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Root Cause Analysis

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## **Battle Pump Failures With Root Cause Analysis – A version of this article was featured in the February 2008 issue of Pumps & Systems magazine**

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Explore how root cause analysis helps to identify the problems that lead to pump failures, essential elements in the process and case studies that illustrate effective use of root cause analysis.

With pumps part of just about every manufacturing operation, proper functioning of entire facilities often relies on a single pump.

Half of a plant's maintenance budget is very often spent on pumps, and pumps are commonly the single largest source of unplanned downtime. They have a significant impact on environmental compliance, product quality, mission assurance and, ultimately, the bottom line.

With pump problems so common, it's often easy to accept them as inevitable. On the surface, it would seem that if good solutions existed, they would have been implemented by now, right?

Often when a pump fails, the operations manager concludes that maintenance is not adequately maintaining the pump and calls them to task. In turn, the maintenance/reliability manager gets annoyed and asserts that little can be done to improve reliability since operations continues to abuse the equipment. This vicious cycle does not help prevent recurrence.

In contrast, many thought leaders in the industry resist this inaccurate stereotype of the failure-prone pump. Instead, they have dramatically reduced their incident rates and pump maintenance budgets—not to mention impacting the bigger-picture ripple effect—by pinpointing the root causes of the problems and developing truly effective solutions that meet everyone's objectives.

They are carefully fact-finding about:

- People – How are they performing? What are they doing?
- Procedures – What specific procedure is causing the problem?
- Hardware – Is it right for the job? What design choices have been made? What specifications are being followed?
- Nature – How are natural and external environmental conditions affecting reliability?

In my experience helping companies work through pump problems—both from the inside as a reliability engineer and as an outside consultant—the conclusions people instinctively draw are often very different from the causes identified through root cause analysis (RCA). Simply put, the solutions people often implement are an attempt to mitigate consequences of failures rather than to eliminate the causes of the problem. For example, how many of you keep fully built spares in your warehouse and focus on quick change out? Do you “accept the inevitable” and incorporate the expected unreliability of the pump into your production plans?

Having spent numerous years in production, I understand and accept if/when your reliability program is still in the “reactive” state. However, if you are not investing the time to understand and correct the causes of pump failures, you have a significant missed opportunity and you will likely never make it to the ‘proactive’ realm.

### **Common Causes of Pump Failure**

The hidden causes of pump failure can be discovered with focused RCA. A few common causes to consider include:

1. The selected pump does not match the need or the process has changed, thus rendering the original design inappropriate.

2. When trying to solve a problem, people inadvertently and unknowingly create separate and new problems.
3. Supervisors often aren't aware of the little things people are doing—usually with good intentions—that have adverse effects on the system.
4. For equipment that conforms to the specs and operating parameters, it's all too common that the “abnormal” situations are not considered. Steam-outs, acid flushes, loss of tracing and dry-running at the end of a transfer are common events for pumps and should be considered part of the “normal” operating scenario. Rarely are these common operational practices incorporated into the design, specification and installation phases.
5. Slight changes in operation or process chemistry can impact reliability. People often do not realize the impact subtle changes may have and thus don't bother to review the changes with their pump and process experts to understand the potential impact on pump life and performance.
6. Occasionally, a mismatch of goals exists between management and labor. If the reliability culture has not matured, maintenance personnel may view pump unreliability as desirable because of the inherent rewards: overtime pay and recognition of “saving the day” through expeditious pump repairs. Sometimes, known problems are hidden to protect the work.
7. Maintenance/reliability staff default to looking for hardware solutions—the next big, shiny thing—which are often unnecessary or ineffective.
8. Due to a retiring generation of skilled mechanics and millwrights, there's a shrinking number of people who know how to effectively maintain and repair equipment. The incumbents are being asked to perform a broader array of tasks in less time, which precludes development of skill proficiency. Because this trend is not likely to change, the engineer who specifies pumps the same as 20 years ago will introduce unreliability (failure causes) in the pump before it is even commissioned.

### **Root Cause Analysis in Action**

Success stories abound of companies that have pinpointed causes of failure through RCA. For example, I was asked to help determine why a piston pump was leaking horribly into the power-end and causing damage to the gear box. The pump had braided packing and stainless steel pistons. The pumped liquid was wax-like and had to be kept hot (approximately 160-deg F) to avoid solidification. In a root cause analysis, the operations team indicated that there was a small amount of suspended solids in the stream. Thus, every time the pump stroked, solids entrenched in the voids in the braided packing and ground on the shaft, causing erosion at the sealing area (supported by visual evidence of thinned shafts in the sealing area).

Even though this was not the optimum pump for the job, once the manufacturer understood the causes of the problem as revealed in the RCA, they recommended installation of ceramic-coated shafts with chevron packing. This proved to be successful and the plant avoided significant capital expenditures for pump replacement, which made everyone happy. Not only was the life of the pump quadrupled; there was also a significant reduction in mess, eliminating a slipping hazard and disposal costs.

In another situation, a plant was struggling with a piston pump that would make just one liquid transfer before the pump would start to leak. The liquid was viscous and contained dissolved solids, so it was important to empty the piping at the end of the transfer. Root cause analysis helped the plant understand that the operations procedure to clean out the lines at the end of the transfer by isolating the tank and blasting steam through the entire system was a cause of the failures. The piston seals were experiencing “slip stick” and destroying themselves due to loss of lubricity. The MTBF of the pump was one batch.

Although their intentions were good, one problem was eliminated (emptying the lines) while creating a new one (seal failures). When operations, maintenance and the manufacturer came together for the RCA, they developed a simple solution that isolated the pump to blow the lines dry without destroying the seals. This no-cost solution increased pump life to 16 batches.

Finally, a plant that processed liquid ammonia found they would frequently lose flow from their centrifugal pumps, and the pump seal faces were heat-checking and failing at an unacceptable rate. RCA revealed the causes. In an effort to save money, the expensive chilled-water system the plant had been using for years to keep the ammonia vapor pressure low was switched to cheaper cooling tower water. As a result, the water was not cold enough to prevent flashing of the ammonia, so the pump's flow would frequently drop out due to vapor lock. The problem of flashing/cavitation was especially severe in the summer months (daily occurrences) and also when the available NPSH was low during low tank levels. With minor suction piping changes and a return to chilled water for cooling (the chilled water system was necessary for other parts of the process, so little real savings would have been realized by removing it from the ammonia system), the flow losses and seal failures were virtually eliminated.

These examples illustrate that the most effective root cause analysis processes involve people from various levels and departments within an organization, including management, operations, maintenance and the supplier. When all the parties are included in the RCA, you assure no aspects of the pumps' reliability are sub-optimized at the expense of others, and you almost always find cheaper and more innovative solutions.

### Impacting the Bottom Line

These scenarios demonstrate how adoption of certain philosophies can have a significant, positive impact on the bottom line:

- While capital expenditures to install the optimum pump and support systems may initially seem prohibitive, the long term cost of unreliability of the "close enough" pump grossly overshadows the additional upfront investment. For many "bad actor" pumps, I have seen the *annual* total cost of ownership (repairs, lost production, clean up and disposal, etc.) exceed the incremental, *one-time* capital cost for the optimum pump by factors ranging between four to twenty times. (Note: This is just one year of ownership costs, too!)
- We often underestimate the total cost of pump failures for our organizations. For facilities in "sold out" status, the costs associated with operational downtime frequently average seven times more than pump repair costs. One must also consider the environmental, health and safety impact pump failures have on air permit violations, chemical exposures due to line and equipment openings and the potential for injury when maintenance personnel remove and reinstall large pumps. When pumps run reliably, you eliminate the conditional causes that create additional problems—beyond cost—that impact your organizational goals and objectives. A good RCA will identify your total lost value and overall impact to the organizational goals, thus enabling you to make a good economic decision on how much you can afford to spend to correct it.
- When all involved parties come together in the RCA process, the solutions are normally much more cost-effective than what would be generated by any single party alone and they are committed to assuring their solutions are fully implemented.

Reduce finger pointing by helping everyone understand each other's roles and responsibilities. Help each party understand the struggles and challenges the others face. When all groups understand the other's constraints, mutually acceptable solutions can and will be found.

Remember: The devil is in the details, so dig deep for causes and expose *your* devil.

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