Perry Johnson Laboratory Accreditation, Inc.

Calibration Scopes of Accreditation

1.0 INTRODUCTION

1.1 This policy has been developed by PJLA and its technical committee in order to ensure consistency among calibration organization's scopes of accreditation. It establishes guidelines used by PJLA to determine the most accurate expression of range and calibration and measurement capability on calibration scopes of accreditation.

1.1.1 Additionally, this document includes an Appendix A outlining examples of appropriate entries for various calibration disciplines and Appendix B to provide guidance for the use of SI units on the scope of accreditation.

1.2 All applicant and accredited organizations shall adhere to this policy. The policy detailed within this document applies only to calibrations for which an accredited result is to be reported.

2.0 SCOPES OF ACCREDITATION

2.1 The scope of accreditation is a formal document issued by PJLA to its accredited organizations. It contains information expressing the calibration parameters, ranges over which a calibration applies, the uncertainty or CMC (Calibration and Measurement Capability) associated with the calibration as well as pertinent information about the equipment, methods and references used in performing the calibration.

2.2 Prior to accreditation applicant organizations are responsible for providing PJLA with the most accurate and current information available in regards to their intended scope of accreditation. This should be completed on an application (LF-1) and should comply with this policy. This also applies to organizations who have been previously accredited. Prior to accreditation, PJLA will provide the organization with our proposed scope of accreditation for review. Once the organization accepts the scope of accreditation, PJLA will relay the scope to the assessor to verify on-site for accuracy and completeness. Once your assessor has agreed with the proposed scope of accreditation, both the organization and the assessor will sign the proposed scope and submit it to PJLA for review with the assessment package. Please note that the submitted scope of accreditation can be modified by PJLA after the technical review of the assessment package has been completed.

2.3 When accreditation is granted, PJLA will issue a final scope of accreditation certificate. A draft of this document will be submitted to the organization for review and approval. Following organization approval the final scope of accreditation will be accessible to the public through direct inquiry to PJLA or through the PJLA website. Per PJLA procedures, an organization whose accreditation is suspended or terminated shall not use or display the scope of accreditation or the PJLA name and symbol in any way.

2.4 The scope of accreditation will be reviewed at the accreditation and reaccreditation assessments in its entirety. During surveillance assessments, those areas of the scope of accreditation directly pertaining to the assessment will be reviewed in detail. Any changes or additions to the scope of accreditation, which have occurred since the previous assessment or any areas affected by nonconformities identified during the previous assessment will also be reviewed.

Formatting the Scope of Accreditation

(REFER TO APPENDIX A AND APPENDIX B TO VIEW EXAMPLES OF THIS SECTION)

3.0 CALIBRATION FIELD

3.1 PJLA currently accredits organizations performing calibrations in the following fields:

3.1.1 Dimensional

3.1.2 Electrical

3.1.3 Time and Frequency

3.1.4 Acoustic

3.1.5 Mass, Force, and Weighing Devices

3.1.6 Mechanical

3.1.7 Chemical

3.1.8 Thermodynamic

3.1.9 Optical

3.2 Scopes of accreditation will contain calibration fields selected from the list above (as appropriate to the calibrations performed by the organization), and the related measured instrument, quantity or gauge, range, CMC and calibration equipment, and reference standards used with the information necessary to define the calibration capability of the organization. Should an organization find that a calibration they perform does not fall into any of the above calibration fields; they are encouraged to contact PJLA for guidance.

4.0 MEASURED INSTRUMENT, QUANTITY OR GAUGE

4.1 This entry needs to represent the calibration that is being performed by the organization.

4.1.1 For example, analytical balances, equipment to measure, indirect verification of Rockwell Hardness HRC, or Outside Micrometers.

5.0 RANGE

5.1 The ranges stated on the certificate are the magnitudes between the lower and upper boundaries of the calibration parameter. For devices which are nonvariable or nonadjustable the range is reduced to a discrete value. When stating the range, the calibration capabilities of the organization need to be fully expressed in a manner that is accurate and easy to understand format.

5.2 Organizations should exercise care in determining the lower limit of the range. Zero is not acceptable as the low end of a range when it cannot be physically attained as a valid measurement result or when a physical standard calibrated at zero magnitude is not possible.

5.2.1 For example, in scale calibration a calibrated weight of 0.0 grams is not possible. The lower limit of the range for scale calibration should be the smallest calibrated weight (within the required weight class) the organization will place on the scale in performing the calibration. A pin gage of 0.0 in diameter is not possible. Zero is valid as a low end of range when calibrating temperature using the Fahrenheit or Celsius scale since it is only an intermediate point on the continuum between a fixed lower end of range and the undefined high end of range. It is not a valid low end of range when calibrating temperature using the Kelvin or Rankin scale since it represents the complete and total absence of heat and as such would require a calibrated standard that could not exist.

5.3 An additional consideration for low end of range values is that as the magnitude of the measurement result approaches zero in most cases it also approaches the minimum value of the CMC estimate or actual uncertainty associated with a specific calibration. When the uncertainty becomes a significant component of the measurement result, confidence in the validity of the result diminishes. For this reason, PJLA has established that the low end of the range for which it will accredit calibration disciplines typically should not be less than three times the CMC for that discipline or sub discipline. PJLA will consider exceptions to this policy on a case-by-case.

5.4 PJLA will accept the range stated in one of the following three formats:

5.4.1 A fixed value:

5.4.1.1 This format is appropriate when the device to be calibrated has a fixed nominal value such as the length of an end standard, the stated value of an SRM (Standard Reference Material) or the temperature of a TPW (Triple Point of Water Cell) cell. In this case the fixed value is understood to represent the expected nominal value of the device or specimen. When the range is expressed as a fixed value the fixed value typically should not be less than three times the CMC for that discipline or sub discipline

5.4.2 A range beginning with up to and ending with a fixed value:

5.4.2.1 This format is appropriate when the organization wishes to indicate the measurement capacity of equipment it can calibrate rather than stating its actual range of calibration capability for the calibration to which the range applies. In this case it is understood that a non-zero low end of the range does exist but there is no requirement that it be specified. Organizations should exercise care when using this format for representing the range of their calibration capability. It must be clearly understood by the organization that values of zero as the low end of the range are not permitted. Since zero is understood to mean "the absence of all magnitude or quantity", calibrated standards for the parameter in question cannot physically exist at zero magnitude or in zero amounts. For example, calibration of a scale or balance at 0.0 grams is not possible because it would require the use of a calibrated mass of 0.0 g. Since 0.0g represents "the absence of all … quantity" of mass, such a standard could not be calibrated. The lower limit of the range for scale or balance calibration shall be the smallest calibrated weight (within the required weight class) the organization will place on the scale in performing the calibration. Zero is valid as a low end of range when calibrating temperature using the Fahrenheit or Celsius scale since it is only an intermediate point on the continuum between a fixed lower end of range and the undefined high end of range. It is not a valid low end of range when calibrating temperature using the Kelvin or Rankin scale since it represents the complete and total absence of heat and as such would require a calibrated standard that could not exist. The organization must demonstrate an awareness of the actual value of the low end of its calibration capability range and use it in estimating CMC for calibration disciplines included on its scope of accreditation when it is appropriate and necessary to do so.

5.4.2.2 If an organization elects this format, then any range beginning with up to within the sub-discipline cannot encompass like calibration points unless there is a change specified such as the resolution of the device under test, or the equipment used in the calibration. Additionally, there cannot be two like values specified with different CMCs unless there is a clear indication that there is a change.

5.4.3 A range between two fixed values:

5.4.3.1 This is appropriate when the device to be calibrated has the ability to measure "the absence of all magnitude or quantity" within the uncertainty of measurement associated with its calibration. In this case the low end of the range represents the smallest calibrated standard used by the laboratory in calibrating the device. The high end of the range represents the largest calibrated standard used by the laboratory in calibrating the device.

5.4.3.2 An additional consideration for low end of range values is that as the magnitude of the measurement result approaches zero in most cases it also approaches the minimum value of the CMC estimate or actual uncertainty associated with a specific calibration. When the uncertainty becomes a significant component of the measurement result, confidence in the validity of the result diminishes. For this reason, PJLA has established that when the range is expressed as the interval between two fixed values (see number 3 above) the low end of the range for which it will accredit calibration disciplines typically should not be less than three times the CMC for that discipline or sub discipline. PJLA will consider exceptions to this policy on a case by case basis.

5.5 Care must be taken to ensure that measurement results produced as part of the calibration is expressed in acceptable units and that the expression of results is properly formatted. Mass measurements must be expressed in mass units and dimensional measurements must be expressed in dimensional units etc. Please refer to NIST SP 811 for guidance in the use of appropriate units and formatting of measurement expressions. In those instances where use of U.S. Customary units (USC) is deemed appropriate NIST SP 811 will govern formatting and is a reliable source of conversion factors between the SI and USC units.

6.0 CALIBRATION AND MEASUREMENT CAPABILITY (CMC) EXPRESSED AS AN UNCERTAINTY:

6.1 PJLA grants accreditation on the organization’s capability to perform a calibration. This capability is partially defined by stating the magnitude or range of values over which the calibration capability applies. The definition of the calibration capability is completed by specifying the CMC associated with the magnitude or range stated. The CMC is expressed as an expanded uncertainty with a coverage factor “k” = 2 resulting in an approximate 95% confidence level. The CMC stated in the proposed scope, is defined as “*the smallest uncertainty an organization can achieve* within its scope of accreditation *when performing a more or less routine calibration on a nearly ideal device being calibrated*.” The CMC stated on the scope supplement must be achievable by the organization when calibrating a nearly ideal UUT (Unit Under Test) and documentary evidence to that affect must be maintained.

6.2 Uncertainty occurs in one of three mathematical conditions:

6.2.1 The first is a set of values that remain approximately constant over the stated range. CMC can be expressed on the scope of accreditation as an absolute uncertainty. In this situation one value is appropriate for all points in the stated range.

6.2.2 The second is a set of values that are linear meaning that they vary in approximate direct proportion to the increase in magnitude of the stated range. CMC can be expressed on the scope of accreditation as a relative uncertainty equation. The equation takes the form (1.21 + 1.34L) where L is a variable representing the magnitude of any value within the stated range. In this example L represents length. Other variables may be used appropriate to the parameter being defined. Any variable used in this manner must be clearly defined in a footnote at the end of the scope of accreditation. An additional form of relative uncertainty statement is expressing the uncertainty as a percentage of the reading or a percentage of the reading plus a fixed or “floor” value. Although an absolute uncertainty can be used for uncertainties of condition 2, the value must be the largest for any point in the range, which means that the CMC for all other values in the range will be overstated. When an organization chooses to express its CMC as an RUS (Relative Uncertainty Statement) it may do so using either of the following formats:

-Following is a valid RUS: 72 µV/V + 2 µV

-Following is a valid RUS: 0.016 % of reading + 8 µV

-Following is a valid RUS: 0.021 % of reading

-Following is a valid RUS: (0.13 + 0.127Wt) g

-Organization developed RUS: Must be submitted for approval by PJLA headquarters prior to use.

6.2.2.1 As an alternative the organization may propose an additional format for the relative uncertainty expression, any such formats developed by the organization shall be submitted to PJLA headquarters for approval. Once approval has been granted the organization may proceed to use the approved format. Although PJLA expresses no preference for a specific format, the organizations shall choose the format most appropriate for each calibration discipline and shall utilize the same format throughout specific calibration disciplines for expression of relative uncertainty statements. An exception exist when the organization must use a type 1 or type 2 (but not both) and a type 3 which does not have a fixed or “floor” term. The organization is free to use either type 1 or type 2 (or acceptable organization developed alternative formats) and type 3 as dictated by the specific disciplines for which they are accredited.

6.2.2.2 Should the organization wish to expand the scope of disciplines for which they are accredited any added calibration activities whose CMC is expressed as a RUS shall use the format prevailing on the scope of accreditation prior to expansion for calibrations in the same discipline.

6.2.3 The third is a set of values that are non-linear meaning that they vary at a non-uniform rate relative to the increase in magnitude of the stated range. This third type of uncertainty would produce a curve if plotted. It is necessary to determine uncertainty at enough points in the range to understand the general shape of the curve it would produce if all points were plotted. Then break the stated range down into several smaller ranges, which are approximately linear and process them as if they satisfy condition 2.

6.3 Several discipline specific and general purpose uncertainty calculator spreadsheets are available for download from the PJLA website. Others will be added as they become available. Also available is a spreadsheet to generate the relative uncertainty equation from two uncertainties, one determined near the low end and one determined near the high end of the range. It also has provisions to test indeterminate points to verify linearity of the uncertainties.

7.0 SIGNIFICANT DIGITS

7.1 Numbers used to express the range of calibration capability or its associated CMC differ from numbers that represent the result of measurement. As a measurement is repeated it can be reasonably expected that different digits may be found in one or more of the right most spaces due to non-repeatability resulting from various random and systematic sources of variation. This is not the case for numbers that are used to represent the range of calibration capability or its associated CMC. These numbers are fixed values that remain unchanged until the value of one or more of the underlying constant value numbers is changed (e.g. the uncertainty of the standard changes at the time of scheduled recalibration) or a new value is determined during the required periodic review. During the time between events such as these, the value of the range or the CMC will not change so the stated value is in fact a constant (with respect to the period of time between such events). Since the range and the CMC are considered as constant value or fixed value numbers (or expressions of a numerical relationship which will produce constant values relative to specific values of an included variable) any trailing zeros to the left of the decimal point are considered as placeholders. Trailing zeros to the right of the decimal point neither increase or decrease the value of the CMC and are considered as insignificant for that reason. The examples below all represent the same value in mV:

0.03000 mV

0.0300 mV

0.030 mV

0.03 mV

7.1.4.1 The trailing zeros in all instances above do not enhance the level of precision of the number and are therefore insignificant. Insignificant digits are not permitted in expressions of the range or CMC.

7.1.4.2 Examples:

7.1.4.2.1 170.0 Ω: The zero to the left of the decimal point is a place holder which is necessary to permit the digits 1 and 7 to represent one hundred and seventy rather than seventeen. The zero to the right of the decimal point is not required in order to represent the magnitude of the number and therefore it is considered as insignificant and is discarded for that reason. The acceptable method to represent this number is as follows: 170 Ω

7.1.4.2.2 0.070 µm: The zero immediately to the right of the decimal point is a place holder which is necessary to permit the digit 7 to represent three one hundredths rather than three tenths. The trailing zero to the extreme right is not required in order to represent the magnitude of the number and therefore it is considered as insignificant and is discarded for that reason. The acceptable method to represent this number is as follows: 0.07 µm

7.2 Values entered in the range fields are not restricted with regard to significant digits however care should be taken to avoid expressing range values to unreasonable levels of precision. When the stated range is the result of conversion from one system of units to another (SI to USC as an example), the resulting stated value will typically require a larger number of significant digits in order to retain numerical equivalence. The number of significant digits to be used in range expressions resulting from conversion shall be no greater than that which produces a stated value or values that will, upon conversion back to the original system of units and rounded appropriately, generate the original value.

7.3 In order to round a number used in stating the range of calibration capability the last digit must be examined. If it is found to be equal to or greater than 6 it is dropped and the preceding digit is increased in value by 1. If on the other hand it is found to be equal to or less than 5 it is dropped and the preceding digit is unchanged. This process is to be repeated as necessary until the desired number of significant digits is obtained.

7.3.1 Example (when it is desired to round to 2 significant digits):

-11.73 mV which contains 4 significant digits the last being equal to or less than 5 therefore it is dropped and the resulting number (below) has 3 significant digits:

-11.7 mV which contains 3 significant the last being equal to or greater than 6 therefore it is dropped and the preceding digit is increased in value by 1. The resulting number has 2 significant digits---12 mV

7.4 Values entered in the CMC fields shall be entered using not more than 2 significant digits. When CMC is expressed as a Relative Uncertainty Equation it is permissible to employ a greater number of significant digits to preserve accuracy during computation of specific CMC values. This is done with the understanding that when the equation is solved for specific values of the variable, the solution will be reduced to not more then 2 significant digits prior to recording the result. When the stated CMC is the result of conversion from one system of units to another (SI to USC as an example), the resulting stated value will typically require a larger number of significant digits in order to retain numerical equivalence. The number of significant digits to be used in CMC expressions resulting from conversion shall be no greater than that which produces a stated value that will, upon conversion back to the original system of units and rounded appropriately, generate the original value.

7.5 The rule for rounding numbers used in stating the CMC is that the 2 digits immediately following the last desired significant digit shall be discarded if they are 5 percent or less of the last desired significant digit. If on the other they exceed 5 percent of the last desired significant digit then the last desired significant digit is increased in value by 1.

7.5.1 See the following examples:

-0.1103 mV rounded to 2 significant digits is 0.11 mV

-0.1104 mV rounded to 2 significant digits is 0.11 mV

-0.1105 mV rounded to 2 significant digits is 0.11 mV

-0.1106 mV rounded to 2 significant digits is 0.12 mV

7.5.2 In the above example, if additional digits exist to the right of the 4th decimal place they are to be eliminated by applying the rules for rounding numbers used in expressing the range (see 7.3.1 above). When only 2 digits remain to the right of the last desired significant digit apply the rules for rounding as stated in 7.5.1 above. If only one digit exist beyond the last desired significant digit and it has a non-zero value then drop it and increase the value of the last desired significant digit by 1.

8.0 CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED

8.1 This field includes pertinent information related to the calibration of the device identified in the Measured Instrument, Quantity or Gauge field. Typical entries would include the type of standards used, reference documents and any pertinent information about the measurement method.

DIMENSIONAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Cylindrical Diameter Outside	0.01 in to 1 in	20 µin	Universal Measuring Machine
	1 in to 5 in	(17.5 + 2.5L) µin	
Cylindrical Diameter Inside	0.04 in to 0.5 in	26 µin	
	0.5 in to 5 in	(24.75 +2.5L) µin	
Protractors	0º to 90º	0.01º	Gage Blocks/Sine Bar
Outside Micrometers	0.05 in to 3 in	(50 + 3L) µin	Gage Blocks
	3 in to 12 in	(59 + 10L) µin	
Gage Blocks	0.05 in to 1 in	3.5 µin	Gage Block Comparator and Master Blocks
	1 in to 2 in	5 µin	
	2 in to 4 in	7.9 µin	
Thread Plugs Pitch Diameter	0-80 to 4-12	140 µin	Measurement over wires with Supermicrometer
Thread Plugs Major Diameter	0-80 to 4-12	67 µin	Supermicrometer
Surface Plate Flatness	10 in to 72 in diagonal	(51 + 1.2D) µin	Autocollimator
Repeat Measurement	0.002 in	60 µin	Repeat-O-Meter

ELECTRICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Equipment to Output DC Voltage	0.3 µV to 200 mV	4.5 µV/V + 0.1 µV	Fluke 8508A
	200 mV to 2 V	3 µV/V + 0.4 µV	
	2 V to 20 V	3 µV/V + 4 µV	
	20 V to 200 V	4.5 µV/V + 40 µV	
	200 V to 1 000 V	4.5 µV/V + 500 µV	
Equipment to Measure DC Voltage	1.2 µV to 220 mV	7.5 µV/V + 0.4 µV	Fluke 5720A
	220 mV to 2.2 mV	5 µV/V+ 0.7 µV	
	2.2 V to 11 V	3.5 µV/V +2.5 µV	
	11 V to 22 V	3.5 µV/V + 4 µV	
	22 V to 220 V	5 µV/V + 40 µV	
	220 V to 1 110 V	6.5 µV/V + 400 µV	
Equipment to measure AC Voltage At the listed frequencies			Fluke 8508A
1 Hz to 10 Hz	211 µV to 200 mV	0.165 mV/V + 70 µV	
10 Hz to 40 Hz	211 µV to 200 mV	0.14 mV/V + 20 µV	

40 Hz to 100 Hz	211 µV to 200 mV	0.115 mV/V + 20 µV	
100 Hz to 2 kHz	211 µV to 200 mV	0.11 mV/V + 10 µV	
2 kHz to 10 kHz	211 µV to 200 mV	0.135 mV/V + 20 µV	
10 kHz to 30 kHz	211 µV to 200 mV	0.34 mV/V + 40 µV	
30 kHz to 100 kHz	211 µV to 200 mV	0.765 mV/V + 0.1 µV	

ELECTRICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Equipment to output AC Voltage At the listed frequencies			Fluke 5520A
10 Hz to 45 Hz	33 mV to 330 mV	0.3 mV/V + 8 µV	
45 Hz to 10 kHz	33 mV to 330 mV	0.15 mV/V + 8 µV	
10 kHz to 20 kHz	33 mV to 330 mV	0.16 mV/V + 8 µV	
20 kHz to 50 kHz	33 mV to 330 mV	0.35 mV/V + 8 µV	
50 kHz to 100 kHz	33 mV to 330 mV	0.8 mV/V + 32 µV	
100 kHz to 500 kHz	33 mV to 330 mV	2 mV/V + 70 µV	
Equipment to Measure Resistance Fixed Points	150 µΩ	40 µΩ	Fluke 5720A
	1 Ω	95 µΩ/Ω	
	1.9 Ω	95 µΩ/Ω	
	10 Ω	23 µΩ/Ω	
	19 Ω	23 µΩ/Ω	
	100 Ω	10 µΩ/Ω	
	10 kΩ	8.5 µΩ/Ω	
	19 kΩ	8.5 µΩ/Ω	
	100 kΩ	11 µΩ/Ω	
	190 kΩ	11 µΩ/Ω	
	1 MΩ	20 µΩ/Ω	
	1.9 MΩ	21 µΩ/Ω	
	10 MΩ	40 µΩ/Ω	
	19 MΩ	47 µΩ/Ω	
	100 MΩ	100 µΩ/Ω	
pH Simulation- Generate	0.5 pH to 14 pH	0.01 pH	ESI DB877
Temperature Calibration, Indication and Control Equipment used with Thermocouple Type B	600 ℃ to 800 ℃	0.44 ℃	Fluke 5520A Electrical Simulation of Thermocouple Output
	800 ℃ to 1 000 ℃	0.34 ℃	
	1 000 ℃ to 1 550 ℃	0.3 ℃	
	1 550 ℃ to 1 820 ℃	0.33 ℃	
Temperature Calibration, Indication and Control Equipment used with Thermocouple Type C	0 ℃ to 150 ℃	0.3 ℃	
	150 ℃ to 650 ℃	0.26 ℃	
	650 ℃ to 1 000 ℃	0.31 ℃	
	1 000 ℃ to 1 800 ℃	0.5 ℃	
	1 800 ℃ to 2 316 ℃	0.84 ℃	

Due to regulatory requirements and Industrial practices, the following alternate format will be used for expressing the range of calibration capability for electrical parameters in the Japanese economy. Alternate formats for other calibration disciplines will be developed on an as needed basis. Although differing in appearance, the information in the range statement must satisfy all requirements of PJLA PL-4 and define the exact same range of calibration capability.

When expressed in this format, the range is to be interpreted as in the following example:

In the **standard format** lines, 1, 2, 3, 4, 5 & 6 each express specific ranges of calibration capability from a minimum value to a maximum value.

In the **alternate format,** line 1 expresses the low end of the first range. Lines 2, 3, 4, 5, 6 & 7 identify the high end of 6 ranges.

The low end of each range in this example is the high end of the previous range.

Interpreted in this manner, the first range in the alternate format would be 1.1 µV to 100 mV, the second range would be 100 mV to 1 V etc.

Examination will indicate that these ranges are exactly equivalent to the first and second ranges in the standard format. The same is true for all remaining ranges.

Care must be taken when applying this alternate format to ensure that as expressed it defines exactly the same range of calibration capabilities as the range when expressed in the standard format.

<table>
<tr><td rowspan="5">Equipment to Output
1
DC Voltage
2

3
Standard format
4

5

6</td><td>1.1 µV to 100 mV</td><td>10.7 µV/V + 1.07 µV</td><td rowspan="5">Agilent 3458A</td></tr>
<tr><td>100 mV to 1 V</td><td>5.86 µV/V + 5.86 µV</td></tr>
<tr><td>1 V to 10 V</td><td>5.59 µV/V + 55.9 µV</td></tr>
<tr><td>10 V to 100 V</td><td>7.93 µV/V + 793 µV</td></tr>
<tr><td>100 V to 1000 V</td><td>21.2 µV/V + 2.12 x 10^{-4} µV</td></tr>
<tr><td rowspan="6">Equipment to Output
1
DC Voltage
2

3
Alternate format
4

5

6

7</td><td>1.1 µV low end of range</td><td></td><td rowspan="6">Agilent 3458A</td></tr>
<tr><td>100 mV</td><td>10.7 µV/V + 1.07 µV</td></tr>
<tr><td>1 V</td><td>5.86 µV/V + 5.86 µV</td></tr>
<tr><td>10 V</td><td>5.59 µV/V + 55.9 µV</td></tr>
<tr><td>100 V</td><td>7.93 µV/V + 793 µV</td></tr>
<tr><td>1000 V</td><td>21.2 µV/V + 2.12 x 10^{-4} µV</td></tr>
</table>

TIME AND FREQUENCY

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Frequency-Generate	50 mHz to 18 GHz	1 part in 10^{11} of Freq. + 1 LSD of generator	GPS Disciplined Oscillator and Signal Generators
Stopwatch Calibration	7 200 s to 28 800 s	0.05 s/day	Timometer

ACOUSTIC

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Acoustic Level-Generate	3.15 Hz	0.11 dB	Pistophone reference standard
	63 Hz, 125 Hz, 250 Hz, 500 Hz	0.10 dB	
	1 kHz, 2 kHz, 4 kHz, 8 kHz	0.10 dB	
	12.5 kHz, 16 kHz	0.11 dB	
Calibration of Acoustic Calibrators 124 dB, re 2 x 10^{-5} Pa	250 Hz	0.05 dB	1 inch reference microphone

MASS, FORCE, AND WEIGHING DEVICES

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Mass-Weights and Weight Sets	50 kg	20 mg	Double Substitution with Air Buoyancy correction. Class E2 mass set and Mass Comparators
	30 kg,	16 mg	
	25 kg	13 mg	
	20 kg	11 mg	
	10 kg	0.49 mg	
	5 kg	0.32 mg	
	3 kg	0.14 mg	
	2 kg	0.13 mg	
	1 kg	0.04 mg	
	500 g	0.027 mg	
	300 g	0.024 mg	
	200 g	0.017 mg	
	100 g	0.017 mg	

	50 g	8.7 µg	
Force –Compression and Tension- Source and Measure	200 lbf to 5 000 lbf	1.2 lbf	Proving Rings and Morehouse Test Stand
	5 000 lbf to 20 000 lbf	4.2 lbf	
	20 000 lbf to 60 000 lbf	14 lbf	
Analytical Balances	1 mg to 200 g	(0.013 + 0.003Wt) mg	Class 1 weights

MECHANICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Pressure- Pneumatic, Gage	0.2 psi to 1 000 psi	0.002 5% of reading	Ruska 2465
Torque Wrenches	45 lbf·in to 450 lbf·in	0.026 lbf·in	Torque Transducer
	74 lbf·ft to 740 lbf·ft	6 lbf·ft	

MECHANICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Indirect Verification of Rockwell Hardness Testers HRA	60 HRA to 70 HRA	0.32 HRA	ASTM E 18 and calibrated Rockwell Hardness Test Blocks
	70 HRA to 80 HRA	0.25 HRA	
	80 HRA to 93 HRA	0.23 HRA	
Indirect Verification of Rockwell Hardness Testers HRC	20 HRC to 40 HRC	0.58 HRC	
	40 HRC to 60 HRC	0.44 HRC	
	60 HRC to 70 HRC	0.41 HRC	
Direct Verification of Durometer Hardness Tester Types A, B, C, D, E, O & DO			ASTM D-2240
Extension at zero reading	2.46 mm to 2.54 mm	7.4 µm	Video Comparator 20x
Indentor Shape (Not all parameters apply to all of Durometer Types)			
Indentor Diameter		7.4 µm	Video Comparator 20x
Indentor Tip Diameter		7.4 µm	Video Comparator 20x
Indentor Tip Radius		7.4 µm	Video Comparator 20x
Indentor Tip Angle		0.06°	Video Comparator 20x
Durometer Indentor Spring			
Types A, B, E & O	0.55 N to 8.05 N	1.4 N	Load Cell
Types C, D & DO	4.445 N to 44.45 N	1.4 N	Load Cell
Indirect Verification of Brinell Hardness Tester	92.5 HBW to 650 HBW	4 HBW	Stage Micrometer ASTM E-10

HBW 10/3000			
Indirect Verification of Micro Hardness Tester Vickers	100 HV to 900 HV	15 HV	Stage Micrometer ASTM E384
Indirect Verification of Micro Hardness Tester Knoop	100 HK to 900 HK	17 HK	

CHEMICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
pH meter/probe calibration	4 pH to 10 pH	0.027 pH	pH Buffer Solutions
Conductivity meter	5 µS to 10 µS	0.47 µS	Conductivity solutions
	10 µS to 100 µS	0.46 µS	
	100 µS to 10 000 µS	3.2 µS	
	10 000 µS to 100 000 µS	320 µS	

THERMODYNAMIC

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Temperature Measurement Thermocouple Type J	-196 °C to -100 °C	0.66 °C	SPRT and Dry Block Fluke 5520A
	-100 °C to 800 °C	0.34 °C	
	800 °C to 1 200 °C	0.55 °C	
Temperature Measurement RTD Pt 395, 100 Ω	100 °C to 300 °C	0.45 °C	SPRT and Dry Block Fluke 5520A
	300 °C to 400 °C	0.39 °C	
	400 °C to 630 °C	0.43 °C	
Equipment to Measure Humidity @ 25 °C	10 % RH to 95 % RH	1 % RH	Two Pressure Humidity Generator

OPTICAL

MEASURED INSTRUMENT, QUANTITY OR GAUGE	RANGE (AND SPECIFICATION WHERE APPROPRIATE)	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)	CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED
Fiber Optics Power 10 nW to 100 µW Fixed Points	850 nm	14 nm	Detector Based
	1 310 nm	21 nm	
	1 550 nm	25 nm	
Fiber Optic Wavelength	600 nm to 1 700 nm	0.2 nm	Spectrum analyzer and intrinsic source

Spectral Radiance- 300 nm to 1 600 nm	(1 x 10^{-9} to 1 x 10^{-5}) Wcm^{-2} sr^{-1} nm^{-1})	5 %	Detector and source based
Spectral Transmission (300 to 1500) nm	10 % to 100 %	3 %	Spectrophotometer
Photometric- Illuminance	10 fcd to 500 fcd	2 % of reading	Detector and source based
Photometric- Luminance	10 fL to 10 000 fL	2 % of reading	
Photometric- Color Temperature	2 000 K to 3 200 K	11 K	

1. The CMC (Calibration and Measurement Capability) stated for calibrations included on this scope of accreditation represent the smallest measurement uncertainties attainable by the organization when performing a more or less routine calibration of a nearly ideal device under nearly ideal conditions. It is expressed at a confidence level of 95 % using a coverage factor *k* (usually equal to 2). The actual measurement uncertainty associated with a specific calibration performed by the organization will typically be larger than the CMC for the same calibration since capability and performance of the device being calibrated and the conditions related to the calibration may reasonably be expected to deviate from ideal to some degree.
2. The term L represents length in inches or millimeters appropriate to the uncertainty statement.
3. The term Wt represents weight in pounds or grams (including SI multiple and submultiple units) appropriate to the uncertainty statement.

APPENDIX B

GUIDELINES FOR THE USE OF SI UNITS FOR THE SCOPE OF ACCREDITATION

The General Conference on Weights and Measures established the International System of Units (SI). It is the modern metric system of measurement used throughout the world. PJLA policy strongly encourages the exclusive use of SI units for stating ranges and CMC(s) on scopes of accreditation. This policy calls for the use of NIST SP 811 and the ISO 31 series of documents for direct guidance on the use of symbols and numbers. NIST SP 811 is a publication that was created to provide assistance to those who use SI units in their work. In order to make scopes of accreditation more accessible to the U.S. market, PJLA does allow the use of USC (US Customary) units of measure. Any scopes with USC units of measure will conform to the formatting of Appendix B of NIST SP811.

It is the responsibility of the client to know and understand the requirements of the SI on their scope of accreditation. The NIST SP 811 is available on the Internet from the NIST website. The ISO 31 series of documents is available for purchase from the ISO website. The cost varies depending on which standards in the series you will need. If you choose to purchase these, we recommend at least acquiring the ISO 13-0, General Principles, and ISO 31-11, Mathematical signs and symbols for use in the physical sciences and technology.

The following pages contain a small sampling of guidelines and examples contained in the NIST SP 811.

Rule:	**Example:**	**Instead Of:**
Only units of the SI and those recognized by the SI are used.	10 m 100 ℃	10 ft 100 ℉
Abbreviations are avoided	s or second cm^3 or cubic centimeter	sec cc
Unit symbols are not modified in order to provide information about the quantity.	V_{max} = 1000 V	V = 1000 V_{max}
The symbol “%” can be used in place of the number 0.01	x_{β} = 0.003 8 = 0.38 %	x_{β} = 0.25 percent
Quantities are to be defined so that they can be expressed solely in acceptable units	The Ca content is 25 ng/L	25 ng Ca/L
Unit and mathematical symbols and names are not mixed	m/s or meter per second	meter/s
Values for quantities are expressed in acceptable units using Arabic numerals and the SI symbols for units	The weight of the box was 35 kg.	The length of the box was thirty-five kilograms.
There is always a space between the quantity and the unit symbol, except when it is a plane angle	189 kg 25 ℃ 357 Ω 24° (plane angle)	189kg 25℃ 357Ω 24 ° (plane angle)

Rule:	**Example:**	**Instead Of:**
A thin space is used to separate digits with more than four per side of a decimal point	123 586 257.004 1	123586257.0041 or 123,586,257.0041
Quantity equations are preferred to numerical value equations	l = vt	$\{l\}_m = 3.6^{-1}\{v\}_{km/h}\,\{t\}_s$
A quotient quantity is expressed using “divided by” instead of “per unit”	Pressure is force divided by area.	Pressure is force per unit area.

GUIDELINES FOR THE USE OF SI UNITS FOR THE SCOPE OF ACCREDITATION

Rule:	Example:	Instead Of:
The terms Normality and Molarity, symbols N and M respectively are obsolete. The preferred name is amount of substance concentration of B.	A solution having an amount of substance concentration of $c[(1/2)H_2SO_4]$	A 0.5 N solution of H_2SO_4
Values of quantities are to be written so that it is clear to which unit symbols the numerical values of the quantities belong.	51 mm x 51 mm x 25 mm	51 x 51 x 25 mm
The word “to” is used to indicate a range of values instead of a dash.	0 V to 5 V	0 V – 5 V

1. The word “weight” is used with the intended meaning clear. In science and technology, weight is defined as a force, for which the SI unit is the Newton. In commerce and everyday use, weight is used as a synonym for mass, for which the SI unit is the kilogram.
2. Standardized quantity symbols given in the ISO 31 series are used. Similarly, standardized mathematical signs and symbols such as those given is ISO 31-11 are used.