Why Did The Material Fail?
Was it poor design, lack of maintenance, misuse, other? How do you properly determine why a system, product, or component led to a loss? Before beginning the forensic investigation it's imperative to determine the scope of the assignment and the client's requirements.

Will it involve Failure Analysis (FA) or Root Cause Analysis (RCA)?
FA focuses on the mechanical aspects of the failure or the physical root cause only. RCA, on the other hand, entails a more thorough investigation to determine the reasons for the loss or failure, including evaluation of mechanical and non-mechanical matters. If it's a small component such as industrial samples or a relatively small loss then it might only be necessary to carry out failure analysis, after consulting with the client. The scope of the assignment could be determining the immediate cause of failure, for example, did the material experience brittle or ductile fracture?

These components are typical of industrial samples:

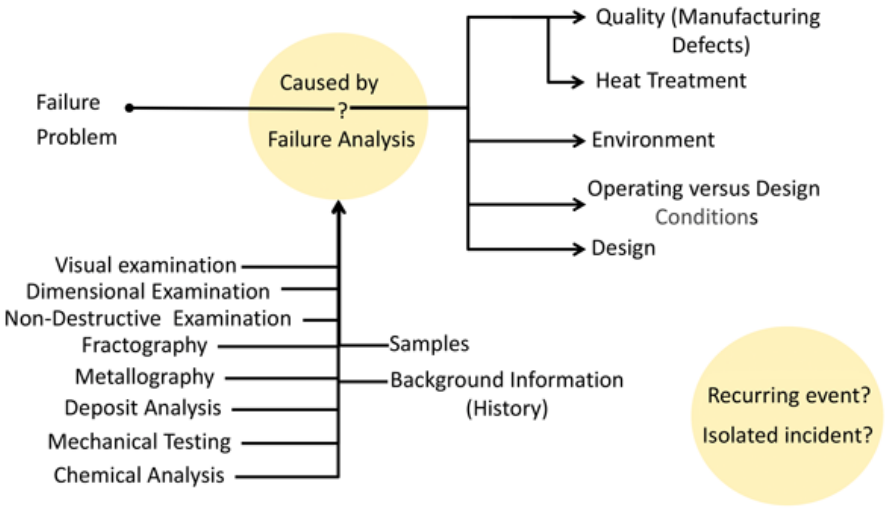
Brittle Fracture

@ -193°C

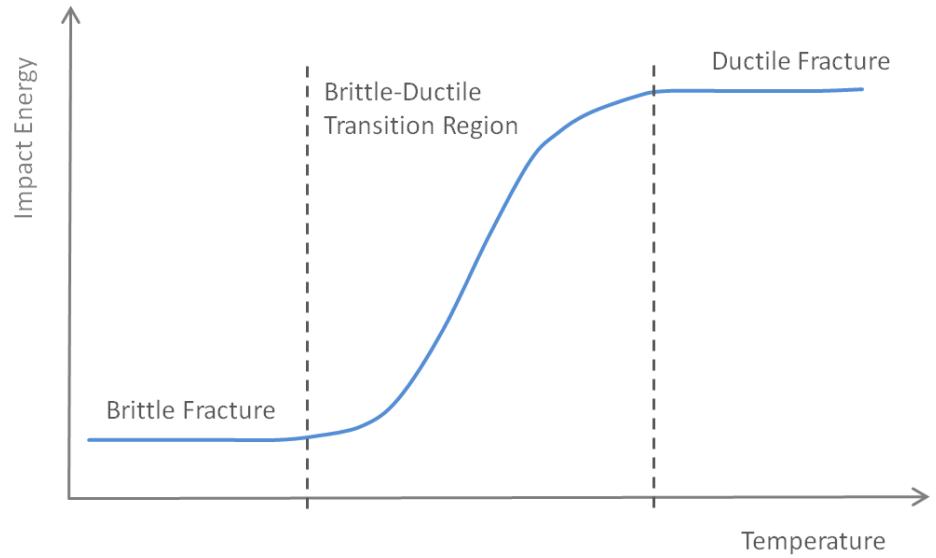
Ductile Fracture

@ 27°C

In this case, FA would be typical for the determination of an appropriate solution, if only mechanical issues need to be addressed, as demonstrated below:

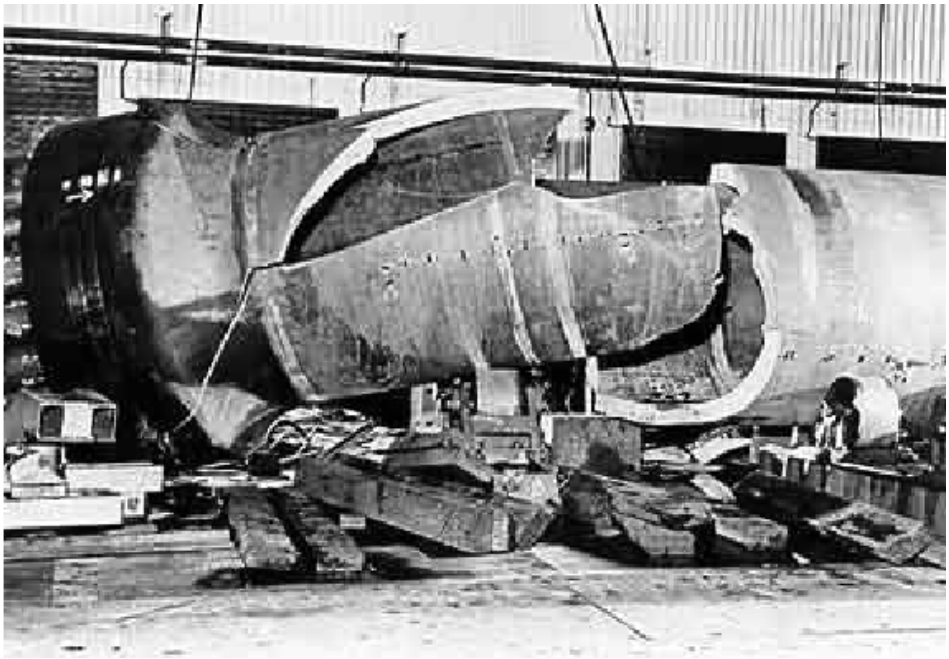


Brittle fractures usually occur at lower temperatures while ductile fractures occur at higher temperatures.

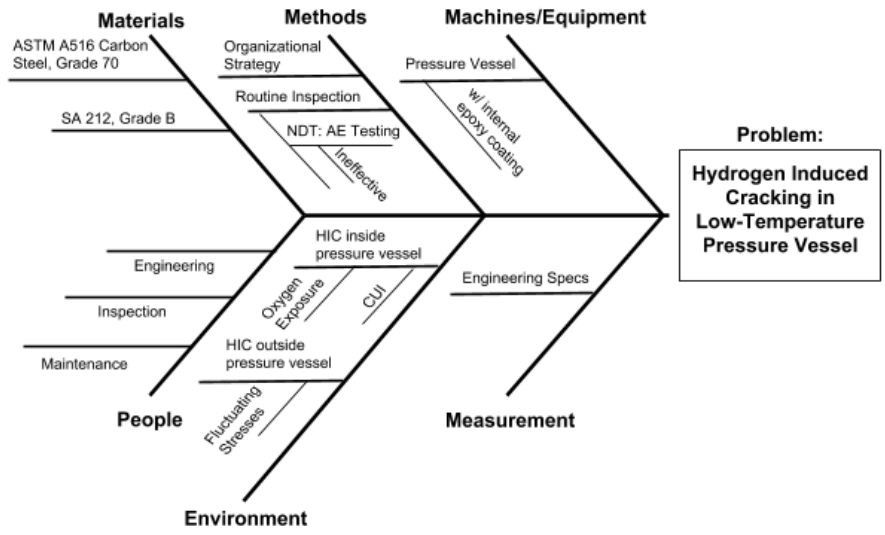


However, root cause analysis is often required for components above a certain size, equipment failures, or large losses. For an item such as a pressure vessel that failed due to a certain condition, answering how it failed, why it failed, when it failed, and where it failed, in addition to what failed are needed. These investigations typically require multiple stages and several sources of information before determining the right solution. Examples are shown below.

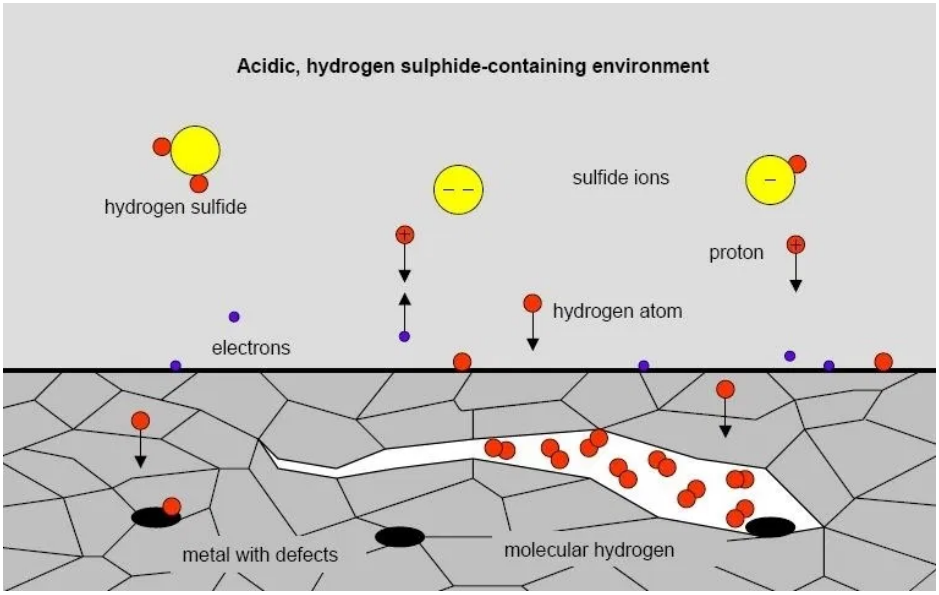
Larger item such as a fractured pressure vessel:



Example of Root Cause Analysis (RCA) using the Fishbone Technique to identify all or most potential contributors to failure in the early stages:



Evaluation of the material's environment that possibly preceded failure, as part of the analysis:



Review of service level severity, for sample testing and reference, during the investigation:

TABLE 1. Severity of Service

Category 1 (Low Severity)	Category 2 (Moderate Severity)	Category 3 (High Severity)
• H_2S concentration is 50 to 2,000 ppmw in water phase, and • No known cyanide compounds or cyanide concentration is <20 ppmw, and • No previous experience of significant blistering, HIC, or SOHIC • pH range is 4.5 to 7.6 • Most lean amine services remove H_2S	• H_2S concentration is between 2,000 and 10,000 ppmw in water phase, or • Previous experience in this or similar service showed significant blistering, HIC, or SOHIC problems • pH range is 4.5 to 7.6 • Most rich amine services remove H_2S	• H_2S concentration is above 10,000 ppmw in water phase, or • Presence of HCN or other cyanide compounds (>20 ppmw in water phase), or • Acidic aqueous phase with pH value <4.5 or >7.6, or • History of high corrosion rate and significant cracking and/or blistering

Communication with the client is integral for the establishment of project scope and problem definition before deciding between failure analysis and root cause analysis. This was a brief discussion of metallic fractures. For more information or if you have any questions feel free to contact John El Khazen, Principal at El Khazen Engineering Corporation, john@elkhazen.ca, 647-393-6212.

#oipa #elkhazenengineering #metallicfractures #ductilefracture #brittlefracture #forensicengineer #materialsengineer #failureanalysis #rootcauseanalysis