

Brian K. Spillar

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Mr. William Farrell

8/5/2013

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Reference GTI Report 20835.1.08 and 111724 Issued 3/16/2012, Rev. B DRAFT

Dear Mr. Farrell:

We have revised the report with clarification and explanation to Table 1. Our testing utilized a custom test rig using data collection instrumentation with calibrations traceable to NIST using compressed air. Copies of these certifications are supplied in the Annex of this report. The performance requirement you required was defined by MGL Section 75A of Chapter 164, Ruling #14899 (March 1974) Section 8 (c) and (d). The requirement specified an activation (trip) temperature not to exceed 250°F and a post trip flow rate not exceeding 1% of the open (pre-tripped) flow rate. All of the submitted units tripped below 250°F and exhibited no detectable flow once tripped. Specifics for each of these are contained in the following text.

Pressure Testing

Each of the units was assembled in the test apparatus as shown in Figure 1 through Figure 3.

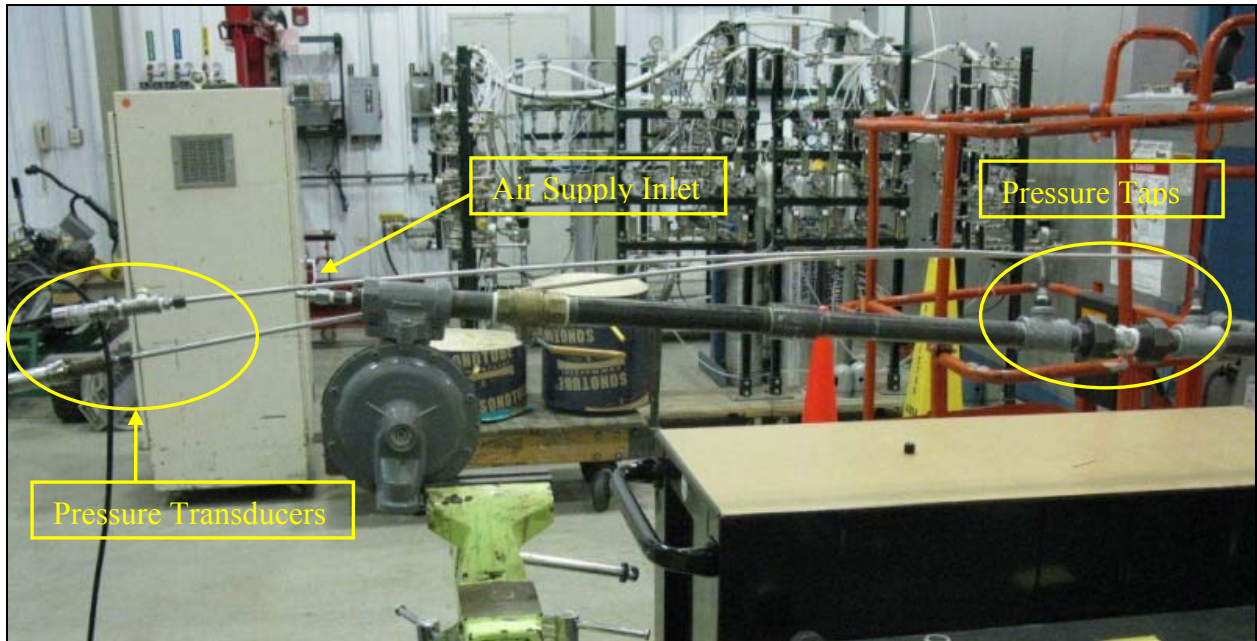


Figure 1. Documentary Image, General Test Rig Configuration

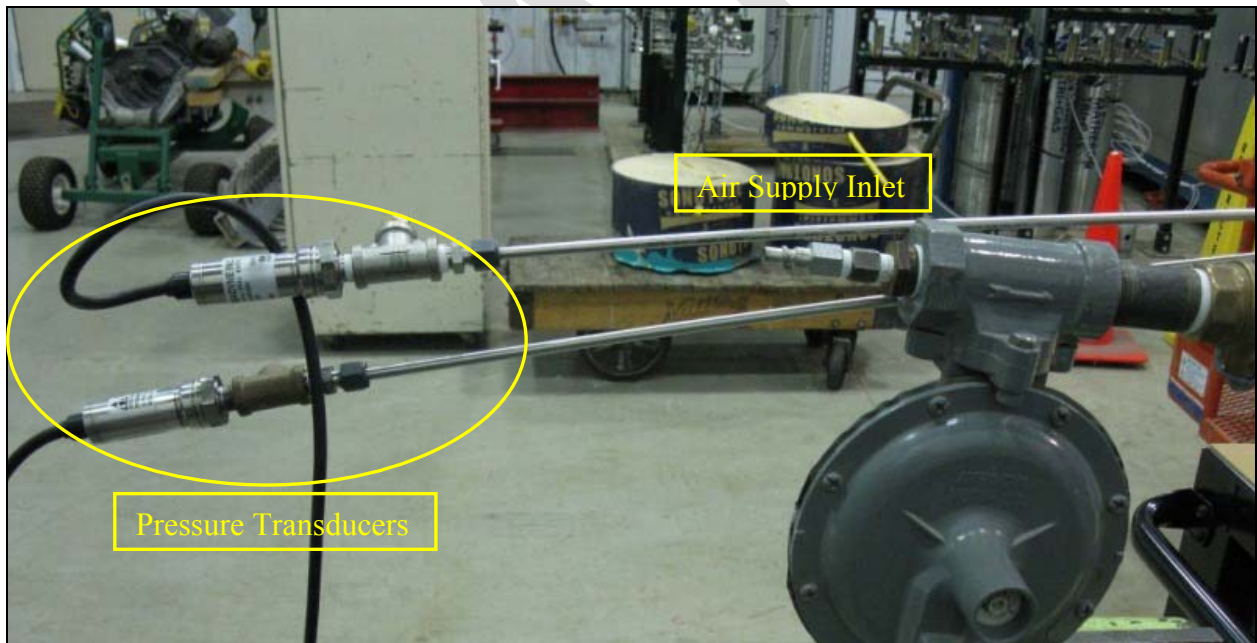


Figure 2. Documentary Image, Transducer Location and Regulator

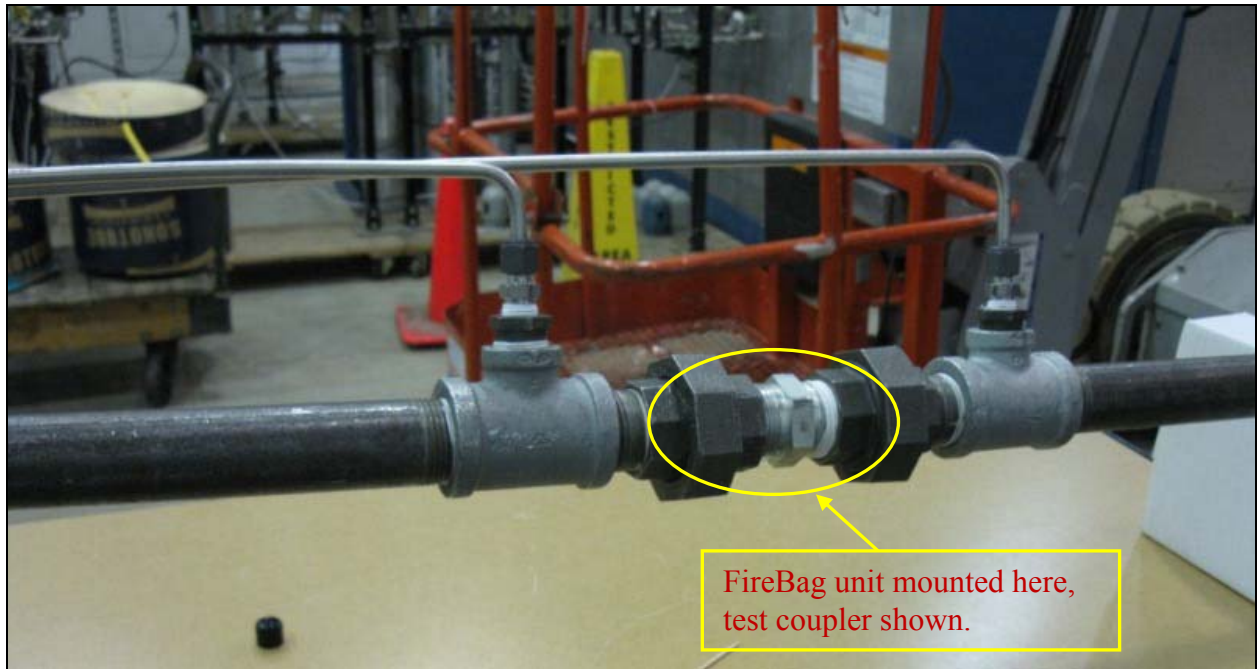


Figure 3. Pressure Tap Locations

The initial regulator pressure was set at the no flow condition. When flowing the FireBag units in the un-tripped condition, the inlet pressures dropped significantly and no adjustments were made to maintain the regulator set pressure. High accuracy pressure transducers were used to monitor the upstream and downstream pressures and averaged between the replicates of each size unit. These average pressure measurements were then used along with the outlet bore size to calculate flow. These flow rates were then converted from air to methane. Finally, the percentage pressure drops were calculated for all three (3) unit sizes and were found to be within approximately 10% between sizes. The results are presented in **Error! Reference source not found.**

Table 1. Pre-tripped Pressure Test Results

Size: NPT-Unit	Regulator Set Pressure [inWC]	Fitting Inlet Pressure [inWC]	Fitting Outlet Pressure [inWC]	Fitting Pressure Differential [inWC]	Fitting Pressure Drop [%]	Estimated Flow, Methane [CFM]
1"-1	5.759	0.542	0.098	0.444	81.9	----
1"-2	6.290	0.539	0.088	0.45	83.5	----
1"-3	6.254	0.546	0.1	0.446	81.7	----
Average	----	0.542	0.095	0.447	82.5	7.095
¾"-1	6.161	1.583	0.248	1.335	84.3	----
¾"-2	6.324	1.76	0.322	1.384	78.6	----
¾"-3	6.327	1.708	0.332	1.376	80.6	----
Average	----	1.666	0.301	1.365	81.9	7.562
½"-1	6.276	4.273	1.034	3.239	75.8	----
½"-2	6.327	4.241	1.018	3.223	76.0	----
½"-3	6.252	4.257	1.104	3.242	76.2	----
Average	----	4.257	1.022	3.235	76.0	5.742

Equivalent length of the three (3) units was calculated using the following equation and solving for L. All values for air at ambient laboratory conditions:

For low pressure, less than 1.5psig:

$$Q = 2313D^{2.623} \left(\frac{\Delta H}{Cr \cdot L} \right)^{0.541}$$

$$\left(\frac{Q}{2313D^{2.623}} \right)^{1/0.541} = \frac{\Delta H}{Cr \cdot L}$$

$$L = \frac{\Delta H}{Cr} \left(\frac{Q}{2313D^{2.623}} \right)^{-1/0.541}$$

L = Length in Feet

ΔH = Pressure Drop in WC Average for three runs

Cr = Factor for viscosity, density, and temperature Air = 1

Q = Flow Rate CFH

D = Pipe Inside Diameter, in for Schedule 40 steel pipe

Table 2. Calculated Equivalent Lengths

Size: NPT-Unit	Equivalent Length [Feet]
1"	20.60
3/4"	17.59
1/2"	17.50

Trip Point Temperature

Figure 4 shows the units in the pre-tripped condition.



Figure 4. Documentary Image, Pre-tripped Condition

The units were replaced in a laboratory oven set at 212°F. The temperature of the units was monitored using a series of remote thermocouples placed strategically among and in contact with them. After four (4) minutes the remote thermocouples reported a temperature range of 182°F to 190°F and visual examination indicated that none of the units had tripped.

The oven controller temperature was increased to 234°F and after five (5) minutes the remote thermocouples indicated a temperature range of 200°F to 210°F with all units remaining un-tripped. After another five (5) minutes elapsed test time, the remote thermocouples read 205°F to 221°F and visual observation indicated that the one inch (1") units and half inch(1/2") units had tripped while two (2) of the three-quarter inch (3/4") units tripped. Two (2) min. later the remaining three-quarter inch (3/4") unit had tripped. The temperature at which all of the units in tripped ranged from 205°F to 221°F, which was below the specified max trip temperature of 250° F. See Figure 5.

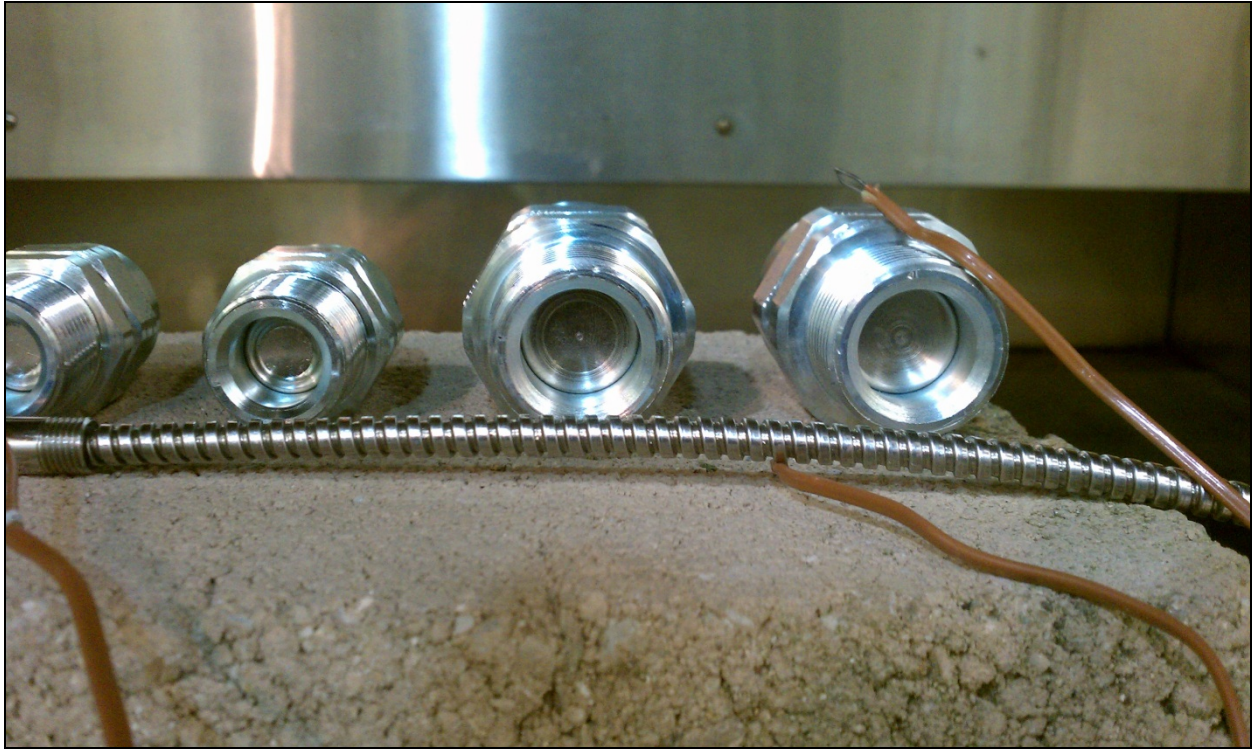


Figure 5. Documentary Image, Tripped Condition

The units were allowed to cool and reassembled into the pressure test rig and tested. The results of this testing indicated the absence of pressure readings on the outlet side of all of the units. See Table 3. Accuracy of the pressure transducers is certified at 0.08% of full scale (0.008inWC). The calculated error in flow measurement was determined to be 0.41%. This 0.41% value is below the specified requirement of 1% of un-tripped flow for the units in the tripped position.

Table 3. Tripped Pressure Test Results

Size: NPT-Unit	Regulator Set Pressure [inWC]	Fitting Outlet Pressure [inWC]	Flow: [CFM]
1"-1	6.458	0.000	0.000
1"-2	6.311	0.000	0.000
1"-3	6.694	0.000	0.000
¾"-1	6.336	0.000	0.000
¾"-2	6.312	0.000	0.000
¾"-3	6.342	0.000	0.000
½"-1	6.291	0.000	0.000
½"-2	6.305	0.000	0.000
½"-3	6.291	0.000	0.000

Thank you for allowing GTI to assist you in this work. Should you have any additional questions please don't hesitate to contact me.

Sincerely,



Brian K. Spillar
Senior Engineer

This laboratory maintains A2LA accreditation to ISO/IEC 17025 for specific tests listed in A2LA Certificate 2139-01 and meets the relevant quality system requirements of ISO 9000:2005. The tests included in this report however are not covered by this accreditation.

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- c. The results within this report relate only to the items tested.



Annex of Equipment Certifications (Next Page)

**OMEGADYNE INC.
CERTIFICATE OF CALIBRATION**

Model Number: PX409-10WG5V
Serial Number: 405953
Date: 6/8/2011
Job: R3121

Capacity: 10.00 in H₂O^z
Excitation: 24.00 Vdc
Technician: GRS

Pressure Connection: 1/4-18 NPT Male

WIRING CODE

Electrical Connection: Integral Cable 4-Cond
BLACK = - EXCITATION
WHITE = + OUTPUT
GREEN = N/C
RED = + EXCITATION

CALIBRATION WORKSHEET

NOTES

Pressure in H ₂ O	OUTPUT Vdc
0.00	- 0.002
5.00	2.494
10.00	4.992
5.00	2.494
0.00	- 0.003

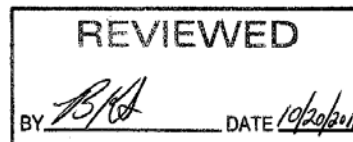
NIST Traceable Number(s): C-1954, C-1289

Omegadyne Inc. certifies that the above instrumentation has been calibrated and tested to meet or to exceed the published specifications. This calibration was performed using instrumentation and standards that are traceable to the National Institute of Standards and Technology. This document also ensures that all testing performed complies with MIL-STD 45662-A, ISO 10012-1, and ANSI/NCSL Z540-1-1994 requirements. After Final Calibration our products are stored in an environmentally controlled stock room and are considered in bonded storage. Depending on environmental conditions and severity of use, factory calibration is recommended every one to three years after the initial service installation date.

Bruce Lott

Accepted and Certified By

6/8/2011
Date



OMEGADYNE INC. CERTIFICATE OF CALIBRATION

Model Number: PX409-10WG5V

Serial Number: 404366

Date: 8/20/2010

Job: R2128

Capacity: 10.00 in H2O

Excitation: 24.00 Vdc

Technician: GRS

Pressure Connection: 1/4-18 NPT Male

WIRING CODE

Electrical Connection: BLACK = - EXCITATION

WHITE = + OUTPUT

GREEN = N/C

RED = + EXCITATION

CALIBRATION WORKSHEET

Pressure in H2O	OUTPUT Vdc
0.00	0.003
5.00	2.504
10.00	5.002
5.00	2.504
0.00	0.004

NIST Traceable Number(s): C-1954, C-2466

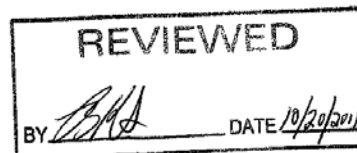
Omegadyne Inc. certifies that the above instrumentation has been calibrated and tested to meet or to exceed the published specifications. This calibration was performed using instrumentation and standards that are traceable to the National Institute of Standards and Technology. This document also ensures that all testing performed complies with MIL-STD 45662-A, ISO 10012-1, and ANSI/NCSL Z540-1-1994 requirements. After Final Calibration our products are stored in an environmentally controlled stock room and are considered in bonded storage. Depending on environmental conditions and severity of use, factory calibration is recommended every one to three years after the initial service installation date.

Bruce Lott

Accepted and Certified By

8/20/2010

Date



GAGE & ABSOLUTE PRESSURE SENSOR																		
PX 409, 409C, 419, 429 0 TO 5 VDC																		
CERTIFICATE OF CONFORMANCE DOCUMENT A012570																		
MODEL NUMBER INTERPRETATION																		
PX	X1	X2	X3	X4	X5	X6	X7	X8	PRESSURE RANGE (PSI)	SUPPLY VOLTAGE (VDC)	OUTPUT (VDC)	COMPENSATED TEMPERATURE (C)	ZERO SHIFT +/-SPAN	SPAN SHIFT +/-SPAN	OVER PRESSURE (TIMES)	CONTAINMENT GAGE UNITS PSIG	CONTAINMENT ABS UNITS PSIA	
CABLE	4	0	9	1	0	W	G	N/A	5V	10"H2O	10 TO 30	0 TO 5	-17 TO 85	1.00	1.00	10	1000	NA
DIN	4	1	9	0	0	1	G	N/A	5V	1	10 TO 30	0 TO 5	-17 TO 85	1.00	1.00	6	1000	NA
BENDIX	4	2	9	2		5	G	N/A	5V	2.5	10 TO 30	0 TO 5	-17 TO 85	0.50	0.50	4	1000	NA
CONDUIT	4	0	9C	0	0	5	G	A	5V	5	10 TO 30	0 TO 5	-17 TO 85	0.50	0.50	4	1000	6000
				0	1	5	G	A	5V	15	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				0	3	0	G	A	5V	30	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				0	5	0	G	A	5V	50	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				1	0	0	G	A	5V	100	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				1	5	0	G	A	5V	150	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				2	5	0	G	A	5V	250	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				5	0	0	G	A	5V	500	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				7	5	0	G	A	5V	750	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				1	0	K	G	A	5V	1000	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	3000	6000
				1	5	K	G	A	5V	1500	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	15000	15000
				2	5	K	G	A	5V	2500	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	15000	15000
				3	5	K	G	A	5V	3500	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	4	15000	15000
				5	0	K	G	A	5V	5000	10 TO 30	0 TO 5	-29 TO 85	0.50	0.50	15K MAX	15000	15000

SERIES TYPE	RANGE TYPE AND OUTPUT	ACCURACY IDENTIFIER	ACCURACY STATEMENT
PX 409, 409C, 419, 429	X4, X5, X6, X7, X8	NO IDENTIFIER	0.08% BSL INC NON LINEARITY, HYST AND NON REPEAT
		EH	0.05% BSL INC NON LINEARITY, HYST AND NON REPEAT
		XL	0.03% BSL INC NON LINEARITY.

GENERAL SPECIFICATION	
INPUT	VDC SEE TABLE
OUTPUT	0 TO 5 VDC SEE TABLE
OVER PRESSURE	SEE TABLE
CONTAINMENT	SEE TABLE
ACCURACY	SEE TABLE
SETTING ACCURACY ZERO	±.5% FS TYP 1% MAX (±.5% TYP ±2% MAX FOR 2.5 PSI AND BELOW)
SETTING ACCURACY SPAN	±.5% FS TYP 1% MAX (±.5% TYP ±2% MAX FOR 2.5 PSI AND BELOW)
	CALIBRATION IN VERTICAL DIRECTION WITH FITTING DOWN
LONG TERM STABILITY	±0.1%BFS TYPICAL (1 YEAR)
DURABILITY	1 MILLION TYPICAL
MEDIA COMPATIBILITY	ALL WETTED MATERIALS 316 (L) STAINLESS STEEL
EMC COMPATIBILITY (CE)	EC DIRECTIVE 2004/108/EC (CONSOLIDATED 89/336); STANDARD IEC 61326:2006 FOR INDUSTRIAL LOCATIONS
ROHS	YES

0 TO 5 VDC EXTERNAL WIRING CODES			
	CABLE PX409 AND PX409C	MINI DIN PX419	TWIST LOCK PX429
SUPPLY (+)	RED	PIN 1	PIN A
SUPPLY (-)	BLACK	PIN 2	PIN B
SIGNAL	WHITE	PIN 3	PIN C
NC	GREEN	PIN 4	PIN D
SPARE			PIN E
SPARE			PIN F

REVIEWED

BY: *[Signature]* DATE: 10/20/01

FILE0070

17035 Westview Avenue
South Holland, IL 60473
Phone: 800-373-1759
www.callabco.com
il@callabco.com

CAL LAB
Calibration Certificate



LABORATORY ACCREDITATION BUREAU
ACCREDITED ISO/IEC 17025
Certificate # L2216 Calibration
www.l-a-b.com

896057



<u>Customer</u>	<u>Instrument Profile</u>
Gas Technology Institute (9051) 1700 S. Mt. Prospect Road Room 119 Des Plaines, Illinois 60018 PO Number: KI00053198	Manufacturer: Omega Model: HH-23 Asset ID #: T-264556 Serial #: T-264556 Description: Digital Thermometer

<u>Calibration Information</u>	
Calibration Date: 09/13/2010	Technician: Rich Sine
*Calibration Due Date: 09/13/2012	Calibration Location: Illinois Lab
Ambient Conditions: 74.7 °F (23.7 °C) / 33.3% RH	Calibration Procedure: CP0030
Calibration Requested: Level 2	
Service Requested: Accredited Calibration with no Measurement Uncertainty	

<u>Condition</u>
Physical Damage: No evidence of physical/cosmetic damaged noted during this calibration. As Found: Fully operational and within tolerance As Left: Calibrated to Manufacturers specifications and left within tolerance

<u>Technician Remarks</u>
Replaced battery.

Quality & Traceability Statement
The results reported herein apply only to the calibration of the item described above. All calibration standards used in this calibration are traceable to SI units through NIST or equivalent NMI (National Measurement Institute). Our Quality System is accredited to ISO/IEC 17025:2005 and ANSI/NCSL Z540-1:1994 via the Laboratory Accreditation Bureau. Details of the scope of our accreditation are available at www.L-A-B.com.
*Per the requirements of ISO-17025:2005, Cal Lab Co., Inc. does not make recommendations for recall therefore the listed Calibration Due Date is dictated by the owner of this equipment. Although the item calibrated meets the conditions or specifications at the time of the calibration, due to a number of factors the due date of the item calibrated does not imply continuing conformance during the calibration interval.
The parameters of this calibration are covered under our current scope of accreditation; however, the measurement uncertainty is not listed on this certificate by explicit request of the customer. All pertinent information is retained to calculate the measurement uncertainty per the requirements of ISO-17025:2005 in the event this information is requested.

REVIEWED
By Date 10/1/10

J. Brent Shaddy
Quality Manager Review & Approval
quality@callabco.com

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Calibration Certificate # 896057
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Calibration Standard(s)

ID #	Manufacturer	Model #	Description	Due Date	Traceability #
1002-1507	Fluke	5520A-SC	Calibrator, Multi-Function	09/30/2010	621209

Calibration Data

Function / Attribute	Nominal Value	As Found	OOT	As Left	OOT	Tolerance
K Tc T1 -200 to 1375 °C	-190.0 °C	-190.3		-190.3		-190.8 to -189.2 °C
K Tc T1 -200 to 1375 °C	-100.0 °C	-100.0		-100.0		-100.7 to -99.3 °C
K Tc T1 -200 to 1375 °C	0.0 °C	0.0		0.0		-0.6 to 0.6 °C
K Tc T1 -200 to 1375 °C	100.0 °C	99.8		99.8		99.3 to 100.7 °C
K Tc T1 -200 to 1375 °C	200.0 °C	199.7		199.7		199.2 to 200.8 °C
K Tc T1 -200 to 1375 °C	300.0 °C	299.7		299.7		299.1 to 300.9 °C
K Tc T1 -200 to 1375 °C	400.0 °C	399.7		399.7		399.0 to 401.0 °C
K Tc T1 -200 to 1375 °C	500.0 °C	499.5		499.5		498.9 to 501.1 °C
K Tc T1 -200 to 1375 °C	600.0 °C	599.4		599.4		598.8 to 601.2 °C
K Tc T1 -200 to 1375 °C	700.0 °C	699.4		699.4		698.7 to 701.3 °C
K Tc T1 -200 to 1375 °C	800.0 °C	799.4		799.4		798.6 to 801.4 °C
K Tc T1 -200 to 1375 °C	900.0 °C	899.5		899.5		898.5 to 901.5 °C
K Tc T1 -200 to 1375 °C	1000.0 °C	999.3		999.3		998.4 to 1001.6 °C
K Tc T1 -200 to 1375 °C	1100.0 °C	1099.2		1099.2		1098.3 to 1101.7 °C
K Tc T1 -200 to 1375 °C	1200.0 °C	1199.1		1199.1		1198.2 to 1201.8 °C
K Tc T1 -200 to 1375 °C	1300.0 °C	1299.0		1299.0		1298.1 to 1301.9 °C
J Tc T1 -200 to 760 °C	-190.0 °C	-190.4		-190.4		-190.8 to -189.2 °C
J Tc T1 -200 to 760 °C	-100.0 °C	-100.3		-100.3		-100.7 to -99.3 °C
J Tc T1 -200 to 760 °C	0.0 °C	-0.2		-0.2		-0.6 to 0.6 °C
J Tc T1 -200 to 760 °C	100.0 °C	99.8		99.8		99.3 to 100.7 °C
J Tc T1 -200 to 760 °C	200.0 °C	199.4		199.4		199.2 to 200.8 °C
J Tc T1 -200 to 760 °C	300.0 °C	299.5		299.5		299.1 to 300.9 °C
J Tc T1 -200 to 760 °C	400.0 °C	399.4		399.4		399.0 to 401.0 °C
J Tc T1 -200 to 760 °C	500.0 °C	499.8		499.8		498.9 to 501.1 °C
J Tc T1 -200 to 760 °C	600.0 °C	599.6		599.6		598.8 to 601.2 °C
J Tc T1 -200 to 760 °C	700.0 °C	699.5		699.5		698.7 to 701.3 °C
T Tc T1 -200 to 350 °C	-200.0 °C	-200.1		-200.1		-200.8 to -199.2 °C
T Tc T1 -200 to 350 °C	-100.0 °C	-100.2		-100.2		-100.7 to -99.3 °C
T Tc T1 -200 to 350 °C	0.0 °C	-0.1		-0.1		-0.6 to 0.6 °C
T Tc T1 -200 to 350 °C	100.0 °C	99.8		99.8		99.3 to 100.7 °C
T Tc T1 -200 to 350 °C	200.0 °C	199.7		199.7		199.2 to 200.8 °C
T Tc T1 -200 to 350 °C	300.0 °C	299.6		299.6		299.1 to 300.9 °C

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Calibration Certificate # 896057
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Datasheet Revision: 09/13/2010

Out of tolerance readings (OOT) are annotated with a ✕

End of Calibration Data