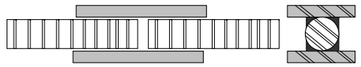
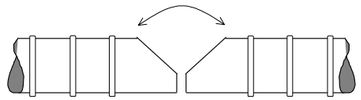
Applying Science And Engineering To Mechanical Testing, Failure Analysis, Field Inspections, Manufacturing, Fabrication, And Diverse Engineering Projects

Recent Projects Completed:

- ► Metallurgical evaluation of severely discolored new stainless steel toilet units
- ► Failure analysis of wire rope from crane
- ► Critical review of Weld Procedure Specifications for construction project



Flare-Bevel-Groove Weld In Rebar



Complete Joint Penetration Groove Weld

CONTACT DETAILS

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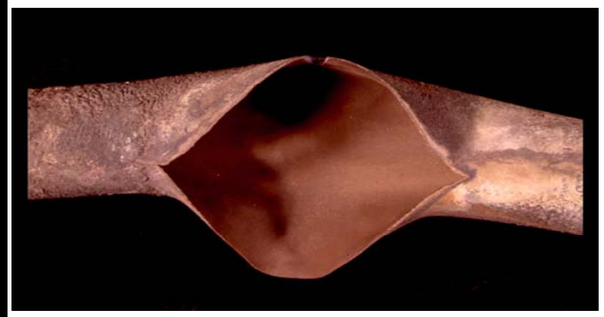
Metallurgical Failure Analysis

Thar She Blows!



Fishmouth' High-Temperature Failure Of Waterwall Tube

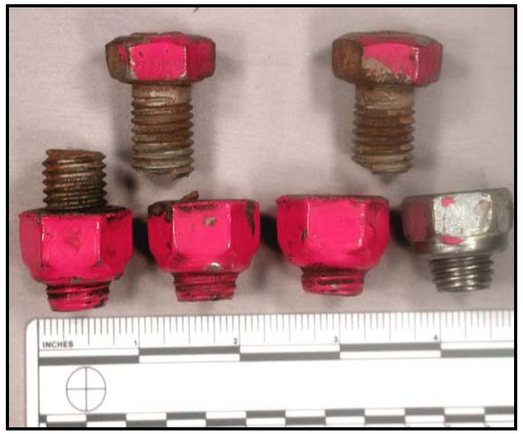
When parts fail, it is essential to identify the failure mode, and root cause to avoid costly, unscheduled outages

Managing risks economically, to ensure business continuity and adequate return on investments are the major objectives of many businesses. In today's intense competitive environment, significant demands are made on hardware to maintain uninterrupted performance, extend item life, minimize downtime and expenditures on maintenance. The reality is that failure of plant and equipment does occur, and therefore it is crucial to analyze the failures to prevent unnecessary costly outages, and repetition of such failures.

What Is Failure Analysis ?

Essentially it aims to answer two basic questions—How did it fail, and how can it be prevented from happening again. From the analysis, the *failure mode* is evaluated, and the *root cause* can also be determined.

There are many types of failure modes, and each has its unique features that are observed visually, and microscopically. Failures can be stress, corrosion related, high temperature type, or a combination of all. The simple stress type category are: i) Ductile - overload; ii) Brittle—sudden and unforeseen; and, iii) Fatigue—progressive



Failed High-Strength Fasteners. How did they fail, and who is to blame? The manufacturer, installer, or the user!

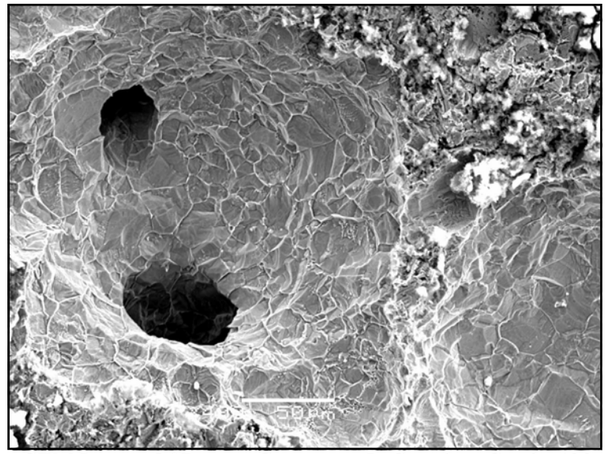
There are many types of failure modes, and failure analysis aims to determine which type so that prevention strategies can be implemented to avoid repetition

Corrosion failure modes are typically:

- Uniform corrosion
- Pitting
- Galvanic
- Crevice
- Intergranular
- Microbiological

Combination failure modes include:

- Stress Corrosion Cracking
- Corrosion Fatigue
- Creep
- Hydrogen Embrittlement
- Metal Dusting, amongst others



SEM Image Of Pitting Corrosion In Stainless Steel x400

The intelligent use of metallurgical experience, drawing on the analysis of failures, can be effective in the design, operation, maintenance and construction of plant

Root Causes include:

- Misuse or abuse
- Operator error
- Manufacturing defects
- Design inadequacies
- Wrong material
- Unforseen conditions
- Assembly errors
- Fabrication errors

Failure Analysis Process

Preliminary Review—Although the sequence of analysis will be subject to variation dependant upon the event, nevertheless there are stages that will be applicable to most failure analysis. In all instances, the most *crucial* aspect is collection, and review of background information. This facilitates the orderly collection of samples from pertinent location/s.

Visual Examination—Before physically touching, or attempting to collect samples, the entire event or physical site should be carefully visually examined. Photographs of the incident are also important for an accurate analysis.

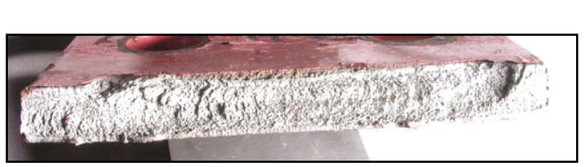
Visual examination should be thorough and searching

Examination is frequently aided by a magnifying glass, or low power binocular.

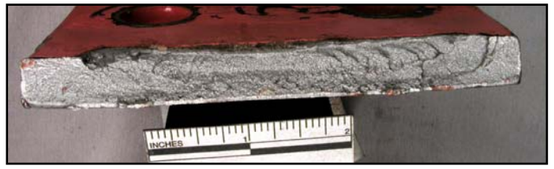
Simple techniques as tilting the sample, or shining light at an oblique angle can also enhance the observed features.

The example shown on the next page shows how the fractured surface of a steel plate is visually enhanced by tilting the specimen. Relatively more important metallurgical features are now evident on the fractured surface with oblique lighting.

The examination can also be supplemented by performing dimensional checks of the failed part, and/or the use of non-destructive techniques such as magnetic particle, dye Penetrant testing, or x-ray imaging.



With Normal Lighting

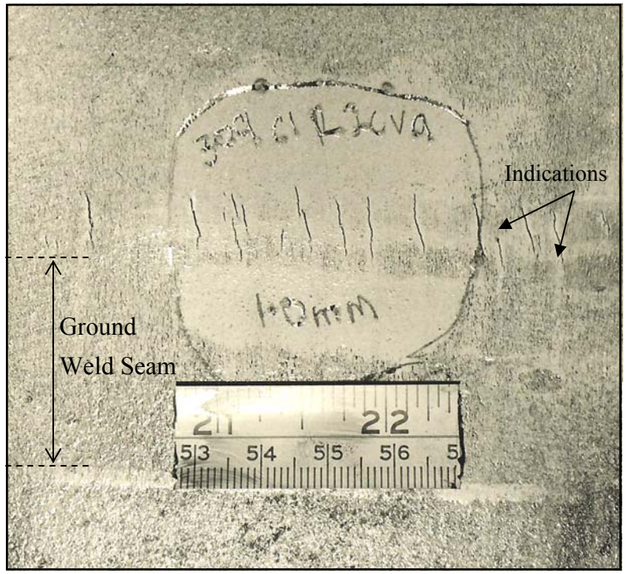


Using Oblique Lighting

Fractured Surface Of 0.5-in Thick Steel Plate

Typical Nondestructive Testing Methods

Acronym	Technique	Information Gained
EC	Eddy Current	Anomaly detected by differential current response
PT	Penetrant Testing	Detects surface open cracks and flaws in many materials
MT	Magnetic Particle	Detects surface and near surface flaws in ferromagnetic materials
RT	Radiography	X-ray examination of internal flaws in material
UT	Ultrasonic	Anomalies detected by differential reflection of ultrasonic pulses



The photo on the left shows a previously ground area on a horizontal weld seam (also ground flush) inside a 100-ft diameter Anhydrous Ammonia Sphere after MP (magnetic particle testing with white background) testing. The indications found are approximately 7/16-in long situated transverse to the weld seam at the top weld toe. They propagate thru the heat affected zone and into the base metal.

The examination was part of a 'Fitness-For-Purpose' certification. Carbon steel spheres that store Anhydrous Liquid Ammonia are prone to Stress Corrosion Cracking. However, structural integrity assessment together with pertinent inspection techniques safely permit continuation in service.

In future issues, examples will illustrate how indications such as those shown above can be microscopically evaluated in-situ (without removing samples) by 'Replication' technique.

In the next issue:

Failure Analysis cont'd -

- ► *Mechanical Testing*
- ► *Chemical Analysis*