Failure Analysis of Metals

Failure Analysis

This course is about analysis of metal objects that stop performing as required or fail to meet quality requirements.

Metal stock used to fabricate components

Metal components

Welds, brazes, or solder joints

Course modules

1. Failure and Root Cause Analysis (15 minutes)
2. Failure Modes and Mechanisms (15 minutes)
3. Failure Analysis Process (20 minutes)
4. Analysis Techniques (60 minutes)
5. Fracture Modes and Mechanisms (15 minutes)
6. Fracture and Crack Failure Analysis Steps (15 minutes)
7. Fracture and Crack Case Studies (60 minutes)
8. Corrosion Failure Analysis Steps (35 minutes)
9. Corrosion Case Studies (60 minutes)
10. Manufacture and Assembly Failure Analysis Steps (15 minutes)
11. Manufacturing and Assembly Case Studies (30 minutes)

Module 1. Failure and Root Cause Analysis

Module learning objectives

By the end of this module learners, will be able to:

- Describe the situations when a metallurgical failure analysis is required
- Distinguish among the categories of failure root causes for specific failures

Click Next to continue

Purpose of failure root cause analysis

Identify primary event or initial decision that enabled failure to occur.

Use this information to:

- Implement corrective action to prevent failure from reoccurring, or
- Assign blame to make a claim for compensation or defend against a claim.

Purpose of failure analysis

Failure analysis part of root cause analysis process.

Purpose is to gain information that will assist in determining:

- Failure mechanism
- Root cause of failure

Failure, defined

When an item or process stops performing as required

Examples of items that fail

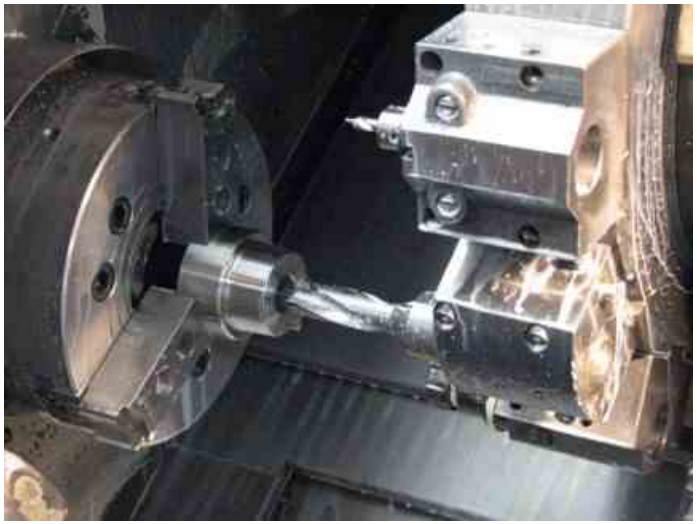
Metal stock

Component

Joints between components

Devices

Examples of process failures



Manufacturing process

Assembly process

Root cause, defined

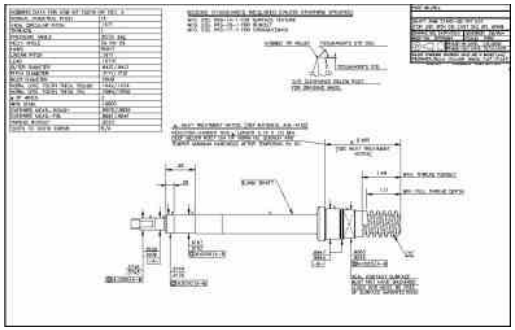
Primary event or initial decision that enabled operation of a failure mechanism

Use root cause information toé

- Put measures in place to prevent failure from reoccurring in a design and manufacturing environment, or
- Assign blame for reimbursement of damages associated with the failure for insurance and legal claims.

Situations that require failure analysis and root cause analysis

You would perform a failure analysis and root cause analysis duringé



Product development

Manufacturing and assembly

Shipping and storage

Use

Click each failure situation to learn more. Click ñNextòwhen you are ready for the next topic.

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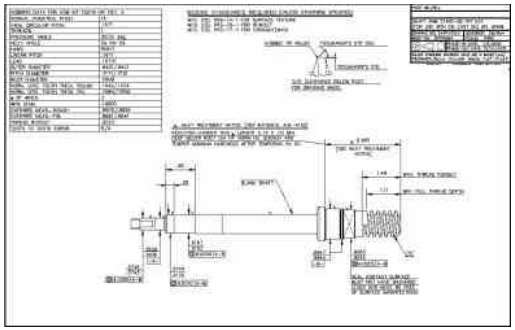

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Failure during product development testing

Design engineersé

- Test products during development.
- Evaluate reliability by exposing products to simulated use conditions.

One or more components or joints commonly fail early in development.

Failure during manufacturing and assembly

Sometimes, an item being produced does not meet specifications

Due to a number of reasons including:

- Problems with incoming materials
- Operator error
- Process has not been optimized
- Equipment malfunction

Failure during shipping and storage

Exposure to shipping and storage conditions can damage metal stock, components, or assemblies.

Failure during use

Exposure to operating conditions can cause components and joints to degrade and fail during use.

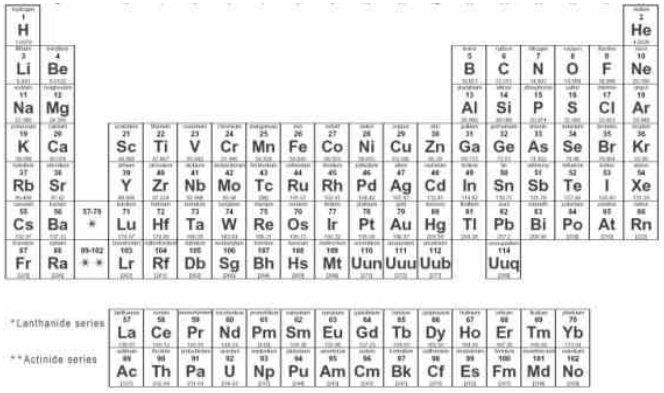
For simplicity, failure during installation, repair, and modification is included with failure during use.

Performing a Failure Analysis

Examine samples foré

Physical appearance

Microstructure



Composition

Mechanical, electrical, thermal, and cosmetic properties

Performing a Failure Analysis

Use the data obtained to determineé

- Failure mode
- Failure mechanism

Common categories of root cause failures

Poor design

Problems with product reliability test methods

Problems with manufacturing or assembly processes

Poor supplier quality control

Insufficient specification

Improper installation or repair

Misuse/abuse

Poor maintenance

Wear out

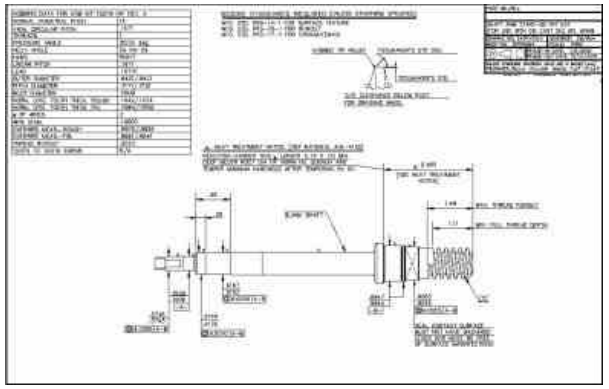
Click each link to learn more. Click ñNextò to continue to next section.

Root cause of failure: Poor design

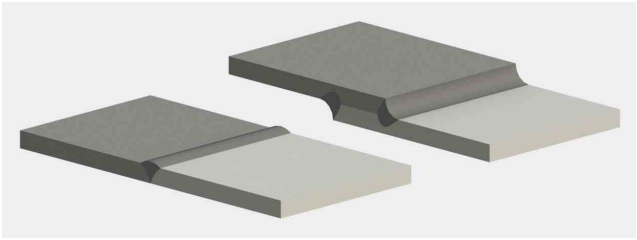
Decisions that result in components and joints not capable of withstanding exposure to conditions typical for application

Deficiency may be due toé

Insufficient specification of product, components, joints, and subassemblies



Physical design of components and joints



Selection of materials that are inappropriate for application

Root cause of failure: Problems with product reliability test methods

Methods used to evaluate product reliability can cause failures.

- Exposure conditions during testing too aggressive or poorly controlled
- Test samples poorly designed
- Test samples **not** properly prepared

Root cause of failure: Poor supplier quality control

Refers to supplierôs inability to ensure that item or material supplied is indeed what was ordered.

Related toé

- Mistakenly sending wrong material, or
- Not verifying that material meets purchaserôs specifications

Examples

- Supplying bolts made of 304 stainless steel instead of 316
- Supplying coil of sheet metal with low tensile strength

Root cause of failure: Insufficient specification

Not enough instruction to ensure that an item is properlyé

- Used
- Installed
- Repaired
- Modified

Category covers issues unrelated to product design.

Can lead to unintended exposure to conditions that cause degradation.

Root cause of failure: Improper installation or repair

Can result iné

Å Damage to a product that reduces its reliability

Å Unreliable connections between components

Examples

Å Over-tightening a fitting onto a pipe or valve

Å Poor weld or solder joint between components

Root cause of failure: Misuse/abuse

Using something outside of the manufacturer's design parameters

Examples

Driving a car in water

Using a brass fitting in an ammonia environment

Root cause of failure: Poor or improper equipment maintenance

Many products require periodic maintenance.

Neglect or improper maintenance can result in failure.

Root cause of failure: Wear out

Components and equipment have a certain life expectancy.

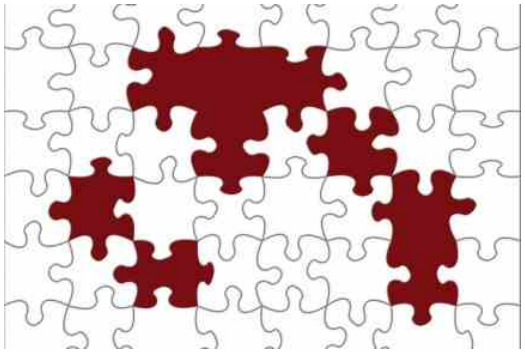
Under normal use, most products degrade over time.

- Stop functioning due to failure of component or joint.

No certainty of determining failure mechanism or root cause

Analysis results may be inconclusive or background information may be insufficient.

However, it may be possible to identify probable causes or rule out possible causes.



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