TEGAM

94XA Series

THERMOCOUPLE CALIBRATOR

Models:

940A	Thermocouple Calibrator, 4 Thermocouple Types
945A	Thermocouple Calibrator, 14 Thermocouple Types
948A	Wireless Thermocouple Calibrator, 14 Thermocouple Types

Operation Manual

rev AB

CE

Manual Part Number: 94XA-900, Rev. AB
Published October 2024, Geneva, OH

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NOTICES

Copyright Notice

This Manual

*Part Number:*94XA-900
Revision AB, October 2024
Supersedes: Rev AA
Published by:
TEGAM, Inc.
10 TEGAM Way
Geneva, OH 44041

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- CE, (2014/30/EU), UL, CSA, MIL-PRF-28800F Class 2
- RoHS 2 Directive, 2011/65/EU Compliant, REACH

Safety Notice Symbols and Terms

Safety Notices denote hazards. They indicate an operating procedure, instruction, or practice that, if not correctly performed or followed, could result in damage to equipment, or injury or death to personnel. Do not proceed beyond a Safety Notice until all conditions and instructions are fully understood and complied with.

Safety Notices Symbols:

WARNING WARNING denotes an imminent hazard that *could* result in injury to personnel or death.

CAUTION CAUTION denotes a hazard that *could* result in damage to the unit or other equipment.

REMINDER denotes important information about instrument functions, menus, and measurements.

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1. Instrument Description

1.1 Specifications

General Specifications:		
Source/Measure Accuracy (18° to 28° C)[1]	±0.005% [Reading] ± 5µV	
Recommended Calibration Cycle	1 Year	
Resolution	0.01°C up to 999.99°C and 0.1°C ≥ 1000°C	
Range	-15mV to 85mV	
Cold Junction Error	±0.15°C	
Display	5-Digit Auto-Resolution (0.1/0.01) with Backlight and function Annunciators	
Conformity	ITS-90	Types B,E,J,K,N,R,S,T
	EN 60584-1 2013	Type C
	ASTM E988 Table 3	Type D
	ASTM E1751 5.1.1	Type G
	DIN 43710	Types L and U
	ASTM E1751 5.1.2	Type P
Connector Type	Two (2) Mini-TC Copper	
Temperature Units	°C, °F, mV	
Probe Zero Function	Resolution 0.1 °C/°F	
Reading Rate	3/sec. for Readings and TREND indicators	
Battery Type	3 AA (IEC LR6, ANSI 15) Alkaline	
Battery Life	500 Hours Typical (940A, 945A)	
Battery Indicator	Four (4) Stage Battery Charge Indicator	
Display	Two (2) rows of Five (5) digit LCD with separate minus sign, decimal indicators, with offset, thermocouple types KJTEBNRSGCDPLU, battery, source, read, temperature units, voltage units, percent, trend, PRST (0-19), MIN, MAX, AVG, RNG, STDEV, Transfer, symbols: Fast Ramp, Slow Ramp, Step, Bluetooth	
Statistics	Minimum Reading, Maximum Reading, Average Reading, Reading Range, Standard Deviation	
Display Backlight	Four (4) LED Backlight with 30-second timeout	
Display Resolution	0.01 ° < 1000 °	0.1 ° ≥ 1000 °
Auto Off	20-minute no key pressed Auto Off. Feature can be disabled.	
Keypad	Twelve (12) momentary switches with audible and tactile feedback (Thirteen switches on Model 948A)	

[1] See Appendix D for expanded uncertainties, Accuracy based on recommended calibration cycle

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Power Cycle Configuration Retention	Instrument retains: Sensor Type, Temperature Unit Offset Values, Presets, Statistics, Open Lead detection status, 0%/100% span settings, and operating mode	
Internal Preset Storage	20 Preset user-determined storage registers, 0-19	
Input Current	±50 nA maximum	
Maximum Common Mode Voltage	42 V peak to earth	1 V p-p between T1 and T2
Low Resistance Load	Less than 5µV change in output with a 100 kΩ resistance	
DATA STORAGE AND COMMUNICATION (MODEL 948A ONLY)		
Communication	*Bluetooth*® low energy technology / version 4.0	
Communication Range	10 m	30 ft
Transmitter FCC ID	J7V1740	
Storage Modes	Automatic and Manual	
Remote Operation	Android™ and Apple Mobile Device Applications	
Mobile Compatibility	**Device**	**Operating System**
Android	Devices with *Bluetooth* low energy technology / version 4.0 support	Android 4.3 or higher
Apple	iPhone 4S or newer	iOS 5.0 or higher
	iPad 3 or newer	iOS 5.1 or higher
OPERATING ENVIRONMENT:		
Operating Temp	-20 to 55 °C	-4 to 131 °F
Storage Temp	-51 to 71 °C	-59.8 to 159.8 °F
Humidity	<10 °C (50 °F): Non-condensing 10 °C to 30 °C (50 °F to 86 °F): 5% to 95% RH 30 °C to 40 °C (86 °F to 104 °F): 5% to 85% RH 40 °C to 55 °C (104 °F to 131 °F): 5% to 60% RH	
Altitude	0 to 4600 m	0 to 15,092 ft
Vibration	Random 10 – 500 Hz, 0.03 g^2/Hz	
Shock	30 g Half Sine	
Drop	4 Drops from 1 m to Concrete	
Compliance, Electrical	CE, MIL-PRF-28800F Class 2	
Compliance, Substances	RoHS 2 Directive, 2011/65/EU Compliant, REACH	
Electrical Safety	IEC-61010	
EMC	EN 61326, MIL-PRF-28800F, Class 2 EN55032:2015 and FCC Part 15, Subpart B, Class B (30 MHz to 2.7 GHz); EN 61000-4-3:2006+A2:2010, 10 V/m (80 MHz to 1 GHz); 3 V/m (1.4 GHz to 2 GHz), 1 V/m (2 GHz to 2.7 GHz); EN 61000-4-2:2008, Performance Criteria B, 4 kV CD, 8kV AD	
ESD	IEC 61326 Criterion B	

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Sanitation	NSF/ANSI/3-1 14159-2
Standards	MIL-PRF-28800F, Class 2
Temperature Coefficient	For specification variances due to ambient operating temperature, see the Expanded Instrument Uncertainty charts in *Appendix D* of this manual. For ambient operating temperatures not shown in *Appendix D*, accuracies shall be interpolated linearly.
Included Accessories	3 AA Batteries, Quick Start Guide, Tilt Stand/Magnetic, Calibration Report

PHYSICAL CHARACTERISTICS:		
Dimensions	193 x 84 x 28 mm	7.6 x 3.3 x 1.1 in
Weight including Batteries	363 g	12.8 oz

94XA FAMILY MAXIMUM UNCERTAINTY OVER 100° INTERVALS

Range °C	Type K	Type J	Type T	Type E
-100 to 0	0.36	0.32	0.37	0.34
0 to 100	0.27	0.25	0.28	0.25
100 to 200	0.27	0.23	0.24	0.22
200 to 300	0.26	0.23	0.20	0.20
300 to 400	0.26	0.23	0.19	0.19
400 to 500	0.25	0.23	0.16	0.18
500 to 600	0.25	0.23		0.19
600 to 700	0.26	0.23		0.20
700 to 800	0.27	0.22		0.21
800 to 900	0.28	0.22		0.21
900 to 1000	0.29	0.24		0.22
1000 to 1100	0.3	0.3		
1100 to 1200	0.3	0.3		
1200 to 1300	0.3			
1300 to 1400	0.3			

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945A/947A/948A Maximum Uncertainty over 100° Intervals

Range °C	Type N	Type B	Type R	Type S
-100 to 0	0.42		1.94	1.45
0 to 100	0.32		1.10	1.08
100 to 200	0.27		0.75	0.80
200 to 300	0.26		0.71	0.71
300 to 400	0.24		0.61	0.65
400 to 500	0.23		0.59	0.62
500 to 600	0.22		0.55	0.63
600 to 700	0.22	0.94	0.54	0.59
700 to 800	0.23	0.87	0.51	0.57
800 to 900	0.23	0.76	0.48	0.55
900 to 1000	0.24	0.69	0.49	0.54
1000 to 1100	0.3	0.7	0.5	0.6
1100 to 1200	0.3	0.7	0.5	0.6
1200 to 1300	0.3	0.7	0.5	0.6
1300 to 1400		0.7	0.5	0.6
1400 to 1500		0.7	0.5	0.6
1500 to 1600		0.7	0.5	0.6
1600 to 1700		0.7	0.5	0.6
1700 to 1800		0.7	0.6	0.6

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945A/947A/948A Maximum Uncertainty over 100° Intervals

Range °C	Type G	Type C	Type D
0 to 100	4.02	0.50	0.61
100 to 200	1.02	0.42	0.44
200 to 300	0.62	0.39	0.36
300 to 400	0.46	0.37	0.32
400 to 500	0.38	0.35	0.30
500 to 600	0.33	0.34	0.29
600 to 700	0.30	0.35	0.28
700 to 800	0.28	0.36	0.28
800 to 900	0.27	0.37	0.29
900 to 1000	0.26	0.37	0.30
1000 to 1100	0.3	0.4	0.3
1100 to 1200	0.3	0.4	0.4
1200 to 1300	0.3	0.4	0.4
1300 to 1400	0.3	0.4	0.4
1400 to 1500	0.3	0.5	0.4
1500 to 1600	0.3	0.5	0.4
1600 to 1700	0.3	0.5	0.4
1700 to 1800	0.3	0.5	0.4
1800 to 1900	0.4	0.5	0.4
1900 to 2000	0.4	0.5	0.4
2000 to 2100	0.4	0.5	0.4
2100 to 2200	0.4	0.5	0.4
2200 to 2300	0.4	0.5	0.4

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945A/947A/948A Maximum Uncertainty over 100° Intervals

Range °C	"P" Platinel	Type L J-DIN	Type U T-DIN
-100 to 0		0.42	0.52
0 to 100	0.30	0.32	0.32
100 to 200	0.25	0.43	0.43
200 to 300	0.22	0.31	0.31
300 to 400	0.20	0.46	0.46
400 to 500	0.19	0.32	0.32
500 to 600	0.20	0.33	0.33
600 to 700	0.21	0.38	
700 to 800	0.22	0.42	
800 to 900	0.23	0.27	
900 to 1000	0.25		
1000 to 1100	0.3		
1100 to 1200	0.3		
1200 to 1300	0.3		
1300 to 1400	0.3		

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1.2 Optional Accessories and Ordering Information

PRODUCT	MODEL	DESCRIPTION
Hard Carry Case	911-911	Foam-Filled Hard Carry Case
Soft Carrying Pouch	710-912	Soft Carry pouch
Sure Grip Cover	700-915	Sure Grip Cover
Wire Probe	9K002MTC36	3' Type K wire probe
Calibration Adapter Cable	940-912K 940-912J 940-912T 940-912E 940-912U 940-912R/S 940-912N	Available in Type K,J,T,E,U,R/S or N: Includes a 3' Calibration cable terminated with a male MTC and ¼" spade lug; a standard thermocouple connector; and a standard to male mini adapter.
Printed Manual	94XA-900	Operation Manual
Manual Translations		Chinese, Dutch, French, German, Japanese, Korean, and Spanish (download at aei.com)
Service Options		Calibration with Statement of Traceability

1.3 Error! Reference source not found. Family of Thermometers

Thermocouple Thermometers	911B	Thermocouple Thermometer, Single Input
	912B	Thermocouple Thermometer, Dual Input
Intrinsically Safe Thermometers	921B	ATEX Thermocouple Thermometer, Single Input
	922B	ATEX Thermocouple Thermometer, Dual Input
Data Thermometers	931B	Data Thermometer, Single Input
	932B	Data Thermometer, Dual Input
Thermocouple Calibrators	940A	Thermocouple Calibrator, 4 Thermocouple Types
	945A	Thermocouple Calibrator, 14 Thermocouple Types
	948A	Wireless Thermocouple Calibrator, 14 Thermocouple Types

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2. Preparation for Use

2.1 General Information

This manual provides operating instructions and maintenance information for three calibrator instruments: Models 940A, 945A, and 948A. These instruments are high performance calibrator-thermometers capable of simulating and measuring a wide-variety of sensors. In addition, features such as high accuracies, preset storage, ramp, step and transfer modes further enhance their versatility.

It is recommended that you read this manual thoroughly, especially the sections on safety, prior to operating these instruments.

2.2 Feature Overview

- 0.01 ° / 0.1 ° display resolution
- Internal storage for 20 presets
- 500-hour battery life[2]
- Five (5) digit dual LCD with LED Backlight
- Simultaneous Source/Measure
- Comprehensive real-time statistics: MIN, MAX, AVG, RNG, and STDEV
- Easy to clean
- Probe offset function to minimize probe error
- °F, °C, and mV temperature and voltage units
- Durable: Meets MIL-PRF-28800F, Class 2 requirements
- Tilt Stand/Magnet/Hanger

940A	945A	948A
		
4 Thermocouple Types: K, J, T, & E	14 Thermocouple Types	14 Thermocouple Types + Wireless communication and Data logging

[2] Typical battery life under normal use conditions in laboratory environment. Continuous or repeated use of features such as the backlight or Bluetooth use or storage at high or low temperature extremes may reduce battery life.

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2.3 Safety Notices and Information

Read this Operation Manual thoroughly before using the instrument to become familiar with its operations and capabilities.

Visually inspect instrument before using. Do not use if unit appears damaged or with any part of the case removed.

WARNING

MAINTENANCE INSTRUCTIONS WITHIN THIS MANUAL ARE FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. DO NOT ATTEMPT TO SERVICE THIS UNIT UNLESS YOU ARE QUALIFIED TO DO SO.

SHOCK HAZARD

Disconnect all temperature probes and turn the unit off before removing the battery cover.

Never connect thermocouple leads to any source where more than 42 Volts (peak) could exist between the lead and earth ground. If it is necessary to make measurements of an object at elevated electrical potential, the user is responsible for obtaining and properly using a probe that provides adequate insulation between the surface with elevated potential and the thermocouple wiring.

Always disconnect probe leads before opening the battery door or the instrument housing. Internal circuits can present a shock hazard if leads are connected to a source of elevated potential.

Do not use this instrument if the housing, probe wiring, probe, or probe handle are damaged or distorted. Housings and wire insulation are part of the personnel protection system, and if damaged could expose users to elevated potentials.

EXPLOSION HAZARD

Never use or store this product with batteries installed, or change batteries, in an environment where explosive or flammable vapors or dust suspensions may exist. For thermocouple thermometers suitable for use in explosive environments, see **Error! Reference source not found.**'s 921A or 922A Intrinsically Safe Thermometers.

Do not attempt to recharge alkaline batteries.

Do not put batteries into bags designed to protect parts from electrostatic discharge (ESD). These bags are specially designed with metal shielding which can short circuit a battery.

Do not expose batteries to extreme heat or fire. Observe all regional laws and regulations when disposing of batteries.

Never use this instrument or any temperature probe or sensor inside a microwave oven.

BURN HAZARD

Do not touch a temperature probe sheath that has been exposed to toxic substances or extremely high or low temperatures.

Do not attempt to measure temperatures beyond the range of the temperature probe. Probe damage or personal injury could result from exceeding a probe's maximum temperature rating.

Safety Notices and Information continued on next page . . . .

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CAUTION

RISK OF INCORRECT READING

Do not use when AC or DC voltages in excess of 1V exist between thermocouple channels (on instruments with more than one channel). Excessive voltage could result in an incorrect reading, or in more extreme cases, a blown fuse that will result in incorrect readings and need for repair.

Purely reactive loads of 0.1 uF or greater will cause errors and/or measurement instability.

RISK OF INSTRUMENT DAMAGE

Only replace batteries with size AA (IEC LR6, ANSI 15). Observe proper polarity when installing batteries. Do not mix old and new batteries.

Do not apply voltages across thermocouple leads in excess of normal thermocouple voltage for the selected range. Excessive input voltage could result in blown fuse, component damage, or fire. Application of excessive voltage is not covered by the warranty.

Avoid making sharp bends in probe or sensor lead wires. Bending lead wires at sharp angles can damage the wire and cause probe failure.

When using source and thermometer inputs and a voltage differential exists between the two measurement points, at least one probe should be electrically insulated. If not, a ground-loop current can flow through the thermocouple leads causing measurement error or instrument damage.

Static discharge through a connected temperature probe may cause instrument damage. Use care to avoid static discharge when handling the instrument or connected probes.

Commented [MT([P3]: Not certain how to state this, but channel one is a source. This statement is more applicable to the 911 family. Or so I think?

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2.4 Unpacking and Inspection

Each instrument is electrically and mechanically inspected before shipment. Upon receiving your new TEGAM Thermocouple Calibrator, unpack all items from the shipping container and check for any obvious damage that may have occurred during transit. Use the original packing materials if reshipment is necessary.

If any dents, broken, or loose parts are seen, do not use the equipment. Notify TEGAM immediately.

Check that all items are present. If any items are missing, notify TEGAM immediately.

The following items are included with every new instrument:

- One (1) Thermocouple Calibrator
- One (1) Quick Start Guide
- Calibration Report
- Three (3) AA, 1.5 V batteries
- Optional accessories (if purchased)

2.5 Battery Installation and Replacement

Three (3) AA 1.5 V batteries are supplied with the instrument, but not installed. Read the following battery replacement instructions before attempting to install or remove the batteries.

CAUTION	Always turn the instrument off and disconnect any input connections before replacing the batteries. Re-install the battery compartment cover before resuming use of the instrument.

CAUTION	The battery compartment is sealed with a rubber gasket. Use care to not damage the gasket when removing or installing the battery compartment cover.

CAUTION	Remove the batteries when storing the instrument for an extended period of time or in a high temperature environment to prevent battery leakage and possible damage to the instrument.

	All measurement parameters may be reset to factory default if batteries are removed while the instrument is powered on. Always turn the instrument off before changing batteries.

To install or replace batteries:

Required Tools: Phillips Head Screwdriver

1. Identify the battery compartment located on the back of the instrument (*see Figure 1 below*).
2. Remove the two (2) battery compartment retaining screws.
3. Remove the battery compartment cover.
4. If present, carefully remove old batteries being careful to not damage the battery contacts.
5. Observing proper polarity, install three (3) new, AA alkaline (IEC LR6, ANSI 15) batteries.
6. Re-install the battery cover and two (2) retaining screws.

7. At initial power on after battery replacement, allow approximately 30 seconds for instrument to stabilize.

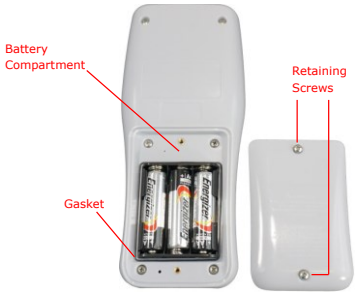

Figure 1: Battery Installation

2.6 Initial Power ON

TEGAM's 900 Series Thermocouple Calibrators are designed for easy operation, while still providing a feature-rich experience via the intuitive user interface.

To get started follow these steps:

1. Perform *Section 2.5, Battery Installation and Replacement*.
2. The instrument will initially display every segment on the LCD for 2 seconds as a test. An internal hardware, memory and battery self-test is performed during this time.
3. Upon completing the internal tests, the instrument will immediately display the Source and Read mode last user settings and battery indicator.
4. Set the desired measurement parameters as follows:
    a. Enter the Setup Menu by pressing SET, hold the key down for approximately 1.5 seconds, and then release it.
    b. The active thermocouple type is flashing on the display. Use ^ v or < > to select the desired thermocouple type. You are setting the thermocouple type of the Read Channel.

> The ^ v arrows always change a value. The < > arrows position the cursor or will act to select only when changing Thermocouple type, desired digit or changing the mode.

    c. Momentarily (do not hold) press SET to save your selection and move to the next parameter.

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d. The active temperature unit is flashing on the display. Use ▲▼ to select the desired temperature unit (°C, °F, or mV).

e. Momentarily press SET to save your selection and move to the next parameter.

f. Read Channel 2 offset value is flashing on the display. If the temperature probe's offset value is known, press ▲▼ to set the Channel 2 probe offset to the probe's offset value. See *Section 3.10, Probe Offset*, for more information.

g. Momentarily press SET to save your selection and move to Open Lead Detection, press ▲▼ to toggle on/off.

h. Momentarily press SET to save your selection and move to Source on/off; see *Section 3.3, Set Up, figure 4* for more information.

i. To save the current parameter value and exit the Setup Menu, press VIEW.

j. To disregard changes made to the current parameter value and exit the Setup Menu, press CLR.

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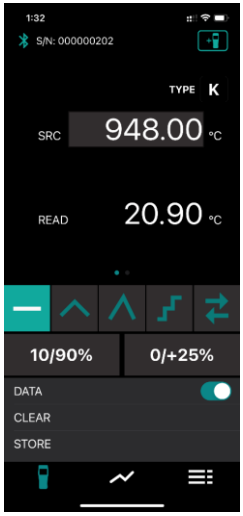
2.7 Wireless Operation (948A only)

The TEGAMLink C mobile application provides convenient two-way communication between your TEGAM Wireless Datalogging Calibrator and compatible *Bluetooth* low energy technology / version 4.0 mobile devices. TEGAMLink C duplicates the calibrator display for easy operation and monitoring from up to 30 feet away and provides real-time measurement charting for the read channel. TEGAMLink C is available on Google Play and Apple App Store. See *Figure 2* below for a description of the TEGAMLink C user interface.



	Connect to device within range
STORE	Manually record a temperature measurement
DATA	Automatically record temperature measurements at programed interval
CLEAR	Erase data stored on device
	View current measurement
	View Stored Data
	View current reading while in stored data screen
	Manual Input Mode
	Slow Ramp Mode
	Fast Ramp Mode
	Step Mode
	Transfer Mode
10/90%	Toggle between 10%and 90% of Span
0/+25%	Set to 0% or increase by 25% of Span

Figure 2: TEGAMLink C User Interface Description

3. Operating Instructions

3.1 Keypad Functions

The instrument keypad is a twelve (12) key, sealed membrane keypad. Each key provides audible and tactile user feedback when pressed. Key functions are described in *Figure 2* below. (Note: image shows the 948A keypad, which has a 13th key for Bluetooth on/off.)

	Power instrument ON or OFF and exits Key Lock mode
(1.5s)	Disable auto-power OFF
SET (1.5s)	Enter instrument Setup Menu
SET	While in Setup Menu, save current value and step to next parameter
	Toggle display backlight
(1.5s)	Disable backlight 30-second timeout
CLR	While in Setup Menu, discard all unsaved changes and exit menu
CLR (1.5s)	Delete all saved measurement data and reset all statistics currently stored in memory, MIN/MIX/AVG/RNG/STDEV
CLR (1.5s)	While in PRST selection mode with PRST flashing, erases current preset number contents
	Displays in order: Current Read Channel reading, MIN, MAX, AVG, RNG, STDEV
VIEW	While in Setup Menu, save changes and exit menu
	While displaying Cold Junction Compensation (CJC) reading, toggles between CJC 1 and CJC 2
VIEW (1.5s)	Displays Cold Junction Compensation (CJC) readings
10/90%	The 10%/90% key toggles between 10% and 90% of span. The first press of the key goes to 10%.
0/+25%	The 0%/+25% key manually increments the output by 25% of the defined span for the selected TC. Once the output reaches 100% the next press of the key will wrap around to 0%.
PRST	Once in Preset, single press saves and exits leaving the selected preset number active
PRST (1.5s)	Enters the Preset selection mode
	Turn wireless communication ON/OFF (948A only)
	Up and Down Buttons: Increment/Decrement currently selected Source digit by 1
	Left and Right Buttons: Move active Source digit indicator by 1 place left or right

Figure 3: Keypad Button Functional Description

The , CLR, SET, and keys have multiple functions which can be accessed by momentarily pressing the key, or alternatively, by pressing and holding the key for approximately 1.5 seconds. Throughout this Operation Manual, the press and hold sequence is indicated by the key designator followed by the subscript (1.5s). For instance, SET (1.5s)

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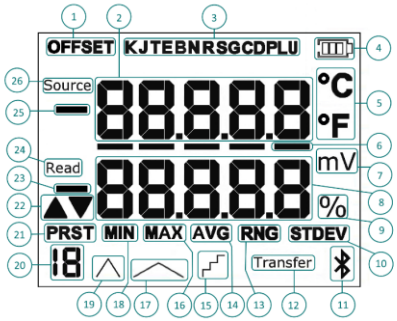
indicates that the SET key should be pressed and held for 1.5 seconds, then released to access the desired function.

3.2 LCD Display

The display is a large, easy to read, dual LCD display, with an LED backlight for clear viewing in low-light conditions. It simultaneously displays Source channel and Read channel values, current thermocouple type and temperature unit, Source and Read channel labels, trend indicators for the Read Channel and a battery voltage indicator.

In Statistics View, the initial value displayed is a mirror of the Source channel. Each press of the View key after that displays the active statistic result and its corresponding label below. See *Figure 3* below for further description of each display indicator.



1	OFFSET is applicable to Reading in Line 2
2	Source Channel 5 digit display
3	The active thermocouple type
4	Remaining battery life
5	Temperature units
6	Active Digit Indicator
7	Millivolt designation
8	Read Channel 5 digit display
9	Value displayed in Read Channel display is a percentage
10	Value displayed in the Read Channel is the Standard Deviation (using total population formula) over the last 1000 measurement cycles.
11	Flashing: Broadcasting to pair with a device
	Solid On: Bluetooth connection has paired
12	Transfer is active. TRANSFER mode reads the input TC and outputs an offset corrected mV signal to an upstream TC input. Source output is matched to the reading using the same user settings.
13	Range is currently displayed, the MAX minus MIN value.
14	Instrument is displaying the Average reading over the last 1000 measurement cycles.
15	Step Function: There are 10 equal steps between 0 °C and Span. Source continuously steps up and down. There is a 2 second dwell time on each step.

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16	MAX statistic. Displays the maximum reading over the last 1,000 measurement cycles.
17	Slow Ramp: Source Channel continuously cycles from 0°C to Span and then back to 0°C. The ramp rate is 5°C per second.
18	MIN statistic. Displays the minimum reading over the last 1,000 measurement cycles.
19	Fast Ramp: Source Channel continuously cycles from 0°C to Span and then back to 0°C. The ramp rate is 50°C per second.
20	Displays the number of the current 20 possible presets, (0-19).
21	PRST: Preset is active. Each preset value includes Source Value, TC Type, (no TC type if in mV), Units, Mode, Span (0% and 100%), and preset number.
22	Trend Indicators, Read channel.
23	Minus sign, Read channel.
24	Read channel Label.
25	Minus sign, Source channel.
26	Source channel Label.

Figure 4: LCD Display Description

The LCD can display error information about the current measurement, as shown in *Figure 5* below.

DISPLAY	DESCRIPTION
OPEn	No thermocouple probe is connected
O rnG	Over Range: The applied temperature is greater than the maximum temperature for the selected thermocouple type
U rnG	Under Range: The applied temperature is less than the minimum temperature for the selected thermocouple type

Figure 5: LCD Error Indications

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3.3 Setup Menu

While changing settings, the values displayed on the screen may not accurately reflect the state of the unit until SET or VIEW is pressed to save the setting.

Key designators followed by (1.5s), e.g. SET(1.5s), indicate that the key should be pressed and held for 1.5 seconds, then released to access the desired function.

Measurement settings are configured in the Setup Menu. Press SET(1.5s) to access the Setup Menu. From within the Setup Menu, press SET to step through the user-definable parameters and the ^ v keys to increment/decrement or < > keys to move left/right while in the Setup Menu. The active parameter value will flash on the display or the active digit indicator will flash beneath the digit.

Press VIEW to save a setting and exit the Setup Menu. Press CLR to disregard unsaved changes and exit the Setup Menu. If no key is pressed for 10 seconds, the current configuration is saved and the instrument will exit the Setup Menu.

Figure 5 lists the user-definable parameters and the available values for each parameter.

To set a parameter value:

1. Press SET(1.5s) to enter the Setup Menu.
2. Press SET to cycle through parameters as shown in *Figure 6* until the desired parameter is reached.
3. To change the value of the current parameter, press ^ v or < >.
4. To save the current parameter value and cycle to the next parameter, press SET(1.5s).
5. To save the current parameter value and exit the Setup Menu, press VIEW.
6. To disregard changes made to the current parameter value and exit the Setup Menu, press CLR.
7. If parameter 2, "Temperature and Voltage Units" are set as either "°C" or "°F", the remaining parameter choices available are in Figure 5 below under "Setup Choices for °C and °F". If parameter 2 is set to "mV", the remaining parameter choices available are in Figure 5 below under "Setup Choices for mV".

STATS are not active in mV mode.

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SETUP MENU CHOICES FOR °C AND °F		
PARAMETER	**AVAILABLE VALUES**	
Thermocouple Type[3]	K, J, T, E	
Temperature and voltage Units	°C, °F, mV	
Probe Offset	±0.1 ° increments	
Open Lead detection (old)	On / Off	
Source (SourC)	On / Off	
If on – Set Span[4]	Set 100% Level	
	Set 0% Level	
If on – Set Mode	Manual	blinking
	Fast Ramp	
	Slow Ramp	
	Step	
	Transfer	Transfer
SETUP MENU CHOICES FOR mV		
PARAMETER	**AVAILABLE VALUES**	
Thermocouple Type[5]	K, J, T, E	
Temperature and voltage Units	°C, °F, mV	
Probe Offset	±0.1 mV increments	
Open Lead detection (old)	On / Off	
Source (SourC)[6]	On / Off	

[3] The 945A/948A support: K,J,T,E,B,N,R,S,G,C,D,P,L,U.
[4] Span limits may change if the span is outside the selected thermocouple type range. Always verify span limits after changing thermocouple types.
[5] Although still selectable, TC type is not visible on LCD while mV is the active unit
[6] Turning off the Source channel will improve battery life. Do not turn the Source channel on or off with any instrument connected.
[8]Low range is for calibration verification only.

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If on – Set Span	Set 100% Level	
	Set 0% Level	
Range (rAnGE)	Range High mV (default) [-15 mV to +85 mV]	
	Range Low[7] mV (mV flashing) [-15 mV to +35 mV]	
If on – Set Mode	Manual	blinking "_ _ _ _"
	Fast Ramp	
	Slow Ramp	
	Step	
	Transfer	Transfer

Figure 6: Setup Menu Choices

If no key is pressed for 10 seconds, the instrument will save the current configuration and exit the Setup Menu.

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3.4 View Modes and Statistics

The instrument features multiple view modes including a variety of real-time statistics, all available at the touch of a button. *Figure 7* below describes each view mode.

VIEW MODE	DISPLAY INDICATOR	DESCRIPTION
Minimum	MIN	Minimum temperature recorded during current session
Maximum	MAX	Maximum temperature recorded during current session
Average	AVG	Average of all temperatures recorded during current session
Range	RNG	Maximum minus Minimum
Standard Deviation[8]	STDEV	Standard deviation of all temperatures recorded during the current session.

Figure 7: View Modes and Statistics

Press VIEW to change view modes. For each mode, the active measurement or statistic result is displayed on the second line of the display.

When viewing statistics, the active statistic is indicated directly below the result.

Statistics are calculated continuously, beginning when the instrument is powered on or when CLR (1.5s) is pressed.

It is important to note that changing parameter values or temperature probes will invalidate the current statistics session. When using statistics, always begin by pressing CLR (1.5s) to delete existing statistics data and initiate a new statistics session.

Press VIEW to step through the available statistics. Statistics are displayed in the order shown in *Figure 8* below.

When using statistics, always begin by pressing CLR (1.5s) to clear existing statistics results and initiate a new statistics session.

The first line of the display indicates the current Source Channel value, regardless of which view mode statistic is currently displayed.

[8] Standard Deviation is calculated using the population formula: $\sigma = \sqrt{\frac{\sum(x-\mu)^2}{N}}$

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MODEL	SOURCE CHANNEL	STATISTIC VIEW SEQUENCE				
940A/ 945A/ 948A	Value from source channel	MIN	MAX	AVG	RNG	STDEV

Figure 8: Statistics Sequence

If the instrument records invalid measurement data during the statistics session such as an over-range, under-range, or open input value, ————— will be displayed for each affected statistic result.

To return to the active measurement mode, press VIEW repeatedly to step through the remaining view modes, or cycle power.

3.5 Auto-Power Off

Key designators followed by (1.5s), e.g., ⏻(1.5s), indicate that the key should be pressed and held for 1.5 seconds, then released to access the desired function.

To conserve battery life, the instrument automatically turns off if no key is pressed for 20 minutes. To disable this feature, press ⏻(1.5s). The remaining battery life indicator will flash once, indicating auto-power off is disabled.

Auto-power off will remain disabled until instrument power is cycled. At next power on, auto-power off returns to the default enabled condition.

3.6 Backlight and Backlight Timeout

The instrument includes an LED backlight feature to ensure measurement data can be easily read in low-light conditions. To activate the backlight, press ☼.

Once the backlight is activated, it will automatically turn off after 30 seconds if no key is pressed to preserve battery life. To disable the backlight timeout feature, press ☼(1.5s). The backlight will flash to indicate the timeout feature has been disabled. To re-enable the backlight timeout feature, turn the backlight off then on by pressing ☼ twice.

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3.7 Operating Modes

The instrument has five (5) operating modes for channel one, "Source" including manual operation explained in *Figure 9* below. The operating modes are Manual, Fast Ramp, Slow Ramp, Step and Transfer.

Operating Mode	Display Indicator	Description
Manual	blinking "— — — —"	Instrument operates by outputting a voltage that corresponds to the set temperature or millivoltage.
Fast Ramp		Instrument ramps the output temperature or millivoltage from 0% of span to 100% of span and back to 0% of span in 20 seconds. This repeats until stopped. Any other key press will stop the output at the existing value (temperature or millivoltage) and clear the fast ramp setting.
Slow Ramp		Instrument ramps the output temperature or millivoltage from 0% of span to 100% of span and back to 0% of span in 120 seconds. This repeats until stopped. Any other key press will stop the output at the existing value (temperature or millivoltage) and clear the slow ramp setting.
Step		Instrument steps the output temperature or millivoltage from 0% of span to 100% of span and back to 0% of span stepping at 10% increments, dwelling 5 seconds at each step. This repeats until stopped. Any other key press will stop the output at the existing value (temperature or millivoltage) and clear the Step ramp setting.
Transfer[9]	Transfer	Instrument sets the source output (temperature or millivoltage) equal to the value on the "Read" channel, (channel 2). This is an offset corrected value. SOURCE output = READ voltage + CJC voltage. This mode would be used for troubleshooting systems and readouts. The "Transfer" icon will blink and illuminate if selected.

Figure 9: Operating Modes

While in any of the Operating Modes above, unless Auto Power Off was disabled, the instrument will automatically turn off if no key is pressed for 20 minutes.

[9] Do not use Transfer mode if the Source channel is connected directly to the Read channel.

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3.8 Trend Indicators

Trend indicators provide a visual representation of the measurement's stability and are provided for the Read channel. An up arrow indicates that the current measurement is trending upwards, while a down arrow indicates the measurement is trending downwards. The trend indicators code looks for a greater than, plus or minus 0.1 degree change in 5 seconds. It will then light the up or down arrow based on which way the temperature is moving. If the temperature change for the last 5 seconds is less than 0.1 degrees, the indicators will go off. Neither arrow is visible when the measurement is stable. For best accuracy, always allow the measurement to stabilize before evaluating or recording the measured temperature.

3.9 Battery Indicator

Battery depletion or battery replacement will reset all measurement parameters to their default values and deletes all existing statistics data. After battery replacement, set measurement parameters as required.

The battery voltage indicator provides a visual representation of the approximate remaining battery life. It is located at the top-right of the display.

The battery voltage indicator uses three bars to represent remaining battery life. *Figure 9* shows the approximate battery life for each bar.

Bars	Approx. Battery Life
3	100% - 50%
2	50% - 20%
1	20% - 5%
0	0% - Shutdown Initiated

Figure 10: Battery Voltage Indicator

At zero (0) bars, the instrument will display "**Chang Bttry**" for 30 seconds and then initiate a shutdown sequence. To prevent disruption of the measurement process and statistics and data collection, the batteries should be replaced before the battery voltage indicator reaches zero (0) bars. *See Section 2.5, Battery Installation and Replacement*.

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3.10 Probe Offset

The probe offset feature compensates for temperature probe errors, significantly improving overall measurement uncertainty. Probe offset can be set for the Read channel. Once set, the probe offset is automatically applied to all subsequent measurements and statistics on the Read channel. The reference for the probe offset should be as near the intended measuring condition of the thermometer as possible. For example, if the anticipated measurement temperature is 205 °C, a probe offset derived from a boiling point reference (100 °C) will provide better accuracy than a probe offset derived from an ice bath (0 °C).

Current statistics will be invalidated after changing settings such as probe offset. Press CLR (1.5s) to delete existing statistical data and initiate a new statistics session.

Probe offset rounding errors may occur if temperature units are changed while a probe offset is active. When using a probe offset, verify and, if necessary, correct the programmed probe offset after changing temperature units.

To set the probe offset when using an un-calibrated temperature probe:

1. Connect the temperature probe to the Read Channel of the instrument.
2. Place the probe into a known temperature reference such as a thermowell or ice bath[10].
3. Allow the temperature probe to stabilize in the ice bath or thermowell by observing the instrument trend indicators for the Read channel.

   Neither trend indicator is displayed when the temperature measurement has stabilized.
4. Press SET (1.5s) to enter the Setup Menu.
5. Press SET two (2) times to cycle to the Offset parameter.
6. Observe the current offset displayed on the top segments of the display, and current Read value displayed on the second line of the display.
7. Press ∧ ∨ to increment/decrement the currently selected digit until the displayed temperature equals the known temperature reference value. Press ‹ › to change the digit place.
8. Press SET to save the offset value and proceed to Open lead detection or press VIEW to save the offset value and exit the Setup Menu.
   a. Alternatively, to disregard the new offset value and exit the Setup Menu, press CLR.
9. **OFFSET** is displayed at the top-left of the LCD display.

[10] Probe offset measurement using an ice bath or thermowell should only be performed by personnel trained and qualified in the use of such instruments and related metrology methods.

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To set the probe offset when using a calibrated temperature probe with a known offset:

1. Press SET (1.5s) to enter the Setup Menu.
2. Press SET two (2) times to cycle to the Offset parameter.
3. Observe the current offset value displayed on the first line of the display.
4. Press ^ v to increment/decrement the currently selected digit until the displayed temperature equals the known temperature reference value. Press < > to change the digit place.
5. Press SET to save the offset value and proceed to Open lead detection or press VIEW to save the offset value and exit the Setup Menu.
    a. Alternatively, to disregard the new offset value and exit the Setup Menu, press CLR.
6. **OFFSET** is displayed at the top-left of the LCD display.

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3.11 Open Lead Detection Enable/Disable

Open Lead Detection allows the unit to detect if a thermocouple probe is connected to the thermometer. This feature is not compatible with some thermocouple probes and can result in measurement instability.

Disabling Open Lead Detection in these situations can significantly improve reading stability. Once disabled, Open Lead Detection will remain disabled until changed by following the below steps, or the instrument is powered off.

If no thermocouple probe is connected and Open Lead Detection is disabled, the unit will not indicate OPEn and may display erratic readings.

To change the Open Lead Detection setting:

1. Press SET (1.5s) to enter the Setup Menu.
2. Press SET three (3) times to cycle to the Open Lead Detection parameter.
    a. **OLd** is displayed on Line 1 of the LCD, and the current Open Lead Detection status is displayed on Line 2, On/OFF.
3. Press ^ v to change the Open Lead Detection setting.
    a. ON indicates that Open Lead Detection is enabled.
    b. OFF indicates that Open Lead Detection is disabled.
4. Press VIEW or SET to save the Open Lead Detection setting and exit the Setup Menu.
    a. Alternatively, to disregard the Open Lead Detection setting and exit the Setup Menu, press CLR.

While plugged into the "SOURCE" channel, certain thermometers may affect the "MEASURE" channel of the unit. If this behavior is observed, turn Open Lead Detection off on the thermometer (if this feature is supported by the thermometer).

3.12 Clear Function

From active measurement mode, press CLR (1.5s) to clear the statistics registers and begin a new statistics session. The LCD display will indicate **CLEAr** to confirm the action and return to active measurement mode.

Pressing CLR (1.5s) deletes all measurement data currently saved in the instrument's internal memory except for Presets.

From the Setup Menu, press CLR to disregard changes to the current parameter value and exit the Setup Menu.

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3.13 Presets: Save, Recall and Erase

There are 20 presets in the instrument numbered 0 – 19. The presets allow the user to save the parameters chosen during setup. There are 3 preset actions. The user can save, recall or erase.

When a preset is saved, the current operating options are stored in one of the 20 selected presets. The operating options include:

- Thermocouple Type
- Units
- Offset
- Open Lead Detection Status
- 100% and 0% Span Settings
- Operating Mode: Fast Ramp, Slow Ramp, Step or Transfer

To save a preset

Press the PRST (1.5s). The preset number will start flashing. Use the ▲▼ to move to the preset number location you want to use to store the current operating options. Press the PRST. The current operating options are now saved in the chosen preset location and the flashing stops.

To recall a preset

Press the PRST button. "PRST" will begin to flash. Use the ▲▼ to move to the desired saved preset, 0-19. When the desired preset is reached, press the preset button again to exit. The instrument will only display the numbers where presets are stored. For example: If there are presets stored in 3 and 10 and all others are empty, in this case the ▲▼ would only toggle between and display 3 and 10.

To erase a preset

To erase a preset, it must first be recalled by following the "To recall a preset" steps above. Once the desired preset is recalled, press the PRST (1.5s). The preset number should now be flashing. While the preset number is flashing, press CLR (1.5s). "CLEAr" will appear on the LCD momentarily. The location is now empty and will not appear with any of the saved presets when trying to recall a preset.

The preset number just erased will still appear on the LCD until moved from that preset number. Once moved to a different preset, it will no longer appear when trying to recall a preset.

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3.14 Invalid Measurement Indications

The LCD display indicates when a measurement or statistic is invalid, as shown in *Figure 11* below.

INDICATION	DESCRIPTION
O rnG	The current measurement or statistic is over-range for the selected thermocouple type. Also, Instrument is in mV mode, "old" is off and "Source" is off. Those settings can lead to an Over range display.
U rnG	The current measurement or statistic is under-range for the selected thermocouple type
OPEn	No probe is connected, or the probe sensor is faulty
—————	Cannot compute a valid statistical result
Short ChAn1[11]	A thermocouple, shorted transducer, or other short circuit is plugged into the Source Channel during startup.

Figure 11: Invalid Measurement Indications

[11] Purely reactive loads of 0.1 uF or greater will also cause errors and/or measurement instability

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4. SERVICE INFORMATION

4.1 Inspection and Cleaning

To extend the life of the instrument, inspect and clean the instrument regularly. Inspect the instrument for any significant abrasions, cuts, cracks, dents, or other signs of damage on the case, keypad, and display lens. Inspect the connectors for breaks, dirt, or corrosion. Ensure all screws are securely fastened, and if equipped, that the tilt stand/magnet/hanger is in good condition and locks into position properly.

With all screws securely fastened and the battery compartment cover in place, use a damp cloth or towel to wipe down the instrument. Use care to avoid scratching the display lens. Mild, non-abrasive detergents may be used providing the instrument is then wiped down with a clean damp cloth or towel.

4.2 Calibration

4.2.1 Verification Procedure

The voltage calibration of the instrument can be verified by checking the mV points noted in *Figure 13* below. A Digital Multi-Meter with suitable accuracy[13] is needed along with a set of Copper mini-TC male connectors, with good quality, low-thermals wire. The wire cannot be tinned.

1. This procedure shall be performed within environmental conditions of 23 ±1 °C and 5% to 95% RH.
2. The unit under test ("UUT") shall be acclimated to the Controlled Environment for a minimum of four (4) hours.
3. Disable the auto-power off feature by pressing (1.5s). The remaining battery life indicator will flash once, indicating auto-power off is disabled.
4. Connect a copper daisy-chain from Source Channel 1 to Read Channel 2 and to a DMM of suitable accuracy[12].

[12] Suitable accuracy means a metrology-grade DMM. To achieve mV limits shown in Appendix B, the DMM must have accuracy equivalent to 30 ppm of reading and 9 ppm of range on the 100mV range.

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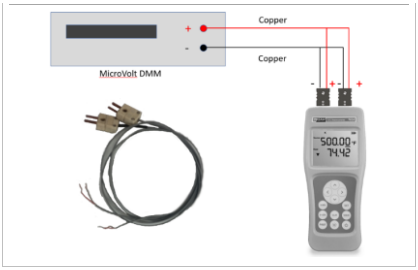

Figure 12: Calibrator-DMM Connections

HIGH RANGE: (IN MV) [-15 MV TO +85 MV]	LOW RANGE: (IN MV) [-15 MV TO +35 MV]
-13.000	-13.000
-10.000	-10.000
0.000	0.000
5.000	10.000
20.000	30.000
80.000	33.000
83.000	n/a

Figure 13: Millivolt Verification Points

5. Use the Instrument Verification Data Sheet, Appendix B to verify the measurements in *Figure 13* above.

6. Enter setup mode, SET (1.5s) and ensure the following parameters are set: units = "mV" and rAnGE = "Hi".

7. Connect the Positive of the Source and Read channels to the positive input of the DMM. Connect the negative of the Source and Read channels to the negative input of the DMM.

8. By using the ∧∨ and/or ‹› keys, adjust the instrument Source to match each value in *Figure 13* above for the "High range", notating the result from the DMM on the "Instrument Verification Data Sheet", Appendix D in "Source DC Volts Channel 1" "Measurement Result" and "Measure DC Volts Channel 2" "Standard" column.

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9. Pass/Fail Criteria:

   a) For "Source DC Volts Channel 1", a **PASS** result is any "Measurement Result" value that is equal to or in between the Lower Limit and Upper Limit error numbers.

   b) For "Measure DC Volts Channel 2", Calculate the limits of error by adding/subtracting the value noted in the "Tolerance" column to the value of the "Standard" column for each setpoint. A **PASS** result is any "Measurement Result" value that is equal to or in between the Lower Limit and Upper Limit error numbers.

10. Enter setup mode, SET (1.5s) and ensure the following parameters are set: units = "mV" and rAnGE = "Lo".

11. By using the ^ v and/or < > keys, adjust the instrument Source to match each value in *Figure 13* in the "Low range", notating the result from the DMM on the "Instrument Verification Data Sheet", Appendix B in "Source DC Volts Channel 1" "Measurement Result" and "Measure DC Volts Channel 2" "Standard" column.

12. Pass/Fail Criteria:

   c) For "Source DC Volts Channel 1", a **PASS** result is any "Measurement Result" value that is equal to or in between the Lower Limit and Upper Limit error numbers.

   d) For "Measure DC Volts Channel 2", Calculate the limits of error by adding/subtracting the value noted in the "Tolerance" column to the value of the "Standard" column for each setpoint. A **PASS** result is any "Measurement Result" value that is equal to or in between the Lower Limit and Upper Limit error numbers.

13. To verify the Cold Junction Compensation, (CJC) of the Source, (Channel 1) and Read, (Channel 2).

14. Place the 940A in a Controlled Environment[13] along with an accurate thermometer[14] for one hour to stabilize. Compare CJC readings with the reference thermometer reading. Display the CJC temperature by pressing ⏻ (1.5s). The screen will display "CJC 1" and the current temperature of CJC 1 in °C. Pressing the VIEW key again will display "CJC 2" and the current temperature of CJC 2 in °C. Notate the results in the "Cold Junction Compensation" section on the Instrument Verification Data Sheet, placing the Thermometer reading in the "Standard" column, and the CJC readings in the "Measurement Result" column. Select CLR to exit.

[13] An insulated box inside a calibration lab environment, see Appendix A.
[14] An accurate thermometer specification is 2 Sigma uncertainty ≤ .04°C (40mK) at the verification temperature.

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Insulated container with lid for controlled environment	Position accurate thermometer sensor in middle of MTC 1 and 2 as shown above

Figure 14: Insulated Container and External Temperature Sensor Position

15. Calculate the Lower and Upper limits: First, add a factory determined offset of 0.06°C to the "Standard" value, then add/subtract 0.11°C from the result. For example: the thermometer reading stabilized at 23.82 °C; add 0.06 °C offset to get 23.88 °C, then determine the upper limit as 23.99°C (23.88 + 0.11), and the lower limit as 23.77 °C (23.88 minus 0.11). The CJC values should be no greater than these limits. (NOTE: The 0.11 °C value is derived from the 0.15 °C specification minus the .04 °C uncertainty of the temperature measurement device.)

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4.2.2 Alignment Procedure

Published temperature uncertainty values can only be achieved if the temperature of UUT is known within 40 mK. Customers performing CJC adjustments in their facility will need to calculate their own uncertainty.

For best results, the instrument keypad is the only part of the instrument that should be touched after the acclimation period inside the controlled environment. The temperature sensor should not be touched.

1. This procedure shall be performed within environmental conditions of 23 ±1 °C and 5% to 95% RH.
2. The unit under test ("UUT") shall be acclimated to the Controlled Environment for a minimum of four (4) hours. The customer supplied calibrated temperature measurement device used for CAL 11 and CAL 12 below shall also be acclimated in the same Controlled Environment simultaneously with the UUT.
3. The equipment listed in *Appendix A* is required to align the UUT to operate within the expanded instrument uncertainties for mV values specified in *Appendix B*. Customers performing CJC adjustments in their facility will need to calculate their own CJC uncertainty.
4. Remove the UUT battery door housing to expose the alignment access hole.
5. Connect the Positive of the Source and Read channels to the positive input of the DMM. Connect the negative of the Source and Read channels to the negative input of the DMM.
6. Press UUT ⏻ to turn the UUT on. Disable the Auto-Power Off press ⏻(1.5s)

CAUTION	Do not apply voltages greater than 83 mV DC to the UUT inputs. Voltages greater than 83 mV may damage the instrument.

Continued on next page…

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7. Insert the Straightened Paper Clip through the alignment access hole and gently press the calibration enable switch located on the circuit board to enter CAL mode. See *Figure 15* for location.

Figure 15: Alignment Access Hole Location

8. Temporary calibration values are set to a gain of 1 and offset of 0 every time calibration is entered. If the calibration is accepted and saved without entering new values, the temporary values are copied to the system values for use.

Voltage Gain and Offset Alignment

9. The UUT display will indicate as follows:
   a. Line 1: "-10.000"
   b. Line 2: "CAL 1"

   The instrument is now sourcing -10.000 mV.

10. By using the ^ v and/or < > keys, adjust the instrument to match as close as possible the DMM display voltage.

    Use the VIEW key to save the settings and advance to "CAL 2". Repeat this step to and including CAL 10.

CAL 1	-10.000 mV
CAL 2	80.000 mV
CAL 3	-10.000 mV
CAL 4	80.000 mV
CAL 5	-10.000 mV
CAL 6	30.000 mV
CAL 7	-10.000 mV
CAL 8	80.000 mV
CAL 9	-10.000 mV
CAL 10	30.000 mV
CAL 11	External measured temperature in °C
CAL 12	External measured temperature in °C

Figure 16: Voltage Gain and Offset Alignment Values

11. CAL 11 and CAL 12 are used to set the Cold Junction Compensation, (CJC) of the Source, (Channel 1) and Read, (Channel 2). These steps require the use of a customer supplied calibrated temperature measurement device. With the probe as close as reasonable to the channel 1 CJC, and temperature stabilized, enter the externally measured temperature in Celsius for channel 1. Repeat this step for Channel 2, CAL 12. See *Figure 16* above.

12. The device now displays  for a 2-digit month. By using the ^ v and/or < > keys, adjust the instrument to the 2-digit month for the calibration being conducted. Press VIEW to save and advance to day.

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13. The device now displays  for a 2-digit day. By using the ▲▼ and/or ◄► keys, adjust the instrument to the 2-digit day for the calibration being conducted. Press VIEW to save and advance to year.

14. The device now displays  for a 4-digit year. By using the ▲▼ and/or ◄► keys, adjust the instrument to the 4-digit year for the calibration being conducted. Press VIEW to save and advance to Tech ID.

15. The device now displays  for a technician ID. By using the ▲▼ and/or ◄► keys, adjust the instrument to the calibration technician ID. Select a value from 0 – 99999 for the calibration technician ID and press SET to save and exit.

4.3 Troubleshooting

TEGAM's digital handheld thermometers are designed and built to provide years of uninterrupted use. In the event the instrument malfunctions or does not perform as expected, helpful troubleshooting tips are provided below. *Figure 17* below lists some of the more common issues and their resolutions.

SYMPTOM	DESCRIPTION	RESOLUTION
Unexpected reading on Line 2 of Display	Statistics View Mode is active	Press VIEW to cycle through statistics views until active measurement is displayed (see *Section 3.4 View Modes and Statistics*)
Unexpected or Erroneous Measurement	Probe offset is active	Set probe offset to correct value for connected temperature probe (see *Section 3.10, Probe Offset)*
	Temperature probe has not stabilized	Observe display trend indicators and wait for stable measurement (see *Section 3.8 Trend Indicators*)
	Instrument is set to the wrong thermocouple type for the attached probe	Set the thermocouple type as appropriate for the attached probe (see *Section 0, Setup* Menu)
	When sourcing from a thermocouple simulator, Open Lead Detection is enabled.	See *Section 3.11, Open Lead Detection Enable/Disable* to disable

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SYMPTOM	DESCRIPTION	RESOLUTION
Unresponsive	Static discharge through connected probes	Press ⏻ to cycle instrument power
Shuts down unexpectedly or will not power on	Batteries are low or depleted	Replace batteries (see *Section 2.5, Battery Installation and Replacement*)
Display shows "Short ChAn1" on power up.	A thermocouple, shorted transducer, or other short circuit is plugged into the Source Channel during startup.	Remove the shorting device. Be sure thermocouple is plugged into the Read Channel, not Source.

Figure 17: Common Troubleshooting Issues

4.4 Diagnostic Routines and Error Codes

The instrument momentarily activates all display annunciators and segments during startup to allow for visual inspection of the LCD. Observe the LCD and verify all segments activate.

Internal diagnostic routines are also executed during startup. If any diagnostic routine detects a malfunction, an error will be displayed as shown in *Figure 18* below.

ERROR CODE	DESCRIPTION
Err ADC	Analog to digital converter error
Err InP	Stuck key or other keypad error

Figure 18: Diagnostic Routine Error Codes

4.5 Memory Sterilization

To erase all locally stored measurement data and reset accumulated statistics, press CLR (1.5s) . See *Section 3.12, Clear Function* for instructions.

Instrument parameters will be retained. Refer to *Section 0, Setup* Menu to set instrument parameters as desired.

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4.6 Preparation for Calibration or Repair Service

Once you have verified that the cause of the malfunction cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA (Returned Material Authorization) number. You can contact TEGAM customer service via the Advanced Energy TEGAM website, www.aei.com or by calling 440-466-6100 (*All Locations*) or 800-666-1010 (*United States Only*).

The RMA number is unique to your instrument and will help us identify your instrument and to address the particular service request by you which is assigned to that RMA number.

Of even greater importance, a detailed written description of the problem should be attached to the instrument. Many times, repair turnaround is unnecessarily delayed due to a lack of repair instructions or a detailed description of the problem.

This description should include information such as measurement range and other instrument settings at the time of the malfunction, type of components being tested, frequency of the symptoms (intermittent or continuous), conditions that may cause the symptoms, changes to the test setup or operating environment that may affect the instrument, etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use a copy of the Repair and Calibration Service form provided on the next page.

Once this information is prepared and sent with the instrument to our service department, we will do our part to make sure that you receive the best possible customer service and turnaround time possible.

4.7 Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The completion of this form and including it with your instrument will expedite the processing and repair process.

RMA#:		Instrument Model #:	
Serial Number:		Company:	
Technical Contact:		Phone Number:	
Additional Contact Info:			

Service Instructions:

☐ Evaluation ☐ Calibration Only ☐ Repair Only

☐ Repair & Calibration ☐ ISO 17025 Calibration with Data

Detailed Symptoms:

Include information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent? Has anything changed with the application since the last time the instrument was used, etc.?

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4.8 Warranty

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of three (3) years from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of one (1) year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other location. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever is greater.

4.9 Warranty Limitations

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

The foregoing warranty of TEGAM is in lieu of all other warranties, expressed or implied. TEGAM specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. In no event will TEGAM be liable for special or consequential damages. Purchaser's sole and exclusive remedy in the event any item fails to comply with the foregoing express warranty of TEGAM shall be to return the item to TEGAM; shipping charges prepaid and at the option of TEGAM obtain a replacement item or a refund of the purchase price.

4.10 Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by TEGAM, Inc.

TEGAM, Inc. certifies the above listed instrument has been inspected and calibrated and meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or other recognized National Metrology Institutes.

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A. Required Calibration Equipment

Equipment	Function	Range	Specification (2-Sigma)
DMM	DC Voltage Measurement	-13 mV to 83 mV	± (30 ppm of reading + 9 ppm of range)
Calibrated temperature measurement device	Measure ambient temperature during cold junction test.	18 °C to 28 °C	±40 mK (.04°C)
Controlled Environment	Insulated box to create a Controlled Environment; a very stable, low gradient air bath.		
Copper Mini-TC Cable	NOTE: This process requires a set of COPPER mini-TC connectors, with good quality, low-thermals wire. These cannot be tinned. (2) Copper Mini-TC Cables required for Voltage Gain and Offset alignment only. This cable does not require calibration. See Figure 11 above. One end shall be terminated with a male miniature copper thermocouple connector for connection to the UUT. The opposite end shall be terminated with copper connections appropriate for the DMM.		
Straightened Paper Clip	Required to access the calibration enable switch. Any rigid wire, approximately 0.8 mm in diameter, may be used.		

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B. Instrument Verification Data Sheet

Model:_____ Serial Number:_____

Parameter	Setpoint	Measurement Result	Limits of Error		Expanded[1] Uncertainty	Pass/Fail
			Lower Limit	Upper Limit		
Source DC Volts Channel 1						
High Range -13mV to 83 mV						
-13 mV	-13 mV		-13.00498 mV	-12.99502 mV	0.00194 mV	
-10 mV	-10 mV		-10.00498 mV	-9.99502 mV	0.00192 mV	
0 mV	0 mV		-0.0046 mV	0.0046 mV	0.0019 mV	
5 mV	5 mV		4.99525 mV	5.00475 mV	0.00191 mV	
20 mV	20 mV		19.99482 mV	20.00518 mV	0.00199 mV	
80 mV	80 mV		79.99325 mV	80.00675 mV	0.00306 mV	
83 mV	83 mV		82.99317 mV	83.00683 mV	0.00313 mV	
Low Range -13mV to 33 mV						
-13 mV	-13 mV		-13.00498 mV	-12.99502 mV	0.00194 mV	
-10 mV	-10 mV		-10.00498 mV	-9.99502 mV	0.00192 mV	
0 mV	0 mV		-0.0046 mV	0.0046 mV	0.0019 mV	
10 mV	10 mV		9.99511 mV	10.00489 mV	0.00192 mV	
30 mV	30 mV		29.99455 mV	10.00545 mV	0.0021 mV	
33 mV	33 mV		32.99446 mV	30.00554 mV	0.00214 mV	

Parameter	Standard	Measurement Result	Tolerance	Limits of Error		Expanded[1] Uncertainty	Pass/Fail
				Lower Limit	Upper Limit		
Measure DC Volts Channel 2 – The values entered in the "Standard" column below are the DMM readings for each setpoint. Calculate your Limits of Error by adding/subtracting the value noted in the "Tolerance" column for each setpoint.							
High Range -13 mV to 83 mV							
-13 mV			0.005 mV			0.00194 mV	
-10 mV			0.005 mV			0.00192 mV	
0 mV			0.0046 mV			0.0019 mV	
5 mV			0.0048 mV			0.00191 mV	
20 mV			0.0052 mV			0.00199 mV	
80 mV			0.00675 mV			0.00306 mV	
83 mV			0.00675 mV			0.00313 mV	
Low Range -13 mV to 33 mV							
-13 mV			0.005 mV			0.00194 mV	
-10 mV			0.005 mV			0.00192 mV	
0 mV			0.0046 mV			0.0019 mV	
10 mV			0.0049 mV			0.00192 mV	
30 mV			0.00545 mV			0.0021 mV	

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33 mV			0.00545 mV			0.00214 mV	

Channel	Standard	Measurement Result	Limits of Error		Expanded[2] Uncertainty	Pass/Fail
			Lower Limit	Upper Limit		
Cold Junction Compensation						
Note: The values entered in the "Standard" column below are the Reference Thermometer readings for each channel. Calculate your Limits of Error by: first add a factory determined offset of 0.06 °C to the "Standard" value, then add/subtract 0.11 °C from the result to determine upper/lower limits. See section 4.2.1 paragraph 15 for an example calculation.						
1			_____°C	_____ °C		
2			_____°C	_____°C		

[1]The estimated expanded uncertainties are based on a standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95%

[2]Published temperature uncertainty values can only be achieved if the temperature of UUT is known within 40 mK. Customers performing CJC adjustments in their facility will need to calculate their own CJC uncertainty.

Datasheet P/N 94X-DS Revision 1.0

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Thermocouple Calibrator Maximum Uncertainty over 100° Intervals

940A (K,J,T and E only) 945A/947A/948A Maximum Uncertainty over 100° Intervals

Range °C	K	J	T	E	N	B	R	S	G	C	D	"P"	L	U
-200* to -100	0.8	0.7	0.7	0.6	0.9								0.6	0.8
-100 to 0	0.4	0.3	0.4	0.3	0.4		1.9	1.5					0.4	0.5
0 to 100	0.3	0.3	0.3	0.3	0.3		1.1	1.1	4.0	0.5	0.6	0.3	0.3	0.3
100 to 200	0.3	0.2	0.2	0.2	0.3		0.8	0.8	1.0	0.4	0.4	0.3	0.4	0.4
200 to 300	0.3	0.2	0.2	0.2	0.3		0.7	0.7	0.6	0.4	0.4	0.2	0.3	0.3
300 to 400	0.3	0.2	0.2	0.2	0.2		0.6	0.7	0.5	0.4	0.3	0.2	0.5	0.5
400 to 500	0.3	0.2	0.2	0.2	0.2		0.6	0.6	0.4	0.4	0.3	0.2	0.3	0.3
500 to 600	0.3	0.2		0.2	0.2		0.6	0.6	0.3	0.3	0.3	0.2	0.3	0.3
600 to 700	0.3	0.2		0.2	0.2	0.9	0.5	0.6	0.3	0.4	0.3	0.2	0.4	
700 to 800	0.3	0.2		0.2	0.2	0.9	0.5	0.6	0.3	0.4	0.3	0.2	0.4	
800 to 900	0.3	0.2		0.2	0.2	0.8	0.5	0.6	0.3	0.4	0.3	0.2	0.3	
900 to 1000	0.3	0.2		0.2	0.2	0.7	0.5	0.5	0.3	0.4	0.3	0.3		
1000 to 1100	0.3	0.2			0.3	0.7	0.5	0.5	0.3	0.4	0.3	0.3		
1100 to 1200	0.3	0.3			0.3	0.7	0.5	0.5	0.3	0.4	0.3	0.3		
1200 to 1300	0.3				0.3	0.7	0.5	0.6	0.3	0.4	0.3	0.3		
1300 to 1400	0.3					0.7	0.5	0.5	0.3	0.4	0.3	0.3		
1400 to 1500						0.7	0.5	0.5	0.3	0.4	0.3			
1500 to 1600						0.6	0.5	0.6	0.3	0.4	0.3			
1600 to 1700						0.7	0.5	0.6	0.3	0.4	0.3			
1700 to 1800						0.6	0.5	0.6	0.3	0.4	0.3			
1800 to 1900									0.3	0.4	0.3			
1900 to 2000									0.3	0.4	0.4			
2000 to 2100									0.3	0.5	0.4			
2100 to 2200									0.3	0.5	0.4			
2200 to 2300									0.3	0.5	0.4			

*Or Lower Limit of Thermocouple Type

Commented [MT([P5]: Should 947 and 948 be added to the 945 line?

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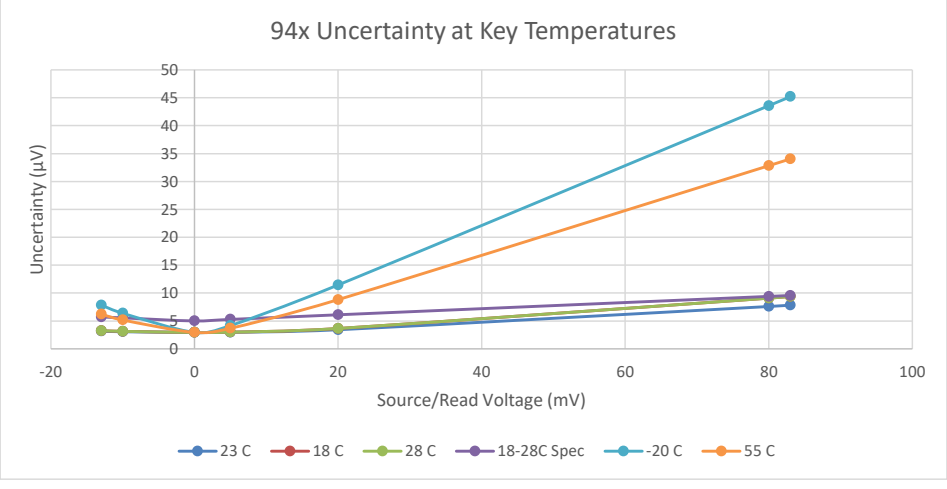
C. Expanded Instrument Uncertainties

All uncertainty specifications for all charts are K = 2 unless otherwise noted.



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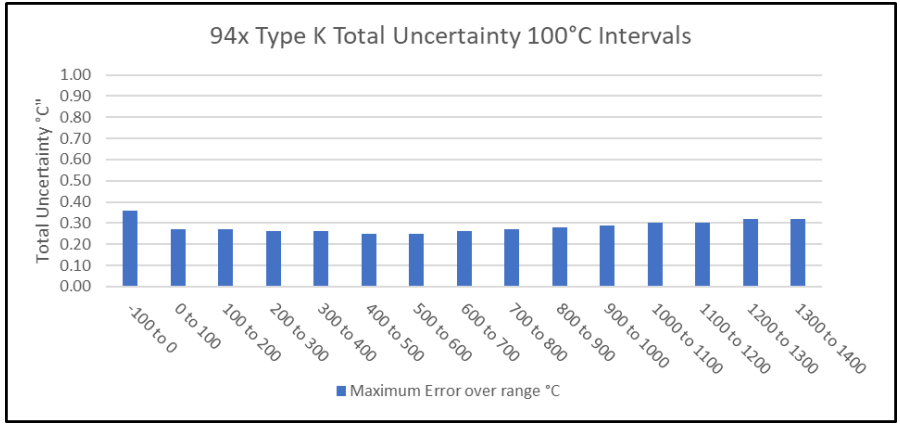
The following graphs show total uncertainty in degrees C (k=2), with operating conditions between 18-28 °C unless otherwise noted.



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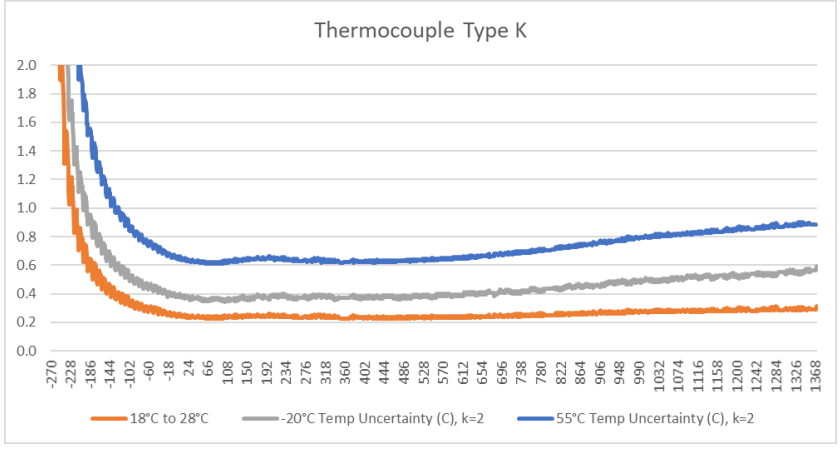

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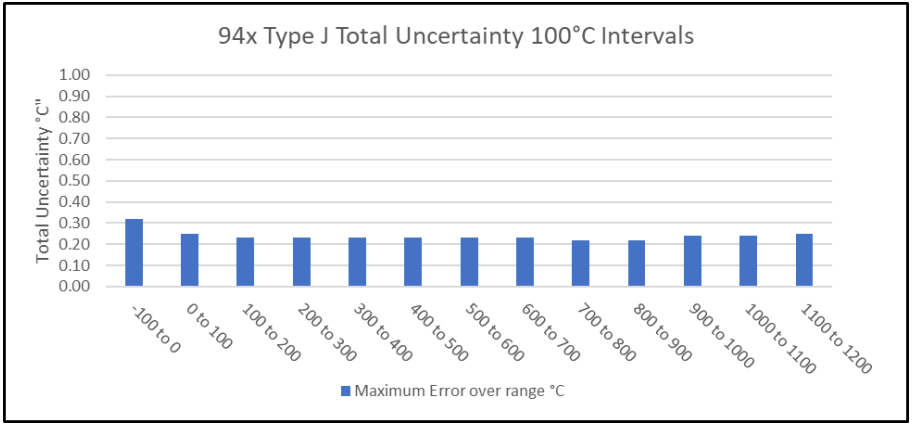

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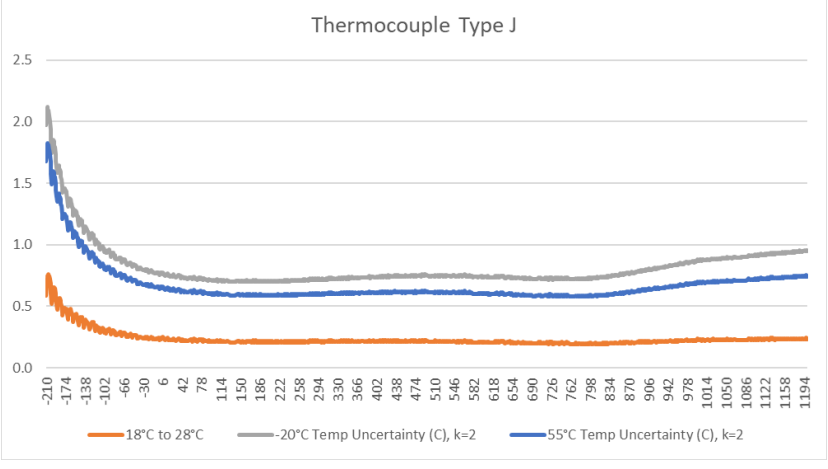

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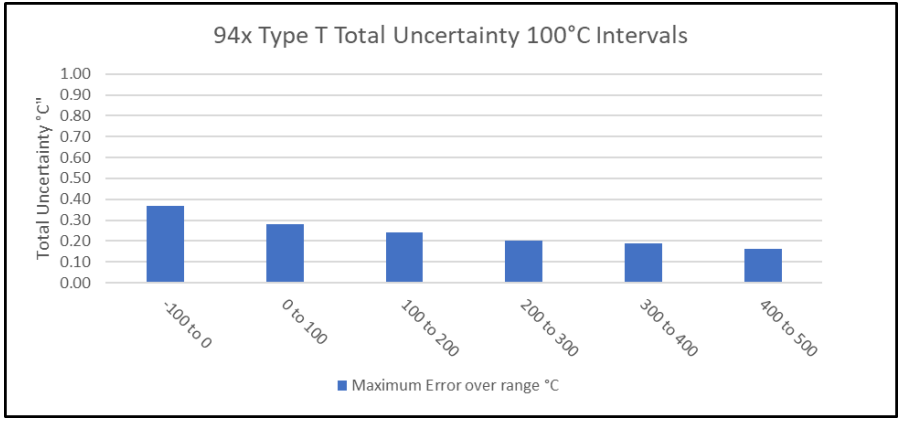

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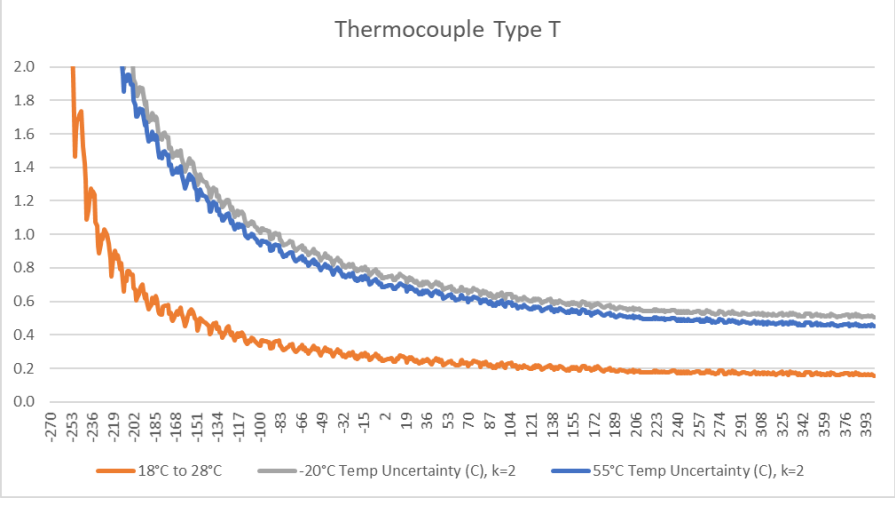

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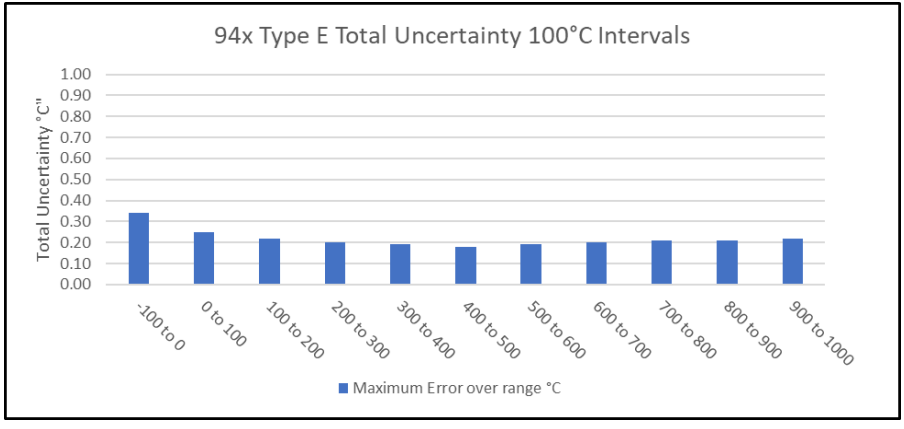

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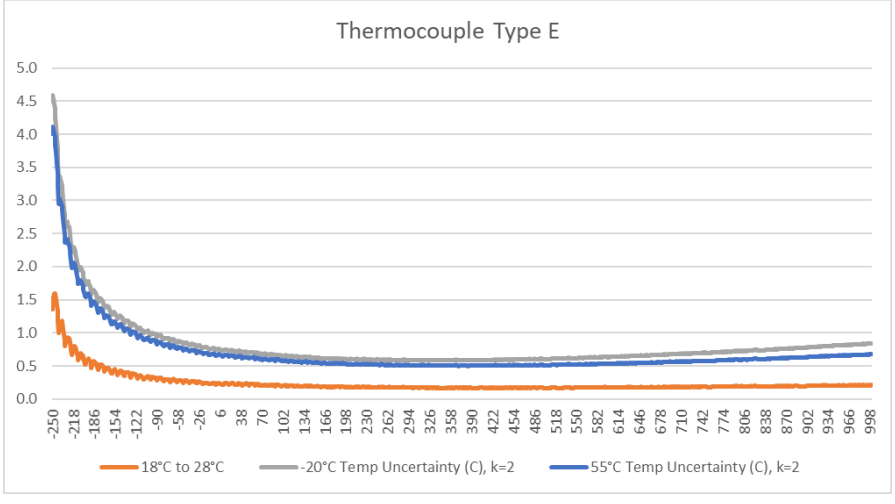

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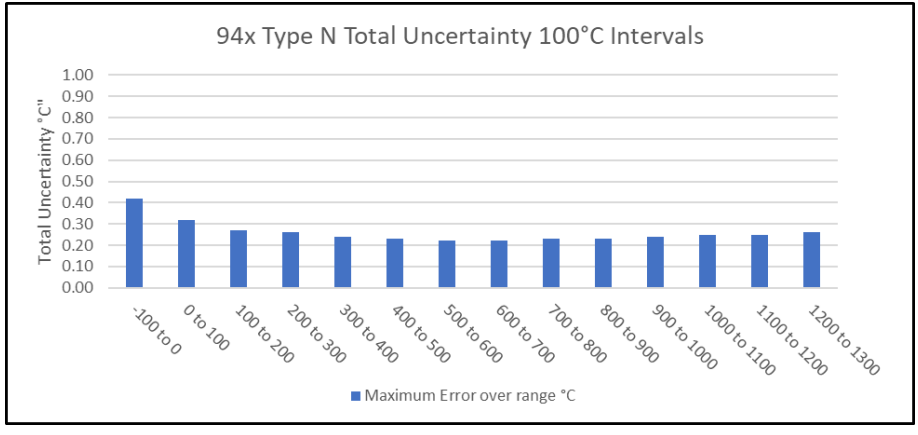

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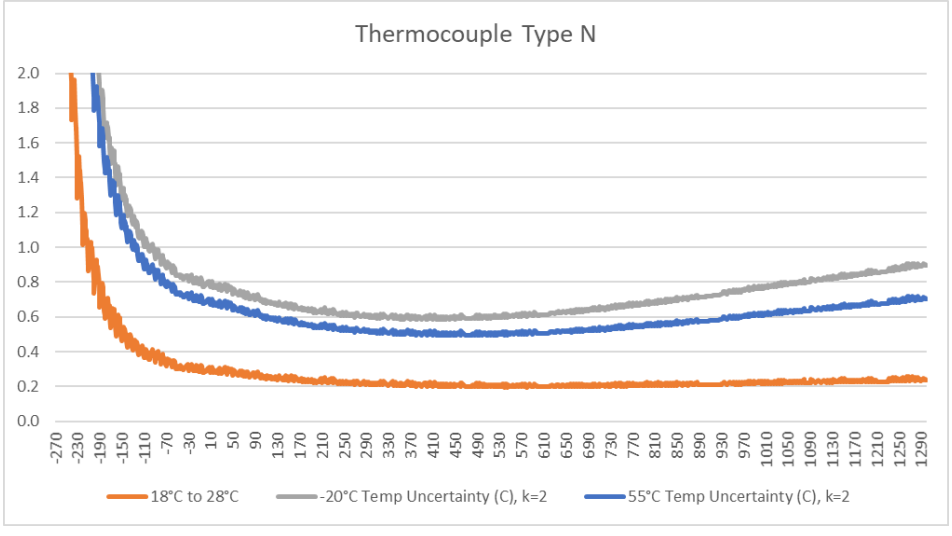

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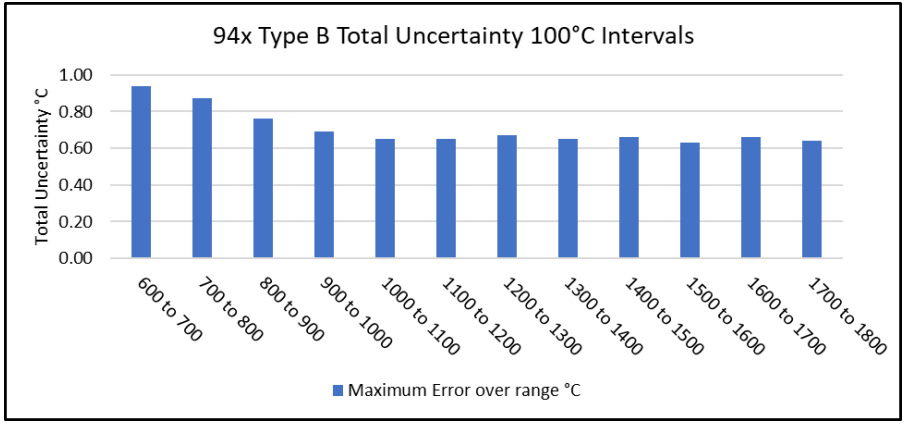

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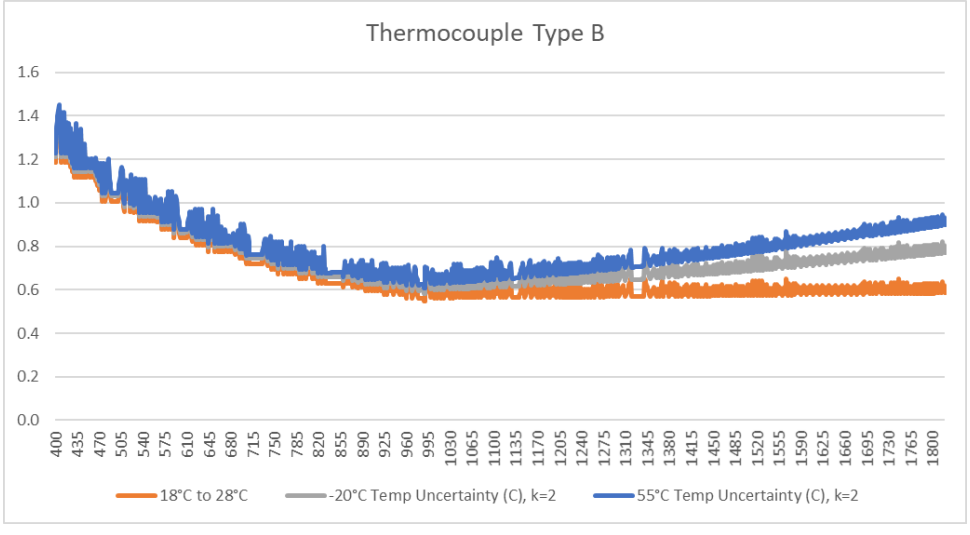

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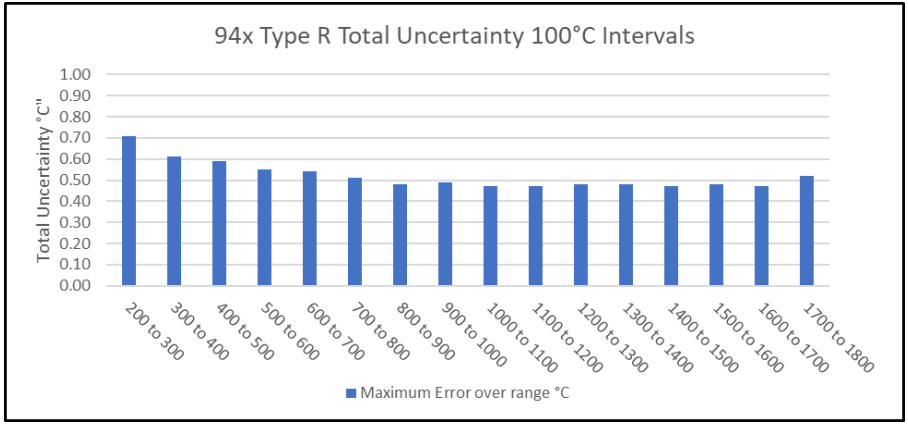

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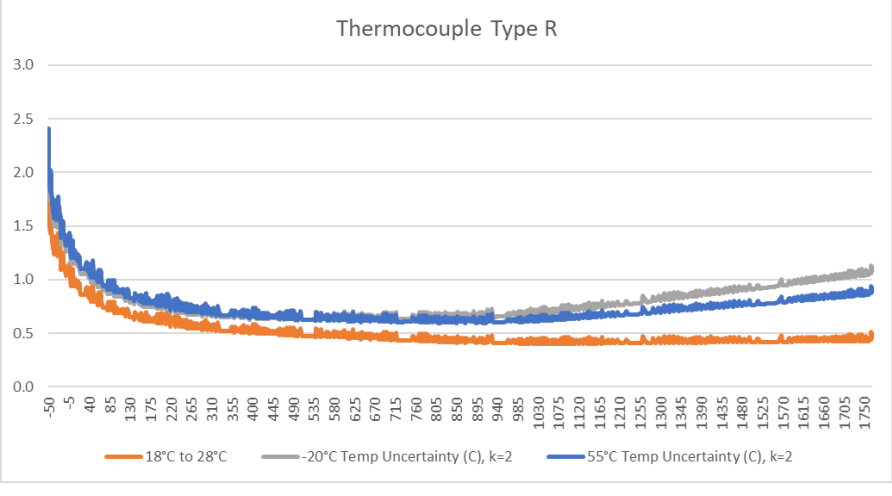

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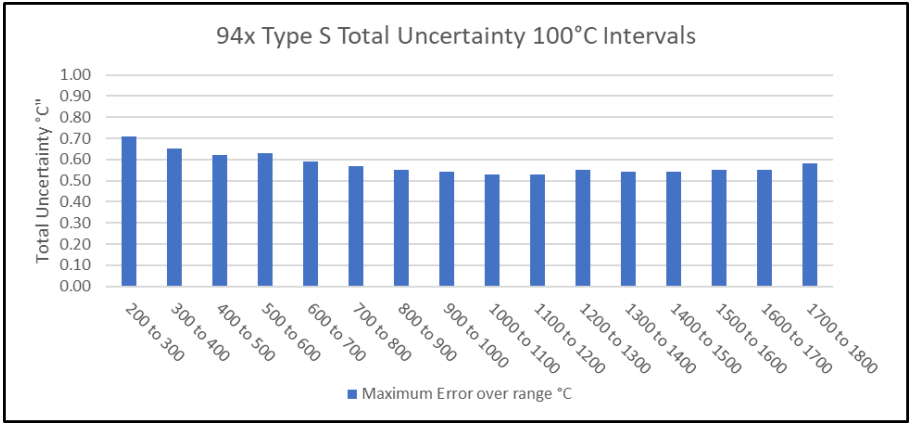

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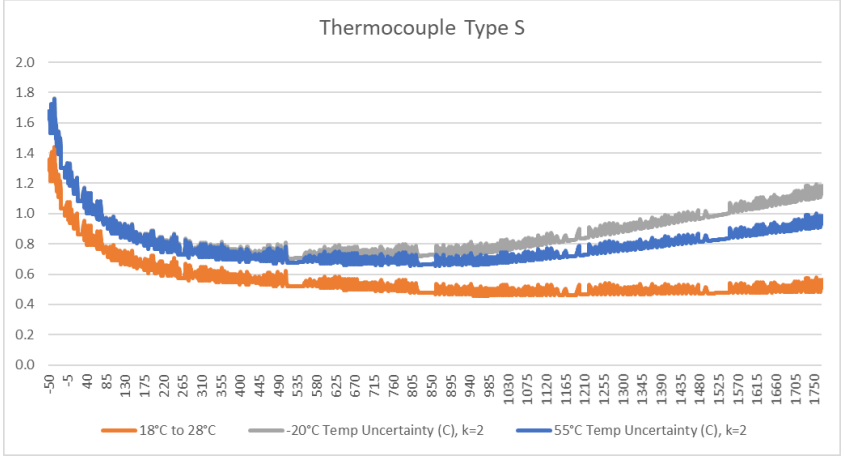

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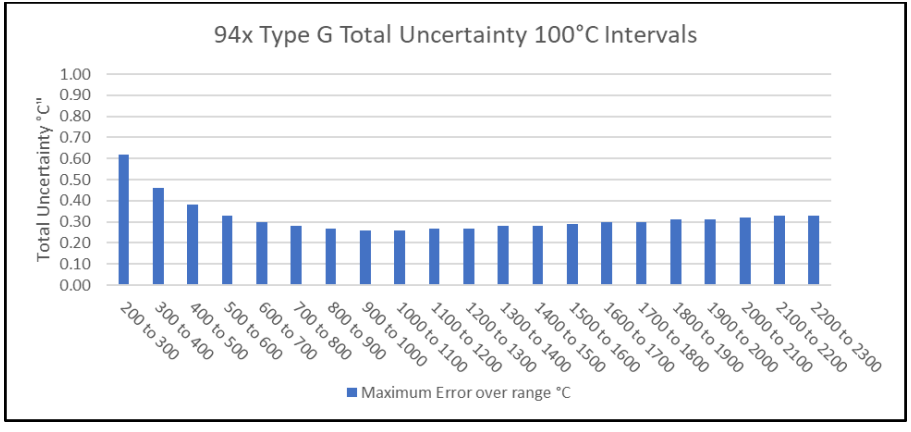

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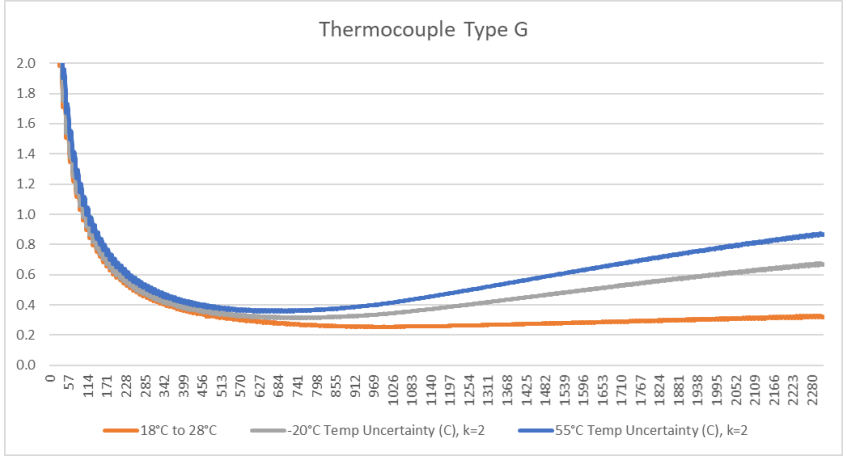

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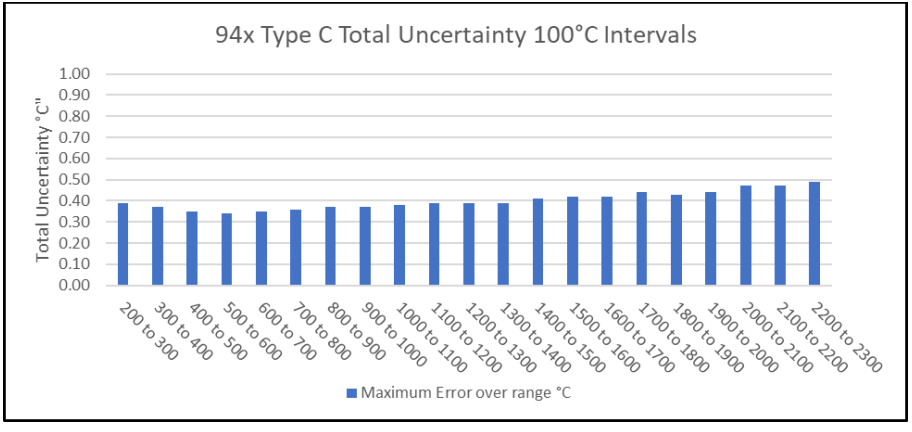

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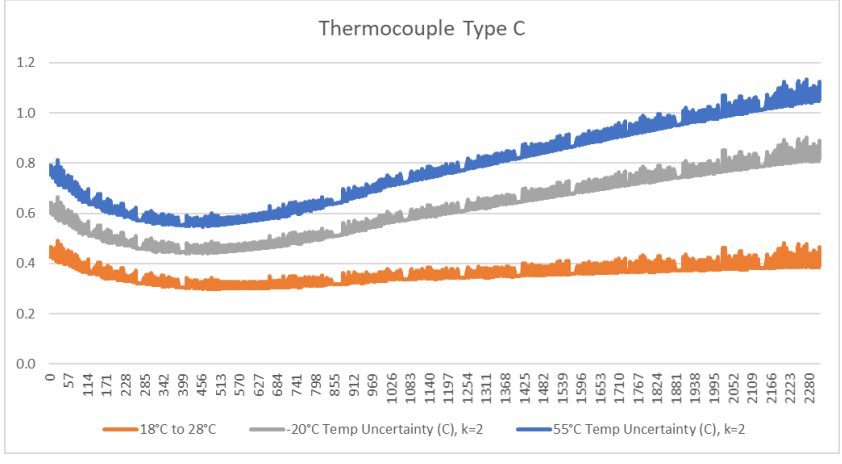

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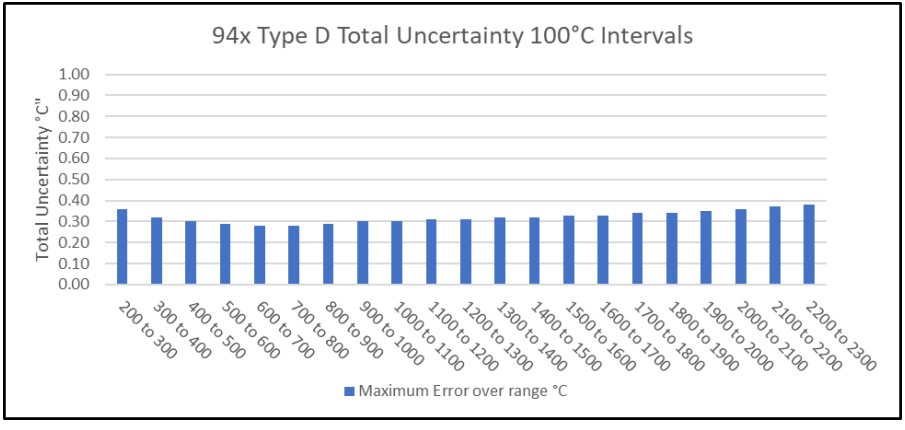

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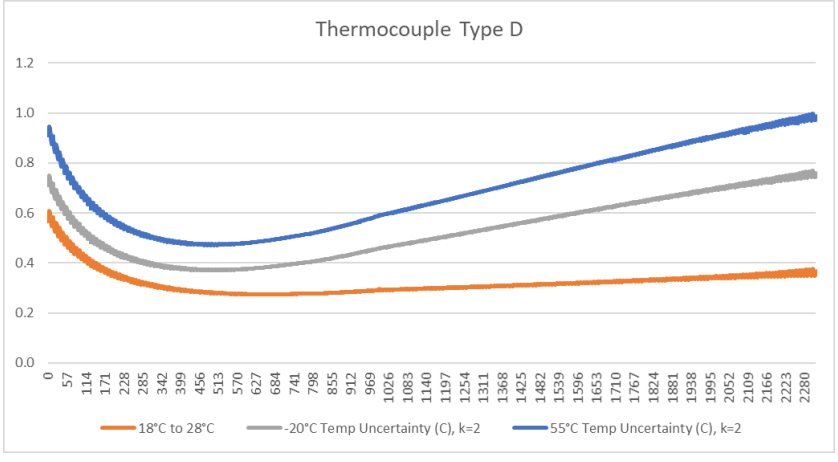

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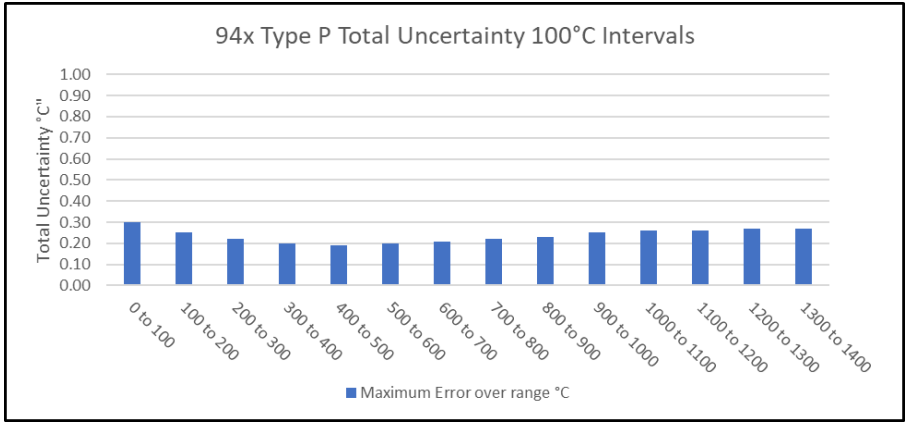

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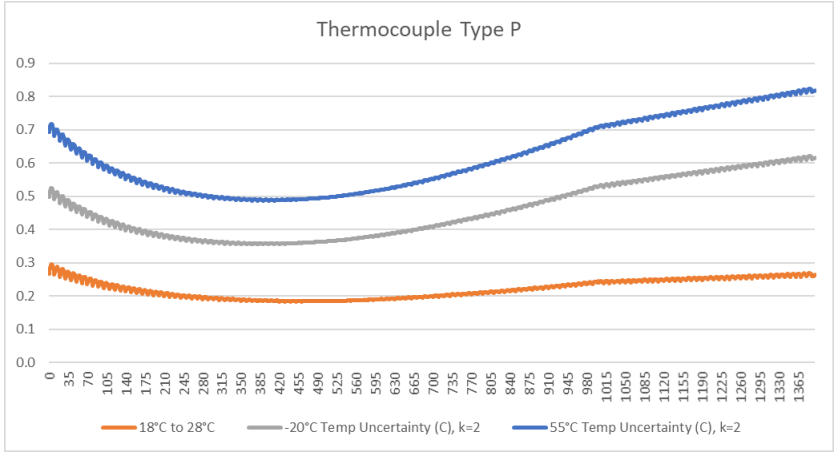

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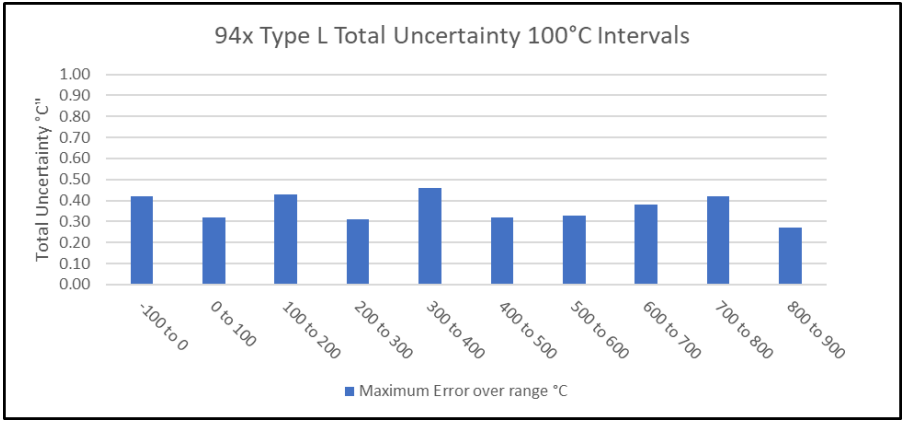

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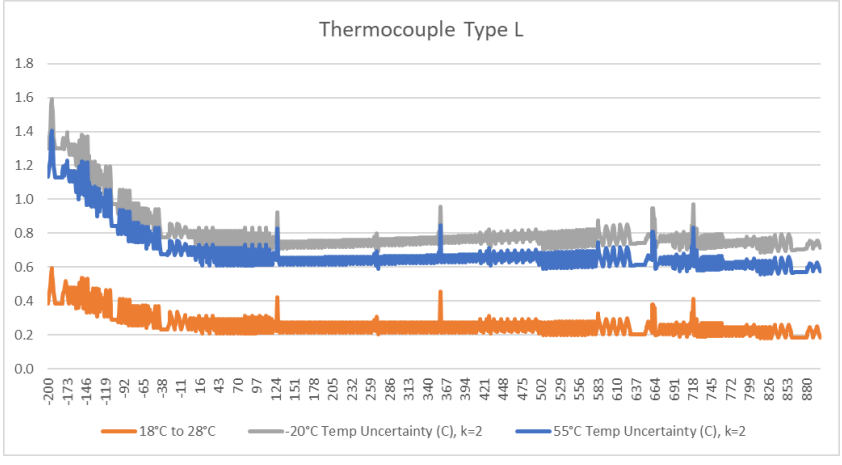

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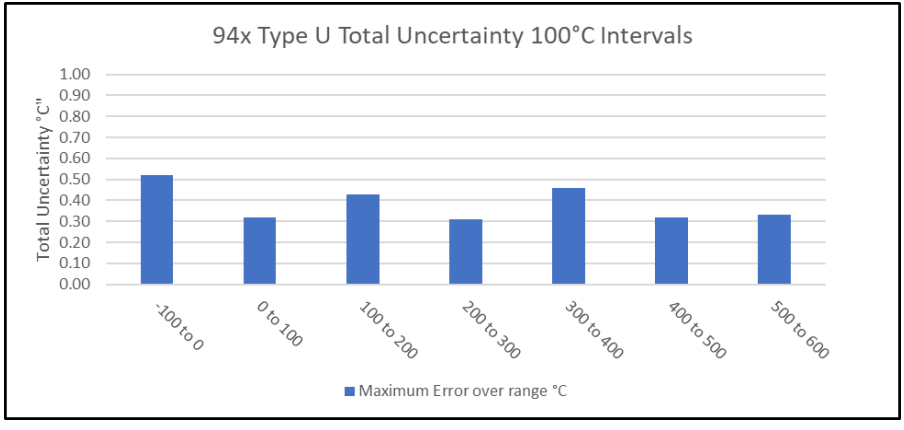

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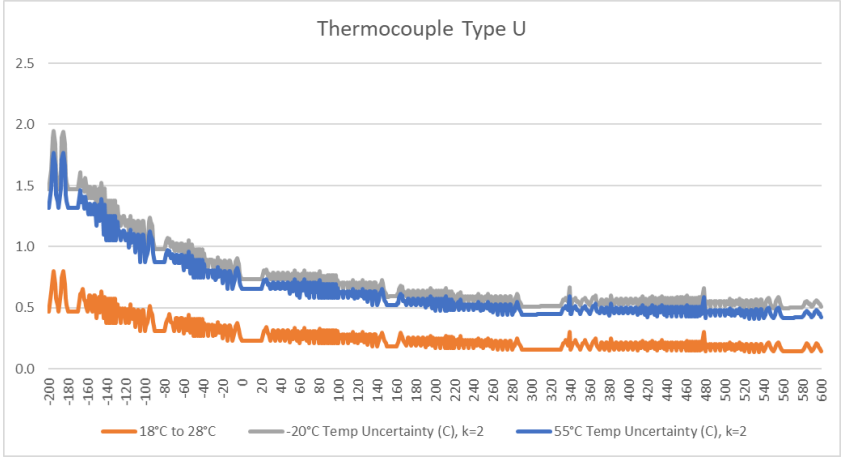

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TEGAM, Inc.
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Geneva, OH 44041
www.aei.com