METAL & WELD TESTING
a guide for the Forensic Engineer

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Jesse A. Grantham, Ph.D., P.E.
NAFE 597M

Abstract
Considerable developments in metal failure analysis techniques and reliability are emerging with legal community acceptance of traditional methodologies in mechanical tests and nondestructive tests. Mechanical tests assess metal properties such as ductility, tensile strength, toughness and weldability. Nondestructive tests provide surface and sub-surface flaw detection, location and features. Verification of metal properties by tests is a good policy for the Forensic Engineer.

Introduction
One test is better than a thousand expert opinions. The seasoned Forensic Engineer knows that quality satisfies design and quality cannot be inspected into a part. During manufacturing a metal item, the responsibility of management is to evaluate all costs and benefits of production activities, including exposure to product-liability issues because of their decisions. Validation of metal properties by proper tests is just a good, standard policy for the Forensic Engineer.

Mechanical Tests
The Forensic Engineer relies on technical reports about metal tests containing terms that have different meanings to different people. The Forensic Engineer's reports attempt to make complex topics simple to understand by the non-technical, legal community.

Several mechanical tests used by the Forensic Engineer involve "direct measurement" of metal properties. The Annual Book of ASTM Standards Volume 03.01 contains descriptions of standards and specifications for mechanical tests. Several of these tests are listed:

- Bends
- Hardness – Rockwell, Vickers
- Tensile – Yield, Ultimate
- Charpy V-notch - toughness
- Alloy Analysis by OES
- Weldability
- Other mechanical tests

Nondestructive Tests
Most of the vital characteristics of an item can be determined indirectly or can be inferred from the measurement of some other characteristic. Nondestructive tests (NDT) are widely used to indirectly examine metal in an attempt to locate surface discontinuities or subsurface indications.

The choice of NDT methods depends on the type of flaw anticipated, as well as the nondestructive inspection location, in the shop or field. Visual Tests (VT) is the most common NDT and least costly inspection method for locating discontinuities on base metal, welds and adjacent surfaces. Surface discontinuities are typically located by these methods;

- Visual in adequate light
- Magnetic Particle Tests (MT)
- Liquid Penetrant Tests (PT)
- Other NDT methods

Finished products, rolled plate, forgings, castings, and welds, are examined for sub-surface (volumetric) discontinuities by Ultrasonic Tests (UT), Radiographic Tests (RT), other methods.

Test Results
The Forensic Engineer recognizes the need for accreditation of each mechanical test laboratory as a necessity for acceptance of test data for the litigious matters. Laboratory accreditation is addressed in the ASM Handbook Volume 8, Mechanical Tests and Evaluation.

Ethics
Forensic Engineers take seriously their responsibility for ethical investigations and the welfare of the public. The guiding principles for the Forensic Engineer, a Registered Professional Engineer, are contained in the National Society of Professional Engineer's Code of Ethics and the Engineer's Creed.

The Forensic Engineer's final work-product may be an oral testimony or a written report. The Forensic Engineer is charged with the responsibility to find the truth, know the truth and tell the truth. One test is worth a thousand expert opinions.

References:

- *CHOICES, A Welding Guide for the Legal Community*, by Jesse A. Grantham, P.E., NAFE 597M
- ASM Handbook Volume 8, Mechanical Tests and Evaluation.
- ASM Handbook Volume 11, Nondestructive Testing.
- ASNT(American Society of Nondestructive Testing) SNT-TC-1A Recommended Practice.
- NSPE (National Society of Professional Engineers) Code of Ethics for Engineers.
- The Annual Book of ASTM Standards Volume 03.01 Standard Specifications, Metals - Mechanical Testing.