



**Thunder Scientific Corporation**  
623 Wyoming Blvd. SE • Albuquerque, NM 87123 • 505-265-8701

## *Certificate of Conformance*

Customer: MESA LABORATORIES, INC.  
12100 W. 6th Avenue, Lakewood, CO 80228  
Purchase Order: PO-007981  
Item: Thunder Scientific 2500 Humidity Generator  
ID Number: TE10706  
Serial Number: 1106851  
Quality Manual: CL-QM-01, Issue 8, 08 Jan 15  
Procedure: CL-SOP-0013, Issue 7, 10 Oct 16  
Calibration Date: 23 Mar 17  
Cert. Number: 14874

This certifies the above product was calibrated in compliance with ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994; Part 1 using applicable Thunder Scientific procedures.

At planned intervals, Thunder Scientific measurement and generation standards are calibrated by comparison to or measurement against national standards, natural physical constants, consensus standards, or by ratio type measurements using self-calibrating techniques.

This calibration is traceable to the International System of Units (SI) through NIST-maintained standards.

At the time of shipment, this instrument did meet published operating/user specifications at the required test points and did conform to the procurement document requirements. Refer to calibration report.

Supporting documentation relative to traceability is on file and is available for examination upon request. This report contains flow data that is not covered by the NVLAP accreditation.

  
Thunder Scientific Corporation

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REPORT OF  
HUMIDITY COMPARISON

Customer: MESA LABORATORIES, INC.  
12100 W. 6th Avenue, Lakewood, CO 80228  
Purchase Order Number: PO-007981

Item: Thunder Scientific 2500 Humidity Generator s/n 1106851 ID# TE10706  
Comparison Required: As Rcvd/As Left at 10, 20, 50 & 80 %RH at 25 °C.

Cert. Number: 14874  
Quality Manual: CL-QM-01, Issue 8, 08 Jan 15  
Procedure: CL-SOP-0013, Issue 7, 10 Oct 16  
Comparison Date: 23 Mar 17  
Ambient Conditions: 24 °C (±4 °C) & 40 %RH (±20 %RH)  
Generator Flow Rate: 20 slpm  
Test Gas: Air

Std's Used: MBW DP-30 EN0040 exp 07 Sep 17  
0.08 °C FP/DP uncertainty, k=2  
Hart 1504/5665 EN0124 exp 03 Aug 17  
0.03 °C uncertainty, k=2  
Heise DXD EN0138 exp 23 May 17  
0.01 psiA uncertainty (0 to 50 psiA), k=2

The Model 2500 produces an atmosphere of known humidity based on the "two-pressure" principle. The accuracy was verified using a reference chilled mirror hygrometer. "Ref %RH" was calculated using "Ref DP", "Ref Temp" and "Ref Pressure" measurements. This comparison is traceable to the International System of Units (SI) through NIST-maintained standards. Supporting documentation relative to traceability is available for review by appointment.

**U<sub>Comparison</sub>** (Measurement Comparison Uncertainty) is the RSS (root sum square) of the UUT's standard deviation of ten readings at each test point, the UUT resolution and the uncertainty of the standards, with a coverage factor of k=2 at a 95 percent confidence level.

**As Rcvd Data:**

Ref	2500	Ref	Ref	2500	2500	2500	2500	Ref	2500	Difference	<b>U<sub>Comparison</sub></b>
DP	DP	Temp	Pressure	Saturator	Saturator	Chamber	Chamber	%RH	%RH	%RH	%RH
°C	°C	°C	psiA	psiA	°C	psiA	°C				
-8.76	-8.74	24.97	12.193	125.1	25.00	12.21	25.01	10.00	9.98	-0.02	0.07
0.47	0.51	24.10	12.184	61.63	25.00	12.21	25.03	20.00	19.97	-0.03	0.12
13.86	13.89	24.98	12.177	24.43	25.00	12.20	25.03	50.00	50.03	0.03	0.28
21.33	21.36	24.99	12.170	15.22	25.00	12.20	25.05	80.01	80.14	0.13	0.42

**As Left Data:**

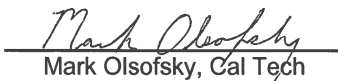
Ref	2500	Ref	Ref	2500	2500	2500	2500	Ref	2500	Difference	<b>U<sub>Comparison</sub></b>
DP	DP	Temp	Pressure	Saturator	Saturator	Chamber	Chamber	%RH	%RH	%RH	%RH
°C	°C	°C	psiA	psiA	°C	psiA	°C				
-8.78	-8.74	24.96	11.988	123.2	25.00	12.02	25.02	9.97	10.00	0.03	0.07
0.46	0.50	24.98	11.973	60.65	25.00	12.01	25.02	19.95	20.00	0.05	0.12
13.84	13.88	24.99	11.964	24.05	25.00	12.01	25.03	49.94	49.98	0.04	0.28
21.30	21.34	25.00	11.956	14.98	25.00	12.00	25.03	79.94	80.01	0.07	0.42

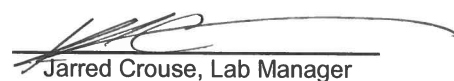
Adjustments: System verification before and after all adjustments.

Thunder Scientific 2500 uncertainty is 0.5 %RH. This uncertainty includes the long term stability, reproducibility, repeatability and resolution of the 2500 for a period of up to one year, as long as the unit is maintained per Thunder Scientific's recommendations.

As Rcvd: Within Tolerance: YES  
Operational Failure: NONE  
Physical Damage: NONE

As Left: Within Tolerance: YES  
Limited Range: NONE  
Calibration Seals: 0

  
Mark Olsosky, Cal Tech

  
Jarred Crouse, Lab Manager

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REPORT OF  
PRESSURE CALIBRATION



Customer: MESA LABORATORIES, INC.  
12100 W. 6th Avenue, Lakewood, CO 80228  
Purchase Order Number: PO-007981

Item: Thunder Scientific 2500 Humidity Generator s/n 1106851 ID# TE10706  
Low Range Pressure Transducer s/n: 1323558  
High Range Pressure Transducer s/n: 1299038

Low Pressure Calibration Required: As Rcvd/As Left at 12.5, 20, 30, 40 & 50 psiA.  
High Pressure Calibration Required: As Rcvd/As Left at 50, 75, 100, 125 & 150 psiA.

Cert. Number: 14874  
Quality Manual: CL-QM-01, Issue 8, 08 Jan 15  
Procedure: CL-SOP-0013, Issue 7, 10 Oct 16  
Calibration Date: 21 Mar 17  
Ambient Conditions: 24 °C (±4 °C) & 40 %RH (±20 %RH)  
Test Gas: Nitrogen

Std Used: Mensor PCS400 EN0037 exp 18 May 17  
0.02 psiA uncertainty (0 to 100 psiA), k=2  
0.04 psiA uncertainty (100 to 300 psiA), k=2

Reference pressures were generated for each transducer and curve fit coefficients were verified, or calculated and stored to memory. This calibration is traceable to the International System of Units (SI) through NIST-maintained standards. Supporting documentation relative to traceability is available for review by appointment.

**U** (Measurement Uncertainty) is the RSS (root sum square) of the standard deviation of the UUT's error over the test range, the UUT resolution and the uncertainty of the standard, with a coverage factor of k=2 at a 95 percent confidence level.

**As Rcvd Data:**

Low Pressure Transducer:				High Pressure Transducer:			
Ref psiA	2500 psiA	Error psiA	<b>U</b> psiA	Ref psiA	2500 psiA	Error psiA	<b>U</b> psiA
12.500	12.49	-0.01	0.02	50.000	49.99	-0.01	0.11
20.000	19.99	-0.01	0.02	75.000	75.00	0.00	0.11
30.000	29.99	-0.01	0.02	100.00	100.0	0.00	0.13
40.000	39.99	-0.01	0.02	125.00	124.9	-0.10	0.13
50.000	49.99	-0.01	0.02	150.00	149.9	-0.10	0.13

**As Left Data:**

Low Pressure Transducer:				High Pressure Transducer:			
Ref psiA	2500 psiA	Error psiA	<b>U</b> psiA	Ref psiA	2500 psiA	Error psiA	<b>U</b> psiA
12.500	12.50	0.00	0.02	50.000	50.00	0.00	0.02
20.000	20.00	0.00	0.02	75.000	75.00	0.00	0.02
30.000	30.00	0.00	0.02	100.00	100.0	0.00	0.07
40.000	40.00	0.00	0.02	125.00	125.0	0.00	0.07
50.000	50.00	0.00	0.02	150.00	150.0	0.00	0.07

Adjustments: New calibration coefficients were calculated and saved to memory.

Manufacturer's specifications: ±0.15% of full scale.

As Rcvd: Within Tolerance: YES  
Operational Failure: NONE  
Physical Damage: NONE

As Left: Within Tolerance: YES  
Limited Range: NONE

Mark Olsofsky, Cal Tech

Jarred Crouse, Lab Manager

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**THUNDER SCIENTIFIC CORPORATION**  
 623 Wyoming Blvd SE, Albq, NM 87123  
**REPORT OF**  
**TEMPERATURE CALIBRATION**



Customer: MESA LABORATORIES, INC.  
 12100 W. 6th Avenue, Lakewood, CO 80228  
 Purchase Order Number: PO-007981

Item: Thunder Scientific 2500 Humidity Generator s/n 1106851 ID# TE10706  
 Temperature Calibration Required: As Rcvd/As Left at 0, 20, 35, 50 & 70 °C.

Cert. Number: 14874  
 Quality Manual: CL-QM-01, Issue 8, 08 Jan 15  
 Procedure: CL-SOP-0013, Issue 7, 10 Oct 16  
 Calibration Date: 21 Mar 17  
 Ambient Conditions: 24 °C (±4 °C) & 40 %RH (±20 %RH)  
 Test Medium: FC-77 Fluorinert™

Std Used: Hart 1504/5665 EN0095 exp 26 Jul 17  
 0.03 °C uncertainty, k=2

The 2500's four RTD's were compared to the standard thermometer in a temperature bath containing FC-77 Fluorinert™. Reference temperatures were generated and curve fit coefficients were verified, or calculated and stored to memory. This calibration is traceable to the International System of Units (SI) through NIST-maintained standards. Supporting documentation relative to traceability is available for review by appointment.

**U** (Measurement Uncertainty) is the RSS (root sum square) of the standard deviation of the UUT's error over the test range, the UUT resolution and the uncertainty of the standard, with a coverage factor of k=2 at a 95 percent confidence level.

**As Rcvd Data:**

Ref °C	Saturator °C	Error °C	Chamber °C	Error °C	Presat °C	Error °C	Exp Valve °C	Error °C	U °C
70.021	70.02	-0.001	70.00	-0.021	70.01	-0.011	70.01	-0.011	0.03
49.990	49.99	0.000	49.98	-0.010	49.98	-0.010	49.98	-0.010	0.03
35.018	35.01	-0.008	34.99	-0.028	35.00	-0.018	35.00	-0.018	0.03
20.055	20.04	-0.015	20.05	-0.005	20.04	-0.015	20.04	-0.015	0.03
0.007	0.000	-0.007	0.014	0.007	0.000	-0.007	0.000	-0.007	0.03

**As Left Data:**

Ref °C	Saturator °C	Error °C	Chamber °C	Error °C	Presat °C	Error °C	Exp Valve °C	Error °C	U °C
70.015	70.01	-0.005	70.01	-0.005	70.01	-0.005	70.01	-0.005	0.03
50.003	50.00	-0.003	50.01	0.007	50.01	0.007	50.01	0.007	0.03
35.001	34.99	-0.011	35.00	-0.001	35.00	-0.001	34.99	-0.011	0.03
20.009	20.01	0.001	20.01	0.001	20.01	0.001	20.01	0.001	0.03
0.003	0.000	-0.003	0.000	-0.003	0.000	-0.003	0.000	-0.003	0.03

Adjustments: New calibration coefficients were calculated and saved to memory.

Manufacturer's specifications: ±0.06 °C

As Rcvd: Within Tolerance: YES  
 Operational Failure: NONE  
 Physical Damage: NONE

As Left: Within Tolerance: YES  
 Limited Range: NONE

*Mark Olsosky*  
 Mark Olsosky, Cal Tech

*Jarred Crouse*  
 Jarred Crouse, Lab Manager

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**THUNDER SCIENTIFIC CORPORATION**

623 Wyoming Blvd SE, Albq, NM 87123

**REPORT OF  
FLOW CALIBRATION**

Customer: MESA LABORATORIES, INC.  
12100 W. 6th Avenue, Lakewood, CO 80228  
Purchase Order Number: PO-007981

Item: Thunder Scientific 2500 Humidity Generator s/n 1106851 ID# TE10706  
Mass Flow Meter s/n: 141168

Mass Flow Calibration Required: As Rcvd/As Left at approximately 0, 10 & 20 slpm

Cert. Number: 14874  
Quality Manual: CL-QM-01, Issue 8, 08 Jan 15  
Procedure: CL-SOP-0013, Issue 7, 10 Oct 16  
Calibration Date: 22 Mar 17  
Ambient Conditions: 24 °C (±4 °C) & 40 %RH (±20 %RH)  
Test Medium: Air

Std Used: BIOS DC-2 EN0003 exp 05 Nov 17  
uncertainty 1.4% of reading, k=2

Flow output of the 2500 was monitored by a BIOS DC-2 primary flow meter. Reference flows were generated and curve fit coefficients were verified, or calculated and stored to memory. This calibration is traceable to the International System of Units (SI) through NIST-maintained standards. Supporting documentation relative to traceability is available for review by appointment.

*U* (Measurement Uncertainty) is the RSS (root sum square) of the standard deviation of the UUT's error over the test range, the UUT resolution and the uncertainty of the standard, with a coverage factor of k=2 at a 95 percent confidence level.

**As Rcvd Data:**

Ref slpm	2500 slpm	Error slpm	<i>U</i> slpm
19.68	19.27	-0.41	0.28
10.25	9.62	-0.63	0.16
0.00	0.02	0.02	0.06

**As Left Data:**


Ref slpm	2500 slpm	Error slpm	<i>U</i> slpm
20.94	20.70	-0.24	0.30
10.59	10.59	0.00	0.16
0.00	0.02	0.02	0.06

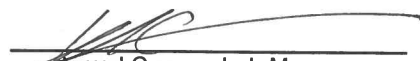
Adjustments: Calibration coefficients were calculated and saved to memory.

Manufacturer's specifications: ±0.8 slpm

As Rcvd: Within Tolerance: YES  
Operational Failure: NONE  
Physical Damage: NONE

As Left: Within Tolerance: YES  
Limited Range: NONE

  
Mark Olsosky, Cal Tech

  
Jarred Crouse, Lab Manager

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Calibration Report  
for  
TSC Model 2500 Humidity Generator

SW v 2.1  
S/N 1106851  
Date 03/23/17

Temperature	Zero	Span	Linearity	CalDate
Saturation Temperature	1.54499E-01	9.96147E-03	3.98603E-09	03/21/17
PreSat Temperature	2.72488E-01	9.91533E-03	2.09262E-09	03/21/17
Ex Valve Temperature	2.26202E-01	9.91483E-03	1.70153E-09	03/21/17
Chamber Temperature	-4.17678E-02	9.93991E-03	1.75725E-09	03/21/17
Temp Reference Resistor	-2.50000E+01	1.00000E-02	0.00000E+00	03/21/17

Pressure	Zero	Span	Linearity	CalDate
Low Range (0-50 psia)	1.22999E-01	2.00199E-03	2.64539E-11	03/21/17
Hi Range (50-150 psia)	1.95142E-01	5.92695E-03	1.28433E-09	03/21/17

Flow	Zero	Span	Linearity	CalDate
Mass Flow Rate	0.00000E+00	1.76880E-03	-1.08800E-08	03/22/17

Certified by 

Date 23 Mar 17

MODEL 2500 BENCHTOP TWO-PRESSURE HUMIDITY GENERATOR  
COEFFICIENT & PARAMETER LISTING

Software: v 2.1

Serial Number: 1106851

Date: 03/23/17

Temperature Calibration Coefficients

CT( 0 , 0 ) .154499  
CT( 0 , 1 ) 9.96147E-03  
CT( 0 , 2 ) 3.98603E-09  
CT( 0 , 3 ) 10  
Cal Date 03/21/17

CT( 1 , 0 ) .272488  
CT( 1 , 1 ) 9.91533E-03  
CT( 1 , 2 ) 2.09262E-09  
CT( 1 , 3 ) 10  
Cal Date 03/21/17

CT( 2 , 0 ) .226202  
CT( 2 , 1 ) 9.91483E-03  
CT( 2 , 2 ) 1.70153E-09  
CT( 2 , 3 ) 10  
Cal Date 03/21/17

CT( 3 , 0 ) -.0417678  
CT( 3 , 1 ) 9.93991E-03  
CT( 3 , 2 ) 1.75725E-09  
CT( 3 , 3 ) 10  
Cal Date 03/21/17

CT( 4 , 0 ) -25  
CT( 4 , 1 ) .01  
CT( 4 , 2 ) 0  
CT( 4 , 3 ) 50  
Cal Date 03/21/17

Pressure Calibration Coefficients

CP( 0 , 0 ) .122999  
CP( 0 , 1 ) 2.00199E-03  
CP( 0 , 2 ) 2.64539E-11  
CP( 0 , 3 ) 10  
Cal Date 03/21/17

CP( 1 , 0 ) .195142  
CP( 1 , 1 ) 5.92695E-03  
CP( 1 , 2 ) 1.28433E-09  
CP( 1 , 3 ) 10  
Cal Date 03/21/17

Flow Calibration Coefficients

CF( 0 , 0 ) 0  
CF( 0 , 1 ) 1.7688E-03  
CF( 0 , 2 ) -1.088E-08  
CF( 0 , 3 ) 10  
Cal Date 03/22/17

Software: v 2.1  
Serial Number: 1106851  
Date: 03/23/17

Serial Port Parameters

SR( 0 , 0 ) 2400  
SR( 0 , 1 ) 8  
SR( 0 , 2 ) 1  
SR( 0 , 3 ) 0  
SR( 0 , 4 ) 13  
SR( 0 , 5 ) 3

SR( 1 , 0 ) 9600  
SR( 1 , 1 ) 8  
SR( 1 , 2 ) 1  
SR( 1 , 3 ) 0  
SR( 1 , 4 ) 60  
SR( 1 , 5 ) 50

Bath PID Parameters

BP( 0 ) 1  
BP( 1 ) .1  
BP( 2 ) .01  
BP( 3 ) 2.1  
BP( 4 ) 10  
BP( 5 ) 1  
BP( 6 ) .1  
BP( 7 ) .05  
BP( 8 ) .02  
BP( 9 ) 0  
BP( 10 ) 1  
BP( 11 ) .2

PreSat PID Parameters

GP( 0 ) .75  
GP( 1 ) 1  
GP( 2 ) .01  
GP( 3 ) 1  
GP( 4 ) 10  
GP( 5 ) 1  
GP( 6 ) 14  
GP( 7 ) 1.111

Expansion Valve PID Parameters

VP( 0 ) .5  
VP( 1 ) 15  
VP( 2 ) .01  
VP( 3 ) 1  
VP( 4 ) 1  
VP( 5 ) 1  
VP( 6 ) 1.5  
VP( 7 ) 1



Software: v 2.1  
Serial Number: 1106851  
Date: 03/23/17

Sat Pressure PID Parameters

PP( 0 ) .4  
PP( 1 ) 15  
PP( 2 ) 8  
PP( 3 ) 0  
PP( 4 ) 0  
PP( 5 ) 1  
PP( 6 ) 10  
PP( 7 ) 0  
PP( 8 ) 10  
PP( 9 ) 50  
PP( 10 ) 0  
PP( 11 ) 0  
PP( 12 ) 5  
PP( 13 ) 195  
PP( 14 ) 200

Flow PID Parameters

FP( 0 ) 1  
FP( 1 ) .5  
FP( 2 ) 5  
FP( 3 ) 0  
FP( 4 ) 0  
FP( 5 ) 1  
FP( 6 ) 20  
FP( 7 ) 28  
FP( 8 ) 5  
FP( 9 ) 80  
FP( 10 ) 100

PreSat Fill Parameters

FC( 0 ) 1  
FC( 1 ) 0  
FC( 2 ) 100  
FC( 3 ) 200

Cool Pulse Formula

CM( 0 ) .4  
CM( 1 ) -3E-03

Factory Options

OPT 0  
NEG