

SOUTHWEST RESEARCH INSTITUTE

Calibration Laboratory

WORK ORDER

Processed by RCRUZ at 2:49:57PM on 11/16/00



Work Order 444041437

Arrived 11/16/00

Asset No. 008430 Manufacturer DURO-SENSE

Model TYPE K

Instrument Type/Class THERMOCOUPLE

Serial No. 326

Accessory No. _____ Calibration Procedure _____

Location B57

Div/Client DIV20

Custodian DARRELL DUNN

Mail Stop B57

Tel. 6090

Charge/Project No. 20.00751.006

Delivered By / Telephone _____

IN4CAL

Special Instructions _____

WORK NOTES

| Date | Hours | Remarks/Notes |
|-------|-------|---------------|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

REPAIR PARTS

| Date | Hours | Part Name | Part Number | Failure Description | Cost |
|-------|-------|-----------|-------------|---------------------|-------|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

WORK SUMMARY

Failure Description _____

Repair Action _____

Calibration Procedure Customer Temp 68 F Hum. 41 %

Tech [Signature] Totals Cal Hours 1 Repair Hours _____ Parts Cost _____

Standards Used 0219 1505 2868

Date Picked Up 12/14/2000

Picked Up By [Signature]

444041437



GNWRA *A center of excellence in earth
sciences and engineering*

6220 Culebra Road · San Antonio · Texas, U.S.A. 78228-5166

MEMORANDUM

Date: November 16, 2000
From: Darrell S. Dunn *DD*
To: SwRI Calibration Laboratory
Subject: Calibration of Thermocouples and RTDs

I would like to check the calibration of the Duro-Sense Corporation thermocouples (serial numbers 326 to 335) and RTDs (serial numbers 322 to 325) using temperatures of 0 and 150 °C. The calibration check for the thermocouples should be conducted with 12 inches of the thermocouple exposed to controlled temperature bath. The output of the thermocouples in mV should be recorded at these temperatures. Similarly, the entire length of the RTDs should be exposed to the controlled temperature bath and the resistance of the RTDs should be recorded at these temperatures.

Following calibration at 0 and 150 °C, the thermocouples and RTDs need to be appropriately marked. A 6 month interval for checking the calibration of the thermocouples and RTDs is suggested. The vendor documentation is attached for your reference. Please call me at extension 6090 if you have any questions.

Sincerely,

Darrell S. Dunn



DURO-SENSE CORPORATION
 20801 Higgins Court, Torrance, CA 90501
 Phone: (310) 533-6877 Fax: (310) 533-0330

TO: Southwest Research Institute
 6220 Culebra Road
 San Antonio, Tx 78238

Date: October 23, 2000
 Calib No.: 51313
 Cust. P.O.: X97570I

CALIBRATION CERTIFICATE

This will certify that your material used to manufacture Type 'K' T/C Assy # MTC-B-0632-U-36-48-TEX was/were calibrated I.A.W. calibration procedure 26.00 Rev. A on October 23, 2000 against our standard, which is traceable to the National Institute of Standards Technology.

Ambient Temperature: 75.90°F
 Furnace Atmosphere: Air
 Humidity: 41.00%
 Temperature Points: See Below
 Lot #: MAT660L

CALIBRATION RESULTS ARE AS FOLLOWS:

| Standard | Corrections | | | |
|----------|-------------------|-------------------|--------------------|--------------------|
| | <u>Inside End</u> | <u>Inside End</u> | <u>Outside End</u> | <u>Outside End</u> |
| 32°F | +0.2°F | 0.000 MV | +0.3°F | 0.000 MV |
| 500°F | +0.6°F | 10.539 MV | +0.7°F | 10.539 MV |
| 1000°F | +1.2°F | 22.232 MV | +1.3°F | 22.232 MV |
| 1500°F | +1.7°F | 33.867 MV | +1.8°F | 33.867 MV |
| 2000°F | +2.0°F | 44.824 MV | +2.1°F | 44.824 MV |

Calibration procedure I.A.W. ISO 10012-1:1992(E), ANSINCNSL Z540-1-1994, AMS 2750C, ASTM E 220-96, ASTM E 230-96, ASTM E 207-96
 The calibration of thermocouples is subject to change during use. The amount of change depends on factors such as temperature, time, and condition of use.
 Total Uncertainty of Readings is Less Than .01%. Accuracy I.A.W. industry standards noted in calibration procedure 26.8.
 This certificate shall not be reproduced except in full, without the written approval of the laboratory.

| | |
|--|---|
| N.I.S.T. Recertification Date: January 24, 2001 | <p>We hereby certify that the above is a true copy of our records. DURO-SENSE CORPORATION</p>  Quality Control Department |
| Leeds and Northrup K-5: Model 7555 | |
| Precision Potentiometer S/N: 1752900 | |
| Eppley Standard Cell: Model 100 - S/N 700851 | |
| Cage Code: 58042 | |
| Master Std. Thermocouple: Type 'S' | |
| N.I.S.T. Test Numbers: 263035 | |



DURO-SENSE CORPORATION
 20801 Higgins Court, Torrance, CA 90501
 Phone: (310) 533-6877 Fax: (310) 533-0330

TO: Southwest Research Institute
 6220 Culebra Road
 San Antonio, Tx 78238

Date: October 23, 2000
 Calib No.: 51313
 Cust. P.O.: X97570I

CALIBRATION CERTIFICATE

This will certify that your RTD Assy # RPL-1-125-PD-316-3-6"-B-48"-D300-CU-D301-CU was/were calibrated I.A.W. calibration procedure 26.00 Rev. A on October 23, 2000 against our standard, which is traceable to the National Institute of Standards Technology.

Ambient Temperature: 75.90°F
 Furnace Atmosphere: Air
 Humidity: 41.00%
 Temperature Points: See Below

CALIBRATION RESULTS ARE AS FOLLOWS:

| Standard | | Corrections | |
|-----------------|-----------------|-------------|------------|
| <u>SERIAL #</u> | <u>STANDARD</u> | | <u>OHM</u> |
| 322 | 32°F | +0.2°F | 100 OHM |
| | 212°F | +0.2°F | 138.51 OHM |
| | 500°F | +0.4°F | 197.71 OHM |
| | 1000°F | +0.6°F | 293.30 OHM |
| 323 | 32°F | +0.2°F | 100 OHM |
| | 212°F | +0.2°F | 138.51 OHM |
| | 500°F | +0.3°F | 197.71 OHM |
| | 1000°F | +0.8°F | 293.30 OHM |

Calibration procedure I.A.W. ISO 10012-1:1992(E), ANSINCNSL Z540-1-1994, AMS 2750C, ASTM E 220-06, ASTM E 230-06, ASTM E 207-06
 The calibration of thermocouples is subject to change during use. The amount of change depends on factors such as temperature, time, and condition of use.
 Total Uncertainty of Readings is Less Than .01%. Accuracy I.A.W. industry standards noted in calibration procedure 26.8.
 This certificate shall not be reproduced except in full, without the written approval of the laboratory.

| | |
|--|---|
| N.I.S.T. Recertification Date: January 24, 2001 | <p>We hereby certify that the above is a true copy of our records. DURO-SENSE CORPORATION</p>  <hr/> Quality Control Department |
| Leeds and Northrup K-5: Model 7555 | |
| Precision Potentiometer S/N: 1752900 | |
| Eppley Standard Cell: Model 100 - S/N 700851 | |
| Cage Code: 58042 | |
| Master Std. Thermocouple: Type 'S' | |
| N.I.S.T. Test Numbers: 263035 | |



DURO-SENSE CORPORATION
 20801 Higgins Court, Torrance, CA 90501
 Phone: (310) 533-6877 Fax: (310) 533-0330

TO: **Southwest Research Institute**
 6220 Culebra Road
 San Antonio, Tx 78238

Date: **October 23, 2000**
 Calib No.: **51313**
 Cust. P.O.: **X97570I**

CALIBRATION CERTIFICATE

This will certify that your **RTD Assy # RPL-1-125-PD-316-3-6"-B-48"-D300-CU-D301-CU** was/were calibrated I.A.W. calibration procedure 26.00 Rev. A on **October 23, 2000** against our standard, which is traceable to the National Institute of Standards Technology.

Ambient Temperature: **75.90°F**
 Furnace Atmosphere: **Air**
 Humidity: **41.00%**
 Temperature Points: **See Below**

CALIBRATION RESULTS ARE AS FOLLOWS:

| Standard | | Corrections | |
|------------------------|------------------------|--------------------|-------------------|
| <u>SERIAL #</u> | <u>STANDARD</u> | | <u>OHM</u> |
| 324 | 32°F | +0.1°F | 100 OHM |
| | 212°F | +0.2°F | 138.51 OHM |
| | 500°F | +0.5°F | 197.71 OHM |
| | 1000°F | +0.8°F | 293.30 OHM |
| 325 | 32°F | +0.2°F | 100 OHM |
| | 212°F | +0.1°F | 138.51 OHM |
| | 500°F | +0.4°F | 197.71 OHM |
| | 1000°F | +0.7°F | 293.30 OHM |

Calibration procedure I.A.W. ISO 10012-1:1992(E), ANSINCNSL Z540-1-1994, AMS 2750C, ASTM E 220-96, ASTM E 230-96, ASTM E 207-96
 The calibration of thermocouples is subject to change during use. The amount of change depends on factors such as temperature, time, and condition of use.
 Total Uncertainty of Readings is Less Than .01%. Accuracy I.A.W. industry standards noted in calibration procedure 26.8.
 This certificate shall not be reproduced except in full, without the written approval of the laboratory.

| | |
|--|--|
| N.I.S.T. Recertification Date: January 24, 2001 | <p>We hereby certify that the above is a true copy of our records.</p> <p>DURO-SENSE CORPORATION</p>  Quality Control Department |
| Leeds and Northrup K-5: Model 7555 | |
| Precision Potentiometer S/N: 1752900 | |
| Eppley Standard Cell: Model 100 - S/N 700851 | |
| Cage Code: 58042 | |
| Master Std. Thermocouple: Type 'S' | |
| N.I.S.T. Test Numbers: 263035 | |



Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory



Certificate #
0972-01

Certificate of Calibration

6 December 2000

Issued to: DARRELL DUNN DIV20 B57
Manufacturer/Model: DURO-SENSE TYPE K
Description: THERMOCOUPLE
Serial Number: 326
Asset Number: 008430

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. The results of this calibration relate only to the individual item as described above. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results of this calibration certificate were determined in accordance with the terms of accreditation unless stated otherwise below.

The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 68.0 Degrees Fahrenheit Humidity: 41 % RH

Calibration Date: 6 Dec 00 **Calibration Procedure:** CUSTOMER

Condition as Received: SEE REMARKS

Condition as Released: SEE REMARKS

Remarks: CALIBRATION DATA ATTACHED

Approved by:

Jim Patterson, Supervisor, or Walt Hill, Metrologist

Certificate # 444041437

m:\a2la.rpt Rev date 22 May 00

Measurements performed by:

Mack Wood, Technician

SOUTHWEST RESEARCH INSTITUTE

Calibration Laboratory

WORK ORDER

Processed by RCRUZ at 2:49:32PM on 6/8/01

1 10000 0000 0000 0000 0000 0000 0000 0000 0000

Work Order 444043983

Arrived 6/8/01

Asset No. 008430 Manufacturer DURO-SENSE

Model TYPE K

Instrument Type/Class THERMOCOUPLE

Serial No. 326

Accessory No. Calibration Procedure CUSTOMER

Location B57

Div/Client DIV20

Custodian DARRELL DUNN

Mail Stop B57

Tel. 6090

Charge/Project No. 00751.006 1.20

Delivered By / Telephone

IN4CAL

Special Instructions _____

WORK NOTES

| Date | Hours | Remarks/Notes |
|-------------|------------|---------------|
| <u>6/12</u> | <u>1.0</u> | <u>Cal</u> |
| <u>6/13</u> | <u>.5</u> | <u>Cal</u> |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

| | |
|---------------------------------|---------|
| SwRI Cal-Lab | By: cmw |
| CAL: Dec 06, 00 DUE: Jun 06, 01 | |
| AN: 008430 SN: 326 | |

1 10000 0000 0000 0000 0000 0000 0000 0000 0000

REPAIR PARTS

| Date | Hours | Part Name | Part Number | Failure Description | Cost |
|-------|-------|-----------|-------------|---------------------|-------|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

WORK SUMMARY

Failure Description N/A

Repair Action N/A

Calibration Procedure Customer Temp 76 F Hum. 54 %

Tech R Dijkster Totals Cal Hours 1.5 Repair Hours _____ Parts Cost _____

Standards Used 5212, 7001, 4528, 0219

Date Picked Up 6/15/01

Picked Up By Darrell Dunn

43983



Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory

Certificate of Calibration

13 June 2001

Issued to: DARRELL DUNN DIV20 B57
Manufacturer/Model: DURO-SENSE TYPE K
Description: THERMOCOUPLE
Serial Number: 326
Asset Number: 008430
Work Order Number: 444043983

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 76.0 Degrees Fahrenheit Humidity: 54 % RH

Calibration Date: 13 Jun 01 **Calibration Procedure:** CUSTOMER

Condition as Received: SEE REMARKS

Condition as Received: SEE REMARKS

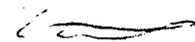
Remarks: CALIBRATION DATA SHEET ATTACHED.

Approved by:



Walt Hill, Supervisor
Institute Calibration Laboratory

Measurements performed by:



Roger Dykstra, Technician

SOUTHWEST RESEARCH INSTITUTE

Calibration Laboratory

WORK ORDER

Received by JIBARRA, 1/8/02 11:36:03AM

||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||

Arrived 1/8/02

Work Order **444046669**

Asset No. 008430 Manufacturer DURO-SENSE

Model TYPE K

Equipment Type THERMOCOUPLE

Serial No. 326

Accessory No.

Interval 6 M

Calibration Procedure CUSTOMER

Location B57

Div/Client DIV20

Custodian DARRELL DUNN

Mail Stop B57

Tel 6090

IN4CAL

Special Instructions _____

Notify before adjustments or repairs. () Provide data with certificate () Certificate Typ _____

Charge/Project No. 00751.006 1.20

Requester / Telephone DARRELL DUNN/ X6090

This information is correct for the work requested. *Darrell Dunn*

WORK NOTES

| Date | Hours | Remarks/Notes |
|----------------|------------|---------------|
| <u>1/11/02</u> | <u>1.0</u> | <u>cal</u> |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

SwRI Cal-Lab By: rjk
CAL: Jun 13, 01 DUE: Dec 13, 01
AN: 008430 SN: 326

| Date | Hours | Part Name | Part Number | Failure Description | Cost |
|------------|----------|-----------|-------------|---------------------|------|
| <u>n/a</u> | <u>→</u> | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

WORK SUMMARY

Failure Description n/a

Repair Action n/a

Tech R Dyksh Cal Hrs. 1.0 Repair Hrs. _____ Parts Cost _____ Temp 77 F Hum. 26 %

Standards Used 7001, 0219

Date Picked Up 1/21/02

Picked Up By *Darrell Dunn*

444046669



Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory

Certificate of Calibration

14 January 2002

Issued to: DARRELL DUNN DIV20 B57
Manufacturer/Model: DURO-SENSE TYPE K
Description: THERMOCOUPLE
Serial Number: 326
Asset Number: 008430
Work Order Number: 444046669

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 77.0 Degrees Fahrenheit Humidity: 26 % RH

Calibration Date: 11 Jan 02 **Calibration Procedure:** CUSTOMER

Condition as Received: SEE ATTACHED DATA

Condition as Returned: SEE ATTACHED DATA

Remarks: PROVIDED CUSTOMER WITH READINGS.

Approved by:

Walt Hill, Supervisor
Institute Calibration Laboratory

Measurements performed by:

Roger Dykstra, Technician

Measurement uncertainty Budget for DURO-SENSE thermocouple model type K..

The following are assumptions and estimates used in the measurement uncertainty budget.

- a.) The 1 yr specifications for 3458A
 100 Ohm range +/- (12ppm of reading + 5 ppm of range)
 1 K ohm range +/- (10 ppm of reading + 0.5 ppm of range)

b.) The uncertainty due to temperature bath and standard is not significant.

100 Ohm range

| | Units | Reading | Accuracy +/- | Resolution |
|------------------------|--------------------|--------------|--------------|------------------------------|
| | Ohms | 100 | | 0.00001 |
| Source of uncertainty | Value +/- Ohms | Distribution | Divisor | Standard Uncertainty Ohms |
| Standard | 0.0017 | Rectangular | Sqrt 3 | 0.000981 |
| Repeatability | 0 | Normal | 1 | 0.000000 |
| Instrument Resolution | 0.00001 | Rectangular | 2*Sqrt 3 | 0.000009 |
| Combined Uncertainty | RSS | | | 0.0010 |
| Expanded Uncertainty | K=2 | | | 0.002 |
| | TI Acc. / STD Tol. | | | |
| Test Accuracy Ratio | 0.0 | to 1 | | |
| | TI Acc. / k=2. | | | |
| Test Uncertainty Ratio | 0.00 | to 1 | | |

1000 Ohm range

| | Units | Reading | Accuracy +/- | Resolution |
|------------------------|--------------------|--------------|--------------|------------------------------|
| | Ohms | 150 | | 0.0001 |
| Source of uncertainty | Value +/- Ohms | Distribution | Divisor | Standard Uncertainty Ohms |
| Standard | 0.002 | Rectangular | Sqrt 3 | 0.001155 |
| Repeatability | 0 | Normal | 1 | 0.000000 |
| Instrument Resolution | 0.0001 | Rectangular | 2*Sqrt 3 | 0.000087 |
| Combined Uncertainty | RSS | | | 0.0012 |
| Expanded Uncertainty | K=2 | | | 0.002 |
| | TI Acc. / STD Tol. | | | |
| Test Accuracy Ratio | 0.0 | to 1 | | |
| | TI Acc. / k=2. | | | |
| Test Uncertainty Ratio | 0.00 | to 1 | | |