



Weld Failures in Forensic Engineering: Design Insights and Diagnostic Considerations

BY TRISTAN YOUNT AND SHANE KENNETT

March 2026

In forensic engineering, weld failures often serve as critical evidence in the investigation of structural or mechanical system breakdowns. These failures can lead to catastrophic outcomes, including structural collapse, equipment malfunction, or safety hazards. Understanding the root causes and design vulnerabilities behind weld failures is essential for accurate diagnosis and prevention.

Understanding the Types and Causes of Weld Failures

COMMON WELD FLAWS AND FAILURE MODES

Problematic welds are typically linked to several issues: cracking, porosity, lack of fusion, undercut, and corrosion.

- Cracks may occur during the welding process (hot cracking) or after cooling (cold cracking), often due to residual stress or hydrogen embrittlement.
- Porosity results from trapped gases during welding, creating voids that weaken the joint.
- Incomplete fusion or penetration occurs when the weld metal fails to bond properly with the base metal or fill the joint, while undercut leaves stress concentration grooves that may compromise structural integrity.
- Corrosion subsequently, especially in outdoor or chemically aggressive environments, can accelerate degradation of the joint, particularly when dissimilar metals are joined without proper considerations.

Causes of Weld Failures

From a forensic perspective, failure modes often point to improper execution, design oversights, or inadequate quality assurance/control.

DESIGN-RELATED VULNERABILITIES

Proper material selection is pivotal. Incompatible metals can lead to galvanic corrosion, and some alloys are inherently more prone to cracking during welding. Joint design must minimize stress concentrations and allow for proper welding access. Inadequate load and stress analysis, especially in dynamic or thermally variable environments, can result in fatigue or brittle fracture over time.

ENVIRONMENTAL FACTORS

Environmental exposure is another key factor. Welds subjected to moisture, temperature extremes, or corrosive agents require protective coatings or sealing strategies. Forensic investigations often reveal that such measures were either insufficient or omitted entirely.

WELDING PROCESS CONTROL

Process control during fabrication is equally critical. The choice of welding technique (e.g., GTAW/TIG, GMAW/MIG, SMAW/Stick), the skill of the welder, and post-weld treatments all influence long-term performance. In forensic cases, non-destructive testing (NDT) methods

similar to those used during original construction, such as ultrasonic, radiographic, or dye penetrant testing are used to assess weld integrity and identify “hidden” flaws.

Forensic Engineering Insights — Taking a Systems-Level Approach

Ultimately, forensic engineering demands a systems-level understanding of how design decisions, environmental conditions, and fabrication practices interact. Weld failures are rarely isolated events; they are often symptomatic of broader engineering, surrounding or adjacent materials, or operational shortcomings. By integrating robust design principles and thorough inspection protocols, engineers can not only prevent failures but also strengthen the evidentiary foundation for forensic analysis when failures do occur.

HOW CAN SECRETARIAT ASSIST?

Our engineers and certified welding inspectors play a vital role in forensic weld investigations, especially when failures involve complex interactions between materials, environmental conditions, and fabrication processes. Not only can we perform root cause investigations within our laboratories, but our team also has the necessary skills to perform finite element analyses (FEA) as a part of our independent assessments. Our objective expertise helps uncover the root causes of weld failures and informs recommendations for prevention and remediation.

AUTHORS



Tristan Yount, PhD, PE
MANAGER
tyount@secretariat-intl.com



Shane Kennett, PhD, PE, CWI
MANAGING DIRECTOR
skennett@secretariat-intl.com



SECRETARIAT'S EXPERTS AND ADVISORS

are trusted in the highest-stakes legal, risk, and regulatory matters around the world. Our highly credentialed engineering and scientific professionals investigate incidents, analyze technical problems, evaluate implications, and present clear, evidence-based findings to key stakeholders, including clients, regulators, arbitrators, judges, and juries.

OUR AREAS OF EXPERTISE

- Batteries & Energy Storage
- Civil & Structural Engineering
- Electrical Engineering
- Geotechnical & Foundation Engineering
- Human Factors
- Mechanical Engineering
- Metallurgy & Material Sciences
- Product Risk & Safety
- Rail
- Thermal Sciences

We would like
to hear from you

info@secretariat-intl.com
secretariat-intl.com