

Pump Reliability Checklist



***It's a matter of economics ...
a little extra work and care go a long way!***

Douglas C. Branham, Lubrication & Reliability Manager - Lubrication Systems Company

What makes a Rolls Royce different from a Chevy? Each of these cars has a drive train, four wheels, a steering wheel, seats, a body, etc. The difference is in the additional workmanship that goes into the Rolls, and the tighter specifications to which it's built. For example, the pistons in a Rolls Royce are weight balanced and matched. This makes for a smoother running engine, a longer life and lower maintenance costs.

The same type of question can be asked of ANSI or API 610 pumps. Each has a case, shaft, seals, an impeller, a driver, etc. But, why does one user achieve a six-month Mean Time Between Failure (MTBF) and another get eight years? What's the difference in a good machine and a great machine? The answer to these questions is simple—a little extra work and care make the difference.

Take a look at the following checklist. If all of the points on it are followed, chances are that you, too, will have a great machine.

✓ **Remove all possible misalignment and its causes.** This is important when you consider that misalignment is the cause of about 50% of vibration problems. Vibration will always exist, but the question is to what extent do we allow it to exist. The quality process is a continuous improvement one. Because we should always be "raising the bar," what was acceptable last year should not be acceptable this year, nor next year. What we accept for allowable vibrations should follow this philosophy. Therefore, as a minimum and a starting point, align to the following specifications:

- Allowable offset at the centerline – 0.5 mils.
- Allowable angularity – 0.1 mils per inch with no correction move at the feet greater than or equal to 1.0 mil.
- Allowable soft foot – 1.0 mil.

- Allowable pipe strain – none greater or equal to 2.0 mils.
- The bearings are aligned with the shaft and bearing housing.
- Base flatness and foot flatness must be less than or equal to 2.0 mils of the overall foot plane.
- When appropriate, consider thermal growth and provide adequate offset.

✓ **Balance the rotor assembly to the API 4W/n or lower.** Unless there are some unusual circumstances, an experienced balance machine operator should be able to achieve this in a couple of spin-ups. However, one additional spin-up in the balance machine will make the difference between a good machine and a great machine. It is common to get 1/10 the API specification with one additional spin-up. Remember that about 40% of all vibration problems are caused by imbalance.

✓ **Install machine on a properly designed foundation.** A properly designed foundation will eliminate the possibility of a natural frequency vibration problem and prevent housekeeping problems.

✓ **Grout the base plate with non-shrinking grout,** being sure to fill all voids. The grout is important not only to support the pump, but to dampen out vibrations.

✓ **Choose the metallurgy and elastomers suitable for the service intended.** Inappropriate materials will doom the machine's MTBF to a short one. The upfront costs should be based on a Life Cycle Cost Analysis—not on some preconceived notion about initial purchase cost or lowest bid.

✓ **Start up the pump with the assistance of a complete Startup Checklist, being sure to carefully accomplish each step along the way.** Otherwise, a perfect job by Engineering, Construction and/or Maintenance is wasted and useless. For example, failure of an operator to ensure proper lubricant levels and a full seal cavity will, in seconds, undo all the work of others and leave you with a wrecked machine.

✓ **Operate the pump as close to the Best Efficiency Point as possible.** Operating too far away from that point will cause large bearing loads and may cause destructive cavitation.

✓ **During overhauls/repairs, assemble the pump in a clean room, using tools that have near surgical cleanliness—avoid field assembly.** Some refiners have clean assembly rooms that have air locks to keep out unfiltered air. The tools, parts and equipment are maintained, stored and used only in the assembly room. Pumps are meticulously cleaned before they are brought in for repair. The technicians are required to put on clean lab coats and shoe covers before they enter the room. When you consider that bearing clearances are in the thousandths of inches, it becomes clear why all of this effort is necessary and has a good payout.

✓ **Perform predictive checks (vibration and temperature monitor) on a regular basis.** Require operators to make basic checks daily. Machine failures happen at two levels: primary and secondary. The primary failure is a component defect that may be a pit in a ball in a ball bearing. The secondary failure is total failure, and may be bearing seizure causing impeller damage, volute damage and seal failure. A fire is often a result. If the operator can detect a primary failure, the cost of labor, parts, and post production will be significantly smaller than those associated with a secondary failure. The situation is a proactive one—not reactive. Here, the owner is in control, rather than being controlled.

✓ **Set seal and maintain flush and quench rates at optimum rates.** If rates are too high, damage to the machine may be as great as if the rates were too low. This also can lead to poor housekeeping and wasted energy.

✓ **Use non-lubed couplings where possible. This eliminates problems with lubrication.** If the coupling is greased, use only grease that is designed for couplings. Grease is nothing more than oil in suspension in a thickening matrix. General-purpose greases have thickeners that are heavier than the oil. When subjected to the high centrifugal forces of an operating coupling, the thickener is centrifuged to the outer limits of the coupling, where it collects. Unfortunately, that is exactly where the oil is needed. Couplings that are lubricated with non-coupling greases must be lubed every three months. Coupling greases have functioned up to three years

in field tests, but one-year replacement is recommended. They have high load capabilities, are resistant to water wash, may be used up to 350° F, and they stay in place in high-speed applications.

✓ **Use the proper lubricants in the proper amounts.** Post a sign with the name and grade of the recommended lubricant on or near the machine. It is tempting to standardize on a very small number of lubricants to reduce costs. But, if the right lubricant is not used, such savings can be overshadowed by a shorter MTBF. Although it may seem trite, more is not better when it comes to lubricants. More machines fail from over-lubrication than under-lubrication. Liquid friction significantly contributes to high bearing operating temperatures.

✓ **Remove water-cooling from bearings where possible.** Cooling water easily can cause premature failure. In a pump that handles fluids at a high temperature, the heat of that liquid is transferred down the shaft. The shaft expands, causing the bearing clearances to reduce as the inner race is expanded. That situation is exacerbated when the outer race is shrunk because of cooling water. Insufficient clearances raise bearing temperatures and greatly reduce bearing lives.

✓ **Filter lubricants through 5-micron elements or smaller when refilling wet sump operations.** Dirt particles larger than the oil wedge in the bearing are usually not a problem. For example, a 40-micron sized particle usually will not cause bearing failures unless it breaks into smaller particles. Particles that are less than one micron usually will not cause a problem. However, particles that are the size of the oil wedge and slightly larger cause bearing failures by fatiguing the ball. The need to filter oils, including new, unused oils, is vital to the life of bearings.

✓ **Use dry sump or pure oil mist lubrication where possible.** Users of oil mist report up to a 90% reduction in bearing failures with the installation of pure oil mist lubrication. One West Texas user reports a 98% reduction. Users claim a 30% reduction in seal failures because their functionality is so closely related to rolling element bearings holding their clearances. In addition, a 2-3% reduction in energy consumption is achieved because of the elimination of liquid friction. With the elimination of liquid friction, users typically get up to a 50° F reduction in bearing operating temperatures. One user achieved a 90° F reduction in their crude charge pump bearings by switching to oil mist. The temperature drop alone is a significant contributor to added bearing life. Probably the largest reason for the phenomenal success of oil mist is that it apparently does not carry dirt particles to the bearings. The dirt particles will stay in suspension in the 1-3-micron sized oil droplets.

So why should a machine owner (or end user) be concerned with improving reliability anyway? The answer is simply a matter of economics. From accounting, we know that income is equal to revenue minus liabilities. The contribution of reliability to income is reduced maintenance costs and reduced inventory of spare parts. In addition, mechanics will have more time to devote to quality improvements because they have fewer wrecks to repair. Their morale and desire to contribute to the company's success will be elevated. These are a reduction in liabilities. An improved reliability also means less unplanned downtime and a lower Lost Profit Opportunity. More uptime translates into more on-spec product for sale and a more predictable revenue stream. The connection between reliability and economics is strong and clear.

With increasing competition and decreasing profit margins, end users need every advantage they can find. Failure to take advantage of great machines and improved reliability will undoubtedly lead to poor performance, which, in turn, will put more pressure on employees, resulting in poorer performance, which then will lead to more stress, etc. This is a death spiral—it must be broken if a company wants to survive, much less excel.

Improved reliability and resulting superior MTBF are absolute necessities. If used correctly, this checklist will prove to be a powerful tool, propelling your operations to a position of industry performance leadership. **P&S**

DOUGLAS C. "Doug" BRANHAM, is the Lubrication and Reliability Manager for Lubrication Systems Company in Houston, TX. He has over 30 years of industrial experience, having started his career as a Mechanical Engineer with Amoco in 1969. Branham later joined the Texaco organization and served in a number of maintenance and reliability engineering positions at various Texaco refineries around the world until June of 2001. Branham received his BSME from the University of Maryland. Contact him directly at dcbraham@lsc.com

Acknowledgement

The author would like to thank three long-time mentors, Heinz Bloch, Ralph Buscarello and Charles Latino, for selflessly sharing their knowledge and wisdom regarding reliability with him over the years, which, in turn, has contributed greatly to the preparation of this article