

APPLICATION OF INTELLIGENT SYSTEM DATA TO CURING PROCESSES

Orlando, Florida, 10 March 2020, Darrin Leonhardt



INTRODUCTION – EVERYONE WANTS MORE INTELLIGENCE

Why?

- › Compatibility with Industry 4.0 and other systems
- › Less black-box, more process ownership
 - › Cost reduction
 - › Increased efficiency

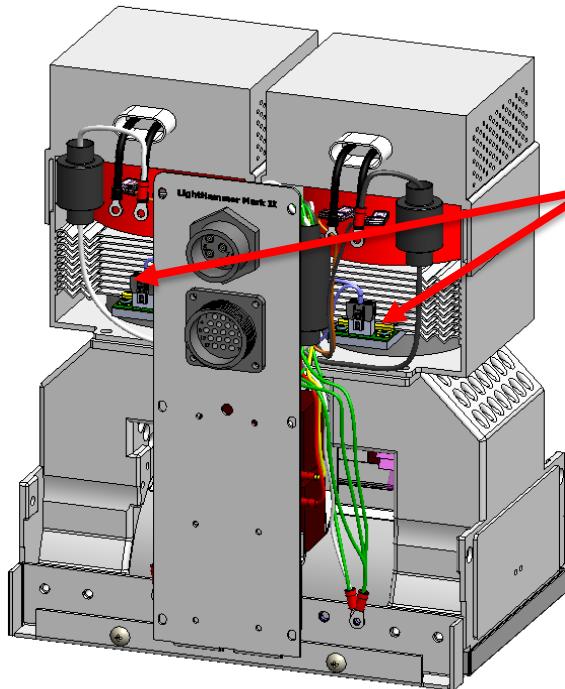
How?

- › Insert a Service Technician
- › Leverage years of experience & customer input
- › Focus on key sensors that can diagnose or forewarn
- › Sensors need the same accuracy & robustness as the system they are being used

INTRODUCTION: MARK 3 SYSTEM

Sensor package for LAMP (UV, temperature, pressure) operation

Front View



- **Magnetron Temp Sensors**
Provides life time indication and air flow validation

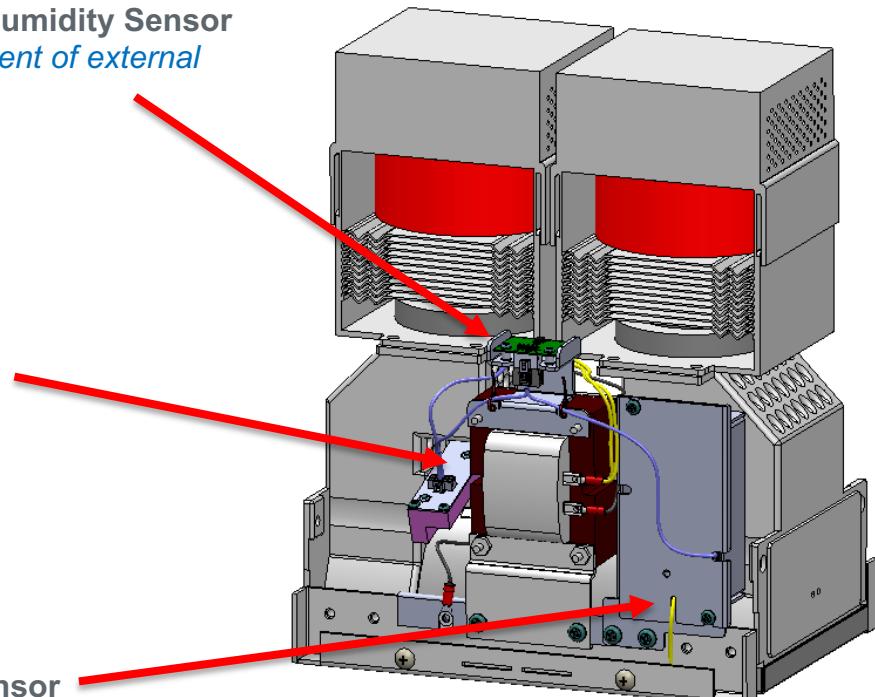
- **Inlet Air Temp/Humidity Sensor**
Enables measurement of external conditions

- **UV Sensor**
Enables relative UV measurements

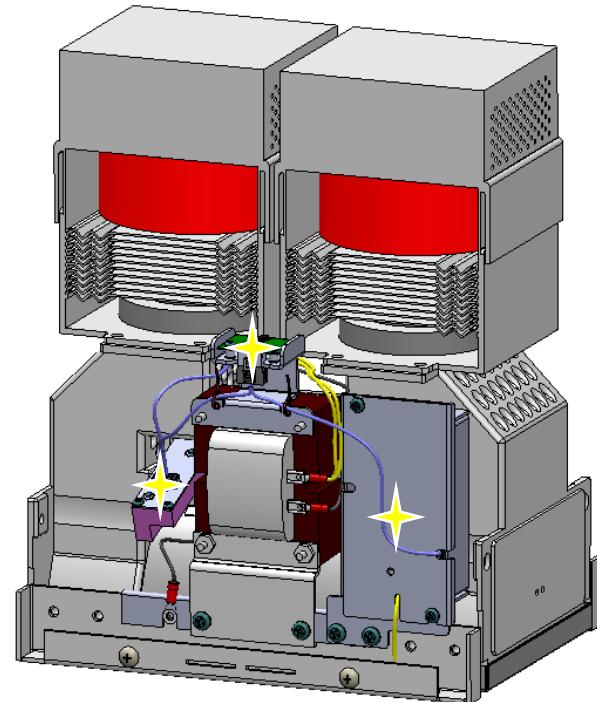
- **Thermopile**
Enables bulb temperature measurements

- **Analog Air Pressure sensor**
Enables variable cooling function

Back View



INTERNAL AND EXTERNAL MEASUREMENTS



INTERNAL AND EXTERNAL MEASUREMENTS

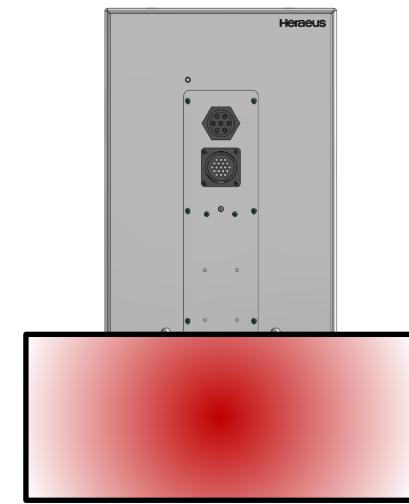
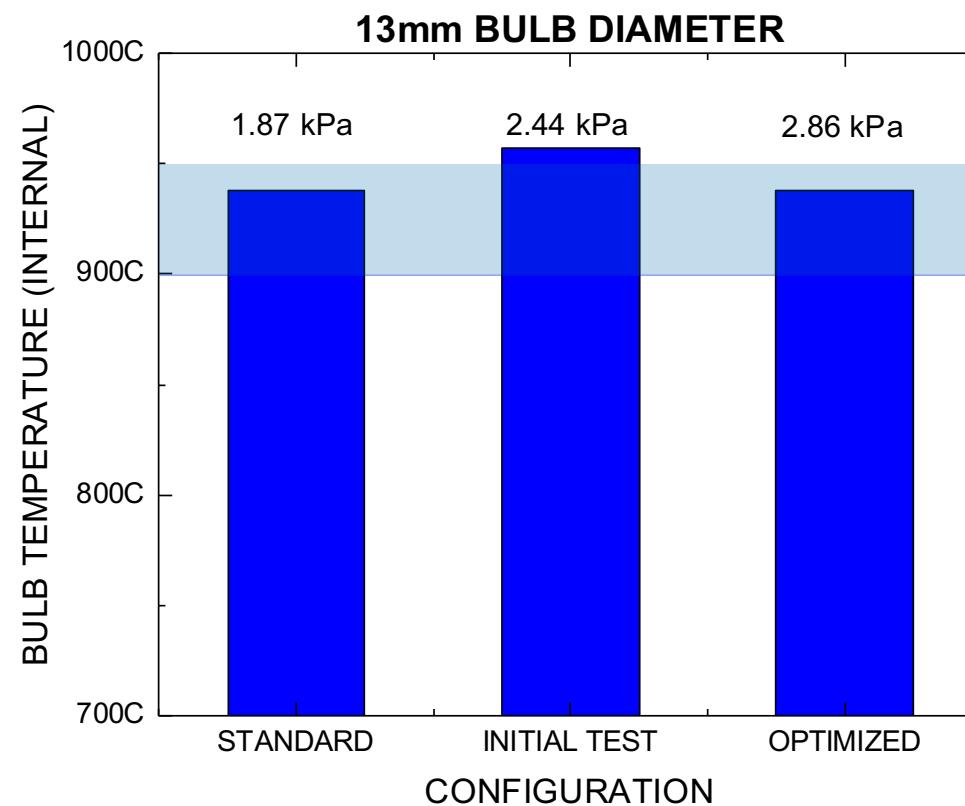


RADIOMETRY
EIT PowerPuck2
UVA, UVB, UVC



CASE 1: RESTRICTED AIRFLOW

Simple case of restricted air flow - Avoid unintentional overheating of bulb



Strong dependency:

- Cooling air pressure & flow

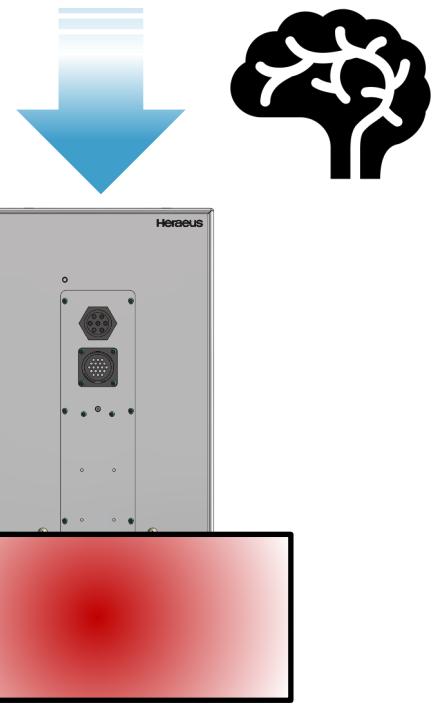
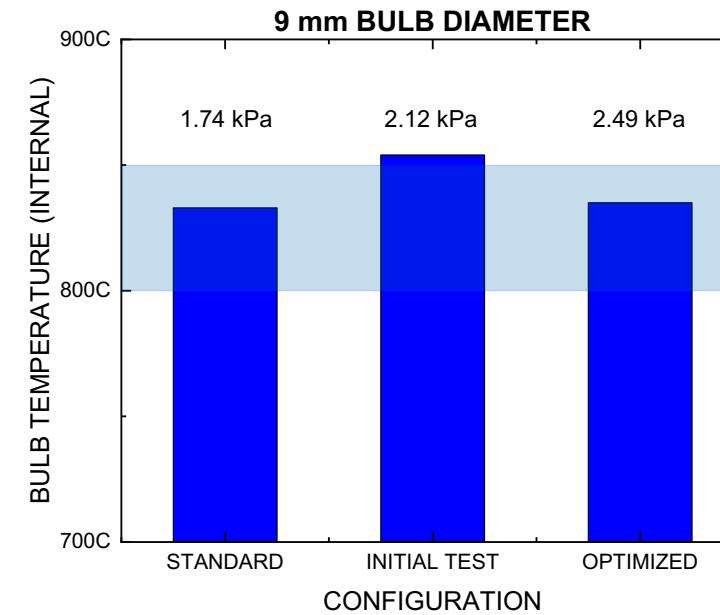
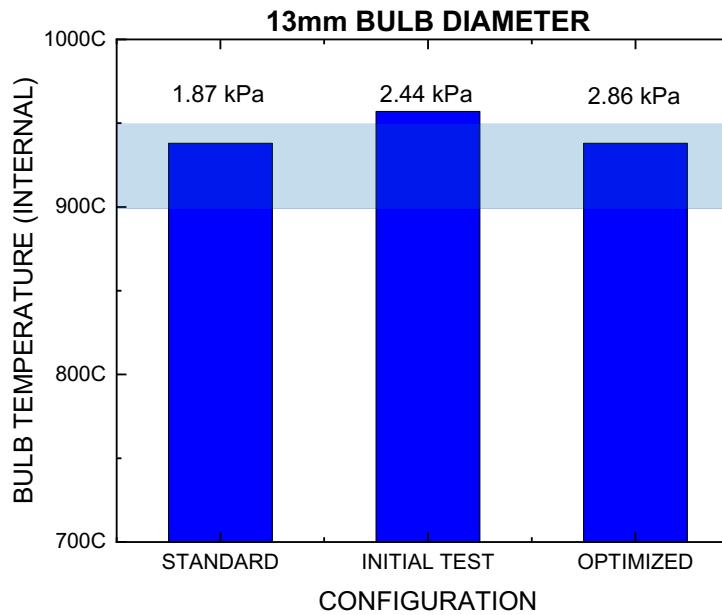
Weaker dependency

- Cooling air pressure
- Bulb Temperature

CASE 1: RESTRICTED AIRFLOW

Simple case of restricted air flow - Avoid unintentional overheating of bulb

Applicable to all bulb types and sizes



Strong dependency:

- Cooling air pressure & flow

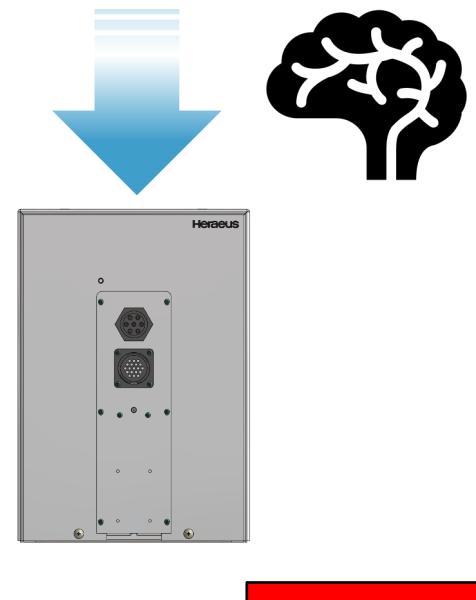
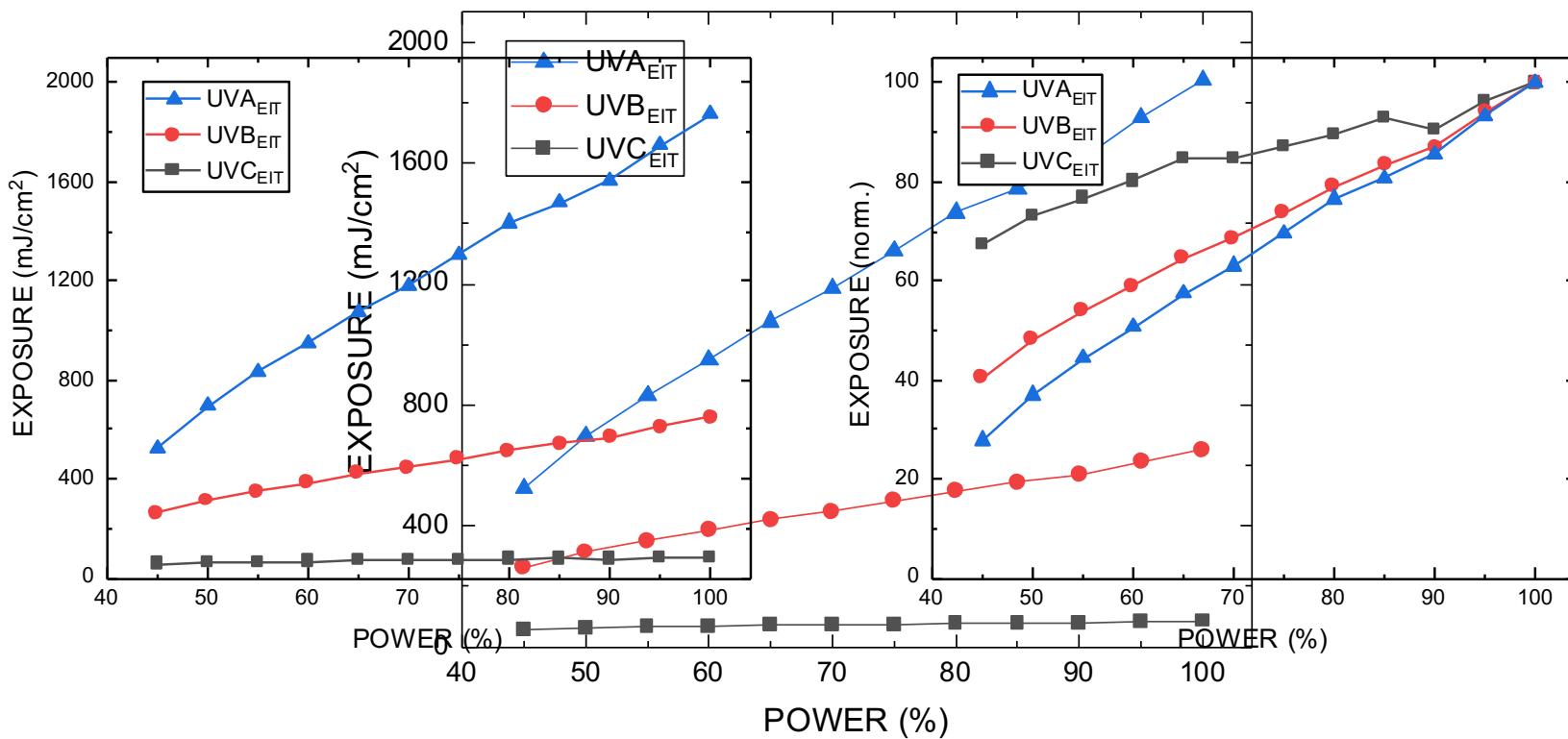
Weaker dependency

- Cooling air pressure
- Bulb Temperature

CASE 2A: UV OUTPUT VS POWER (COOLING CORRECTED)

UV output from additive bulbs (D, V) are dependent on cooling level

› RADIOMETRY WHEN cooling level adjusted



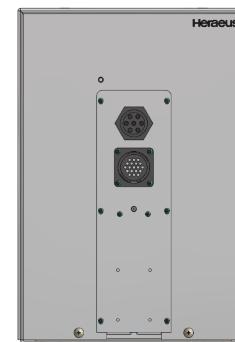
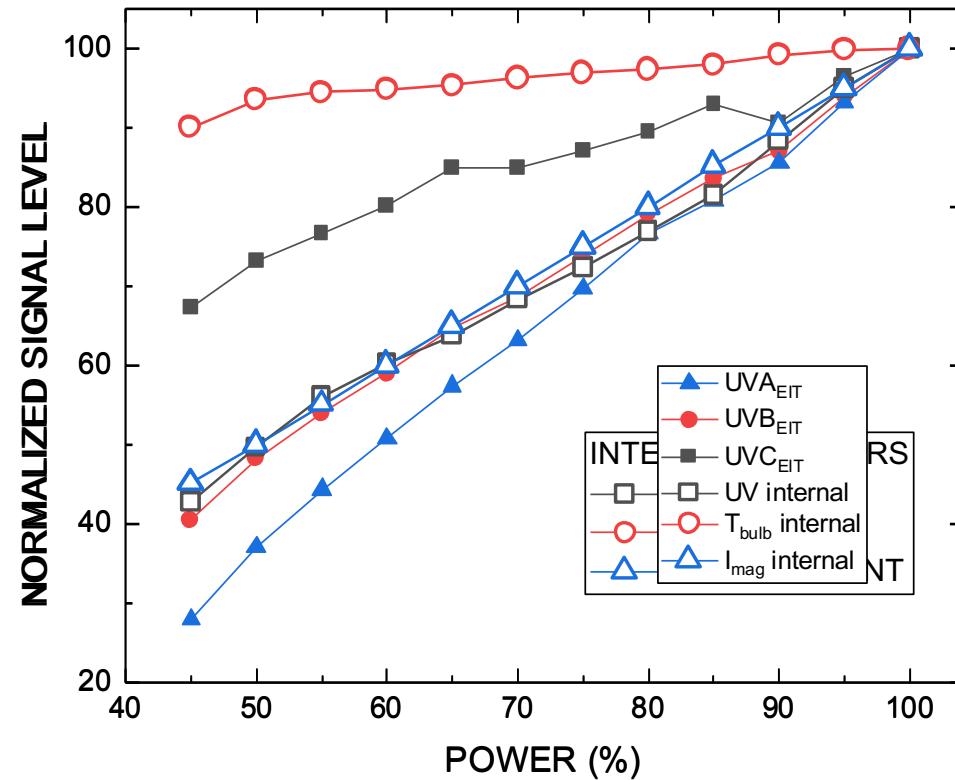
CASE 2A: UV OUTPUT VS POWER (COOLING CORRECTED)

UV output from additive bulbs (D, V) are dependent on cooling level

› INTERNAL SENSORS when cooling level adjusted



PUTTING IT ALL TOGETHER:



Strong dependencies:

- Magnetron current
- UV sensor
- UVB output
- UVA output

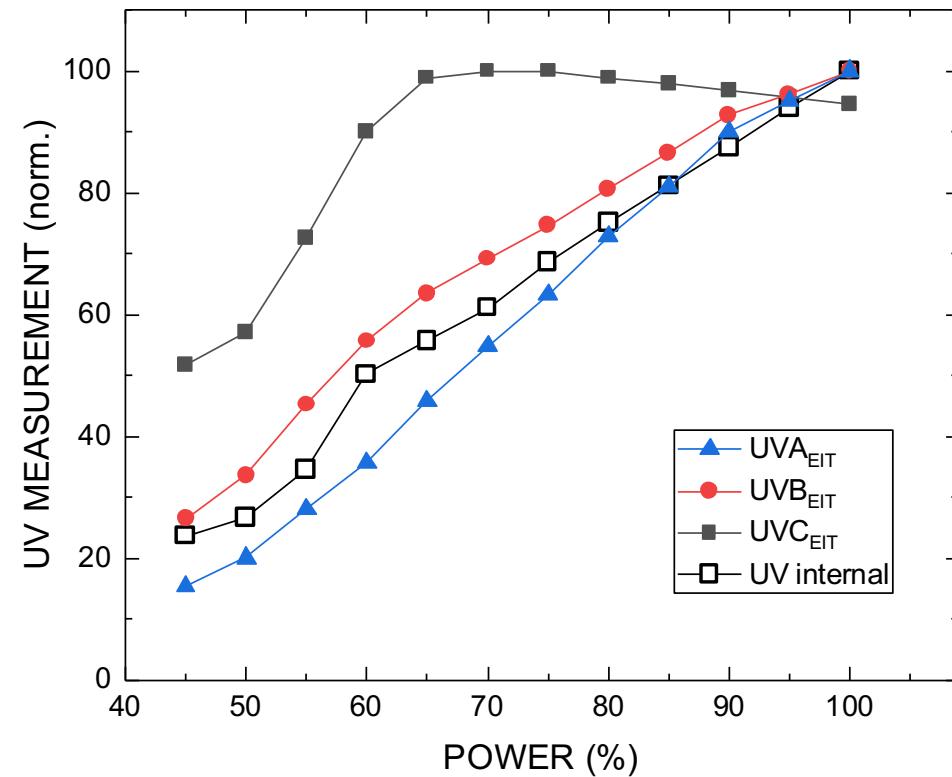
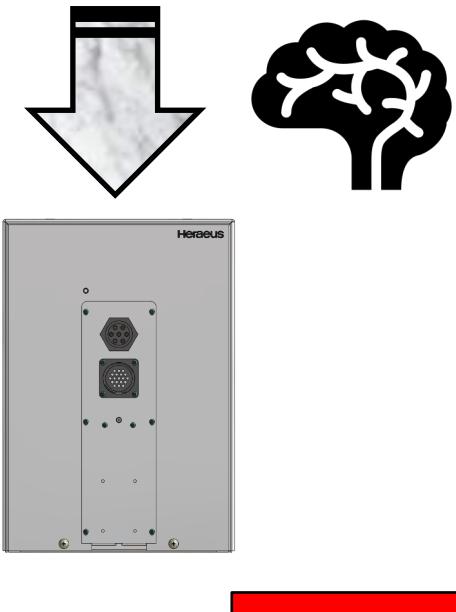
Weak dependencies/correlations:

- UVC output
- Bulb temperature

CASE 2B: UV OUTPUT VS POWER (COOLING CONSTANT)

UV output from additive bulbs (D, V) are dependent on cooling level

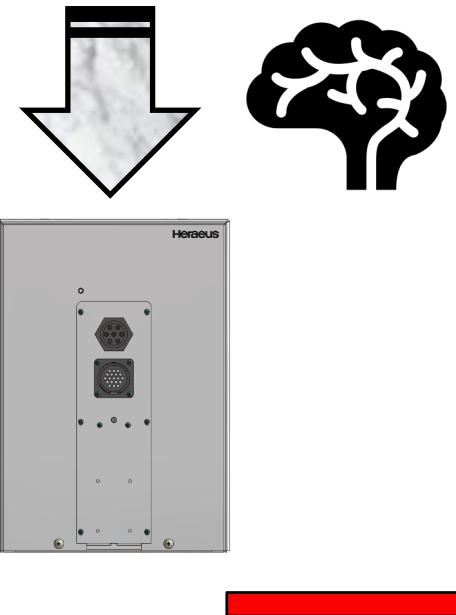
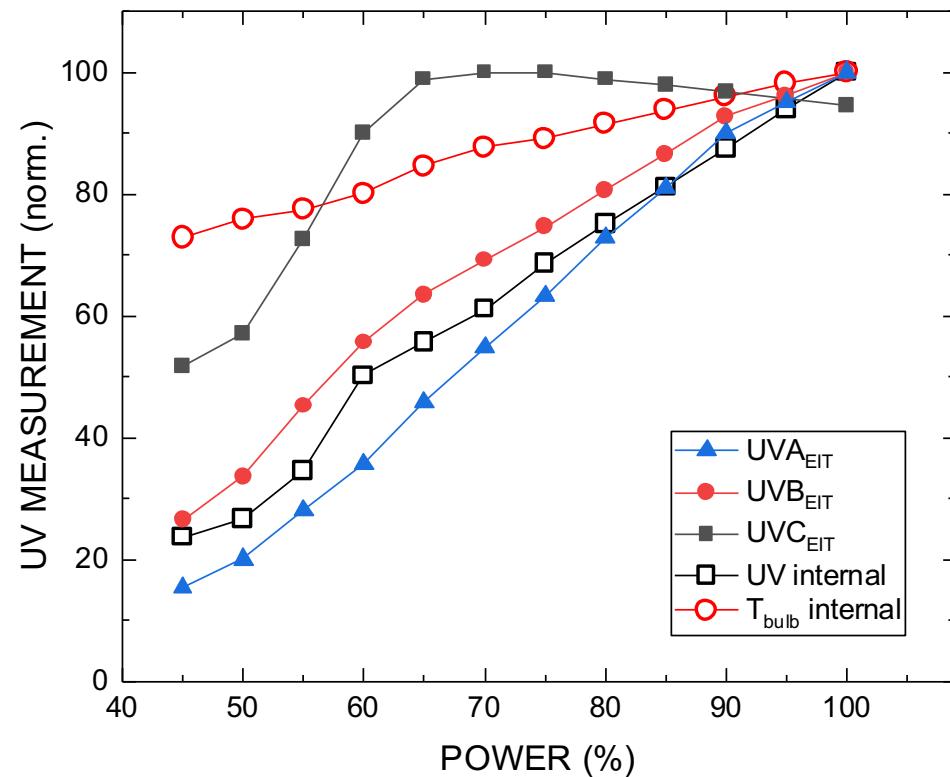
- › Constant cooling level



CASE 2B: UV OUTPUT VS POWER (COOLING CONSTANT)

UV output from additive bulbs (D, V) are dependent on cooling level

- Constant cooling level



Stronger dependencies

- Bulb temperature

Weakened dependencies:

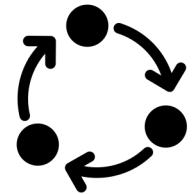
- UV sensor
- UVB, UVA output

No dependencies/correlations:

- UVC output

SUMMARY & CONCLUSIONS

Sensor integration and implementation into industrial UV systems is viable



Strong dependencies between systems (UV equipment, light shield, air flow) are quantifiable

- › In situ + ex situ sensors supply fuller picture
- › Checks and balances between the process components

Weaker dependencies are also important; can help avoid blind spots in process

[Properly functioning] Sensors ARE telling us a story, we have to fill in the blanks

Still room for improvement, especially for narrow process windows

CO-CONSPIRATORS: BRETT SKINNER, ERIC NELSON, AND MIKE GHARAGOZLOO

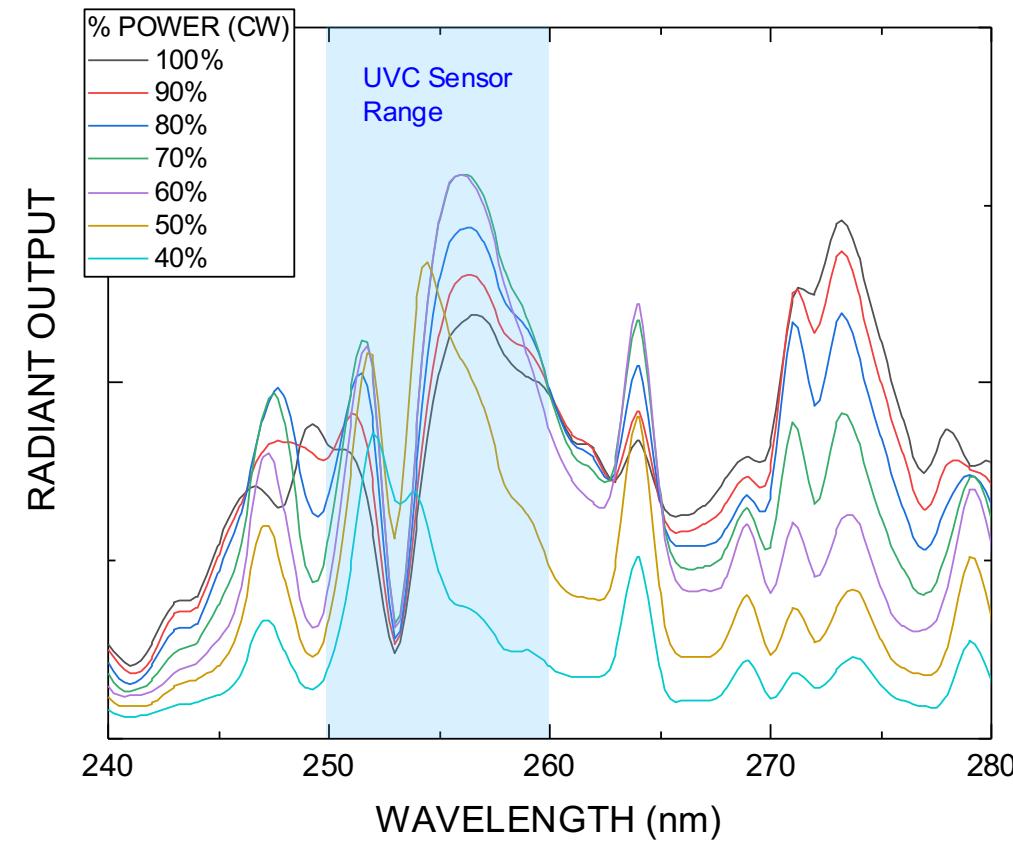


CASE 2B: UV SPECTRA VS. POWER (COOLING CONSTANT)



What is going on with the UVC band?

- › Mercury 254 nm line is strongly self-absorbed in medium pressure discharge
- › As the power level decreases and cooling remains the same:
 - › Bulb wall temperature decreases quickly
 - › Decreased bulb temperature → Less mercury in gas phase
 - › Decreased mercury pressure → Less self-absorption of atomic 254nm line
 - › Decrease in self-absorption → 254 nm 'wings' increase
- › Uncontrolled 'balance' of plasma constituents

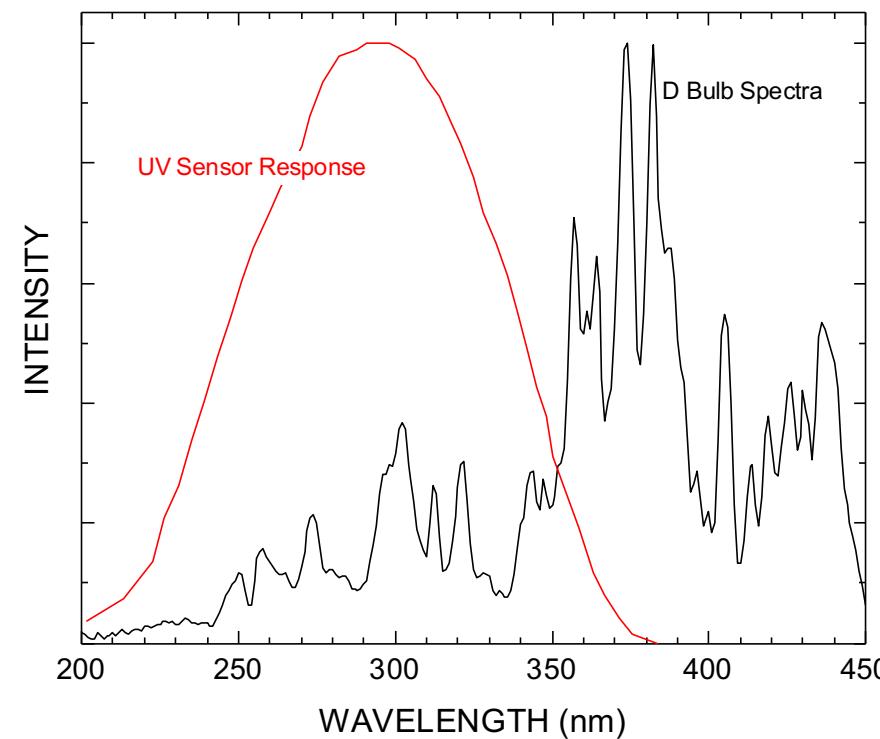


CASE 3: UV SPECTRA VS. POWER VS. MODULATION



In order to structure content, the first enumeration level can be kept in bold.

- › Enumeration level 2
 - › Enumeration level 3
 - › Enumeration level 4
 - › Enumeration level 5



CASE 3: UV SPECTRA VS. POWER VS. MODULATION



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