New Standard Requirements and Possibilities using UV-LED lamps for fluorescent Magnetic-Particle- (MPI) and Penetrant Inspection (FPI) in Aerospace

© 2016 Marc Breit

Marc Breit

Managing Director and Head of development

more than 15 years NDT-experience in Magnetic- and Penetrant-Testing

Active Member and participant of all relevant groups and standardization committees worldwide regarding UV-LED-Technology:

ASTM

DIN EN ISO committees for MT and PT

NADCAP

SAE

Working Aircraft- and Engine-manufacturers

© 2016 Marc Breit

Manufacturer of:

High quality, standard and customized UV-A-LED-sources developed by and for the inspection practice

Ultrasonic-Couplants

Fluorescent Magnetic-Particle consumables

Optimized Electrostatic Spraying Equipment

FPI-Lines (manual, semi-automatic, full-automatic)

Sister company of RIL-CHEMIE

© 2016 Marc Breit

Introduction

- Discharge bulb based UV-A Sources (Mercury Vapor, Xenon, Metal-Halide) shall get unavailable in the near future and they are more and more substituted by LED-based sources in practice

- The technology change interferes the inspection practice enormous

- The user needs a tool that supports the detection of indications of the human vision, not just an UV Source that just stimulates fluorescence

- Standardization does acutally not reflect this requirement, even if we are hardly working on that.

© 2016 Marc Breit

Technical Basis of Fluorescent MPI and FPI

- Process just helps **DETECTING INDICATIONS** (seeing it easier)

- Process has to be:
  - reliable
  - secure
  - fast
  - efficient and economic

IT'S ALL ABOUT CONTRAST

between indication and background

© 2016 Marc Breit

Technical Basis of Fluorescent MPI and FPI

What is commonly summarized as **INSPECTION** of indications are physiologically and technically **3 different steps**:

DETECTION (peripheral vision)

INSPECTION (central vision)

INTERPRETATION (supported by white light)

© 2016 Marc Breit

Technical Basis of Fluorescent MPI and FPI

The human vision and its physiology is the

UNCHANGEABLE PART

of the whole system

THAT NEEDS TO BE SUPPORTED

© 2016 Marc Breit

The Human Vision

Peripheral (outer) Vision (unsharp and fast):

FAST & RELIABLE DETECTION OF INDICATIONS

GIVES ORIENTATION ON THE SURFACE

CONDUCTS THE CENTRAL VISION

TO THE RELEVANT INDICATIONS

➜ **REQUIRES LARGE BEAM or**

SOFT DROP at the edges

© 2016 Marc Breit

The Human Vision

Foveal (central) Vision (very sharp, coloured and slow):

RESPONSIBLE FOR
INTERPRETATION OF INDICATIONS

INAPPROPRIATE TO DETECT INDICATIONS

REQUIRES UNIFORM BEAM

ALLOWS ONLY TUNNELVIEW

© 2016 Marc Breit

The Human Vision

Allows intuitive, fast and reliable inspection

WHEN using its **FULL**

CAPABILITY OF DETECTION

(like when using Mercury vapor lamps)

Stimulation Of Fluorescence

IS BY FAR NOT ENOUGH

© 2016 Marc Breit

Central importance of the UV-Source and its Reliability

A failure (e.g. lost of intensity) of the source can not be seen and realized by inspector due to the invisibility of the radiation

If a physical existing indication does

NOT APPEAR OR IS NOT SEEN,

due to a failure of the source

or insufficient radiation area,

the inspector **TRUSTS that there IS NO indication**

© 2016 Marc Breit

Central importance of the UV-Source and its Reliability

If UV LED sources doesn't work

ALWAYS RELIABLE AND PROPERLY

(as Mercury Vapour lamps do)

THE WHOLE PROCESS CRASHES

© 2016 Marc Breit

Technology Shift

from a simple **electric device** to a

complex sophisticated **electronic system**

with **opposite behavior** after switch-on

used in a harsh industrial environment

© 2016 Marc Breit

Technology Shift:

When using discharge bulb-based UV sources the

user had to find a way to inspect

with the determined tool

UV LED technology offers

optimized lamps for different applications

© 2016 Marc Breit

Technology Shift:

Optimized UV-LED Source can:

- Enhance the process performance (faster and easier inspection)
- Enhance the quality of the inspection process
- Eliminate reflections
- Safe Energy and a lot of money
- Enhance the health and safety of the user

Non-Optimized UV-LED Source can:

- Make inspection more tiring, harder or impossible
- Dramatically increase the process costs
- Crash the process and do NOT stop the user

© 2016 Marc Breit

Process security

Mercury vapor lamps only know 2 status:

ON = works properly

OFF = always in case of any failure

Intensity rises when warming up

© 2016 Marc Breit

Process security

UV LED Lamps:

Intensity drops when warming-up

Errors typically occur inconspicuous and sneaking, what makes it impossible to be realized by the inspector immediately when they occur or get critical.

Undetected failures of the UV sources are inacceptable.

To ensure same or better process security
adequate electronic monitoring
or additional checks are mandatory

© 2016 Marc Breit

Process security

Additional checks (if not electronically monitored)

- Check of proper function of all UV-LED-elements on multi array UV-LED-sources
- Check of correct function of the cooling system
- Monitoring of the allowed ambient temperature
- Check of the output constancy on battery powered lamps
- Determination, Documentation and Monitoring of this additional checks

© 2016 Marc Breit

Features for Enhanced Inspection Quality and Performance

Process Security

Auto Switch OFF at Low Battery or System Failure

Monitoring of UV LEDs

System health monitoring

Signalization of operating status and system status

Tested and Qualified for Ambient Temperatures of 50°C (122°F) or more

SECU CHEK NEXT GENERATION UV LED LAMPS

© 2016 Marc Breit

Features for Enhanced Inspection Quality and Performance

Conformance

Adaption Time Signalization

Detailed Certificate with
- Separated Sections for Each Individual Standard
- Data Linked to Relevant Sections for Easy Demonstration of Evidence

Readiness for Upcoming standards

Sealable Customizing by Responsible

© 2016 Marc Breit

Features for Enhanced Inspection Quality and Performance

Enhanced Interpretation

White Light Toggling (UV or VIS)

Additional White Light (UV and VIS together)

In-Use Adjustable White Light output

SECUCHEK NEXT GENERATION UV LED LAMPS

© 2016 Marc Breit

Features for Enhanced Inspection Quality and Performance

Enhanced Interpretation

Slow **step less** dimming instead of switching

Uninterrupted observation while changing

NO loss of orientation or sharpness

NO flash blinding of the eyes

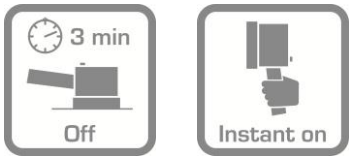
SECUCHEK **NEXT GENERATION UV LED LAMPS**

© 2016 Marc Breit

Features for Enhanced Inspection Quality and Performance

Enhanced Features

Eco Mode to safe energy and lift-time



Optical, acoustical and tactile signals

Individual customizing by the user

SECUCHEK NEXT GENERATION UV LED LAMPS

© 2016 Marc Breit

Lamp selection and usage

Choose the right lamp for a specific application

Check orientation and detectability of indications

Focus on optimal support of the inspection process not price

Compare lamps in practice (not datasheets)

Check uniformity while moving over white sheet of paper

© 2016 Marc Breit

The unwritten standard:
100W Mercury-vapour bulb based UV-Sources

All lamps are technically equal and
based on same bulb, filter and ballast

Same physical determined and fixed spectral output

Same high reliability

Same irradiated area

Same beam pattern (central spot with soft radiation drop)

NO or only only coarse laminar inhomogenities

© 2016 Marc Breit

The unwritten standard:
100W Mercury-vapour bulb based UV-Sources

To ensure **at least** the same

QUALITY, RELIABILITY, PERFORMANCE and COSTS

of the inspection

UV LED sources must be

EQUAL OR BETTER

than mercury vapor lamps in

ALL MATTERS without compromises!

SECUCHEK **NEXT GENERATION UV LED LAMPS**

© 2016 Marc Breit

ASTM Standards

ASTM E 3022 contains only manufacturing requirements for non-aerospace UV LED sources

Is included in aerospace standard ASTM E1444 and E1417

Peak 365 ± 5nm needs only to be reached at low ambient temperatures (Reduction of sensitivity level can occur, due to the emission spectrum of conform UV-LED-lamps)

No additional electronic or manual user checks and further controls required

Certification Report does not require to state results of unit qualification

Existing standards as well as the terminology shall be adapted within the next years.

© 2016 Marc Breit

AMS / SAE Standards

AMS 2647 will be changed in the future

© 2016 Marc Breit

EN /ISO Standards

EN ISO 3059 is in revision

Shall get an appendix for acceptance and qualification criteria for UV-LED

A Technical Report will explain the basics of fluorescent and colour contrast technique

Shall be available late in 2017 or 2018

© 2016 Marc Breit

Rolls-Royce Engineering Specification RRES 90061

First Prime Standard available in Aerospace Industry
that terminated the ban of UV-LED-sources by Rolls Royce

Includes manufacturing requirements and additional user checks

Requires 365 ± 5 nm always during usage
at ambient temperatures within 40 – 122°F (5 to 50 °C)

Requires even irradiation

Requires surrounding area with gradual reduction

Actually the highest reliability requirements

Over temperature switch-off required

Security switch-off for battery powered lamps when output could decrease mandatory

© 2016 Marc Breit

NADCAP

NADCAP NDT task group is working on standard questions

The last draft contains only 4 questions according the following themes:

Evidence that lamp manufacturer validates
peak wavelength 365 ± 5nm

Procedure to ensure correct output of battery powered UV LED lamps in place (does procedure exist and does it ensure correct output)

Torches shall be only used to local inspection

© 2016 Marc Breit

Airbus*

Issue 9 of AITM 6-1001 allows the usage of UV-LED-source with a with peak of 365nm without variation, what is technically a ban of the usage of common UV-LED-lamps available

New revised shall be published soon and contain specific requirement for UV LED sources

* Without claim to be the last updated and complete information

© 2016 Marc Breit

GE Aviation*

Usage of UV-LED sources are not allowed and not forbidden

Acceptance criteria shall be published in the future

* Without claim to be the last updated and complete information

© 2016 Marc Breit

Pratt & Whitney*

lowest aerospace requirements

365 ± 5 nm within 60 – 104°F (10 to 40 °C) when tested, no usage restriction

Visible light output less than 2 fc (20 Lux) at minimum working distance

Limitation of maximum UV-A intensity to
10,000 µW/cm² at 15 inches (38.1 cm)

Some intensity measurements required when using battery powered sources

* Without claim to be the last updated and complete information

© 2016 Marc Breit

Conclusion (technically)

- LED-based UV-Sources are not simple electric lamps, they are electronic device that require adequate qualification and maintenances
- NDT has the highest requirement for UV LED Sources due to its insecure security
- Adequate qualification and additional electronic or manual process controls are required for secure an reliable usage of UV LED sources
- Well qualified and designed high-quality UV-A-LED-sources can easily and completely substitute conventional bulb-based-UV-lamps without any technical and practical disadvantage in NDT
- Fluorescent inspection processes can be improved using optimal UV LED sources
- Fluorescent inspection processes can destroyed by using inadequate and unreliable UV LED sources

© 2016 Marc Breit

Conclusion (practically)

- Users have to select the right sources for their specific applications
- The price of the lamp does not interfere the costs for the process
- The quality of the lamp drastically influences the costs of the process
- Costs of the process can be reduced while the performance of the process will be increased when using optimized UV LED sources.
- Beam size needs to large enough or have sufficient large soft drop surrounding area to ensure orientation on the inspection surface and to allow detection by the peripheral vision
- Uniformity needs to be checked by the user while moving the lamp over a sheet of white paper
- Standardization is far behind the reality and it is not easy to standardize the unwritten Standard ‘100 W Mercury vapor lamp’
- Much inadequate UV LED lamps actually available and used

SECUCHEK NEXT GENERATION UV LED LAMPS

© 2016 Marc Breit

To see what you heard please come to my booth

Thank you very much for your attention!

Any questions?

© 2016 Marc Breit

Influence of lamp characteristic on inspection performance and POD

Beam Pattern

	Main area (>1.200 µW/cm²)	Junction beetween main center and peripheral area	Peripheral area	Support of the central vision	Support of the peripheral vision	Intuitive interaction between eyes and lamp	Orientation on the part	way of detection (scanning)	Influence on inspection performance (compared to Mercury Vapour)	Influence on POD compared to standard
Mercury Vapour (unwritten Standard)	Central hotspot	Steep drop (industry standard)	Optimal and gradual (less than 40% per inch in 15 in. distance)	Semi-optimal support	Supported (industry standard)	Lamp gets intuitively adjusted to the focus of the human eyes	Good orientation	Scanning necessary (industry standard)	Standard inspection performance	Standard POD
Xenon Spot	Tiny central hotspot	Abrupt drop	Less gradual than standardand more even with hard drop at the outer edges	Limited Support	Supported, but less than the standard does	Lamp gets intuitively adjusted to the focus of the human eyes within limits	Limited orientation	Slow detailed scanning necessary, slow and tiring inspection	Lower 2 to 3 times longer	Standard POD
Xenon Flood	Central spot	Steep drop (comparable to Standard)	Comparable to standard, sometimes with hard drop at the outer edges	Semi-optimal support	Supported, similiar to the standard	Lamp gets intuitively adjusted to the focus of the human eyes	Good orientation	Scanning necessary, near industry standard	Standard inspection performance	Standard POD
LED with hard drop	Depending on the lamp type	NO Junction	NO peripheral area	Acceptable	NO support, totally handicaped	Focus has to 'stay' within in the beam, tiring and limited detection	NO orientation on small beams, limited on big beams	Slow detailed scanning necessary, slow and tiring inspection	Much lower performance, up to 10 times slower	Drastical reduction of POD (missing indications), due to the loss of the primary detection capability of the human vision
LED with soft drop	Depending on the lamp type	Smooth and gradual	Depending on lamp type and definition (can be better than standard)	Enhanced support	Optimal support to use the full capability of detection for easy and fast detection	Lamp gets intuitively adjusted to the focus of the human eyes and allows natural movement of the eyes without any interferences	Optimal orientation	intuitive by using optimal usage ofthe full capability of detection	Higher inspection performance and security while less tiring inspection work	Better POD while inspection is more easy and faster than using the standard

© 2016 Marc Breit

Influence of lamp characteristic on inspection performance and POD

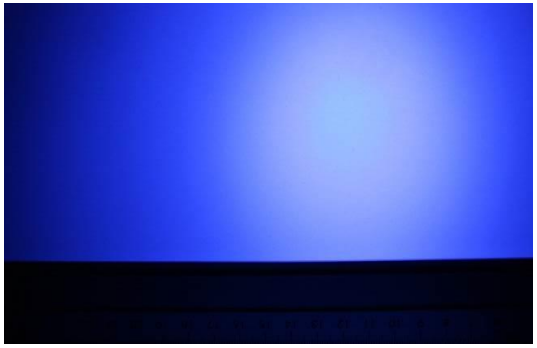
Beam Uniformity

	Description of the non-uniformity	Possibility of separation by the human vision of the variation on the part caused by the non-uniformity of the beam	Strain for the human vision	Influence on inspection performance only about uniformity (independent from soft drop area)	Influence on POD compared to standard only about uniformity (independent from soft drop area)
Mercury Vapour (unwritten Standard)	Some large coarsely splitted areas	Good possibility of separation by the human vision	Acceptable strain	Standard inspection Performance	Standard POD
Xenon Spot	Single main steps at junction between central hotspot and peripheral areas	Good possibility of separation by the human vision	Acceptable strain	Standard inspection Performance	Standard POD
Xenon Flood	Single main steps at junction between central hotspot and peripheral areas	Good possibility of separation by the human vision	Acceptable strain	Standard inspection Performance	Standard POD
LED with some hotspot	Gradual hot spots	Good possibility of separation by the human vision	Acceptable strain	Standard inspection Performance	Similiar to standard POD
LED with marblings	Undefined, unstructured variations of different sizes and shapes	Impossible to separate by human vision, very high up to inacceptable negative influence	Extremly high strain	High reduction of insepction performance, very tiring	High reduction of POD
LED with very tiny variations	Tiny scratches, difficult to be perceived, when not moving the lamp	Impossible to separate by the human vision, detrimental influence, 'moving effect'	Totally inacceptable strain	Detrimental reduction of inspection performance, extremely tiring inspection	Drastical reduction of POD
LED completely uniform	No visual non-uniformity	Not relevant, due to all perceived variations are caused by the inspection surface, optimal inspection conditions, no interference of the perception by the beam	Minimum strain	Enhanced inspection performance, less tiring inspection	Enhanced POD, although faster and less tiring inspection

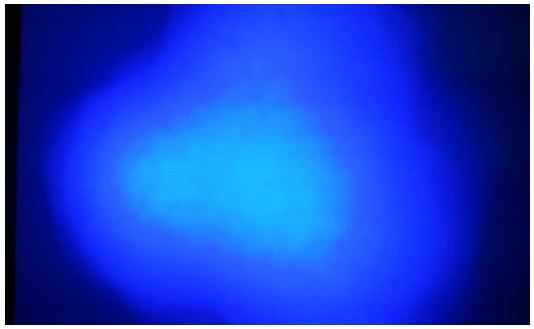
© 2016 Marc Breit

Uniformity of the irradiation area

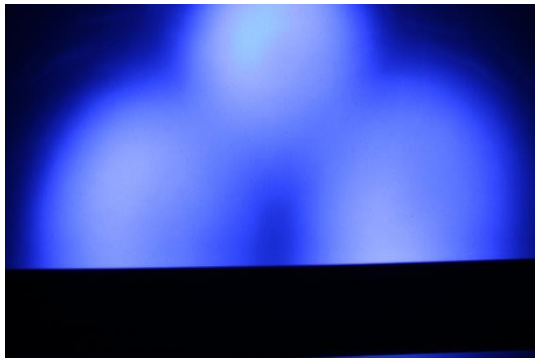
100W Mercury vapour lamp



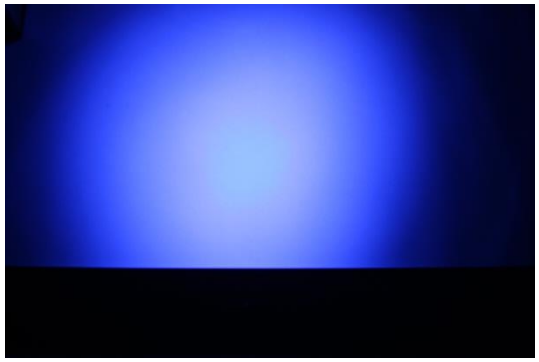
35W Xenon lamp



Non-uniform
UV-LED lamp



UV LED lamp with blind spot



Common UV LED lamp

Optimized UV LED lamp

© 2016 Marc Breit