EFSEN
UV & EB TECHNOLOGY

Safer UV products and increased yield with the ICAD® Technology

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Summary

UV curing technology as well as other technologies are always challenged on their ability to deliver safer end-user products, because most processes result from a number of mixed technologies creating a product – in most UV processes this product is a surface which has some kind of human contact. Direct contact on furniture, medical devices, labels and packaging, but also indirect contact in the form of food packaging etc.

In order to enable safe end-user products, one need to master the mix of technologies used to produce end products. In UV curing one of the main technologies to master is the UV source e.g. the UV lamp or the UV LED. Mastering this has been a challenge for many years and in some industries like printing and converting it has been so difficult to master, that it hasn't been applied.

ICAD® Technology enables manufactures to get FULL control of their UV technology at any time during production. This will enable manufacturers to produce safer end-user products, and drastically minimize the risk of sending poorly cured products into the market.

ICAD® Technology further enables producers to utilize their UV lamps, reflectors, UV LEDs to a maximum, as they don't need to overdrive anything as well as they will get information on exactly when it is time to clean, change or repair any systems.

ICAD® Technology is currently installed in furniture, flooring, label and converting applications in Europe and is a proprietary technology of EFSEN UV & EB Technology.

Introduction

The last decade has seen a rising demand for process control of UV Curing system in production environments. Increasingly manufacturers shorten the interval between controlling and measuring UV lamps, to minimize the risk of insufficient cure at their product.

As an example, most of the wood and furniture industry is now measuring before every shift (every 8 hours) as compared to weekly or monthly some years ago. This demand for increase measurement frequency increases the quality of products but is it also time consuming and leads to more downtime as it is difficult to measure during actual production.

In the printing industry, this process control is even more difficult as it is in most cases impossible to get an instrument to travel on the web as the instrument is heavy and sometimes the web is on a roller, where instruments can't travel. Some static solutions are used, but again they do only give an indication at the specific location they are measuring. If they are constantly monitoring, they either shadow for the product, or measure in a position not comparable with what the product sees.

UV LED Technology and chemistry is now developed to a level where it is a viable alternative to conventional medium pressure UV lamps. As UV LED brings many benefits to the market, it also has some challenges that must be overcome. One of these challenges is the process control. UV LED systems consist of several UV modules (UV-LED boards - see picture 1) compared to conventional mercury-based lamps that consists of a singular UV source (bulb).

Picture 1. Close-up of 9 UV LED sections with one (no.4) being faulty (Curtesy of Excelitas/OmniCure)

The interest and demand for an automated, inline process control as well as the increasing use of UV LED Technology has led to the development of the ICAD® technology.

This paper seeks to show the findings using ICAD® Technology in production and it shows that ICAD® enables manufactures using UV to know the status of the "hidden" performance of the non-visible UV that they base their process on.

ICAD® Technology - how it works:

ICAD® technology stands for Inline, Continuous, Automated and Dynamic sensing technology. It is designed enable to measure UV radiance uniformity during production from a UV emitter. It can do this continuously and dynamically over the width of the UV source, with a certain interval setup. An automated process where measurement can be made at specified intervals e.g. every hour or every 10 minutes. The ICAD® technology includes a software-based algorithm that considers the impact of heat and background reflectivity, among others, in the measurement.

ICAD® works with a specially designed optical rod that travels along the UV emitter, which can be an array of UV LEDs, a conventional UV arc lamps, or an array of microwave UV lamps. During the travel, the rod samples the UV output and profiles the exposure from the UV emitter.

The resultant output profile can be used to evaluate the status of the emitter, it can activate alarms or warnings if certain low or high levels are reached and in it can include the capability to control the UV source and continuously regulate the output so uniformity and constant output is given always.

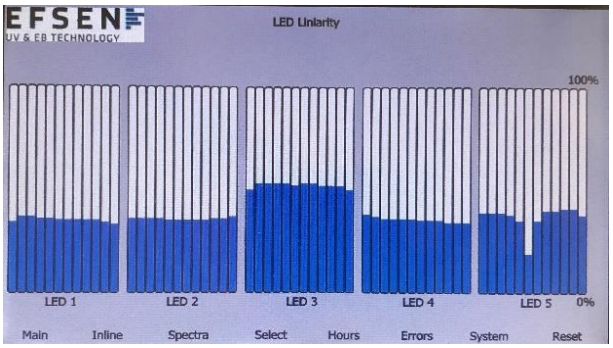


Fig 1 measurement of W-LED inline (5 heads)

Fig 2 Adjustment of 5 heads after measurement

An ICAD® system consist of 4 main components:

- Digital Signal Processor unit (DSP)
- Sensor
- Light delivery system (the rod)
- Mechanism for movement of sensor (Slider)

The DSP-unit controls all communication between emitters, sensor, sensor movement and user interface. It also does all the processing of the data and through different algorithms, generates lamp output values, including lamp errors, such as failed UV LED's etc.

The sensor, rod and slider, work together as one. It uses the slider system to transport a light guiding rod under the UV LED's thereby guiding the light up and into the sensor head.

Picture 2. Close-up of ICAD® rod under UV LED

Test Objectives and Setup

Over the last 2 years we have had ICAD® installations running in the field in various applications. This paper will show some of the findings from these installations with the purpose of giving the reader an in depth understanding of the variables in a UV process in production.

We have evaluated the following applications:

Test 1:

UV LED Curing of furniture surfaces. 7 UV LED stations have been monitored and we will give an overview of the findings from all of these.

We installed 7 pcs W-LED with ICAD® Technology inside at a furniture manufacturer on a new roller coating line. The 7 pcs W-LED had different wavelength of 365, 395 and 405nm and is monitored several times daily in 3 shift production.

Picture 3-4. Furniture line with 7 W-LED with ICAD® and one stand-alone W-LED with ICAD®

Test 2:

UV LED for a filler/putty application on wood flooring. A need to drive UV LED as close to the minimum dose requirement was tested with ICAD® Technology. Finding was compared to EIT LEDCure L395 values.

At a large parquet floor manufacturer we installed a P-LED with ICAD® Technology inside to operate the UV LED output just above minimum dose requirements. UV LEDs of 395nm was installed on this test.

Picture 5. P-LED with ICAD® build into a curing oven with a foil running between LED and surface of product

Test 3:

A 1.5m wide Converting line with a specific need for full cross web uniformity is now running. and the findings from the measurements are reported.

A P-LED with ICAD® Technology inside was installed at a large converter in Europe to create VERY uniform cure on a very powerful 395nm LED array of 1,5m.

Picture 6. P-LED with ICAD® build a 1,5m wide converting line

Test 4:

A narrow web (430mm) printing press with 7 conventional UV mercury bulbs and reflectors is being monitored with ICAD® Technology. The various findings from learning the UV output is reported.

A large global label printer had a request to understand their conventional mercury UV in all their label presses. An ICAD® Test Bench was delivered, where the printer can easily take out their UV lamps and test them in the ICAD® Test Bench with both ICAD® Technology and also compare this to EIT PowerMap 2 values.

Picture 7-8. ICAD® Test Bench used for Hg-based lamp systems

Findings

Test 1:

Gloss variations are gone due to ICAD® uniformity. Gloss is affected by the temperature of cure. Different UV outputs also gives different temperature output, hence products that are normally UV-cured have different surface temperature when it comes to the top layer coating. After implementing ICAD® Technology to each station in the wood line, uniformity in UV output and temperature is assured at all times and customer has eliminated gloss issues. See the different states before and after ICAD® in figure 1 and 2

UV Measurements doesn't require production stop/pause. Customer started out by measuring with the conventional technology (UV radiometer) and ICAD® Technology to compare these two. After a test period it was found that ICAD® Technology was more than able to demonstrate changes in UV output during production, hence the radiometer measurement is done less frequently and the ICAD® Technology runs continuously during production.

ICAD® found lamp faults a radiometer wouldn't have found: 7 UV LED curing stations consists of 5 LED modules each, giving 35 modules running for 12 months. ICAD® found 2 modules that was overheating, giving customer time to react, get new modules under warranty without stopping production. ICAD® also found a damaged lens on one unit and several units that had to be cleaned more often than the rest.

Test 2:

ICAD® increases lifetime of foil in inerted UV process curing putty on flooring boards, by exchanging a conventional UV lamp to a P-LED with ICAD®. Customer succeeded in driving the UV output to a minimum, which increased the lifetime of the foil from 2-3 days up to around 28 days.

ICAD® enabled equal depth of cure. Using ICAD® Technology on a P-LED customer could maintain a uniform UV expose on the 1,3m wide line, as well as a minimum output giving equal depth of cure, ultra low energy consumption as well as longer lifetime on LEDs due to less stress.

Test 3:

A large converter already using UV LED in their production request ICAD® uniformity. A curing and adhesion process require high uniformity to achieve consistent release. Their current UV LED system could not give feedback on the output and their existing mercury-based UV lamps did show 20-30% variations in output which was affecting the quality across the web. P-LED with ICAD® was tested for this with good uniformity results within 2-4% also seen in the quality control of the products. See fig 2.

Test 4:

ICAD® compares to conventional PowerMap radiometer. One printing press with 6 lamps was tested with both ICAD® scanner and an EIT PowerMap2. PowerMap2 was passed under a 340mm long lamp for each 50 mm and ICAD® measured for each 10 mm. The below graph compares the two measures and it is seen that ICAD®s curve is representative of an absolute radiometer measure. (see Fig 3)

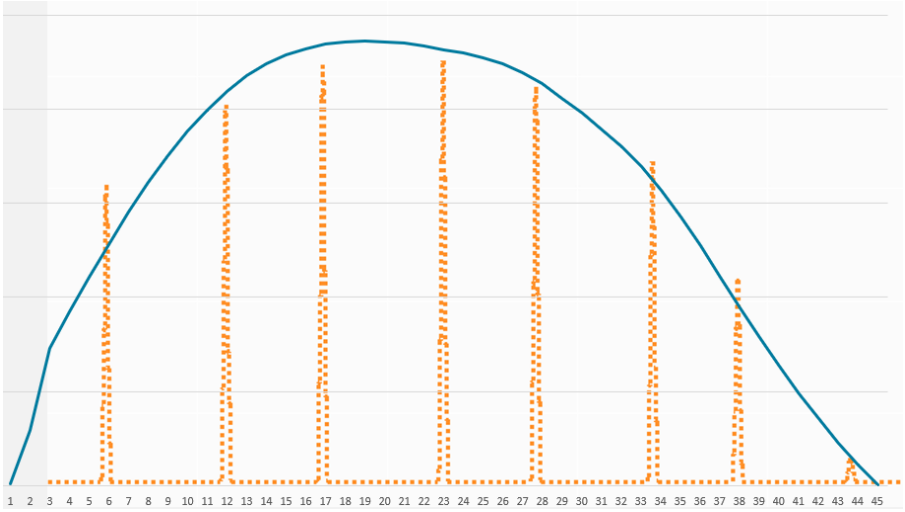


Fig 3: ICAD® Technology graph vs. EIT PowerMap2 in UVA

ICAD® compares 6 Hg lamps on a conventional 340 mm printing press:

6 identically lamps systems with identical settings, bulbs, reflectors and power supply were tested with OLD and NEW UV bulb (see Fig 4-13 and .

- Variance of 73 % percent was seen from middle of web to side of web with old bulbs
- Variance of 48% was seen from middle of bulb to side of bulb/web with NEW bulbs
- Used bulbs showed a large variation of the form of the curve, where symmetry was changed a lot in some cases.
- One reflector was found bad, as output was 350mW/cm2 instead of around 1.000mW/cm2. Changing bulb only increased this to 400mW/cm2
- Variance of more than 25% from 6 identical system with new bulbs and reflectors. Point to point measures.
- ICAD® detects dirt and inks stains on quartz glass and reflector fig 13 and picture 9-10

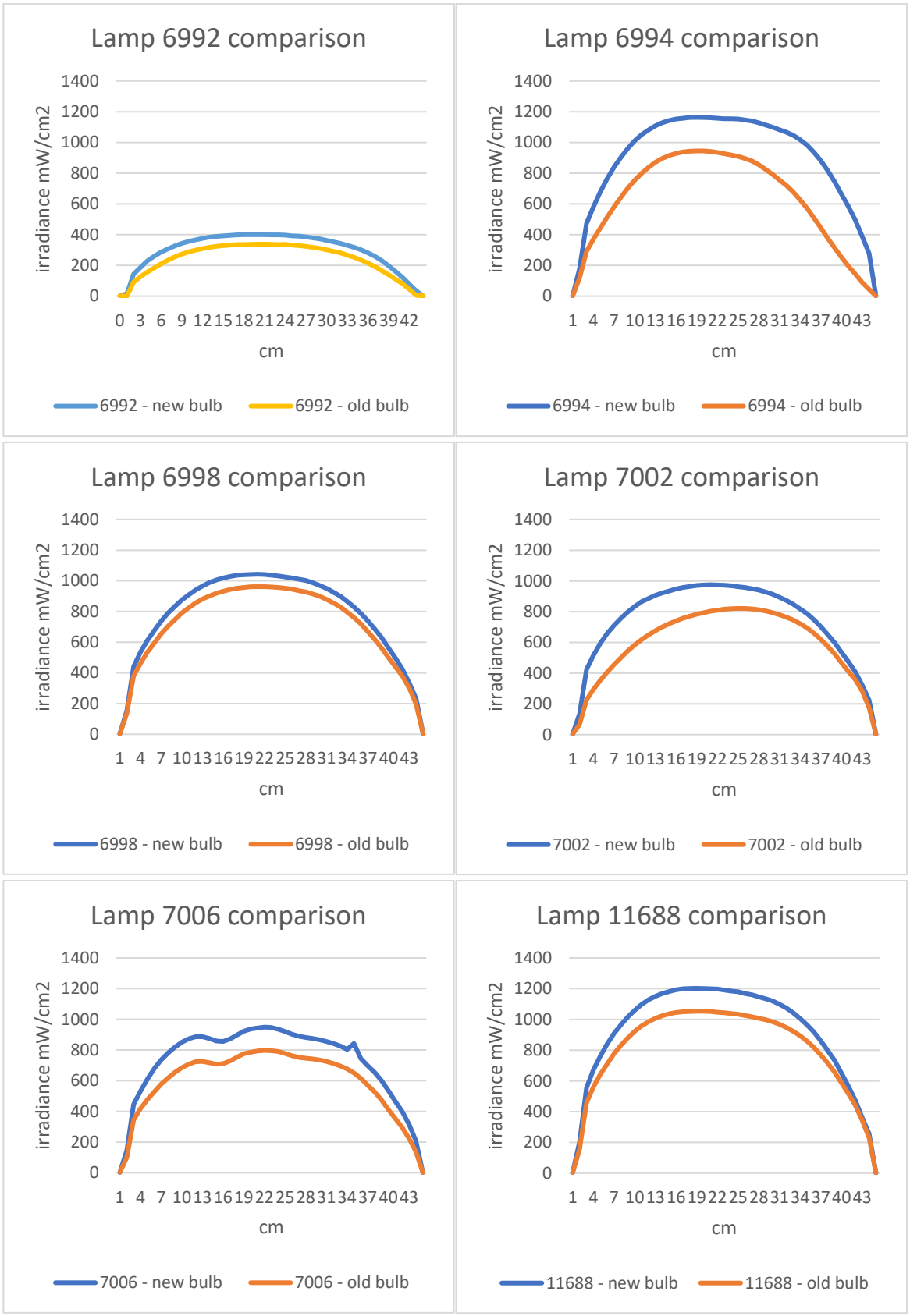


Fig 4-9: Six lamps with used bulbs and new bulbs compared individually with ICAD® Technology

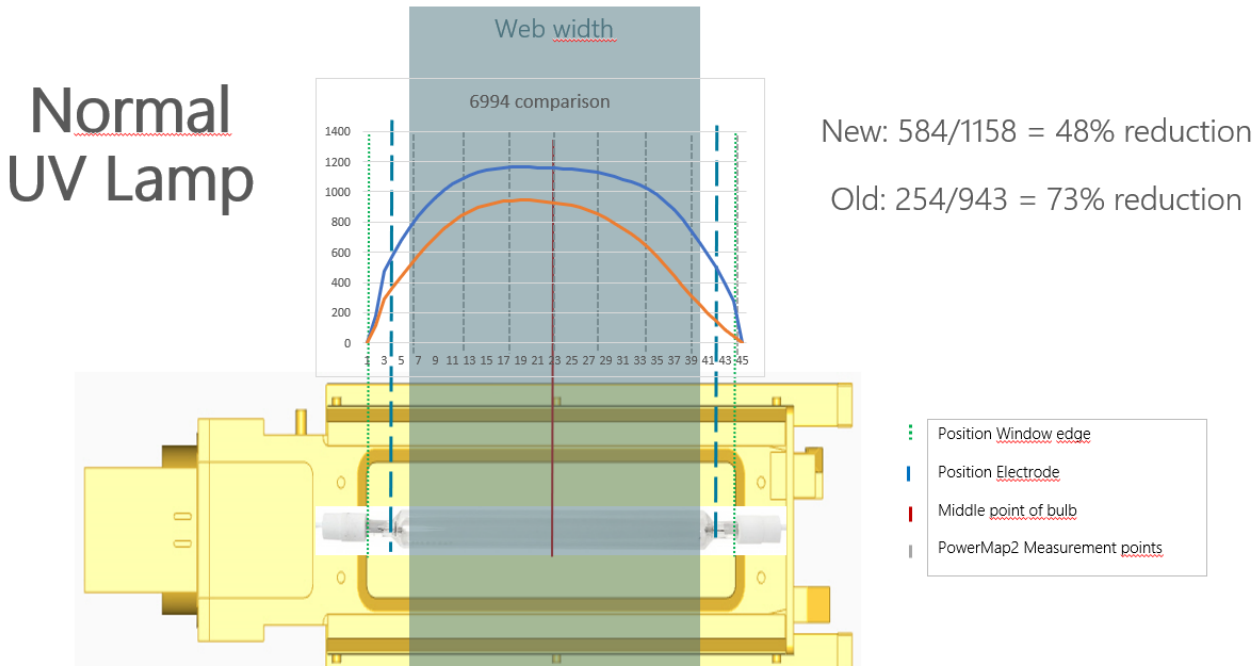


Fig 10: Used bulb vs. new bulb with web width and bulb dimensions.

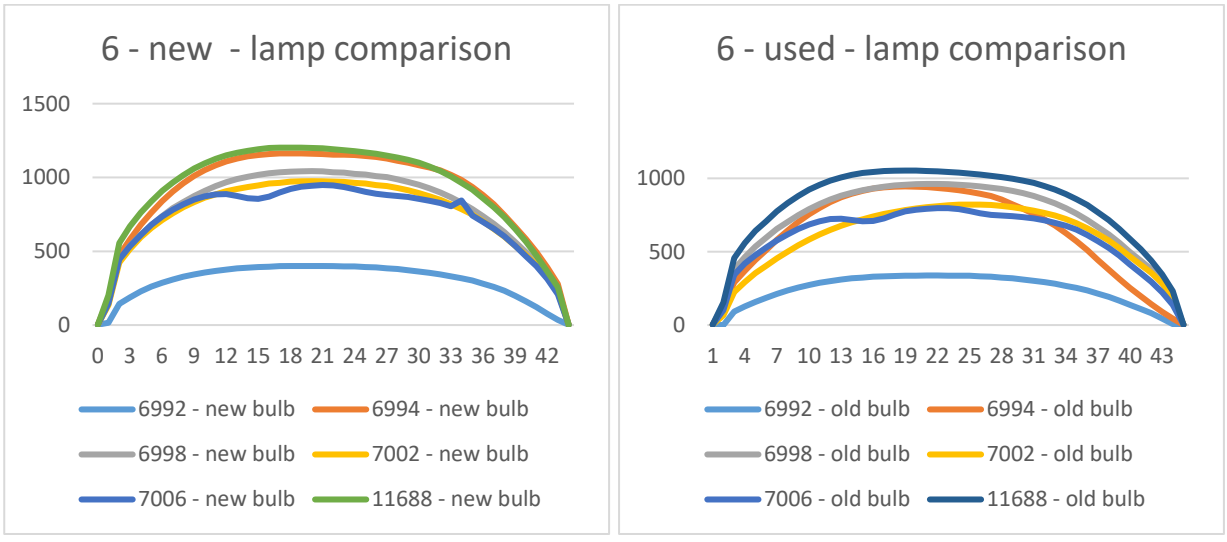


Fig 11-12: Six New and used bulbs on 6 identical lamphouses compared – variance of approximately 25% when outlier is removed.

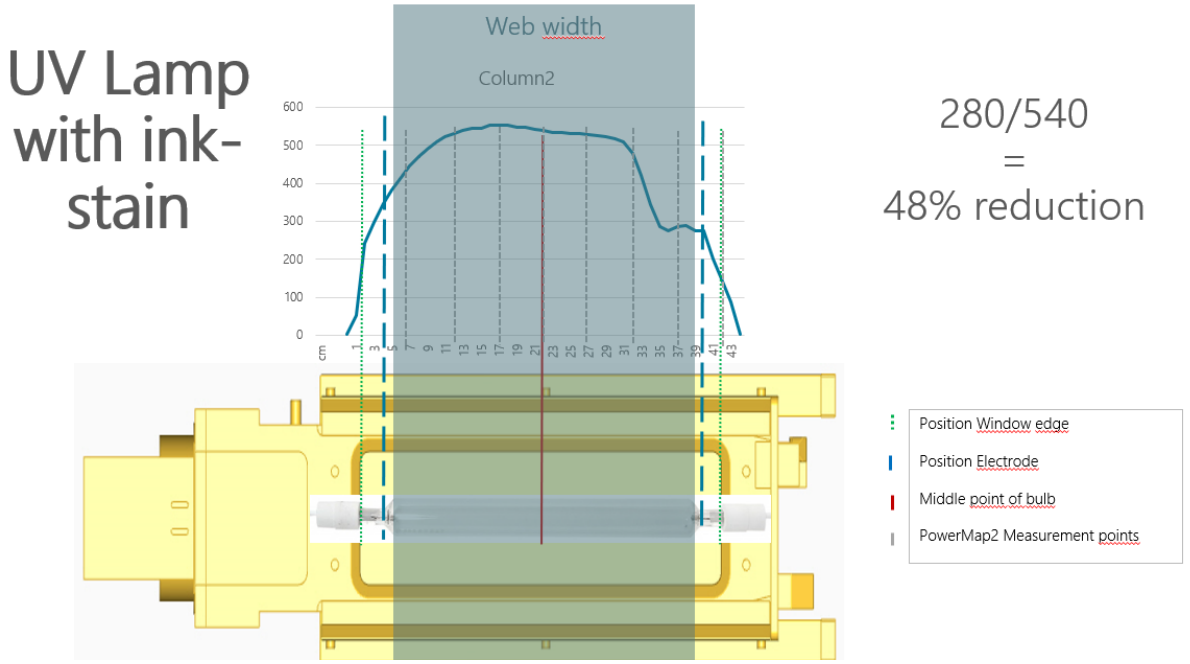
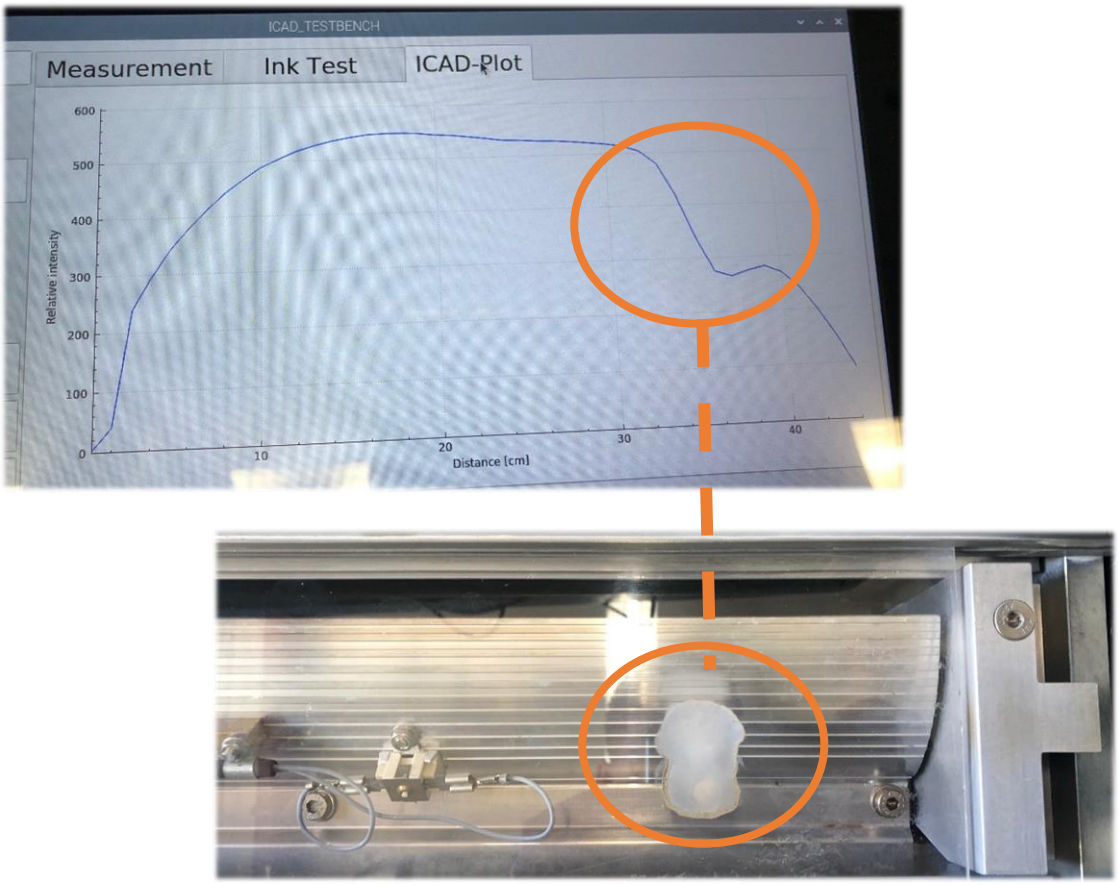


Fig 13: Used bulb on web with ink stain on quartz glass.



Pic 9-10: Ink stain on quartz vs. ICAD® Plot – it is seen the ICAD® detects the stain.

Conclusion

We have seen that ICAD® technology is applicable to UV LED as well as conventional Hg-based UV systems.

ICAD® Technology can document performance changes in the UV output as they happen, as well as investigating the full width of any production line.

ICAD® Technology enables industry 4.0 in the senses that ICAD® Sensor can sample information that can be used to react correctly upon from a machine or production line level.

ICAD® Technology coupled with a feedback control enables optimized production with regards to uniformity, energy consumption, lifetime increase of UV LED and last but not least this leads to safer end user products. For medium pressure UV lamps, microwave powered UV lamps as well as UV LED systems, ICAD® technology can profile the output to a very comparable level of what manufactures document with their systems.