Identifier: **EP-ERSS-SOP-5131 (was ENV-MAQ-402)**	Revision: **0**	Los Alamos NATIONAL LABORATORY EST. 1943
Effective Date: 3/17/2008		

Environment & Remediation Support Services

Standard Operating Procedure

for **CALIBRATION AND MAINTENANCE OF INSTRUMENTS FOR THE METEOROLOGY MONITORING PROJECT**

APPROVAL SIGNATURES:

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1.0 PURPOSE AND SCOPE

The purpose of this procedure is to describe maintenance and calibration procedures for instruments used in the Meteorology Monitoring Project to measure atmospheric variables, data acquisition systems for these measurements, and equipment necessary to calibrate and maintain these meteorological instruments and systems within the Los Alamos National Laboratory (Laboratory or LANL) Environment & Remediation Support Services (ERSS) Division.

2.0 BACKGROUND AND PRECAUTIONS

2.1 Background

None.

2.2 Precautions

None.

2.3 Definitions

Calibration and Maintenance Form (CMF)

Calibration and maintenance are closely related in this program and are recovered on combined forms for each instrument category. Maintenance work is recorded in the comments section of these forms.

Instrument

An instrument is a measuring device consisting of a sensor and a transducer.

Sensor

A sensor is a sensing element of an instrument that reacts to changes in the environment.

Transducer

A transducer is that portion of an instrument that converts energy generated, through sensing, from one form to another.

3.0 EQUIPMENT AND TOOLS

Equipment and tools for calibration and maintenance of instruments are described in the section for each individual instrument.

4.0 STEP-BY-STEP PROCESS DESCRIPTION

4.1 Instruments for Measuring Wind Variables – Propeller Vane Anemometer

Technician	1.	Read Attachment 1, Propeller Vane Anemometer Description, Specifications, and Common Problems, to become familiar with the instrument.

Technician (Continued)	2.	Compile the following equipment and supplies: • RM Young Model 18112 vane angle calibrator; • Bulls-eye level; • RM Young Model 18310 anemometer torque disk; • RM Young Model 18331 vane bearing torque gauge; • RM Young Model 18801 rotational calibration unit; • 1800 RPM spin motor; and • Campbell Scientific 21 x datalogger.
		Calibration
Technician	3.	Read all the manuals and manufacturer's literature on the instrument and calibration equipment before proceeding.
	4.	Install the propvane to be calibrated on the Model 18112 vane angle calibrator.
	5.	Install the Model 18331 gauge on the propvane per the manufacturer's specifications.
	6.	Place the bulls-eye level on the Model 18331 gauge and adjust the leveling screws on the vane angle calibrator.
	7.	Using the Model 18331 torque gauge, measure the wind vane system torque in four quadrants (room air must be still) by following the steps below: • Place the vane at approximately 90 degrees (as measured by the protractor) and measure the torque in both directions; • Move the vane to 180 degrees and measure again; • Move the vane to 270 degrees and measure again; • Move the vane to 360 degrees and measure again; • Record the instrument serial number and the torque value in the appropriate spaces on CMF1, Instruments for Measuring Wind Variables (see Attachment 21); and • If this torque value is > 20 g-cm, replace the vertical shaft bearings in accordance with the instrument manual.
	8.	Conduct wind speed system torque test by conducting the following steps: • Remove the propeller, and using the Model 18310 torque disk, measure the wind speed system torque in four quadrants in the CCW direction; • Verify the torque test is within the acceptance range of ≤ 0.6 g-cm; • If the torque test result is ≤ 0.6 g-cm, record a check mark (√) in the torque test column of the CMF1; and • If the torque test result is > 0.6 g-cm, record the torque value in the torque test column of the CMF1 (see Attachment 21, CMF1, Instruments for Measuring Wind Variables).

Technician (Continued)

9. Conduct a spin-down bearing test by conducting the following steps:
   - With the torque disk still in place, remove all screws from the disk and secure it to the shaft with a small piece of scotch tape;
   - Couple an 1800 rpm spin motor to the shaft;
   - Spin the assembly CCW to speed; and
   - Remove the spin motor, and record the time required to spin down to a stop on the CMF1.

   [NOTE: Empirical work has shown that a > 60-second spin down test indicates good bearings.]

10. Measure the wind speed transducer output by following the steps below:
    - Couple the Model 18801 rotational calibration unit to the propvane;
    - Connect the 21x datalogger to the pigtail adaptor connected to the propvane;
    - Program the datalogger to measure hertz, and wind direction;
    - Run the Model 18801 unit at the five speeds counterclockwise (CCW) only required on CMF1; and
    - Record the tachometer response as measured by the datalogger on the CMF1.

11. Perform azimuth transducer measurements by doing the following:
    - Ensure datalogger program is correct and 3 second sample time;
    - Monitor the degrees on the datalogger;
    - Rotate the propvane to the five azimuth calibration points as measured by the Model 18112's protractor, in a clockwise (CW) direction;
    - For each calibration point, use the datalogger to measure the azimuth angle value and record this value on the CMF1; and
    - Program the datalogger for 0.5 second sampling time;
    - Sweep the propvane slowly through 360 degrees while monitoring the azimuth angle, as measured by the datalogger;
    - If the azimuth potentiometer is good, record a check mark (√) on the CMF1; and
    - If the azimuth potentiometer is not good, note the problem(s) on the CMF1.

    [NOTE: the angle should increase slowly as the vane is moved. Jumps or other inconsistencies indicate that the azimuth potentiometer has bad or worn spots. Remember that the azimuth potentiometer has a dead band from 355 to 360 degrees.]

Technician (Continued)	12.	File the CMF1 by following the steps below: • Perform post-calibrations on all instruments removed from a tower; • Check the CMF1 postcal. Box and date and sign the form at the top; and • Insert the completed CMF1 in the tower activity log notebook post-calibration section for the tower from which the propvane was removed. [NOTE: Completion of the previous steps, along with a filled out CMF1, constitute a post-calibration (postcal.) of an instrument removed from service (before refurbishment).]

Maintenance

Technician	13.	Initiate a new CMF1 for this refurbished instrument(s).
	14.	Repeat calibration steps 4, 5, and 6 above for calibration of propvanes.
	15.	Install new vertical shaft bearings if they fail the < 20 g-cm torque limit test, as qualified in calibration step 6.
	16.	Install new propvane wind speed input shaft bearings.
	17.	Install a new azimuth potentiometer..
	18.	Repeat calibration steps 6 through 10.
	19.	Perform azimuth transducer calibration by performing the following steps: • Repeat calibration step 11; • Rotate the propvane to 180º azimuth as measured by the Model 18112's protractor; • Per the manual, adjust the azimuth potentiometer to provide 180º as read by the datalogger; • Check the readings at 30º, 90º, 180º, 270º, and 330º as measured by the Model 18112's protractor; • Adjust the azimuth potentiometer to balance the measurement error at these five points, as read by the datalogger [NOTE: This position should be the optimum set point for the azimuth potentiometer], • Tighten the azimuth potentiometer in place with the screw as described in the manual.
	20.	Repeat calibration step 10.
	21.	Balance the vane assembly by following the steps below: • Remove the propvane from the Model 18112; • Hold the propvane horizontally (with a propeller installed) in a room with no air currents [NOTE: There should not be any vane rotation from a horizontal vane position if the assembly is balanced.]; and • If balance adjustment is necessary, remove the propeller and insert (or remove) washers to achieve balance.
	22.	Check (√) the pre-calibration box on the CMF1.

Technician (Continued)	23.	Insert the completed CMF1 in the appropriate tower activity log notebook section for the tower for which that instrument(s) is intended.
	24.	Sign and date the CMF1 at the top indicating the refurbishment date.
	25.	When the instrument(s) is installed on a tower, enter the date, time, and signature.
	26.	Apply a good-quality automotive wax to the propvane and T.F.E. Dry Lube aerosol spray to the propeller and tail to minimize snow and ice accumulation and to protect these surfaces.
	27.	Conduct monthly (within the first week of each month) tower visits to inspect the instrumentation.
	28.	Inspect and replace any broken vanes or propellers.
	29.	Visually note propeller rotation and compare vane position and movement between tower levels.
	30.	Perform these inspections within 3 days following a hailstorm or severe snowstorm.

4.2 Instruments for Measuring Wind Variables – Vertical Wind Anemometer

Technician	1.	Read Attachment 2, Vertical Wind Anemometer Description, Specifications, and Common Problems, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Volt meter; • RM Young Model 18310 anemometer torque disk; • RM Young Model 18801 rotational calibration unit; and • 1800 rpm spin motor.
		Calibration
Technician	3.	Read all the manuals and manufacturer's literature on the instrument and calibration equipment before proceeding.
	4.	Conduct a wind speed system torque test by following the steps below: • Remove the propeller, and carefully place the instrument in a vise and level it; • Using the Model 18310 torque disk, measure the wind speed torque in four quadrants in both directions at each point; • If the test result is ≤ 0.5 g-cm, record a check mark (√) in the torque test column on the CMF2; and • If the test result is > 0.5 g-cm, record the torque value in the torque test column on the CMF2 (see Attachment 22, CMF2, Instruments for Measuring Wind Variables) .

Technician (Continued)	5.	Conduct a spin-down bearing test (to duplicate the wind speed system torque test, but is not sensitive to imbalance) by conducting the following steps: • With the torque disk still in place, couple an 1800-rpm spin motor to the shaft; • Spin the assembly to speed; • Remove the spin motor, and, record the time required to spin down to a stop on the CMF2; and • Spin the instrument down in both directions. [NOTE: Empirical work has shown that a > 55-second spin down test indicates good bearings.]
	6.	Measure the wind speed transducer output by completing the following steps: • Couple the Model 18801 rotational calibration unit to the anemometer; • Connect the voltmeter to the instrument output pins (A & B); • Run the Model 18801 unit at the 3 speeds (both CCW and CW) required on the CMF2; • Record on the CMF2 the tachometer response as measured by the voltmeter. [NOTE: Pin A is positive for a CCW rotation.]
	7.	File the CMF2 by conducting the following steps: • Perform post-calibrations on all instruments removed from a tower; • Check (√) the CMF2 postcal box and sign and date the form at the top; and • Insert the completed CMF2 in the tower activity log notebook post-calibration section for the tower from which the anemometer was removed. [NOTE: Completion of the foregoing steps, along with a filled out CMF2, consistute a post-calibration of an instrument removed from service (before refurbishment).]
		Maintenance
Technician	8.	Initiate a new CMF2 for this refurbished instrument(s).
	9.	Install new anemometer tachometer and input shaft bearings.
	10.	Repeat calibration steps 4 through 6.
	11.	Insert the completed CMF2 in the appropriate tower activity log notebook section for the tower that this instrument(s) is intended. [NOTE: The foregoing steps and the CMF2 filled out are a pre-calibration of an instrument(s) to be installed on a tower as part of the annual meteorological instrumentation calibration cycle.]

Technician (Continued)	12.	Apply a good-quality automotive wax to the painted surfaces of the anemometer and T.F.E. Dry Lube aerosol spray to the polypropylene propeller to minimize snow and ice accumulation and to protect these surfaces.

4.3 Instruments for Measuring Wind Variables - SODAR

Technician	1.	Read Attachment 3, Sound Detection and Ranging Description and Specifications, to become familiar with the instrument.
		Calibration
Technician	2.	Compare the SODAR's measured winds with those from the TA-6 tower measured winds and the PJMT tower.
	3.	Do this Monthly to ensure proper operation of the SODAR.
	4.	If the comparison is not favorable, run the operating system diagnostic to evaluate the transducers and the signal amplifiers.
	5.	If the SODAR still does not seem to be operating properly, consult with Scintec AG.
		Maintenance
Technician	6.	Run the Scintec operating system diagnostic routine monthly.
	7.	If the diagnostic test identifies a failed transducer, replace it.
	8.	When required, use the shop vacuum cleaner that is stored at the TA-6 site to clean the antenna.
	9.	Replace the acoustic foam material when degradation due to exposure to the elements is noticed.

4.4 Instruments for Measuring Atmospheric State Variables – Temperature Instrument/Radiation Shield Assembly

Technician	1.	Read Attachment 4, Temperature Instrument/Radiation Shield Assembly Description and Specifications, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Dewar flask; • Precision glass mercury reference thermometer; • Group of probes to be calibrated; • Resistance meter; and • Voice tape recorder.
		Calibration
Technician	3.	Read all the manuals and manufacturer's literature on the instrument and calibration equipment before proceeding.
	4.	Use a Dewar flask to control heat loss (or gain) and minimize bath temperature gradients. [NOTE: The flask dimensions are such that the sensor probe tips will be at mid-volume when inserted in the flask.]

Technician (Continued)	5.	Fill the flask with an ice/water bath (temperature 0º ± 0.1º C).
	6.	Place the temperature probes in the bath with the reference thermometer.
	7.	Insert the thermometer bulb in the flask to the same depth as the sensor tips.
	8.	After the temperature has stabilized, adjust the temperature by adding warmer or colder water until the desired temperature is reached. [NOTE: If you are using ice and water, no temperature adjustment is needed.]
	9.	When the bath temperature has stabilized, record the temperature of the bath, as measured by the reference thermometer.
	10.	Promptly measure and record the resistance of each probe with the voltage/resistance meter.
	11.	To speed this process, and avoid bath temperature drift, use a voice tape recorder to record the measurements.
	12.	Promptly record the temperature of the bath, as measured by the reference thermometer, at the end of the series of resistance measurements.
	13.	Repeat the series of measurements two (2) more times.
	14.	Transcribe the measurements to CMF3, page 2 (see Attachment 23, CMF3, Temperature Probe Calibration).
	15.	Repeat the measurements two (2) more times using 15º C ± 2.0º C and 30º C ± 2.0º C in place of 0º ± 0.1º C in step 5 above.
	16.	For each of the averaged, reference temperatures, use the transducer data sheet to obtain the resistance vs. temperature function for the temperature probe. [NOTE: The transducer data sheet increments by whole degrees, so it is necessary to do a linear interpolation, by tenths of a degree, between two temperatures which span the reference temperature.]
	17.	Enter the values on the appropriate table of CMF3, page 2.
	18.	Use the average of the three (3) measurements made for each probe at one bath temperature to determine, from the table created in steps 16 and 17, the temperature measured by the probe.
	19.	Transcribe the probe temperature values for each bath to CMF3, page 1.
	20.	For a post-calibration (postcal.), group the probes according to the tower from which the probes were removed and enter the serial numbers in the tower assignment table of CM3, page 1.
	21.	Transcribe the required information to a CMF4 (see Attachment 24, CMF4, Instruments for Measuring Atmospheric State Variables), and then insert this postcal. Form in the appropriate tower activity log section.
	22.	For a precal., group the probes and assign a matched set to one tower and enter the serial numbers in the tower assignment table of CMF3, page 1.

Technician (Continued)	23.	Transcribe the information to a CMF4.
	24.	When the temperature probes are installed on a tower, insert the CMF4 in the appropriate tower activity log section.
	25.	For a pre-cal. Log, enter the installation date, time, and signature.
	26.	Insert the CMF3 in the General Calibration Information notebook, temperature section.
		Maintenance
Technician	27.	Replace all of the tower site aspirator fans at 4-year intervals to ensure reliable operation.
	28.	Apply automotive wax to the painted surfaces, when accessible, for protection and to help reduce ice buildup.
	29.	Replace all the tower site temperature probes at the bi-annual meteorological instrument calibration cycle.

4.5 Instruments for Measuring Atmospheric State Variables – Atmospheric Pressure Instrument

Technician	1.	Read Attachment 5, Atmospheric Pressure Instrument Description and Specifications, to become familiar with the instrument.
		Calibration and Maintenance
Technician	2.	Exchange the pressure instruments annually.
	3.	Maintain an operational spare to minimize the downtime.
	4.	Exchange the tower unit with an operational spare and submit the removed instrument to the Standards and Calibration group for recertification.
	5.	Fill out a CMF4 when a new instrument is installed at a tower site.
	6.	Insert the completed CMF4 into the appropriate section of the tower activity log notebook.

4.6 Instruments for Measuring Atmospheric State Variables – Relative Humidity Instrument

Technician	1.	Read Attachment 6, Relative Humidity Instrument Description and Specifications, to become familiar with the instrument.
		Calibration and Maintenance
Technician	2.	Exchange the RH instruments annually. [NOTE: The instrument operational spares inventory minimizes downtime.]
	3.	Return the old instruments, removed after 1 year of service, to Rotronic Instrument Corporation for recertification.
	4.	Fill out a CMF4 when a new instrument is installed at a tower site.
Technician (Continued)	5.	Insert the completed CMF4 into the appropriate section of the tower activity log notebook.

4.7 Instruments for Measuring Atmospheric State Variables – Fuel Moisture Transducer

Technician	1.	Read Attachment 7, Fuel Moisture Transducer Overview, to become familiar with the instrument.
		Maintenance
Technician	2.	In the spring of the year, remove the fuel moisture stick wood dowel and replace it with a new fuel stick (dowel) for the next season.
	3.	Replace the fuel temperature wood dowel also. [NOTE: These dowels are carefully selected by Cambell Scientific so that further adjustment is not required. The wood dowels provided are totally interchangeable.]
	4.	Make an entry in the tower log notebook citing the following: • the work completed; • a description of any adjustments made; • data editing requirements, • the period for which the edits are required, and • any other pertinent information.
	5.	Sign and date the entry.

4.8 Instruments for Measuring Precipitation-Related Variables – Heated Tipping-Bucket Precipitation Gauge

Technician	1.	Read Attachment 8, Heated Tipping-Bucket Precipitation Gauge Description and Specifications, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Pipette, 10 ml; • Purified water; • Duster and a small stiff-bristled cleaning brush; • Alcohol; and • Kimwipes™
		Calibration
Technician	3.	Use a pipette to slowly drop 8.0 ml of water into the collecting funnel. [NOTE: This amount corresponds to 0.01 in. of precipitation.]
	4.	Repeat step 3 at least three (3) more times to thoroughly cycle the mechanism.
	5.	Record the as-is status of the gauge on CMF5 (see Attachment 25, CMF5, Instruments for Measuring Precipitation-Related Variables).
	6.	Open the mechanism to clean and examine.
	7.	Dust out as required.
Technician	8.	Clean the buckets with alcohol and a brush to remove the dissolved solids.

(Continued)	9.	Check the leveling indicator on the bottom to verify that the gauge is level, and adjust if necessary.
	10.	Check proper operation of the AC power source, thermostat, and heaters using a voltage and resistance meter.
	11.	Check heater circuit continuity and the 120V AC power outlet within the gauge by advancing the thermostat until it actuates.
	12.	Reset the thermostat to the normal operating temperature when the test is complete.
	13.	Repeat steps 3 and 4 to verify proper calibration.
	14.	If not within calibration specifications, follow the calibration procedure provided in the gauge manual.
	15.	Fill out CMF5 as required for this procedure.
	16.	Insert the completed CMF5 in the appropriate section of the tower activity log notebook or rain gauges notebook for rain gauges not associated with a tower.

4.9 Instruments for Measuring Precipitation-Related Variables – Snow Depth Gauge

Technician	1.	Read Attachment 9, Snow Depth Gauge Description and Specifications, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Carpenter’s level; • Measuring tape; • Cardboard box (approximately 12” x 12” x 18”); • Desiccant pack (replaced annually); and • Tool for cutting small area of tall grass.
		Calibration and Maintenance
Technician	3.	Read the manual and manufacturer’s literature on the SR50 before proceeding
	4.	Use a carpenter’s level to check the snow gauge plumb.
	5.	With no snow on the ground, check the datalogger output. [NOTE: The reading should be zero ± 0.4”.]
	6.	To adjust the zero value, change the offset in the datalogger program.
	7.	Place a cardboard box on the ground under the SR50 gauge and read the measurement from the datalogger. [NOTE: The measurement should equal the box height ± 0.4”.]
	8.	Replace the desiccant packet within the SR50 at the bi-annual meteorological instrumentation calibration cycle.
	9.	Fill out CMF5 as required for this procedure.

Technician (Continued)	10.	If the SR50 fails the calibration, return it to the manufacturer for repair. [NOTE: There are no SR50 adjustments which the user can make.]
	11.	Insert the CMF5 in the appropriate section of the tower activity log notebook.
	12.	Late in the fall, cut the grass very closely to the ground in a 36" diameter circle beneath the SR50. [NOTE: The SR50 will measure the height of the grass.]
4.10		**Instruments for Measuring Precipitation-Related Variables – Lightning Detector**
Technician	1.	Read Attachment 10, Lightning Detector Description and Specifications, to become familiar with the instrument.
		Calibration and Maintenance
Technician	2.	Read the manual and manufacturer's literature on this instrument before proceeding.
	3.	Set the detector range to position C, which is probably a 5- to 10-mile detection range. [NOTE: The detector range is the only calibration required. Once set, this should not require further adjustment.]
	4.	Test the detector by removing the P-10 plastic cover, and touching the brass plate on top of the M-10 with one hand and flicking the other hand quickly over the top of the M-10 viewing lens. [NOTE: The fingers of the moving hand should be splayed to provide quickly varying light flashes to the M-10. The M-10 will "beep" if it accepts this test, indicating proper operation.]
	5.	Maintain the detector by applying a coat of wax to the P-10 plastic cover twice a year.
	6.	Fill out CMF5 as required by this procedure.
	7.	Insert the completed CMF5 in the appropriate section of the tower activity log notebook.
4.11		**Instruments for Measuring Radiative Fluxes - Pyranometer**
Technician	1.	Read Attachment 11, Pyranometer Description and Specifications, to become familiar with the instrument.
		Calibration and Maintenance
Technician	2.	To recertify the instrument, do the following: • Return the instrument to the manufacturer periodically for recertification; (Approximately 5 years) OR • Evaluate the instrument's performance by collocation with a recently manufacturer-recertified unit.

Technician (Continued)	3.	If the instruments are going to be returned to the manufacturer for recertification, exchange the existing instrument at a tower with a newly-recertified unit until all of the instruments have been manufacturer-recertified.
	4.	For instrument verification by collocation, return an operational spare instrument to the factory for recertification.
	5.	Collocate the reference or standard instrument with the instrument at each tower site.
	6.	Compare the output of this standard with the recorded output of the tower site instrument.
	7.	If necessary, adjust the datalogger multiplier to compensate for aging of the tower site instrument.
	8.	Clean the optical dome during the first week of each month.
	9.	When a new pyranometer is installed, change the datalogger input program multiplier to match the new pyranometer.
	10.	Fill out a CMF6 (see Attachment 26, CMF6, Instruments for Measuring Radiative Flux Variables) when any calibration work is completed at a tower site.
	11.	Insert the completed CMF6 in the appropriate section of the tower activity notebook.
4.12	**Instruments for Measuring Radiative Fluxes - Pyrgeometer**	
Technician	1.	Read Attachment 12, Pyrgeometer Description and Specifications, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Lithium battery number CR123.
		Calibration and Maintenance
Technician	3.	To recertify the instrument, do the following: • Return the instrument to the manufacturer periodically (Approximately 5 years) for recertification; OR • Evaluate the instrument's performance by collocation with a recently manufacturer-recertified unit.
	4.	If the instruments are going to be returned to the manufacturer for recertification, exchange the existing instrument at a tower with a newly-recertified unit until all of the instruments have been manufacturer-recertified.
	5.	For instrument verification by collocation, return an operational spare instrument to the factory for recertification.
	6.	Collocate the reference or standard instrument with the instrument at each tower site.

	7.	Compare the output of this standard with the recorded output of the tower site instrument.
Technician (Continued)	8.	Adjust the datalogger multiplier to compensate for aging of the tower site instrument, if necessary.
	9.	Clean the optical dome during the first week of each month.
	10.	Change the datalogger input program multiplier to match the new pyrgeometer, when a new pyrgeometer is installed.
	11.	If data QA indicates that a battery is failing, replace the battery.
	12.	Fill out a CMF6 when any calibration work is completed at a tower site.
	13.	Insert the completed CMF6 in the appropriate section of the tower activity log notebook.
4.13	**Instruments for Measuring Subsurface Variables – Soil Temperature Probe**	
Technician	1.	Read Attachment 13, Soil Temperature Probe Description and Specifications, to become familiar with the instrument.
	2.	Refer to Section 4.4, Instruments For Measuring Atmospheric State Variables - Temperature Instrument/Radiation Shield Assembly, for the equipment and supplies needed to perform the calibration.
	3.	Refer to Section 4.4, Instruments For Measuring Atmospheric State Variables - Temperature Instrument/Radiation Shield Assembly, process used to perform the calibration.
4.14	**Instruments for Measuring Subsurface Variables – Soil Moisture Instrument**	
Technician	1.	Read Attachment 14, Soil Moisture Instrument Description and Specifications, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • Large beaker approximately 3-inch inside diameter by 16-inches deep; and • 21X datalogger programmed to accept the CS615 instruments signal.
		Calibration and Maintenance
Technician	3.	Ensure the probe rods are straight and parallel during installation in the ground.
	4.	If the weekly data QA check indicates the instrument is not performing properly, remove the instrument and install a new one.
	5.	To verify operational capability program the 21X datalogger in accordance with the CS615 manual.
	6.	Connect the CS615 to be evaluated to the datalogger per the CS615 manual.
	7.	Fill the beaker with water.

	8.	Hold the CS615 in the air and note the reading from the datalogger. [NOTE: For a good CS615, the reading should be about 2%.]
Technician (Continued)	9.	Suspend the CS615 in the center of the beaker with the probe rods totally immersed in the water. [NOTE: For a good CS615, the reading should be about 80%.]

4.15 Data Acquisition Systems

Technician	1.	Read Attachment 15, Data Acquisition Systems Description and Specifications, to become familiar with the instrument.

4.16 Test Equipment Used in Calibrating Meteorological Instruments – Voltage and Resistance Meter

Technician	1.	Read Attachment 16, Voltage and Resistance Meter Description and Specifications, to become familiar with the instrument.
	2.	To calibrate the voltage and resistance meter, return the instrument to the LANL Standards and Calibration group. [NOTE: The calibration cycle is established and controlled by this group. This group provides calibration services and maintains the records on the calibration.]
LANL Standards and Calibration Group	3.	Attach a sticker to the instrument indicating the calibration expiration date.
	4.	Send a sheet detailing the calibration specifications.

4.17 Test Equipment Used in Calibrating Meteorological Instruments – Precision Mercury Thermometer

Technician	1.	Read Attachment 17, Precision Mercury Thermometer Description and Specifications, to become familiar with the instrument.
	2.	To calibrate the voltage and resistance meter, return the instrument to the LANL Standards and Calibration group. [NOTE: The calibration cycle is established and controlled by this group. This group provides calibration services and maintains the records on the calibration.]
LANL Standards and Calibration Group	3.	Attach a sticker to the instrument indicating the calibration expiration date.
	4.	Send a sheet detailing the calibration specifications.

4.18 Test Equipment Used in Calibrating Meteorological Instruments – Propeller Anemometer Wind Speed Calibrators

Technician	1.	Read Attachment 18, Propeller Anemometer Wind Speed Calibrators Description, to become familiar with the instrument.
	2.	To calibrate the voltage and resistance meter, return the instrument to the LANL Standards and Calibration group. [NOTE: The calibration cycle is established and controlled by this group. This group provides calibration services and maintains the records on the calibration.]
LANL Standards and Calibration Group	3.	Attach a sticker to the instrument indicating the calibration expiration date.
	4.	Send a sheet detailing the calibration specifications.

Technician (Continued)	2.	To calibrate the voltage and resistance meter, return the instrument to the LANL Standards and Calibration group. [NOTE: The calibration cycle is established and controlled by this group. This group provides calibration services and maintains the records on the calibration.]

4.19 Test Equipment Used in Calibrating Meteorological Instruments – Propeller Anemometer Vane Angle Calibrator

Technician	1.	Read Attachment 19, Propeller Anemometer Vane Angle Calibrator Description, to become familiar with the instrument.

4.20 Test Equipment Used in Calibrating Meteorological Instruments – Propvane Azimuthal Siting Scope

Technician	1.	Read Attachment 20, Propvane Azimuthal Siting Scope Description, to become familiar with the instrument.
	2.	Compile the following equipment and supplies: • An open area with a good distant landmark, such as at the TA-6 tower site and the distant TA-55 radio tower; • A low table, like the old typewriter table found in the TA-6 instrument shed; • The RM Young Model 18112 vane angle calibrator; • A surveyor's transit and tripod; • A carpenter's level and bull's-eye level; and • Miscellaneous hand tools.
		Calibration
Technician	3.	Mount a propvane on the model 18112 and set and lock the propvane to zero degrees (north) as read on the model 18112 protractor. Set this assembly on a low table (about 24" tall) outside in an open area such as at the TA-6 tower site. Carefully level the table and propvane to ensure that the propvane is plumb.
	4.	Visually align the propvane on a distant object by sighting along the vane to the landmark (the TA-55 radio tower in this test at TA-6).

5.	With the surveyor's transit, check the propvane alignment on the distant landmark. Set the transit up on a line formed by the propvane/landmark, about 20 feet behind the propvane. Take care to properly locate the transit on this “line,” it will be necessary to set up the transit, do a sighting, move and reset the transit, re-sight, etc. With the surveyor's transit, check the propvane alignment on the distant landmark. Set the transit up on a line formed by the propvane/landmark, about 20 feet behind the propvane. Take care to properly locate the transit on this “line,” it will be necessary to set up the transit, do a sighting, move and reset the transit, re-sight, etc.
6.	Once Step 5 is successfully completed, the transit can be “dumped” to sight along the length of the propvane and then on to the distant landmark. The transit provides verification that the propvane (which is set to zero degrees on the model 18112 protractor) is correctly aligned with the landmark.
7.	Set and lock the az-scope to zero degrees as read on the az-scope's transit. Without physically disturbing any part of the setup, remove the propvane from the model 18112 and install the az-scope.
8.	Check that the az-scope is properly calibrated. If it is, then the landmark will be viewed when a sighting is taken through the az-scope. The az-scope cross-hairs will be centered on the landmark
9.	If Step 8 proves that the az-scope is out of calibration, then loosen the az-scope's lock nuts which attach the transit top to the base unit. Adjust the az-scope by rotating the transit top with respect to the base until the az-scope crosshairs center on the landmark. Tighten the loosened lock nuts and verify that the az-scope is still in proper adjustment.
10	This is a tedious process. Take care to not disturb the model 18112 or the table upon which it rests.

4.21 Records

Technician 1. Maintain the following records generated from this procedure in the meteorological calibration Lab.

- Completed CMF1, Instruments for Measuring Wind Variables;
- Completed CMF2, Instruments for Measuring Wind Variables;
- Completed CMF3, Temperature Probe Calibration;
- Completed CMF4, Instruments for Measuring Atmospheric State Variables;
- Completed CMF5, Instruments for Measuring Precipitation-Related Variables;
- Completed CMF6, Instruments for Measuring Radiative Flux Variables; and
- Completed CMF7, Instruments for Measuring Subsurface Variables.

5.0 PROCESS FLOW CHART

Flow chart is to be included at a later date.

6.0 ATTACHMENTS

Attachment 1 5131-1 Propeller Vane Anemometer Description, Specifications, and Common Problems (1 page)

Attachment 2 5131-2 Vertical Wind Anemometer Description, Specifications, and Common Problems (1 page)

Attachment 3 5131-3 Sound Detection and Ranging (SODAR) Description and Specifications (1 page)

Attachment 4 5131-4 Temperature Instrument/Radiation Shield Assembly Description and Specifications (1 page)

Attachment 5 5131-5 Atmospheric Pressure Instrument Description and Specifications (1 page)

Attachment 6 5131-6 Relative Humidity Instrument Description and Specifications (1 page)

Attachment 7 5131-7 Fuel Moisture Transducer Overview (1 page)

Attachment 8 5131-8 Heated Tipping-Bucket Precipitation Gauge Description and Specifications (1 page)

Attachment 9 5131-9 Snow Depth Gauge Description and Specifications (1 page)

Attachment 10 5131-10 Lightning Detector Description and Specifications (1 page)

Attachment 11 5131-11 Pyranometer Description and Specifications (1 page)

Attachment 12 5131-12 Pyrgeometer Description and Specifications (1 page)

Attachment 13 5131-13 Soil Temperature Probe Description and Specifications (1 page)

Attachment 14 5131-14 Soil Moisture Instrument Description and Specifications (1 page)

Attachment 15 5131-15 Data Acquisition Systems Description and Specifications (1 page)

Attachment 16 5131-16 Voltage and Resistance Meter Description and Specifications (1 page)

Attachment 17 5131-17 Precision Mercury Thermometer Description and Specifications (1 page)

Attachment 18 5131-18 Propeller Anemometer Wind Speed Calibrator Description (½ page)

Attachment 19 5131-19 Propeller Anemometer Vane Angle Calibrator Description (½ page)

Attachment 20 5131-20 Propvane Azimuthal Siting Scope Description (1 page)

Attachment 21 5131-21 CMF1, Instruments for Measuring Wind Variables (2 pages)

Attachment 22 5131-22 CMF2, Instruments for Measuring Wind Variables (1 page)

Attachment 23 5131-23 CMF3, Temperature Probe Calibration (3 pages)

Attachment 24 5131-24 CMF4, Instruments for Measuring Atmospheric State Variables (2 pages)

Attachment 25 5131-25 CMF5, Instruments for Measuring Precipitation-Related Variables (2 pages)

Attachment 26 5131-26 CMF6, Instruments for Measuring Radiative Flux Variables (1 page)

Attachment 27 5131-27 CMF7, Instruments for Measuring Subsurface Variables (2 pages)

7.0 REVISION HISTORY

Author: Paul Ortega

Revision No. *[Enter current revision number, beginning with Rev.0]*	Effective Date *[DCC inserts effective date for revision]*	Description of Changes *[List specific changes made since the previous revision]*	Type of Change *[Technical (T) or Editorial (E)]*
0	10/04/96	New Document	T
1	03/99	Reformatted in accordance with LIR 300-00-01, Safe Work Practices	E
2	04/01	Added new Section 9.0, Training	T
3	04/02	Change in Directorate	E
4	04/03	Team name change to Environmental Surveillance	E
5	05/12/04	Updated and reformatted document to conform with MAQ procedures	E

Revision No. *[Enter current revision number, beginning with Rev.0]*	Effective Date *[DCC inserts effective date for revision]*	Description of Changes *[List specific changes made since the previous revision]*	Type of Change *[Technical (T) or Editorial (E)]*
6	05/31/05	Quick change revision to convert HCP to HR, remove chain-of-custody form, and refer to new chain-of-custody procedure	T
0	3/17/2008	Replaced: ENV- MAQ-402, R6,. Removed sections relating to instruments no longer used. Changed methods of calibration using modern test equipment. Modified calibration methods to use calibrated datalogger as a measuring device.	T

Using a CRYPTOCard, click here to record "self-study" training to this procedure.

If you do not possess a CRYPTOCard or encounter problems, contact the ERSS training specialist.

ATTACHMENT 1: PROPELLER VANE ANEMOMETER DESCRIPTION, SPECIFICATIONS, AND COMMON PROBLEMS

5131-1

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Propeller Vane Anemometer Description, Specifications, and Common Problems

Instrument Description

The propeller vanes (propvanes) model 05305 (AQ) is manufactured by the RM Young Co. The wind speed sensor is a 4-blade helicoid propeller and has a 30-cm pitch. The propeller is 20 cm for carbon fiber propellers. The wind direction sensor is a 12 x 25 cm fin mounted on a 42-cm-long horizontal shaft as measured from the instrument pivot axis to the center of the fin. The AQ wind direction sensors has a damping ratio of 0.45 and the damped natural wavelength of 4.9 m. The threshold sensitivity for 10º displacement is 0.5 m/s.

The wind speed transducer is an AC tachometer to which the propeller is coupled. The sine wave signal is induced in a pickup coil by rotating a magnet on the propeller shaft. The output frequency is 3 cycles per propeller revolution. This AC signal, the frequency of which is proportional to the wind speed, is translated in the data logger to wind speed. The wind direction transducer is a precision potentiometer that is coupled to the vane axis shaft. The variable resistance signal, that is proportional to wind direction, is translated in the datalogger to wind direction.

Specifications

Wind Speed

Range: AQ, 0 to 40 m/s (90 mph)

Threshold Sensitivity: 0.4 m/s

Accuracy: ±0.3 m/s (± 3 Hz)

Wind Direction

Range: 1º to 355º

Sensitivity: 28 ohms/degree

Accuracy: ± 3.0º (angle) from 10º to 350º

Speed Parameter:

Threshold: 0.4 m/s

Distance-Constant: 2.1 m

Common Problems

These are mechanical devices, and a partial bearing failure means increased friction, which results in an increased wind speed threshold or a sluggish azimuth response.

In addition, the anemometer propellers and vanes are susceptible to hail damage and to damage from falling clumps of snow which accumulate on the tower during winter storms.

ATTACHMENT 2: VERTICAL WIND ANEMOMETER DESCRIPTION, SPECIFICATIONS, AND COMMON PROBLEMS

5131-2

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Vertical Wind Anemometer Description, Specifications, and Common Problems

Instrument Description

Measurement of the vertical component of the wind is done with the RM Young model 27106 anemometer. This anemometer is mounted vertically and the sensor is a 30-cm-pitch 4-blade helicoid propeller. The propeller diameter is 22 cm for Carbon Fiber Thermoplastic (CFT).

The propeller responds only to that component of the wind that is parallel to its axis. Propeller response as a function of its orientation to the wind closely approximates the cosine law. When the wind is exactly perpendicular to the axis of the propeller (a horizontal wind), rotation stops. The output signal is positive (cw-updraft) or negative (ccw-downdraft), depending on the direction of the vertical wind component. Multiplying the signal by 1.25 to correct for most of the non-cosine response of the propeller obtains a better estimate of the vertical wind. With this correction, which is executed in the datalogger, good estimates are obtained for flow within ± 30 degrees from the horizontal, a condition satisfied most of the time.

The propellers are installed with propeller extensions to improve the response of the instrument at low wind speeds. The extension is 3 inches long and has the same diameter as the front section of the instrument to provide a physical configuration which is symmetrical on each side of the propeller.

The anemometer's transducer is a dc tachometer to which the propeller is coupled. All anemometers use carbon fiber propellers.

Specifications

Range: ± 22 m/s

Sensitivity: 8.8 m/s = 1800 rpm = 500 mV

Accuracy: ± 0.04 m/s (± 2.5 mV)

Speed Parameter: CFT Propeller

Threshold: 0.1 to 0.2 m/s

Distance-Constant: 1.0 m

Common Problems

The most common problem with this instrument is partial or complete bearing failure. A partial bearing failure means increased friction, which results in reduced signal output for vertical wind speed.

In winter, the anemometer propellers at tower level 1 are susceptible to hail damage and to damage from falling clumps of snow which accumulate on the tower during winter storms and hail storms.

ATTACHMENT 3: SOUND DETECTION AND RANGING (SODAR) DESCRIPTION AND SPECIFICATIONS

5131-3

Records Use only

Sound Detection and Ranging (SODAR) Description and Specifications

Instrument Description

The model XFAS52 Doppler acoustic sounder, or SODAR, is manufactured by Scintec AG. The SFAS52 specification states that it will measure winds from the lowest height of 20 m to a maximum of 2,000-5,000 m AGL (above ground level) by transmitting sound pulses and measuring the wind induced Doppler shift of the returned sound energy. It provides measurements of horizontal wind speed and direction, vertical speed, and standard deviation of a maximum of 256 vertical layers. The layers may be from 20-500 m thick. We have configured the SODAR to measure at 40-meter intervals from 100 m to approximately 2,000 meters.

The SODAR is permanently installed at the TA-6 meteorology tower site. The system consists of the signal processing unit (SPU), a large transmit/receive phased array antenna, antenna heater system with a power supply, acoustic barrier for the antenna. There is a computer at the TA-6 site that can be used for diagnostics and a laptop can also be used to connect to the SODAR.

The SODAR has a myriad of operating parameters that the user can adjust to provide optimal SODAR operation at a particular site – please refer to the operator's manual for a complete description of the various parameters.

Specifications

Range (height):	20 to 2000 (-5000) m
Range (horizontal speed):	0 to 50 m/s
Range (vertical speed):	± 10 m/s
Range (wind direction):	0 to 359 degrees
Accuracy (horizontal):	± 0.3 m/s
Accuracy (vertical):	± 0.1 m/s
Accuracy (wind direction):	± 3 degrees

ATTACHMENT 4: TEMPERATURE INSTRUMENT/RADIATION SHIELD ASSEMBLY DESCRIPTION AND SPECIFICATIONS

5131-4

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Temperature Instrument/Radiation Shield Assembly Description and Specifications

Instrument Description

The Met One, Inc. temperature measurement assembly consist of two parts:

* Model 076 solar radiation shield; and
* Model 060A-2 thermistor temperature instrument (also probe).

The Model 076 solar radiation shield is mounted vertically, drawing air in from the bottom and exhausting the air at the top. The top portion is a metal shield that is shaped and acts like an umbrella. This structure provides the mounting hardware and houses the aspirator fan. Beneath the top portion is the thermistor probe housing, which is formed by concentric metal tubes through which the aspirator draws air. The space between the two tubes is a path for high-volume "wash" air that dissipates heat caused by solar energy deposited on the surface of the outer metal tube. The thermistor is mounted within the inner tube, which has a restricted air flow (to ensure the high-volume wash air).

The vertical alignment of this assembly obviates a problem found with horizontal radiation shield designs, which are sensitive to wind direction. A wind which bucks the wash air flow will cause the temperature sensor to respond to solar heating of the radiation shield. The powered aspirator fan is much better than naturally aspirated solar radiation shields, which can overheat on calm sunny days.

The datalogger provides the excitation for the thermister probes and records the measurements through a precision resistor network for each probe. The probes are excited only momentarily for measurements.

Specifications

Range:	- 50º C to + 50º C
Sensitivity:	5.6 mV/º C
Accuracy:	± 0.2º C
Resolution:	± 0.1º C

ATTACHMENT 5: ATMOSPHERIC PRESSURE INSTRUMENT DESCRIPTION AND SPECIFICATIONS

5131-5

Records Use only

Atmospheric Pressure Instrument Description and Specifications

Instrument Description

The Setra Systems, Inc., Model 270 pressure instrument uses a variable capacitance ceramic sensor in the form of a capsule with gold electrodes on the inside surfaces and high vacuum internal reference. The package includes interface electronics to provide high sensitivity, which eases interfacing.

Specifications

Range:	600 to 1,100 millibars (mbar)
Sensitivity:	10 mV/mbar
Accuracy:	± 0.3 mbar, over 6 months
Resolution:	0.01% full-scale range (limited by noise)

ATTACHMENT 6: RELATIVE HUMIDITY INSTRUMENT DESCRIPTION AND SPECIFICATIONS

5131-6

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Relative Humidity Instrument Description and Specifications

Instrument Description

The Rotronic Instrument corp. Model MP100 relative humidity (RH) instrument contains a hygroscopic variable capacitance sensor with an electronic interface which provides the linear high-level output.

Specifications

Range:	0 to 100% RH
Sensitivity:	10 mV/% RH
Accuracy:	< ± 1.5% RH @ 0-100 %RH,
Note: %RH Accuracy valid at 25 degrees Celsius in reference to NBS standards. Add 1%RH over full temperature range	
Resolution:	< ± 0.5 % RH

ATTACHMENT 7: FUEL MOISTURE TRANSDUCER OVERVIEW

5131-7 **Fuel Moisture Transducer Overview**	Records Use only Los Alamos NATIONAL LABORATORY EST. 1943

Overview

The fuel moisture transducer is installed at TA-6 and is on a separate datalogger. The Campbell Scientific Model CS205 fueld moisture stick is refurbished annually by the installation of a new wood dowel. Associated with the fuel moisture stick is a fuel temperature stick which consists of a Campbell Scientific Model 107 temperature probe installed within another dowel.

ATTACHMENT 8: HEATED TIPPING-BUCKET PRECIPITATION GAUGE DESCRIPTION AND SPECIFICATIONS

5131-8

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Heated Tipping-Bucket Precipitation Gauge Description and Specifications

Instrument Description

Precipitation measurements are made with the Weathermeasure Model 6010 electrically-heated tipping-bucket precipitation gauge. This gauge has a thermostatically controlled electric heater in the collection funnel that melts frozen precipitation, resulting in an actual water-content measurement. Rain measurements do not require the heater system. The measurement device is a teeter totter mechanism that tips with each one-hundredth of an inch of precipitation collected. A bucket tipping causes a momentary switch closure that is counted by the datalogger, resulting in a totaling of precipitation for the data-output period of 15 minutes.

The gauges are installed with wind screens, which still the air flow over the top of the gauge. A bare rain gauge (i.e., without a wind screen) is expected to underestimate precipitation by 25%. The tipping-bucket gauge selection was made after comparisons with weighing buckets in several locations. The often-slight amounts of precipitation of this semiarid climate promoted the selection of the tipping-bucket because of its better resolution.

The Weathermeasure Model 6010 precipitation gauge is cleaned, inspected, and calibrated every 6 months. This interval is chosen not so much because the mechanism needs adjustment, but because it needs cleaning. Bugs, dirt, and dissolved solids precipitate out onto the tipping-buckets and can imbalance the system.

Specifications

Range:	Unlimited
Sensitivity:	1 tip/0.01 inch
Accuracy:	0.5% at 0.5 inch/hour
Resolution:	0.01 inch

ATTACHMENT 9: SNOW DEPTH GAUGE DESCRIPTION AND SPECIFICATIONS

5131-9

Snow Depth Gauge Description and Specifications

Records Use only

Los Alamos NATIONAL LABORATORY EST.1943

Instrument Description

The SR50 snow depth gauge is manufactured by Campbell Scientific, Inc. The gauge is used in conjunction with a Campbell Scientific 21X datalogger to provide continuous measurement of snow on the ground. The data logger controls the operation of the SR50 gauge and loges the data as specified by the user.

The gauge installed at TA-6 is suspended from a boom attached to an 8-foot high tower section embedded in the ground. The gauge is 83.4 inches above the ground. The datalogger is programmed to record this distance as zero. Any decrease in this distance is snow on the ground recorded in inches.

Specifications

Range:	2 feet to 33 feet (as installed, 0” to 60”)
Accuracy:	± 0.4 inch
Resolution:	± 0.2 inch

ATTACHMENT 10: LIGHTNING DETECTOR DESCRIPTION AND SPECIFICATIONS

5131-10

Lightning Detector Description and Specifications

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Instrument Description

The M-10/P-10 lightning detector, manufactured by Airborne Research Associates, detects cloud-to-cloud and cloud-to-ground lightning. The M-10 operation switch is set to require coincidence of an optical flash and electric field change (RF). The detector has a range adjustment to limit the detection distance. This range adjustment is not quantified because the actual detection distance depends upon siting and strength of the lightning flash or strike. The only other adjustment is the volume control for an audible warning.

The M-10 response time is such that it detects the individual strokes in what would be called a single lightning strike. Therefore, the lightning strike count recorded by the data logger will be inflated. At this point, the major interest is in daily lightning occurrence at Los Alamos.

Specifications

Range (minimum):	0 to approximately 3 miles (min. range position)
Range (maximum):	0 to approximately 30 miles (max. range position)
Range as used at LANL:	Detuned to limit detection to the local area.
Detection Mode:	Both (optical & RF)

ATTACHMENT 11: PYRANOMETER DESCRIPTION AND SPECIFICATIONS

5131-11 — Records Use only

Pyranometer Description and Specifications

Instrument Description

The Eppley Laboratory, Inc. Model 8-48 pyranometer is used to measure shortwave visible radiation. These pyranometers are installed upward-facing to measure incoming shortwave visible radiation and downward-facing to measure reflected shortwave visible radiation from the ground. The pyranometers measure total solar radiation (direct and diffuse) falling on a flat horizontal plane. The optical glass window passes energy to the sensor from 0.285 to 2.8 microns.

Specifications

Range:	0 to 1400 W/m^2
Sensitivity*:	Approximately 10 µV/W/ m^2
Accuracy:	Cosine response, ± 3.5% from normalization (0º - 70º zenith angle) and ± 6.5% (70º - 80º zenith angle). This accuracy accounts for temperature dependence.

* The value shown for sensitivity is typical, but each pyranometer has its own sensitivity value, determined by the manufacturer’s calibration, which is programmed into the datalogger as a calibration value.

ATTACHMENT 12: PYRGEOMETER DESCRIPTION AND SPECIFICATIONS

5131-12

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Pyrgeometer Description and Specifications

Instrument Description

The Eppley Laboratory, Inc. Model PIR (precision infrared radiometer) pyrgeometer is used to measure long-wave radiation. Pyreometers are installed upward-facing to measure incoming infrared radiation and downward-facing to measure outgoing infrared radiation. The pyrgeometers are temperature compensated internally. The silicon window passes energy to the sensor from 4 to 50 microns.

Specifications

Range:	0 to 700 W/m^2
Sensitivity*:	Approximately 4 μV/W/ m^2
Accuracy:	Cosine response, better than 6% from normalization.
Resolution:	This accuracy accounts for temperature dependence.

* The value shown for sensitivity is typical, but each pyrgeometer has its own sensitivity value, determined by the manufacturer's calibration, which is programmed into the datalogger as a calibration value.

ATTACHMENT 13: SOIL TEMPERATURE PROBE DESCRIPTION AND SPECIFICATIONS

5131-13 **Soil Temperature Probe Description and Specifications**	Records Use only Los Alamos NATIONAL LABORATORY EST. 1943

Instrument Description

The soil temperature probe provided by Met One, Inc. is the Model P8788 thermistor temperature probe. The instrument contains the same thermistor provided in the air temperature probe described in Attachment 4. The P8788 is a special order probe with a minimal thermal mass housing

Specifications

Range:	- 50 to + 50º C
Sensitivity:	5.60 mV/º C
Accuracy:	± 0.2º C
Resolution:	± 0.1º C

ATTACHMENT 14: SOIL MOISTURE INSTRUMENT DESCRIPTION AND SPECIFICATIONS

5131-14

Soil Moisture Instrument Description and Specifications

Records Use only

Instrument Description

The CS615 manual attempts to define and evaluate all of the variables that control the range, resolution, and accuracy of the measurement. The added expense, which would be required to achieve the optimal performance, is not necessary for this subsurface measurement program. We are primarily interested in calculating the energy storage term for the layer of soil above the ground flux heat plates.

To properly measure soil moisture, it would require deploying many CS615s spread over a large area at the TA-6 and TA-54 sites. Because of the cost, we have not deployed an array of these devices but we do provide the single-point measurement data for those who might find it useful.

Specifications

Range:	Approximately 0 to 50%
Accuracy:	> ± 2% for LANL application.

ATTACHMENT 15: DATA ACQUISITION SYSTEMS DESCRIPTION AND SPECIFICATIONS

5131-15

Data Acquisition Systems Description and Specifications

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Instrument Description

The Campbell Scientific, Inc. datalogger (Model 7X and 21X) design is such that one of the first operations performed is an analog-to-digital (A/D) conversion. Thereafter, all signal processing is digital and does not require adjustment. The dataloggers are so stable that it has not been necessary to adjust the A/D calibration for any dataloggers used for this network. Dataloggers are sent back to the manufacturer on an every two-year cycle for calibration. The laptop computer is used at the TA-6 site for SODAR maintenance work and diagnostics. A PC at TA-59 communicates with the SODAR via RF modems. The SODAR must be in continuous communication with this PC, which is running the SODAR's operating system. This PC collects the data and creates the data files.

The tower dial-up computer at TA-59 is a PC that runs the Campbell Scientific, Inc. software (PC208W) for data collection. The software calls the tower dataloggers every 15 minutes, collects the data, and writes the collected data to the appropriate tower file. When data collection is complete, the dial-up PC then FTPs the data as required.

The dataloggers store the meteorological data in ring memory, which means that as the memory is filled, the oldest data are overwritten by the newest data. There are six days worth of data within this memory. In the event of power, telephone, or computer failures, the data are automatically recovered from the datalogger by TELCOM when service is restored. If the outage were to go beyond the ring data storage of the datalogger, it would be necessary to retrieve the data from the affected tower manually with a solid state storage module.

Specifications

Voltage measurement accuracy: ± 0.02% of full-scale range (FSR) from -25º C to +5º C and ± 0.01% of FSR from 0º C to +40º C. Input noise: 7X is 43 nanovolts rms and 21X is 100 nanovolts rms.

Range (volts)	7X Resolution (microvolts)	21X Resolution (microvolts)
± 5.000	166.0	333.0
± 1.500	50.0	N/A
± 0.500	16.6	33.3
± 0.150	5.0	N/A
± 0.050	1.66	3.33
± 0.015	0.5	N/A

ATTACHMENT 16: VOLTAGE AND RESISTANCE METER DESCRIPTION AND SPECIFICATIONS

5131-16

Records Use only

Voltage and Resistance Meter Description and Specifications

Instrument Description

Voltage and resistance measurements are necessary to calibrate the various meteorological instruments. The voltage and resistance meter must provide 4 ½ digit resolution with accuracy that is better than sensor requirements.

Specifications

DC voltmeter accuracy:	± (0.05% + 1)
Ohmmeter accuracy:	± (0.2% + 1)

ATTACHMENT 17: PRECISION MERCURY THERMOMETER DESCRIPTION AND SPECIFICATIONS

5131-17 | Records Use only

Precision Mercury Thermometer Description and Specifications

Instrument Description

Use this mercury-in-glass thermometer as a transfer standard to calibrate the meteorological temperature sensors. The thermometer model ASTM 63C is manufactured by Ertco.

Specifications

Range:	- 8º C to + 32º C
Division:	0.1º C
Calibration uncertainty:	± 0.1º C

ATTACHMENT 18: PROPELLER ANEMOMETER WIND SPEED CALIBRATOR DESCRIPTION

5131-18 **Propeller Anemometer Wind Speed Calibrator Description**	Records Use only Los Alamos NATIONAL LABORATORY EST.1943

Instrument Description

The rotational calibration units are required to calibrate the RM Young wind-speed sensors. The Models 27230, 27231, and 27232 calibrators are simply synchronous 60-Hz AC motors that rotate at constant spees of 300, 1800, and 3600 rpm, respectively. These output speeds are directly proportional to the applied power frequency, which is a critically controlled standard. The Model 18801 is a selectable speed calibration unit with a speed range of 100 to 10,000 rpm.

ATTACHMENT 19: PROPELLER ANEMOMETER VANE ANGLE CALIBRATOR DESCRIPTION

5131-19 **Propeller Anemometer Vane Angle Calibrator Description**	Records Use only Los Alamos NATIONAL LABORATORY EST.1943

Instrument Description

The RM Young Model 18112 vane angle calibrator is necessary to calibrate the azimuth measuring portion of the RM Young propeller anemometers. The vane angle calibrator is a bench-testing fixture that holds the propeller vane and allows the vane to be turned through 360 degrees with the angle mechanically measured on a protractor. This mechanically measured angle is then compared with the electrical output of the potentiometer. This is a mechanical device which does not have or require any calibration or adjustment.

ATTACHMENT 20: PROPVANE AZIMUTHAL SITING SCOPE DESCRIPTION

5131-20 **Propvane Azimuthal Siting Scope Description**	Records Use only Los Alamos NATIONAL LABORATORY EST. 1943

Instrument Description

The “az-scope” is a “home built” azimuthal alignment device designed for this purpose. The az-scope consists of a surveyor’s transit mounted to a salvaged propvane base. The az-scope is placed on a tower boom mounting fixture with the map-determined azimuthal angle from true north (to the landmark) set and locked into a transit and a loosely-mounted orientation ring installed. The az-scope/orientation ring, is rotated as an assembly, until the az-scope is sighted on the landmark. The orientation ring is tightened to the boom mounting fixture. When the az-scope is removed, the orientation ring will ensure that when a propvane is installed, it will be properly oriented to true north.

ATTACHMENT 21: CMF1, INSTRUMENTS FOR MEASURING WIND VARIABLES

5131-21 **PART I**

CMF1, Instruments for Measuring Wind Variables

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Wind Speed Instrument Calibration									
Met. Tower Site Designation:				Check (√): ☐ Pre-Cal. ☐ Post-Cal.				Activity Log Page No.	
Technician's Printed Name:				Technician's Signature:				Calibration Date:	
Serial Number	Tower Level	Pre-Cal. Installation		Person	rpm vs. Design Output (Hz)			Passes 0.6 g-cm Torque Test (limit ≤ 0.6) (√)	Comments (problems, adjustments, observations)
		Date	Time		100-5 3600-180	900-45 7200-360	1800-90		
									Spin Down Test = _____s (limit >60s) Boom Level Verification _____(√) AZ-scope Verification _____(√)
									Spin Down Test = _____s (limit >60s) Boom Level Verification _____(√) AZ-scope Verification _____(√)
									Spin Down Test = _____s (limit >60s) Boom Level Verification _____(√) AZ-scope Verification _____(√)
									Spin Down Test = _____s (limit >60s) Boom Level Verification _____(√) AZ-scope Verification _____(√)

ATTACHMENT 21: CMF1, INSTRUMENTS FOR MEASURING WIND VARIABLES

5131-21 **PART II**

CMF1, Instruments for Measuring Wind Variables

Records Use only

Azimuth Instrument Calibration									
Met. Tower Site Designation:			**Check (√): ☐ Pre-Cal. ☐ Post-Cal.**				**Activity Log Page No.**		
Technician's Printed Name:			**Technician's Signature:**				**Calibration Date:**		
Seial Number	**Tower Limit**	**Azimuth Calibration Check Points (insert measured value)**						**Comments (problems adjustments, observations)** **Site Reference Bearing ____________º**	
		30º	**90º**	**180º**	**270º**	**330º**	**0-360º sweep (√)**		
								Torque Test = _____g-cm (limit ≤ 20 g-cm) **Completed Azimuth Balance _____(√)** **Reference Bearing _____ º**	
								Torque Test = _____g-cm (limit ≤ 20 g-cm) **Completed Azimuth Balance _____(√)** **Reference Bearing _____ º**	
								Torque Test = _____g-cm (limit ≤ 20 g-cm) **Completed Azimuth Balance _____(√)** **Reference Bearing _____ º**	
								Torque Test = _____g-cm (limit ≤ 20 g-cm) **Completed Azimuth Balance _____(√)** **Reference Bearing _____ º**	

ATTACHMENT 22: CMF2, INSTRUMENTS FOR MEASURING WIND VARIABLES

5131-22 CMF2, Instruments for Measuring Wind Variables	Records Use only Los Alamos NATIONAL LABORATORY EST. 1943

W-Anemometer Calibration									
Met. Tower Site Designation:				Check (√): ☐ Pre-Cal. ☐ Post-Cal.				Activity Log Page No.	
Technician's Printed Name:				Technician's Signature:				Calibration Date:	
Serial Number	Tower Level	Pre-Cal. Installation		Person	rpm vs. Design Output (mV)			Passes 0.5 g-cm Torque Test (limit ≤ 0.5) (√)	Comments (problems, adjustments, observations)
					300-83.3	1800-500	3600-1000		
		Date	Time		Actual Output, mV/% Error				
									Spin Down Test: CW = _____s CCW = _____s (limit > 60 s)
									Spin Down Test: CW = _____s CCW = _____s (limit > 60 s)
									Spin Down Test: CW = _____s CCW = _____s (limit > 60 s)
									Spin Down Test: CW = _____s CCW = _____s (limit > 60 s)

ATTACHMENT 23: CMF3, TEMPERATURE PROBE CALIBRATION	
5131-23 **PART I** **CMF3, Temperature Probe Calibration**	Records Use only

Printed Name:	Signature:	Calibration Date:	Page Number:

	Ice Bath Reference Temperature	**Middle Temperature Bath Reference Temperatur**	**Warm Temperature Bath Reference Temperature**
Probe S/N	**Probe Response to each Bath***		

ATTACHMENT 23: CMF3, TEMPERATURE PROBE CALIBRATION

5131-23 **PART II**

CMF3, Temperature Probe Calibration

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Printed Name:	Signature:	Calibration Date:	Page Number:

TA-6 Assignment		TA-41 Assignment		TA-49 Assignment	
Probe S/N	**Tower Level**	**Probe S/N**	**Tower Level**	**Probe S/N**	**Tower Level**
	4		1		3
	3		0		2
	2				1
	1				0
	0				

TA-53 Assignment		TA-54 / WR Assignment	
Probe S/N	**Tower Level**	**Probe S/N**	**Tower Level**
	3		3
	2		2
	1		1

	0		0

ATTACHMENT 23: CMF3, TEMPERATURE PROBE CALIBRATION

5131-23 **Part III**

CMF3, Temperature Probe Calibration

Records Use only

Printed Name:	Signature:	Calibration Date:	Page Number:

Ref. Temp.				
Start →				**Avg. Ref. Temp.**
End →				

						Resistance vs. Temperature (from probe manual) Chart Interpolation	
Probe S/N	**1st Resistance Reading kΩ**	**2nd Resistance Reading kΩ**	**3rd Resistance Reading kΩ**	**Avg. Resistance Reading kΩ**	**Resultant Temperature**	**Reading kΩ**	**Temp. º C**

ATTACHMENT 24: CMF4, INSTRUMENTS FOR MEASURING ATMOSPHERIC STATE VARIABLES

5131-24 PART I

CMF4, Instruments for Measuring Atmospheric State Variables

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Humidity Instrument Calibration						
Mfg. & Model No.	**Serial Number**	**Pre-Cal. Installation**		**Person**	**Instrument Cal. Date**	**Comments (problems, adjustments, observations)**
		Date	**Time**			

Pressure Instrument Calibration						
Serial Number	**Pre-Cal. Installation**		**Person**	**Measure & Record Power Supply Voltage 24 vdc ± 10%**		**Comments (problems, adjustments, observations)**
	Date	**Time**				

ATTACHMENT 24: CMF4, INSTRUMENTS FOR MEASURING ATMOSPHERIC STATE VARIABLES

5131-24 PART II

CMF4, Instruments for Measuring Atmospheric State Variables

Records Use only

Los Alamos NATIONAL LABORATORY EST. 1943

Temperature Probe Calibration								
Serial Number	Tower Level	Pre-Cal. Installation		Person	Ice Bath Check	Ambient Comp.	Warm Comp.	Aspirator Operation
		Date	Time		Sensor Standard	Sensor Standard	Sensor Standard	No Power Friction Test (√)

Comments (problems, adjustments, observations):

ATTACHMENT 25: CMF5, INSTRUMENTS FOR MEASURING PRECIPITATION-RELATED VARIABLES	
5131-25 PART I **CMF5, Instruments for Measuring Precipitation-Related Variables**	Records Use only Los Alamos NATIONAL LABORATORY EST.1943

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Precipitation Gauge Calibration

Date	Time	Person	Pre-cal. Gauge[2] (√)	Level Gauge (√)	AC Power Applied (√)	Check Heater Circuits (√)	Clean Gauge (√)	Calibrate Gauge[3]	Comments

[2] Note any discrepancies in space provided, or in comments section.

ATTACHMENT 25: CMF5, INSTRUMENTS FOR MEASURING PRECIPITATION-RELATED VARIABLES

5131-25 PART II

CMF5, Instruments for Measuring Precipitation-Related Variables

Records Use only

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Snow Depth Gauge Calibration

Date	**Time**	**Person**	**Gauge Plumb**	**Measured Gauge Height**	**Replace Desiccant**	**Gage Zero Reading From Datalogger**	**Gauge Reading Box on Ground From Datalogger**	**Comments (problems, adjustments, observations)**

Lightning Detector Calibration

Date	Time	Person	Detector Test Resp.	Wax Plastic Cover	Comments (problems, adjustments, observations)

ATTACHMENT 26: CMF, INSTRUMENTS FOR MEASURING RADIATIVE FLUX VARIABLES

5131-26

CMF6, Instruments for Measuring Radiative Flux Variables

Records Use only

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Pyranometer Calibration

Serial Number	Calibration Constant ($x10^{-6}$ V/Wm^{-2})	Pre-Cal. Installation		Person	Datalogger Mult. Changed (√)	Comments (problems, adjustments, observations)
		Date	**Time**			

Pyrgeometer Calibration

Serial Number	Calibration Constant (x10^{-6} V/Wm^{-2})	Pre-Cal. Installation		Person	Datalogger Mult. Changed (√)	Comments (problems, adjustments, observations)
		Date	**Time**			

ATTACHMENT 27: CMF7, INSTRUMENTS FOR MEASURING SUBSURFACE VARIABLES

5131-27 Part I **CMF7, Instruments for Measuring Subsurface Variables**	Records Use only Los Alamos NATIONAL LABORATORY EST. 1943

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Soil Temperature Probe Calibration								
Serial Number	**Tower Level**	**Pre-Cal. Installation**		**Person**	**Ice Bath Check**	**Ambient Comp.**	**Warm Comp.**	**Aspirator Operation**
		Date	**Time**		**Sensor Standard**	**Sensor Standard**	**Sensor Standard**	**No Power Friction Test**

Comments (problems, adjustments, observations):								

ATTACHMENT 27: CMF7, INSTRUMENTS FOR MEASURING SUBSURFACE VARIABLES

5131-27 **Part II**

CMF7, Instruments for Measuring Subsurface Variables

Records Use only

Met. Tower Site Designation:	**Check (√):** ☐ **Pre-Cal.** ☐ **Post-Cal.**	**Activity Log Page No.**
Technician's Printed Name:	**Technician's Signature:**	**Calibration Date:**

Soil Moisture								
Model Number	**Serial Number**	**Version Number**	**Pre-calibration Installation**		**Operational Check**		**Person**	**Comments (include installation details)**
			Date	**Time**	**Air**	**Water**		