Application Note: Justifying Single Point Calibration

Introduction

Technical Support is asked daily by customers if we can create a custom calibration for a particular sensor. Most people feel that, if we calibrate at the same power and wavelength as their process, then they can reduce the amount of uncertainty in their sensor's measurement. While correct in thinking this, the change is not by as much as you think it is.

This Application Note describes the process that Coherent uses to justify single point calibration for sensors that typically use a single point calibration.

Single Point Calibration for Power Linearity

Most of our thermopiles are calibrated at one single point. Coherent has chosen an approximate power level such as 1W. The exact power is not important, and it may vary within some range between calibrations.

It is not important that the power be the same during calibrations, as long as the power is in the specification range of the sensor and has a NIST-traceable standard to the measurement.

The single power level used during calibration can be justified because the linearity of most of Coherent's PM-series sensors (for example, a PowerMax 150-50C) is ±1%. Because the linearity is so good on these products, it can be calibrated anywhere within the specified power range of the product.

As long as the power level is within the specified range of the product, that 1% linearity is valid and can be used to justify that the calibration is valid across the entire range as well. To calibrate the product at 27W would be no more accurate than it is when calibrated at 1W. The linearity value stays the same.

Single Point Calibration for Wavelength

The wavelength is chosen based on the calibration station and laser that is used on a given calibration bench. There are two parts to the calibration that is done on all of these sensors.

The first step is that we take the thermopile disk and run it through a full spectral scan. This determines absorption data for the sensor over its specified working wavelength range. That data is programmed into the sensor and is used to determine how the response of the sensor changes with wavelength.

After that step is done, the sensor is calibrated at a single wavelength and power level. This single point calibration is used to anchor the spectral scan data that was collected. By determining the exact response of the sensor at one wavelength, we can then determine the response at any other wavelength based on the spectral scan data.

Uncertainty for Linearity and Wavelength Compensation

There is some additional uncertainty associated with the spectral scan, described in Coherent's catalog. The spectral scan is typically going to have an uncertainty of ±1.5%. For example, a sensor such as the PowerMax 150-50C has a calibration uncertainty of ±1% at 514nm.

If you were using the sensor at a wavelength near +/-10% of 514nm, then the additional wavelength uncertainty would basically be 0%. However, if you are using the sensor at a wavelength away from 514nm, you would add in the 1.5% uncertainty associated with the wavelength correction.

Something similar is true for the linearity. Typically, the linearity is only going to become a factor as you get near the very top and bottom of the specified power range for the sensor. Thus, if you are using the sensor towards the middle of its specified power range, the linearity uncertainty can be ignored. However, if you are using it at a power level very different from where it was calibrated, you would add linearity uncertainty into the total uncertainty accuracy as well.

If the sensor is a meterless power sensor (USB or RS), then the uncertainty of the read-out electronics are already added into the uncertainty.

If you are working with a standard PowerMax sensor that plugs into a meter, you would also need to add the uncertainty of the meter to determine the total system uncertainty.

Determining the Sensor Uncertainty Value

Based on the probability of adding errors, we can use the sum of squares method to determine the total accuracy. These values can be found in the catalog page for your specific sensor.

To determine the total system accuracy (meter and sensor):

$(\text{Total uncertainty})^2 = (\text{Cal uncertainty})^2 + (\text{linearity})^2 + (\text{wavelength uncertainty})^2 + (\text{meter uncertainty})^2$

$\text{Total uncertainty} = \sqrt{[(\text{Cal uncertainty})^2 + (\text{linearity})^2 + (\text{wavelength uncertainty})^2 + (\text{meter uncertainty})^2]}$

$\text{Total uncertainty} = \sqrt{[1^2 + 1^2 + 1.5^2 + 1^2]}$

$\text{Total uncertainty} = \sqrt{5.25}$

$\text{Total uncertainty} = 2.3\%$

When using a USB or RS device without a meter:

$(\text{Total uncertainty})^2 = (\text{Cal uncertainty})^2 + (\text{linearity})^2 + (\text{wavelength uncertainty})^2$

$\text{Total uncertainty} = \sqrt{[(\text{Cal uncertainty})^2 + (\text{linearity})^2 + (\text{wavelength uncertainty})^2]}$

$\text{Total uncertainty} = \sqrt{[1^2 + 1^2 + 1.5^2]}$

$\text{Total uncertainty} = \sqrt{4.25}$

$\text{Total uncertainty} = 2.06\%$

The total system uncertainty calculation takes into account the sensor uncertainty along with linearity and wavelength correction, as well as the meter uncertainty if applicable. In most cases, to simplify things, we say that the total system uncertainty is simply the uncertainty of the sensor plus the uncertainty of the meter. In the example using a PowerMax 150-50C, that would typically result in 1% + 1% = 2%, which is very close to the 2% if you go through the entire calculation.

Summary

To summarize… yes, there is some uncertainty related to wavelength and linearity because we do only a single-point calibration. When you take into account the very good linearity and the spectral scan on these sensors, though, there is still good overall system uncertainty. Note that there are not any significant errors that show up based on the calibration that we provide.

If your goal in the future is to reduce the amount of total uncertainty in your application, then consider the use of a meterless sensor such as a USB or RS device.

Important!

Coherent does not accept requests for custom calibrations for a standard product, nor accept compensation for customized services for such tasks. Technical Support is regularly asked to create custom power levels and custom wavelengths, and is not staffed to provide customized calibrations.

Coherent processes are managed under ISO 17025, with documented guidance for each sensor and bench configuration. Any deviation from standard processes would not allow us to offer ISO 17025 accredited calibrations. Coherent offers accredited calibrations only on the processes on which we are audited, which enhances the timeliness and efficiency of calibration stations for all products.

Contact Coherent

For assistance or additional information, contact Coherent Technical Support as follows:

- Contact your local Coherent Service Representative (or visit www.Coherent.com to view a list of contacts worldwide)
- Send an e-mail to: LSMservice@Coherent.com
- Call the Coherent Technical Support Hotline
  - Within the USA: 1-(800)-343-4912
  - Outside of the USA: 1-(408)-764-4042

For additional information about **sensor products**, go to:

https://www.coherent.com/measurement-control

For answers to **frequently asked questions**, go to this link, scroll down and click FAQ, then select Ask a Question or Read the Answers:

https://www.coherent.com/measurement-control/measurement/laser-measurement-and-control-help-center

To download the **current software** for sensor products, go to this link and scroll down to the Software, Drivers & Manuals section:

https://www.coherent.com/measurement-control/measurement/laser-measurement-and-control-help-center

To arrange for **warranty service or annual recalibration**, contact your regional Coherent service center to obtain a Return Material Authorization (RMA) number. Use the shipping box and packaging materials you retained to safely transport the sensor back to the factory, and ship to this address:

Coherent, Inc.
Attn: RMA #
27650 SW 95th Ave.
Wilsonville, OR 97070