INTEGRATION TECHNOLOGY

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WHITE PAPER

UNDERSTANDING UV

Understanding UV Part 2:

Taking the Right Measures

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In the previous whitepaper from Integration Technology, *Understanding UV Part 1: The Two Key Concepts*, we explored the fundamentals of successful UV integration, **dose** and **intensity**, outlined the basics of UV technology, and detailed some key questions to ask suppliers.

In this paper, we are taking a closer look at why it is so important to accurately measure those parameters, suggesting the information and equipment you will need, and examining some of the pitfalls associated with the process. The use of a UV measuring device on your production equipment is crucial to effective process control, and UV output measurements are subject to significant variation based on a number of factors, from radiometer manufacturer to product type. For these reasons, Integration Technology is following on from Part 1 of our *Understanding UV* series with a brief outline of the UV measurement essentials.

Why is Measurement Important?

Simply differentiating between 'curing' and 'not curing' is not sufficient. For efficient production, the ability to easily determine where an issue originates is key; if you have a strong insight into your UV system and its power output, you are able to ascertain that the issue may also lie with the ink, substrate, or machine speed. As well as being integral to faultfinding, from a quality control perspective accurate measurement can greatly reduce unnecessary waste, or inadvertently supplying a customer with uncured material.

Figure 1:
Measure intensity ready per day

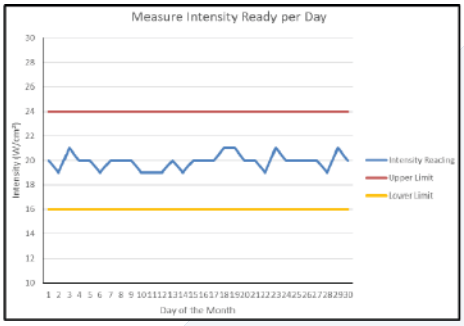
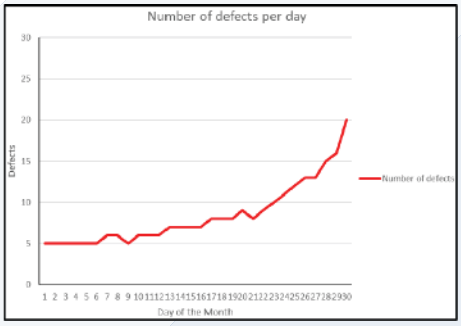


Figure 2:
Number of defects per day



Through the Process Window

Accurately measuring the dose and intensity is crucial to establishing a specification for UV curable products and maintaining a **process window**. Customers or end users including operators, maintenance staff, and quality technicians will need UV measurements to establish and maintain the process window and assist in troubleshooting any curing issues.

A **process window** establishes the minimum and maximum (if needed) level of UV required to cure a chemistry in a given time and plots the decline in UV output over the life of the system. All UV systems exhibit this decline, however in the case of lamps this is much faster,

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typically around 1,000 hours, whereas in an LED system this is usually measured in the tens of thousands of hours.

Time and effort should be invested early on in determining the process window before entering the production stage of a manufacturing process. Depending on the type of production line and the level of Quality Assurance required, the Dose and Intensity readings (and any other measure process readings) can be monitored by job, hour, shift, or day as required to maintain quality levels.

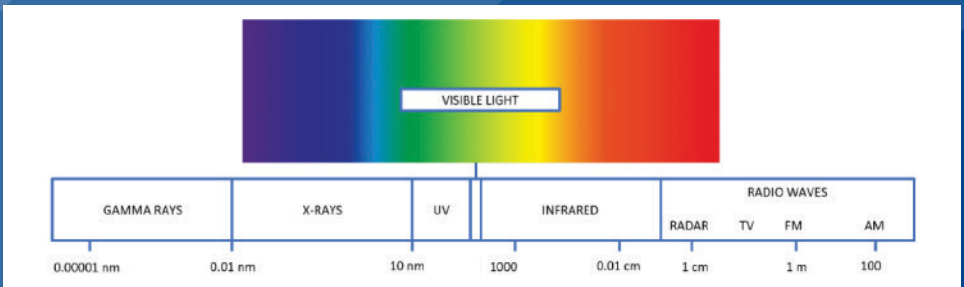
What is Measured?

In Understanding UV Part 1: The Two Key Concepts, we outlined UV's place on the electromagnetic spectrum. Light emitted with a wavelength between 200 and 400nm (nanometres 10^{-9}) is regarded as UV Light. Dose and Intensity readings are required for each wavelength band.

UV light is usually divided into 4 wavebands, and each band is assigned a letter designation, some of which you may be familiar with:

- UVA (320 – 400nm)
- UVB (280 – 320nm)
- UVC (200 – 280nm)
- UVV (395 – 495nm)

Figure 3:
The electromagnetic spectrum



How do we Measure?

An important caveat here is that what we are really answering is 'how do we measure in a production environment', as absolute UV readings are difficult to take, and are usually carried out in laboratory environment with expensive equipment. Fortunately, standard readings of Dose and Intensity required for our purposes can be measured using radiometers.

Image source:
EIT LLC

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In Understanding UV: Part 1, we briefly touched on the fact that there can be significant variations in readings depending on the radiometer manufacturer, due to differences in how they filter the light on the sensors, therefore it is important to note that any Dose and Intensity measurements are not absolute values and would be better described as relative values that correlate directly to the radiometer manufacturer's calibration source.

Radiometers should be used as process control devices where the same radiometer and measurement protocol are consistently used to measure Intensity and Dose in a UV curing process. If the Dose or Intensity measurements are above or below the acceptable specified range, system adjustments can be made to bring the curing process back into range.

Figure 4:
Measured intensity reading per day - within process control

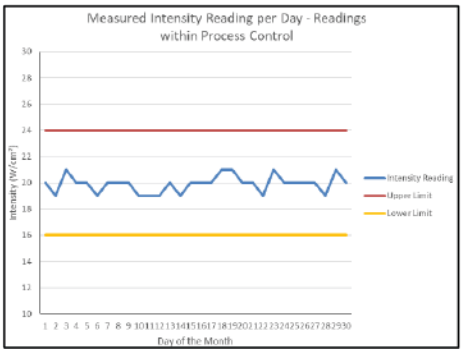
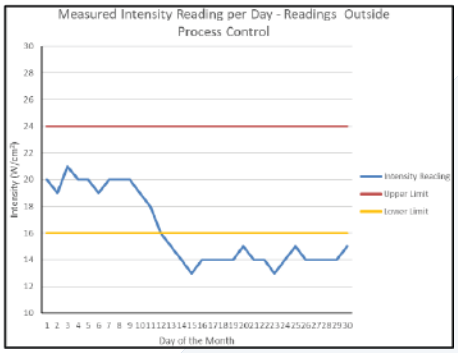


Figure 5:
Measured intensity reading per day - outside process control



It is important to remember that radiometers can be used to measure **either** mercury vapour lamps or LEDs, never both, meaning care must be taken to ensure your radiometer of choice will effectively measure the dose or intensity within a UV curing application.

Absolute instruments such as radiometers can be used to measure Intensity and Dose (Absolute units are mW/cm² and mJ/cm² respectively). The operator can then compare readings between curing units and locations to ensure that the curing process is successful.

Relative instruments measure parameters using relative units – for example, measuring an electronic signal proportional to lamp brightness (percentage of intensity).

Understanding Sampling Rates

Radiometers will sample Intensity readings several times per second over a specified range of wavelengths. The frequency at which samples are recorded is known as the sampling rate. Sampling occurs over time as the radiometer passes the front face of the UV curing source. The system's Intensity is reported as the largest recorded value within the set of sampled data points.

When sampling Intensity values, it is important to understand that the recorded Intensity values are only for one bandwidth such as UVA. Any recorded values for the other bandwidths are not added to the Intensity value for the UVA bandwidth. The range of wavelengths over which Intensity values are sampled is a fixed specification of the radiometer and is controlled by the sensitivity and range of the radiometer's photodiodes.

The full set of Intensity data points collected as a radiometer passes in front of a UV source generates the Intensity profile for the UV source. The integration of the Intensity profile, which is the area under the curve, is the Dose.

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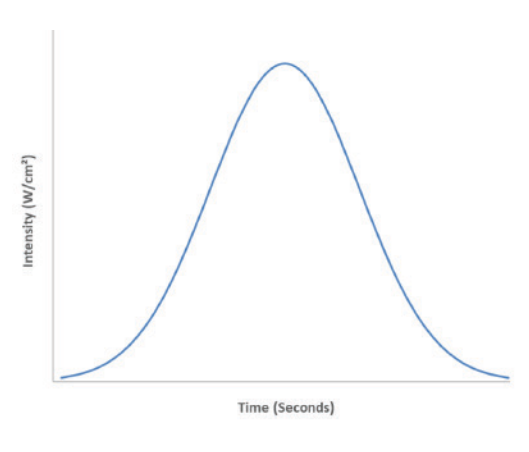

Figure 6:
Intensity profile

How to Select the Right UV Instrument

There are a number of factors that go into the UV instrument selection process. The first to evaluate is the UV curing application, with key considerations including whether the curing process is linear, if a flood area cure is required, or if there is a spot curing process involved.

Here are some of the important aspects of UV measurement that will help you to determine the correct measurement instrument for your application requirements:

Reading Type – is an absolute or relative measurement required, i.e. does this measurement process need to take place under laboratory conditions, or are standard readings of Dose and Intensity acceptable?

Product Type – The product plays a major role in determining whether an online, continuous measurement of UV is necessary, or will a numerical display of Dose and/or Intensity suffice for your production?

Source – The UV source itself is an important consideration – is the source in your curing process a UV Arc, UV Microwave, Pulsed UV, or UV LED system?

Bandwidths – As with the UV source, the UV bandwidths used in the curing process are important – are the bandwidths UVA, UVB, UVC, or UVV?

Calibration is Key

Accuracy is paramount, so calibration of your radiometer, or other measuring device, is crucial to the precision of the reading, and will compensate for changes in optics that may occur over time. The calibration of the radiometer will balance the amount of infrared, visible light, and UV light that the optics and detector within the radiometer see with the output signal from the detector.

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- Intensity and Dose Levels
- Physical damage to the Radiometer
- Optics/Instrument which may be coated in media
- Electronics

Get a Better Measure with Integration Technology

Now that we have explored some of the key components of UV measurement, Integration Technology encourages a proactive approach going forward, armed with the knowledge to assess UV system issues beyond simply changing a lamp if it is failing to cure. Working with your UV curing system partner when your output is down can reduce unnecessary additional time, costs, and waste. Integration Technology leverages our UV and UV LED curing experience and expertise to help you put this information into action and gain a deeper insight into effective and accurate UV measurement in your specific production environment.

For more information contact **support@integrationtechnology.com**

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