Difficult Application Sampling Strategies

Competitive manufacturing and production equipment tend to challenge the equipment design and components by operating under increased loads, increased speeds and challenging environmental conditions. The complex lubrication system, the components and the lubricants of the 3 following machines required a competent condition-monitoring program to evaluate not only their condition but also the presence of any degradation root cause precursors. Oil analysis condition monitoring programs require a sample of oil that is data rich with information such as lubricant condition, contaminants and wear debris particles that represent a chosen location and/or a specific component while under its typical operating conditions. This location must ensure the safety of the personnel extracting the sample while also maintaining the system and sample integrity.

Introduction

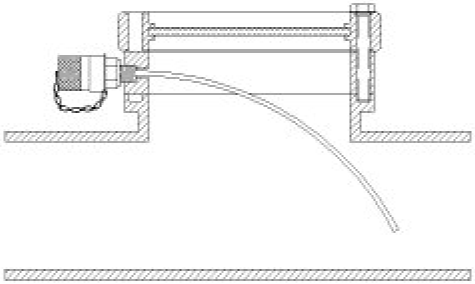
Success in an oil analysis program requires a dedicated commitment to truly understand the equipment design, the lubricant, the operating environment but the evitable path to failure is testing an unrepresentative sample which will be evaluated for present and future maintenance decisions.

Sample point location, sampling hardware, sampling procedures and sampling frequencies all affect the ability to obtain and maintain the integrity of an oil sample that is extracted from an operating system. This paper supplies an overview detailing the sample point location and the sampling hardware required for 3 very different applications that with a bit of imagination and creativity the examples should provide guidance to many other difficult or unusual sampling requirements. Careful evaluation into the sampling location, the hardware used and the environment must be used to ensure personnel safety in all applications.

10 MW Gas Turbine Generator

This like many other gas turbines use a pressurized lubricating system to supply oil to the main bearings along with the other critical components. Using a common non-flooded welded pipe return to the reservoir, made the condition-monitoring program requirement of isolating the generator bearings without drilling and tapping appear to be a difficult task. Inspection windows were originally placed in the weld pipe to allow for monitoring the appearance of the lubricant along with inspecting oil flow. These inspection windows (typical for the era) are bolted to a prepared flange allowing for replacement of the glass if damaged or discolored.

After removing the glass inspection plate, measurements were made to produce a ½” thick spacer plate that allowed the introduction of an oil sampling pitot tube. The sampling tube was bent into the lubricant flow level to approximately ¼” bellow the center level of the oil flow.



Glass lubricant Inspection Plate

Without removal of piping and/or drilling and welding in a sample port, the oil Pitot tube and the spacer block allowed for isolation of each of the bearings. A vacuum pump is used to extract the sample after the sampling tube is flushed.

(see Line Flushing Requirements)

Fertilizer Compressor Train

The Fertilizer Compressor Train is located in a low light environment and uses some very toxic chemicals in its process. Roughly 96% Nitrogen, 2800 ppm Nitrous Oxide, Carbon Dioxide, Carbon Monoxide, water and 1% Oxygen are typical internally used during operation. While at the operational speed of 8200 RPM, a compression flow rate of 48800 CFM (Cubic Feet Per Minute), a compressor discharge temperature of 169'C (336'F), an expander inlet temperature of 665'C (1229'F), and an expander discharge temperature of 313'C (595'F), this rotating equipment requires great care in regards to safety. This was similar piping construction to the Gas Turbine Generator list above, the main common return lines did not allow for isolation of the components required for the oil analysis condition-monitoring program. The physical size of this equipment, permanent "cat-walk" that interferes with the ability to safely access the identified 13 bearing sets required the sample test points to be brought to a well-lit safe environment.

Pitot tubes were installed into the bearing and gearbox housings using existing duplicated drain plugs with the pickup area in a turbulent location to allow for the ability to extract a representative sample of oil. From that point 3/8"stainless steel tubing was installed to take the sample to a location easily accessible for the extraction of the oil samples. Bulkhead fittings were used to install the sample port ends into a localized standoff plate and Sample Identification Plates were installed. Since the length of the tubing varied greatly, an assessment of the length and the required flushing needs where evaluated and recorded on the sample port identification tags.

LINE FLUSHING REQUIREMENTS PRIOR TO OIL SAMPLING

*VOLUME FLUSH IS PER FOOT OF SAMPLE HOSE.
**VOLUME FLUSH IS BASED ON SIX TIMES THE ONE FOOT LENGTH.
***STANDARD SAMPLE BOTTLE IS 120 mL.

SIZE O.D.	WALL THICKNESS	I.D.	VOLUME CU IN/FT	GAL/FT	mL/FT	Flush Volume
SAMPLE HOSE						
0.5"	0.062	0.376	1.33	0.0058	21.96	131.76ml
0.3125"	0.037	0.2385	0.54	0.0023	8.71	52.26ml
0.25"	0.037	0.176	0.29	0.0013	4.82	28.52ml
0.1875"	0.025	0.1375	0.18	0.0007	2.65	15.90ml
STEEL TUBING						
0.5"	0.049	0.402	1.523	0.0066	24.98	148.88mL
0.375"	0.049	0.277	0.722	0.0031	11.73	70.38mL
0.3125"	0.049	0.215	0.433	0.0018	6.81	40.86mL
0.25"	0.049	0.152	0.217	0.0009	3.41	20.46mL
0.1875"	0.032	0.124	0.144	0.0006	2.27	13.62mL
0.125"	0.032	0.061	0.035	0.0002	0.76	4.56mL
BLACK PIPE SCHEDULE 40						
0.5"		0.622	3.646	0.016	60.67	363.43mL
0.375"		0.493	2.291	0.01	37.86	227.16mL
0.25"		0.364	1.249	0.005	18.93	113.58mL
0.125		0.269	0.682	0.003	11.39	68.34mL
MICROBORE HOSE						
2mm Nominal Bore		0.0786	0.0582	0.0002	0.76	4.56mL

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Using a standard oil-sampling vacuum pump revealed that the tubing could not be flushed thoroughly after installation and after each sampling requirement. The length of the 3/8” sample tubing installed required an increased flow rate to ensure that the installation debris was completely removed before the sample of oil was taken. A small AC powered vacuum pump was installed by a flexible hose to a modified hand vacuum pump, which then met all the requirements of the thorough line flushing. This also saved a lot of time for the technician flushing and pulling samples.

Numerous component location identification of cooling water being introduced into the lubricant through defective seals has provided extensive case history along with cost justification benefits of this condition-monitoring program.

Paper Machine

In a very general sense, Paper Machines are comprised of many large drums (rollers) that have a bearing on each end to allow the roller to spin effortlessly. Any imperfection in the bearing can result in a jerking or dragging motion that will allow the high speed feed of paper the opportunity of breaking or tearing. These bearing are lubricated by a constant flow of oil and the return lines from the bearing typically are gravity return on vertical drops into a non-flooded common header in the basement.

Since these drums (rollers) must be able to be quickly removed to be reconditioning, the bearing lubricant supply and return lines have a flexible hose connection to the welded piping. To monitor the condition of the bearing, the return line from each bearing set was evaluated for the possible addition of a sample port on these flexible hoses. Since the removal and installation of the non-flooded hose could not guarantee the ability to capture a sample, the connection from the hose to the fixed vertical piping was chosen.

A stainless steel drop tube was sized and installed on each bearing return to allow the ability to capture a sample of oil directly out of the bearing. The small hole in the catch basin inside the drop tube ensures that the supply of oil is continuously changed and that only a representative sample is obtained from the test point location.

Without great care, the environment around a paper machine poses many opportunities for the sample to be contaminated by either wood fibers or water. To eliminate the opportunity of contamination, all the sample bottles are placed into individual “ziplock” plastic bags. After performing the required flushing activities, the sample bottle cap (while still in the bag) is removed and the vacuum pump sample hose is poked thorough the plastic bag as the bottle is screwed unto the vacuum pump. Once the sample is extracted into the bottle the vacuum pump is removed from the bottle and the cap is replaced (while still in the sealed bag), thus eliminating almost all opportunities of outside contamination coming in contact with your sample.

Condition monitoring programs require equipment specific knowledge to set-up and execute the program effectively and efficiently. Completely understanding the fluid path(s) of a lubrication system will allow for the identification of the optimum sampling location(s) for critical locations and/or components of the system. This location in many cases can appear inaccessible or difficult to access and obtain a repeatable and representative method of extracting a sample of oil. A trained craftsperson, armed with readily available sampling test port accessories and hardware combined with a creative thought pattern can result in the installation of a test port in the optimum location that will supply data rich samples capable of directing present and future maintenance activities.