



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**VACS Ltd.**  
**15 Regan Road, Unit 6**  
**Brampton, ON L7A 1E3 Canada**  
(and satellite locations as shown on the scope)

Fulfills the requirements of

**ISO/IEC 17025:2017**

and national standard

**ANSI/NCSL Z540-1-1994 (R2002)**

In the field of

**CALIBRATION**

This certificate is valid only when accompanied by a current scope of accreditation document.  
The current scope of accreditation can be verified at [www.anab.org](http://www.anab.org).

Jason Stine, Vice President

Expiry Date: 29 July 2027  
Certificate Number: AC-1402



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.  
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory  
quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017**

**AND**

**ANSI/NCSL Z540-1-1994 (R2002)**

**VACS Ltd.**

15 Regan Road, Unit 6  
Brampton, ON L7A 1E3  
Derek Magee 905-840-7651  
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**CALIBRATION**

ISO/IEC 17025 Accreditation Granted: **29 July 2025**

Certificate Number: **AC-1402** Certificate Expiry Date: **29 July 2027**

**Satellite locations in:**

**Edmonton, AB Canada**

**Burnaby, BC Canada**

## Accredited Services performed at Main Site Laboratory

### VACS Ltd.

15 Regan Road, Unit 6  
Brampton, ON L7A 1E3  
Derek Magee 905-840-7651  
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#### Electrical – DC/Low Frequency

Brampton, ON

| Parameter/Equipment               | Range                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                                    | Reference Standard, Method, and/or Equipment                                                       |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| DC Voltage – Measure <sup>1</sup> | Up to 100 mV<br>(0.1 to 1) V<br>(1 to 10) V<br>(10 to 100) V<br>(100 to 1 000) V                                                                                       | 1.6 $\mu$ V<br>10 $\mu$ V<br>0.3 mV<br>1.6 mV<br>30 mV                                                                                                                                                                                                                                       | Comparison to<br>Agilent 3458A<br>8.5 Digit Multimeter                                             |
| DC Voltage – Source <sup>1</sup>  | Up to 20 mV<br>(20 to 200) mV<br>(0.2 to 2) V<br>(2 to 20) V<br>(20 to 200) V<br>(200 to 1 000) V                                                                      | 6.1 $\mu$ V<br>0.13 mV<br>40 $\mu$ V<br>0.43 mV<br>4.3 mV<br>40 mV                                                                                                                                                                                                                           | Comparison to<br>Fluke 5100B<br>Multifunction Calibrator,<br>Agilent 3458A<br>8.5 Digit Multimeter |
| DC Current – Measure <sup>1</sup> | Up to 100 $\mu$ A<br>(0.1 to 1) mA<br>(1 to 10) mA<br>(10 to 100) mA<br>(0.1 to 1) A                                                                                   | 4.3 nA<br>40 nA<br>0.39 $\mu$ A<br>6.3 $\mu$ A<br>0.19 mA                                                                                                                                                                                                                                    | Comparison to<br>Agilent 3458A<br>8.5 Digit Multimeter                                             |
| DC Current – Source <sup>1</sup>  | Up to 200 $\mu$ A<br>(0.2 to 2) mA<br>(2 to 20) mA<br>(20 to 200) mA<br>(0.2 to 1) A                                                                                   | 30 nA<br>0.18 $\mu$ A<br>2.2 $\mu$ A<br>50 $\mu$ A<br>0.2 mA                                                                                                                                                                                                                                 | Comparison to<br>Fluke 5100B<br>Multifunction Calibrator,<br>Agilent 3458A<br>8.5 Digit Multimeter |
| Resistance – Measure <sup>1</sup> | (1 to 10) $\Omega$<br>(10 to 100) $\Omega$<br>(0.1 to 1) k $\Omega$<br>(1 to 10) k $\Omega$<br>(10 to 100) k $\Omega$<br>(0.1 to 1) M $\Omega$<br>(1 to 10) M $\Omega$ | 16 $\mu\Omega/\Omega$ + 87 $\mu\Omega$<br>19 $\mu\Omega/\Omega$ + 0.25 m $\Omega$<br>10 $\mu\Omega/\Omega$ + 2.1 m $\Omega$<br>11 $\mu\Omega/\Omega$ + 12 m $\Omega$<br>11 $\mu\Omega/\Omega$ + 0.12 $\Omega$<br>22 $\mu\Omega/\Omega$ + 1.2 $\Omega$<br>92 $\mu\Omega/\Omega$ + 23 $\Omega$ | Comparison to<br>Agilent 3458A<br>8.5 Digit Multimeter                                             |

**Electrical – DC/Low Frequency**

Brampton, ON

| Parameter/Equipment                                           | Range                                                                                                                         | Expanded Uncertainty of Measurement (+/-)                                                                                                                                     | Reference Standard, Method, and/or Equipment                           |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Resistance – Source <sup>1</sup><br>(Simulation-Fixed Points) | 1 $\Omega$<br>10 $\Omega$<br>100 $\Omega$<br>1 k $\Omega$<br>10 k $\Omega$<br>100 k $\Omega$<br>1 M $\Omega$<br>10 M $\Omega$ | 0.29 m $\Omega$<br>1.2 m $\Omega$<br>6.3 m $\Omega$<br>60 m $\Omega$<br>0.63 $\Omega$<br>6.1 $\Omega$<br>0.12 k $\Omega$<br>5.9 k $\Omega$                                    | Comparison to<br>Fluke 5100B<br>Multifunction Calibrator<br>(6-months) |
| Resistance – Source <sup>1</sup><br>(Fixed Artifacts)         | 1 $\Omega$<br>10 $\Omega$                                                                                                     | 0.64 m $\Omega$<br>1.2 m $\Omega$                                                                                                                                             | Comparison to<br>GR 1440 Resistors                                     |
| Resistance – Source <sup>1</sup><br>(Fixed Artifacts)         | 100 $\Omega$<br>1 k $\Omega$<br>10 k $\Omega$                                                                                 | 6.5 m $\Omega$<br>62 m $\Omega$<br>0.62 $\Omega$                                                                                                                              | Comparison to<br>Vishay S102K Resistors                                |
| DC Voltage – Measure <sup>1</sup>                             | (-110 to 110) mV<br>(-1 to 1) V<br>(-11 to 11) V<br>(-110 to 110) V<br>(-300 to 300) V                                        | 2.9 mV/V + 17 $\mu$ V<br>2.9 mV/V + 55 $\mu$ V<br>2.9 mV/V + 0.55 mV<br>0.58 mV/V + 5.5 mV<br>0.57 mV/V + 15 mV                                                               | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| DC Voltage – Source <sup>1</sup>                              | (-110 to 110) mV<br>(-1 to 1) V<br>(-15 to 15) V                                                                              | 0.16 mV/V + 5.5 $\mu$ V<br>0.12 mV/V + 55 $\mu$ V<br>0.12 mV/V + 0.75 mV                                                                                                      | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| DC Current – Measure <sup>1</sup>                             | (0 to 22) mA<br>(0 to 30) mA<br>(0 to 110) mA                                                                                 | 0.26 mA/A + 6.6 $\mu$ A<br>0.17 mA/A + 4.5 $\mu$ A<br>0.17 mA/A + 17 $\mu$ A                                                                                                  | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| DC Current – Source <sup>1</sup>                              | (0 to 22) mA                                                                                                                  | 0.17 mA/A + 3.3 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| DC Current – Simulate <sup>1</sup><br>(Loop)                  | (4 to 20) mA                                                                                                                  | 0.26 mA/A + 6.6 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| Resistance – Measure <sup>1</sup>                             | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                        | 0.62 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.58 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.59 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>1.2 $\Omega$ /k $\Omega$ + 10 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator                      |
| Resistance – Source <sup>1</sup>                              | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                        | 0.17 m $\Omega$ / $\Omega$ + 20 m $\Omega$<br>0.15 m $\Omega$ / $\Omega$ + 40 m $\Omega$<br>0.25 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>0.35 $\Omega$ /k $\Omega$ + 5 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator                      |

## Electrical – DC/Low Frequency

Brampton, ON

| Parameter/Equipment                                                                     | Range                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                        | Reference Standard, Method, and/or Equipment |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------|
| Electrical Calibration of Thermocouple Indicating Devices – Source/Measure <sup>1</sup> | Type E<br>(-20 to 1 000) °C<br>Type J<br>(-210 to 1 200) °C<br>Type K<br>(-200 to 1 372) °C<br>Type N<br>(-200 to 1 300) °C<br>Type T<br>(-200 to 1 300) °C<br>Type R, S<br>(0 to 1 767) °C                                                            | 0.3 °C<br>0.3 °C<br>0.4 °C<br>0.6 °C<br>0.4 °C<br>1.1 °C                                         | Comparison to Fluke Process Calibrator       |
| Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup>                   | 100 Ω, Pt 385<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>1 000 Ω, Pt 385<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>100 Ω, Pt 3926<br>(-200 to 0) °C<br>(0 to 630) °C<br>100 Ω, Pt 3916<br>(-200 to 0) °C<br>(0 to 630) °C | 0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.1 °C<br>0.2 °C | Comparison to Fluke Process Calibrator       |
| Resistance Thermometers <sup>1</sup><br>(Artifacts)                                     | (10 to 400) Ω                                                                                                                                                                                                                                          | 6 mΩ                                                                                             | Comparison to Resistance Standards           |

## Length – Dimensional Metrology

Brampton, ON

| Parameter/Equipment               | Range        | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment             |
|-----------------------------------|--------------|-------------------------------------------|----------------------------------------------------------|
| Calipers <sup>1,2</sup>           | (0 to 40) in | (289 + 7.3L) μin                          | Comparison to Gauge Blocks, Micrometer Setting Standards |
| Outside Micrometer <sup>1,2</sup> | (0 to 40) in | (32 + 14L) μin                            | Comparison to Grade 2 Gauge Blocks                       |

**Length – Dimensional Metrology**

Brampton, ON

| Parameter/Equipment                                                                                                            | Range                                                                                                                            | Expanded Uncertainty of Measurement (+/-)                               | Reference Standard, Method, and/or Equipment                                                           |
|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Gauge Blocks, Length Standards <sup>1,2</sup>                                                                                  | Up to 4 in<br>(> 4 to 40) in<br><br>Up to 101.6 mm<br>(> 101.6 to 1 016) mm                                                      | 10 µin<br>(20 + 4L) µin<br><br>0.25 µm<br>(0.51 + 0.1L) µm              | Comparison to<br>Grade 2 Gauge Blocks,<br>Heidenhain MT60,<br>MT2581 Length Gauge,<br>Comparator Stand |
| Length Gauges, Indicators <sup>1</sup><br>1 µin resolution                                                                     | Up to 0.062 5 in<br>Up to 0.125 in<br>Up to 0.2 in<br>Up to 0.25 in<br>Up to 0.3 in<br>Up to 0.5 in<br>Up to 1 in<br>Up to 40 in | 3 µin<br>4 µin<br>6 µin<br>8 µin<br>9 µin<br>15 µin<br>29 µin<br>40 µin | Comparison to<br>Grade 2 Gage Blocks,<br>Micrometer Rods<br>Comparator Stand                           |
| Length Gauges, Indicators <sup>1</sup><br>(Mounted in stands or custom fixtures)<br>500 µin resolution<br>1 000 µin resolution | Up to 40 in<br>Up to 40 in                                                                                                       | 335 µin<br>600 µin                                                      | Comparison to<br>Grade 2 Gauge Blocks,<br>Micrometer Rods,<br>Comparator Stand                         |
| Measuring Microscope <sup>1,2,5</sup><br>X-Y-Z Length                                                                          | Up to 300 mm                                                                                                                     | 2 µm or (0.4 + 0.064L) µm                                               | Comparison to<br>Glass Stage Micrometers,<br>Stage Micrometers                                         |
| Displacement Transducer <sup>1</sup>                                                                                           | Up to 5 in<br>(5 to 40) in                                                                                                       | 600 µin<br>0.1 % of reading                                             | Comparison to<br>Height Gauge                                                                          |
| Optical Comparators, Vision Systems <sup>1,2,5</sup><br>X-Y-Z Length                                                           | Up to 300 mm                                                                                                                     | 2 µm or (0.4 + 0.064L) µm                                               | Comparison to<br>Glass Stage Micrometers                                                               |
| Angle                                                                                                                          | Up to 90°                                                                                                                        | 0.5'                                                                    | Angle Blocks                                                                                           |
| Material Testing Machine <sup>1,2</sup><br>Displacement                                                                        | (0.01 to 0.4) in<br>(0.4 to 40) in                                                                                               | 600 µin<br>(600 + 200L) µin                                             | ASTM E2309;<br>Height Gauge,<br>MT25B Heidenhain<br>Length Gauge;                                      |
| Speed                                                                                                                          | (0.01 to 20) in/min                                                                                                              | 0.5 % of reading                                                        | ASTM E2658; Timer                                                                                      |

## Length – Dimensional Metrology

Brampton, ON

| Parameter/Equipment                                                 | Range                                                                                                                                                                                               | Expanded Uncertainty of Measurement (+/-)                                                                                                       | Reference Standard, Method, and/or Equipment                            |
|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Extensometer, Type 1<br>Strain <sup>1,2</sup>                       | Gauge length of 0.5 in:<br>(0.06 to 1) in/in<br>(0.002 to 0.06) in/in<br>Gauge length of 1 in :<br>(0.025 to 1) in/in<br>(0.001 to 0.025) in/in<br>Gauge length of 2 in :<br>(0.000 5 to 0.5) in/in | $(64 + 715L) \mu\text{in/in}$<br>88 $\mu\text{in/in}$<br>$(27 + 300L) \mu\text{in/in}$<br>40 $\mu\text{in/in}$<br>$(17 + 126L) \mu\text{in/in}$ | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                       |
| Extensometer, Type 1<br>Gauge Length <sup>1</sup>                   | (0.5 to 2) in                                                                                                                                                                                       | 400 $\mu\text{in}$                                                                                                                              | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                       |
| Torque Drive Arms <sup>1</sup><br>(2-point Dimensional Measurement) | (1 to 60) in                                                                                                                                                                                        | 0.1 % of arm length                                                                                                                             | Comparison to<br>Height Gauge,<br>60 in Steel Rule,<br>Length Standards |
| Protractors, Inclinometers <sup>2</sup>                             | Up to 90°                                                                                                                                                                                           | 0.5'                                                                                                                                            | Comparison to<br>Angle Blocks,<br>Surface Plate                         |
| Stage Micrometers                                                   | Up to 50 mm<br>(> 50 to 300) mm                                                                                                                                                                     | 2 $\mu\text{m}$<br>$(0.4 + 0.064L) \mu\text{m}$                                                                                                 | Comparison to<br>Heidenhain Length Gauge                                |
| Length Scale,<br>Ruler <sup>2,5</sup>                               | Up to 1 500 mm                                                                                                                                                                                      | 3 $\mu\text{m}$ or 0.01 % of reading                                                                                                            | Comparison to<br>Glass Stage Micrometers                                |
| Tape Measure                                                        | Up to 25 ft plus                                                                                                                                                                                    | 0.02 in/5 ft                                                                                                                                    | Comparison to<br>Steel Rule                                             |

## Mass and Mass Related

Brampton, ON

| Parameter/Equipment                                                        | Range                                   | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                     |
|----------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------|
| Aircraft Wheel Scales <sup>1</sup>                                         | (1 to 100 000) lbf                      | 0.05 % of reading                         | Comparison to<br>Dead Weight Machine,<br>Loading Weights,<br>Secondary Standards |
| Force Testing Machines,<br>Force Measuring Systems <sup>1</sup><br>Tension | 1 gf to 471 kgf<br>(1 to 500 000) lbf   | 0.25 % of reading                         | Loading Weights,<br>Reference Standard<br>Load Cells;<br>ASTM E4,<br>ISO 7500-1  |
| Compression                                                                | 1 gf to 471 kgf<br>(1 to 2 000 000) lbf | 0.25 % of reading                         |                                                                                  |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                                                                                    | Range                                                                                                    | Expanded Uncertainty of Measurement (+/-)                                                                            | Reference Standard, Method, and/or Equipment                                                                                                 |
|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Load Cells <sup>1</sup>                                                                                | 1 gf to 471 kgf                                                                                          | 0.005 % of reading                                                                                                   | Loading Weights;<br>ASTM E74 and ISO 376                                                                                                     |
| Force Gages,<br>Crane Scales,<br>Dynamometers,<br>Load Cells <sup>1</sup><br>(Tension and Compression) | (10 to 1 040) lbf<br>(1 000 to 500 000) lbf<br>(500 000 to 1 000 000) lbf                                | 0.01 % of reading<br>0.05 % of reading<br>0.25 % of reading                                                          | Dead Weight Machine,<br>Calibration Load Frames<br>with Secondary Standards;<br>ASTM E74 and ISO 376                                         |
| Analytical Balances <sup>1,3</sup>                                                                     | Up to 10 g<br>(10 to 200) g<br>200 g to 35 kg<br>200 g to 220 kg                                         | 60 µg<br>0.12 mg<br>0.000 25 % of reading<br>0.000 2 % of reading                                                    | ASTM E617 Class 1,<br>OIML Class F1, NIST<br>Class F Weights and NIST<br>Handbook 44 utilized for<br>calibration of the<br>weighting system. |
| Conventional Mass <sup>1</sup><br>(non-integral weights) (SI)                                          | (1 to 100) kg                                                                                            | 0.003 % of reading                                                                                                   | Electronic Balances,<br>ASTM E617<br>Class 1 Weights;<br>Comparative Method                                                                  |
| Conventional Mass <sup>1</sup><br>(Avoirdupois)                                                        | (0.01 to 0.05) lb<br>(0.05 to 5) lb<br>(5 to 220) lb                                                     | 23 mg/lb<br>4.5 mg/lb<br>14 mg/lb                                                                                    | Electronic Balances,<br>OIML Class F1 Weights;<br>Comparative Method                                                                         |
| Conventional Mass <sup>1</sup><br>(SI)                                                                 | 1 mg<br>2 mg<br>3 mg<br>5 mg<br>10 mg<br>20 mg<br>30 mg<br>50 mg<br>100 mg<br>200 mg<br>300 mg<br>500 mg | 8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg<br>8.8 µg | Electronic Balances,<br>ASTM E617 Class 0 and<br>Class 1 Weights;<br>Comparative Method                                                      |

## Mass and Mass Related

Brampton, ON

| Parameter/Equipment                                  | Range                                                                                                                                                   | Expanded Uncertainty of Measurement (+/-)                                                                                                                                  | Reference Standard, Method, and/or Equipment                                            |
|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Conventional Mass <sup>1</sup><br>(SI)               | 1 g<br>2 g<br>3 g<br>5 g<br>10 g<br>20 g<br>30 g<br>50 g<br>100 g<br>200 g<br>300 g<br>500 g<br>1 kg<br>2 kg<br>3 kg<br>5 kg<br>10 kg<br>20 kg<br>30 kg | 10 µg<br>11 µg<br>23 µg<br>23 µg<br>44 µg<br>39 µg<br>50 µg<br>50 µg<br>68 µg<br>0.28 mg<br>1.3 mg<br>1.3 mg<br>1.5 mg<br>5 mg<br>5 mg<br>30 mg<br>50 mg<br>70 mg<br>0.1 g | Electronic Balances,<br>ASTM E617 Class 0 and<br>Class 1 Weights;<br>Comparative Method |
| Deadweight Testers                                   |                                                                                                                                                         |                                                                                                                                                                            |                                                                                         |
| Effective Area                                       | (0.01 to 0.5) in <sup>2</sup>                                                                                                                           | 0.033 % of reading                                                                                                                                                         | Ametek DWT<br>(PK-854, HK-1000, R-50)                                                   |
| Dead Weights                                         | (0.01 to 10) lb                                                                                                                                         | 0.005 % of reading                                                                                                                                                         | Electronic Balance,<br>ASTM E617<br>Class 1 Weights;<br>Comparative Method              |
| Pressure Calibrators <sup>1</sup>                    | (2 to 854) inH <sub>2</sub> O<br>(30 to 1 000) psig<br>(1 000 to 10 000) psig                                                                           | 0.033 % of reading<br>0.014 % of reading<br>0.033 % of reading                                                                                                             | Comparison to<br>Ametek DWT<br>(PK-854, HK-1000, R-50)                                  |
| Pressure Indicators,<br>Pressure Gauges <sup>1</sup> | Up to 10 inH <sub>2</sub> O<br>(10 to 854) inH <sub>2</sub> O<br>(10 to 10 000) psig                                                                    | 0.005 inH <sub>2</sub> O<br>0.033 % of reading<br>0.015 % of reading                                                                                                       | Comparison to<br>Ametek DWT<br>(PK-854, HK-1000, R-50)                                  |
| Vacuum Devices <sup>1</sup>                          | Up to 28 inHg                                                                                                                                           | 0.042 inHg                                                                                                                                                                 | Comparison to<br>MKS 270B Signal<br>Conditioner with<br>MKS 390HA/270<br>Vacuum Gauge   |
| Absolute Pressure <sup>1</sup>                       | 0 torr                                                                                                                                                  | 0.000 1 % of reading                                                                                                                                                       | Comparison to<br>MKS PVS-6/Ion Gauge                                                    |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                                                                            | Range                                                                                                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                     | Reference Standard, Method, and/or Equipment                                      |
|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Absolute Pressure <sup>1</sup>                                                                 | (1 to 1 000) torr                                                                                                                                                                                                                                                                                                                      | 0.08 % of reading                                                                                                                                                                                                                             | Comparison to<br>MKS 390HA/270<br>Vacuum Gauge                                    |
| Torque Testers, Analyzers,<br>Transducers <sup>1</sup>                                         | (0.1 to 36) lbf·in<br>(40 to 300) lbf·in<br>(22 to 651) lbf·ft                                                                                                                                                                                                                                                                         | 0.19 % of reading<br>0.19 % of reading<br>0.19 % of reading                                                                                                                                                                                   | ASTM E2428;<br>Torque Arms,<br>Loading Weights                                    |
| Torque Wrenches <sup>1</sup>                                                                   | (0.1 to 36) lbf·in<br>(40 to 300) lbf·in<br>(22 to 651) lbf·ft                                                                                                                                                                                                                                                                         | 0.75 % of reading<br>0.75 % of reading<br>0.75 % of reading                                                                                                                                                                                   | ASTM E2624;<br>Torque Testers                                                     |
| Direct Verification of<br>Hardness Testing Machines <sup>1</sup><br>Verification of Test Force | (1 to 3 000) kgf                                                                                                                                                                                                                                                                                                                       | 0.25 % of reading                                                                                                                                                                                                                             | ASTM E10, ASTM E18,<br>ASTM E92, ASTM E384<br>Working Force Standards             |
| Verification of the Indentation<br>Measuring System                                            | (0.01 to 5) mm                                                                                                                                                                                                                                                                                                                         | 1 µm                                                                                                                                                                                                                                          | Stage Micrometer                                                                  |
| Deflection Measuring System                                                                    | (0.025 to 0.05) mm                                                                                                                                                                                                                                                                                                                     | 0.1 µm                                                                                                                                                                                                                                        | Gauge Blocks                                                                      |
| Rockwell Hardness Testers <sup>1</sup>                                                         | (< 70) HRA<br>(≥ 70 and < 80) HRA<br>(≥ 80) HRA<br><br>(< 60) HRBW<br>(≥ 60 to < 88) HRBW<br>(≥ 88) HRBW<br><br>(< 35) HRC<br>(≥ 35 to < 60) HRC<br>(≥ 60) HRC<br><br>(< 51) HRD<br>(≥ 51 to < 71) HRD<br>(≥ 71) HRD<br><br>(< 84) HREW<br>(≥ 84 to < 93) HREW<br>(≥ 93) HREW<br><br>(< 80) HRFW<br>(≥ 80 to < 94) HRFW<br>(≥ 94) HRFW | 0.28 HRA<br>0.17 HRA<br>0.16 HRA<br><br>1.4 HRBW<br>0.87 HRBW<br>0.42 HRBW<br><br>0.4 HRC<br>0.36 HRC<br>0.32 HRC<br><br>0.27 HRD<br>0.26 HRD<br>0.18 HRD<br><br>0.54 HREW<br>0.54 HREW<br>0.54 HREW<br><br>0.54 HRFW<br>0.4 HRFW<br>0.4 HRFW | Indirect verification per<br>ASTM E18, ASTM E110<br>using Rockwell<br>Test Blocks |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                                | Range                | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Hardness Testers <sup>1</sup>             | (< 55) HRGW          | 0.76 HRGW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 55 to < 80) HRGW  | 0.36 HRGW                                 |                                                                          |
|                                                    | (≥ 80) HRGW          | 0.36 HRGW                                 |                                                                          |
|                                                    | (< 96) HRHW          | 0.54 HRHW                                 |                                                                          |
|                                                    | (≥ 96) HRHW          | 0.41 HRHW                                 |                                                                          |
|                                                    | (< 65) HRKW          | 0.64 HRKW                                 |                                                                          |
|                                                    | (≥ 65 to < 85) HRKW  | 0.4 HRKW                                  |                                                                          |
|                                                    | (≥ 85) HRKW          | 0.4 HRKW                                  |                                                                          |
|                                                    | (90 to 114) HRLW     | 0.36 HRLW                                 |                                                                          |
|                                                    | (115 to 130) HRL W   | 0.36 HRLW                                 |                                                                          |
| Rockwell Superficial Hardness Testers <sup>1</sup> | (70 to 99) HRMW      | 0.56 HRMW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (100 to 130) HRMW    | 0.56 HRMW                                 |                                                                          |
|                                                    | (40 to 84) HRPW      | 0.91 HRPW                                 |                                                                          |
|                                                    | (85 to 130) HRPW     | 0.65 HRPW                                 |                                                                          |
|                                                    | (100 to 119) HRRW    | 0.41 HRRW                                 |                                                                          |
|                                                    | (120 to 130) HRRW    | 0.24 HRRW                                 |                                                                          |
|                                                    | (110 to 111) HRSW    | 0.95 HRSW                                 |                                                                          |
|                                                    | (112 to 130) HRSW    | 0.2 HRSW                                  |                                                                          |
|                                                    | (80 to 103) HRVW     | 0.95 HRVW                                 |                                                                          |
|                                                    | (104 to 130) HRVW    | 0.2 HRVW                                  |                                                                          |
|                                                    | (< 78) HR15N         | 0.39 HR15N                                |                                                                          |
|                                                    | (≥ 78 to < 90) HR15N | 0.19 HR15N                                |                                                                          |
|                                                    | (≥ 90) HR15N         | 0.19 HR15N                                |                                                                          |
|                                                    | (< 55) HR30N         | 0.55 HR30N                                |                                                                          |
|                                                    | (≥ 55 to < 77) HR30N | 0.28 HR30N                                |                                                                          |
|                                                    | (≥ 77) HR30N         | 0.28 HR30N                                |                                                                          |
|                                                    | (< 37) HR45N         | 0.43 HR45N                                |                                                                          |
|                                                    | (≥ 37 to < 66) HR45N | 0.22 HR45N                                |                                                                          |
|                                                    | (≥ 66) HR45N         | 0.19 HR45N                                |                                                                          |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                                | Range                 | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|-----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Superficial Hardness Testers <sup>1</sup> | (< 81) HR15TW         | 0.37 HR15TW                               | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 81 to < 87) HR15TW | 0.21 HR15TW                               |                                                                          |
|                                                    | (≥ 87) HR15TW         | 0.21 HR15TW                               |                                                                          |
|                                                    | (< 57) HR30TW         | 0.9 HR30TW                                |                                                                          |
|                                                    | (≥ 57 to < 70) HR30TW | 0.66 HR30TW                               |                                                                          |
|                                                    | (≥ 70) HR30TW         | 0.39 HR30TW                               |                                                                          |
|                                                    | (< 33) HR45TW         | 0.73 HR45TW                               |                                                                          |
|                                                    | (≥ 33 to < 53) HR45TW | 0.41 HR45TW                               |                                                                          |
|                                                    | (≥ 53) HR45TW         | 0.41 HR45TW                               |                                                                          |
|                                                    | (80 to 88) HR15WW     | 0.67 HR15WW                               |                                                                          |
|                                                    | (89 to 100) HR15WW    | 0.67 HR15WW                               |                                                                          |
|                                                    | (40 to 64) HR30WW     | 0.9 HR30WW                                |                                                                          |
|                                                    | (65 to 100) HR30WW    | 0.76 HR30WW                               |                                                                          |
|                                                    | (10 to 47) HR45WW     | 0.3 HR45WW                                |                                                                          |
|                                                    | (48 to 100) HR45WW    | 0.13 HR45WW                               |                                                                          |
|                                                    | (80 to 87) HR15XW     | 0.62 HR15XW                               |                                                                          |
|                                                    | (88 to 100) HR15XW    | 0.33 HR15XW                               |                                                                          |
|                                                    | (60 to 78) HR30XW     | 0.99 HR30XW                               |                                                                          |
|                                                    | (79 to 100) HR30XW    | 0.15 HR30XW                               |                                                                          |
|                                                    | (40 to 68) HR45XW     | 0.81 HR45XW                               |                                                                          |
|                                                    | (69 to 100) HR45XW    | 0.35 HR45XW                               |                                                                          |
|                                                    | (85 to 93) HR15YW     | 1.3 HR15YW                                |                                                                          |
|                                                    | (94 to 100) HR15YW    | 0.63 HR15YW                               |                                                                          |
|                                                    | (60 to 87) HR30YW     | 0.82 HR30YW                               |                                                                          |
|                                                    | (88 to 100) HR30YW    | 0.37 HR30YW                               |                                                                          |
|                                                    | (60 to 81) HR45YW     | 0.94 HR45YW                               |                                                                          |
|                                                    | (82 to 100) HR45YW    | 0.3 HR45YW                                |                                                                          |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                   | Range                                             | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|---------------------------------------|---------------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------|
| Brinell Hardness Testers <sup>1</sup> | 1/62.5<br>(200 to 400) HBW<br>(400 to 600) HBW    | 9.5 HBW<br>25 HBW                         | Indirect verification per ASTM E10 using Brinell Test Blocks and Brinell Scope |
|                                       | 2.5/187.5<br>(200 to 400) HBW<br>(400 to 600) HBW | 6.2 HBW<br>15 HBW                         |                                                                                |
|                                       | 10/500<br>(20 to 100) HBW<br>(100 to 150) HBW     | 1 HBW<br>1.5 HBW                          |                                                                                |
|                                       | 5/1 000<br>(200 to 400) HBW<br>(400 to 600) HBW   | 4 HBW<br>8 HBW                            |                                                                                |
|                                       | 10/1 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 3.3 HBW<br>7 HBW                          |                                                                                |
|                                       | 10/1 500<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2.7 HBW<br>6.5 HBW                        |                                                                                |
|                                       | 10/2 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2.2 HBW<br>5.2 HBW                        |                                                                                |
|                                       | 10/2 500<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2 HBW<br>4.4 HBW                          |                                                                                |
|                                       | 10/3 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 1.9 HBW<br>4.9 HBW                        |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |
|                                       |                                                   |                                           |                                                                                |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                              | Range    | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|--------------------------------------------------|----------|-------------------------------------------|--------------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf | HV 1     |                                           | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                  | 200 HV   | 4.1 HV                                    |                                                                                |
|                                                  | 400 HV   | 8 HV                                      |                                                                                |
|                                                  | 700 HV   | 18 HV                                     |                                                                                |
|                                                  | HV 2     |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 8 HV                                      |                                                                                |
|                                                  | 700 HV   | 14 HV                                     |                                                                                |
|                                                  | HV 5     |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 6 HV                                      |                                                                                |
|                                                  | 700 HV   | 11 HV                                     |                                                                                |
|                                                  | HV 10    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 6 HV                                      |                                                                                |
|                                                  | 700 HV   | 11 HV                                     |                                                                                |
|                                                  | HV 20    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 6 HV                                      |                                                                                |
|                                                  | 700 HV   | 11 HV                                     |                                                                                |
|                                                  | HV 30    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 4 HV                                      |                                                                                |
|                                                  | 700 HV   | 7 HV                                      |                                                                                |
|                                                  | HV 50    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 4 HV                                      |                                                                                |
|                                                  | 700 HV   | 7 HV                                      |                                                                                |
|                                                  | HV 0.01  |                                           |                                                                                |
|                                                  | 200 HV   | 10 HV                                     |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |
|                                                  | HV 0.025 |                                           |                                                                                |
|                                                  | 200 HV   | 10 HV                                     |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |

**Mass and Mass Related**

Brampton, ON

| Parameter/Equipment                                      | Range    | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|----------------------------------------------------------|----------|-------------------------------------------|--------------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf         | HV 0.05  |                                           | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                          | 200 HV   | 10 HV                                     |                                                                                |
|                                                          | 400 HV   | 20 HV                                     |                                                                                |
|                                                          | 700 HV   | 35 HV                                     |                                                                                |
|                                                          | HV 0.1   |                                           |                                                                                |
|                                                          | 200 HV   | 8 HV                                      |                                                                                |
|                                                          | 400 HV   | 20 HV                                     |                                                                                |
|                                                          | 700 HV   | 35 HV                                     |                                                                                |
|                                                          | HV 0.2   |                                           |                                                                                |
|                                                          | 200 HV   | 8 HV                                      |                                                                                |
|                                                          | 400 HV   | 18 HV                                     |                                                                                |
|                                                          | 700 HV   | 35 HV                                     |                                                                                |
|                                                          | HV 0.3   |                                           |                                                                                |
|                                                          | 200 HV   | 5 HV                                      |                                                                                |
|                                                          | 400 HV   | 14 HV                                     |                                                                                |
|                                                          | 700 HV   | 24 HV                                     |                                                                                |
| Vickers Hardness Testers <sup>1</sup><br>< 1 kgf         | HV 0.5   |                                           | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                          | 200 HV   | 5 HV                                      |                                                                                |
|                                                          | 400 HV   | 12 HV                                     |                                                                                |
|                                                          | 700 HV   | 24 HV                                     |                                                                                |
|                                                          | HV 1     |                                           |                                                                                |
|                                                          | 200 HV   | 4 HV                                      |                                                                                |
| Knoop Micro-Indentation<br>Hardness Testers <sup>1</sup> | 200 HV   | 8 HV                                      | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                          | 400 HV   | 17 HV                                     |                                                                                |
|                                                          | 700 HV   |                                           |                                                                                |
|                                                          | HK 0.01  |                                           |                                                                                |
|                                                          | 200 HK   | 7 HK                                      |                                                                                |
|                                                          | 400 HK   | 16 HK                                     |                                                                                |
|                                                          | 700 HK   | 33 HK                                     |                                                                                |
|                                                          | HK 0.025 |                                           |                                                                                |
|                                                          | 200 HK   | 7 HK                                      |                                                                                |
|                                                          | 400 HK   | 14 HK                                     |                                                                                |
|                                                          | 700 HK   | 22 HK                                     |                                                                                |
|                                                          | HK 0.05  |                                           |                                                                                |
|                                                          | 200 HK   | 7 HK                                      |                                                                                |
|                                                          | 400 HK   | 14 HK                                     |                                                                                |
|                                                          | 700 HK   | 20 HK                                     |                                                                                |
|                                                          | HK 0.1   |                                           |                                                                                |
|                                                          | 200 HK   | 7 HK                                      |                                                                                |
|                                                          | 400 HK   | 12 HK                                     |                                                                                |
|                                                          | 700 HK   | 19 HK                                     |                                                                                |

## Mass and Mass Related

Brampton, ON

| Parameter/Equipment                                                                                                                               | Range                                                                                      | Expanded Uncertainty of Measurement (+/-)      | Reference Standard, Method, and/or Equipment                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Knoop Micro-Indentation Hardness Testers <sup>1</sup>                                                                                             | HK 0.2 and 0.3<br>200 HK<br>400 HK<br>700 HK<br>HK 0.5 and 1<br>200 HK<br>400 HK<br>700 HK | 5 HK<br>8 HK<br>17 HK<br>5 HK<br>7 HK<br>15 HK | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks                                   |
| Leeb Hardness Tester <sup>1</sup>                                                                                                                 | (600 to 670) LD                                                                            | 9 LD                                           | Indirect verification per ASTM A956 using Hardness Test Blocks                                             |
| Durometer <sup>1</sup><br>(Types A, B, C, D, DO, E, M, O, OO)<br>Force<br>Indenter Dimensions<br>Length<br>Angle<br>Radius<br>Indenter Deflection | Up to 44.5 N<br>Up to 3.57 mm<br>Up to 35°<br>Up to 0.51 mm<br>Up to 3.57 mm               | 0.06 N<br>10 µm<br>0.066°<br>10 µm<br>2.3 µm   | Direct Verification per ASTM D2240 using Balance<br><br>Optical Comparator<br><br>Gauge Blocks, Transducer |

## Thermodynamic

Brampton, ON

| Parameter/Equipment               | Range           | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                |
|-----------------------------------|-----------------|-------------------------------------------|-----------------------------------------------------------------------------|
| Temperature – Source <sup>1</sup> | 0 °C            | 0.01 °C                                   | Comparison to Ice Bath, Secondary Standard PRT, Instrulab 4312A Thermometer |
| Temperature – Source <sup>1</sup> | (-80 to 200) °C | 0.05 °C                                   | Comparison to Baths, Secondary Standard PRT, Instrulab 4312A Thermometer    |

**Thermodynamic**

Brampton, ON

| Parameter/Equipment                       | Range             | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                                                    |
|-------------------------------------------|-------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Temperature – Source <sup>1</sup>         | (50 to 660) °C    | 0.5 °C                                    | Comparison to Dry Block, Standard PRT, Instrulab 4312A Thermometer                                              |
| Temperature – Measure <sup>1</sup>        | (-196 to 660) °C  | 0.05 °C                                   | Comparison to Secondary Standard PRT, Instrulab 4312A Thermometer                                               |
| Temperature – Measure <sup>1</sup>        | (660 to 1 200) °C | 5.5 °C                                    | Comparison to Type N Thermocouple Probe, Fluke 744 Process Calibrator                                           |
| Dry-well Calibrators <sup>1</sup>         | (-196 to 660) °C  | 0.1 °C                                    | Comparison to Secondary Standard PRT, Instrulab 4312A Thermometer                                               |
| PRT/RTD Probes <sup>1</sup>               | (-80 to 660) °C   | 0.1 °C                                    | Comparison to Ice Bath, Liquid Baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer |
| Thermocouple Probes <sup>1</sup>          | (-78 to 660) °C   | 0.5 °C                                    | Comparison to Ice Bath, Liquid baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer |
| Liquid-in-Glass Thermometers <sup>1</sup> | (-78 to 200) °C   | 0.1 °C                                    | Comparisons to Ice Bath, Liquid baths, Secondary Standard PRT, Instrulab 4312A Thermometer                      |

## Thermodynamic

Brampton, ON

| Parameter/Equipment                                       | Range                                                            | Expanded Uncertainty of Measurement (+/-)                         | Reference Standard, Method, and/or Equipment                                                                              |
|-----------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Radiation (Infrared) Thermometers <sup>1</sup>            | 0 °C<br>100 °C<br>200 °C<br>300 °C<br>400 °C<br>500 °C           | 0.34 °C<br>0.7 °C<br>1.1 °C<br>1.3 °C<br>1.7 °C<br>2 °C           | Radiometric Method using Blackbody Calibrator (Flat Plate)<br>$\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$ |
| Radiation (Infrared) Thermometer Calibrators <sup>1</sup> | 0 °C<br>100 °C<br>200 °C<br>300 °C<br>400 °C<br>500 °C<br>600 °C | 0.34 °C<br>0.6 °C<br>1 °C<br>1.1 °C<br>1.6 °C<br>1.7 °C<br>1.8 °C | Radiometric Method using Heitronics KT19.82 Reference Radiation Thermometer                                               |
| Humidity – Source <sup>1</sup>                            | 11 %RH<br>33 %RH<br>57 %RH<br>75 %RH<br>90 %RH                   | 0.75 %RH<br>0.75 %RH<br>0.75 %RH<br>0.75 %RH<br>0.75 %RH          | Comparison to Custom Humidity Chamber, Salts, Vaisala Humidity Transmitter                                                |

## Time and Frequency

Brampton, ON

| Parameter/Equipment              | Range                           | Expanded Uncertainty of Measurement (+/-)          | Reference Standard, Method, and/or Equipment     |
|----------------------------------|---------------------------------|----------------------------------------------------|--------------------------------------------------|
| Timers <sup>1</sup>              | 1 min to 24 h                   | 0.25 s                                             | Comparison to NRC Time Signal                    |
| Frequency – Measure <sup>1</sup> | (1 to 40) Hz<br>40 Hz to 10 MHz | 0.81 mHz/Hz + 0.83 mHz<br>0.16 mHz/Hz + 6.5 mHz/Hz | Comparison to Agilent 3458A 8.5 Digit Multimeter |
| Frequency – Source <sup>1</sup>  | 1 Hz to 10 MHz                  | 0.12 mHz/Hz + 0.62 mHz                             | Comparison to RIGOL DG 1022 Generator            |

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## Accredited Services performed at Satellite Laboratory

### VACS Ltd.

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Edmonton, AB T6B 2Z7  
Justin Jacobs 780-699-7712  
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#### Electrical – DC/Low Frequency

Edmonton, AB

| Parameter/Equipment                                                                           | Range                                                                                                                       | Expanded Uncertainty of Measurement (+/-)                                                                                                                                     | Reference Standard, Method, and/or Equipment      |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| DC Voltage – Measure <sup>1</sup>                                                             | (-110 to 110) mV<br>(-1 to 1) V<br>(-11 to 11) V<br>(-110 to 110) V<br>(-300 to 300) V                                      | 2.9 mV/V + 17 $\mu$ V<br>2.9 mV/V + 55 $\mu$ V<br>2.9 mV/V + 0.55 mV<br>0.58 mV/V + 5.5 mV<br>0.57 mV/V + 15 mV                                                               | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Voltage – Source <sup>1</sup>                                                              | (-110 to 110) mV<br>(-1 to 1) V<br>(-15 to 15) V                                                                            | 0.16 mV/V + 5.5 $\mu$ V<br>0.12 mV/V + 55 $\mu$ V<br>0.12 mV/V + 0.75 mV                                                                                                      | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Measure <sup>1</sup>                                                             | (0 to 22) mA<br>(0 to 30) mA<br>(0 to 110) mA                                                                               | 0.26 mA/A + 6.6 $\mu$ A<br>0.17 mA/A + 4.5 $\mu$ A<br>0.17 mA/A + 17 $\mu$ A                                                                                                  | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Source <sup>1</sup>                                                              | (0 to 22) mA                                                                                                                | 0.17 mA/A + 3.3 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Simulate <sup>1</sup><br>(Loop)                                                  | (4 to 20) mA                                                                                                                | 0.26 mA/A + 6.6 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Resistance – Measure <sup>1</sup>                                                             | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                      | 0.62 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.58 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.59 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>1.2 $\Omega$ /k $\Omega$ + 10 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Resistance – Source <sup>1</sup>                                                              | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                      | 0.17 m $\Omega$ / $\Omega$ + 20 m $\Omega$<br>0.15 m $\Omega$ / $\Omega$ + 40 m $\Omega$<br>0.25 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>0.35 $\Omega$ /k $\Omega$ + 5 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Electrical Calibration of<br>Thermocouple Indicating<br>Devices – Source/Measure <sup>1</sup> | Type E<br>(-20 to 1 000) °C<br>Type J<br>(-210 to 1 200) °C<br>Type K<br>(-200 to 1 372) °C<br>Type N<br>(-200 to 1 300) °C | 0.3 °C<br>0.3 °C<br>0.4 °C<br>0.6 °C                                                                                                                                          | Comparison to<br>Fluke 743B<br>Process Calibrator |

This Scope of Accreditation, version 014, was last updated on: 30 September 2026 and is valid only when accompanied by the Certificate.

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## Electrical – DC/Low Frequency

Edmonton, AB

| Parameter/Equipment                                                                     | Range                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                        | Reference Standard, Method, and/or Equipment |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------|
| Electrical Calibration of Thermocouple Indicating Devices – Source/Measure <sup>1</sup> | Type T<br>(-200 to 1 300) °C<br>Type R<br>(0 to 1 767) °C<br>Type S<br>(0 to 1 767) °C                                                                                                                                                                 | 0.4 °C<br>1.1 °C<br>1.1 °C                                                                       | Comparison to Fluke 743B Process Calibrator  |
| Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup>                   | Pt 385, 100 Ω<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>Pt 385, 1 000 Ω<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>Pt 3926, 100 Ω<br>(-200 to 0) °C<br>(0 to 630) °C<br>Pt 3916, 100 Ω<br>(-200 to 0) °C<br>(0 to 630) °C | 0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.1 °C<br>0.2 °C | Comparison to Fluke 743B Process Calibrator  |

## Length – Dimensional Metrology

Edmonton, AB

| Parameter/Equipment               | Range                      | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                     |
|-----------------------------------|----------------------------|-------------------------------------------|------------------------------------------------------------------|
| Calipers <sup>1,2</sup>           | (0 to 40) in               | $(289 + 7.3L) \mu\text{in}$               | Comparison to Gauge Blocks, Micrometer Setting Standards         |
| Outside Micrometer <sup>1,2</sup> | (0 to 40) in               | $(32 + 14L) \mu\text{in}$                 | Comparison to Grade 2 Gauge Blocks                               |
| Gauge Blocks <sup>1</sup>         | Up to 4 in<br>Up to 200 mm | 40 $\mu\text{in}$<br>1 $\mu\text{m}$      | Comparison to Grade 2 Gauge Blocks, Heidenhain CT60 Length Gauge |

**Length – Dimensional Metrology**

Edmonton, AB

| Parameter/Equipment                                                                                                                | Range                                                                                                                                                                                               | Expanded Uncertainty of Measurement (+/-)                                                              | Reference Standard, Method, and/or Equipment                                           |
|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Length Gauges, Indicators <sup>1</sup><br>50 µin resolution<br><br>100 µin resolution                                              | Up to 1 in<br>Up to 2 in<br><br>Up to 1 in<br>Up to 2 in                                                                                                                                            | 35 µin<br>50 µin<br><br>60 µin<br>70 µin                                                               | Comparison to Gage Blocks, Comparator Stand                                            |
| Length Gauges, Indicators <sup>1</sup><br>(Mounted in stands or custom fixtures)<br>500 µin resolution<br><br>1 000 µin resolution | Up to 1 in<br><br>Up to 1 in                                                                                                                                                                        | 335 µin<br><br>600 µin                                                                                 | Comparison to Gauge Blocks                                                             |
| Measuring Microscope <sup>1,2,5</sup><br>X-Y-Z Length                                                                              | Up to 300 mm                                                                                                                                                                                        | 2 µm or $(0.4 + 0.064L)$ µm                                                                            | Comparison to Glass Stage Micrometers, Stage Micrometers                               |
| Displacement Transducer <sup>1</sup>                                                                                               | Up to 5 in<br>(5 to 40) in                                                                                                                                                                          | 600 µin<br>0.1 % of reading                                                                            | Comparison to Height Gauge                                                             |
| Optical Comparators <sup>1,2,5</sup><br>X-Y-Z Length<br><br>Angle                                                                  | Up to 300 mm<br><br>Up to 90°                                                                                                                                                                       | 2 µm or $(0.4 + 0.064L)$ µm<br><br>0.5'                                                                | Comparison to Glass Stage Micrometers<br><br>Angle Blocks                              |
| Material Testing Machine <sup>1,2</sup><br>Displacement<br><br>Speed                                                               | (0.01 to 0.4) in<br>(0.4 to 40) in<br><br>(0.01 to 20) in/min                                                                                                                                       | 600 µin<br>$(600 + 200L)$ µin<br><br>0.5 % of reading                                                  | ASTM E2309;<br>Height Gauge,<br>Heidenhain MT25B<br>Length Gauge;<br>ASTM E2658; Timer |
| Extensometer, Type 1<br>Strain <sup>1,2</sup>                                                                                      | Gauge length of 0.5 in:<br>(0.06 to 1) in/in<br>(0.002 to 0.06) in/in<br>Gauge length of 1 in :<br>(0.025 to 1) in/in<br>(0.001 to 0.025) in/in<br>Gauge length of 2 in :<br>(0.000 5 to 0.5) in/in | $(64 + 715L)$ µin/in<br>88 µin/in<br><br>$(27 + 300L)$ µin/in<br>40 µin/in<br><br>$(17 + 126L)$ µin/in | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                                      |
| Extensometer, Type 1<br>Gauge Length <sup>1</sup>                                                                                  | (0.5 to 2) in                                                                                                                                                                                       | 400 µin                                                                                                | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                                      |

## Length – Dimensional Metrology

Edmonton, AB

| Parameter/Equipment                                                 | Range            | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                   |
|---------------------------------------------------------------------|------------------|-------------------------------------------|----------------------------------------------------------------|
| Torque Drive Arms <sup>1</sup><br>(2-point Dimensional Measurement) | (4 to 60) in     | 0.1 % of arm length                       | Comparison to Height Gauge, 60 in Steel Rule, Length Standards |
| Protractors, Inclinometers <sup>2</sup>                             | Up to 90°        | 0.5'                                      | Comparison to Angle Blocks, Surface Plate                      |
| Length Scale, Ruler <sup>2,5</sup>                                  | Up to 1 500 mm   | 3 µm or 0.01 % of reading                 | Comparison to Glass Stage Micrometers                          |
| Tape Measure                                                        | Up to 25 ft plus | 0.02 in/5 ft                              | Comparison to Steel Rule                                       |

## Mass and Mass Related

Edmonton, AB

| Parameter/Equipment                                                                                            | Range                                                            | Expanded Uncertainty of Measurement (+/-)                         | Reference Standard, Method, and/or Equipment                                                                                  |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Force Testing Machines, Force Measuring Systems <sup>1</sup><br>Tension                                        | 1 gf to 471 kgf<br>(1 to 500 000) lbf                            | 0.25 % of reading                                                 | Loading Weights, Reference Standard Load Cells; ASTM E4, ISO 7500-1                                                           |
| Compression                                                                                                    | 1 gf to 471 kgf<br>(1 to 2 000 000) lbf                          | 0.25 % of reading                                                 |                                                                                                                               |
| Force Gages, Crane Scales, Dynamometers, Load Cells, Tension Links <sup>1,4</sup><br>(Tension and Compression) | (1 to 100 000) lbf                                               | 0.25 % of reading                                                 | Calibration Load Frame, Reference Standard Load Cells; ASTM E4, ISO 376                                                       |
| Analytical Balances <sup>1,3</sup>                                                                             | Up to 10 g<br>(10 to 200) g<br>200 g to 35 kg<br>200 g to 220 kg | 60 µg<br>0.12 mg<br>0.000 25 % of reading<br>0.000 2 % of reading | ASTM E617 Class 1, OIML Class F1, NIST Class F Weights and NIST Handbook 44 utilized for calibration of the weighting system. |

## Mass and Mass Related

Edmonton, AB

| Parameter/Equipment                                           | Range                                                                                                                                                                     | Expanded Uncertainty of Measurement (+/-)                                                                                                                               | Reference Standard, Method, and/or Equipment                                                  |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Conventional Mass <sup>1</sup><br>(non-integral weights) (SI) | 1 g<br>2 g<br>3 g<br>5 g<br>10 g<br>20 g<br>30 g<br>100 g<br>200 g<br>300 g<br>1 kg<br>2 kg<br>3 kg<br>5 kg<br>10 kg<br>20 kg<br>25 kg<br>30 kg                           | 10 µg<br>10 µg<br>20 µg<br>20 µg<br>20 µg<br>40 µg<br>50 µg<br>80 µg<br>0.12 mg<br>1.2 mg<br>1.4 mg<br>12 mg<br>13 mg<br>0.12 g<br>0.12 g<br>0.12 g<br>0.12 g<br>0.12 g | Electronic Balances;<br>ASTM E617 Class 0 and<br>Class 1 Weights;<br>Comparative Method       |
| Conventional Mass <sup>1</sup><br>(Avoirdupois)               | 0.062 5 oz<br>0.125 oz<br>0.25 oz<br>0.5 oz<br>0.005 lb<br>0.01 lb<br>0.02 lb<br>0.05 lb<br>0.1 lb<br>0.2 lb<br>0.5 lb<br>1 lb<br>2 lb<br>5 lb<br>10 lb<br>25 lb<br>50 lb | 10 µg<br>20 µg<br>30 µg<br>30 µg<br>10 µg<br>20 µg<br>30 µg<br>40 µg<br>0.1 mg<br>0.13 mg<br>1.2 mg<br>1.2 mg<br>1.5 mg<br>12 mg<br>12 mg<br>0.12 g<br>0.12 g           | Electronic Balances;<br>ASTM E617 Class 1 and<br>OIML Class F1 Weights;<br>Comparative Method |
| Pressure Calibrators <sup>1,4</sup>                           | (0.3 to 300) psig<br>(30 to 1 000) psig<br>(1 000 to 10 000) psig                                                                                                         | 0.015 % of reading<br>0.015 % of reading<br>0.015 % of reading                                                                                                          | Comparison to<br>Ametek DWT<br>(R300, HK-1000, R-50)                                          |
| Pressure Indicators,<br>Pressure Gauges <sup>1,4</sup>        | (30 to 1 000) psig<br>(1 000 to 10 000) psig                                                                                                                              | 0.015 % of reading<br>0.25 % of reading                                                                                                                                 | Comparison to<br>Ametek DWT<br>(R300, HK-1000, R-50)                                          |

This Scope of Accreditation, version 014, was last updated on: 30 September 2026 and is valid only when accompanied by the Certificate.

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**Mass and Mass Related**

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| Parameter/Equipment                                                                            | Range                                                                                                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                     | Reference Standard, Method, and/or Equipment                                      |
|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Vacuum Devices <sup>1,4</sup>                                                                  | (-14 to 0) psi                                                                                                                                                                                                                                                                                                                         | 0.05 psi                                                                                                                                                                                                                                      | Comparison to<br>Fluke Pressure Calibrator,<br>Fluke Vacuum Module                |
| Torque Wrenches <sup>1</sup>                                                                   | (0.1 to 36) lbf·in<br>(40 to 300) lbf·in<br>(22 to 651) lbf·ft                                                                                                                                                                                                                                                                         | 0.75 % of reading<br>0.75 % of reading<br>0.75 % of reading                                                                                                                                                                                   | ASTM E2624;<br>Torque Testers                                                     |
| Direct Verification of<br>Hardness Testing Machines <sup>1</sup><br>Verification of Test Force | (1 to 3 000) kgf                                                                                                                                                                                                                                                                                                                       | 0.25 % of reading                                                                                                                                                                                                                             | ASTM E10, ASTM E18,<br>ASTM E92, ASTM E384<br>Working Force Standards             |
| Verification of the Indentation<br>Measuring System                                            | (0.01 to 5) mm                                                                                                                                                                                                                                                                                                                         | 1 µm                                                                                                                                                                                                                                          | Stage Micrometer                                                                  |
| Deflection Measuring System                                                                    | (0.025 to 0.05) mm                                                                                                                                                                                                                                                                                                                     | 0.1 µm                                                                                                                                                                                                                                        | Gauge Blocks                                                                      |
| Rockwell Hardness Testers <sup>1</sup>                                                         | (< 70) HRA<br>(≥ 70 and < 80) HRA<br>(≥ 80) HRA<br><br>(< 60) HRBW<br>(≥ 60 to < 88) HRBW<br>(≥ 88) HRBW<br><br>(< 35) HRC<br>(≥ 35 to < 60) HRC<br>(≥ 60) HRC<br><br>(< 51) HRD<br>(≥ 51 to < 71) HRD<br>(≥ 71) HRD<br><br>(< 84) HREW<br>(≥ 84 to < 93) HREW<br>(≥ 93) HREW<br><br>(< 80) HRFW<br>(≥ 80 to < 94) HRFW<br>(≥ 94) HRFW | 0.28 HRA<br>0.17 HRA<br>0.16 HRA<br><br>1.4 HRBW<br>0.87 HRBW<br>0.42 HRBW<br><br>0.4 HRC<br>0.36 HRC<br>0.32 HRC<br><br>0.27 HRD<br>0.26 HRD<br>0.18 HRD<br><br>0.54 HREW<br>0.54 HREW<br>0.54 HREW<br><br>0.54 HRFW<br>0.4 HRFW<br>0.4 HRFW | Indirect verification per<br>ASTM E18, ASTM E110<br>using Rockwell Test<br>Blocks |

**Mass and Mass Related**

Edmonton, AB

| Parameter/Equipment                                | Range                | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Hardness Testers <sup>1</sup>             | (< 55) HRGW          | 0.76 HRGW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 55 to < 80) HRGW  | 0.36 HRGW                                 |                                                                          |
|                                                    | (≥ 80) HRGW          | 0.36 HRGW                                 |                                                                          |
|                                                    | (< 96) HRHW          | 0.54 HRHW                                 |                                                                          |
|                                                    | (≥ 96) HRHW          | 0.41 HRHW                                 |                                                                          |
|                                                    | (< 65) HRKW          | 0.64 HRKW                                 |                                                                          |
|                                                    | (≥ 65 to < 85) HRKW  | 0.4 HRKW                                  |                                                                          |
|                                                    | (≥ 85) HRKW          | 0.4 HRKW                                  |                                                                          |
|                                                    | (90 to 114) HRLW     | 0.36 HRLW                                 |                                                                          |
|                                                    | (115 to 130) HRL W   | 0.36 HRLW                                 |                                                                          |
| Rockwell Superficial Hardness Testers <sup>1</sup> | (70 to 99) HRMW      | 0.56 HRMW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (100 to 130) HRMW    | 0.56 HRMW                                 |                                                                          |
|                                                    | (40 to 84) HRPW      | 0.91 HRPW                                 |                                                                          |
|                                                    | (85 to 130) HRPW     | 0.65 HRPW                                 |                                                                          |
|                                                    | (100 to 119) HRRW    | 0.41 HRRW                                 |                                                                          |
|                                                    | (120 to 130) HRRW    | 0.24 HRRW                                 |                                                                          |
|                                                    | (110 to 111) HRSW    | 0.95 HRSW                                 |                                                                          |
|                                                    | (112 to 130) HRSW    | 0.2 HRSW                                  |                                                                          |
|                                                    | (80 to 103) HRVW     | 0.95 HRVW                                 |                                                                          |
|                                                    | (104 to 130) HRVW    | 0.2 HRVW                                  |                                                                          |
|                                                    | (< 78) HR15N         | 0.39 HR15N                                |                                                                          |
|                                                    | (≥ 78 to < 90) HR15N | 0.19 HR15N                                |                                                                          |
|                                                    | (≥ 90) HR15N         | 0.19 HR15N                                |                                                                          |
|                                                    | (< 55) HR30N         | 0.55 HR30N                                |                                                                          |
|                                                    | (≥ 55 to < 77) HR30N | 0.28 HR30N                                |                                                                          |
|                                                    | (≥ 77) HR30N         | 0.28 HR30N                                |                                                                          |
|                                                    | (< 37) HR45N         | 0.43 HR45N                                |                                                                          |
|                                                    | (≥ 37 to < 66) HR45N | 0.22 HR45N                                |                                                                          |
|                                                    | (≥ 66) HR45N         | 0.19 HR45N                                |                                                                          |

**Mass and Mass Related**

Edmonton, AB

| Parameter/Equipment                                | Range                 | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|-----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Superficial Hardness Testers <sup>1</sup> | (< 81) HR15TW         | 0.37 HR15TW                               | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 81 to < 87) HR15TW | 0.21 HR15TW                               |                                                                          |
|                                                    | (≥ 87) HR15TW         | 0.21 HR15TW                               |                                                                          |
|                                                    | (< 57) HR30TW         | 0.9 HR30TW                                |                                                                          |
|                                                    | (≥ 57 to < 70) HR30TW | 0.66 HR30TW                               |                                                                          |
|                                                    | (≥ 70) HR30TW         | 0.39 HR30TW                               |                                                                          |
|                                                    | (< 33) HR45TW         | 0.73 HR45TW                               |                                                                          |
|                                                    | (≥ 33 to < 53) HR45TW | 0.41 HR45TW                               |                                                                          |
|                                                    | (≥ 53) HR45TW         | 0.41 HR45TW                               |                                                                          |
|                                                    | (80 to 88) HR15WW     | 0.67 HR15WW                               |                                                                          |
|                                                    | (89 to 100) HR15WW    | 0.67 HR15WW                               |                                                                          |
|                                                    | (40 to 64) HR30WW     | 0.9 HR30WW                                |                                                                          |
|                                                    | (65 to 100) HR30WW    | 0.76 HR30WW                               |                                                                          |
|                                                    | (10 to 47) HR45WW     | 0.3 HR45WW                                |                                                                          |
|                                                    | (48 to 100) HR45WW    | 0.13 HR45WW                               |                                                                          |
|                                                    | (80 to 87) HR15XW     | 0.62 HR15XW                               |                                                                          |
|                                                    | (88 to 100) HR15XW    | 0.33 HR15XW                               |                                                                          |
|                                                    | (60 to 78) HR30XW     | 0.99 HR30XW                               |                                                                          |
|                                                    | (79 to 100) HR30XW    | 0.15 HR30XW                               |                                                                          |
|                                                    | (40 to 68) HR45XW     | 0.81 HR45XW                               |                                                                          |
|                                                    | (69 to 100) HR45XW    | 0.35 HR45XW                               |                                                                          |
|                                                    | (85 to 93) HR15YW     | 1.3 HR15YW                                |                                                                          |
|                                                    | (94 to 100) HR15YW    | 0.63 HR15YW                               |                                                                          |
|                                                    | (60 to 87) HR30YW     | 0.82 HR30YW                               |                                                                          |
|                                                    | (88 to 100) HR30YW    | 0.37 HR30YW                               |                                                                          |
|                                                    | (60 to 81) HR45YW     | 0.94 HR45YW                               |                                                                          |
|                                                    | (82 to 100) HR45YW    | 0.3 HR45YW                                |                                                                          |

**Mass and Mass Related**

Edmonton, AB

| Parameter/Equipment                              | Range                                             | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|--------------------------------------------------|---------------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------|
| Brinell Hardness Testers <sup>1</sup>            | 1/62.5<br>(200 to 400) HBW<br>(400 to 600) HBW    | 9.5 HBW<br>25 HBW                         | Indirect verification per ASTM E10 using Brinell Test Blocks and Brinell Scope |
|                                                  | 2.5/187.5<br>(200 to 400) HBW<br>(400 to 600) HBW | 6.2 HBW<br>15 HBW                         |                                                                                |
|                                                  | 10/500<br>(20 to 100) HBW<br>(100 to 150) HBW     | 1 HBW<br>1.5 HBW                          |                                                                                |
|                                                  | 5/1 000<br>(200 to 400) HBW<br>(400 to 600) HBW   | 4 HBW<br>8 HBW                            |                                                                                |
|                                                  | 10/1 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 3.3 HBW<br>7 HBW                          |                                                                                |
|                                                  | 10/1 500<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2.7 HBW<br>6.5 HBW                        |                                                                                |
|                                                  | 10/2 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2.2 HBW<br>5.2 HBW                        |                                                                                |
|                                                  | 10/2 500<br>(200 to 400) HBW<br>(400 to 600) HBW  | 2 HBW<br>4.4 HBW                          |                                                                                |
|                                                  | 10/3 000<br>(200 to 400) HBW<br>(400 to 600) HBW  | 1.9 HBW<br>4.9 HBW                        |                                                                                |
|                                                  | HV 1<br>200 HV<br>400 HV<br>700 HV                | 4.1 HV<br>8 HV<br>18 HV                   |                                                                                |
|                                                  | HV 2<br>200 HV<br>400 HV<br>700 HV                | 3 HV<br>8 HV<br>14 HV                     |                                                                                |
|                                                  | HV 5<br>200 HV<br>400 HV<br>700 HV                | 3 HV<br>6 HV<br>11 HV                     |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf |                                                   |                                           | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks       |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |
|                                                  |                                                   |                                           |                                                                                |

**Mass and Mass Related**

Edmonton, AB

| Parameter/Equipment                              | Range    | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|--------------------------------------------------|----------|-------------------------------------------|--------------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf | HV 10    |                                           | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 6 HV                                      |                                                                                |
|                                                  | 700 HV   | 11 HV                                     |                                                                                |
|                                                  | HV 20    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 6 HV                                      |                                                                                |
|                                                  | 700 HV   | 11 HV                                     |                                                                                |
|                                                  | HV 30    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 4 HV                                      |                                                                                |
|                                                  | 700 HV   | 7 HV                                      |                                                                                |
|                                                  | HV 50    |                                           |                                                                                |
|                                                  | 200 HV   | 3 HV                                      |                                                                                |
|                                                  | 400 HV   | 4 HV                                      |                                                                                |
|                                                  | 700 HV   | 7 HV                                      |                                                                                |
| Vickers Hardness Testers <sup>1</sup><br>< 1 kgf | HV 0.01  |                                           | Indirect verification per<br>ASTM E92, ASTM E384<br>using Hardness Test Blocks |
|                                                  | 200 HV   | 10 HV                                     |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |
|                                                  | HV 0.025 |                                           |                                                                                |
|                                                  | 200 HV   | 10 HV                                     |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |
|                                                  | HV 0.05  |                                           |                                                                                |
|                                                  | 200 HV   | 10 HV                                     |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |
|                                                  | HV 0.1   |                                           |                                                                                |
|                                                  | 200 HV   | 8 HV                                      |                                                                                |
|                                                  | 400 HV   | 20 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |
|                                                  | HV 0.2   |                                           |                                                                                |
|                                                  | 200 HV   | 8 HV                                      |                                                                                |
|                                                  | 400 HV   | 18 HV                                     |                                                                                |
|                                                  | 700 HV   | 35 HV                                     |                                                                                |

**Mass and Mass Related**

Edmonton, AB

| Parameter/Equipment                                   | Range                                                                                                                                                                                                                                                          | Expanded Uncertainty of Measurement (+/-)                                                                                                              | Reference Standard, Method, and/or Equipment                             |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>< 1 kgf      | HV 0.3<br>200 HV<br>400 HV<br>700 HV<br>HV 0.5<br>200 HV<br>400 HV<br>700 HV<br>HV 1<br>200 HV<br>400 HV<br>700 HV                                                                                                                                             | 5 HV<br>14 HV<br>24 HV<br>5 HV<br>12 HV<br>24 HV<br>4 HV<br>8 HV<br>17 HV                                                                              | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
| Knoop Micro-Indentation Hardness Testers <sup>1</sup> | HK 0.01<br>200 HK<br>400 HK<br>700 HK<br>HK 0.025<br>200 HK<br>400 HK<br>700 HK<br>HK 0.05<br>200 HK<br>400 HK<br>700 HK<br>HK 0.1<br>200 HK<br>400 HK<br>700 HK<br>HK 0.2 and 0.3<br>200 HK<br>400 HK<br>700 HK<br>HK 0.5 and 1<br>200 HK<br>400 HK<br>700 HK | 7 HK<br>16 HK<br>33 HK<br>7 HK<br>14 HK<br>22 HK<br>7 HK<br>14 HK<br>20 HK<br>7 HK<br>12 HK<br>19 HK<br>5 HK<br>8 HK<br>17 HK<br>5 HK<br>7 HK<br>15 HK | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
| Leeb Hardness Tester <sup>1</sup>                     | (600 to 670) LD                                                                                                                                                                                                                                                | 9 LD                                                                                                                                                   | Indirect verification per ASTM A956 using Hardness Test Blocks           |

## Mass and Mass Related

Edmonton, AB

| Parameter/Equipment                                           | Range         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment     |
|---------------------------------------------------------------|---------------|-------------------------------------------|--------------------------------------------------|
| Durometer <sup>1</sup><br>(Types A, B, C, D, DO, E, M, O, OO) |               |                                           | Direct Verification per ASTM D2240 using Balance |
| Force                                                         | Up to 44.5 N  | 0.06 N                                    |                                                  |
| Indenter Dimensions                                           |               |                                           | Optical Comparator                               |
| Length                                                        | Up to 3.57 mm | 10 µm                                     |                                                  |
| Angle                                                         | Up to 35°     | 0.066°                                    |                                                  |
| Radius                                                        | Up to 0.51 mm | 10 µm                                     |                                                  |
| Indenter Deflection                                           | Up to 3.57 mm | 2.3 µm                                    | Gauge Blocks, Transducer                         |

## Thermodynamic

Edmonton, AB

| Parameter/Equipment                | Range             | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                |
|------------------------------------|-------------------|-------------------------------------------|-----------------------------------------------------------------------------|
| Temperature – Source <sup>1</sup>  | 0 °C              | 0.01 °C                                   | Comparison to Ice Bath, Secondary Standard PRT, Instrulab 4312A Thermometer |
| Temperature – Source <sup>1</sup>  | (> 0.01 to 90) °C | 0.1 °C                                    | Comparison to Baths, Secondary Standard PRT, Instrulab 4312A Thermometer    |
| Temperature – Source <sup>1</sup>  | (> 90 to 660) °C  | 1.2 °C                                    | Comparison to Dry Block, Fluke Process Calibrator, Thermocouple Probe       |
| Temperature – Measure <sup>1</sup> | (-78 to 200) °C   | 0.05 °C                                   | Comparison to Secondary Standard PRT, Instrulab 4312A Thermometer           |
| Temperature – Measure <sup>1</sup> | (200 to 660) °C   | 1.2 °C                                    | Comparison to Type N Thermocouple Probe, Fluke 744 Process Calibrator       |

## Thermodynamic

Edmonton, AB

| Parameter/Equipment                       | Range                                                  | Expanded Uncertainty of Measurement (+/-)               | Reference Standard, Method, and/or Equipment                                                                                 |
|-------------------------------------------|--------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| PRT/RTD Probes <sup>1</sup>               | (> 0.01 to 90) °C                                      | 0.1 °C                                                  | Comparison to Ice Bath, Liquid baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer              |
| Thermocouples <sup>1</sup>                | (> 90 to 660) °C                                       | 0.5 °C                                                  | Comparison to Ice Bath, Liquid baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer              |
| Liquid-in-Glass Thermometers <sup>1</sup> | (> 0.01 to 90) °C                                      | 0.1 °C                                                  | Comparison to Ice Bath, Liquid baths, Secondary Standard PRT, Instrulab 4312A Thermometer                                    |
| Infrared Thermometers <sup>1</sup>        | 0 °C<br>100 °C<br>200 °C<br>300 °C<br>400 °C<br>500 °C | 0.34 °C<br>0.7 °C<br>1.1 °C<br>1.3 °C<br>1.7 °C<br>2 °C | Radiometric Method using Blackbody Calibrator (Flat Plate)<br>$\epsilon = 0.95$ , $\lambda = (8 \text{ to } 14) \mu\text{m}$ |
| Humidity – Measure <sup>1</sup>           | (11 to 90) %RH                                         | 1 %RH                                                   | Comparison to Vaisala Humidity Transmitter                                                                                   |

## Time and Frequency

Edmonton, AB

| Parameter/Equipment | Range         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|---------------------|---------------|-------------------------------------------|----------------------------------------------|
| Timers <sup>1</sup> | 1 min to 24 h | 0.25 s                                    | Comparison to NRC Time Signal                |

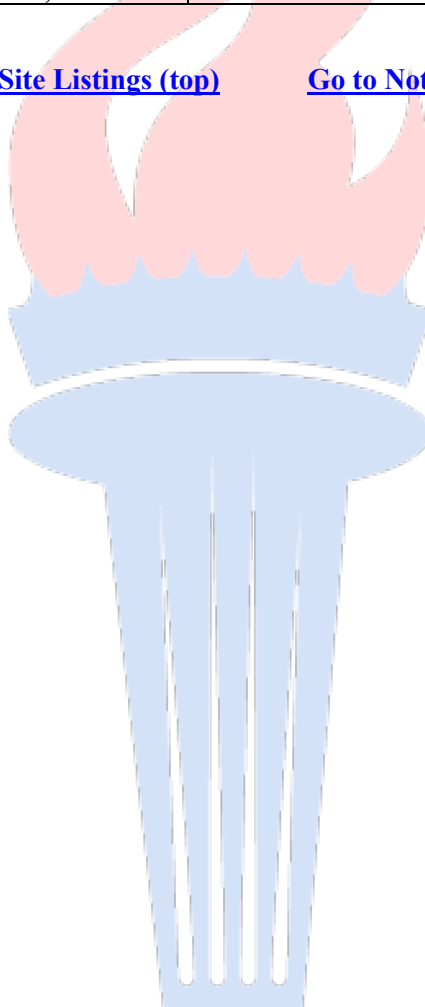
## Time and Frequency

Edmonton, AB

| Parameter/Equipment                                             | Range                                                                                                | Expanded Uncertainty of Measurement (+/-)                                                                   | Reference Standard, Method, and/or Equipment                      |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Frequency – Measure <sup>1</sup><br>Strobe Meter,<br>Tachometer | (1 to 109.99) Hz<br>(110 to 1 099.9) Hz<br>(1.1 to 10.999) kHz<br>(11 to 50) kHz                     | 0.11 mHz/Hz + 50 mHz<br>0.1 mHz/Hz + 0.5 Hz<br>0.75 Hz/kHz + 50 Hz<br>0.22 Hz/kHz + 50 Hz                   | Comparison to<br>Fluke 743<br>Process Calibrator,<br>Strobe Meter |
| Frequency – Source <sup>1</sup><br>Strobe Meter,<br>Tachometer  | Up to 10.99 Hz<br>(11 to 109.99) Hz<br>(110 to 1 099.9) Hz<br>(1 100 to 21 999) Hz<br>(22 to 50) kHz | 1.1 mHz/Hz + 10 mHz<br>0.54 mHz/Hz + 0.1 Hz<br>0.1 mHz/Hz + 0.1 Hz<br>45 µHz/Hz + 2 Hz<br>0.1 Hz/kHz + 5 Hz | Comparison to<br>Fluke 743<br>Process Calibrator,<br>Strobe Meter |

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## Accredited Services performed at Satellite Laboratory

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Burnaby, BC V5A 2G9  
Derek Magee 604-690-4111  
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#### Electrical – DC/Low Frequency

Burnaby, BC

| Parameter/Equipment                                                                           | Range                                                                                                                       | Expanded Uncertainty of Measurement (+/-)                                                                                                                                     | Reference Standard, Method, and/or Equipment      |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| DC Voltage – Measure <sup>1</sup>                                                             | (-110 to 110) mV<br>(-1 to 1) V<br>(-11 to 11) V<br>(-110 to 110) V<br>(-300 to 300) V                                      | 2.9 mV/V + 17 $\mu$ V<br>2.9 mV/V + 55 $\mu$ V<br>2.9 mV/V + 0.55 mV<br>0.58 mV/V + 5.5 mV<br>0.57 mV/V + 15 mV                                                               | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Voltage – Source <sup>1</sup>                                                              | (-110 to 110) mV<br>(-1 to 1) V<br>(-15 to 15) V                                                                            | 0.16 mV/V + 5.5 $\mu$ V<br>0.12 mV/V + 55 $\mu$ V<br>0.12 mV/V + 0.75 mV                                                                                                      | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Measure <sup>1</sup>                                                             | (0 to 22) mA<br>(0 to 30) mA<br>(0 to 110) mA                                                                               | 0.26 mA/A + 6.6 $\mu$ A<br>0.17 mA/A + 4.5 $\mu$ A<br>0.17 mA/A + 17 $\mu$ A                                                                                                  | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Source <sup>1</sup>                                                              | (0 to 22) mA                                                                                                                | 0.17 mA/A + 3.3 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator |
| DC Current – Simulate <sup>1</sup><br>(Loop)                                                  | (4 to 20) mA                                                                                                                | 0.26 mA/A + 6.6 $\mu$ A                                                                                                                                                       | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Resistance – Measure <sup>1</sup>                                                             | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                      | 0.62 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.58 m $\Omega$ / $\Omega$ + 50 m $\Omega$<br>0.59 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>1.2 $\Omega$ /k $\Omega$ + 10 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Resistance – Source <sup>1</sup>                                                              | Up to 11 $\Omega$<br>Up to 110 $\Omega$<br>Up to 1.1 k $\Omega$<br>Up to 11 k $\Omega$                                      | 0.17 m $\Omega$ / $\Omega$ + 20 m $\Omega$<br>0.15 m $\Omega$ / $\Omega$ + 40 m $\Omega$<br>0.25 $\Omega$ / $\Omega$ + 0.5 $\Omega$<br>0.35 $\Omega$ /k $\Omega$ + 5 $\Omega$ | Comparison to<br>Fluke 743B<br>Process Calibrator |
| Electrical Calibration of<br>Thermocouple Indicating<br>Devices – Source/Measure <sup>1</sup> | Type E<br>(-20 to 1 000) °C<br>Type J<br>(-210 to 1 200) °C<br>Type K<br>(-200 to 1 372) °C<br>Type N<br>(-200 to 1 300) °C | 0.3 °C<br>0.3 °C<br>0.4 °C<br>0.6 °C                                                                                                                                          | Comparison to<br>Fluke 743B<br>Process Calibrator |

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## Electrical – DC/Low Frequency

Burnaby, BC

| Parameter/Equipment                                                                     | Range                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                        | Reference Standard, Method, and/or Equipment |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------|
| Electrical Calibration of Thermocouple Indicating Devices – Source/Measure <sup>1</sup> | Type T<br>(-200 to 1 300) °C<br>Type R<br>(0 to 1 767) °C<br>Type S<br>(0 to 1 767) °C                                                                                                                                                                 | 0.4 °C<br>1.1 °C<br>1.1 °C                                                                       | Comparison to Fluke 743B Process Calibrator  |
| Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup>                   | Pt 385, 100 Ω<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>Pt 385, 1 000 Ω<br>(-200 to 0) °C<br>(0 to 400) °C<br>(400 to 800) °C<br>Pt 3926, 100 Ω<br>(-200 to 0) °C<br>(0 to 630) °C<br>Pt 3916, 100 Ω<br>(-200 to 0) °C<br>(0 to 630) °C | 0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.4 °C<br>0.1 °C<br>0.2 °C<br>0.1 °C<br>0.2 °C | Comparison to Fluke 743B Process Calibrator  |

## Length – Dimensional Metrology

Burnaby, BC

| Parameter/Equipment               | Range                      | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                     |
|-----------------------------------|----------------------------|-------------------------------------------|------------------------------------------------------------------|
| Calipers <sup>1,2</sup>           | (0 to 24) in               | $(289 + 7.3L) \mu\text{in}$               | Comparison to Gauge Blocks, Micrometer Setting Standards         |
| Outside Micrometer <sup>1,2</sup> | (0 to 6) in                | $(32 + 14L) \mu\text{in}$                 | Comparison to Grade 2 Gauge Blocks                               |
| Gauge Blocks <sup>1</sup>         | Up to 4 in<br>Up to 200 mm | 40 $\mu\text{in}$<br>1 $\mu\text{m}$      | Comparison to Grade 2 Gauge Blocks, Heidenhain MT25 Length Gauge |

## Length – Dimensional Metrology

Burnaby, BC

| Parameter/Equipment                                                                                                                | Range                                                                                                                                                                                               | Expanded Uncertainty of Measurement (+/-)                                                        | Reference Standard, Method, and/or Equipment                                        |
|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Length Gauges, Indicators <sup>1</sup><br>50 µin resolution<br><br>100 µin resolution                                              | Up to 1 in<br>Up to 2 in<br><br>Up to 1 in<br>Up to 2 in                                                                                                                                            | 35 µin<br>50 µin<br><br>60 µin<br>70 µin                                                         | Comparison to Gage Blocks, Comparator Stand                                         |
| Length Gauges, Indicators <sup>1</sup><br>(Mounted in stands or custom fixtures)<br>500 µin resolution<br><br>1 000 µin resolution | Up to 1 in<br><br>Up to 1 in                                                                                                                                                                        | 335 µin<br><br>600 µin                                                                           | Comparison to Gauge Blocks                                                          |
| Measuring Microscope <sup>1,2,5</sup><br>X-Y-Z Length                                                                              | Up to 300 mm                                                                                                                                                                                        | 2 µm or (0.4 + 0.064L) µm                                                                        | Comparison to Glass Stage Micrometers, Stage Micrometers                            |
| Displacement Transducer <sup>1</sup>                                                                                               | Up to 5 in<br>(5 to 40) in                                                                                                                                                                          | 600 µin<br>0.1 % of reading                                                                      | Comparison to Height Gauge                                                          |
| Optical Comparators <sup>1,2,5</sup><br>X-Y-Z Length<br><br>Angle                                                                  | Up to 300 mm<br><br>Up to 90°                                                                                                                                                                       | 2 µm or (0.4 + 0.064L) µm<br><br>0.5'                                                            | Comparison to Glass Stage Micrometers<br><br>Angle Blocks                           |
| Material Testing Machine <sup>1,2</sup><br>Displacement<br><br>Speed                                                               | (0.01 to 0.4) in<br>(0.4 to 40) in<br><br>(0.01 to 20) in/min                                                                                                                                       | 600 µin<br>(600 + 200L) µin<br><br>0.5 % of reading                                              | ASTM E2309;<br>Height Gauge,<br>MT25B Heidenhain Length Gauge;<br>ASTM E2658; Timer |
| Extensometer, Type 1 Strain <sup>1,2</sup>                                                                                         | Gauge length of 0.5 in:<br>(0.06 to 1) in/in<br>(0.002 to 0.06) in/in<br>Gauge length of 1 in :<br>(0.025 to 1) in/in<br>(0.001 to 0.025) in/in<br>Gauge length of 2 in :<br>(0.000 5 to 0.5) in/in | (64 + 715L) µin/in<br>88 µin/in<br><br>(27 + 300L) µin/in<br>40 µin/in<br><br>(17 + 126L) µin/in | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                                   |
| Extensometer, Type 1 Gauge Length <sup>1</sup>                                                                                     | (0.5 to 2) in                                                                                                                                                                                       | 400 µin                                                                                          | Extensometer Calibrator;<br>ASTM E83 and ISO 9513                                   |

## Length – Dimensional Metrology

Burnaby, BC

| Parameter/Equipment                                                 | Range            | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                   |
|---------------------------------------------------------------------|------------------|-------------------------------------------|----------------------------------------------------------------|
| Torque Drive Arms <sup>1</sup><br>(2-point Dimensional Measurement) | (4 to 60) in     | 0.1 % of arm length                       | Comparison to Height Gauge, 60 in Steel Rule, Length Standards |
| Protractors, Inclinometers <sup>2</sup>                             | Up to 90°        | 0.5'                                      | Comparison to Angle Blocks, Surface Plate                      |
| Length Scale, Ruler <sup>2,5</sup>                                  | Up to 1 500 mm   | 3 µm or 0.01 % of reading                 | Comparison to Glass Stage Micrometers                          |
| Tape Measure                                                        | Up to 25 ft plus | 0.02 in/5 ft                              | Comparison to Steel Rule                                       |

## Mass and Mass Related

Burnaby, BC

| Parameter/Equipment                                                                                                     | Range                                                            | Expanded Uncertainty of Measurement (+/-)                         | Reference Standard, Method, and/or Equipment                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Force Testing Machines,<br>Force Measuring Systems <sup>1,4</sup><br>Tension                                            | 1 gf to 471 kgf<br>(1 to 500 000) lbf                            | 0.25 % of reading                                                 | Loading Weights,<br>Reference Standard<br>Load Cells;<br>ASTM E4,<br>ISO 7500-1                                                              |
| Compression                                                                                                             | 1 gf to 471 kgf<br>(1 to 2 000 000) lbf                          | 0.25 % of reading                                                 |                                                                                                                                              |
| Force Gages,<br>Crane Scales,<br>Dynamometers,<br>Load Cells, Tension Links <sup>1,4</sup><br>(Tension and Compression) | (1 to 100 000) lbf                                               | 0.25 % of reading                                                 | Calibration Load Frames<br>with Secondary Standards;<br>ASTM E74,<br>ISO 376                                                                 |
| Analytical Balances <sup>1,3</sup>                                                                                      | Up to 10 g<br>(10 to 200) g<br>200 g to 35 kg<br>200 g to 220 kg | 60 µg<br>0.12 mg<br>0.000 25 % of reading<br>0.000 2 % of reading | ASTM E617 Class 1,<br>OIML Class F1, NIST<br>Class F Weights and NIST<br>Handbook 44 utilized for<br>calibration of the<br>weighting system. |

**Mass and Mass Related**

Burnaby, BC

| Parameter/Equipment                                           | Range                                                                                                                                                                     | Expanded Uncertainty of Measurement (+/-)                                                                                                                               | Reference Standard, Method, and/or Equipment                                                  |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Conventional Mass <sup>1</sup><br>(non-integral weights) (SI) | 1 g<br>2 g<br>3 g<br>5 g<br>10 g<br>20 g<br>30 g<br>100 g<br>200 g<br>300 g<br>1 kg<br>2 kg<br>3 kg<br>5 kg<br>10 kg<br>20 kg<br>25 kg<br>30 kg                           | 10 µg<br>10 µg<br>20 µg<br>20 µg<br>20 µg<br>40 µg<br>50 µg<br>80 µg<br>0.12 mg<br>1.2 mg<br>1.4 mg<br>12 mg<br>13 mg<br>0.12 g<br>0.12 g<br>0.12 g<br>0.12 g<br>0.12 g | Electronic Balances;<br>ASTM E617 Class 0 and<br>Class 1 Weights;<br>Comparative Method       |
| Conventional Mass <sup>1</sup><br>(Avoirdupois)               | 0.062 5 oz<br>0.125 oz<br>0.25 oz<br>0.5 oz<br>0.005 lb<br>0.01 lb<br>0.02 lb<br>0.05 lb<br>0.1 lb<br>0.2 lb<br>0.5 lb<br>1 lb<br>2 lb<br>5 lb<br>10 lb<br>25 lb<br>50 lb | 10 µg<br>20 µg<br>30 µg<br>30 µg<br>10 µg<br>20 µg<br>30 µg<br>40 µg<br>0.1 mg<br>0.13 mg<br>1.2 mg<br>1.2 mg<br>1.5 mg<br>12 mg<br>12 mg<br>0.12 g<br>0.12 g           | Electronic Balances;<br>ASTM E617 Class 1 and<br>OIML Class F1 Weights;<br>Comparative Method |
| Pressure Calibrators <sup>1,4</sup>                           | (0.3 to 300) psig<br>(30 to 1 000) psig<br>(1 000 to 10 000) psig                                                                                                         | 0.015 % of reading<br>0.015 % of reading<br>0.015 % of reading                                                                                                          | Comparison to<br>Ametek DWT<br>(PK-854, HK-1000, R-50)                                        |
| Pressure Indicators,<br>Pressure Gauges <sup>1,4</sup>        | (30 to 1 000) psig<br>(1 000 to 10 000) psig                                                                                                                              | 0.015 % of reading<br>0.015 % of reading                                                                                                                                | Comparison to<br>Ametek DWT<br>(PK-854, HK-1000, R-50)                                        |

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**Mass and Mass Related**

Burnaby, BC

| Parameter/Equipment                                                                            | Range                                                                                                                                                                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                     | Reference Standard, Method, and/or Equipment                                      |
|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Vacuum Devices <sup>1,4</sup>                                                                  | (-14 to 0) psi                                                                                                                                                                                                                                                                                                                         | 0.05 psi                                                                                                                                                                                                                                      | Comparison to<br>Fluke Pressure Calibrator,<br>Fluke Vacuum Module                |
| Torque Wrenches <sup>1</sup>                                                                   | (0.1 to 36) lbf·in<br>(40 to 300) lbf·in<br>(22 to 651) lbf·ft                                                                                                                                                                                                                                                                         | 0.75 % of reading<br>0.75 % of reading<br>0.75 % of reading                                                                                                                                                                                   | ASTM E2624;<br>Torque Testers                                                     |
| Direct Verification of<br>Hardness Testing Machines <sup>1</sup><br>Verification of Test Force | (1 to 3 000) kgf                                                                                                                                                                                                                                                                                                                       | 0.25 % of reading                                                                                                                                                                                                                             | ASTM E10, ASTM E18,<br>ASTM E92, ASTM E384<br>Working Force Standards             |
| Verification of the Indentation<br>Measuring System                                            | (0.01 to 5) mm                                                                                                                                                                                                                                                                                                                         | 1 µm                                                                                                                                                                                                                                          | Stage Micrometer                                                                  |
| Deflection Measuring System                                                                    | (0.025 to 0.05) mm                                                                                                                                                                                                                                                                                                                     | 0.1 µm                                                                                                                                                                                                                                        | Gauge Blocks                                                                      |
| Rockwell Hardness Testers <sup>1</sup>                                                         | (< 70) HRA<br>(≥ 70 and < 80) HRA<br>(≥ 80) HRA<br><br>(< 60) HRBW<br>(≥ 60 to < 88) HRBW<br>(≥ 88) HRBW<br><br>(< 35) HRC<br>(≥ 35 to < 60) HRC<br>(≥ 60) HRC<br><br>(< 51) HRD<br>(≥ 51 to < 71) HRD<br>(≥ 71) HRD<br><br>(< 84) HREW<br>(≥ 84 to < 93) HREW<br>(≥ 93) HREW<br><br>(< 80) HRFW<br>(≥ 80 to < 94) HRFW<br>(≥ 94) HRFW | 0.28 HRA<br>0.17 HRA<br>0.16 HRA<br><br>1.4 HRBW<br>0.87 HRBW<br>0.42 HRBW<br><br>0.4 HRC<br>0.36 HRC<br>0.32 HRC<br><br>0.27 HRD<br>0.26 HRD<br>0.18 HRD<br><br>0.54 HREW<br>0.54 HREW<br>0.54 HREW<br><br>0.54 HRFW<br>0.4 HRFW<br>0.4 HRFW | Indirect verification per<br>ASTM E18, ASTM E110<br>using Rockwell Test<br>Blocks |

**Mass and Mass Related**

Burnaby, BC

| Parameter/Equipment                                | Range                | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Hardness Testers <sup>1</sup>             | (< 55) HRGW          | 0.76 HRGW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 55 to < 80) HRGW  | 0.36 HRGW                                 |                                                                          |
|                                                    | (≥ 80) HRGW          | 0.36 HRGW                                 |                                                                          |
|                                                    | (< 96) HRHW          | 0.54 HRHW                                 |                                                                          |
|                                                    | (≥ 96) HRHW          | 0.41 HRHW                                 |                                                                          |
|                                                    | (< 65) HRKW          | 0.64 HRKW                                 |                                                                          |
|                                                    | (≥ 65 to < 85) HRKW  | 0.4 HRKW                                  |                                                                          |
|                                                    | (≥ 85) HRKW          | 0.4 HRKW                                  |                                                                          |
|                                                    | (90 to 114) HRLW     | 0.36 HRLW                                 |                                                                          |
|                                                    | (115 to 130) HRL W   | 0.36 HRLW                                 |                                                                          |
| Rockwell Superficial Hardness Testers <sup>1</sup> | (70 to 99) HRMW      | 0.56 HRMW                                 | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (100 to 130) HRMW    | 0.56 HRMW                                 |                                                                          |
|                                                    | (40 to 84) HRPW      | 0.91 HRPW                                 |                                                                          |
|                                                    | (85 to 130) HRPW     | 0.65 HRPW                                 |                                                                          |
|                                                    | (100 to 119) HRRW    | 0.41 HRRW                                 |                                                                          |
|                                                    | (120 to 130) HRRW    | 0.24 HRRW                                 |                                                                          |
|                                                    | (110 to 111) HRSW    | 0.95 HRSW                                 |                                                                          |
|                                                    | (112 to 130) HRSW    | 0.2 HRSW                                  |                                                                          |
|                                                    | (80 to 103) HRVW     | 0.95 HRVW                                 |                                                                          |
|                                                    | (104 to 130) HRVW    | 0.2 HRVW                                  |                                                                          |
|                                                    | (< 78) HR15N         | 0.39 HR15N                                |                                                                          |
|                                                    | (≥ 78 to < 90) HR15N | 0.19 HR15N                                |                                                                          |
|                                                    | (≥ 90) HR15N         | 0.19 HR15N                                |                                                                          |
|                                                    | (< 55) HR30N         | 0.55 HR30N                                |                                                                          |
|                                                    | (≥ 55 to < 77) HR30N | 0.28 HR30N                                |                                                                          |
|                                                    | (≥ 77) HR30N         | 0.28 HR30N                                |                                                                          |
|                                                    | (< 37) HR45N         | 0.43 HR45N                                |                                                                          |
|                                                    | (≥ 37 to < 66) HR45N | 0.22 HR45N                                |                                                                          |
|                                                    | (≥ 66) HR45N         | 0.19 HR45N                                |                                                                          |

Mass and Mass Related

Burnaby, BC

| Parameter/Equipment                                | Range                 | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|----------------------------------------------------|-----------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Rockwell Superficial Hardness Testers <sup>1</sup> | (< 81) HR15TW         | 0.37 HR15TW                               | Indirect verification per ASTM E18, ASTM E110 using Rockwell Test Blocks |
|                                                    | (≥ 81 to < 87) HR15TW | 0.21 HR15TW                               |                                                                          |
|                                                    | (≥ 87) HR15TW         | 0.21 HR15TW                               |                                                                          |
|                                                    | (< 57) HR30TW         | 0.9 HR30TW                                |                                                                          |
|                                                    | (≥ 57 to < 70) HR30TW | 0.66 HR30TW                               |                                                                          |
|                                                    | (≥ 70) HR30TW         | 0.39 HR30TW                               |                                                                          |
|                                                    | (< 33) HR45TW         | 0.73 HR45TW                               |                                                                          |
|                                                    | (≥ 33 to < 53) HR45TW | 0.41 HR45TW                               |                                                                          |
|                                                    | (≥ 53) HR45TW         | 0.41 HR45TW                               |                                                                          |
|                                                    | (80 to 88) HR15WW     | 0.67 HR15WW                               |                                                                          |
|                                                    | (89 to 100) HR15WW    | 0.67 HR15WW                               |                                                                          |
|                                                    | (40 to 64) HR30WW     | 0.9 HR30WW                                |                                                                          |
|                                                    | (65 to 100) HR30WW    | 0.76 HR30WW                               |                                                                          |
|                                                    | (10 to 47) HR45WW     | 0.3 HR45WW                                |                                                                          |
|                                                    | (48 to 100) HR45WW    | 0.13 HR45WW                               |                                                                          |
|                                                    | (80 to 87) HR15XW     | 0.62 HR15XW                               |                                                                          |
|                                                    | (88 to 100) HR15XW    | 0.33 HR15XW                               |                                                                          |
|                                                    | (60 to 78) HR30XW     | 0.99 HR30XW                               |                                                                          |
|                                                    | (79 to 100) HR30XW    | 0.15 HR30XW                               |                                                                          |
|                                                    | (40 to 68) HR45XW     | 0.81 HR45XW                               |                                                                          |
|                                                    | (69 to 100) HR45XW    | 0.35 HR45XW                               |                                                                          |
|                                                    | (85 to 93) HR15YW     | 1.3 HR15YW                                |                                                                          |
|                                                    | (94 to 100) HR15YW    | 0.63 HR15YW                               |                                                                          |
|                                                    | (60 to 87) HR30YW     | 0.82 HR30YW                               |                                                                          |
|                                                    | (88 to 100) HR30YW    | 0.37 HR30YW                               |                                                                          |
|                                                    | (60 to 81) HR45YW     | 0.94 HR45YW                               |                                                                          |
|                                                    | (82 to 100) HR45YW    | 0.3 HR45YW                                |                                                                          |

**Mass and Mass Related**

Burnaby, BC

| Parameter/Equipment                              | Range                         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                   |
|--------------------------------------------------|-------------------------------|-------------------------------------------|--------------------------------------------------------------------------------|
| Brinell Hardness Testers <sup>1</sup>            | 1/62.5<br>(200 to 400) HBW    | 9.5 HBW                                   | Indirect verification per ASTM E10 using Brinell Test Blocks and Brinell Scope |
|                                                  | (400 to 600) HBW              | 25 HBW                                    |                                                                                |
|                                                  | 2.5/187.5<br>(200 to 400) HBW | 6.2 HBW                                   |                                                                                |
|                                                  | (400 to 600) HBW              | 15 HBW                                    |                                                                                |
|                                                  | 10/500<br>(20 to 100) HBW     | 1 HBW                                     |                                                                                |
|                                                  | (100 to 150) HBW              | 1.5 HBW                                   |                                                                                |
|                                                  | 5/1 000<br>(200 to 400) HBW   | 4 HBW                                     |                                                                                |
|                                                  | (400 to 600) HBW              | 8 HBW                                     |                                                                                |
|                                                  | 10/1 000<br>(200 to 400) HBW  | 3.3 HBW                                   |                                                                                |
|                                                  | (400 to 600) HBW              | 7 HBW                                     |                                                                                |
|                                                  | 10/1 500<br>(200 to 400) HBW  | 2.7 HBW                                   |                                                                                |
|                                                  | (400 to 600) HBW              | 6.5 HBW                                   |                                                                                |
|                                                  | 10/2 000<br>(200 to 400) HBW  | 2.2 HBW                                   |                                                                                |
|                                                  | (400 to 600) HBW              | 5.2 HBW                                   |                                                                                |
|                                                  | 10/2 500<br>(200 to 400) HBW  | 2 HBW                                     |                                                                                |
|                                                  | (400 to 600) HBW              | 4.4 HBW                                   |                                                                                |
|                                                  | 10/3 000<br>(200 to 400) HBW  | 1.9 HBW                                   |                                                                                |
|                                                  | (400 to 600) HBW              | 4.9 HBW                                   |                                                                                |
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf | HV 1<br>200 HV                | 4.1 HV                                    | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks       |
|                                                  | 400 HV                        | 8 HV                                      |                                                                                |
|                                                  | 700 HV                        | 18 HV                                     |                                                                                |
|                                                  | HV 2<br>200 HV                | 3 HV                                      |                                                                                |
|                                                  | 400 HV                        | 8 HV                                      |                                                                                |
|                                                  | 700 HV                        | 14 HV                                     |                                                                                |
|                                                  | HV 5<br>200 HV                | 3 HV                                      |                                                                                |
|                                                  | 400 HV                        | 6 HV                                      |                                                                                |
|                                                  | 700 HV                        | 11 HV                                     |                                                                                |

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Burnaby, BC

| Parameter/Equipment                              | Range                                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                             |
|--------------------------------------------------|----------------------------------------|-------------------------------------------|--------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>≥ 1 kgf | HV 10<br>200 HV<br>400 HV<br>700 HV    | 3 HV<br>6 HV<br>11 HV                     | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
|                                                  | HV 20<br>200 HV<br>400 HV<br>700 HV    | 3 HV<br>6 HV<br>11 HV                     |                                                                          |
|                                                  | HV 30<br>200 HV<br>400 HV<br>700 HV    | 3 HV<br>4 HV<br>7 HV                      |                                                                          |
|                                                  | HV 50<br>200 HV<br>400 HV<br>700 HV    | 3 HV<br>4 HV<br>7 HV                      |                                                                          |
| Vickers Hardness Testers <sup>1</sup><br>< 1 kgf | HV 0.01<br>200 HV<br>400 HV<br>700 HV  | 10 HV<br>20 HV<br>35 HV                   | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
|                                                  | HV 0.025<br>200 HV<br>400 HV<br>700 HV | 10 HV<br>20 HV<br>35 HV                   |                                                                          |
|                                                  | HV 0.05<br>200 HV<br>400 HV<br>700 HV  | 10 HV<br>20 HV<br>35 HV                   |                                                                          |
|                                                  | HV 0.1<br>200 HV<br>400 HV<br>700 HV   | 8 HV<br>20 HV<br>35 HV                    |                                                                          |
|                                                  | HV 0.2<br>200 HV<br>400 HV<br>700 HV   | 8 HV<br>18 HV<br>35 HV                    |                                                                          |
|                                                  | HV 0.3<br>200 HV<br>400 HV<br>700 HV   | 5 HV<br>14 HV<br>24 HV                    |                                                                          |

**Mass and Mass Related**

Burnaby, BC

| Parameter/Equipment                                   | Range                                                                                                                                                                                                                                                          | Expanded Uncertainty of Measurement (+/-)                                                                                                              | Reference Standard, Method, and/or Equipment                             |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Vickers Hardness Testers <sup>1</sup><br>< 1 kgf      | HV 0.3<br>200 HV<br>400 HV<br>700 HV<br>HV 0.5<br>200 HV<br>400 HV<br>700 HV<br>HV 1<br>200 HV<br>400 HV<br>700 HV                                                                                                                                             | 5 HV<br>14 HV<br>24 HV<br>5 HV<br>12 HV<br>24 HV<br>4 HV<br>8 HV<br>17 HV                                                                              | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
| Knoop Micro-Indentation Hardness Testers <sup>1</sup> | HK 0.01<br>200 HK<br>400 HK<br>700 HK<br>HK 0.025<br>200 HK<br>400 HK<br>700 HK<br>HK 0.05<br>200 HK<br>400 HK<br>700 HK<br>HK 0.1<br>200 HK<br>400 HK<br>700 HK<br>HK 0.2 and 0.3<br>200 HK<br>400 HK<br>700 HK<br>HK 0.5 and 1<br>200 HK<br>400 HK<br>700 HK | 7 HK<br>16 HK<br>33 HK<br>7 HK<br>14 HK<br>22 HK<br>7 HK<br>14 HK<br>20 HK<br>7 HK<br>12 HK<br>19 HK<br>5 HK<br>8 HK<br>17 HK<br>5 HK<br>7 HK<br>15 HK | Indirect verification per ASTM E92, ASTM E384 using Hardness Test Blocks |
| Leeb Hardness Tester <sup>1</sup>                     | (600 to 670) LD                                                                                                                                                                                                                                                | 9 LD                                                                                                                                                   | Indirect verification per ASTM A956 using Hardness Test Blocks           |

## Mass and Mass Related

Burnaby, BC

| Parameter/Equipment                                           | Range         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment     |
|---------------------------------------------------------------|---------------|-------------------------------------------|--------------------------------------------------|
| Durometer <sup>1</sup><br>(Types A, B, C, D, DO, E, M, O, OO) |               |                                           | Direct Verification per ASTM D2240 using Balance |
| Force                                                         | Up to 44.5 N  | 0.06 N                                    |                                                  |
| Indenter Dimensions                                           |               |                                           | Vision System                                    |
| Length                                                        | Up to 3.57 mm | 10 µm                                     |                                                  |
| Angle                                                         | Up to 35°     | 0.066°                                    |                                                  |
| Radius                                                        | Up to 0.51 mm | 10 µm                                     |                                                  |
| Indenter Deflection                                           | Up to 3.57 mm | 2.3 µm                                    | Gauge Blocks, Transducer                         |

## Thermodynamic

Burnaby, BC

| Parameter/Equipment                | Range             | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                |
|------------------------------------|-------------------|-------------------------------------------|-----------------------------------------------------------------------------|
| Temperature – Source <sup>1</sup>  | 0 °C              | 0.01 °C                                   | Comparison to Ice Bath, Secondary Standard PRT, Instrulab 4312A Thermometer |
| Temperature – Source <sup>1</sup>  | (> 0.01 to 90) °C | 0.1 °C                                    | Comparison to Baths, Secondary Standard PRT, Instrulab 4312A Thermometer    |
| Temperature – Source <sup>1</sup>  | (> 90 to 660) °C  | 1.2 °C                                    | Comparison to Dry Block, Fluke Process Calibrator Thermocouple Probe        |
| Temperature – Measure <sup>1</sup> | (-78 to 200) °C   | 0.05 °C                                   | Comparison to Secondary Standard PRT, Instrulab 4312A Thermometer           |
| Temperature – Measure <sup>1</sup> | (200 to 660) °C   | 1.2 °C                                    | Comparison to Type N Thermocouple Probe, Fluke 744 Process Calibrator       |

## Thermodynamic

Burnaby, BC

| Parameter/Equipment                            | Range                                                  | Expanded Uncertainty of Measurement (+/-)               | Reference Standard, Method, and/or Equipment                                                                                 |
|------------------------------------------------|--------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| PRT/RTD Probes <sup>1</sup>                    | (> 0.01 to 90) °C                                      | 0.1 °C                                                  | Comparison to Ice Bath, Liquid Baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer              |
| Thermocouples <sup>1</sup>                     | (> 90 to 660) °C                                       | 0.5 °C                                                  | Comparison to Ice Bath, Liquid Baths, Dry Block Calibrator, Secondary Standard PRT, Instrulab 4312A Thermometer              |
| Liquid-in-Glass Thermometers <sup>1</sup>      | (> 0.01 to 90) °C                                      | 0.1 °C                                                  | Comparison to Ice Bath, Liquid Baths, Secondary Standard PRT, Instrulab 4312A Thermometer                                    |
| Radiation (Infrared) Thermometers <sup>1</sup> | 0 °C<br>100 °C<br>200 °C<br>300 °C<br>400 °C<br>500 °C | 0.34 °C<br>0.7 °C<br>1.1 °C<br>1.3 °C<br>1.7 °C<br>2 °C | Radiometric Method using Blackbody Calibrator (Flat Plate)<br>$\epsilon = 0.95$ , $\lambda = (8 \text{ to } 14) \mu\text{m}$ |
| Humidity – Measure <sup>1</sup>                | (11 to 90) %RH                                         | 1 %RH                                                   | Comparison to Vaisala Humidity Transmitter                                                                                   |

## Time and Frequency

Burnaby, BC

| Parameter/Equipment | Range         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|---------------------|---------------|-------------------------------------------|----------------------------------------------|
| Timers <sup>1</sup> | 1 min to 24 h | 0.25 s                                    | Comparison to NRC Time Signal                |

## Time and Frequency

Burnaby, BC

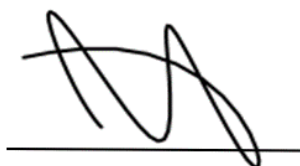
| Parameter/Equipment                                             | Range                                                                                                | Expanded Uncertainty of Measurement (+/-)                                                                        | Reference Standard, Method, and/or Equipment                      |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Frequency – Measure <sup>1</sup><br>Strobe Meter,<br>Tachometer | (1 to 109.99) Hz<br>(110 to 1 099.9) Hz<br>(1.1 to 10.999) kHz<br>(11 to 50) kHz                     | 0.11 mHz/Hz + 50 mHz<br>0.1 mHz/Hz + 0.5 Hz<br>0.75 Hz/kHz + 50 Hz<br>0.22 Hz/kHz + 50 Hz                        | Comparison to<br>Fluke 743<br>Process Calibrator,<br>Strobe Meter |
| Frequency – Source <sup>1</sup><br>Strobe Meter,<br>Tachometer  | Up to 10.99 Hz<br>(11 to 109.99) Hz<br>(110 to 1 099.9) Hz<br>(1 100 to 21 999) Hz<br>(22 to 50) kHz | 1.1 mHz/Hz + 10 mHz<br>0.54 mHz/Hz + 0.1 Hz<br>0.1 mHz/Hz + 0.1 Hz<br>45 $\mu$ Hz/Hz + 2 Hz<br>0.1 Hz/kHz + 5 Hz | Comparison to<br>Fluke 743<br>Process Calibrator,<br>Strobe Meter |

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Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ( $k=2$ ), corresponding to a confidence level of approximately 95%.

### Notes:

- On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
- $L$  = length in inches; ' = arc-minute;  $l$  = length in mm.
- The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
- The resolution will be included in the reported measurement uncertainty at the time of calibration.
- Whichever is greater of the two Uncertainty Values.
- Unless otherwise specified in the far-right column, the calibration procedure utilized by the laboratory was developed internally.



Jason Stine, Vice President