

## Failure Analysis

### Rochon Engineering Incorporated's Metallurgical Investigations Expose the Facts

The causes of structure, equipment and material failures Rochon Engineering Incorporated investigates can be determined through visual and microscopic examination combined with the knowledge of failure mechanisms such as fatigue, corrosion, overloading, manufacturing defects and other causes too numerous to mention.

To thoroughly investigate a failure, all drawings and other pertinent information regarding manufacturing, processing, and service history should be obtained. As this is not always possible, the causes of failures can still often be determined without knowledge of all the circumstances regarding use, age, temperature, etc. by an experienced eye, engineering calculations and the aid of a microscope, or if necessary sophisticated laboratory equipment.

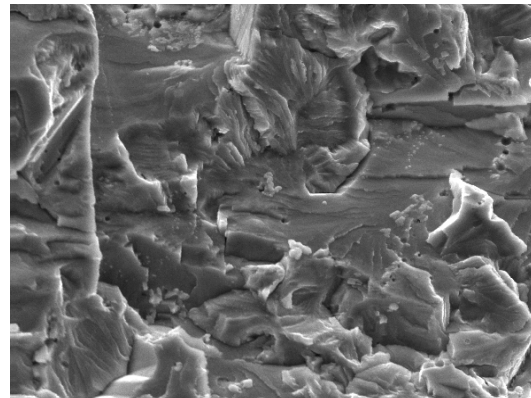


**Galvanic corrosion failure of a steel pipe nipple interconnecting two stainless steel fittings**

Forensic investigation is performed to determine a variety of issues such as whether a material defect existed at the origin of a crack, the properties and failure modes of materials, and

even if the properties of metals have been degraded from heat exposure in a fire.

When exploring fine details, a scanning electron microscope that provides useful magnification up to 60,000x, has 10x the resolution with over 200x greater depth of field than an optical microscope is used. When equipped with Energy Dispersive X-ray (EDX) analysis, a determination of the elemental constituents of a specimen and foreign materials on a fracture surface can be determined to a pinpoint of about 1 cubic micrometer.



**SEM micrograph showing cleavage fracture caused by stress corrosion cracking due to the dezincification of brass and resulting brittle failure of a water fitting**

It is very important to protect the fracture surfaces and not mate fragments back together. Fracture surface details such as “chevron” marks and fatigue crack striations can be traced to the fracture origin. The crack pattern can be analyzed to determine the component loading characteristics and close examination of the origin may find stress raisers such as machining marks, corrosion pits, inclusions, etc.

At a certain stage in every investigation, all evidence revealed by examinations and test results is analyzed to formulate preliminary conclusions. If the investigation is familiar with the type of failure or if it is a “text book” case, work will be conducted to verify the probable

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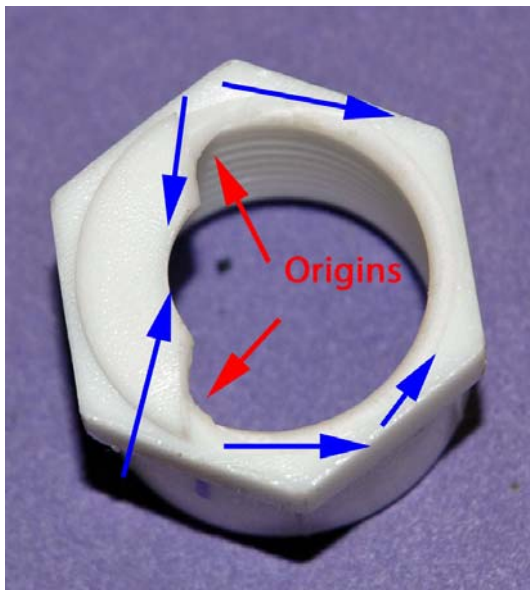
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cause and eliminate other possibilities. Uncovering new facts may change the direction of the investigation. Some work may not produce useful results that directly assist the investigation but negative evidence may be helpful in dismissing some causes of failure from consideration and address possible future rebuttal reports that raise questions regarding undocumented findings to obfuscate the issue. Research is conducted on similar failures, material properties, the manufacturer's product information and product recalls.

## Some Examples

Plumbing fittings that fail without apparent cause, suspected freezing damage, mechanical equipment failures and fuel oil tank leaks can all be investigated to determine and document the actual cause(s). This information is documented in a detailed report that will be backed by expert explanation and testimony.

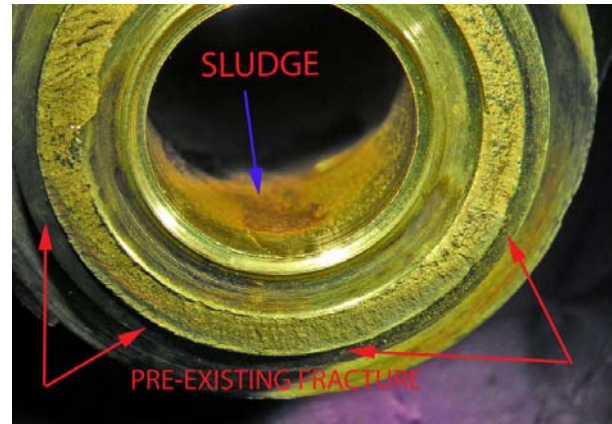
Some \$5 toilet water supply fittings undergo delayed fracture of the plastic ballcock fitting resulting in costly water damage claims. One design has a material defect caused during the plastic injection moulding process.



**Failed toilet water supply fitting with defects at fracture origins and fracture directions identified**

The failure of a fuel oil fitting that resulted in an oil spill was determined to have a pre-existing

crack caused by a bending load due to settlement of the tank.



**Failure of a fuel oil fitting with a pre-existing crack identified. Its orientation could be determined by sludge deposits indicating loading was from below**

Water escape occurred in a high-rise building due to the improper fitment of a hot water heating pipe. The pipe was not fully seated into the cup of the elbow and tension from bending the pipe to fit caused a delayed separation.



**Separation of soldered pipe joint due to insufficient insertion into cup**

To evaluate the cause of shipping damage, calculations of the forces to cause the failure of clamping bolts or brackets must be made to determine deceleration rates experienced during shipping and handling which are then compared to allowable values.

## **Evidence must be Available to All Concerned Parties**

When failed components are too large to be examined under a microscope or the metallurgical properties must be examined, sectioning of the sample is necessary. In most cases, the critical evidence is maintained. If any destructive examination is required, a protocol is developed and agreed to by all concerned parties who also must be invited to the examination. The evidence and the examination procedure are thoroughly documented in compliance with industry standards.

The client must be advised on the estimated scope and complexity required to make a detailed failure analysis. The extent and cost of forensic investigations does depend to some degree on the claim cost and in this regard, the client must guide the consultant.



**Gary W. Howard, B. Sc., P. Eng.** of Rochon Engineering Incorporated is a Metallurgical Engineer with over 25 years experience in accident investigations, failure analysis, equipment, rigging and engine failure and occupational safety. He has been qualified as an expert witness in criminal, superior, provincial, and coroner's courts.