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The Do's and Don'ts of Field Failure Analysis

In the real world, components fail. There are many reasons why. If a premature failure occurs, it is important to evaluate all possible causes and then isolate a root cause that can be corrected to assure that the problem will not reoccur. Let's learn more.

Failures that occur during testing on the factory floor in controlled laboratory conditions or during product manufacture can be classified as "regular" failures, ones in which a significant amount of resources (people and test equipment) can be brought to bear on the problem. By contrast, field failures are those in which an assembly has failed in its normal working environment, often remote to the manufacturer, and where resources for analysis can be limited and must be transported to the jobsite. Field failures are particularly challenging. To help, here are some simple suggestions.

A Baker's Dozen

1. ***Have a plan.*** Failure analysis starts with documented procedures and good training. Anticipate your needs. Don't be surprised or confused with what has to be done. Do not attempt to investigate a failure in a haphazard way.
2. ***Set up a team*** composed of representatives of all disciplines (management, purchasing, engineering, service, metallurgy, manufacturing, quality and legal). Meet to discuss the problem and review the facts (this step is often overlooked but can be invaluable if someone is able to recall details of this circumstances surrounding how the part was originally manufactured). Make recommendations as to the type and extent of the analysis that should be performed in the field. Understand the implications of the failure and the potential liability exposure of the company.
3. ***Use your time efficiently.*** Be prepared for the inspection. Plan your work carefully to obtain as much evidence as possible. Gather the right people and tools. Don't become distracted.
4. ***Inspect failed components immediately.*** Information relating to the failure should be compiled as soon and as thoroughly as possible. A "rapid response team" should be in place. Know that the longer the time between the failure and the inspection, the greater the risk that external influences will induce error into the analysis process.
5. ***Preserve the evidence.*** The ideal situation is to have information gathered on-site by a person or team familiar with failure analysis methods. If you can't get to the failure site, have someone at the site you can trust report the situation to you or follow your explicit instructions. Photograph everything (especially in this age of digital photography), even details that seem like incidentals. Try to emphasize the importance of having quality tools at the jobsite (especially the right digital camera—the ones we use can photography up to 1.2 in. away from an object with 8 megapixal resolution).
6. ***Evaluate if field disassembly is a good idea.*** In a perfect world, the assembly that failed would be undisturbed when the people assigned the task of field failure analysis arrive on the scene. Often, however, the assembly has already been taken apart; which, admittedly, may have been necessary to determine which component had failed. In some instances, the equipment has already been placed back into service. This usually makes the job of determining the root cause of failure much more difficult.

   Prior to arrival, if asked by field personnel for permission to disassemble and return equipment to service before a thorough inspection by the failure analysis team takes place, resist the urge to say yes. It may be necessary to ship the assembly back to the factory in one piece for a more controlled analysis where more specialized resources may be available. If field disassembly is required, the failure analysis team should participate and not defer "hands on" work to technicians or less qualified individuals.
7. ***Document each step of the disassembly*** (whether in the field or in the laboratory). Do not hurry. Disassembly should stop while you inspect and document the condition

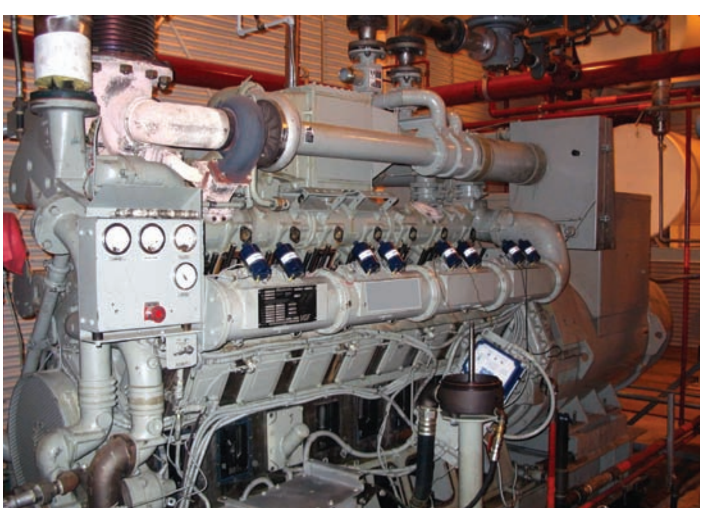

Fig. 1. Power generation diesel engine failure (photograph courtesy of Materials Engineering Inc.)

of a component before proceeding to the next component.

8. ***Do not form premature conclusions,*** no matter how obvious the cause may seem. Concentrate on gathering facts (not speculation) along with all the evidence (and not just the evidence that may support a hastily drawn conclusion). Consider but don't be swayed by the opinion of others.
9. ***Be patient.*** Gather your thoughts and analyze the collected data. Don't let fatigue or conditions at the jobsite (wind, cold) become distractions or cause you to lose perspective. Be prepared for the environment you will find yourself in.
10. ***Document what you see, and*** (perhaps of equal importance) what you don't see. Remember that there is a reason for everything you are observing, and it may become important later on when you reconstruct the failure or when you consider the evidence as a whole. Taking photographs at each step of the disassembly is perhaps the best method of documentation, but should be supplemented with notes of your observations and measuring key dimensions.
11. ***Control the investigation.*** Make sure you come away with what you need. This includes such items as: service conditions (temperature, pressure, chemical or environmental exposure); time in service; circumstances surrounding the failure; cyclic conditions (if any); complete service history of both the failed component and assembly or machine which it is a part of (cleaning procedures, maintenance history); related or similar failures in the same or similar applications.
12. ***Secure the evidence*** for shipment back to the laboratory. Identify which components need to be analyzed with more powerful techniques than might be available in the field. Take more evidence than you think you might need. And be aware of the special handling of the failed components. Spare no expense in seeing to it that the components will not suffer additional damage during transportation back to the laboratory for a more detailed analysis.

Fig. 2. Piston Head Component From Failed Power Generation Engine (photograph courtesy of Materials Engineering Inc.)

Finally,

13. ***Do not bow to unreasonable pressure.*** Insist on privacy and don't become distracted. Do not report your findings until the investigation is complete and until you've had a chance to think through the consequences of your conclusions.

And remember, failures occur for a variety of reasons including:

- Overloading: tensile stresses, torsional forces and shear forces
- Impact: mechanical shock, thermal shock
- Wear: abrasive, adhesive, fretting, cavitation damage, erosion
- Fatigue: vibration
- Corrosion: uniform, pitting, galvanic, crevice, intergranular
- Stress corrosion cracking: hydrogen embrittlement, sulfide embrittlement
- Heat Treatment: improper hardening, tempering, quenching, cryogenic treatment

The Best Laid Plans...

Unfortunately, it's not unusual for a failed part or assembly to arrive at the lab accompanied by cryptic and/or incomplete information. If this occurs, or if adequate resources were not available to do a thorough field investigation, remember that this increases the uncertainty of your conclusion. Learn from the experience and educate others on the proper techniques for next time. **IH**

Sources:

- Errichello, Robert, "The Ten Commandments of Gear Failure Analysis," *Gear Technology Magazine,* September/October 2003
- *Practical Failure Analysis,* ASM International
- Mr. William Durako, Materials Engineering Inc. (www.materials-engr.com), private correspondence

Additional related information may be found by searching for these (and other) key words/terms via BNP Media LINX at www.industrialheating.com: field failure analysis, failure analysis and preventative maintenance.