ZDDP				

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Contact us for more information:

info@therigteam.com
800-770-4510 (Domestic)
+1 281-339-5751 (International)
www.TheRigTeam.com