Fail to Improve? Using Failure Analysis as a Means to Improve Product Quality

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What is Failure Analysis?

Failure analysis is the mechanical, physical and chemical investigation into the cause and sequence of events that leads to a product condition in which the product no longer meets expectations. Failure analysis is using materials science to solve a mystery: Why did the product fail? Understanding what failure analysis is then requires understanding two things: 1) What is meant by failure, and 2) What is involved in analysis?

Failure can be defined in three ways: 1) failure to meet a specification, 2) failure to meet the customer's expectations, 3) behavior that is inconsistent with the design intent. All three kinds of failure can occur because of fractures, malfunction of a component, subsystem or system, visual defect or unexpected behavior of a material that causes product dissatisfaction.

Three Categories of Failures :

1. Infant or Production
2. Extreme or Abusive Life
3. Wear or Damage Accumulation

In this case, analysis comes in two parts. First, the use of mechanical, physical and chemical experiments to gather information about the failed part, and second, the intelligent application of the scientific method: hypothesize and test to determine the cause or causes. The second part of the analysis requires expertise and experience with the combination of materials, processes and test methods involved.

Although failures may occur at any time in the product's life, they do fall into three general categories: 1) infant or production failures, 2) extreme or abusive failures during life, 3) wear or damage accumulation failures. Often failures are noticed in a context much different than the origin of the failure both in space and time. An infant or production failure in a power resistor inside of a circuit may go unnoticed until the unit is in the field and provided with marginal power. This disparity between a root cause and the field event is one of the main reasons for conducting failure analysis. The apparent relationship can lead to very incorrect conclusions: failure analysis helps avoid this.

Failures can also occur during development, production, assembly and transportation. Understanding the true cause of the failure is essential in making profitable choices in fixing a problem. Good quality can only come from good information.

Because of the complexities that can arise between the root cause of a failure, the time and circumstances in which the failure is observed and the tools available to determine the physical, mechanical and chemical characteristics of the product and the failure, it is often helpful to have a "good" component to compare to the failed component. When

a reference part is not available, as much information as possible is needed about the product, materials and circumstances of the failure. Which piece of information will be relevant is not always understood ahead of time.

When Should Failure Analysis be Utilized?

There are many conditions under which a formal failure analysis is valuable. Ultimately the purpose is to provide the root cause of a failure so that action can be taken to fix the problem. Failure analysis can be valuable in any situation where knowing the true causes of a failure will fundamentally improve engineering and management decisions.

Following are areas where failure analysis is typically utilized:

Primary process problems:

- Material flows incorrectly through process
- Visual defects observed
- Performance parameters do not meet expectations (or specifications)

Secondary process problems:

- Breakage or irregularities that interfere with assembly
- Visual defects observed
- Adhesion problems with mating components (blocking, welding, or adhesion failures depending on desired assembly behavior)
- Failure due to contact with incompatible materials
- Transport related failures:
  - Breakage
  - Contamination from environment (dirt, transfer of materials from packaging, moisture, etc.)
  - Heat or vibration damage

End-use failures:

- Incompatibilities with end-use environments
- Abuse
- Slow failures (repeated cycling, oxidation, fatigue, etc.) from processes or environments unanticipated in design

- Failures observed in end use but not detected in previous production or transport processes

In addition to applying failure analysis to physical failures, failure analysis tools can be used in other situations:

1) Analysis prior to failure by analyzing parts that passed testing or field sampling
2) Competitive analysis to evaluate the materials and nuances of two or more competing designs
3) Developmental information to make better use of DFMEA's (Design Failure Mode & Effect Analysis) or accelerated test methods.

Failures can occur due to one or more of the following causes:

- Design—under-design, inappropriate stress concentrations, inappropriate tolerances for use or material thermal/chemical changes
- Material—incorrect material, cross-contamination
- Primary processing—molding, casting, machining, heat treatment, coating, etc.
- Secondary processing—assembly, packaging and transport
- Contamination—functional fouling of assemblies or processes
- Environment—oxidation, chemical incompatibility
- Improper operation in end-use

Any product that experiences one or more of these activities is a candidate for failure analysis.

Interesting Failures Encountered in FMVT® Programs

Failure Mode Verification Testing (FMVT) is a durability test designed to cause failures. Failure Analysis is often used in conjunction with this testing to determine the cause of the failure. From these test programs, Intertek has produced hundreds of failures. Following are some interesting and common types of failures uncovered:

- Failures at or near constrained points such as fasteners between two large components
- Separation of attachment tabs due to fatigue, then overload.

- Unanticipated consequences of electrical routing and connection (ground loops, hardware/software interaction)
- Short circuits that could lead to fires
- Fretting corrosion in contacts
- Disconnections
- PC board components detaching from combined ambient temperature and resistance heating melting the solder connection
- Solenoids that fail to function at certain narrow temperature ranges while under vibration
- Powdering and dusting of matting components

Failure Analysis is a tool manufacturers can utilize to pinpoint and address product issues, thereby improving overall quality.

Intertek is now offering a Subscription Failure Analysis program with special pricing and priority service. For more information on how your organization can implement failure analysis, or for a quote on the Subscription Failure Analysis program, please contact icenter@intertek.com or call 1-800-WORLDLAB and reference Program #SA2007.