NEW EQUIPMENT FOR MOBILE PENETRANT TESTING

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Introduction

Fluorescent Penetrant Testing (PT) is one of the most sensitive Non Destructive Testing (NDT) methods for detection of surface defects with a width up to 0,2 µm. This method is being also widely applied for leak testing, its sensitivity comes to $2x10^{-7}$ m^3Pa/s. The method application requires often some mobile techniques, both for inspection and for documentation. The subject of this paper is the application of high sensitive fluorescent penetrant systems (cleaner, penetrant, developer), mobile ultraviolet radiation sources, test blocks and special portable microscope camera with adjustable built-in UV LED light for precise, fast and traceable documentation in the field. This equipment use allows to perform prompt and reliable surface inspection, to discover and identify microscopic details that need attention and to transmit high definition images with observations, comments and measurements.

Penetrant system and equipment

Penetrant system

An aerosol penetrant system is very useful when testing in field conditions. Suggested system (Picture 1) includes following components:

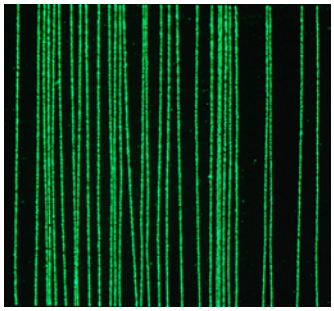
Cleaner / solvent MET-L-CHEK NPU is an environmentally safe, fast evaporating cleaner on the isopropyl alcohol base. The NPU cleaner is appropriate both for precleaning of the test surface from oil and other organic contaminations and for removing of penetrant

residues. The NPU cleaner is classified as a Second class cleaner in accordance to AMS-2644, i.e. it is very low in halogens (< 0,01%).

Fluorescent Penetrant MET-L-CHEK FP 97A(M) is a post emulsifiable fluorescent penetrant, designed for ultrahigh critical inspection of turbine engines and other high stress aerospace applications [1]. It is listed on the Qualified Products List for AMS-2644 as a sensitivity level 4 penetrant. It meets the requirements of AMS-2647, ASME Boiler and Pressure Vessel Code, ASTM E-165, and ASTM E-1417 for penetrant inspection materials. It meets the OSHA open tank use requirement of having a Flash Point over 93°C. It is low in Sulphur, Sodium, Chlorine, and other Halogens, making it safe for use on Titanium and high Nickel alloys. For a mobile application the penetrant has been used according to Method C – Solvent Wipe Removal. It means, for the intermediate cleaning the excess surface penetrant is first removed with a dry cloth, followed by cleaning with a cloth dampened with a solvent remover (NPU cleaner).

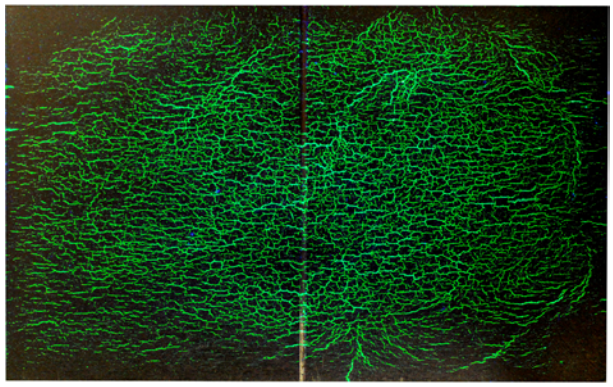
Developer Met-L-Chek D-70 is a nonaqueous inspection developer used with both fluorescent and visible penetrants [1]. It is listed on the Qualified Products List for AMS-2644 as a form "d" & "e" developer. It meets the requirements of AMS-2647, ASME Boiler and Pressure Vessel Code, ASTM E-165 and ASTM E-1417 for penetrant inspection materials. It is applied by spraying, either from an aerosol can or by conventional spray gun. Developer particles will settle out upon standing, requiring agitation prior to application. The solvent carrier is flammable and use around open flames should be avoided. It is low in Sulphur, Sodium, Chlorine, and other Halogens, making it safe for use on Titanium and high Nickel alloys found in nuclear components.

Picture 2 shows some defect indications resulted from this system application. It's obvious that this technique makes it possible to discover even the finest defects. It should be also pointed out that this system not only ensures the highest sensitivity, but due to aerosol form enables effective and reliable testing even in the field.



Picture 2: Cracks indication on Ni-Cr Panels, after treatment with MET-L-CHEK aerosol penetrant system. Dwell time 10 min, development time 3 min., room temperature, defects width 0,25 µm, defects depth 5 µm – left photo, defects width 0,5 µm, defects depth 10 µm – right photo.

This penetrant system can be used even at low temperatures up to -5°C. Picture 3 shows an ASME V Panel, which right half is treated at 21°C and the left one – at -5°C. There is no indication degradation on the left half.



Picture 3. ASME V Panel treated at -5°C (the left half) and at 21°C (the right half)

When applying fluorescent systems both for checking for penetrant residues after intermediate cleaning (background / no background) and for final inspection and interpretation the UV sources have been used.

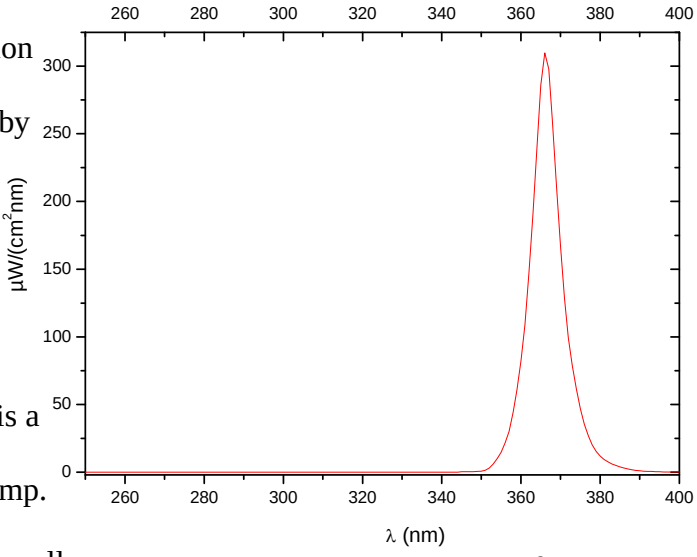
Ultraviolet sources

The UV-A irradiation is required for the fluorescent penetrant inspection. Commonly, the high-pressure or low-pressure mercury-vapour lamps have been used as ultraviolet sources for non-destructive testing [2]. In order to isolate only the UV-A range from the total emission spectrum, a combination of a band pass filter and an optical edge filter is required. This kind of UV lamps has been used for plenty years and has proved itself well in practice.

However there are some shortcomings inherent in conventional UV sources like rather low efficiency factor, high energy consumption, short life time (about 1500 hours), long starting time, high disposal costs, etc.

Not long ago the progress of nitride semiconductor technology made it possible to get high-power ultraviolet light-emitting diodes as an alternative for conventional UV irradiation sources. Due to this development the production of portable and mobile UV lamps, borescopes and endoscopes of high UV light intensity has become possible. High efficiency factor (more than 10%) at low power consumption, next to unlimited life time (more than 20.000 hours), insensibility to electromagnetic fields, vibration resistance, immediate readiness for use after switch on - all the features make them indispensable by mobile penetrant or magnetic particle testing. The next advantage of UV LED sources is the determined wavelength (maximum by 365 nm) in the UV-A spectral range (320 – 400nm). (See picture 4). UV-A range is considered to be the most harmless in comparison with UV-B or UV-C spectral range but it ensures the optimal excitation of fluorescent penetrant.

Due to their low power consumption the UV LED lamps can be powered by accumulators, so their field application during many hours without UV intensity decreasing is quite practicable [3].



Picture 4. Spectral distribution of Helling UV-LED-Inspector 365

The UV Inspector 365 (Picture 5) is a handy, accumulator powered pocket lamp. The aluminum lamp casing contains all electronic components. The user can switch between two intensity levels. The irradiation intensity and area can be adjusted by turning the lamp head. The rechargeable NiMh accumulators can be charged using the optional battery charger. The max. UV intensity at 400

Picture 5. Helling UV-LED-Inspector 365

mm distance is ca 6.000 µW/cm². The continuous working time of UV Inspector 365 is about 4 hours.

Picture 6. Helling UV-Endoscope

The semi flexible UV Endoscope (Picture 6) is a high resolution image guide of 8 mm diameter and 1000 mm working length with 7400 optical fibers; its curvature radius is 60mm. The image pixels are transmitted by individual fibers in the flexible probe and are then re-aligned at the eyepiece to form the high-resolution image. The black light guiding fibers are optimized for the wavelength of 365 nm. The UV intensity at the distance of 20 mm is ca 6.000µW/cm². This waterproof, oil and petrol-resistant endoscope is exactly the right instrument for the inspection of hard-to-get-to areas whether in the automotive, manufacturing or construction branch. Its continuous working time is about 6 hours.

UV-Inspector 2000-A-W (Picture 7) is a portable accumulator powered UV LED hand lamp with additional white light for orientation in the dark. This lamp type is notable for its large and even irradiation area along with high intensity of 2.500µW/cm² at 400mm distance. The continuous working time is about 4 hours. This lamp has been delivered with a charging station and a reserve accumulator for independent working in the field.

Picture 7.
Helling UV-Inspector 2000-A-W

After the penetration process is completed and the indications are observed, the final step will be to document them for further estimation.

X-Loupe microscope camera

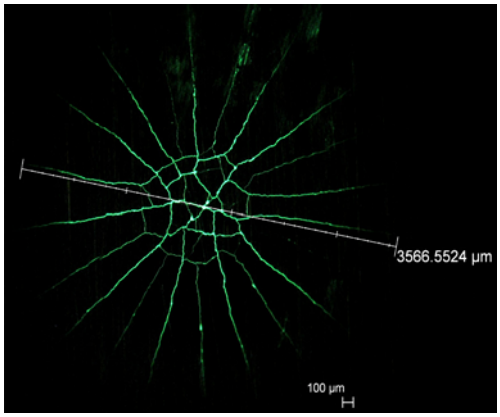
Formerly the documentation was possible by means of adhesive or gelatinous films, photographs, hand sketches. But now the portable X-Loupe microscope camera (Picture 8) is irreplaceable for precise, fast and traceable documentation in the field. This is a modified Canon IXUS camera with attachable battery module and three interchangeable lenses – of 60x, 100x and 150x magnification. The lenses incorporate an adjustable LED light. This feature solves the most challenging illumination problems when taking micro photography. The X-Loupe is completely independent of all exterior light sources and can be used under any light conditions.

Moreover the microscope camera can be combined with an UV lens, which enables defects estimation and further documentation under UV light.

The X-Loupe captures images of objects in the range from 15 mm to 0,005mm, making it possible to identify microscopic details that need attention, and via image management software making them available to customer within minutes. The software enables to transmit high definition images where observations, comments as well as measurements are included within the image. The image can then be sent as a JPEG file or as a detailed Excel spreadsheet.

Picture 8.
Helling X-Loupe microscope camera

As an example Picture 9 shows a PSM 5 star indication after treatment with above mentioned penetrant system. It is obvious, that this microscope camera enables not only high resolution photographing but also estimation of defect geometry.



Picture 9. PSM 5 star indication

Resume

The fluorescent penetrant testing is one of the most sensitive methods for detection of discontinuities open to the surface, which are in quite a number of cases the most critical surface defects. The major advantages of fluorescent penetrant testing are portability, simplicity, sensitivity. The usage of the new technique described in this paper makes the method even more mobile and effective.

References

[1] QPL-AMS2644-4 Qualified Products List of Products Qualified under SAE AMS2644 Aerospace Material Specification.

[2] ASTM E 2297-04 Standard Guide for Use of UV-A and Visible Light Sources and Meters used in the Liquid Penetrant and Magnetic Particle Methods.

[3] N. Riess, A. Ivankov. Möglichkeiten und Grenzen bei der Dichtheitsprüfung und Lecksuche mit Hilfe von neuentwickelten UV-LED-Prüfgeräten und Penetrants // 4.Fachseminar – Dichtheitsprüfung und Lecksuche. – DGZfP, 2006.

[4] Liquid Penetrant Testing /ASNT Nondestructive Testing Handbook; v.2 // Ed.by R.C. Mc.Master. – ASNT, 1982. – 616 p.