Calibration Report: Heitronics Pyrometer

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ABSTRACT

A calibration of three Heitronics KT19.85 pyrometers with each of three different foroptics was completed on 20 May 1998 at Goddard Spaceflight Center. The particular foroptic was mounted to a given pyrometer unit and pointed at a black body source. At each temperature set point data were taken by the pyrometer through a serial interface, read by a basic program and written to disk files. The data were analyzed and calibrations were prepared in terms of Kelvin to Kelvin and VDC to Kelvin. The results of the calibration indicate that the sensor is linear in this measurement range and that the deviation from the manufacturer calibration is small.

1. Introduction

A calibration of three Heitronics KT19.85 pyrometers with each of three different foroptics was completed. The particular foroptic was mounted to a given unit and pointed at a black body source. The distance between the black body source and the foroptic of the pyrometer was 7 inches. The black body source was then set at 6 temperature points, nominally 273.16, 283.16, 293.16, 303.16, 313.16, 323.16 K (0 deg. C to 50 deg. C in 10 deg. C increments). At each temperature set point data were taken by the pyrometer through a serial interface, read by a basic program and written to disk files. The data were analyzed and calibrations were prepared in terms of Kelvin to Kelvin and VDC to Kelvin.

2. Preliminary Uncertainty Analysis

A preliminary Uncertainty Analysis was completed. This analysis was performed to determine the reasonable range in which the pyrometer calibration values should lie. The components of the measurement system included the blackbody temperature control unit and each pyrometer output. All suspected sources of error within this system were listed and the magnitudes calculated or determined from manufacture's data or prior experience. The results are shown in Table 1.

A. *Calibration Unit Uncertainty*

This blackbody device will be considered a calibration unit. Calibration data on this blackbody are incomplete. As a result, the uncertainty will be approximated by using a zero-order uncertainty and an instrument uncertainty. The zero-order uncertainty is defined as: U1 = +/- 0.5 resolution to an uncertainty of 95%. The resolution of the output of the black body temperature controller is 0.1 Therefore the zero-order uncertainty is 0.05 deg C (%U95). The manufacturer stated accuracy of +/- 0.1 deg. C will be

assumed to be a Gaussian instrument uncertainty. These two values may be combined using root-mean squares. The RSS of these values is +/- 0.11 deg C (%U95)

B. *Data Acquisition Uncertainty*

These data will be read over a serial cable and produce ASCII text with a resolution of 0.1 deg C. The same assumptions will be made as for the black body source due to lack of information

C. *Data Reduction Uncertainty*

The data reduction uncertainty is assumed to be negligible.

Table 1
Preliminary Uncertainty Analysis

Source	Type	Magnitude
Calibration Standard		
Blackbody	random	+/-0.11 deg C
Data Acquisition		
Serial Data Stream	random	+/-0.11 deg C
TOTAL	RSS	+/- 0.16 deg C

This preliminary uncertainty analysis indicates that a calculated measurement error of greater than +/- 0.16 deg C should be held suspect.

3. Methodology

The infrared source used was the Advanced Kinetics Black Body Source, EABB-250. The black body target was a 6 by 6 inch square. The manufacturer stated emissivity was 0.995. The frequency range of the unit was from 1 to 1000 micrometers. The stated accuracy of the unit was +/- 0.1 deg. C [K].

Each of the three pyrometer instruments was set to have an analog minimum of 273.16K and a maximum of 323.16K in a 0.0VDC to 1.0VDC output range, the emissivity was set at 0.995 and the response was set at 0.10 seconds. The pyrometer detector was setpointing into the black body at a distance of 7 inches.

4. Data Analysis

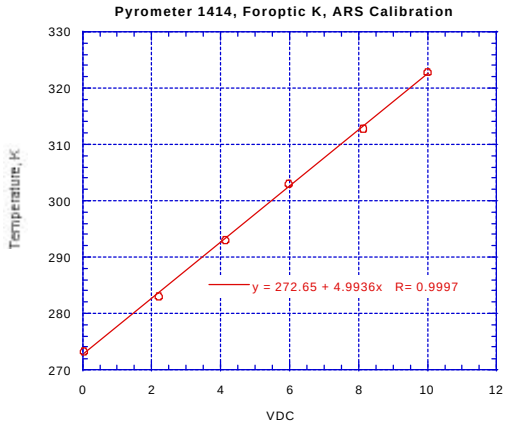
Each temperature run consisted of making 100 measurements with the KT19.85 at each blackbody temperature setpoint. The 100 values were averaged and the standard deviation was calculated. The black body source setpoints and serial output means were then fit to an equation across the 0 to 50 deg. C range.

5. Results

The results are presented in tabular and plot format as follows;

Unit 1414 Foroptic K

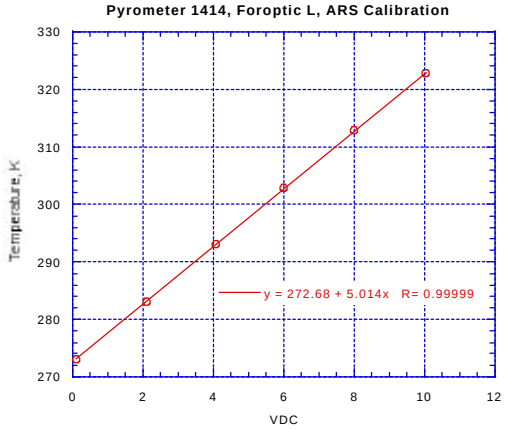
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.3	273.4	0.36
283.1	284.2	0.30
293.0	293.9	0.32
303.0	303.0	0.27
313.0	313.9	0.27
322.9	323.2	0.27



1414K :
T(K) = 272.65 + 4.9936 * (VDC)
R=0.9997

Unit 1414 Foroptic L

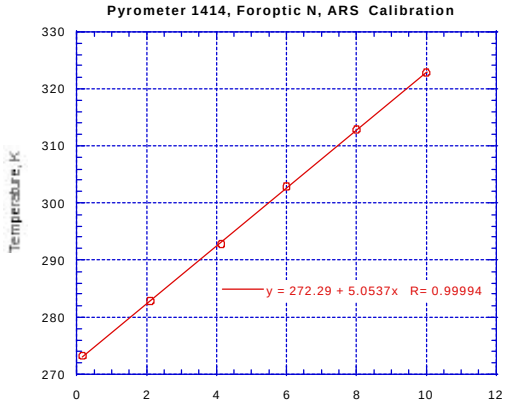
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.16	273.59	0.36
283.16	283.71	0.35
293.06	293.54	0.29
302.96	303.25	0.20
312.86	313.18	0.26
322.86	323.27	0.21



1414L:
T(K) = 272.68 + 5.0140 * (VDC)
R=0.99999

Unit 1414 Foroptic N

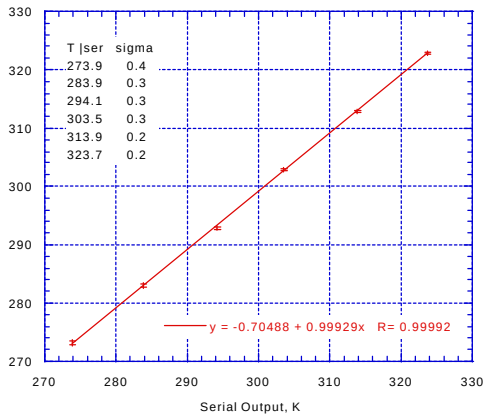
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.25	273.95	0.40
282.95	283.75	0.33
292.85	293.85	0.27
302.85	303.19	0.22
312.85	313.23	0.28
322.85	323.19	0.23



1414N :
T(K) = 272.29 + 5.0537 * (VDC)
R=0.99994

Unit 1415 Foroptic K

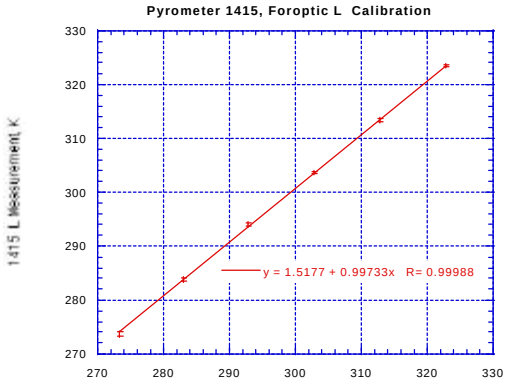
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.2	273.9	0.38
283.0	283.9	0.34
292.9	294.1	0.30
302.9	303.5	0.26
312.9	313.9	0.22
322.9	323.7	0.24



1415K : T(K)|cal = -0.70488 + 0.99929 * T(K)|ser R= 0.99992

Unit 1415 Foroptic L

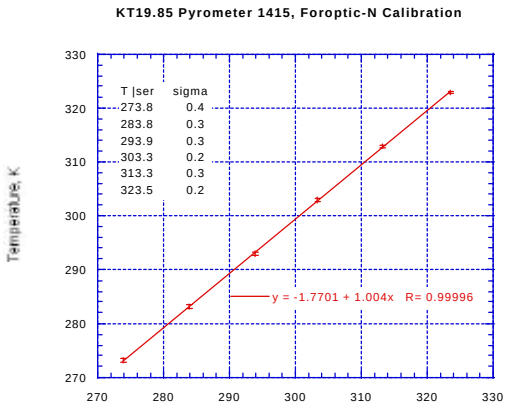
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.3	273.68	0.39
283.0	283.84	0.32
292.9	294.08	0.30
302.9	303.62	0.19
312.9	313.36	0.28
322.9	323.42	0.22



1415L : T(K)|cal = -1.44700 + 1.00240 * T(K)|ser R= 0.99988

Unit 1415 Foroptic N

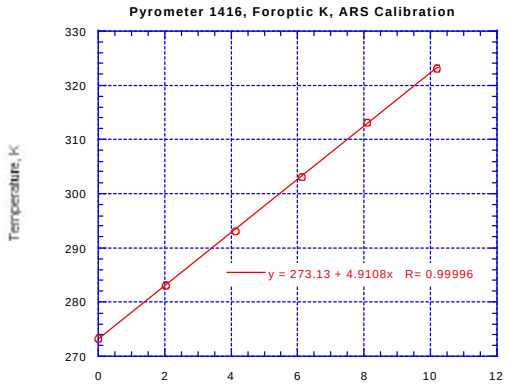
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.2	273.8	0.36
283.2	283.8	0.30
293.1	293.9	0.31
303.0	303.3	0.23
312.9	313.3	0.27
322.9	323.5	0.22



1415N : T(K)|cal = -1.77010 + 1.00400 * T(K)|ser R= 0.99996

Unit 1416 Foroptic K

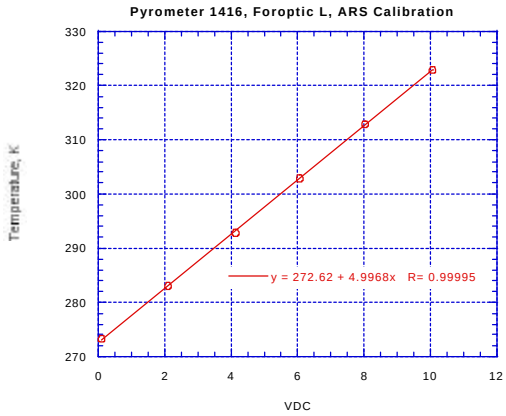
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.4	273.2	0.39
283.1	283.3	0.29
293.2	293.8	0.31
303.2	303.8	0.21
313.1	313.6	0.28
323.2	324.1	0.23



1416K :
T(K) = 273.13 + 4.9108 * (VDC)
R=0.99996

Unit 1416 Foroptic L

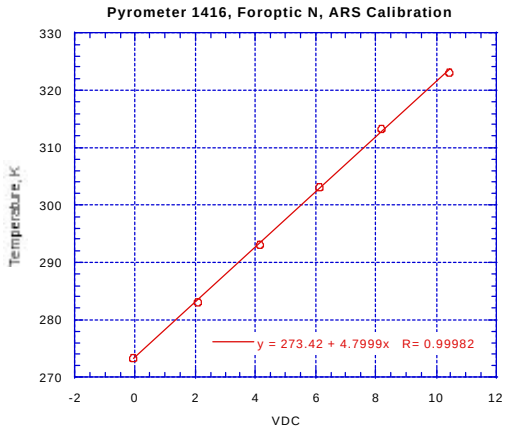
Blackbody Setpoint K	Pyrometer Mean K	sigma
273.4	273.7	0.39
283.1	283.7	0.38
293.0	293.9	0.30
303.0	303.5	0.22
312.9	313.4	0.30
323.0	323.5	0.25



1416L :
T(K) = 272.62 + 4.9968 * (VDC)
R= 0.99995

Unit 1416 Foroptic N

Blackbody Setpoint K	Pyrometer Mean K	sigma
273.3	273.0	0.40
283.2	283.5	0.35
293.2	294.0	0.34
303.2	303.8	0.23
313.3	314.2	0.32
323.2	325.5	0.26



1416N :
T(K) = 273.42 + 4.7999 * (VDC)
R=0.99982

6. Discussion

The calibration of Pyrometers 1414, 1415 and 1416 were completed at Goddard Spaceflight Center on 20 May 1998. The calibrating source was a Advanced Kinetics Black Body Source, EABB-250. Insufficient information regarding the calibration history of the blackbody source made a preliminary uncertainty analysis of little use.

7. Summary

Calibration data were taken and analyzed for three Heitronics Pyrometers with serial numbers 1414, 1415, 1416 at Goddard Spaceflight Center on 20 May 1998. The calibration equations are as follows.

1414K :
T(K) = 272.65 + 4.9936 * (VDC)
R=0.9997
1414L :
T(K) = 272.68 + 5.0140 * (VDC)
R=0.99999
1414N :
T(K) = 272.29 + 5.0537 * (VDC)
R=0.99994

1415K : T(K)|cal = -0.70488 + 0.99929 * T(K)|ser R= 0.99992
1415L : T(K)|cal = -1.44700 + 1.00240 * T(K)|ser R= 0.99988
1415N : T(K)|cal = -1.77010 + 1.00400 * T(K)|ser R= 0.99996

1416K :
T(K) = 273.13 + 4.9108 * (VDC)
R=0.99996
1416L :
T(K) = 272.62 + 4.9968 * (VDC)
R= 0.99995
1416N :
T(K) = 273.42 + 4.7999 * (VDC)
R=0.99982

These values should be used for interpreting the data collected from 20 May 1998.

REFERENCES

American National Standard for Expressing Uncertainty-U.S. Guide to the Expression of Uncertainty in Measurement, ANSI/NCSL Z540-2-1997.

Figliola, R.S., Beasley, D.E., “Theory and Design for Mechanical Measurements”, 2nd Edition, John Wiley & Sons, Inc, 1995