Radiance Temperature Measurements Laboratory Procedures Manual

Safety Issues

Safety glasses are required in lab at all times.

The following hazards have been identified in this lab. Safety measures are in place to reduce risk of injury from hazards below.

BRIGHT SOURCE
Staring at source is to be avoided because staring can cause severe eye damage. Using correct neutral density filter when viewing is required

BURN
To avoid burns, it is wise to keep body and clothes away from lamps and blackbodies.

COLLISION
The boxcar path should be kept clear of collision with any objects, and cables should not be hung from boxcar at any time.

ELECTROCUTION
Since high voltage connections are present, electrical parts should not be touched at all.

LASER
As with other bright sources, staring into laser is to be avoided because staring can cause severe eye damage. When lasers are not in use, block laser with opaque object and turn off laser when it is not in use.

Symbols, similar to one below, are used throughout this document to alert operator to potential hazards.

CAUTION
LASER

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedures

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Radiance Temperature Measurements Laboratory Procedure

Running General Data Taking Program

Written by:	Charles Gibson	Procedure:	RTMLP1
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Running the General Data Taking Program

1. Turn on computer
2. Enter password to work online or click on Cancel button to work offline
3. Load Visual Basic program: *c:\programs\datatakn\pyro.mak* (do one of following)
   a. Click on Pyro.mak shortcut icon
   b. Double click on folder *c:\programs\datatakn\pyro.mak* using Windows Explorer
4. Run program (do one of following)
   a. Press F5
   b. Click on → tool bar icon
   c. Click on menu item “Run” then “Start”
5. Run *Hardware.frm* to set up equipment with settings used by other programs
6. Run *Software.frm* to input data used by other programs
7. Run all other programs from these forms

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Radiance Temperature Measurements Laboratory Procedure

NIST Photoelectric Pyrometer (PEP) Operation

Written by:	Charles Gibson	Procedure:	RTMLP2
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

NIST Photoelectric Pyrometer (PEP) Operation

1. Turn on equipment
   a. PMT thermoelectric cooler
   b. Digital multimeters
   c. Motor controller
   d. High voltage power supply
   e. Current amplifier
   f. Environment monitor

CAUTION
LASER

2. Check alignment of optics
   a. Align laser on source table so that beam goes through center of pin hole aperture and field stop
   b. Check that collimating lens is centered on and normal to optical axis (retroreflection checked at field stop)
   c. Check that aperture stop is centered on and normal to optical axis (place microscope slide against aperture stop to check retroreflection at field stop)
   d. Check scope alignment (see step 3)
   e. Check that lamp beam is centered on aperture stop
   f. Record aperture stop micrometer position in lab notebook

CAUTION
BRIGHT SOURCE
BURN
COLLISION
ELECTROCUTION

3. Check scope alignment (scope is used to define optical axis of PEP)
    a. Turn on SL20 or other lamp in focal plane of PEP (see RTMLP7)
    b. Move lamp to PEP
    c. Close PMT shutter
    d. Open enclosure doors
    e. Open scope door
    f. Place 3/4" aperture on objective lens
    g. Put in field stop
    h. Put in prism
    i. Focus reticle to operator's eye
    j. Focus scope on field stop
    k. Rotate reticle so that #5 vertical scale line is parallel to side of field stop opening
    l. Position reticle center (intersection of #5 vertical scale line and horizontal scale line) on field stop opening
    m. Remove prism
    n. Remove field stop
    o. Put in prism
4. Set up PEP for measurements
    a. Remove aperture from objective lens
    b. Remove prism
    c. Close scope door
    d. Put in field stop
    e. Close all enclosure doors
    f. Position baffles at front of PEP
    g. Open PMT shutter
    h. Begin calibration (see (RTMLP8) for lamps or (RTMLP14) for radiation thermometers)

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Radiance Temperature Measurements Laboratory Procedure

Gold-point Blackbody (GPBB) Alignment

Written by:	Charles Gibson	Procedure:	RTMLP3
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Gold-point Blackbody (GPBB) Alignment

CAUTION
COLLISION
LASER

1. Align laser on source table so that beam goes through center of pin hole aperture and field stop
2. Move first laser to laser on PEP table
3. Align second laser so that it coincides with first laser
4. Remove outer most graphite ring
5. Put in alignment jig
6. Translate GPBB to center jig on laser
7. Rotate GPBB to make jig normal to laser (retroreflect laser beam)
8. Turn on GPBB (see RTMLP4)
9. Radiometrically center GPBB
    a. Center X along horizontal axis
    b. Center Y along vertical axis
    c. Center <X about horizontal axis
    d. Center <Y about vertical axis
    e. Make "8 turns along optical axis
    f. Repeat steps a and b until centered
    g. Check centering
        i. Monitor BB signal on graph logger
        ii. Hold card in front of BB opening
        iii. Check for equal signal drop-offs when blocking top, bottom, left, and right portions of BB opening

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Radiance Temperature Measurements Laboratory Procedure

Gold-point Blackbody Operation

Written by:	Charles Gibson	Procedure:	RTMLP4
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Gold-point Blackbody (GPBB) Operation

CAUTION
BRIGHT SOURCE
BURN
ELECTROCUTION

1. Close GPBB door
2. Turn on cold water at flow rate of 10 GPH
3. Set argon at flow rate of 54 mL/min (set black ball to 50)
4. Go to rack of power supplies
5. Turn on digital multimeter
6. Check that correct cable is connected to GPBB power supply connector
7. Switch on power supply (labeled HPPS)
8. Run lamp current monitoring program
   a. Turn on computer
   b. Type 2 and press [Enter] at DOS prompt to load and run lamp monitoring program
   c. Prepare GPBB
      i. Ramp up GPBB
         (1) Ramp up GPBB to about 1040 EC
         (2) Set current at 2 A
         (3) Wait 3 h
         (4) Ramp up to 8 A in 4 h (ramping rate 1.5 A/h)
         (5) Set GPBB temperature to about 1040 EC in 8 h to 10 h
      ii. Press 8 to ramp up GPBB
      iii. Type (start time) and press [Enter]
      iv. program will start ramping up GPBB at start time

d. Cycle GPBB through melt and freeze cycles
   i. Press 3 to monitor lamps and read GPBB temperature
   ii. Press [Esc] to return to main menu
   iii. Set current to 8.5 A and begin GPBB melt cycle when set point falls below 1050 EC
   iv. Set current to 7.95 A and begin GPBB freeze cycle when set point rises above 1071 EC

9. Set argon at flow rate of 235 mL/min (set black ball to 120)
10. Open GPBB door
11. Turn off GPBB
    a. Close GPBB door
    b. Set argon at flow rate of 54 mL/min (set black ball to 50)
    c. Turn of power to GPBB
    d. Leave water and argon on overnight until GPBB is cool

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Radiance Temperature Measurements Laboratory Procedure

Ribbon Filament Lamp Preparation

Written by:	Charles Gibson	Procedure:	RTMLP5
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Ribbon Filament Lamp Preparation

CAUTION
BRIGHT SOURCE
BURN
ELECTROCUTION

1. Lamp inspection
   a. Check filament continuity
   b. Check clarity of envelope (and window)
   c. Check flatness of filament
   d. Check that filament is within 2 mm of being centered in envelope (or window)
2. Clean lamp envelope
3. Anneal lamp
   a. Anneal gas lamp
      i. Leak test lamp
         (1) Set lamp to 1700 EC (PMT signal = 2.5 V on 8 range, high voltage = 449 V) (About 25 A dc)
         (2) Turn off lamp
         (3) Wait 15 min to allow air to enter any leaks
         (4) Set lamp to 2350 EC (PMT signal = 1.2 V on 7 range, high voltage = 394 V)(About 45 A dc)
         (5) Wait 15 min
      ii. Anneal lamp for 2 h
      iii. Age lamp for 50 h at 2300 EC (About 42 A dc)

b. Anneal vacuum lamp
   i. Leak test lamp
      (1) Set lamp to 1000 EC (PMT signal = 5.3 V on 9 range, high voltage = 730 V)
      (2) Turn off lamp
      (3) Wait 15 min to allow air to enter any leaks
      (4) Set lamp to 1450 EC (PMT signal = 5.1 V on 9 range, high voltage = 449 V)
      (5) Wait 15 min
   ii. Anneal lamp for 14 h

4. Locate arrow on lamp
   a. Set lamp to 1700 EC for gas lamps or 1200 EC for vacuum lamps (for 1200 EC, PMT signal = 5.5 V on 8 range, high voltage = 730 V)
   b. Use plumb line to make notch side of filament vertical
   c. Translate lamp horizontally so that reticle center bisects filament lengthwise
   d. Translate lamp vertically so that reticle center is positioned at center of notch opening
   e. Translate lamp along optical axis until filament is in focus
   f. Rotate lamp about vertical axis so that both edges of filament are in focus
   g. Use graph logger to locate angular settings with smallest change in radiance with respect to rotation about horizontal and vertical axes
   h. First person looks through alignment scope and guides second person to notch
   i. Second person makes dot on lamp envelope at notch
   j. Draw picture of notch in lab notebook showing its relationship to dot
   k. Draw arrow showing relationship of alignment arrow to dot
   l. Repeat steps for each lamp

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Radiance Temperature Measurements Laboratory Procedure

Ribbon Filament Lamp Alignment

Written by:	Charles Gibson	Procedure:	RTMLP6
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Ribbon Filament Lamp Alignment

CAUTION
BRIGHT SOURCE
BURN
COLLISION
ELECTROCUTION

1. Check PEP scope alignment (see RTMLP2)
2. Place 3/4" aperture on objective lens
3. Turn on lamp (see RTMLP7)
4. Move lamp to PEP optical axis
5. Use plumb line to make notch side of filament vertical
6. Translate lamp horizontally so that reticle center bisects filament lengthwise
7. Translate lamp vertically so that reticle center is positioned at height of notch opening
8. Translate lamp along optical axis until filament is in focus
9. Rotate lamp about vertical axis so that both edges of filament are in focus
10. Translate lamp horizontally and vertically to reticle center
11. Place 1/4" aperture on objective lens
12. Place mirror behind lamp alignment arrow
13. Rotate lamp about horizontal axis so that tip of arrowhead is positioned at height of notch opening
14. Rotate lamp about vertical axis so that tip of arrowhead is positioned at notch opening
15. Repeat steps 13 and 14 until tip of arrowhead is centered at notch opening
16. Translate lamp horizontally and vertically to reticle center at height of notch
17. Repeat steps 3 to 16 for standard and test lamps
18. Set up PEP for measurements (see RTMLP2)

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Radiance Temperature Measurements Laboratory Procedure

Ribbon Filament Lamp Operation

Written by:	Charles Gibson	Procedure:	RTMLP7
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Ribbon Filament Lamp Operation

CAUTION
BRIGHT SOURCE
BURN
ELECTROCUTION

1. Use Kimwipe to avoid touching lamp envelope
2. Place lamp in socket
   a. Check lamp polarity (center contact for screw base, longer filament support for mogal base at positive potential)
   b. Set alignment arrow or mark away from PEP
3. Go to rack of power supplies
4. Turn on digital multimeter
5. Turn on GP-IB Programmer(s) for supply(s) to be used
   a. cables and programmers are numbered with corresponding power supply number
   b. programmers are two channel 12 bit D/A converters
6. Check that correct cable is connected to power supply
7. Switch on power supply
8. Run lamp current monitoring program
   a. Turn on computer
   b. Type 2 and press [Enter] at DOS prompt to load and run lamp monitoring program
   c. Set lamp current
      i. Press 1 to set power supply current
      ii. Type (supply #) and press [Enter]
      iii. Type (lamp current) and press [Enter]
   d. Monitor lamp currents
      i. Press 3
      ii. Press [Esc] to return to main menu

e. Turn off supply
   i. Press 2
   ii. Type (supply #) and press [Enter]
f. Change lamp current
   i. same as (1)
g. Set multiple lamp currents
   i. Press A to select power supplies to turn on
   ii. Type (lamp current) and press [Enter] to select supplies to turn on
   iii. Type 0 and press [Enter] to skip supply
h. Turn off all supplies
   i. Press B to turn off all lamps
   ii. Type OFF and press [Enter] to turn off all lamps
i. Trouble-shoot
   i. Check program locking
      (1) Type Ctrl [Break]
      (2) Type GOTO 20, press [Enter] to return to main menu

9. Align lamps (see RTMLP6)
10. Use **EMERGENCY TURN OFF** procedure when necessary
    a. Go to supply
    b. Turn CURRENT knob counter clockwise to turn down lamp current
    c. Turn off supply
    d. Turn off GP-IB Programmer for supply

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Radiance Temperature Measurements Laboratory Procedure

Ribbon Filament Lamp Procedure

Written by:	Charles Gibson	Procedure:	RTMLP8
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Ribbon Filament Lamp Calibration Procedure

1. Review calibration summary
    a. Align and measure test lamp at 1700 EC
    b. Measure 2300 EC to 800 EC in 100 EC steps
    c. Repeat 1700 EC, 2300 EC, 1900 EC, 1500 EC, 1100 EC, and 800 EC
2. Run general data taking program (see RTMLP1)
3. Align standard and test lamps (see RTMLP6))
4. Run calibration program
    a. Click on "Calibrations" from *Hardware.frm* menu to load *Rtcal.frm*
    b. Select "Lamps and blackbodies" button
    c. Enter data filename
    d. Enter test filename suffix$
        i. Create test filenames from names on *Software.frm*
    e. Select Yes and use suggested ranges (PMT high voltage and amplifier ranges are part of *Rtcal.frm* program)
    f. Click on "Start" button
    g. Enter data on *Software.frm*
        i. Enter lamp and blackbody data
            (1) Enter data for reference and test lamps
            (2) Select "Use" button
            (3) Enter lamp position
            (4) Enter lamp name
            (5) Select "Reference" button
            (6) Enter lamp current (no necessary, lamp current automatically read from lamp monitoring computer)
            (7) Enter power supply number
        ii. Select temperature scale
        iii. Select measurement wavelength [nm]
        iv. Enter number of repeats (number of test/standard measurements)

   v. Enter number of readings (number of readings per DMM trigger)
   vi. Select lamp type
   vii. Select detector channel

h. Click on "Save Configuration" button
i. Select "Continue" button to return to *Rtcal.frm*
j. Enter Standard temperature in EC in input box
k. Enter Nominal radiance temperature in input box
l. Read lamp currents automatically
m. Adjust test lamp current so that test lamp signal matches that indicated on *Suggest.frm*
n. Wait for lamp to stabilize (5 min, 10 min, 15 min, or 20 min depending on measurement temperature)
o. Check lamp alignment
p. Move source table to reference source and measure full scale signal
q. Move source table to dark signal position and measure dark signal
r. Move source table to test source and measure full scale signal
s. Move source table to dark signal position and measure dark signal on test source amplifier range, if reference and test source amplifier ranges are different
t. Repeat steps r to s for each test source
u. Repeat steps p to s "number of repeats" times
v. Select next action and then select "Continue" button
   i. Repeat measurement with no changes
   ii. Measure with new temperature
   iii. Measure with new software changes
   iv. Stop measurements
w. Repeat steps k to v for each measurement point

5. Store calibration data in log file "CALMMDD.YY"
6. Use sample log file below:

Date 08-15-1995 Time 12:49:14 PM
File Name = CAL0815.95
PMT Detector PMT HV = 449 NRDS = 5 Integration Time = 8.35 s
Wavelength = 655.3 nm Nominal Rad Temp = 1700 EC

Name	SL20	P51
Rad. Temp	1255.07 EC	1700.37 EC
Current	7.7788 A	26.960 A
Sp. Rad.	5.696E+02	1.456E+04
Ratio	1.000E+00	2.556E+01
Std. Ratio	0.01%	0.04%
Amp Range	9	8
Full Scale	1.052E+00 ±0.00%	2.685E+00 ±0.00%
	1.052E+00 ±0.00%	2.683E+00 ±0.00%
	1.052E+00 ±0.00%	2.684E+00 ±0.00%
Dark Sig.	1.501E-04	-8.035E-05
Mean	1.052E+00	2.684E+00
Std(Mean)	0.01%	0.04%
Range Cf.	9.9858E-02	1.0000E+00
SS Cf.	1.000E+00	1.000E+00
Corr. Mean	1.050E-01	2.684E+00
Position #	1	6
Table Pos.	37500	246000

7. Store lamp data in test file "XXXXMMDD.YY"
8. Use sample test file below:

P510815.95
08-15-1995 12:49:14 PM

Tnom EC	Tmeas EC	Imeas EC	Test/Standard
1700	1700.37	26.960	2.5558E+01
2300	2300.22	43.340	3.4164E+02
2200	2200.29	40.330	2.4203E+02
2100	2100.04	37.440	1.6636E+02
2000	2000.04	34.670	1.1075E+02
1900	1900.16	31.990	7.1053E+01
1800	1800.13	29.420	4.3646E+01

9. Reduce data (see RTMLP9)

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Radiance Temperature Measurements Laboratory Procedure

Ribbon Filament Lamp Data Reduction

Written by:	Charles Gibson	Procedure:	RTMLP9
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Ribbon Filament Lamp Data Reduction

1. Print out test file
2. Look in lab notebook and make changes on printout and then edit file
3. Load Visual Basic program: *c:\programs\lmpredn\Rtred.mak* (do one of following)
   a. Click on Rtred.mak shortcut icon
   b. Double click on folder *c:\programs\lmpredn\Rtred.mak* using Windows Explorer
4. Run program (do one of following)
   a. Press F5
   b. Click on → tool bar icon
   c. Click on menu item "Run" then on "Start"
5. Select number of lamps to reduce
6. Enter 4 character serial number for each lamp
7. Enter data file suffix
8. Select directory that contains data file
9. Select degrees of freedom for curve fit
10. Click on "Run" button
11. Print data in list box
12. Calculate mean (T_{meas}) and standard deviation are calculated
13. Compare standard deviation to control limit
14. Correct lamp current to nominal temperature using following method, because measured temperatures are different from nominal temperatures (T_{nom})
    a. Fit data to fifth degree polynomial using least squares approximation
    b. Define independent variable: $T_{mean} = (T_{meas}(n\text{-}1) + T_{meas}(n))/2$
    c. Define dependent variable: $\Delta I/\Delta T = (I_{meas}(n\text{-}1) - I_{meas}(n))/(T_{meas}(n\text{-}1) - T_{meas}(n))$
    d. Calculate dI/dT from fit
    e. Define corrected lamp current: $I_{corr} = I_{meas} + dI/dT * (T_{nom} - T_{meas})$
15. Store reduced data in log file "REDMMDD.YY"
16. Use sample log file on next page:

Reducing ‘C\PYRO\P510815.95’ 08-17-1995 11:26:56 AM

P510815.95
08-15-1995 12:49:14 PM

Tnom EC	Tmeas EC	Imeas A	Test/Standard
1700	1700.37	26.96	2.5558E+01
2300	2300.22	43.34	3.4164E+02
2200	2200.29	40.33	2.4203E+02
2100	2100.04	37.44	1.6636E+02
2000	2000.04	34.67	1.1075E+02
1900	1900.16	31.99	7.1053E+01
1800	1800.13	29.42	4.3646E+01

Tnom EC	Tmean EC	Imeas A	Std Error	Limit	Flag	Nrpt
800	800.82	11.850	0.09	0.21		3
900	899.58	12.720	0.00	0.19		1
1000	1000.04	13.800	0.00	0.15		1
1100	1100.02	15.100	0.00	0.09		1
1200	1199.63	16.620	0.00	0.10		1

Tnom EC	Imeas A	Tmeas EC	Tmean EC	DelI/DelT EC	dI/dT	DelT	DelI	Icorr A
0800	11.850	0800.82	0850.20	0.0088	0.0079	-0.82	-0.007	11.843
0900	12.720	0899.58	0949.81	0.0108	0.0097	0.42	0.004	12.724
1000	13.800	1000.04	1050.03	0.0130	0.0119	-0.04	0.000	13.800
1100	15.100	1100.02	1149.83	0.0153	0.0141	-0.02	0.000	15.100
1200	16.620	1199.63	1249.74	0.0174	0.0163	0.37	0.006	16.626

Coefficients used to calculate d*I*/d*T* from a 5th degree polynomial

C(0)= 0.063517488043157
C(1)=-2.4035523727757E-04
C(2)= 3.56720919376003E-07
C(3)=-2.29083987235765E-10
C(4)= 6.90646490071546E-14
C(5)=-7.96328820986401E-18

800	11.843
900	12.724
1000	13.800
1100	15.100
1200	16.626
1300	18.363
1400	20.289
1500	22.376
1600	24.599
1700	26.951
1800	29.417
1900	31.988
2000	34.669
2100	37.441
2200	40.321
2300	43.331

Data is stored in 'C:\PYRO\P510895.TXT'

Reduction of file 'C:\PYRO\P510815.95 ' is complete

17. Save T_{nom} and I_{corr} in data file "XXXXMMYY.TXT"
18. Use sample test data file below:

C:\PYRO\P510895.TXT

800	11.843
900	12.724
1000	13.800
1100	15.100
1200	16.626
1300	18.363
1400	20.289
1500	22.376
1600	24.599
1700	26.951
1800	29.417
1900	31.988
2000	34.669
2100	37.441
2200	40.321
2300	43.331

19. Compare current calibration to previous calibration
20. Click on "Compare calibrations" from menu
21. Select previous calibration filename
22. Select current calibration filename
23. Select temperature scale (EC, EF, or K)
24. Select international temperature scale (ITS-48, ITS-68, ITS-90)
25. Enter wavelength (nm) for previous data file
26. Enter wavelength (nm) for current data file
27. Click on "Run" button
28. Enter data file name "XXXXmyy.MYY"
    a. Define myy: month and year of previous calibration
    b. Define MYY: month and year of current calibration
29. Store comparison data in log file "CMPMMDD.YY"
30. Use sample log file on next page:

08-17-1995 11:50:32
Previous calibration data file = 'c:\files\p510393.txt'
Current calibration data file = 'c:\files\p510895.txt'
Comparing previous to current calibration

Temp [EC]	655.3nm Old [I] ITS-90 [A]	New [I] ITS-90 [A]	655.3nm New [I] ITS-90 [A]	dI ITS-90 [A]	DI/DT [A/EC]	WL Corr.	Change Temp. ITS-90	Total Change ITS-90	%Change Rad.	Scale Corr. [EC]
800	11.847	11.843	11.843	0.004	0.0078	0.00	0.51	0.51	0.98%	0.00
900	12.724	12.724	12.724	0.000	0.0096	0.00	0.00	0.00	0.00%	0.00
1000	13.799	13.800	13.800	-0.001	0.0119	0.00	-0.08	-0.08	-0.11%	0.00
1100	15.098	15.100	15.100	-0.002	0.0142	0.00	-0.14	-0.14	-0.16%	0.00
1200	16.623	16.626	16.626	-0.003	0.0164	0.00	-0.18	-0.18	-0.18%	0.00
1300	18.361	18.363	18.363	-0.002	0.0185	0.00	-0.11	-0.11	-0.10%	0.00
1400	20.287	20.289	20.289	-0.002	0.0201	0.00	-0.10	-0.10	-0.08%	0.00
1500	22.372	22.376	22.376	-0.004	0.0216	0.00	-0.18	-0.18	-0.13%	0.00
1600	24.600	24.599	24.599	0.001	0.0230	0.00	0.04	0.04	0.03%	0.00
1700	26.956	26.951	26.951	0.005	0.0242	0.00	0.21	0.21	0.12%	0.00
1800	29.423	29.417	29.417	0.006	0.0252	0.00	0.24	0.24	0.12%	0.00
1900	31.992	31.988	31.988	0.004	0.0262	0.00	0.15	0.15	0.07%	0.00
2000	34.666	34.669	34.669	-0.003	0.0272	0.00	-0.11	-0.11	-0.05%	0.00
2100	37.442	37.441	37.441	0.001	0.0283	0.00	0.04	0.04	0.01%	0.00
2200	40.329	40.321	40.321	0.008	0.0295	0.00	0.27	0.27	0.10%	0.00
2300	43.340	43.331	43.331	0.009	0.0307	0.00	0.29	0.29	0.10%	0.00

Comparison data stored in 'CMP0817.95'
Total change and %Change Radiance stored in 'P51_393.895'

31. Use sample comparison data file below:

P51_393.895	08-17-1995	11:50:49 AM
Temp [EC]	dT [EC]	%dL
800	0.51	0.98%
900	0.00	0.00%
1000	-0.08	-0.11%
1100	-0.14	-0.16%
1200	-0.18	-0.18%
1300	-0.11	-0.10%
1400	-0.10	-0.08%
1500	-0.18	-0.13%
1600	0.04	0.03%
1700	0.21	0.12%
1800	0.24	0.12%
1900	0.15	0.07%
2000	-0.11	-0.05%
2100	0.04	0.01%
2200	0.27	0.10%
2300	0.29	0.10%

32. Prepare calibration summary sheet
33. A sample calibration summary sheet is below:

Radiance Temperature Lab
Calibration Summary Sheet

Today's date: June 10, 1998

NIST Test No: 844/123456-95 Use sample report: 35050c.rfl

Company: Radiometric Systems Inc
Contact: John Doe Phone: 301 123-4567

P.O.#: AB1234 dated January 1, 1995

Test number: 35050C Radiance Temperature Standard, Ribbon Filament Lamp

Test item: One General Electric Tungsten Ribbon Filament Lamp, Model # 30/T24/6, Serial # P51

Temperatures measured: 800 EC to 2300 EC Aligned at 1700 EC

Standard(s) used: SL20 (7.7788 A, 2.093 V), (Pcos(2θ)=0.001107, 12/92 TR2 p 123)

Temperature: 21 EC " 1 EC Relative humidity: 38% " 5%

Calibration date: 5/24/95 Measurement date(s):5/24/95 TR3 p42

Data taking program: C:\programs\datatakn\pyro.mak|rtcal.frm 10/9/96
Calibration files: CAL0815.95, P510815.95

Data reduction program:C:\programs\lampredn\rtred.mak|lmpred.frm 5/25/95
Reduction summary: Red0525.95
Final data filename: P510895.TXT

Data analysis program:C:\programs\lampredn\rtred.mak|compare.frm 5/25/95
Reduction summary: Cmp0817.95
Previous calibration filename: P510393.TXT
Comparison filename: P51_393.895

34. Enter data file name "XXXXmyy.MYY"
    a. Prepare history file consisting of Microsoft EXCEL spreadsheet with plots of temperature difference from first calibration versus nominal temperature

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Variable Temperature Blackbody (BB) Alignment

Written by:	Charles Gibson	Procedure:	RTMLP10
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Variable Temperature Blackbody (BB) Alignment

CAUTION
COLLISION

1. Align PEP (see RTMLP2)
2. Remove field stop
3. Remove objective lens aperture, if any
4. Level aluminum plate (<X)
5. Use fiber optic light to illuminate BB
6. Translate BB along optical axis until center partition is in focus (Z)
7. Center BB on optical axis (X and Y)
8. Turn on BB (see RTMLP11)
9. Radiometrically center BB
    a. Center <Y about vertical axis
    b. Center X along horizontal axis
    c. Repeat i and ii until centered
    d. Check centering
        i. Monitor BB signal on graph logger
        ii. Hold card in front of BB opening
        iii. Check for equal drop-offs when blocking top, bottom, left, and right portions of BB opening

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Variable Temperature Blackbody (BB) Operation

Written by:	Charles Gibson	Procedure:	RTMLP11
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Variable Temperature Blackbody Operation

CAUTION
BRIGHT SOURCE
BURN
ELECTROCUTION

1. Turn On BB
   a. Open tap water valve 1/8 turn
   b. Check that blue box flow rate is about 2 gpm
   c. Open chilled water valves
      i. Open supply valve 1/4 turn
      ii. Open return valve fully
   d. Press reset button on blue water switch box to select chilled water
   e. Check that blue box flow rate is about 5 gpm
   f. Open argon cylinder valve fully
   g. Turn on argon alarm and check that it trips at 10 cfh
   h. Purge BB using argon flow rate of 70 cfh
      i. Cover both BB openings for 5 s with your hands
      ii. Uncover one end and wait 5 s
      iii. Cover both BB openings for 5 s with your hands
      iv. Uncover other end and wait 5 s
   i. Repeat step h 5 times
   j. Reduce argon flow rate to 10 cfh
   k. Check that BB housing is cool and that argon is flowing
   l. Insert correct detector filter for initial set point
      i. Filter 0, 700 EC to 1300 EC, Low with insulation (LIN)
      ii. Filter 1, 1300 EC to 1800 EC, Medium (MED)
      iii. Filter 2, 1800 EC to 2500 EC, High (HI)
      iv. Filter 3, 2500 EC to 3100 EC, Extra High(XH)
   m. Switch control mode to [MANUAL]
   n. Turn potentiometer to 0

o. Press [START], [WATER ON], and [RUN] buttons
   i. Note that BB does not control chilled water flow, because automatic BB shutoff switch has been disabled
p. Turn potentiometer slowly until voltmeter reads between 150 VAC and 200 VAC (sets BB below 1300 EC)

2. Operate BB
   a. Run BB control program
      i. Program is BBPROG.PRG in BetterBasic
      ii. Enter BB at DOS prompt
      iii. Enter measurement direction
         (1) '0' to run high to low
         (2) '1' to run low to high
      iv. Enter set point unit
         (1) 'C' for EC
         (2) 'F' for EF
      v. L Enter temperature range
         (1) LOW
         (2) LIN
         (3) MED
         (4) HI
         (5) XH
      vi. Insert correct filter and press [Enter]
   b. Press [Shift S] to enter initial set point
   c. Adjust potentiometer until temperature is 20 EC above set point
   d. Switch control mode to [PC] to maintain set point

WARNING! DO NOT INCREASE SET POINT BY STEPS LARGER THAN 20 EC TO REDUCE DAMAGE TO BB

   e. Select new set point (set point is in EC or EF depending on set point unit selected)
      i. Press [Shift S] to enter set point
      ii. Use numeric keypad to increment set point
         (1) Press increment key
            (a) Press 7 for 100 EC
            (b) Press 4 for 10 EC
            (c) Press 1 for 1 EC

(d) Press 0 for 0.1 EC

(2) Press direction key to set new set point

(a) Press 8 to increase set point

(b) Press 2 to decrease set point

f. Pause program (suspending BB control) if new set point is not in current range

i. Use default set points depending on measurement direction

(1) Use high to low default set points

(a) Select XH for 2500 EC

(b) Select HI for 2300 EC

(c) Select MED for 1800 EC

(d) Select LOW for 1300 EC

(2) Use low to high default set points

(a) Select LOW for 800 EC

(b) Select MED for 1300 EC

(c) Select HI for 1800 EC

(d) Select XH for 2500 EC

ii. Switch control mode to [MANUAL] if new set point is not default value

iii. Loop program step 2.a.v. (see L)

3. Use **EMERGENCY TURN OFF** procedure when necessary

a. Press [EMERGENCY STOP] button on power supply (chilled water and argon will continue flowing)

b. Continue with steps 4.b. to 4.j.

4. **Turn Off** BB

a. Switch control mode to [MANUAL]

b. Turn to potentiometer to 0

c. Press [EMERGENCY STOP] button on power supply (chilled water and argon will continue flowing)

d. Switch off main breaker on wall

e. Wait until furnace has stopped glowing

f. Close chilled water supply valve

g. Close chilled water return valve

h. Close cold water supply valve

i. Close argon cylinder valve

j. Close argon flow meter valve

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Disappearing Filament Optical Pyrometer Alignment

Written by:	Charles Gibson	Procedure:	RTMLP12
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Disappearing Filament Optical Pyrometer Alignment

1. Align BB (see RTMLP10)
2. Check that objective lens and eye piece are clean
3. Check batteries
4. Zero galvanometer
5. Use post with magnetic base, height adjustment, and angle bracket to mount pyrometer
6. Position post and level angle bracket mounting surface
7. Mount pyrometer to angle bracket

CAUTION
COLLISION

8. Use joystick to move BB to test pyrometer position
9. Use fiber optic light to illuminate BB
10. Set pyrometer at measuring distance from BB center partition
    a. Use distance of 30.2 cm from center partition to end of graphite extension tube
    b. Measure distance from front surface of objective lens holder to extension tube (for 1 m, distance is 69.8 cm)
11. Adjust pyrometer eye piece to focus on illuminated lamp filament
12. Focus pyrometer on center partition
13. Adjust pyrometer and/or move BB so that pyrometer views down center of BB cavity
14. Check distance
15. Adjust pyrometer and/or move BB so that pyrometer views down center of BB cavity
16. Record table position
17. Repeat for other test pyrometers

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Radiation Thermometer (RT) Alignment

Written by:	Charles Gibson	Procedure:	RTMLP13
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Radiation Thermometer (RT) Alignment

1. Align BB (see RTMLP10)
2. Check that objective lens and eye piece are clean
3. Use post with magnetic base, height adjustment, and angle bracket to mount RT
4. Position post and level angle bracket mounting surface
5. Mount RT to angle bracket

CAUTION
COLLISION

6. Use joystick to move BB to test RT position
7. Use fiber optic light to illuminate BB
8. Set RT at measuring distance from BB center partition
   a. Use distance of 30.2 cm from center partition to end of graphite extension tube
   b. Measure distance from front surface of objective lens holder to extension tube (for 1 m, distance is 69.8 cm)
   c. Measure distance from alignment mark to extension tube for Land Cyclops RT (for 1 m, distance is 69.8 cm)
9. Adjust RT eye piece to operator's eye
10. Focus RT on center partition
11. Adjust RT and/or move BB so that RT views down center of BB cavity
12. Check distance
13. Adjust RT and/or move BB so that RT views down center of BB cavity
14. Record table position
15. Repeat steps 2 to 14 for each test RT
16. Turn on BB (see RTMLP11)
17. Check centering of each test RT
    a. Monitor RT signal on graph logger or look at RT display panel
    b. Hold card in front of BB opening
    c. Check for equal drop-offs when blocking top, bottom, left, and right portions of BB opening

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Radiation Thermometer (Optical Pyrometer) Calibration Procedure

Written by:	Charles Gibson	Procedure:	RTMLP14
Approved by:	_____	Date:	_____
Revised by:	_____	Date:	_____

Radiation Thermometer (Optical Pyrometer) Calibration Procedure

1. Review calibration summary
    a. Align standard lamp, BB, and test RTS
    b. Measure from 2700 EC to 800 EC in 100 EC steps
    c. Repeat 2300 EC, 1900 EC, 1500 EC, 1300 EC, 1100 EC, and 800 EC
2. Run general data taking program (see RTMLP1)
3. Align standard lamp (see RTMLP6)
4. Align BB (see RTMLP10)
5. Align RTS (see RTMLP13)
6. Run calibration program
    a. Click on "Calibrations" from *Hardware.frm* menu to load *Rtcal.frm*
    b. Select "Radiation thermometer" button
    c. Enter data filename
    d. Enter test filename suffix$
        i. Create test filenames from names on *Software.frm*
    e. Select Yes and use suggested ranges (PMT high voltage and amplifier ranges are part of *Rtcal.frm* program)
    f. Click on "Start" button
    g. Enter data on *Software.frm*
        i. Enter lamp and blackbody data
            (1) Enter data for reference and BB
            (2) Select "Use" button
            (3) Enter lamp position
            (4) Enter lamp name
            (5) Select "Reference" button
            (6) Enter lamp current (not necessary because lamp currents are automatically read from lamp monitoring computer)
            (7) Enter power supply number

ii. Enter radiation thermometer data
  (1) Enter data for check standard and test RTS
  (2) Select "Use" button
  (3) Enter RT name
  (4) Enter source table position
  (5) Enter digital multimeter channel to read signal
  (6) Enter RT type (O for optical pyrometers and R for radiation thermometers)
  (7) Enter output type (P for panel or scale, D for digital, A for analog)
  (8) Select instrument wavelength (nm)
iii. Select temperature scale
iv. Select measurement wavelength [nm]
v. Enter number of repeats (number of test/standard measurements)
vi. Enter number of readings (number of readings per DMM trigger)
vii. Select lamp type
viii. Select detector channel

h. Click on "Save Configuration" button
i. Select "Continue" button to return to *Rtcal.frm*
j. Enter Standard temperature in EC in input box
k. Enter Nominal radiance temperature in input box
l. Read lamp currents automatically
m. Enter BB set point
n. Wait 5 min for BB to stabilize
o. Move source table to reference source and measure full scale signal
p. Move source table to dark signal position and measure dark signal
q. Move source table to BB and measure full scale signal
r. Move source table to dark signal position and measure dark signal on BB amplifier range if reference and BB amplifier ranges are different
s. Repeat steps o to r "number of repeats" times
t. Enter emissivity correction for test RT wavelength
  i. Enter 0 for 655.3 nm
  ii. Enter 1 for 900 nm
  iii. Enter 2 for 1000 nm
  iv. Enter 3 for true temperature

u. Move BB in front of each RT and take reading
   i. Read RTs with digital outputs 3 times
   ii. Read RTs with analog outputs 3 times
   iii. Enter display value for RTs with digital display panels
   iv. Read OPs matching from bright to dark and then from dark to bright
      (1) Enter scale value or press [Enter] to read output signal
      (2) Read 2 sets
v. Select next action and then select "Continue" button
   i. Repeat measurement with no changes
   ii. Measure with new temperature
   iii. Measure with new software changes
   iv. Stop measurements
w. Repeat xxii for each measurement point

7. Store calibration data in log file "CALMMDD.YY"
8. Use sample log file on next page:

Date 12-13-1996 Time 9:48:10 AM
File Name = CAL1213.96
PMT Detector PMT HV = 449 V NRDS = 5 Integration Time = 8.35 s
Wavelength = 655.3 nm Nominal Rad Temp = 1800 EC

Name	SL20	TGBB
Rad. Temp	1254.96 EC	1799.01 EC
Current	7.7788 A	
Sp. Rad.	5.690E+02	2.472E+04
Ratio	1.000E+00	4.344E+01
Std. Ratio	0.06%	0.05%
Amp Range	9	8
Full Scale	1.016E+00 ±0.00%	4.411E+00 ±0.00%
	1.016E+00 ±0.00%	4.411E+00 ±0.01%
	1.015E+00 ±0.00%	4.410E+00 ±0.01%
Dark Sig.	1.510E-04	-1.166E-04
Mean	1.015E+00	4.411E+00
Std(Mean)	0.04%	0.01%
Range Cf.	9.9858E-02	1.0000E+00
SS Cf.	1.000E+00	9.987E-01
Corr. Mean	1.014E-01	4.405E+00
Position #	1	3
Table Pos.	37500	127500

Position CY52 TEST PYRO # 1
Reading # 1 1804 EC 0.0 EC
Mean = 1804.0 EC STD = 0.0 EC

Temperature Set for THERMOGAGE = 1800 EC
Measured Temperature at 655.3 nm = 1799.01 EC
Calculated Temperature at 655.3 nm = 1799.01 EC
Mean 1804.0 EC
Test Std 0.0 EC
Test Corr. -6.0 EC

9. Store RT data in test file "XXXXMMDD.YY"
10. Use sample test data file below:

c:\PYRO\CY521213.96
12-13-1996 9:59:06 AM
Standard used is SL20 at 1254.96 EC
Temperature in EC
Temperature measured at 655.3 nm Temperature calculated at 1000 EC

Tnom	Tbb	Tcorr	CY52	Std	Corr
1800	1799.01	1797.98	1804.0	0.0	-6.0
1700	1699.18	1698.26	1704.5	0.0	-6.2
1600	1599.47	1598.64	1603.0	0.0	-4.4
1500	1499.31	1498.56	1502.0	0.0	-3.4
1400	1399.24	1398.57	1401.0	0.0	-2.4
1300	1299.30	1298.71	1302.0	0.0	-3.3
1200	1199.36	1198.85	1201.0	0.0	-2.2
1100	1099.34	1098.89	1100.5	0.0	-1.6
1100	1099.25	1098.80	1100.5	0.0	-1.7
1000	999.15	998.76	1000.0	0.0	-1.2

11. Reduce data (see RTMLP15)

Optical Technology Division (844)
Radiance Temperature Measurements Laboratory Procedure

Radiation Thermometer (RT) Data Reduction

Written by: Charles Gibson Procedure: RTMLP15
Approved by: _____ Date: _____
Revised by: _____ Date: _____

Radiation Thermometer (RT) Data Reduction

1. Print out test file for RT check standard
   a. Verify that RT check standard values are within uncertainty
2. Print out test file for BB RT check standard
   a. Verify that BB RT check standard values are within uncertainty
3. Print out test files
4. Look in lab notebook and document any changes on print out and then edit file
5. Load EXCEL and open test file
6. Separate data by range or filter
7. Sort data
8. Calculate mean and standard deviation of repeats
9. Plot data
10. Save in data file "XXXXMMYY.XLS"
11. Use sample data file below:

TEST1096.XLS			11/7/96					
c:\PYRO\TEST1007.96								
Tnom	Tbb	Tcorr	TEST	Std	Corr	Corr Mean	Corr Std	Filter
°C	°C	°C	°C	°C	°C	°C	°C	
800	799.10	798.83	801	0	-2.2	-2.5	0.4	Clear
800	800.58	800.30	803	0	-2.7			
900	899.04	898.71	900.5	0	-1.8			
1000	999.13	998.74	1000	0	-1.3			
1100	1099.19	1098.74	1100	0	-1.3	-1.2	0.2	
1100	1100.48	1100.03	1101	0	-1.0			
1200	1199.32	1198.80	1200	0	-1.2			

12. Use, for repeats, values of blackbody temperature (T_{corr}), test RT reading (TEST), and test RT correction (Corr) that best represents mean of repeats so that actual reading is reported
13. Save data in text file (tab delimited) "XXXXMMYY.TXT"

14. Use sample file below:

Test1096.TXT			11/4/96	
Tnom	Tcorr	TEST	Corr	Filter
[EC]	[EC]	[EC]	[EC]	Clear
800	800.3	803	-2.7	
900	898.7	900.5	-1.8	
1000	998.7	1000	-1.3	
1100	1098.7	1100	-1.3	
1200	1198.8	1200	-1.2	

15. Prepare calibration summary sheet
16. Use sample calibration summary sheet on next page:

Radiance Temperature Lab
Calibration Summary Sheet

Today's date: June 10, 1998

NIST Test No: 844/123456-95 Use sample report: 35070sdc.1um

Company: Radiometric Systems Inc
Contact: Joe Calibration Phone: 301 123-4567

P.O.#: AB1234 dated January 1, 1995

Test number: 35070S Special Test of Radiation Thermometer

Test item: One Minolta-Land Infrared Thermometer, Model # Cyclops 52, Serial # 0000000
Wavelength = 1000 nm Distance: 100 cm from alignment mark
Target size: 5.6 mm Focus: 1 meterClear and dark lenses (sn L1)

Temperatures measured: 800 EC to 2500 EC
800 EC to 1200 EC with clear filter
1100 EC to 2500 EC with dark filter

Standard(s) used: SL20 (7.7788 A / 2.093 V), (Pcos(2θ)=0.001107, 12/92 TR2 p 123)
Land Cyclops 52 pyrometer, Serial no.: 202681
Thermogage 7000-1 pyrometer, Serial no.: 5127

Temperature: 21 EC " 1 EC Relative humidity: 38% " 5%

Calibration date: 2/16/96 Measurement date(s):2/15-16/96 TR3 p79

Data taking program: C:\programs\Lmpredn\pyro.mak|rtcal.frm 10/9/96
Calibration files: Cal1007.96, Test1007.96 Tgbb1007.96

Data reduction program: Excel 7.0
Data reduction file: Test1096.xls Final data file: Test1096.txt

17. Print out test file for RT check standard
    a. Prepare history file consisting of Microsoft EXCEL spreadsheet with plots of temperature difference from first calibration versus nominal temperature