The March 2011 Penetrant Professor from Met-L-Chek®

The Dilemma of How to Measure Sensitivity

The thermally cracked aluminum panel was an early method of comparing the sensitivity of one penetrant to another, and was written into the first issue of MIL-I-25135. At that time there was apparently no concept for a specific and identifiable method of quantifying absolute sensitivity, and the panel was solely used to make comparisons. But the idea for a quantitative method was apparently recognized, and the Air Force Materials Laboratory investigated methods of determining this.

One such trial system involved taking a large number of double edge razor blades and threading them onto a set of through bolts that then forced the blades into a stack that was tightly bound. The idea presumably was that the spaces between the blades was very small and could be used to test penetrant sensitivity. To use this device, penetrant was applied to the stack of blade edges and then developed. The idea proved to not be fruitful.

Beginning in the 1960's, the Air Force contracted with several organizations to work on a reliable test method. These included the Ohio State Research Foundation, which developed cracked chrome panels, and Monsanto, which worked on all issues relevant to the specification. The Monsanto Report, issued in March 1965, was prescient in their abstract, noting as follows:

"Crack sensitivity is a value of major importance requiring improvements upon the insensitive aluminum block specimens, plated iron, ceramic, titanium, and the Ohio State nickel chrome specimens."

They then contracted with Paul Packman, of the University of Tennessee, who developed the infamous "Packman bar" (approximately 15" x 4" x ½"), now regarded as an excellent doorstop. Packman issued his report in 1976.

It was clear that two things were essential in this development. The first was specimens of cracks that were similar to those that were to be detected by penetrants, and the second was a reliable method of measuring the brightness of the cracks that were detected. Experimentation with the Photo Research Spectra Spotmeter™ at WPAFB began in July 1974. Scans of cracks in Monsanto cracked-chrome panels were recorded, both transversely across all the cracks in a panel and along selected cracks This line of investigation was abandoned primarily because of the difficulty repeating the scanning tracks across or along the cracks and the oft encountered deterioration of the brightness of the crack indications with repeated processing and cleaning of a panel.

Among the "brightness standards" tried were various features on the Tracer-Tech Inspectability Chart (Plastic Laminated Card) and a fluorescent piece of glass with simulated cracks created by removing narrow bands of flat black paint that had been applied to the glass.

In 1975 the Spotmeter™/HP XY recorder was tried for the first time on fatigue cracks in aluminum plates (6" x 4" x ½") manufactured as demonstration specimens for fluorescent penetrant inspection of A-10 aircraft structure. Scans were also made of a variety of Japanese cracked-chrome panels and the Paul Packman cracked-chrome plate.

ASNT Spring conference
March 21 -24, 2011 in
San Francisco, CA

Mar 2011

In 1992 the NASA Johnson Space Center offered some 6” x 4” x 1/8” flat titanium panels that contained fatigue cracks. Reliable and repeatable crack detection continued to be a problem with all of these.

Eventually digital-output versions of the Spotmeter™ were used and scanning the crack indications was replaced with static brightness measurements. The Inconel 718 and Ti-6Al-4V fatigue-crack bars are positioned on a microscope stage, which is manually adjusted to position the crack indication in the center of the Spotmeter™ field of view. There were over 200 fatigue cracks manufactured in those Inconel and titanium bars. Efforts at AFRL a couple years ago to manufacture 40 similar bars to replenish inventory and replace “tired” cracks showed how difficult it is to manufacture controlled-size cracks that can be detected with liquid penetrant and how difficult it is to produce penetrant indications of tight cracks.

In the early days of developing the MIL-I-25135D revision before the current technique was adopted as “the” sensitivity measurement technique, the brightness of a fatigue-crack indication was assigned a value of 1 through 4 by Ed Porter, a UTC lab technician. This subjective technique was quite repeatable but, of course, it would not stand the test of time since Ed would not be around forever.

There were other test specimens evaluated at places other than WPAFB.

Monsanto expanded upon the medium-crack panels developed by Ohio State and generated fine- and coarse-crack panels as well. In the course of developing these well known panels, they also unsuccessfully tried a few others for evaluating penetrant sensitivity: the thermally-cracked aluminum panels, 16-gage hot rolled steel panels electroplated with a brittle iron coating and bent in a manner of the chrome-nickel panels.

Patent records show that James Alburger developed the following:

Grit blasted glass panels, in which the blasting produced cracks, the sizes of which could be controlled by the size of the grit,

Anodized aluminum panels, where the anodized coating was cracked by bending the panel,

Soft metal panels that were coated and then stretched to form cracks in the coating,

The “meniscus” method, by which the concentration of the dye in the penetrant could be estimated, using a glass apparatus and the application of Beers law.

Purex, then marketing Turco products, developed metal panels that were impressed with needle-like tools to form impressions of varying diameters and depths, simulating defects of different sizes.

A patent was issued for a tool made from laminated metal sheets that were then machined at an angle, the face of which would show the laminations. Depending upon the angle that was machined, the laminations would have different spacing and widths which could be detected with penetrants.

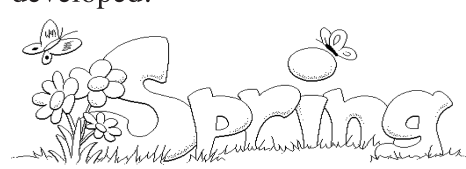
GE Aircraft engine group had developed low cycle fatigue cracked bars that they were using internally to train inspectors, and to run POD tests.

Frank Vicki had developed a chrome panel that was plated with a tapered thickness of chrome, bent, and therefore had parallel cracks of known different sizes.

From the Committee K Round Robin Test the following are among those not already mentioned:

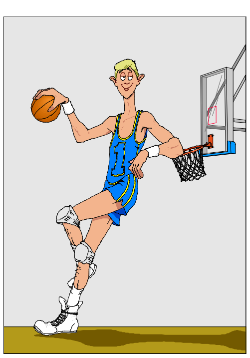
- Actual test parts with known defects
- Jet engine blades
- NBS crack standards
- Ardrox® Runcheck Panel
- P&W TAM panel
- Rockwell fracture critical blocks

During the many meetings of AMS Committee K, the topic of measuring absolute sensitivity occupied a major portion of the discussions, and each method that was suggested was tested by the AFML. One by one, all of the various test methods were eliminated until only the low cycle fatigue cracked bars remained. When this was determined to be the best tool to determine sensitivity, the job was not quite done. Reference penetrants needed to be selected and the method of scoring the candidate penetrants had to be developed.



Selecting the reference penetrants was done by AFML, and the selection was spread among the major manufacturers. Candidate penetrants were to be compared to the references selected. The comparison involved a bit of statistics that took the committee and the Air Force some time to work out and to agree upon. The testing involved duplicate tests of both the reference and the candidate, using the low cycle fatigue cracked bars. The data from these tests were used to develop standard distribution curves for the reference and for the candidate, which then formed the basis for comparison. The actual wording is as follows:

Acceptance Criteria:
Indication brightness data from the candidate material shall be compared to the lower standard deviation curve for corresponding data from the appropriate reference material. The lower standard deviation curve shall be generated from a minimum of three runs of the appropriate reference. The candidate material shall be acceptable when 80% of the points that generate its curve lie above the lower standard deviation curve of the appropriate reference material. The tests shall be valid only if the data for the current run with the referenced material falls within the standard deviation established from previous runs, or if the three runs to establish the lower standard deviation are current. Reference material shall be tested periodically to check validity of tests.



March Madness 2011

In a related topic, the following discussion concerns the use of TAM panels:

Recently there was an article published in the french journal, CONTROLES ESSAIS MESURES, describing a different method of using PSM-5 panels to determine the comparative sensitivity of a penetrant system that is in use. The PENETRANT PROFESSOR read the article and thought that it described a way that the panels could be used to determine the absolute sensitivity of a penetrant, and published this opinion. This resulted in a discussion between Babbco and Met-L-Chek in which we both found that we had each misunderstood each other, and the problem resulted from the difference between the two languages, and also the fact that the word “sensitivity” is used differently in AMS-2644 and ASTM E-1417. We want to clarify this by pointing out that the TAM or PSM 5 panels cannot be used to determine the absolute sensitivity level of a penetrant, and are not allowed to be used for this purpose by either the manufacturer or ASTM E-1417. Instead, these panels are designed to be used to determine the penetrant system comparative performance, and the French article only discussed the use of the panels in this test.

The PENETRANT PROFESSOR is grateful for the contributions to this article made by Grover Hardy and Noel Tracy, both of whom worked for years to develop the method used today.

The Penetrant Professor

PENETRANT PROFESSOR
is an occasional publication
of
The Met-L-Chek Company.
To receive it,
call or Email
Beverly Clarke.

HAPPY ST. PATRICK'S DAY