ENTERPRISE PRODUCTS IMPROVES RELIABILITY WITH LUBRICANT UPGRADES

COURTESY OF Machinery Lubrication

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Enterprise Products Partners L.P. is one of the largest publicly traded energy partnerships with an enterprise value of more than $14 billion, and a leading North American provider of midstream energy services to producers and consumers of natural gas, natural gas liquids (NGLs) and crude oil. Enterprise transports natural gas, NGLs and crude oil through 32,500 miles of onshore and offshore pipelines and is an industry leader in the development of midstream infrastructure in the deepwater trend of the Gulf of Mexico. Just eight years ago, Enterprise Products operated 200,000 brake horsepower of equipment, most of which was at its Mont Belvieu facility in Texas. Today, Enterprise Products operates equipment totaling in excess of 1.6 million brake HP.

THEN

In 1996, the Mont Belvieu facility had no mechanical or reliability engineers on-site. Efforts at predictive maintenance consisted of oil analysis of critical equipment two to three times a year with vibration measurements not exceeding twice yearly. No online equipment monitoring was in place. As a result, the plant operated in a reactive maintenance mode. Everyone wanted good reliability, but no one wanted to pay to put the people and tools in place necessary to achieve it. Therefore the plant relied heavily on consultants and vendors resulting in a patchwork of partial solutions to the plant's reliability issues.

NOW

Today, limited reactive maintenance occurs at the Mont Belvieu plant, even though production demands often greatly extend, or even eliminate, routine maintenance and oil change intervals. The key to achieving this was making an ongoing commitment to dedicate resources specifically to reliability, which included on-site engineers with the proper equipment and training. Extensive preventive and predictive maintenance is now in place that includes online monitoring and equipment protection of critical equipment, routine oil analysis and monthly vibration monitoring on all equipment (more than 7,000 points monthly).

LESSONS LEARNED

We learned many things on our journey to improved reliability about the value and proper use of various reliability tools for different applications and how to work as a team to develop a total program. These important aspects in attaining our goals cannot be adequately addressed in this article, but the competent and dedicated efforts of Tommy Branning, maintenance superintendent, and David Wright, maintenance foreman cannot be overstated. This story is about how we discovered an important and unexpected reliability tool that might have been completely overlooked, if not for a request for assistance from the operations group to help them reduce oil consumption.

The Mont Belvieu plant operates 25 York centrifugal compressors, 15 of which are in DIB ISO butane service. These 15 compressors averaged seven to 10 equipment failures each year. The common failure mode was that the 5,800 RPM shaft would weld to the babbited aluminum journal bearing, resulting in a repair cost of $60,000 to $150,000 per failure, depending on the damage. These failures were caused because the lubricating oil would absorb hydrocarbon gasses causing a significant drop in oil viscosity of two ISO viscosity grades or more. The six "swing service" compressors were particularly susceptible to oil viscosity loss resulting in the need for frequent oil changes. While operations accepted the failures as normal, they viewed the $200,000 annual lubricant cost for the compressors as excessive, and asked for assistance in reducing this expense.

We elected to run controlled tests using the currently used major brand polyalfaolefin (PAO) synthetic oil, an alternate major brand poly glycol (PAG) synthetic oil and Royal Purple Synfilm NGL synthetic oil. Both of the alternate oils are designed to reduce the dilution effects of light hydrocarbons on oil viscosity. All oils were an ISO viscosity 68. After five months of testing, we determined that the PAG fluid was most resistant to hydrocarbon gas dilution and we converted three compressors to this fluid. That is when we discovered the unintended consequences of our decision. The PAG's tendency to hold water created emulsions in our oil water separator, creating an environmental issue. It also resulted in unacceptable moisutre traveling downstream of the compressor to the catalyst bed.

FIGURE 1 - Mont Belvieu Plant

FIGURE 2 - David Wright

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We had to drain the PAG lubricant from the compressors and thoroughly flush them of all residual oil. We then refilled the six "swing" compressors with Synfilm NGL, which had originally been our second lubricant choice. Royal Purple claimed that Synfilm NGL's high film strength additives offered an added advantage of greater wear protection and machine reliability and indeed, we found a dual benefit from using this oil. In the first year, we not only reduced oil purchases but also reduced historical maintenance costs by $350,000. Based on these results, we converted the balance of the compressors to Synfilm NGL. We still have occasional compressor failures, but the damage is limited to the thrust bearings caused by excessive compressor surge events. We no longer have catastrophic failure modes with bearings welded to shafts. We have even avoided damage on several occasions when process upsets have caused compressors to coast down under low oil pressure alarms. We avoided one catastrophic failure when a faulty shutdown switch allowed one of the York compressors to run for three hours with only 1 psi of oil pressure. Damage was limited to high wear on the thrust bearing. Over the last seven years, we estimate that the improved compressor lubrication has resulted in maintenance savings of $800,000 per year.

OUR SUCESSES

This success prompted us to look for other opportunities where reliability might be improved through improved lubrication. One such opportunity was a 200 HP RotoFlow warm expander. Two of these machines shared the same oil reservoir. One never failed and the other experienced catastrophic failure every four to five months like clockwork. The failure mode was that two 180°F opposed ball bearings would split in half. The manufacturer suggested a change in the lube delivery system but couldn't provide information where it had ever been successfully implemented. Each failure resulted in a $30,000 repair cost and a $160,000 cost in lost production. We elected to try a new lubricant while continuing to work with other consultants and vendors for a solution. We changed the mineral oil 32 to Royal purple Synfilm 32, which increased the time to failure to nine months, saving more than $200,000. The ultimate solution, however, proved to be the addition of a small needle bearing on the lower gear to relieve thrust loading on the deep groove roller bearings.

We had another problem with the journal bearing in a 10,000 HP Demag Delaval compressor that routinely had high temperatures in the summer which limited production. By changing the mineral oil 32 to Royal Purple Synfilm GT 32, bearing temperatures were reduced from 225°F to 170 to 175°F (a 50°F drop) eliminating the need to reduce production in summer months. We achieved additional savings after changing our four Solar genset turbines to this same oil. One turbine experienced a lube oil pump shaft failure which interrupted oil flow to the turbine. The high film strength properties of the oil enabled the turbine to coast down without damage. This same turbine experienced the same failure six months later with only minor bearing damage in the gear box resulting in a $30,000 repair. The potential maintenance savings from using the high film strength oil was $325,000 per incident.

We have since upgraded the lubricant in all pumps, motors and turbines and have seen improved reliability across the board: lower temperatures, lower bearing vibrations and much longer trend intervals between first diagnosis of bearing problems until failure.

The Mont Bellvieu facility operates more than 500 pumps ranging from 10 to 600 HP, 90 percent of which run at 3,600 RPM. The 40 horizontal splitline pipeline pumps averaged one failure in the babbited sleeve bearing and / or ball thrust bearing every six weeks. The failure rate has been reduced to one every six months since changing the oil from the mineral oil 32 to Synfilm 32. Cooling tower gearboxes that used to experience annual bearing replacements have now exceeded five years in service since upgrading the lubricant. We have reduced the failure rate in our 200 fin fans from two to three repairs per week to one per month by upgrading to a high film strength synthetic grease. There have simply been no applications where we have elected to upgrade the quality of our lubricants that we did not see measurable improvement.

FIGURE 3 - Frick Compressor

FIGURE 4 - Warm Expander

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SUMMARY

When we began our efforts to implement a comprehensive maintenance reliability program, lubricant selection was limited to making sure we had the right type and viscosity of oil in our equipment. It was only by chance that we began an initial lubricants evaluation program which quickly taught us how significantly lubricant selection can alter equipment reliability and availability. In hindsight, this should not have been so surprising because most of our rotating equipment maintenance involves the replacement of lubricated components. While improved lubrication has proven to be only part of the solution to Enterprise Products' significantly improved equipment reliability, our experience has shown it to be an immensely important part, and one that is too frequently discounted or overlooked by many maintenance groups.

ABOUT THE AUTHOR

Francisco J. Gonzalez is the corporate reliability manager for Enterprise Products. Francisco holds a B.S. in Mechanical Engineering from the University of Houston and has more than 16 years of hands-on and supervisory experience in the maintenance, operations and performance assessments of rotating equipment.

AUTHOR'S NOTE

The key to a successful preventive and predictive maintenance program is competent maintenance personnel. Tommy Branning, maintenance superintendent and David Wright, maintenance foreman, were instrumental in identifying equipment problem areas.

FIGURE 5 - Warm - Cold expamder