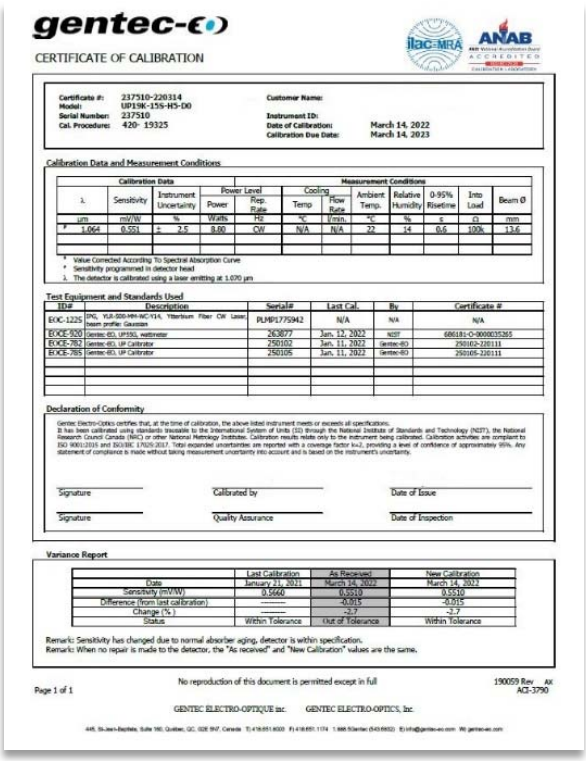
TECHNICAL NOTE

UNDERSTANDING YOUR CALIBRATION CERTIFICATE

A calibration certificate is an official document that contains very important information on the product that it accompanies. It states the instrument's calibration parameters and provides traceability to international standards.

Each calibrated product only has one valid **calibration** at any time. Detectors that are calibrated at multiple wavelengths also have a **personal wavelength correction™**. Both documents are explained in this technical note.

Laser power meters and energy meters are used across a wide variety of industries to provide accurate data on how a laser process or system is operating in a given situation or experiment. Measurement accuracy is an essential part of quality control. All measurement devices drift over time; instruments will lose their measurement accuracy unless calibrated at certain intervals.



gentec-eo

CERTIFICATE OF CALIBRATION

Certificate #: 237510-220314
Model: UP19K-15S-H5-D0
Serial Number: 237510
Cal. Procedure: 420- 19325

Customer Name:

Instrument ID:
Date of Calibration: March 14, 2022
Calibration Due Date: March 14, 2023

Calibration Data and Measurement Conditions

Calibration Data				Measurement Conditions							
λ	Sensitivity	Instrument Uncertainty	Power Level	Rep. Rate	Cooling		Ambient Temp.	Relative Humidity	0-95% Risetime	Into Load	Beam Ø
			Power		Temp	Flow Rate					
µm	mV/W	%	Watts	Hz	°C	l/min	°C	%	s	Ω	mm
* 1.064	0.551	± 2.5	8.60	CW	N/A	N/A	22	14	0.6	100k	13.6

* Value Corrected According To Spectral Absorption Curve
* Sensitivity programmed in detector head
λ The detector is calibrated using a laser emitting at 1.070 µm

Test Equipment and Standards Used

ID#	Description	Serial#	Last Cal.	By	Certificate #
EOC-1225	DYL, YLR-500-MM-WC-Y14, Ytterbium Fiber CW Laser, beam profile: Gaussian	PLMP1775942	N/A	N/A	N/A
EOCE-920	Gentec-EO, UP19L, wattmeter	263877	Jan. 12, 2022	NIST	686181-O-0000035265
EOCE-782	Gentec-EO, UP Calibrator	250102	Jan. 11, 2022	Gentec-EO	250102-220111
EOCE-785	Gentec-EO, UP Calibrator	250105	Jan. 11, 2022	Gentec-EO	250105-220111

Declaration of Conformity

Gentec Electro-Optics certifies that, at the time of calibration, the above listed instrument meets or exceeds all specifications.
It has been calibrated using standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), the National Research Council Canada (NRC) or other National Metrology Institutes. Calibration results relate only to the instrument being calibrated. Calibration activities are compliant to ISO 9001:2015 and ISO/IEC 17025:2017. Total expanded uncertainties are reported with a coverage factor k=2, providing a level of confidence of approximately 95%. Any statement of compliance is made without taking measurement uncertainty into account and is based on the instrument's uncertainty.

Signature | Calibrated by | Date of Issue
Signature | Quality Assurance | Date of Inspection

Variance Report

	Last Calibration	As Received	New Calibration
Date	January 21, 2021	March 14, 2022	March 14, 2022
Sensitivity (mV/W)	0.5660	0.5510	0.5510
Difference (from last calibration)	———	-0.015	-0.015
Change (%)	———	-2.7	-2.7
Status	Within Tolerance	Out of Tolerance	Within Tolerance

Remark: Sensitivity has changed due to normal absorber aging, detector is within specification.
Remark: When no repair is made to the detector, the "As received" and "New Calibration" values are the same.

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GENTEC ELECTRO-OPTIQUE Inc. GENTEC ELECTRO-OPTICS, Inc.

Calibration is comparing and documenting the measurement of a device to a traceable reference standard. Your instrument's calibration documents detail the calibration conditions and the traceability of the equipment used so that you can be confident that your measurements are correct.

A complete Gentec-EO calibration certificate is composed of six different sections, each having its own purpose and type of information:

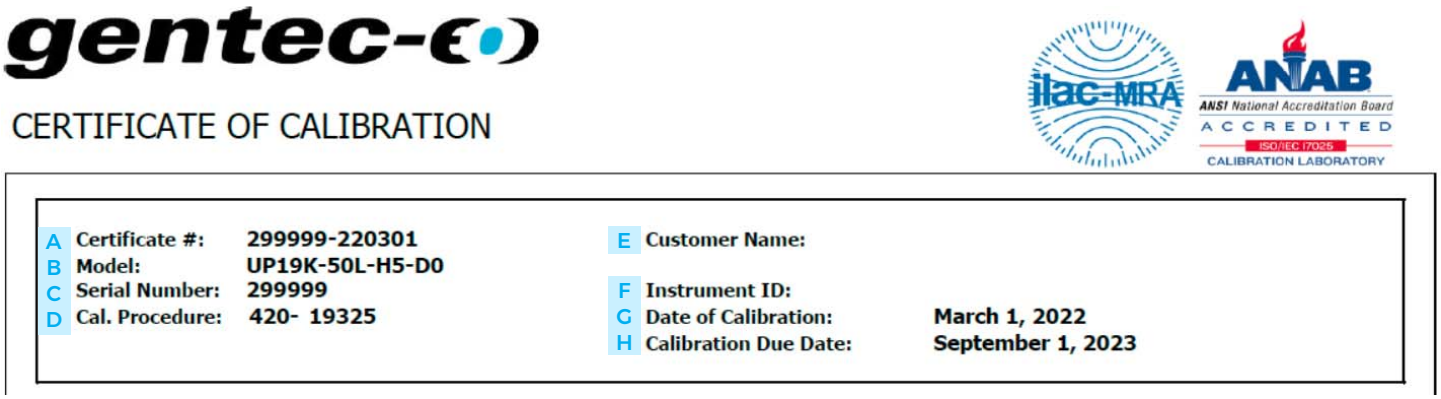
1. Identification
2. Calibration data and measurement conditions
3. Test equipment and standards used
4. Declaration of conformity
5. Variance report
6. Gentec-EO information

The structure of this technical note is divided in the same manner.

TECHNICAL NOTE

1. IDENTIFICATION

The first section contains different identification elements. The Gentec-EO official logo is displayed in the top left corner. Just below, the words "CERTIFICATE OF CALIBRATION" state the nature of the document. If the calibration is listed in our laboratory's **ISO/IEC 17025:2017** scope of accreditation, the accreditation logo is displayed in the top right corner.



Then, the first box contains the following elements:

A. **Certificate #:** This number identifies the certificate and links it to one single physical unit. It is a combination of the product's serial number and the issue date in the format YYMMDD.

B. **Model:** This is the official Gentec-EO model name of this product.

C. **Serial Number:** This is the unique serial number attributed to the calibrated physical unit.

D. **Cal. Procedure:** This number identifies the calibration procedure, which has been established by Gentec-EO's development team and calibration specialists, and approved by the ISO/IEC 17025 standard.

E. **Customer Name:** *On customer request only.* This is only available for recalibrations.

F. **Instrument ID:** *On customer request only.* This is the customer's desired identification for the product. This is only available for recalibrations.

G. **Date of Calibration:** This is the date on which the calibration procedure was performed on the unit. It may be different from the "Date of Issue" that is found at the bottom of the certificate.

H. **Calibration Due Date:** For new units, the recommended interval is 18 months after the initial calibration date. For recalibrated units, the recommended interval is 12 months. This interval can be changed on special request, before we issue the certificate. You may choose to send back your product for recalibration at any time.

2. CALIBRATION DATA AND MEASUREMENT CONDITIONS

The second section is the main part of the calibration certificate. This is where the calibration data and measurement conditions are reported. The calibration was obtained under the reported conditions.

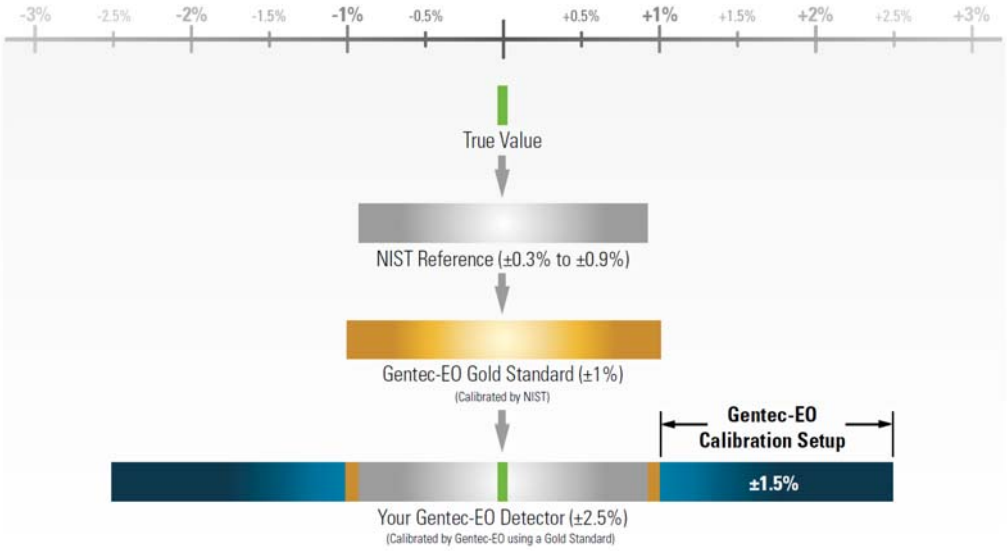
The instrument uncertainty reported in this table is the total expanded uncertainty, which means the product is considered accurate within a certain level of confidence. This level, expressed in %, applies a coverage factor to the standard uncertainty. These values are defined in NIST Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST*

Measurement Results. In the calibration certificate, total expanded uncertainties are reported with a coverage factor k=2, providing a level of confidence of approximately 95%, because uncertainty confidence is modelled with a Gaussian function. Like every other step in the calibration process, our uncertainty calculations are performed by experienced professionals and approved as part of our ISO/IEC 17025 accreditation.

DETECTORS

At Gentec-EO, we always use "Gold" calibration standards (also known as "primary standards") as reference for the detector calibrations. Gold standards are detectors that are regularly calibrated by NIST at different wavelengths, power levels and energy levels, in accordance to the different lasers used to calibrate each detector that we manufacture. This extra carefulness in the comparison process comes from decades of experience in the laser measurement business.

The figure below shows these steps and their respective contribution to the value of uncertainty. As you can see, the manufacturer itself is only one of these sources. The customer must use the product within the normal operating conditions defined in the user manual in order for the total expanded uncertainty to be valid.



Before we perform the calibration measurements, the detector under test is allowed to reach equilibrium with the laboratory environment. The instrument's sensitivity is found by dividing the instrument output reading by the incident laser power, which is measured by a traceable standard.

Calibration Data and Measurement Conditions

Calibration Data			Measurement Conditions								
λ	Sensitivity	Instrument Uncertainty	Power Level		Cooling		Ambient Temp.	Relative Humidity	0-95% Risetime	Into Load	Beam Ø
			Power	Rep. Rate	Temp	Flow Rate					
µm	mV/W	%	Watts	Hz	°C	l/min.	°C	%	s	Ω	mm
P 1.064	0.551	± 2.5	8.80	CW	N/A	N/A	22	14	0.6	100k	13.6

S Value Corrected According To Spectral Absorption Curve
P Sensitivity programmed in detector head
λ The detector is calibrated using a laser emitting at 1.070 µm

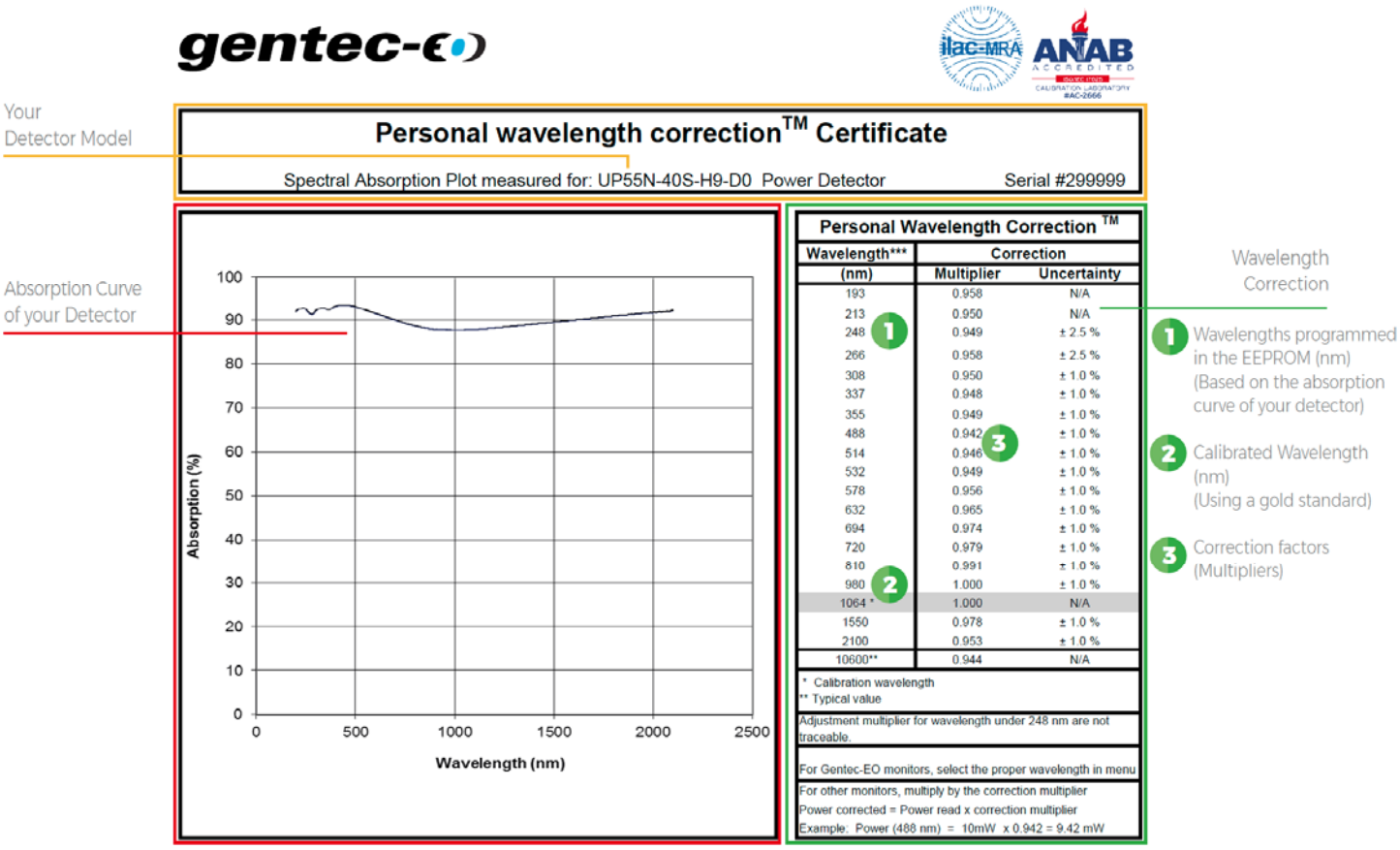
TECHNICAL NOTE

Most Gentec-EO detectors also include a spectral calibration, which defines the wavelength-dependent correction factors read by Gentec-EO displays and PC interfaces. The correction factors are measured for each detector. They are not "typical values." These values are provided on a separate document called the "**Personal wavelength correction™ Certificate.**"

While the NIST only supplies references for distinct wavelengths, Gentec-EO offers you NIST-traceable calibration in nm steps, from 250 nm to 2.5 µm. We achieve this using our proprietary setup that is based on a NIST-traceable spectrophotometer. This way, instead of supplying you with only typical values, we offer you a complete calibrated spectral range.

The correction factors are based on measurements that were made with your detector. They are not based on the general curve of the absorbing material or the general response of equivalent products. This means you get the best wavelength correction tool available on the market. This data is stored in the smart interface of your Gentec-EO detector, you just have to select the wavelength in your display device or PC interface to get the most precise laser measurements on the market.

The Personal wavelength correction™ Certificate is separated in three section: The detector model identification at the top, the detector's absorption curve on the right and the wavelength correction table on the left.



Under the spectral graph and wavelength correction table, you will find the same sections as in the calibration certificate, detailed below: test equipment and standards used, declaration of conformity, and Gentec-EO information.

The Personal wavelength correction™ Certificate does not include a variance report for recalibrations.

DISPLAYS AND PC INTERFACES (MONITORS)

The calibration of displays and PC interfaces does not require a laser source, hence this very simple table:

Calibration Data and Measurement Conditions

Calibration Data	Measurement Conditions	
Instrument uncertainty	Ambient Temperature	Relative Humidity
%	°C	%
±0.25% ±5µV (Wattmeter) ±1% ±50µV (Joulemeter)	24	46

3. TEST EQUIPMENT AND STANDARDS USED

The third section lists the controlled devices (including the standards) used to perform the calibration procedure. **This is where the traceability of the calibration to international standards is established.** Each device used is identified by its ID#, serial number, and calibration status: last calibration date, name of the calibration service supplier and the standard's certificate number.

With a few exceptions, the last calibration date shall be less than one year before the product's calibration date.

Test Equipment and Standards Used

ID#	Description	Serial#	Last Cal.	By	Certificate #
EOC-1225	IPG, YLR-500-MM-WC-Y14, Ytterbium Fiber CW Laser, beam profile: Gaussian	PLMP1775942	N/A	N/A	N/A
EOCE-920	Gentec-EO, UP55G, wattmeter	263877	Jan. 12, 2022	NIST	686181-O-0000035265
EOCE-782	Gentec-EO, UP Calibrator	250102	Jan. 11, 2022	Gentec-EO	250102-220111
EOCE-785	Gentec-EO, UP Calibrator	250105	Jan. 11, 2022	Gentec-EO	250105-220111

4. DECLARATION OF CONFORMITY

The fourth section is a statement from Gentec-EO regarding the state of the equipment used and its traceability to an internationally recognized metrology institute, such as NIST, NRC, PTB or AIST. This statement is dated and is signed by the calibration technician who performed the calibration of the unit and by a Quality Assurance representative.

The signatures qualify the calibration certificate as an original and official document.

Declaration of Conformity

Gentec Electro-Optics certifies that, at the time of calibration, the above listed instrument meets or exceeds all specifications.
It has been calibrated using standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), the National Research Council Canada (NRC) or other National Metrology Institutes. Calibration results relate only to the instrument being calibrated. Calibration activities are compliant to ISO 9001:2015 and ISO/IEC 17025:2017. Total expanded uncertainties are reported with a coverage factor k=2, providing a level of confidence of approximately 95%.
Any statement of compliance is made without taking measurement uncertainty into account and is based on the instrument's uncertainty.

Signature	Calibrated by	Date of Issue
Signature	Quality Assurance	Date of Inspection

5. VARIANCE REPORT

This section only applies to recalibrated units. For new units, the variance report table is present on the certificate but empty.

The variance report is critical to maintain the historic traceability of a unit and to validate the results of the measurements that you performed with it since its last calibration.

When Gentec-EO receives a unit for recalibration, the initial inspection is immediately followed by a verification measurement, which allows us to answer 2 questions:

1. Is the unit functional?
2. Is the unit still measuring within its uncertainty?

If the unit is not functional or requires repairs, our Service team will contact you to validate if you wish to move forward with a replacement or repairs. After the recalibration takes place or a repair is made, a second verification measurement is performed in order to ensure the instrument achieves its uncertainty tolerances.

Finally, a remark might be added just below the variance report table, when needed, to explain a particular result. For example, a power detector's sensitivity may change significantly when its sensor disk is replaced.

DETECTORS

In a variance report for a detector, the "Change (%)" value of the "As Received" column is the most important parameter to consider. For a detector to be considered "Within Tolerance", the "Change (%)" value must be lower than the "Instrument Uncertainty" specified in the "Calibration Data" section. This means that prior to its arrival at the calibration laboratory, the detector was still measuring within the specified tolerance. When this is the case, we enter the new calibration values in the unit and it is ready for you to use again.

Here is an example of Variance Report for a unit that was within tolerance upon reception. Since no adjustment or repair was made, only one recalibration was performed and the "As Received" and "New Calibration" columns are identical.

Variance Report

	Last Calibration	As Received	New Calibration
Date	October 20, 2020	February 28, 2022	February 28, 2022
Sensitivity (mV/W)	249.4	253.6	253.6
Difference (from last calibration)	---------	4.2	4.2
Change (%)	---------	1.7	1.7
Status	Within Tolerance	Within Tolerance	Within Tolerance

Remark: When no repair is made to the detector, the "As received" and "New Calibration" values are the same.

In this example, the initial sensitivity was 249.4 mV/W. In October 2020, 1 W of laser power on this detector would have generated a signal of 249.4 mV. Over time, the sensitivity drifted up, leading to an over-estimation of the measured power. We can find out the effect of the drifted sensitivity on our measurement with this formula:

Measured Power = Real Power * Real Sensitivity / Programmed Sensitivity = 1 W * 253.6 mV/W / (249.4 mV/W) = **1.017 W**

Because this 1.7% change in measured power is within the detector's uncertainty, this unit did not require further adjustments. The new sensitivity is then recorded in the detector's smart interface the unit is sent back to the customer with its new calibration data.

Below is an example of variance report for a unit that required repairs because it was “Out of Tolerance” upon reception. In this case, when we received the unit, its sensitivity had changed by 9.7%, which is must higher than the unit’s uncertainty. A part of the detector was replaced and the unit was recalibrated a second time before sending it back to the customer

Variance Report

	Last Calibration	As Received	New Calibration
Date	March 29, 2021	June 7, 2022	June 10, 2022
Sensitivity (mV/W)	0.647	0.710	0.582
Difference (from last calibration)	---------	0.063	---------
Change (%)	---------	9.7	---------
Status	Within Tolerance	Out of Tolerance	Within Tolerance

Remark: Sensitivity has changed due to excessive absorber aging or excessive wear, detector was out of specification.
Remark: Absorber was replaced. Sensitivity has changed.

DISPLAYS AND PC INTERFACES (MONITORS)

The variance report of electronic instruments looks somewhat different but has the same purpose. For these products, there are two tables: “Before” and “After”. The “Before” table is filled in when we receive your instrument, before we recalibrate it. The measured values are displayed for each scale of the electronics. Due to the nature and typical use of these instruments, repairs are not often required, and we can proceed directly with the recalibration. After the recalibration, a final verification is carried out to fill in the “After” table.

Before

Scale	Applied	Target Value	As Found	Comment
Wattmeter (@ 5 mV/W)				
W	V	W	W	
0.3	0.0005386	0.1077 ± 0.0013	0.1080	Within Tolerances
3	0.013846	2.7691 ± 0.0079	2.7685	Within Tolerances
10	0.04744	9.488 ± 0.025	9.487	Within Tolerances

After

Scale	Applied	Target Value	As Found	Comment
Wattmeter (@ 5 mV/W)				
W	V	W	W	
0.3	0.0005391	0.1078 ± 0.0013	0.1078	Within Tolerances
3	0.013843	2.7686 ± 0.0079	2.7683	Within Tolerances
10	0.04743	9.486 ± 0.025	9.483	Within Tolerances

6. GENTEC-EO INFORMATION

The last section contains control information regarding the edition and revision of its template as well as a limitation on the reproduction of the document. It also contains Gentec-EO’s contact information (address, phone and fax numbers, e-mail and website).

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TECHNICAL NOTE

HOW TO ORDER A RECALIBRATION

Our service department is happy to repair and/or recalibrate your instrument at any time. We can also help you meet any ISO and/or quality requirements. In every case, you will get the same accurate calibration and detailed certificate as when your instrument was new. In addition, we perform an "As Received" or "Before" verification to let you know how your product was performing before service.

To send an RMA request:

BY PHONE 1-418-651-8003, ext. 302

BY E-MAIL service@gentec-eo.com

ONLINE https://www.gentec-eo.com/contact-us/support-rma-request
Fill out the online form and click "SUBMIT"

If you have any questions about your calibration certificate, please contact us at service@gentec-eo.com.

LEADER IN LASER BEAM MEASUREMENT SINCE 1972

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