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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SITE SELECTION FOR OPTICAL MONITORING EQUIPMENT (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4050**
DATE	**FEBRUARY 1994**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
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REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Add responsibilities and equipment.	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines site selection criteria for optical monitoring instruments operated according to IMPROVE Protocol. Documented site selection criteria and procedures assure consistent, quality data at sites that exhibit most or all of the following characteristics:

- Be located in an area representative of the air mass to be monitored
- Be removed from local pollution sources (e.g., vehicle exhaust, wood smoke, road dust, etc.)
- Have AC power, solar exposure, and/or telephone lines available
- Have telephone lines and AC power or solar exposure available
- Allow for proper orientation of nephelometer sample inlet
- Be close to an existing aerosol monitoring station or other instruments that are being used to monitor the air mass of interest
- Be representative of the same air mass measured by associated aerosol (particle monitors) and scene (camera) instrumentation
- Have a clear, unobstructed sight path between the transmissometer components
- Be representative of regional (not local) visibility
- Be secure from vandalism
- Have available servicing personnel (operator)
- Be reasonably accessible during all months of the year

The two (2) types of optical monitoring instruments currently operating in the IMPROVE monitoring network are Optec NGN-2 ambient nephelometers and Optec LPV-2 transmissometers. Additional, detailed instrument-specific site characteristic criteria are described in the following technical instructions (TIs):

- TI 4050-3000 *Site Selection for Optec NGN-2 Nephelometer Systems*
- TI 4050-3010 *Site Selection for Optec LPV-2 Transmissometer Systems*

This SOP serves as a guideline to facilitate the following:

- Locating potential sites
- Evaluating potential sites
- Selecting the most appropriate site from the potential sites
- Finalizing the selected site

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Inform the project manager of the location area and site-specific monitoring objectives for a proposed optical monitoring site.
- As required, review the selected site with the project manager and project-specific Contracting Officer's Technical Representative (COTR).

2.2 PROJECT MANAGER

The project manager shall:

- Prepare the project-specific siting and operational objectives, guidelines, and considerations.
- Review with the field specialist photographic documentation, maps, and other information to determine the suitability of a site.
- Select the site based on the criteria outlined in the appropriate instrument-specific technical instructions (TIs).
- As required, review the selected site with the program manager.

2.3 FIELD SPECIALIST

The field specialist shall:

- Initiate the search for potential sites by sending the pertinent siting criteria and associated materials to the local contact.
- Conduct a siting visit if required (always required for transmissometer sites).
- Contact local power and telephone companies for information concerning availability and installation.
- Obtain permission to perform any site preparation that may be required.
- Obtain permission from private or public landowners for permanent access to the monitoring location.
- Obtain permits or Environmental Impact Statements if required.
- Work with the local contact or sponsoring agency to identify a site operator and local primary contact to service the equipment.
- Review with the project manager photographic documentation, maps, and other information to determine the suitability of a site.
- Enter all site selection information in the site-specific Quality Assurance Database.

2.4 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Locate and document potential sites upon receiving the siting criteria and associated materials from ARS.
- Provide the field specialist with any pertinent site-related information.
- Assist the field specialist in obtaining any site access and/or installation-related clearances or permissions.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment and materials are generally required to complete the site selection process:

- Topographic maps of the area of interest
- Camera(s) and film to photograph the proposed site and area
- A list of monitoring objectives, requirements, and associated IMPROVE protocol monitoring equipment
- A list of local sources affecting the air in the area of interest
- Information about the availability of AC power and telephone service
- Photographic Log
- <u>Nephelometer siting:</u>
  - An Optec NGN-2 Nephelometer Siting Information Form
  - Installation Site Photographs and Drawing Instructions
- <u>Transmissometer sitings:</u>
  - Brunton compass
  - Transmitter telescope unit with tripod
  - Tape measure
  - Signal mirrors
  - Binoculars
  - Shelter option diagrams
  - Solar panel array installation configuration diagrams

4.0 METHODS

This section describes site selection procedures and includes two (2) major subsections:

4.1 Nephelometer Site Selection Methods
4.2 Transmissometer Site Selection Methods

4.1 NEPHELOMETER SITE SELECTION METHODS

4.1.1 Locating Potential Sites

- Obtain siting and monitoring objective criteria from the project manager.
- Locate potential sites using maps and through consultation with the local contact(s).
- Send siting package to the local contact.
- Perform a field survey, document site selection with photographs and maps, and collect information about site accessibility, security, and special requirements.
- Check returned siting package for completeness.

4.1.2 Reviewing and Selecting Potential Sites

- Evaluate potential sites after review of the siting information.
- Select the best site.

4.1.3 Finalizing Site Selection

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.
- Obtain approval from the program manager.
- If required, obtain approval from the project-specific COTR.
- Provide a detailed description of the proposed installation to the local contact and property manager.
- Obtain permission for site use and any site preparation.
- Complete permits or Environmental Impact Statements if required.
- Initiate installation protocols as described in TI 4070-3000, *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)* and TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*.

4.2 TRANSMISSOMETER SITE SELECTION METHODS

4.2.1 Siting Criteria

Criteria categories that must be considered when siting a transmissometer system are:

- Sight path (height above ground, length, and vertical angle)
- Air mass (the air mass along the sight path must be representative of the regional air mass)
- Location characteristics (of the individual transmissometer transmitter and receiver stations)
- Selection of appropriate shelters and solar panel arrays (solar-powered sites)

4.2.2 Locating Potential Sites

- Obtain siting and monitoring objective criteria from the project manager.
- Locate potential sites using maps and through consultation with the local contact(s).
- Send siting package to the local contact.
- Perform a field survey, document site selection with photographs and maps, and collect information about site accessibility, security, and special requirements.
- Check returned siting package for completeness.
- Make a preliminary evaluation of the proposed sites.
- Schedule a siting trip and coordinate with the site operator.
- Determine the need for any clearances and document related information.
- Gather additional information and evaluate potential sites.

4.2.3 Reviewing and Selecting Potential Sites

- Evaluate proposed sites after review of the siting information and site visit.
- Select the best site.

4.2.4 Finalizing Site Selection

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.
- Obtain approval from the program manager.

- If required, obtain approval from the project-specific COTR.
- Provide a detailed description of the proposed installation to the local contact and property manager.
- Obtain permission for site use and any site preparation.
- Complete permits or Environmental Impact Statements if required.
- Initiate installation protocols as described in TI 4070-3010, *Installation and Site Documentation of Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SITE SELECTION FOR OPTEC LPV-2 TRANSMISSOMETER SYSTEMS**
TYPE	**TECHNICAL INSTRUCTION**
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AUTHORIZATIONS		
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OTHER		

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REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Additions to responsibilities and methods.	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes site selection requirements for Optec LPV-2 transmissometer systems to be operated according to IMPROVE Protocol. The purpose of documented site selection requirements and procedures is to assure consistent quality data capture and minimize data loss by selecting a site that exhibits all or most of the following characteristics:

- Be located in an area representative of the air mass to be monitored
- Have a clear, unobstructed sight path between the receiver and transmitter
- Have adequate sight path length and height for representative monitoring of the air mass
- Be representative of the same air mass measured by associated aerosol (particle monitors) and scene (camera) instrumentation
- Have AC power or adequate solar exposure for continuous year-round operation
- Be oriented so that lighting conditions do not affect measurements
- Be removed from local pollution influences (e.g., vehicle exhaust, wood smoke, road dust, etc.)
- Be representative of regional (not local) visibility
- Be secure from vandalism
- Have available servicing personnel (operator)
- Be reasonably accessible during all months of the year

This TI serves as a guideline to facilitate the following:

- Locating potential sites
- Evaluating potential sites
- Selecting the most appropriate site from the potential sites
- Finalizing the selected site

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Inform the project manager of the location area and site-specific monitoring objectives for a proposed transmissometer site.

- As required, review the selected site with the project manager and the project-specific Contracting Officer's Technical Representative (COTR).

2.2 PROJECT MANAGER

The project manager shall:

- Prepare project-specific siting and operational objectives, guidelines, and considerations.
- Review with the field specialist photographic documentation, maps, and other information to determine the suitability of a site.
- Select the site for the transmissometer installation based on the criteria described in this TI.
- Review the selected site with the program manager.

2.3 FIELD SPECIALIST

The field specialist shall:

- Initiate the search for potential sites by sending pertinent siting criteria and associated materials to the local contact.
- Conduct a siting trip to the area to evaluate potential sites as determined by the local contact and identify any other potential sites.
- Fully document and evaluate each potential site according to the criteria outlined in this TI.
- Obtain permission to perform any site preparation that may be required.
- Obtain permission from private or public landowners for permanent access to the transmissometer locations.
- Complete permits or Environmental Impact Statements if required by the property managers.
- Contact the existing site operator or arrange for a new site operator to service the instruments.
- Review with the project manager, photographic documentation, maps, and other information to determine the suitability of a site.
- Enter all site selection information in the site-specific Quality Assurance Database.

2.4 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Locate and document potential sites upon receiving the siting criteria and associated materials from the field specialist.
- Provide the field specialist with any pertinent site-related information.
- Review the potential sites with the field specialist during the siting visit and assist in locating additional potential sites.
- Assist the field specialist in obtaining any site access and/or installation-related clearances or permissions.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment and materials are generally required to complete the site selection process:

- Topographic maps of the area of interest
- Camera(s) and film to photograph the proposed site and area
- A list of monitoring objectives, requirements, and associated IMPROVE protocol monitoring equipment
- A list of local sources affecting the air in the area of interest
- Brunton compass
- Transmissometer transmitter telescope unit with tripod
- Tape measure
- Signal mirrors
- Binoculars
- Instrument shelter option diagrams
- Solar panel array installation configurations
- A Photographic Log

4.0 METHODS

This section describing site selection criteria and procedures and includes four (4) major subsections:

4.1 Siting Criteria
4.2 Locating Potential Sites
4.3 Reviewing and Selecting Potential Sites
4.4 Finalizing Site Selection

4.1 SITING CRITERIA

The following sections outline and describe the siting criteria as they pertain to the instrument, the monitored air mass, and site operation.

4.1.1 Sight Path Siting Criteria

The fundamental requirement for operation of the LPV-2 transmissometer is a clear, unobstructed line-of-sight (sight path) between the transmitter and receiver. Specific criteria for sight path height, length, and vertical angle are discussed in the following subsections.

4.1.1.1 Sight Path Height

Adequate sight path height is dependent on minimizing distortion of the transmitter light beam as viewed by the receiver. The LPV-2 transmissometer is optically configured as follows:

Transmitter:	0.17° uniform portion of beam
	1.00° total cone of light
	2.30° telescope field of view
Receiver:	0.07° detector acceptance cone
	1.30° telescope field of view

Also refer to Figure 4-1, Transmissometer and Receiver Telescope Reticule Diagrams.

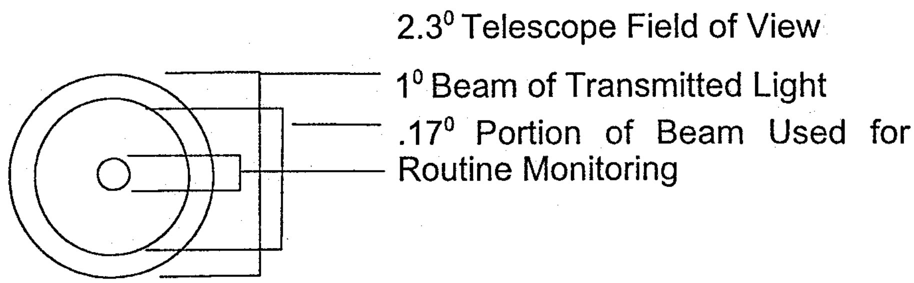
The field of view of both transmitter and receiver telescopes should be considered when selecting a sight path. Optimally, the sight path should be elevated as much as possible above the terrain surface, with both receiver and transmitter located at the edge of a dropoff. Refer to Figure 4-2, Sight Path Profile Examples, for depictions of acceptable and unacceptable sight path profiles. Figure 4-2 shows four examples:

4-2 (a) - This figure depicts an ideal sight path where both the transmitter light beam and the receiver detector cone of acceptance are well elevated above terrain features.

4-2 (b) - This figure depicts a good sight path. Although the transmitter beam touches the terrain surface, it does so at a point well away from the detector cone. The detector cone is also well elevated above the terrain.

Transmitter

Alignment Reticule
The figure below depicts the reticule as viewed through the transmitter eyepiece:



Receiver

Alignment Reticule
The figure below depicts the reticule as viewed through the receiver eyepiece.

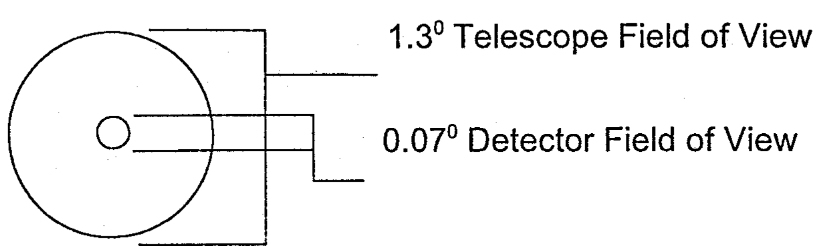


Figure 4-1. Transmitter and Receiver Telescope Reticule Diagrams.

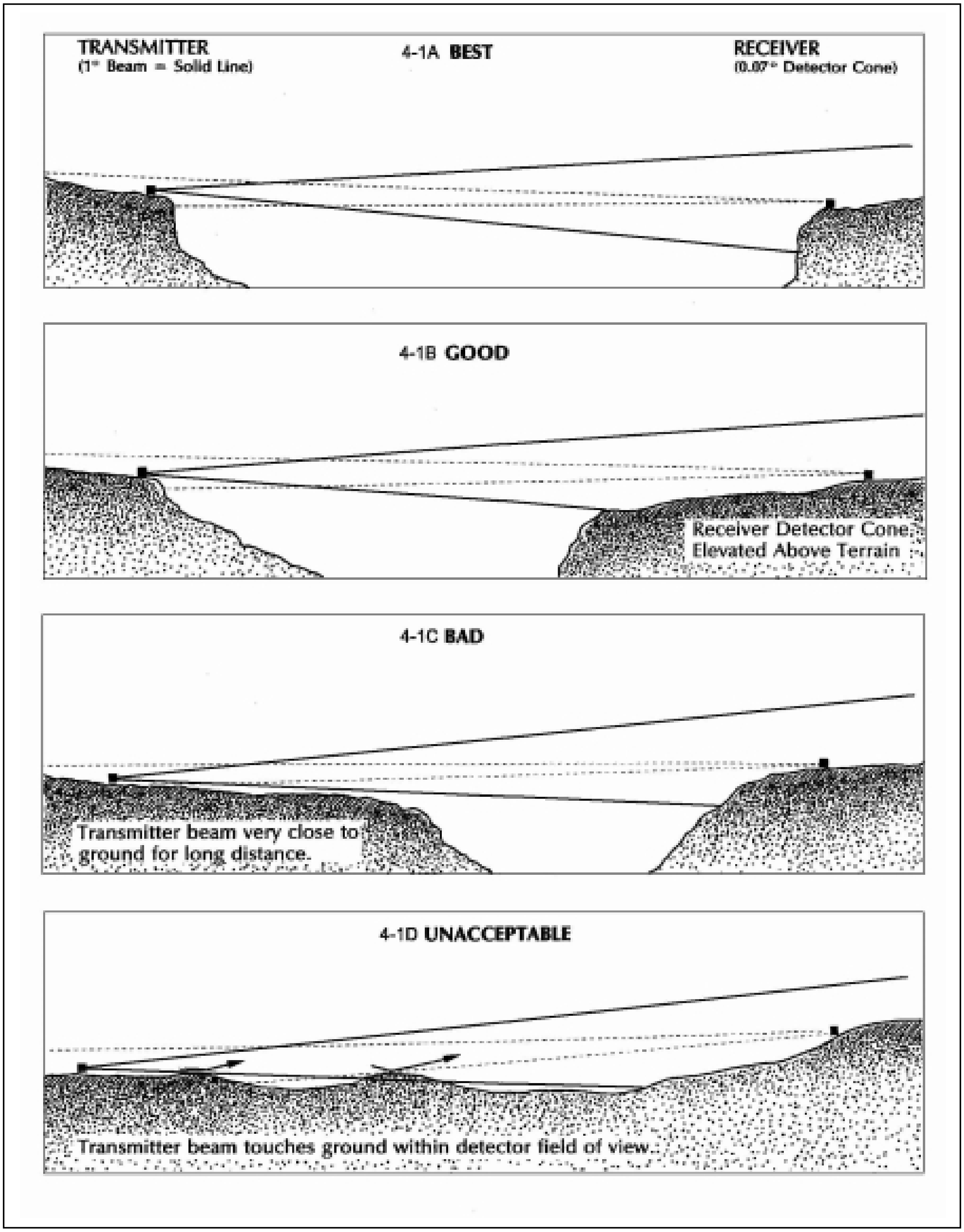


Figure 4-2. Sight Path Profile Examples.

4-2 (c) - In this figure, the transmitter beam passes too close to the terrain surface. Surface heating/cooling may distort the beam.

4-2 (d) - This figure depicts a transmitter beam striking the ground within the detector cone. Both refraction and reflection of the beam will occur, producing invalid measurements.

If possible, avoid locating the sight path over a body of water due to the increased frequency of temperature inversions, fog, etc. Optical effects due to terrain heating/cooling turbulence can affect instrument readings if the sight path is too low over terrain features.

During the siting visit by the field specialist, the transmitter telescope (mounted on a tripod) can be used to determine beam clearances for potential sight paths. The transmitter telescope can also be used to estimate receiver telescope field-of-views. Refer to Figure 4-2, Transmitter and Receiver Telescope Reticule Diagrams, for diagrams and descriptions of the transmitter and receiver eyepiece reticules.

4.1.1.2 Sight Path Length

The primary consideration when determining whether a path length is acceptable, is the expected range of visual air quality in that area. Generally, remote areas in the western United States require path lengths from 4-8 km, while eastern sites require 1-4 km lengths. If the mean visual range for the area is known, a usable path distance can be calculated as follows:

$$Sight\ Path\ Length = Mean\ Visual\ Range\ x\ 0.033$$

In an area with a wide range of visual air quality, the path length should be carefully selected.

4.1.1.3 Sight Path Vertical Angle

Unless otherwise specified in the monitoring objectives for a transmissometer site, the sight path should be as level as possible. If siting constraints result in a significant (>1.0°) sight path vertical angle, orientation of the receiver telescope to lighting conditions throughout the year should be thoroughly considered (e.g., a receiver telescope viewing approximately south at an upward angle could be susceptible to periods of receiver detector saturation, especially with low winter sun angles). It is generally preferable in such situations to configure the site with the receiver at the higher point and viewing downward toward the transmitter.

4.1.2 <u>Air Mass-Related Siting Criteria</u>

The primary siting criterion is to ensure that the air mass along the entire sight path between the receiver and transmitter is representative of the larger air mass to be monitored.

Specific air mass-related criteria to be considered when siting are:

- Proximity and influence of local pollution sources such as vehicle exhaust, wood smoke, dust, etc.

- Measurement of the same air mass as other aerosol or optical monitoring instrumentation.

- Potential of significant cold air drainage. Transmissometer readings can be adversely affected by the varying optical properties of the sight path if cold air (typically funneled down from higher, colder areas) flows through the sight path.

- Small-scale, localized weather/climate regimes that are not representative of the region (e.g., areas that are susceptible to localized inversions, fog, clouds, etc.)

4.1.3 Transmitter and Receiver Site-Specific Siting Criteria

Various siting criteria to be considered as they apply to the actual transmitter and receiver station locations are:

- Stability of Ground Surface - Frost-heaving, downslope soil movement, soil saturation, and other earth movements will affect alignment of the instrument.

- Line Power (AC) Availability - If a receiver or transmitter system is to be line-powered (AC), verify that 110 volt, 15 amp electrical service is available at the site.

- Potential of Power-Related Problems - Frequency of power outages at AC-powered sites and sufficient year-round solar exposure at solar-powered sites must be considered.

- Ease of Site Access - Accessibility of the site for installation and weekly operator servicing must be considered.

- Lightning Exposure - Sites that are susceptible to lightning strikes should be avoided.

- Security From Vandalism - Sites should be selected that minimize the potential of vandalism or make provisions for preventative modifications to the installation to deter vandalism.

- Local Land Manager or Land Owner Cooperation - Establish whether the local land manager or land owner will be cooperative in allowing installation of the sites and continuous access to the sites for the duration of the study.

- Vegetation Growth - Growth of vegetation into the sight path must be taken into account.

- Data Collection Platform (DCP) Transmission Clearance - Verify that DCP transmissions will not be blocked by vegetation, geographical features, or structures.

- Isolation From Radio Interference - Instrument circuitry is sensitive to strong radio signals. Avoid siting close to broadcast antennas or repeaters.

- Snow Accumulation - The effects of significant snowfall accumulations on instrument, DCP, and solar panel operation should be considered.

- Avoidance of Lighting Interference - Sunlight reflecting from solar panels, large windows, or other large reflective surfaces near the transmitter can saturate the receiver detector and affect readings.

4.1.4 Shelter and Solar Panel Array Configuration Selection (Solar-Powered Sites)

The following subsections describe the different types of shelters and solar panel array installation configurations and the guidelines to be followed in the selection of these. The local monitoring project overseer and/or land manager should be consulted during the shelter and solar panel array selection process to ensure compliance with local guidelines and restrictions.

4.1.4.1 Selection of Transmitter and Receiver Shelters

Refer to Figure 4-3, Transmissometer Shelter Options.

Standard transmissometer system shelters are 6' x 6' x 8' insulated wood shelters (receiver) and 3½' x 3½' x 4½' wood or metal shelters (transmitter). The smaller transmitter shelters can be insulated, depending on climate severity. The larger receiver shelter provides substantial space for instrumentation, related equipment/supplies, and storage of shipping cases. It also allows the operator to perform instrument servicing while protected from weather.

The standard transmitter shelter provides adequate housing for the instrument and related servicing supplies. It is also relatively easy to transport and install. Use of other shelter types may be warranted by the following factors and constraints:

- Difficulty in transporting a larger shelter to the site
- Visual obtrusion of larger shelters
- Site configuration and/or space restrictions
- Need for additional height of transmitter telescope
- Need for protection from weather when servicing the transmitter

4.1.4.2 Selection of Solar Panel Array Configuration (Solar-Powered Sites)

Refer to Figure 4-4, Solar Panel Array Installation Configurations.

The three (3) standard types of solar panel array installation configurations are: free-standing, shelter wall-mounted, and shelter roof-mounted. General guidelines and considerations for selection of solar array type are:

- Adequacy of year-round solar exposure
- Orientation of large shelter conducive to wall-mounting of array
- Minimizing visual obtrusion of the array
- Expected snowfall accumulations
- Location-specific constraints due to site configuration, terrain, vegetation, etc.

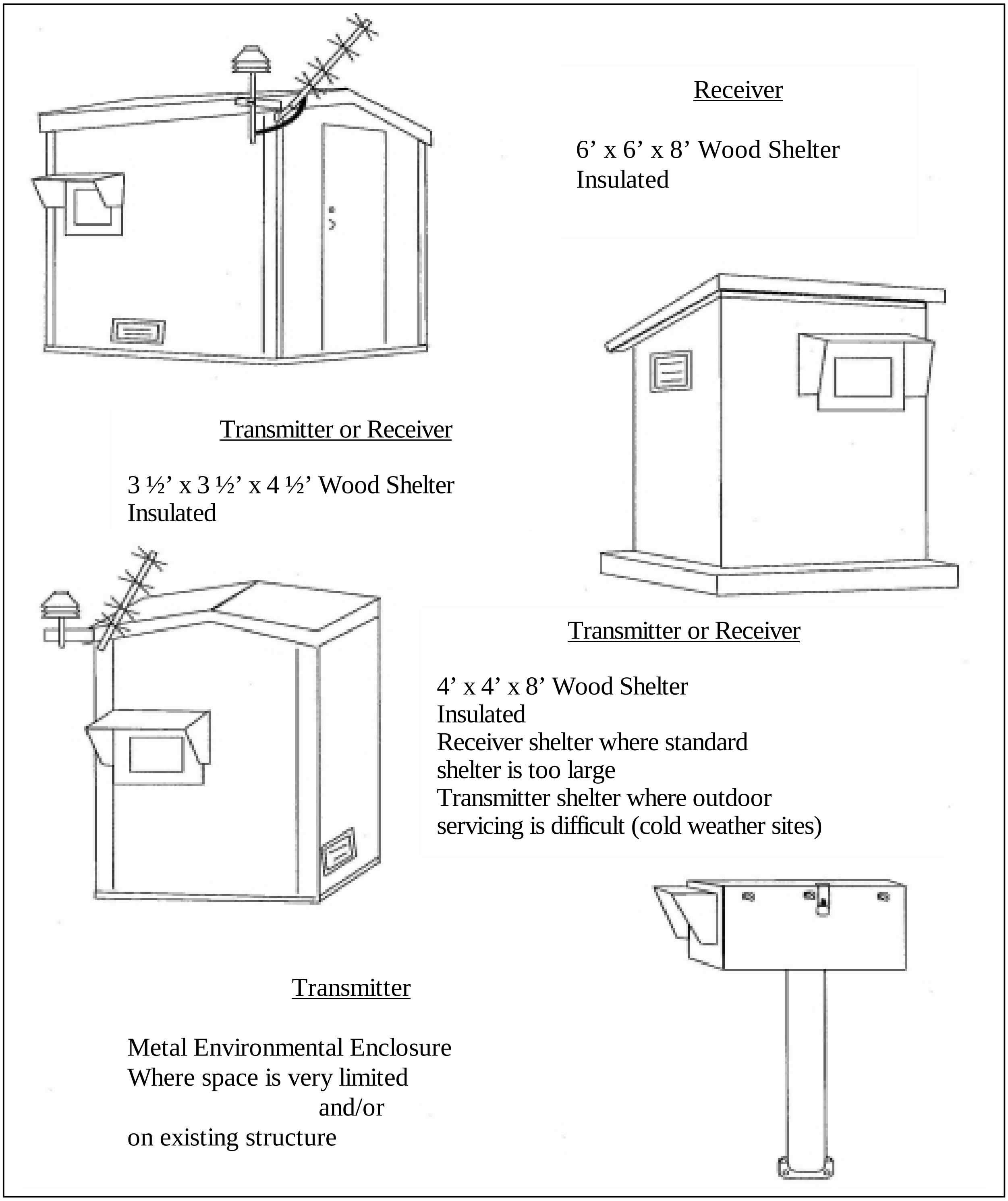
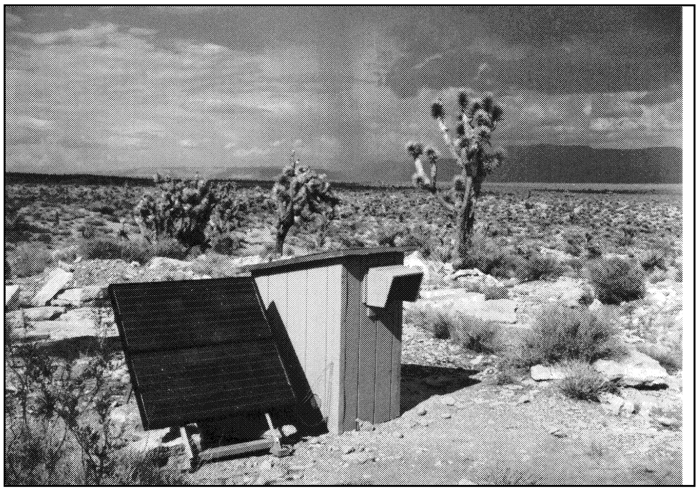
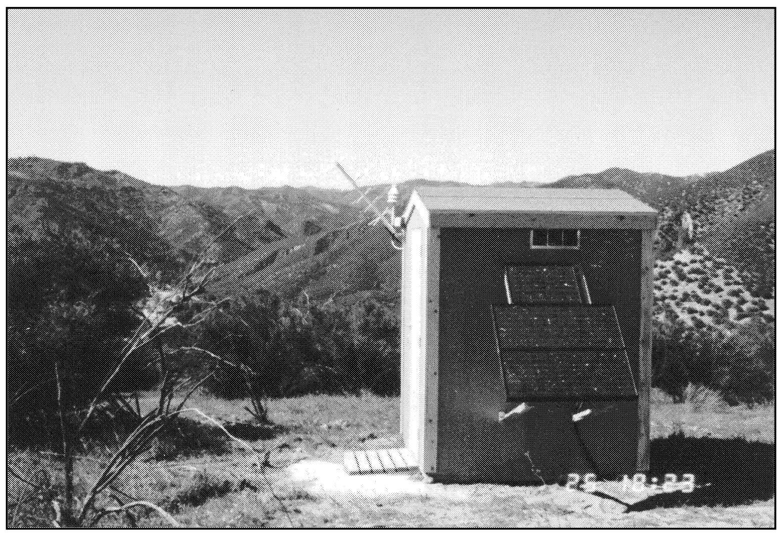


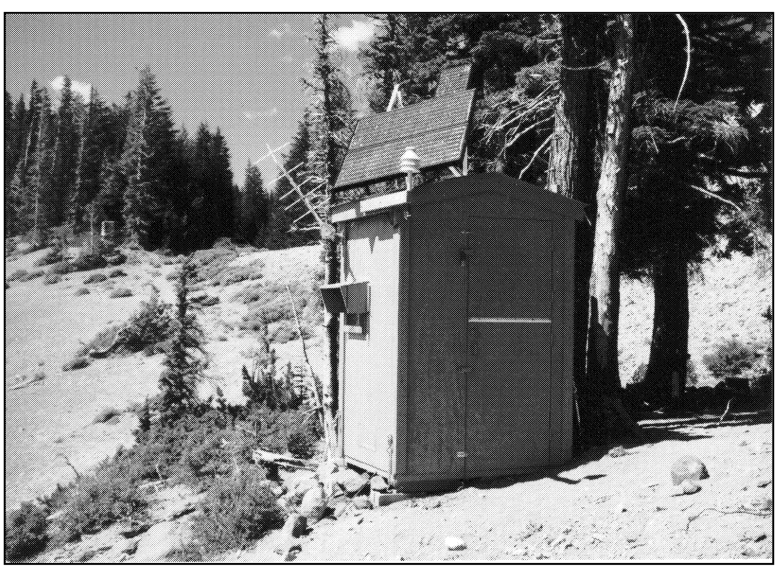
Figure 4-3. Transmissometer Shelter Options.



Free-standing
Solar Array

Shelter
Wall-mounted
Solar Array





Shelter
Roof-mounted
Solar Array

Figure 4-4. Solar Panel Array Installation Configurations.

4.2 LOCATING POTENTIAL SITES

Site selection begins with the process of locating potential sites in the monitoring area of interest by the local contact. The local contact and field specialist then prepare a site visit. Methods and procedures are described in the following two (2) subsections.

4.2.1 Local Contact Potential Site Location Methods and Procedures

OBTAIN SITING CRITERIA

The field specialist obtains specific siting criteria from the project manager. Siting criteria may include regional or site-specific program objectives, meteorological conditions of the monitoring area and/or other considerations.

LOCATE POTENTIAL SITES

Locate potential sites from maps and through consultation with local contacts familiar with the monitoring area of interest.

SEND SITING PACKAGE TO LOCAL CONTACT

Send the transmissometer siting package to a local contact familiar with the proposed monitoring area. The siting package includes the following:

- A cover letter that includes a brief description of the monitoring area and associated program objectives.
- Instrument shelter option diagrams (Figure 4-3)
- Solar panel array installation configurations (Figure 4-4)
- A disposable 35 mm camera or a camera and a roll of 35 mm print film
- A Photographic Log (Figure 4-5)

FIELD SURVEY AND SITE SELECTION DOCUMENTATION

The local contact should review the technical and monitoring requirements and identify potential sites and in relation to the protocols provided. Actual field surveys can be performed by the local contact, an ARS field specialist, or both.

The results of the field survey should include a series of photographs of the area. Photographs of each site location should also be provided. The location, azimuth, and predominant scenic features should be documented on the provided Photographic Log.

Identify and record the selected site location(s) and sight paths on a topographic map of the area.

Record any pertinent information regarding accessibility, security, special requirements, etc.

Return the processed or unprocessed print film Photographic Log, site location maps, and any other selection materials to ARS for final review.

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Site ___________________________

Roll # _________________________

PHOTOGRAPHIC LOG

EXPOSURE NUMBER	DATE	TIME	DESCRIPTION/COMMENTS

Figure 4-5. Example Photographic Log.

CHECK RETURNED SITING PACKAGE	Check the returned transmissometer siting package for completeness. Obtain any missing information from the local contact. Process any undeveloped film. Evaluate the photographs of each potential site. If additional photographs are required, send another camera or additional film to the local contact with instructions detailing the photographs required.
PRELIMINARY POTENTIAL SITE REVIEW	All the siting information received from the operator is reviewed by the field specialist and a preliminary evaluation is made of the proposed sites and sight paths.

4.2.2 Field Specialist Siting Visit Methods and Procedures

Once the preliminary review of potential sites and information provided by the local contact is complete, a siting visit is conducted by the field specialist. Siting visit methods and procedures are performed as follows:

TRIP SCHEDULING	When scheduling the siting trip, verify that the local contact will be present and have time to visit all potential sites (including any found by the field specialist during the siting visit).
VISITATION POTENTIAL SITES	The field specialist and local contact should visit all potential sites OF established by the contact. If necessary, more detailed documentation (photographs, map locations, etc.) should be made of the sites.
LOCATION AND DOCUMENTATION OF ADDITIONAL POTENTIAL SITES	The field specialist determines if there are any additional potential sites and documents these fully.
EVALUATION OF POTENTIAL SITES	The field specialist shall make a preliminary evaluation of all potential sites based on the criteria listed in Sections 4.1.1, 4.1.2, and 4.1.3, establish a primary potential site, and at least one alternative site. This evaluation should be reviewed with the local contact and also his/her superior. Tentative installation configurations, instrument shelters, power provisions, support equipment, installation assistance, site clearances, etc. should be discussed at this time.
CLEARANCES	Determine if any clearances (for installation access or related activities, clearing of vegetation, archeological, etc.) are needed. If so, establish and document who is involved in the process and the approximate time frame necessary to obtain the clearance(s).
MISCELLANEOUS INFORMATION	Document all miscellaneous information that could be pertinent to installation or operation of the system. This may include, but is not limited to, the following:

- Names, addresses, and numbers for regular and backup operators, land managers, etc.

- Local power company and the local contact person (if either transmitter or receiver site will be AC-powered)

- Local businesses that carry installation or operation-oriented supplies (hardware stores, lumber yards, electrical supply stores, etc.)

- Shipping address and other shipping information for the site

Obtain a local telephone book for future reference.

4.3 REVIEWING AND SELECTING POTENTIAL SITES

Upon completion of the siting trip, the following procedures and tasks are performed for review and selection of the transmissometer installation site:

COMPILATION OF INFORMATION — The field specialist compiles all information from the returned siting package and the siting trip for presentation to the project manager. The information materials should include the following for each potential site:

- Full photographic documentation of proposed transmitter and receiver sites and sight paths.

- Sight path specifications (e.g., path length, height, vertical angle, etc.) and individual site specifications (location, elevation, etc.).

- A list of advantages and disadvantages for each potential site and sight path. Degree of conformity with the monitoring program-specific criteria and the general siting criteria (refer to Section 4.1) should be noted for each site and sight path.

- Map(s) with designated sites and sight paths.

SELECT BEST SITE — The project manager and field specialist review all potential site-related information and select the sight path and transmitter and receiver sites that best meet the monitoring program-specific and general siting criteria.

4.4 FINALIZING SITE SELECTION

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.

- As required, the final site selection and related information are presented to the program manager and/or the project-specific COTR for final review and approval.

- If required, obtain approval from the project-specific COTR.

- Provide a detailed description of the selected site, transmitter and receiver station configurations, and the installation methods to the local contact and property manager.

- Obtain permission to use the site and arrange for any site preparation from the property manager, land manager (public lands), or land owner (private lands).

- Compile permits or Environmental Impact Statements (EISs) if required by the property manager.

- Initiate installation protocols as described in TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol).*

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**INSTALLATION AND SITE DOCUMENTATION FOR OPTICAL MONITORING EQUIPMENT**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4070**
DATE	**JULY 1996**

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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general procedures regarding installation and site documentation of optical monitoring instrumentation operated according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

To assure quality data capture and minimize data loss, site installation and documentation procedures include:

- Installing the instrumentation, shelters, and support components in a standard configuration to ease data collection, troubleshooting, and servicing.
- Performing thorough on-site specification measurements.
- Documenting site specification measurements and other site-related information.

The following technical instructions provide detailed information regarding installing optical monitoring equipment or documenting optical site information:

- TI 4070-3000 *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- TI 4070-3001 *Site Documentation for Optec NGN-2 Nephelometer Systems*
- TI 4070-3010 *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall review site preparation, installation requirements, and the installation schedule with the project manager.

2.2 PROJECT MANAGER

The project manager shall:

- Review site preparation, installation requirements, and the installation schedule with the program manager and/or the project-specific Contracting Officer's Technical Representative (COTR) as required.
- Schedule the system installation.
- Review final site configuration plans presented by the field specialist.
- Review the completed site documentation forms for completeness and accuracy.

2.3 FIELD SPECIALIST

The field specialist shall:

- Review the installation with the project manager.
- Coordinate with on-site personnel regarding the installation location, schedule, installation assistance, and availability of materials.
- Ship all required equipment to the site.
- Install the optical systems.
- Perform an installation calibration or field audit.
- Schedule and conduct an operator training session.
- Complete all site documentation.
- Provide completed site documentation to the data analyst.

2.4 DATA ANALYST

The data analyst shall:

- Verify transmission of data from the system upon completion of the installation.
- Enter all site documentation into the Quality Assurance Database.
- File all hard copy site documentation provided by the field specialist.

2.5 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Review site preparation and installation requirements with the field specialist.
- Identify and contact local landowners, land managers, primary contacts, and site operators regarding site installation and routine maintenance requirements.
- Perform or ensure completion of any site preparation required prior to the installation.
- Assist in obtaining any site-, installation-, and regular servicing-related clearances and permits.
- Provide on-site equipment and tools required during the installation.
- As required, provide assistance with the installation.
- Schedule the operator training session with pertinent routine servicing personnel and the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

3.1 EQUIPMENT AND MATERIALS REQUIRED FOR NEPHELOMETER INSTALLATIONS

- Optec NGN-2 ambient nephelometer with extra lamps
- Rohn tower, base plate, and hardware
- Solar radiation and precipitation shield
- Precipitation hood
- Nephelometer datalogging and support subsystem
- Span gas calibration system
- Ambient air temperature and relative humidity sensor in force-aspirated shield
- AC power line and telephone line
- Complete set of installation tools
- A camera loaded with color print film
- Laptop computer equipped with PROCOMM
- Replacement connector kit
- Telephone line simulator
- Topographic maps of the area
- Information documented during the site selection process
- NGN-2 Nephelometer Site Documentation Form
- Site Operator's Manual for Nephelometer Systems
- Complete set of standard operating procedures and technical instructions regarding annual site visit procedures, calibration of monitoring systems, replacing and shipping optical components, monitoring system diagrams, site documentation, and operator maintenance procedures
- Pen or pencil

3.2 EQUIPMENT AND MATERIALS REQUIRED FOR TRANSMISSOMETER INSTALLATIONS

- Installation transmissometer with calibrated lamps

- Audit transmissometer with calibrated lamps
- Programmed data collection platform (DCP) with antenna, antenna cable, and solar panel charging system or AC-trickle charger
- AT/RH sensor with housing and cable
- Strip chart recorder and supplies
- Electronic distance meter (EDM) with mirror assembly and tripods
- Receiver and transmitter shelters with anchor assemblies
- Receiver and transmitter mounting posts and alti-azimuth bases
- Window/hood assemblies
- Terminal strip board
- Power supplies and/or solar panel assemblies
- Metal shelves for larger shelters
- Shelter anchor assemblies
- Deep-cycle batteries for solar-powered installations
- Hardware for shelter assembly, post installation, and miscellaneous installation-related tasks
- Miscellaneous servicing supplies, as detailed in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*, and TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- Concrete mix
- Caulking
- Rock/concrete epoxy capsules
- Surge protectors
- Solar panel regulators
- Dust pan, brushes, and broom
- AC or battery jigsaw with wood and metal blades

- AC or battery hammer drill with 5/8" hammer bit
- Hand sledge hammer and 5/8" star drill
- Wheelbarrow
- Wood saw
- Topographic maps of the area
- Ruler and protractor
- Photographs of sites, sight path, shelters, equipment configurations, etc.
- Information documented during the site selection process
- Transmissometer Site Description Sheet
- Site Map and Site Specifications Sheet
- Site Operator's Manual for Transmissometer Monitoring Systems
- Complete set of standard operating procedures and technical instructions regarding annual site visit procedures, calibration of monitoring systems, replacing and shipping optical components, monitoring system diagrams, site documentation, and operator maintenance procedures
- Pen or pencil

4.0 METHODS

This section includes four (4) major subsections that describe installation and documentation procedures applied to optical instruments:

4.1 Site Preparation and Communication
4.2 Installation Methods and Procedures
4.3 Operator Training
4.4 Site Documentation and Documentation Archival

4.1 SITE PREPARATION AND COMMUNICATION

Site preparation includes reviewing installation requirements with the local contact and scheduling all site preparation activities, including obtaining permission from landowners to access the monitoring location, determining site operators, and ensuring that all other necessary installation assistance is obtained.

The project manager schedules a site installation visit. The field technician schedules assistance from on-site personnel (such as obtaining required tools and equipment) and an operator training session.

4.2 INSTALLATION METHODS AND PROCEDURES

Nephelometer systems require installation of a tower, the nephelometer (with solar radiation and precipitation shield, precipitation hood, and AT/RH sensor) and support system components (datalogging and control subsystem, and span gas calibration system). Specific installation requirements are detailed in TI 4100-3375, *Replacing and Shipping Nephelometer System Components*. In addition, AC line power and a telephone line must be connected. After installation of the instrumentation, the entire system operation must be calibrated and verified.

Transmissometer systems require installation of shelters for both the transmitter and receiver units, mounting posts, the specific transmissometer components (transmitter and receiver) and support system components (alti-azimuth bases, terminal strip, AT/RH sensor, DCP and antenna, and strip chart recorder). Specific installation requirements are detailed in TI 4110-3375, *Replacing and Shipping Transmissometer Components*. In addition, either AC line power or DC solar power installation is required. After installation of the instrumentation, the entire system operation must be verified, and sight path distance measured.

4.3 OPERATOR TRAINING

Upon completion of the optical installation and system operation verification, all operators, back-up operators, and any other involved or interested on-site personnel are trained according to the procedures in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)* or TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*. Operators are trained in an overview of the monitoring program, instrument function and theoretical operation, component overview, routine servicing, and troubleshooting procedures. The site operator's manual for the appropriate instrumentation is reviewed and a copy is left with the site operators.

4.4 SITE DOCUMENTATION AND DOCUMENTATION ARCHIVAL

The field specialist completes site documentation including a site visit trip report, site specifications, geographic reference including landmarks, and location of monitoring equipment. Photographic documentation is also collected of the instrumentation.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**INSTALLATION AND SITE DOCUMENTATION FOR OPTEC LPV-2 TRANSMISSOMETER SYSTEMS (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor text changes and updated format.	July 1996	

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LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the procedures for installation and site documentation of Optec LPV-2 transmissometer stations operated according to IMPROVE Protocol. The purpose of this TI is to assure quality data capture and minimize data loss by:

- Installing the instrumentation, shelters, and support components in a standard configuration to assure ease in data collection, troubleshooting, and servicing.
- Performing thorough on-site specification measurements.
- Documenting site specification measurements and other site-related information.

This TI is referenced from Standard Operating Procedure (SOP) 4070, *Installation and Site Documentation for Optical Monitoring Equipment*. The following SOPs and TIs are referenced in this document:

- TI 4050-3010 *Site Selection for Optec LPV-2 Transmissometer Systems*
- TI 4110-3350 *Transmissometer Monitoring System Diagrams and Component Descriptions*
- TI 4110-3375 *Replacing and Shipping Transmissometer Components*
- TI 4115-3000 *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4200-2100 *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*
- SOP 4710 *Transmissometer Field Audit Procedures*

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall review site preparation, installation requirements, and the installation schedule with the project manager.

2.2 PROJECT MANAGER

The project manager shall:

- Review the site preparation, installation requirements, and the installation schedule with the program manager and/or the project-specific Contracting Officer's Technical Representative (COTR) as required.
- Review final site configuration plans presented by the field specialist.
- Schedule the system installation.

2.3 FIELD SPECIALIST

The field specialist shall:

- Review final site preparation and installation plans with the project manager.
- Inform the site-specific local contact of the installation schedule.
- Review the determined site preparation and installation requirements with the local contact, as required.
- Maintain communications with the local contact during site preparation. Verify that all required site preparation is completed prior to installation.
- Verify that all required clearances and permissions relating to the specific site, system installation, and regular servicing have been obtained prior to the installation.
- Schedule and arrange for any on-site assistance needed during the installation.
- Install the transmissometer system according to this TI.
- Complete all site documentation according to this TI.
- Perform all applicable tasks for annual site visits according to TI 4115-3000, *Annual Site Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- Perform an installation field audit according to SOP 4710, *Transmissometer Field Audit Procedures*.
- Schedule an operator training session for all identified operators and conduct the training according to the procedures described in TI 4115-3000.
- Provide completed site documentation to the data analyst.

2.4 DATA ANALYST

The data analyst shall:

- Verify transmission of data from the system upon completion of the installation.
- Enter all site documentation into the Quality Assurance Database.
- File all hard copy site documentation provided by the field specialist.

2.5 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Review site preparation and installation requirements with the field specialist.

- Identify and contact local landowners, land managers, primary contacts, and site operators regarding site installation and routine maintenance requirements.

- Perform or ensure completion of any site preparation required prior to the installation.

- Assist in obtaining any site-, installation-, and regular servicing-related clearances and permits.

- Provide on-site equipment and tools required during the installation.

- As required, provide assistance with the installation.

- Schedule the operator training session with pertinent routine servicing personnel and the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Equipment and materials required to install a transmissometer system include instrumentation, equipment for varying site configurations, tools, informational materials, and documentation materials. Equipment and materials are detailed in the following subsections.

3.1 INSTRUMENTATION

- Installation transmissometer with calibrated lamps

- Audit transmissometer with calibrated lamps

- Programmed data collection platform (DCP) with antenna, antenna cable, and solar panel charging system (if solar-powered site) or AC-trickle charger (if AC-powered site)

- AT/RH sensor with housing and cable

- Strip chart recorder and supplies

- Electronic distance meter (EDM) with mirror assembly and tripods

Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)* for additional required instrumentation.

3.2 EQUIPMENT CONFIGURATIONS

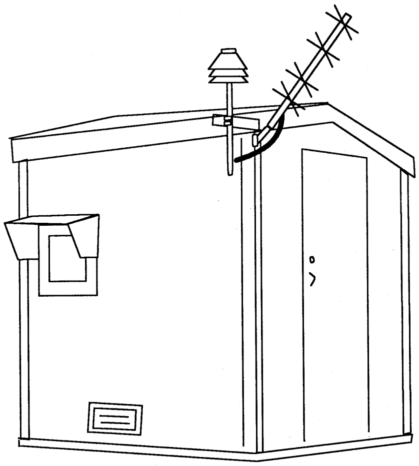
This list will vary depending on individual sites:

- Receiver and transmitter shelters (assembled or disassembled, dependent on site installation constraints). Refer to Figure 3-1 for standard transmissometer shelters.

- Receiver and transmitter mounting posts and alti-azimuth bases.

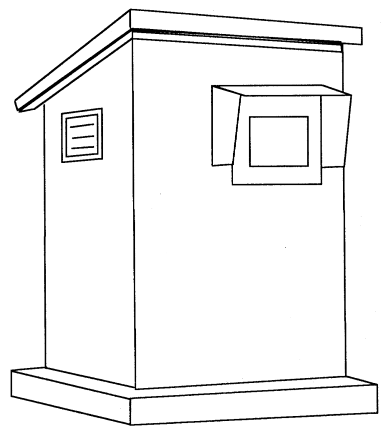
- Window/hood assemblies.

- Terminal strip board.



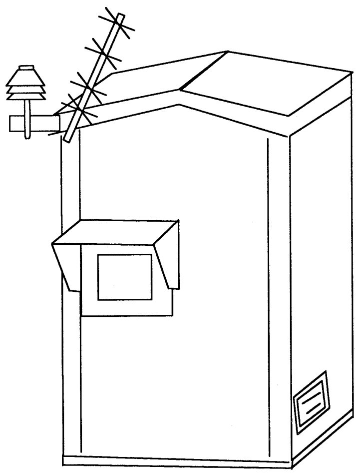
Receiver

6' x 6' x 8' Wood Shelter
Insulated



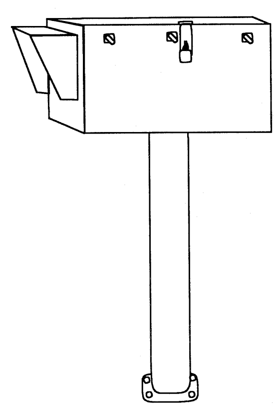
Transmitter or Receiver

3 1/2' x 3 1/2' x 4 1/2' Wood Shelter
Insulated



Transmitter or Receiver

4' x 4' x 8' Wood Shelter
Insulated
Receiver shelter where standard
shelter is too large
Transmitter shelter where outdoor
servicing is difficult (cold weather sites)



Transmitter

Metal Environmental Enclosure
Where space is very limited
and/or
on existing structure

Figure 3-1. Transmissometer Shelter Options.

- Power supplies and/or receiver and transmitter solar panel assemblies with associated wiring and security cables (dependent on AC-power availability and reliability).
- Receiver and transmitter servicing supplies and tool boxes (refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)* and TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*).
- Metal shelves (for large receiver and transmitter shelters).
- Shelter anchor assemblies.
- Deep-cycle batteries with interconnect wiring (solar-powered sites). Batteries are typically purchased locally. Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- Hardware for shelter assembly, mounting post installation, and miscellaneous installation-related tasks.
- Concrete mix (for mounting post piers).
- Caulking.
- Rock/concrete epoxy capsules.
- Surge protector(s) (AC-powered sites).
- Solar panel regulator(s) with connectors (solar-powered sites).
- Dust pans and brushes.
- Broom(s) (for larger shelters).

Refer to TI 4115-3000 for additional equipment needed for on-site tasks.

3.3 TOOLS

Refer to TI 4115-3000, for standard and non-standard tools needed at sites. Additional tools required for installation include the following (these will vary depending on individual site-specific configurations):

- AC or battery jigsaw with wood and metal blades
- AC or battery hammer drill with 5/8" hammer bit
- Hand sledge hammer and 5/8" star drill
- Large pry bar (can usually be borrowed on-site)
- Shovel (can usually be borrowed on-site)

- Wheelbarrow (can usually be borrowed on-site)
- Single-wheel field transport cart
- Caulking gun
- Extension cords
- Staple gun with staples
- Wood saw

3.4 INSTALLATION MATERIALS

Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)* for standard materials needed when at a site. Note that calibration memos for the installation and audit transmissometers will need to be revised when the sight path length has been measured with the electronic distance meter (EDM). The following additional materials should also be taken when installing a site:

- Information documented during the site selection process. Refer to TI 4050-3010, *Site Selection for Optec LPV-2 Transmissometer Systems*.
- Manuals, technical notes, instructions, and other applicable information for the previously listed instrumentation and equipment (Sections 3.1 and 3.2).
- Site Operator's Manual for Transmissometer Monitoring Systems (3 copies).
- TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*.

3.5 SITE DOCUMENTATION MATERIALS

The following materials are generally required to complete the site documentation process:

- TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- Transmissometer Network Servicing Site Visit Trip Report and Data Sheet
- On-site documentation acquired by the field specialist during installation
- Topographic maps of the area
- Ruler and protractor
- Photographs of the sites, shelters, sight path, equipment configurations, etc.

4.0 METHODS

Refer to Figure 3-1, Transmissometer Shelter Options, and Figure 4-1, Monitoring Component Placement, for general diagrams of standard transmissometer shelters and system component placement and configuration.

Refer to TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*, for specific diagrams and descriptions of individual system components.

This section describes site installation and documentation procedures and includes nine (9) major subsections:

4.1 Site Preparation and Communication
4.2 Mounting Post Installation
4.3 Shelter Transportation and Installation
4.4 Line-Power (AC) and Solar Power (DC) System Installation
4.5 Installation of Instrumentation
4.6 Sight Path Distance Measurement
4.7 System Operation Verification
4.8 Operator Training
4.9 Site Documentation and Documentation Archival

4.1 SITE PREPARATION AND COMMUNICATION

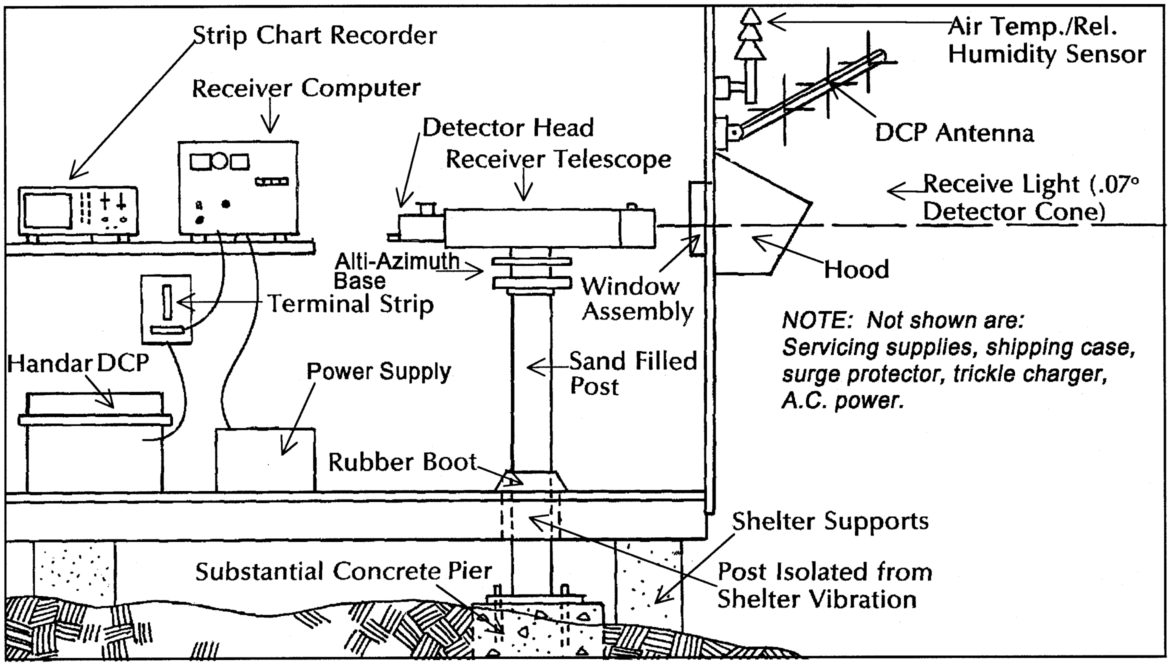
Prior to any installation visit:

- Review the determined site preparation and installation requirements with the local contact.
- Schedule all site preparation activities.
- Maintain communications with the local contact during site preparation. Verify that all required site preparation is completed prior to the installation.
- Document the primary site operator(s) and backup operator(s).
- Obtain permission from private or public landowners to access the monitoring location for installation and training.
- Schedule the site installation visit and operator training session. (Typically an installation will require approximately 3-4 on-site work days. Training should be scheduled in the latter part of the week when the system is fully installed and operational).
- Arrange for any necessary installation assistance, as well as tools and/or equipment (e.g., shovels, wheelbarrow, water containers).

Once on-site:

- Inspect any site preparation that has been done.

Receiver Station
(6'x 6'x 8')



Transmitter Station
(3'x3'x4'6")

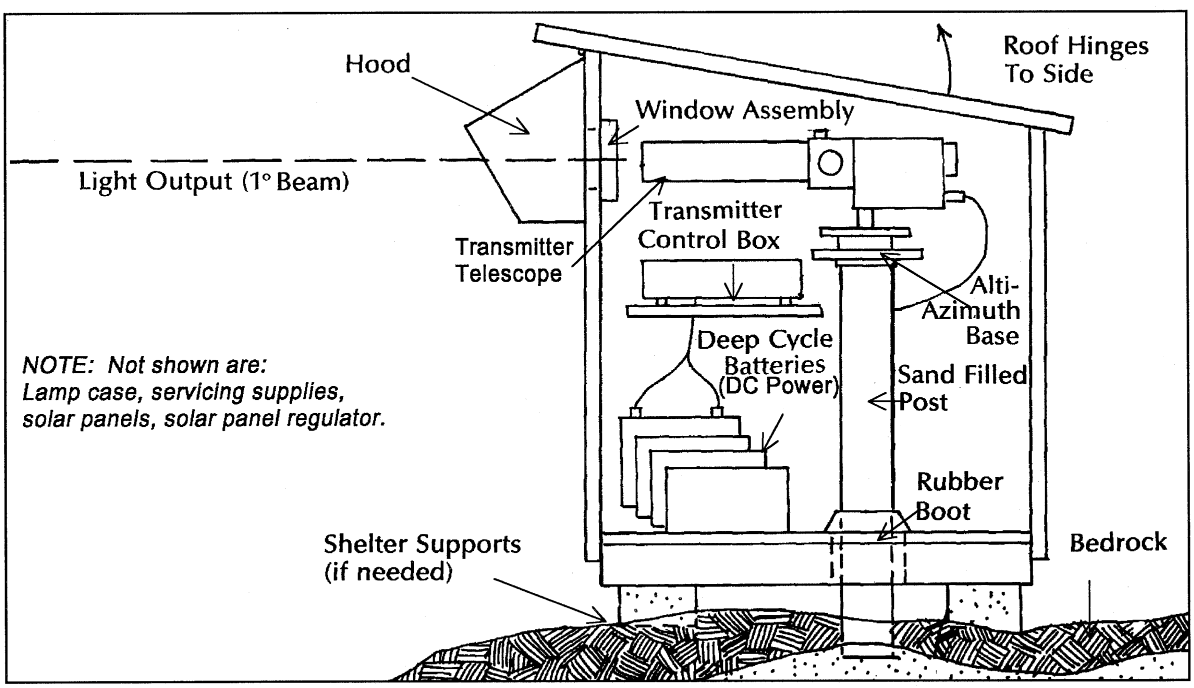


Figure 4-1. Monitoring Component Placement.

- Verify that all shipped items have arrived in good condition.
- Verify the proposed installation configuration and scheduling for the operator training session with on-site personnel.

4.2 MOUNTING POST INSTALLATION

Continuous, correct transmitter and receiver telescope alignment is critical for proper transmissometer operation. The transmitter and receiver mounting posts must be installed in such a manner that any movement due to earth movement, temperature fluctuations, vibration, etc. is minimized. The procedures for mounting post installation depend on the type of surface material to which the post is mounted. Mounting posts can be attached to pre-existing rock or concrete surface, to a concrete pier in the soil, or to a concrete pad.

ATTACHMENT TO PRE-EXISTING ROCK OR CONCRETE SURFACE

Typically, it is most convenient to use ½" diameter bolts with concrete/rock inserts. If the mounting surface is uneven, use threaded rods instead of bolts; this method allows leveling of the post. In cases where the rock or concrete is not strong enough for inserts to seat securely, rock/concrete epoxy capsules should be used with threaded rod sections. Refer to Figure 4-2, Mounting Post Configuration on Pre-Existing Concrete/Rock Surface, for diagrams of these various mounting methods.

ATTACHMENT TO CONCRETE PIER IN SOIL

The hole size and amount of concrete used may vary depending on the type of soil and ease of hole excavation. Typically, a concrete pier should be approximately 1.5 feet in diameter and 2 feet deep. J- (foundation) bolts of ½" diameter are set into the wet concrete with a wood template. Approximately 8 to 12 hours are usually required before the concrete is firm enough for post-attachment. Refer to Figure 4-3, Mounting Post Configuration in Concrete Pier in Soil Surface, for a diagram of a typical concrete pier and post attachment configuration. Leveling of the post is achieved by adjustment of the lower set of nuts.

ATTACHMENT TO CONCRETE PAD

Concrete pad installations are normally performed on roof surfaces or at locations where the ground surface cannot be altered or where other post attachment methods are impractical.

Due to the weight, it is advisable to pour the concrete pad after the form has been placed at the installation site. Pad size will vary according to individual site constraints and configurations. If a small shelter is to be used, the pad is typically large enough to support the shelter.

Refer to Figure 4-4, Mounting Post Configuration on Concrete Pad, for diagrams of a typical concrete pad form and bolt attachment. If a shelter is to be attached to the pad, additional bolts are required.

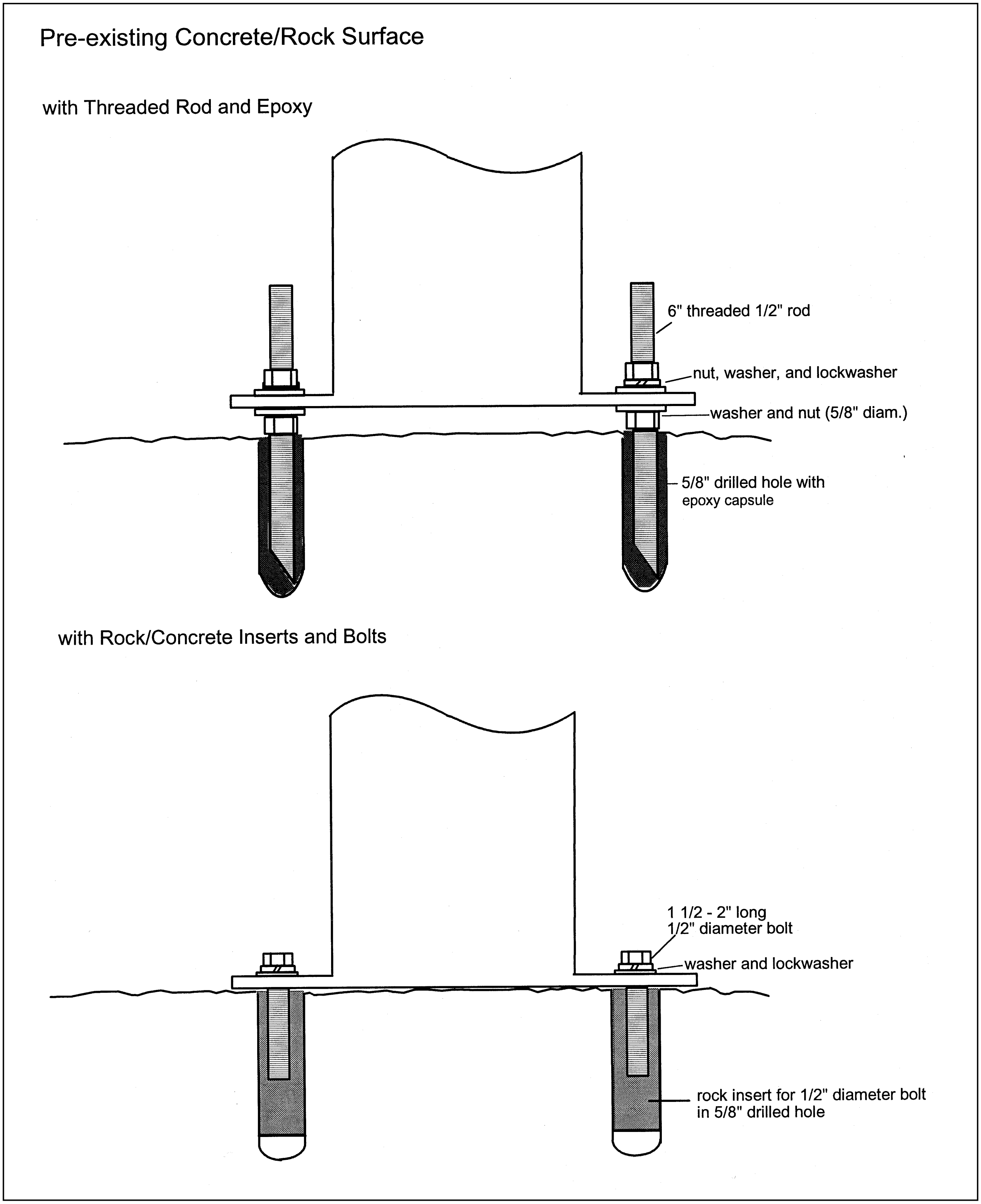


Figure 4-2. Mounting Post Configuration on Pre-Existing Concrete/Rock Surface.

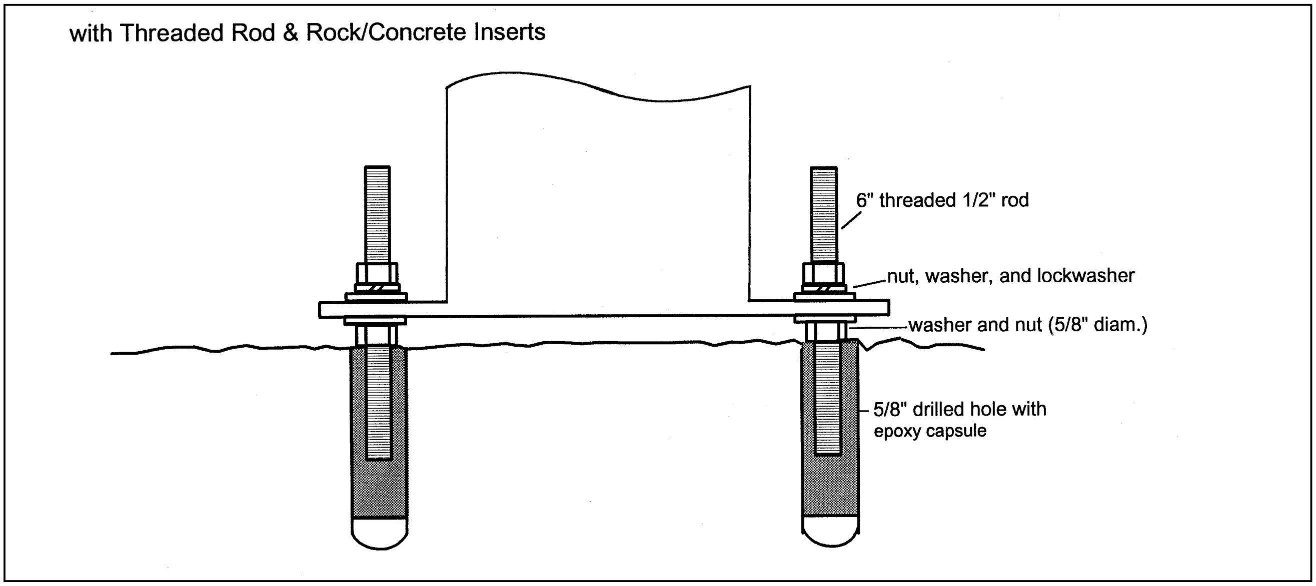


Figure 4-2. (Continued) Mounting Post Configuration on Pre-Existing Concrete/Rock Surface.

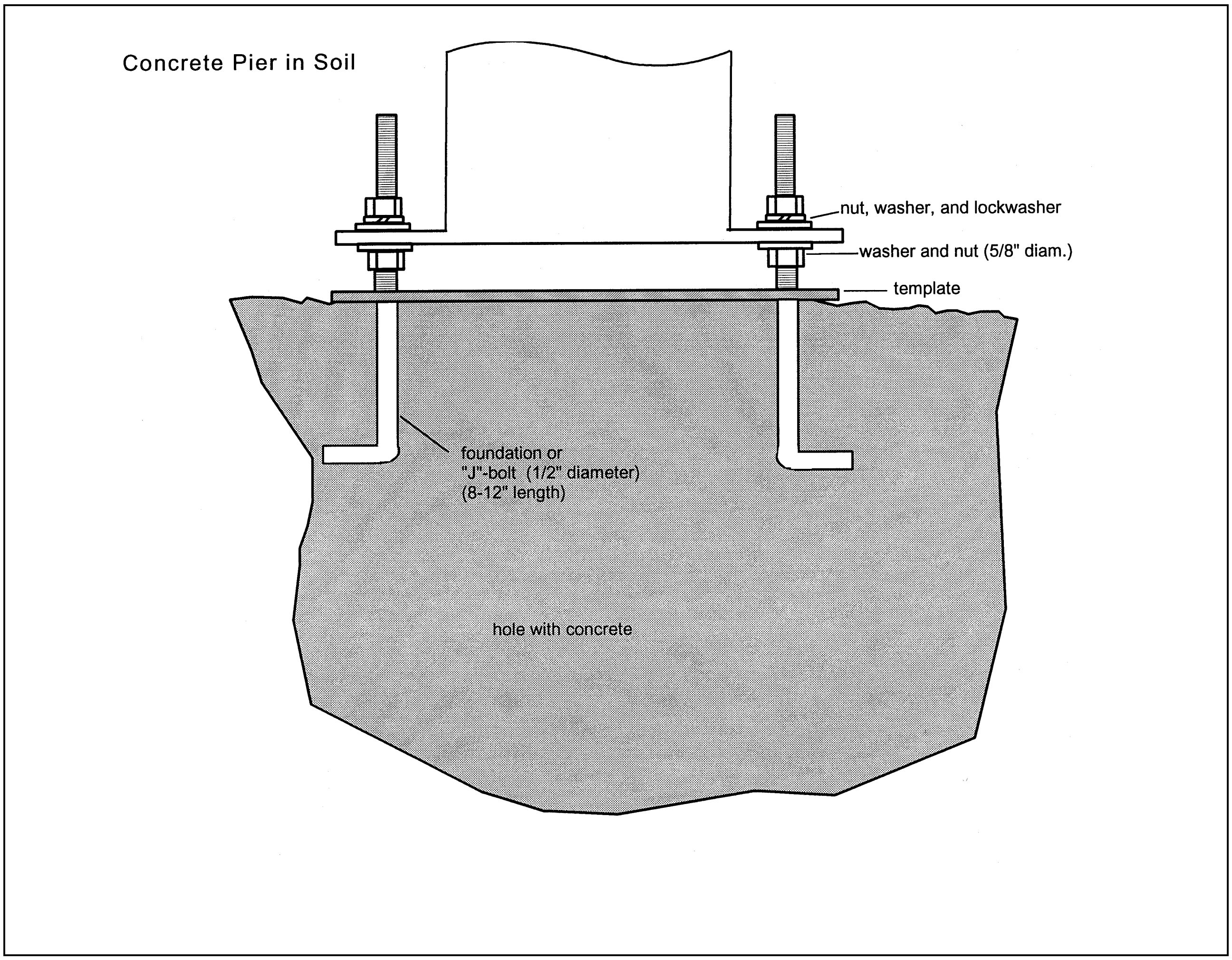


Figure 4-3. Mounting Post Configuration on Concrete Pier in Soil Surface.

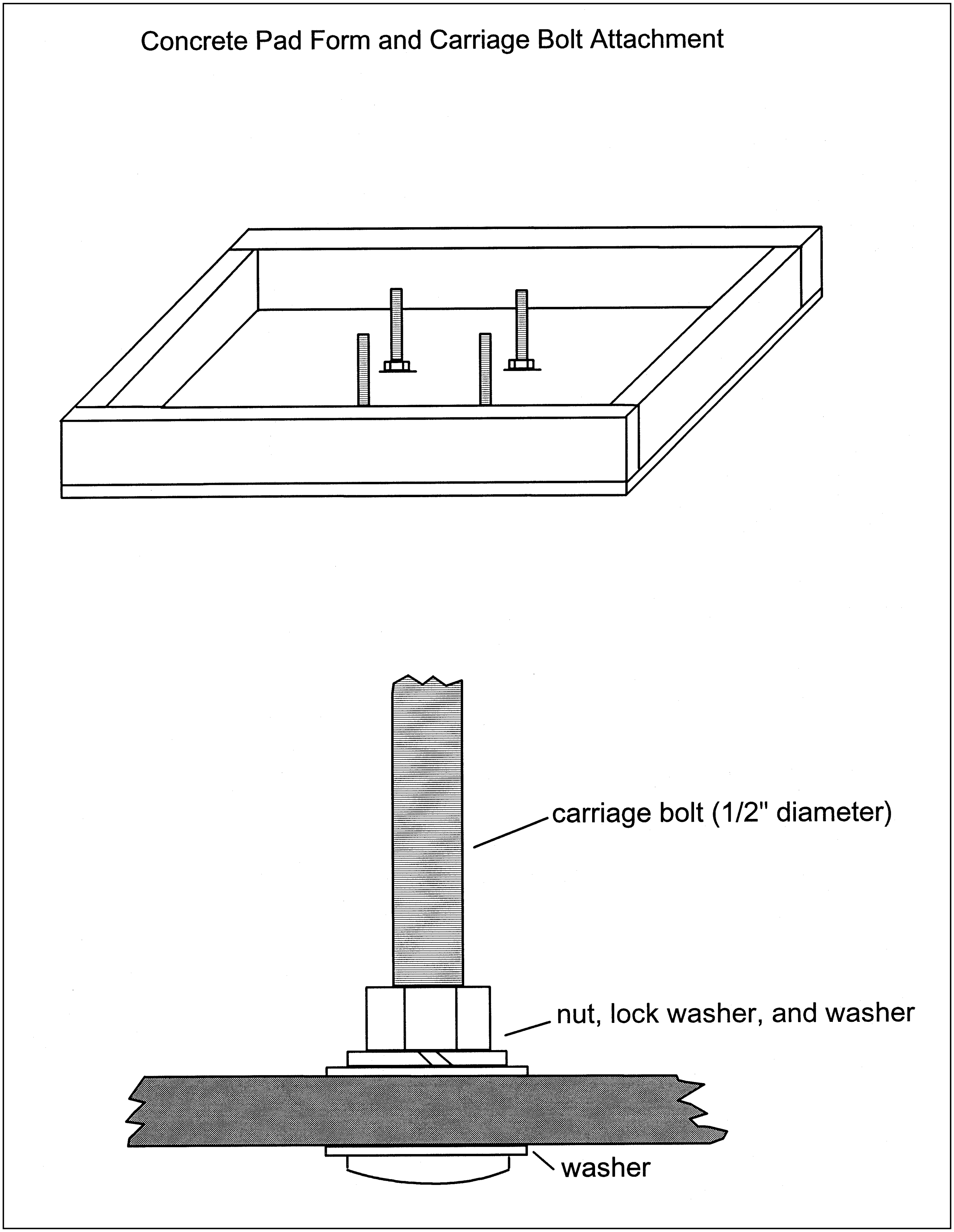


Figure 4-4. Mounting Post Configuration on Concrete Pad.

4.3 SHELTER TRANSPORTATION AND INSTALLATION

SHELTER TRANSPORTATION

The method(s) of long-distance and on-site transportation of transmissometer shelters depend on the following factors:

- Type(s) of shelter(s)
- Disassembled or assembled shelter(s)
- Distances
- Shipping (trucking) company limitations
- Site accessibility

Large shelters are usually transported by trailers or, if disassembled, can also be shipped with trucking companies. Small shelters can be transported by truck, trailer, or be shipped.

On-site transportation of the shelters to the installation locations is primarily dependent on site accessibility. If vehicle access to the site is not possible, the shelters or disassembled sections can be transported by carrying, handcart, or wheeled trail transport cart. If site access is very difficult, use of a helicopter should be considered.

SHELTER INSTALLATION

The general procedures for shelter installation are as follows:

- Verify that preparations for attachment of the instrument mounting post have been completed.
- Place the shelter (or shelter floor section, if disassembled) on concrete blocks or piers. Verify that the floor is level and that the shelter correctly oriented with respect to the transmitter sight path.
- Assemble the shelter (if disassembled) and attach the window/hood assembly.
- Install the instrument mounting post. Verify that there is at least ½" clearance between the post and the edge of the shelter floor hole to ensure that shelter vibration is not transferred to the post and instrument.

A rubber boot is placed around the post and attached to the floor to prevent dust, insects, snow, rodents, etc. from entering the shelter. Adjust post height for correct instrument/window alignment and fill the post with sand to minimize post movement due to thermal contraction/expansion.

- Anchor the shelter to the ground with eyehooks, turnbuckles, and the appropriate ground attachment method. The method of attaching the anchor assembly depends on the ground surface type. These are outlined as follows:

  - Soil (clay, sand, silt, etc.) - Use soil screw anchors (length of anchor is dependant on hardness of soil).

  - Rocky soil or soil too hard for screw anchors - Use steel construction stakes.

  - Rock - Use rock/concrete inserts similar to the type used for mounting post attachment to rock/concrete.

  - Concrete - The shelter can be directly attached to the concrete using the above-mentioned rock/concrete inserts and bolts.

4.4 LINE-POWER (AC) AND SOLAR POWER (DC) SYSTEM INSTALLATION

Refer to Figures 4-5 and 4-6, Receiver Station and Transmitter Station Line Power (AC) Configuration Diagrams, and Figures 4-7 and 4-8, Receiver Station and Transmitter Station Solar Power (DC) Configuration Diagrams, for diagrams of standard power system configurations and related components. Diagrams and descriptions of individual components are contained in TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*.

LINE-POWER (AC) SYSTEM INSTALLATION

Install the various components according to Figures 4-5 and 4-6, Receiver Station and Transmitter Station Line Power (AC) Configuration Diagrams. Also refer to TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions* and component-specific installation/operation instructions.

Power system components should be installed in such a manner that servicing checks and/or maintenance procedures can easily be performed.

SOLAR-POWER (DC) SYSTEM INSTALLATION

Refer to Figure 4-9, Solar Panel Array Installation Configurations, for photographs of standard solar panel array installation configurations. Guidelines for the selection of array mounting configurations are contained in TI 4050-3010, *Site Selection for Optec LPV-2 Transmissometer Systems*.

The standard receiver station solar panel array is comprised of two large Solarex SX-56 solar panels which charge the four NAPA Group 27 deep-cycle batteries that provide receiver system power. A third smaller Solarex SX-10 solar panel provides power to the data collection platform (DCP).

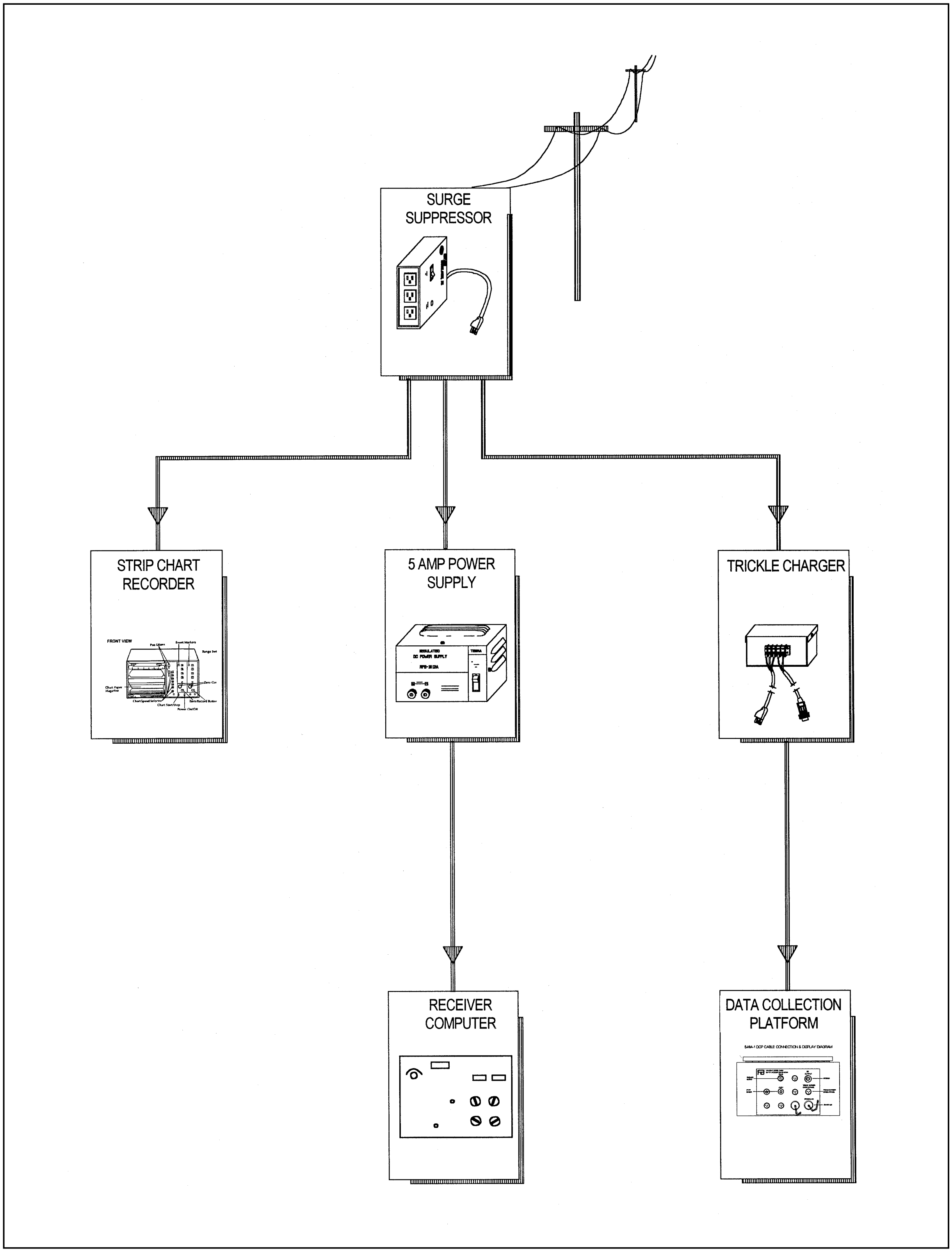


Figure 4-5. Receiver Station Line Power (AC) Configuration Diagram.

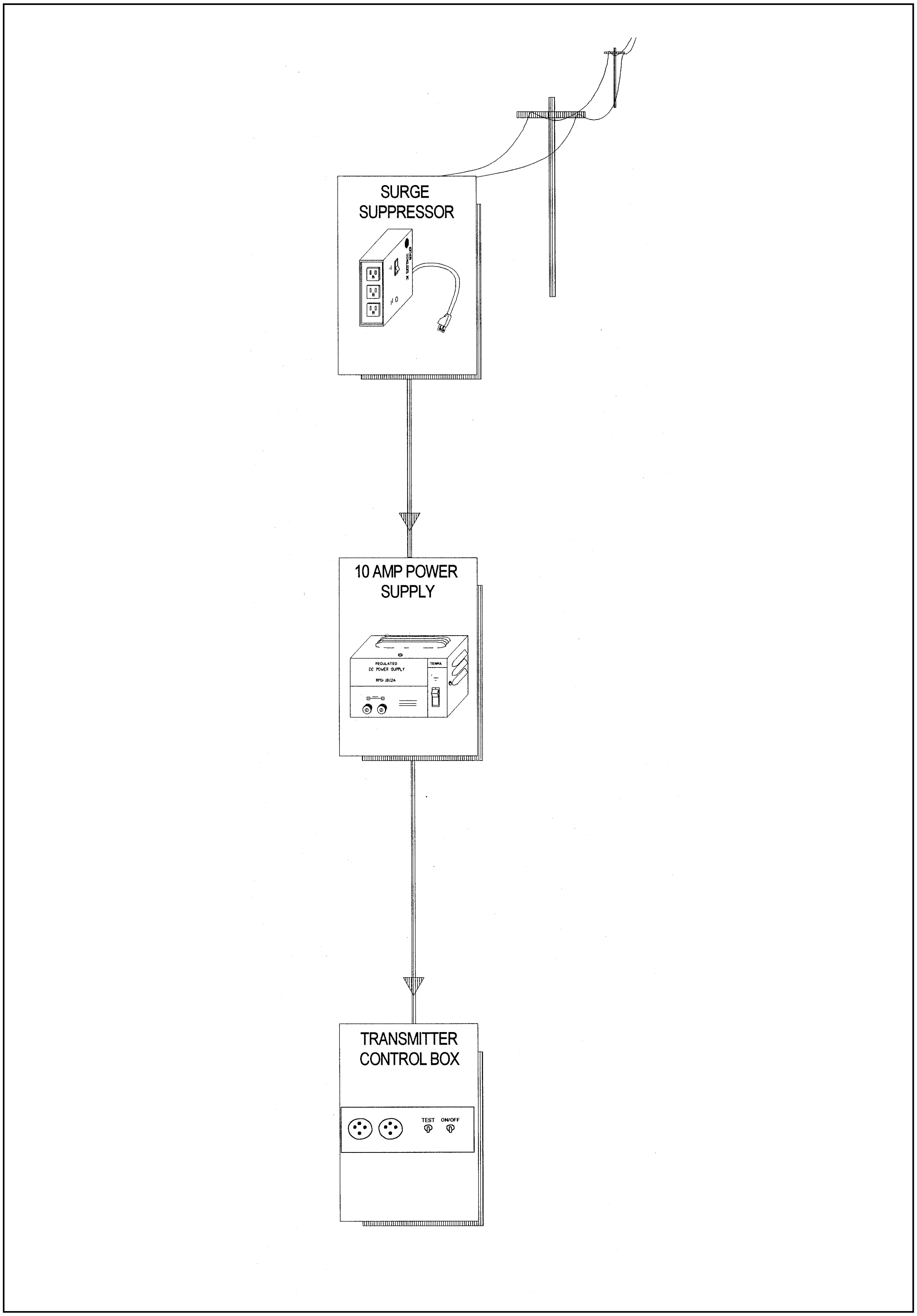


Figure 4-6. Transmitter Station Line Power (AC) Configuration Diagram.

The standard transmitter station solar panel array is comprised of three large Solarex SX-56 solar panels which charge the four NAPA Group 27 deep-cycle batteries that provide transmitter system power.

Install the various components according to Figures 4-7 and 4-8, Receiver Station and Transmitter Station Solar Power (DC) Configuration Diagrams. Also refer to TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions* and component-specific installation/operation instructions.

A security cable should be run through the solar panel frames and secured inside the shelter to deter theft of the panels.

Install the four deep-cycle batteries and interconnect wiring according to TI 4110-3350.

4.5 INSTALLATION OF INSTRUMENTATION

Refer to TI 4110-3350 for depictions of the various instruments and related equipment and standard installation configurations. Installation procedures for transmissometer components, data collection platform (DCP), strip chart recorder, and air temperature/relative humidity (AT/RH) sensor are described in TI 4110-3375, *Replacing and Shipping Transmissometer Components*.

TRANSMITTER AND RECEIVER ALTI-AZIMUTH BASE INSTALLATION

Attach the transmitter and receiver alti-azimuth bases to the respective mounting posts. Verify that there is adequate horizontal adjustment tension when the transmitter and receiver telescopes are properly aligned. Non-level sight paths may require placing washers underneath the front or back portions of the bases to ensure proper vertical alignment adjustment.

TERMINAL STRIP INSTALLATION (RECEIVER SHELTER)

Attach the terminal strip to the shelter wall close to where the receiver computer, strip chart recorder, and data collection platform (DCP) will be located. Ensure that the terminal strip is readily accessible for servicing checks.

AT/RH SENSOR INSTALLATION (RECEIVER SHELTER)

The AT/RH sensor should be mounted close to the roofline of the shelter and be far enough from the roof (or any other surface) to provide representative ambient AT/RH measurements. The AT/RH cable is routed from the sensor into the shelter and connected to the DCP. If possible, install the sensor near the DCP antenna in order that both cables can be routed into the shelter together.

Refer to TI 4110-3375, *Replacing and Shipping Transmissometer Components*.

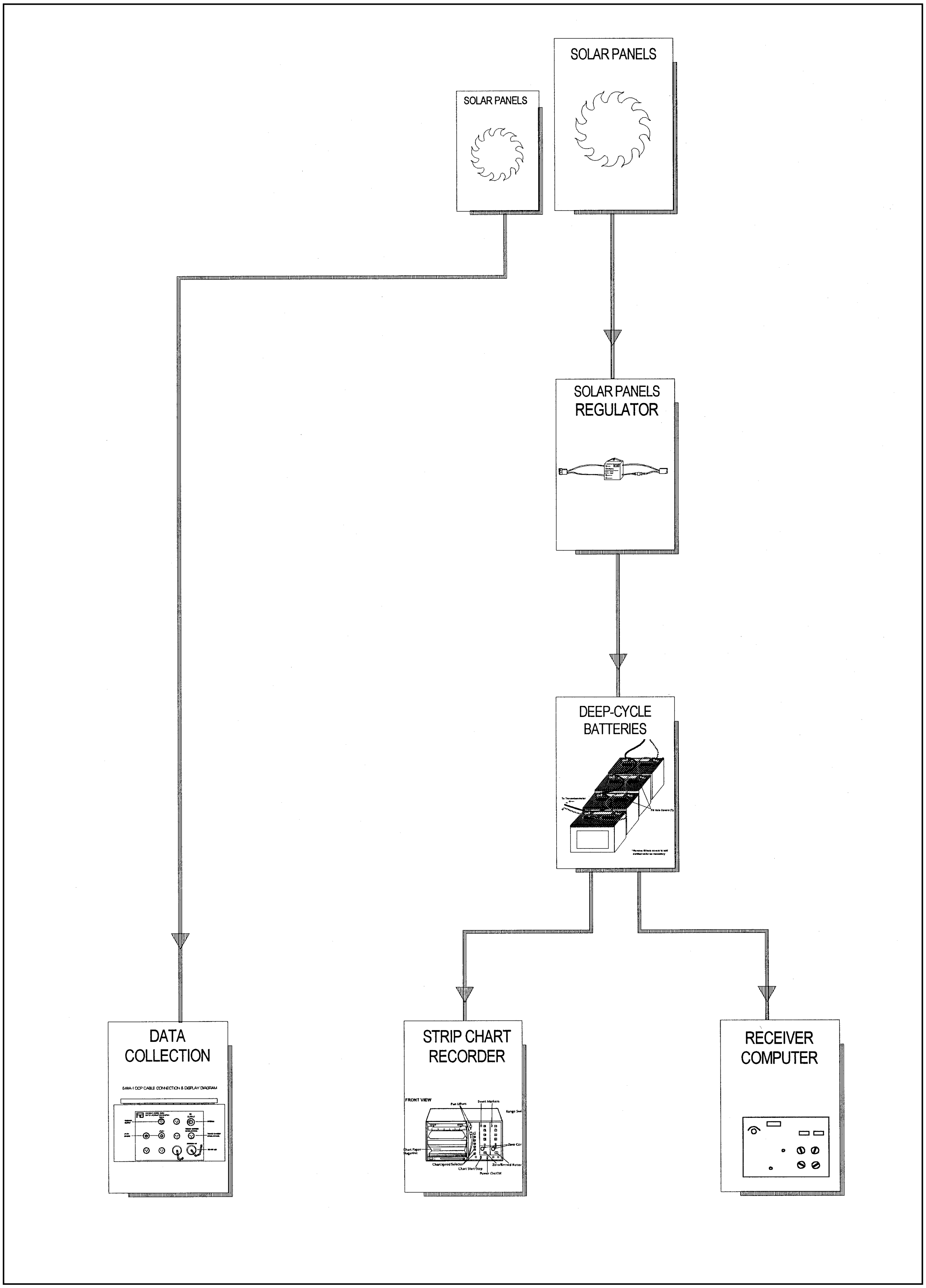


Figure 4-7. Receiver Station Solar Power (DC) Configuration Diagram.

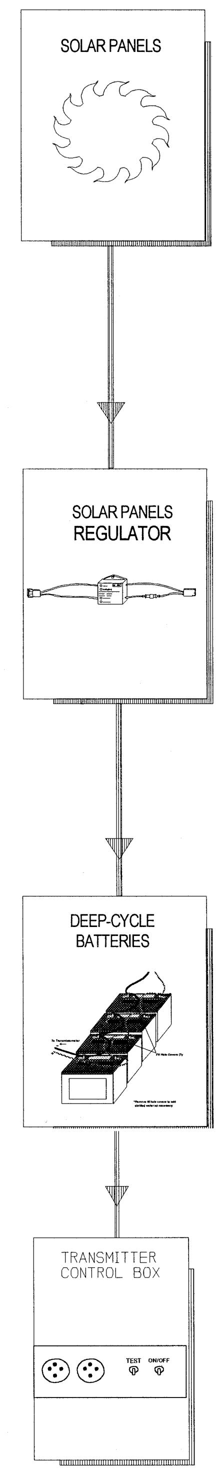
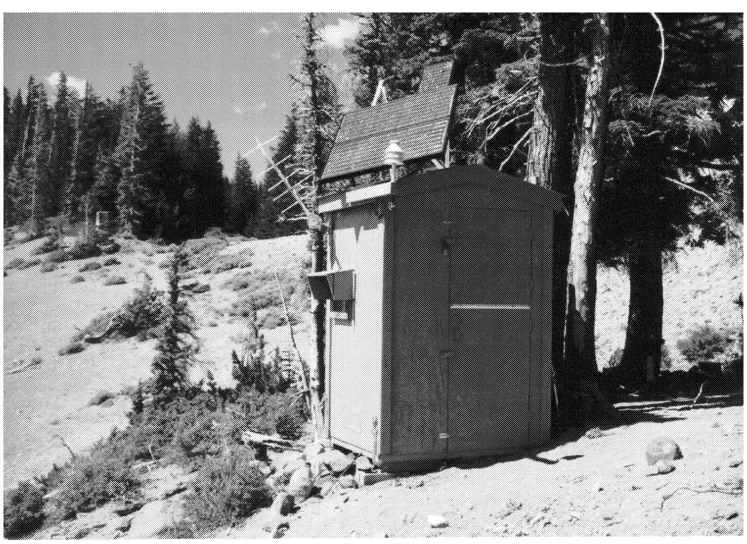


Figure 4-8. Transmitter Station Solar Power (DC) Configuration Diagram.

Free-standing
Solar Array

Shelter
Wall-mounted
Solar Array



Shelter
Roof-mounted
Solar Array

Figure 4-9. Solar Panel Array Installation Configurations.

DCP AND ANTENNA INSTALLATION (RECEIVER SHELTER)

Mount the DCP antenna near the roofline of the shelter. If possible, the antenna should be near the AT/RH sensor in order that both cables can be routed into the shelter together. Antenna installation and orientation specifications and procedures are outlined in the Handar DCP Operating and Servicing Manual for each model of DCP (Handar, 1983, 1986, and 1988). Install the DCP according to the procedures described in Section 4.4, Line Power (AC) and Solar Power (DC) System Installation, and TI 4110-3375, *Replacing and Shipping Transmissometer Components*.

TRANSMISSOMETER INSTALLATION

Install the transmitter and receiver unit components according to the procedures described in TI 4110-3375.

STRIP CHART RECORDER INSTALLATION (RECEIVER SHELTER)

Install the strip chart recorder according to the procedures described in TI 4110-3375.

GENERAL INSTALLATION GUIDELINES

General guidelines during the placement and installation of instrumentation, related equipment, and supplies are as follows:

- Place items in an orderly, space-efficient manner.
- Group related items/instrumentation together.
- Ensure that all instrument displays/indicators are easily and clearly visible.
- Ensure that all switches, dials, etc., are labeled and clearly visible, and easily accessible.
- Ensure that all connectors/connections are labeled and easily accessible.
- In larger shelters, install a shelf for storage of miscellaneous items.
- Upon installation, verify correct operation of each system component. Operation verification for the entire system is performed after measurement of the sight path distance.
- Secure excess and/or loose wiring with wire ties.
- Caulk any shelter holes or cracks around the window/hood assembly, etc. to prevent dust, precipitation, insects, etc. from entering the shelter.

4.6 SIGHT PATH DISTANCE MEASUREMENT

Measurement of the sight path distance is made with the electronic distance meter (EDM). Refer to the EDM operating manual (Hewlett Packard) for operational procedures.

The distance measurement is made from the front of the receiver telescope tube to the front of the transmitter telescope tube. The measurement should be repeated at least three times.

Once the distance measurement has been made, the distance is communicated to the project manager in order that the transmissometer calibration numbers can be recalculated using the accurate distance value.

The recalculated calibration numbers are communicated to the on-site field specialist, and the correct calibration number is dialed in on the receiver computer.

4.7 SYSTEM OPERATION VERIFICATION

Once the instrument settings and system timing have been set at the transmitter and receiver, system operation can be verified. Operation verification and documentation is performed according to the procedures described in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*. Also, all other pertinent operational- and servicing-related tasks and procedures are performed as described in the afore-mentioned TI 4115-3000.

4.8 OPERATOR TRAINING

Upon completion of the installation and system operation verification, all operators, back-up operators, and any other involved or interested on-site personnel are trained according to the procedures outlined in TI 4115-3000. The Site Operator's Manual for Transmissometer Monitoring Systems is reviewed and a copy left at both transmitter and receiver sites. The third copy is to be kept at the office of on-site personnel.

4.9 SITE DOCUMENTATION AND DOCUMENTATION ARCHIVAL

ON-SITE DOCUMENTATION

On-site documentation is performed by the field specialist as follows:

- Completion of the Transmissometer Network Servicing Site Visit Trip Report and Data Sheet
- Photographic documentation of the following:
  - Shelters, various views
  - Windows and hoods
  - Antenna with mount
  - AT/RH sensor with mount

- Shelter supports and mounting post attachments
- Sight path, receiver to transmitter, and transmitter to receiver, at various zoom settings (35 mm, 50 mm, 135 mm)
- Shelter interior configurations/layouts
- Computer and strip chart
- Terminal strip board
- Receiver and transmitter telescopes on mounts
- DCP and associated wiring
- Batteries and solar panel regulator (solar-powered sites)
- Power supply and surge protector (line-powered sites)
- Solar panels (solar-powered sites)

• Documentation of miscellaneous information necessary to complete the Transmissometer Site Description Sheet and the Site Map and Site Specifications Sheet. Refer to Figure 4-10, Example Transmissometer Site Description Sheet and Figure 4-11, Example Site Map and Site Specifications Sheet.

POST-INSTALLATION TRIP SITE DOCUMENTATION AND ARCHIVAL

Within one week after return from the installation trip, the following documentation is completed:

• Completion of the Transmissometer Site Description and the Site Map and Site Specifications Sheets

• Developing of all film from site photographic documentation

Upon completion of this documentation, post-visit procedures, as described in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol),* are performed. Additional procedures, not described in these post-visit procedures are performed as follows:

• Archival of the Transmissometer Site Description and the Site Map and Site Specifications Sheets in site-specific operations files located in the ARS data collection center

• Organization and filing of the site photographic documentation by the data analyst

TRANSMISSOMETER SITE DESCRIPTION
GRAND CANYON NATIONAL PARK
(IN-CANYON SIGHT PATH)

Site Location - Grand Canyon National Park is located approximately 100 km north of Flagstaff, Arizona. The transmissometer is located approximately 20 km east of the park headquarters, along the east rim drive (State Highway 64).

Operational Period -
- Installation Date: December 13, 1989
- Removal Date: Ongoing

Receiver Station - Located on the canyon rim, adjacent to the north corner of the Yavapai Museum.

Transmitter Station - Located at the bottom of the canyon at the north edge of Phantom Ranch, adjacent to water tank.

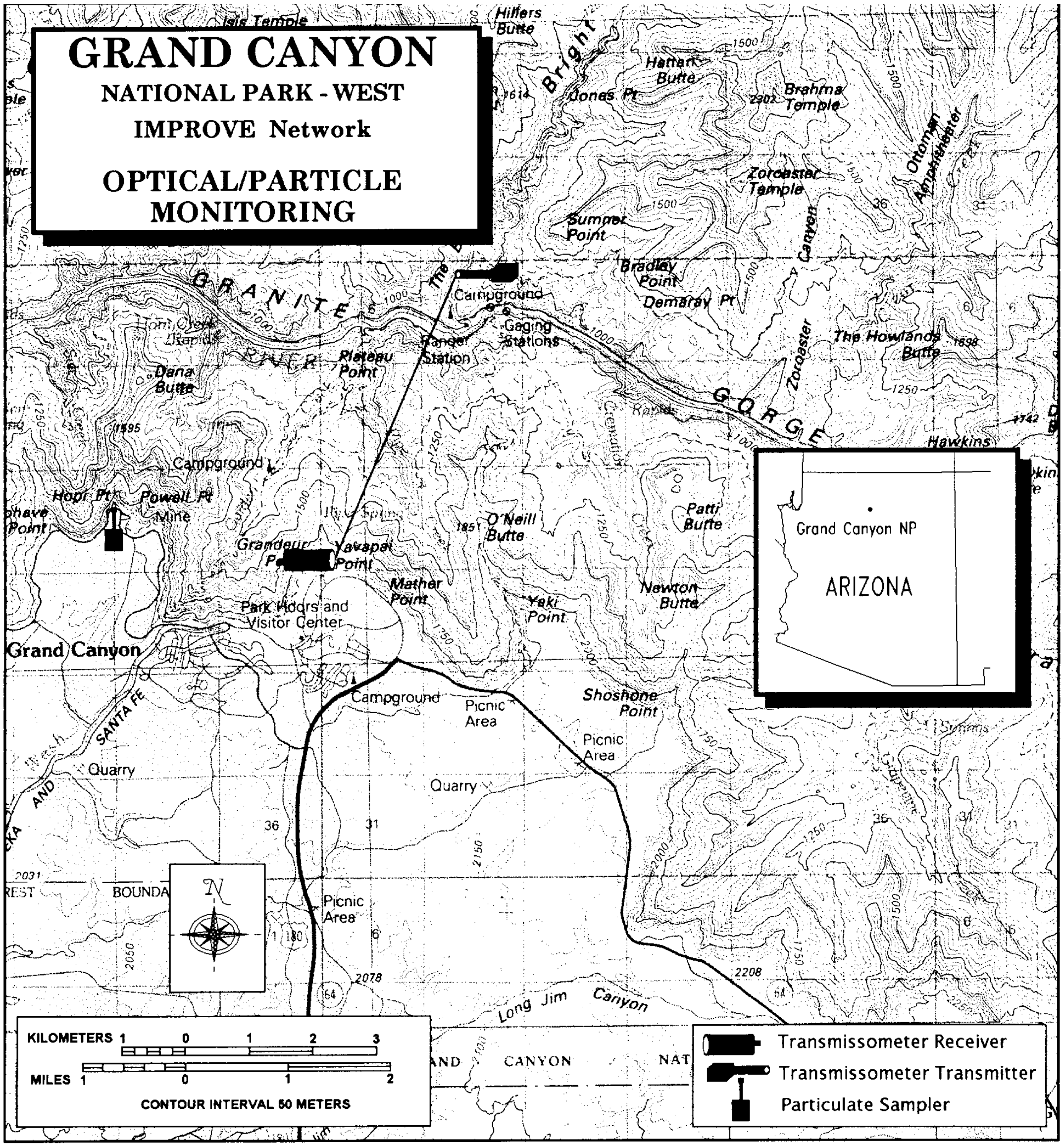
Power -
- Receiver Station: Line power
- Transmitter Station: Line power

Sight Path - Elevation angle approximately -16° from receiver to transmitter. Elevation difference between receiver and transmitter is 1390 meters. Beam height is well above terrain features along the entire path.

Siting Constraints -
- Operator Site Access Considerations: Availability of site operators at transmitter site.
- Power Considerations: AC line power required on canyon floor.
- Terrain Considerations: Few sight paths from the rim to the canyon floor exist.

SITE FACTORS POTENTIALLY AFFECTING TRANSMISSOMETER READINGS	
FACTOR	**EFFECT ON DATA/OPERATION**
Power outages at receiver due to lightning hits near the power line.	Receiver operation interrupted during power outages. Transmissometer data are not available for these periods.

Figure 4-10. Example Transmissometer Site Description Sheet.



SITE SPECIFICATIONS

Transmissometer

Site Abbreviation: GRCW

Receiver

Elevation: 2145 m
Longitude: 112° 07' 00"
Latitude: 36° 03' 59"
Bearing: 205°

Transmitter

Elevation: 755 m
Longitude: 112° 05' 35"
Latitude: 36° 06' 23"

Site Path

Mean Elevation: 1450 m
Elevation Angle: -15.78°
Distance: 5.1103 km

Particulate Sampler

Site Abbreviation: GRCA1

Elevation: 2164 m
Longitude: 112° 09' 14"
Latitude: 36° 03' 57"

Map Reference: Tuba City, Cameron, Valle, - Arizona (1:100,000)

Figure 4-11. Example Site Map and Site Specification Sheet.

5.0 REFERENCES

Handar, Inc., May 1983, Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545 Programming Set.

Handar, Inc., September 1986, Operating and Service manual for 540A-1 Multiple Access Data Acquisition System, 560A Data Collection System, 570A Expandable Hydromet Data Acquisition System.

Handar, Inc., March 1988, 570A Data Acquisition System Operating and Service Manual.

Hewlett Packard, The HP 3808A Medium Range Distance Meter.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER MAINTENANCE (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4110**
DATE	**OCTOBER 1993**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor text changes	August 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines and describes the components of a comprehensive program for operating and maintaining the Optec LPV-2 transmissometer. The purpose of this program is to provide detailed operations and maintenance procedures that will assure quality data capture and minimize data loss.

The LPV-2 transmissometer is manufactured by Optec, Inc. The instrument has evolved to its present configuration as a result of the visibility monitoring needs defined by the National Park Service (NPS) Visibility Monitoring and Data Analysis Program and the Interagency Monitoring of Protected Visual Environments (IMPROVE) Committee.

The LPV-2 meets the following criteria:

- Measures the light transmission properties of the atmosphere both day and night at 550 nanometers or other preselected wavelengths.
- Provides a variety of sampling and averaging options.
- Directly integrates scattering and absorbing properties of aerosols and gases in the selected sight path; these transmission measurements have an exact relationship to the total atmospheric extinction coefficient.
- Operates unattended for extended periods.
- Operates at low power, 12-volt D.C. for remote and solar installations.
- Operates at ambient temperatures.
- Is modular, lightweight, and easily transported.
- Is easily serviced.

The first LPV-2 was installed in August 1986. Since that time, the instrument has become the standard against which other visibility monitoring techniques have been compared.

The Optec LPV-2 transmissometer measures the ability of the atmosphere to transmit light of a specific wavelength (generally 550 nm, green). It accomplishes this by continuously measuring the loss in light received from a light source of known intensity as the light beam travels a known distance. Unlike nephelometers, which only measure the scattering component of total extinction at a point source, the LPV-2 measures total extinction by integrating the light scattering and absorbing properties of the atmosphere along a selected sight path.

The LPV-2 transmissometer has two primary components: a light source (transmitter), and a light detector (receiver). Depending on the expected range of visual air quality, the two components are generally placed from 0.5 to 10 kilometers apart. The system can take measurements day and night because the light emitted from the transmitter is "chopped" at 78 pulses a second to allow the receiver to differentiate the lamp signal from background, ambient lighting. The receiver-measured transmitter light intensity is compared to the known (calibrated) transmitter light output to calculate the percent transmission of the atmosphere. When the path distance is supplied, the receiver computer can calculate the express visibility measurements in terms of extinction (km^{-1}) or visual range (km).

The LPV-2 transmissometer system's low power consumption permits remote operation from a small supply, such as a solar power system. Both components have self-resetting, battery-backup circuitry to accommodate extended periods of unattended operation. Both components operate at ambient temperatures, but require sheltering from precipitation and dirt. Routine servicing of the system can be performed by trained, non-technical personnel. Instrument calibration, generally performed annually, and repair requires trained technical personnel or factory-authorized service.

The Optec LPV-2 operations and maintenance quality assurance program consists of four (4) major categories:

- Routine Site Operator Maintenance
- Troubleshooting and Emergency Maintenance
- Annual Site Visit
- Annual Maintenance

Detailed descriptions of the procedures to be followed in performing specific maintenance tasks referenced in this SOP are provided in the following SOPs and technical instructions (TIs):

- TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*
- TI 4110-3375, *Replacing and Shipping Transmissometer Components*
- TI 4110-3400, *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- SOP 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*
- TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- SOP 4710, *Transmissometer Field Audit Procedures*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Oversee the activities of the data coordinator, instrument technician, and field specialist.
- Oversee and review site operator documentation.
- Oversee and review instrument maintenance records.
- Review routine and emergency maintenance and troubleshooting plans with the data coordinator, field specialist, and instrument technician as required.
- Review and approve any changes to maintenance procedures.

2.2 DATA COORDINATOR

The data coordinator shall:

- Coordinate site operator activities and schedules.
- Review site operator documentation.
- Provide technical support to the site operator.
- Initiate emergency maintenance and troubleshooting plans in response to transmissometer system malfunctions.
- Coordinate replacement of malfunctioning equipment.
- Document all communications with the site operator.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform annual servicing of transmissometers and associated support equipment.
- Repair damaged or malfunctioning transmissometers and associated support equipment.
- Maintain an inventory of spare parts and servicing supplies.
- Provide technical support to the site operator and data coordinator and/or field specialist.
- Document all service and repair work performed to transmissometers and transmissometer system support equipment.

2.4 FIELD SPECIALIST

The field specialist shall:

- Coordinate maintenance schedules with the project manager, data coordinator, and site operator.

- Provide technical support to the site operator and/or data coordinator as required.
- Perform field repair or replacement of transmissometer system components.
- Train the site operator in routine and emergency maintenance procedures.

2.5 SITE OPERATOR

The site operator shall:

- Perform routine transmissometer system service and maintenance tasks.
- Perform troubleshooting and emergency maintenance tasks as directed by the data coordinator or field specialist.
- Document all on-site service, troubleshooting and maintenance work performed.

3.0 REQUIRED EQUIPMENT AND MATERIALS

ARS will maintain a sufficient inventory of spare components and repair parts to accommodate routine and emergency maintenance of the Optec LPV-2 transmissometer and associated support equipment.

3.1 ROUTINE MAINTENANCE

Routine maintenance requires a small set of standard mechanical tools (screwdrivers, wrenches, etc.), a 3 1/2 digit digital voltmeter, and cleaning supplies. A detailed list of equipment and materials for routine maintenance is provided in TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

3.2 TROUBLESHOOTING AND EMERGENCY MAINTENANCE

Troubleshooting and emergency maintenance normally requires the same equipment and materials as routine maintenance. Certain troubleshooting tasks may require specialized test fixtures or test instruments. These items are sent to the site operator on an as needed basis.
A detailed list of equipment and materials for troubleshooting and emergency maintenance of the LPV-2 transmissometer system are provided in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

3.3 ANNUAL LABORATORY MAINTENANCE

Annual laboratory maintenance requires a well-equipped electronics laboratory, an optical bench and associated optical fixtures, and a field test facility. A detailed list of equipment and materials needed for laboratory maintenance is provided in TI 4110-3400, *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

3.4 INVENTORY

It is imperative that all capital instrumentation changes made as a result of routine and annual maintenance be thoroughly documented and maintained in the ARS Purchase Order/Inventory Database. Specific model and serial number items tracked are discussed further in the instrument-specific troubleshooting and emergency maintenance TIs.

4.0 METHODS

This section includes five (5) major subsections:

4.1 Description of Transmissometer Components
4.2 Routine Site Operator Maintenance
4.3 Emergency Maintenance and Troubleshooting
4.4 Annual Site Visit
4.5 Annual Laboratory Maintenance

Each transmissometer site is supplied with a *Site Operator's Manual for Transmissometer Monitoring Systems*. This manual includes SOPs and TIs applicable to site operator maintenance and manufacturer's instruction manuals for the LPV-2 transmissometer and associated support equipment.

4.1 DESCRIPTION OF TRANSMISSOMETER COMPONENTS

The LPV-2 transmissometer has two primary components: a light source (transmitter), and a light detector (receiver). Additional instrumentation and support equipment provided at transmissometer sites in the IMPROVE network generally includes:

- Instrument shelters.
- Handar data collection platform (DCP).
- Primeline two-pen strip chart recorder.
- Rotronics air temperature/relative humidity sensor.

Both the transmitter and receiver operate under ambient conditions but require waterproof sheltering. Figure 4-1 shows typical transmitter and receiver shelters as configured in the IMPROVE network.

The following subsections briefly describe the basic operation of the LPV-2 transmitter and receiver.

4.1.1 <u>Transmitter</u>

The LPV-2 transmitter emits a uniform, chopped, incandescent light beam of constant intensity at regular intervals for a programmed duration. The transmitter has two components: an electronic control box, and a light source or transmitter. The transmitter optics perform two functions:

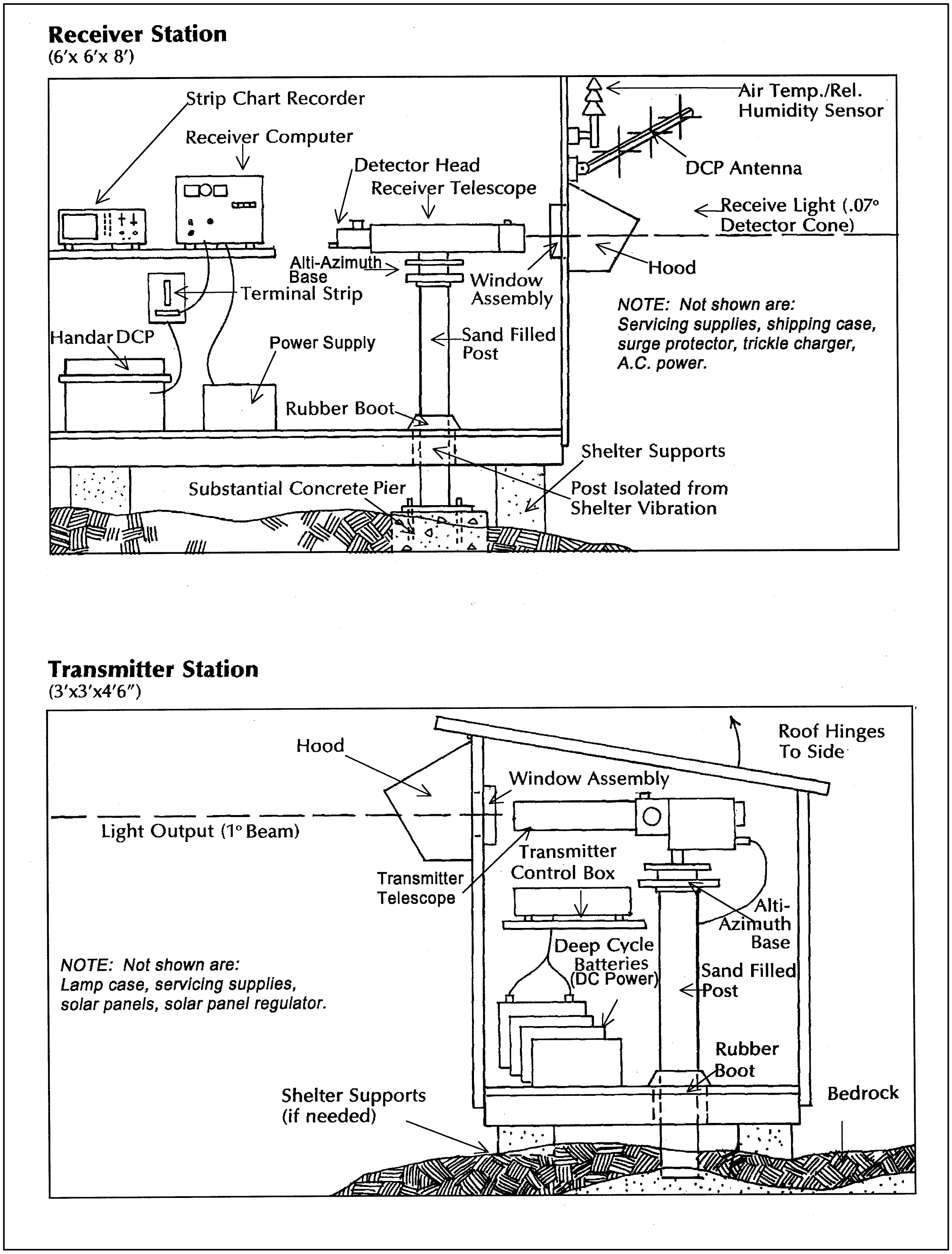

Figure 4-1. Typical Transmissometer Configuration - IMPROVE Network.

- Concentrates light from the 15 watt tungsten filament lamp into a narrow, well-defined uniform cone, magnifying the beam to the equivalent of a 1500 watt lamp.

- Allows the operator to precisely aim the light at the receiver. Although a 1 degree cone of light is emitted from the transmitter, only the center 0.17 degree portion is used for routine monitoring. This portion of the beam is very uniform in illumination.

The intensity of the light emitted from the transmitter is precisely controlled by an optical feedback system, which continuously samples the center 0.17 degree portion of the outgoing beam and performs fine adjustments to keep the light output constant. Light emitted from the transmitter is "chopped" at 78 pulses a second by a mechanical spinning disk in front of the lamp. The light is chopped to allow the receiver computer to differentiate the lamp signal from background or ambient lighting. An eyepiece lets the operator precisely aim the light beam.

The transmissometer can be operated in either a continuous or cycled mode. In the continuous mode the transmitter projects the chopped signal continuously. To prolong lamp life, reduce power consumption, or to accommodate various sampling strategies, the transmitter can be operated in a cycled mode. In the cycled mode the transmitter is programmed on at precise intervals and stays on for selected durations.

IMPROVE network transmissometers operate in a cycled mode, with the transmitter on for sixteen (16) minutes, beginning at the top of the hour. All TIs referenced by this SOP reflect this operating mode.

4.1.2 Receiver

The LPV-2 receiver gathers light from the transmitter, converts it to an electrical signal, isolates and measures the received transmitter light, and calculates and outputs visibility results in the desired form. The receiver has three components:

- Long focal-length telescope

- Photodetector eyepiece assembly

- Low power computer

The telescope gathers the transmitter light and focuses it on a photodiode that converts it to an electrical signal. The receiver computer "locks-on" to the transmitter light's chopped frequency and separates the transmitter light from ambient lighting. The computer compares the measured transmitter light with the known (calibrated) transmitter light to calculate the transmission of the intervening atmosphere.

The effect of atmospheric turbulence is minimized by using 6,250 samples of the signal to calculate a one-minute average reading. The resultant reading is held in the computer and available to a datalogger until the next value is calculated.

Like the transmitter, the receiver is equipped with an eyepiece to precisely aim the detector, and an interval timer to control the interval and duration of measurements.

The receiver can operate in either a continuous or cycled mode. In the continuous mode the receiver measures one-minute averages (using 6,250 samples as described above) on a continuous basis. In the cycled mode the receiver is programmed to begin sampling at precise intervals and stays on for selected durations.

IMPROVE network transmissometers operate in a cycled mode, collecting a 10-minute average of the transmitter irradiance at the start of each hour of the day. The receiver is programmed to begin sampling three minutes after the transmitter lamp turns on. Over the next 10 minutes, the receiver collects and stores 10 one-minute averages. The receiver then uses the 10 one-minute averages to calculate a 10-minute average value for the received lamp irradiance.

4.2 ROUTINE SITE OPERATOR MAINTENANCE

Routine site operator maintenance for the LPV-2 transmissometer includes routine servicing and intermittent servicing. Routine servicing should be performed at 7 to 10 day intervals and includes the following general tasks:

- Checking and resetting telescope alignment
- Cleaning windows, lenses, and solar panels
- Checking system timing
- Verifying power system status
- Documenting "as found" conditions
- Documenting system settings and readings

Intermittent servicing includes preventative maintenance tasks that need to be performed several times throughout the year. Tasks related to system malfunctions and emergency maintenance are considered special servicing as described in Section 4.3, Emergency Maintenance and Troubleshooting.

Intermittent servicing intervals are specific to individual tasks and are usually performed in response to a request by the data coordinator. Intermittent servicing includes:

- Inspecting the physical conditions of the solar panels, deep-cycle batteries, and DCP antenna (monthly).
- Checking the fluid level in deep-cycle batteries and refilling as required (monthly).
- Replacing the transmitter lamp (every two months).

Detailed descriptions of the routine servicing and intermittent servicing tasks and the procedures for accomplishing these tasks are provided in TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

4.3 EMERGENCY MAINTENANCE AND TROUBLESHOOTING

Site operator maintenance of the LPV-2 transmissometer includes prompt detection of any system malfunction and timely application of emergency maintenance procedures. A system malfunction (obvious or suspected) may be detected by either the site operator during a routine service visit, or the data coordinator's daily data review.

When a malfunction is noted during a site visit, the site operator will either initiate immediate corrective action or contact the data coordinator with a description of the problem. The data coordinator will specify appropriate troubleshooting procedures for the site operator to follow in isolating the malfunction. When the malfunction is identified the data coordinator will initiate the appropriate corrective action.

When the data coordinator's daily data review indicates a possible system malfunction, the data coordinator will notify the site operator of the suspected problem and ask the operator to initiate specific troubleshooting procedures. Corrective action will be initiated by the site operator if the problem is identified during the site visit and can be corrected with on-site parts. If the corrective action requires component replacement or repair, corrective action will be initiated by the data coordinator.

Detailed procedures for troubleshooting and emergency maintenance of the LPV-2 transmissometer are provided in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

In cases requiring repair and/or replacement of a transmissometer system component, the site operator will remove and replace the malfunctioning component and ship the component back to ARS. It is important that the malfunctioning instrument or component be removed and reinstalled without causing damage or disturbing critical adjustments or alignment. Proper preparation for shipping will also prevent instrument damage. TI 4110-3375, *Replacing and Shipping Transmissometer System Components*, describes procedures for performing these tasks.

4.4 ANNUAL SITE VISIT

IMPROVE transmissometers operate in the field for a period of 12 months. An ARS field specialist annually visits each site and removes the "old" transmissometer and replaces it with a fully-serviced instrument and nine calibrated lamps. As a part of this annual site visit, the field specialist performs the following general tasks:

- Documents initial conditions.
- Verifies existing system operation (pre-removal).
- Replaces transmissometer and AT/RH sensor.
- Verifies replacement system operation.
- Cleans and repairs the shelter as required.
- Inspects, checks operation, maintains and/or replaces support equipment and instrumentation.

- Performs a field audit of existing and replacement transmissometers with a reference transmissometer.

- Performs miscellaneous servicing, cleaning, and maintenance.

- Trains site operator(s).

SOP 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*, describes the annual site visit. Detailed procedures for the annual site visit are provided in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, and SOP 4710, *Transmissometer Field Audit Procedures*.

4.5 ANNUAL LABORATORY MAINTENANCE

The Optec LPV-2 transmissometer is a precision instrument that requires careful cleaning and alignment of all instrument optics to ensure optimum measurement accuracy. This level of servicing must be performed in a laboratory environment using specialized electronic and optical test equipment. Transmissometers operating in the IMPROVE network are replaced in the field and serviced on an annual basis.

When the operational instrument is removed from the field, it is shipped back to ARS for servicing. Each instrument must be fully serviced before it is reinstalled at a field site. Servicing includes the following major tasks:

- Visual inspection

- Post-field calibration

- Pre-servicing alignment check

- Cleaning

- Optics alignment

- Hardware upgrade/modifications

- Component functional tests

- Pre-field calibration

Specific tasks in the laboratory servicing procedure are shown in Figure 4-2, Annual Service Procedure for Optec LPV-2 Transmissometers. Each servicing task and procedure for performing the task is fully described in TI 4110-3400, *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

Instrument calibration is described in SOP 4200, *Calibration of Optical Monitoring Systems (IMPROVE Protocol)*. Calibration procedures are presented in TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*; and TI 4200-2110, *Transmissometer Lamp Preparation (Burn-in) Procedures*.

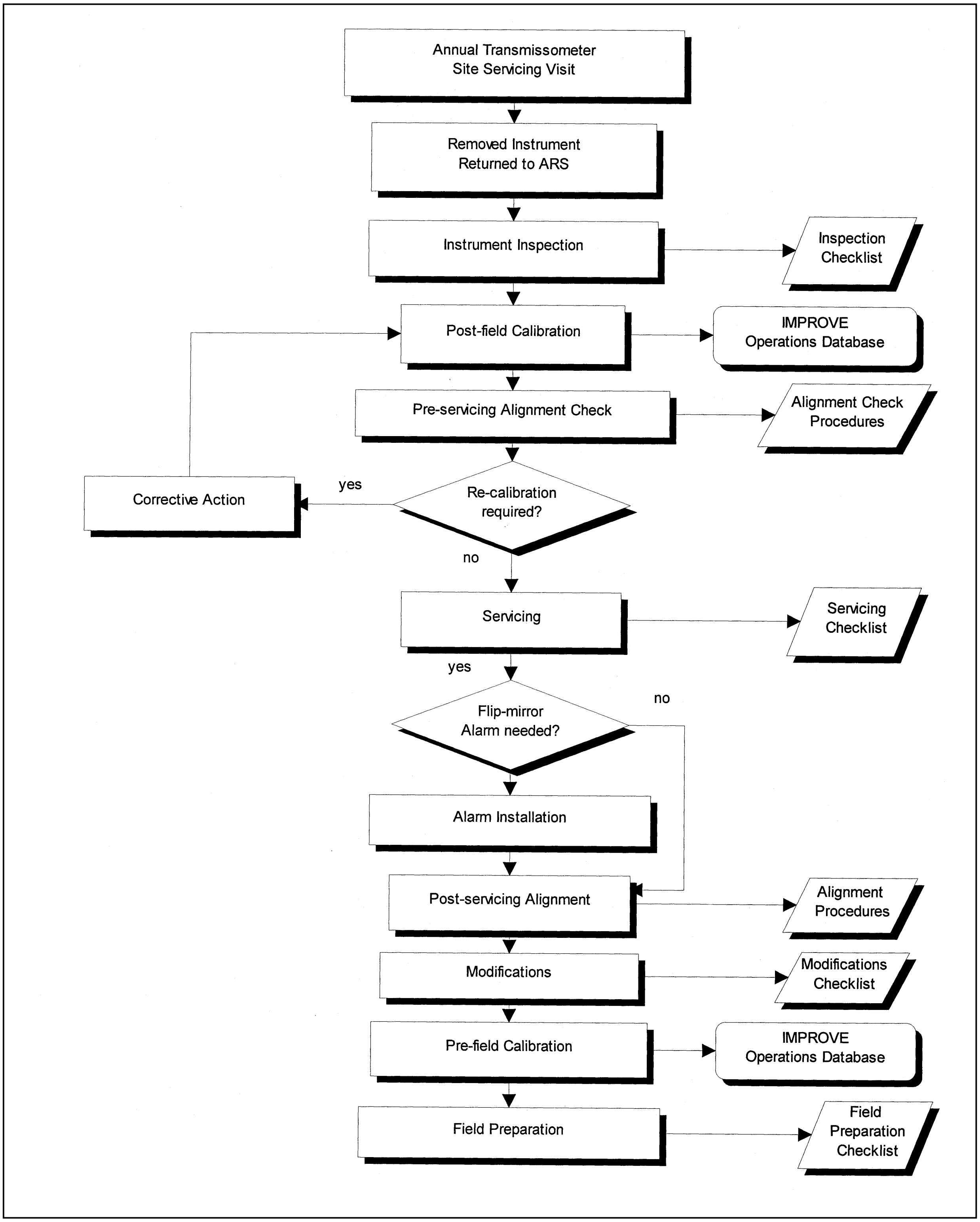

Figure 4-2. Annual Service Procedure for Optec LPV-2 Transmissometers.

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Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**ROUTINE SITE OPERATOR MAINTENANCE PROCEDURES FOR LPV-2 TRANSMISSOMETER SYSTEMS (IMPROVE PROTOCOL)**
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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the steps of a routine site operator maintenance visit to an Optec LPV-2 transmissometer station (receiver and transmitter) operated according to IMPROVE Protocol. The purpose of routine site operator maintenance is to assure quality data capture and minimize data loss by performing and documenting scheduled operational checks and preventive maintenance on transmissometers, meteorological sensors, data acquisition and control systems, power systems, and support equipment.

The transmissometer servicing schedule is provided in Table 1-1.

This TI, as referenced from Standard Operating Procedure (SOP) 4110, *Transmissometer Maintenance (IMPROVE Protocol)*, specifically describes the service and maintenance procedures to be performed at the transmissometer transmitter and receiver stations. A summary of the procedures for the transmitter station is provided in Table 1-2 and for the receiver station in Table 1-3. Tasks are listed in the suggested order of completion. For more detailed instructions, see Section 4.0.

Due to variations in the site configurations of IMPROVE Protocol sites, portions of this TI may not apply to every transmissometer station.

Table 1-1

Transmissometer Servicing Schedule

INTERVAL	TASKS
7 to 10 Day Interval	Complete the servicing tasks listed on the site assessment log sheets. Both the receiver and transmitter shelters must be visited at 7 to 10 day intervals. The transmitter should be serviced first. Correct operation of the system should be verified at the receiver shortly afterward (same day). The transmitter and receiver system timing should be checked at each site visit.
Monthly Interval	The transmitter lamp status LED must be checked at least once a month. Inspect the physical condition of solar panels, batteries, and DCP antenna. Battery fluid levels should be checked at least once a month. Check strip chart recorder operation at least once a month to make sure it is capable of working properly in case it is needed as backup (DCP failure).
2 Month Interval	Transmitter lamps should be changed every two months. ARS will notify site operators when a lamp change is needed.
Annual Interval	Field specialists will make visits once a year to exchange the existing transmissometer system for a newly serviced system. Training of site operators in the servicing and maintenance of the monitoring system components will take place during annual field specialist visits.

Table 1-2

Transmissometer Transmitter Station
Summary of Servicing Tasks

ORDER OF COMPLETION	SERVICING TASKS
Before Leaving the Office	At least once a month, schedule your servicing trip to be at the transmitter station while the transmitter is in the "ON" mode to check the lamp status LED. When checking the system timing, set your digital watch to the correct time prior to leaving the office by calling the Bureau of Standards recording 303/499-7111 (Boulder, CO).
At the Transmitter Station (Complete the servicing tasks listed on the site assessment log sheet.)	Complete log sheet general information section. Document the initial alignment conditions and/or comment. Verify that the flip mirror is in the correct position. Inspect and document the window cleanliness. Clean the window and comment as necessary. Recheck alignment. Inspect and document telescope lens cleanliness. Clean the solar panels and inspect them for damage. Observe and record the transmitter "on" time. Observe and record the LED status light while transmitter is "ON." Document lamp voltage five minutes into lamp "ON" cycle. Observe and record the transmitter turn "off" time. Record special servicing tasks - timing reset, lamp change, and deep-cycle battery voltage. Check supply inventory. Request needed supplies on the log sheet. Record any comments on the log sheet. Leave a copy of the log sheet in the shelter; take the original back to the office and send it to ARS. Double-check the alignment and the flip mirror position before leaving the shelter.
Back at the Office	Send original log sheets from both the receiver and transmitter to ARS. Call an ARS field specialist or data coordinator promptly if a problem or need arises.

Table 1-3

Transmissometer Receiver Station
Summary of Servicing Tasks

ORDER OF COMPLETION	SERVICING TASKS
Before Leaving the Office	Schedule your servicing trip to be at the receiver station 10 minutes before the hour. Servicing tasks should be performed before the top of the hour. System timing and the updated reading should be observed before leaving. When checking the system timing, set your digital watch to the correct time prior to leaving the office by calling the Bureau of Standards recording 303/499-7111 (Boulder, CO).
At the Receiver Station (Complete the servicing tasks listed on the site assessment log sheet.)	Complete log sheet general information section. Record the time, receiver computer reading and toggle state. Compare the readings to actual visual conditions. Record the receiver computer settings. Record the A1 "B" reading. Important: Return the A1 switch to the "C" position. Document the initial alignment conditions and/or comment. Inspect and document the window cleanliness. Inspect and document telescope lens cleanliness. Clean the window and comment as necessary. Recheck alignment. Clean the solar panels and inspect them for damage. Observe and record the transmitter light "on" time. Observe and record the toggle update time. Note the updated receiver reading and record. Also, compare the reading to actual visibility conditions. Observe and record the transmitter light "OFF" time. Record special servicing tasks: computer reset, timing reset, lamp changes, cal. # change, and deep-cycle battery voltage. Document the site visit on the strip chart. Change chart paper and pens, if necessary, and re-document visit. Check supply inventory. Request needed supplies on the log sheet. Record any comments on the log sheet. Leave a copy of the log sheet in the shelter. Take the original back to the office and send it to ARS. Double-check the alignment and the flip mirror position before leaving shelter.
Back at the Office	Send original log sheets from both the receiver and transmitter shelters to ARS. Call an ARS field specialist or data coordinator promptly if a problem or need arises.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and data coordinator concerning the schedule and requirements for routine maintenance.
- Oversee and review documentation completed by the site operator for accuracy and completeness.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, and data coordinator concerning the schedule and requirements for routine maintenance.
- Train the site operator in all phases of the routine maintenance and special servicing procedures necessary for site visits.
- Provide technical support to the site operator via telephone to assure high quality site visits.
- Document all technical support provided to the site operator.
- Resolve problems reported by the site operator.

2.3 DATA COORDINATOR

The data coordinator shall:

- Coordinate with the site operator, his/her supervisor, project manager, and field specialist concerning the schedule and requirements for routine maintenance.
- Review documentation completed by the site operator for accuracy and completeness.
- Verify that scheduled visits are performed and notify the site operator if he/she fails to make a scheduled visit.
- Provide technical support to the site operator via telephone to assure high quality site visits.
- Document all technical support provided to the site operator.
- Review and file all site documentation.
- Resolve problems reported by the site operator.

- Ship cleaning and other necessary supplies for routine maintenance to the site operator.
- Enter all correspondence with site operators and the results of all performed procedures into the site-specific timeline.

2.4 SITE OPERATOR

The site operator shall:

- Coordinate with his/her supervisor, project manager, field specialist, and data coordinator concerning the schedule and requirements for routine maintenance.
- Perform all procedures described in this TI.
- Thoroughly document all procedures on the LPV-2 Transmissometer Operator Log Sheet and fax and mail the log sheet to the data coordinator.
- Report any noted inconsistencies immediately to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The equipment generally required to support a weekly site visit includes:

- Medium and small flat-blade screwdriver
- Medium adjustable wrench
- Keys for shelters and padlocks
- Voltmeter and cables
- Battery tester
- Isopropyl alcohol and Kimwipes
- Glass cleaner and paper towels
- Photographic (blower) brush
- Distilled water
- Battery terminal cleaner
- Flashlight and/or signal mirror
- Site Operator's Manual for Transmissometer Monitoring Systems
- LPV-2 Transmissometer Operator's Guide
- LPV-2 Transmissometer Operator Log Sheets (transmitter and receiver)

- Pen or pencil
- Notebook for yellow copies of log sheets
- Strip chart recorder paper
- Digital watch

4.0 METHODS

This section includes four (4) major subsections:

4.1 Routine Servicing
4.2 Intermittent Servicing and Maintenance
4.3 Problems or Questions
4.4 Handling Log Sheets

The procedures described in these sections refer to specific instrument components. Detailed schematic diagrams and instrument component descriptions are provided for reference in TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*. Resolution of problems noted during routine or intermittent servicing can be more fully investigated by following the troubleshooting procedures defined in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

4.1 ROUTINE SERVICING

This subsection describes transmissometer monitoring system routine servicing tasks and log sheet entries. Task descriptions are listed in the order in which they appear on the operator log sheets. Information or procedures to be followed are described with the appropriate log sheet entry (see Figures 4-1 and 4-2).

Log sheet entries and general task descriptions common to servicing of both the transmitter and receiver stations are presented in Section 4.1.1. Servicing tasks and log sheet entries relating to only the transmitter or receiver stations follow in separate sections. An operator's guide to transmissometer servicing has been prepared as a field reference for routine servicing. A copy of the guide is provided in Appendix A. Blank operator log sheets are shown as Figures 4-1 and 4-2. Examples of completed log sheets are included in Appendix B (Transmitter), and C (Receiver).

The transmissometer operator log sheets are divided into four (4) main sections:

- Initial Condition
- Servicing
- Timing
- Special Servicing

The initial condition, servicing, and timing sections are a part of routine servicing and should be completed during every site visit. Special servicing includes tasks that are normally performed in response to a request by the data coordinator. Procedures related to special servicing tasks are presented in Section 4.2, Intermittent Servicing and Maintenance.

Air Resource Specialists, Inc.

Location____________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
TRANSMITTER STATION

Date__________ Local Time__________ Operator(s) __________
Weather Conditions__________
Visibility Conditions__________

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment__________
2. ALIGNMENT: Mark initial location of receiver shelter window with a "+".
   Initial Alignment Comments__________

   IMPORTANT: Return flip mirror to proper (ON) position.
3. Instrument Number LPV-__________ Lamp Number__________
4. Initial Window Cleanliness GOOD MODERATE POOR
   Comment__________

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned __________ If NO, why not? __________
2. Lens Inspected? YES NO Comment __________
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned __________
4. Solar Panels Cleaned? YES NO Comment __________
5. Lamp Check IMPORTANT: Must be done when lamp is <u>ON</u> under automatic control.
   a) LED (indicator light on side of control box) ON OFF (if ON , call ARS)
   b) Lamp Voltage Reading (switch voltmeter to 20 VDC range) __________ volts, for lamp number __________
   IMPORTANT: Switch voltmeter to "OFF" after taking voltage reading.

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) ______:______:______
3. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) ______:______:______

SPECIAL SERVICING (upon ARS instruction)

1. Timing Reset? YES NO If YES, time reset __________
2. Lamp Changed? YES NO If YES, new lamp number__________ time lamp changed__________
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Alignment rechecked after lamp change? YES NO
4. Battery Voltage (charging)__________ Battery Voltage (analyzing)__________

GENERAL COMMENTS/SUPPLIES NEEDED__________

Send the original copy of this form to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Phone: 1-800-344-5423
FAX: 1-970-484-3423

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Figure 4-1. Transmissometer Operator Log Sheet - Transmitter Station.

Air Resource Specialists, Inc.

Location______________________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
RECEIVER STATION

Date__________________ Local Time______________ Operator(s) ______________________________
Weather Conditions____
Visibility Conditions____

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment____
2. Receiver Display Reading ________________ Local Time ______________ Toggle ON OFF
3. Settings: Gain________ Cal________ Dist________ A1________ A2________ Int________ Cycle________
   Switch A1 Readings: C________ B________
   Does the Bext represent actual conditions? YES NO Comment ______________________
   IMPORTANT: Return A1 Switch to "C" position after check.
4. ALIGNMENT: Mark initial location of transmitter light source with a "+".
   Initial Alignment Comments______________________________________
   IMPORTANT: Return flip mirror to proper (ON) position.
5. Instrument Number LPV-__________
6. Initial Window Cleanliness GOOD MODERATE POOR
   Comment ____
7. Strip Chart Operating? YES NO (If operating, refer to SPECIAL SERVICING #4 below.)

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned __________ If NO, why not? ______________
2. Lens Inspected? YES NO Comment ______________________________________
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned ________________
4. Solar Panels Cleaned? YES NO Comment ______________________________________

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) ______:______:______
3. Receiver Toggle Update, Exact Time, (HR:MIN:SEC) ______:______:______
4. Updated Receiver Reading ________________ Toggle ON OFF
   Does the updated Bext reading represent actual conditions? YES NO Comment ______________
5. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) ______:______:______

SPECIAL SERVICING (upon ARS instruction)

1. Computer Reset? YES NO Timing Reset? YES NO If YES, time reset ________________
2. Lamp changed at Transmitter Station? YES NO
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Receiver computer calibration (cal) number changed? YES NO If YES, new cal number entered ________
4. Strip Chart: Marked? YES NO Zeroed? YES NO Paper /Pens OK? YES NO
5. Battery Voltage (charging)________________ Battery Voltage (analyzing)________________

GENERAL COMMENTS/SUPPLIES NEEDED______________________________________

Send the original copy of this form to:
Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Phone: 1-800-344-5423
FAX: 1-970-484-3423

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Figure 4-2. Transmissometer Operator Log Sheet - Receiver Station.

4.1.1 Transmitter and Receiver - Common Routine Servicing Tasks

HAND-HELD RADIO PRECAUTION	The transmissometer circuitry, especially the internal auto-timers, can be adversely affected by strong radio signals. Do not transmit on a hand-held radio within 10 feet of the transmitter. Avoid aiming the antenna at or over the circuitry. Strong radio signals may reset the internal auto-timer, resulting in incorrect system timing.

The following general information appears at the top of both the transmitter and receiver log sheets.

LOCATION	Enter either the full location name or the four-letter site abbreviation.
DATE	Use the standard calendar date, not the Julian date.
TIME	Current local time in 24-hour format should be used. Use Daylight Savings Time when applicable. The operator must set his/her watch to the correct time prior to leaving the office by calling the Bureau of Standards recording 303/499-7111 (Boulder, CO).
OPERATOR(S)	Use your full name, or use your first initial and last name.
WEATHER CONDITIONS	Describe current or recent weather conditions that may be helpful in interpreting the transmissometer readings. Such conditions may include, but are not limited to: • Passing storm fronts • Impending precipitation • Precipitation events • Stagnant air masses • High winds • Fog
VISIBILITY CONDITIONS	Describe current or recent visibility conditions that may be useful in verifying correct transmissometer operation. A partial list of such conditions includes: • Extremely clean • Plumes visible • Control burns • Widespread, uniform haze • Haze layers

4.1.2 Transmitter Station - Routine Servicing

Before leaving the office, set your digital watch to the correct time by calling the Bureau of Standards recording 303/499-7111 (Boulder, CO). The following information describes log sheet entries and servicing tasks required at the transmitter station.

4.1.2.1 Initial Condition

OPERATIONAL STATUS

A general overview of the shelter, instrument, and support equipment should be made to ensure that the system appears to have operated properly since the last servicing visit. Thoroughly document any noted inconsistencies.

DOCUMENT INITIAL ALIGNMENT

To check the alignment, turn the flip mirror knob fully clockwise against the stop to the "OFF" position. Document the position of the receiver shelter window with respect to the circle on the data sheet with a "+." The receiver would be at the intersection of the "+."

Avoid making alignment checks or adjustments while the transmitter is on. If the flip mirror knob is moved from the "ON" position to the "OFF" position while the receiver is making a reading, the extinction reading for that hour will not be valid. If a reading has been affected by an alignment check, note this on the log sheet comment section.

If an initial alignment check is impossible due to weather, haze, turbulence, or lighting conditions, return the flip mirror to the "ON" position -- <u>Do not</u> attempt to align. Record pertinent comments regarding alignment problems to the right of the circle on the log sheet.

CORRECTING ALIGNMENT

If the alignment has drifted so that the receiver is not in the center of the reticle circle, adjust the alti-azimuth base controls to center the receiver. Make sure the flip mirror knob is fully against the stop while aligning. Do this only after the initial alignment has been documented.

The circle depicted on the log sheet represents the small, inner reticle circle. The inner reticle circle must remain aligned on the receiver telescope for correct instrument operation.

One of your eyes will be dominant; if you are having difficulty viewing the scene, try it with your other eye. Some people find it easier to view the scene from behind the telescope while others prefer to view from the side. Schedule site visits for times of the day with the best viewing conditions. All shelters are equipped with signal mirrors and flashlights for occasions when alignment checks are made with operators at both stations. Finally, keep the eyepiece clean for better viewing.

INSTRUMENT AND LAMP NUMBERS

The instrument number is on stickers attached to both the control box and the telescope. The lamp number is on a sticker attached to the back of the lamp.

INITIAL WINDOW CLEANLINESS

Remove the window pane from its frame and visually inspect it for water drop deposits, film, unusually heavy dust, and insects or pests that may reduce the transmission of light through the glass. Make comments when applicable. It is most important to inspect the portion of the glass pane that is directly in front of the transmitter lens.

4.1.2.2 Servicing

CLEAN WINDOW

Shelter windows should be cleaned during every site visit. If for some reason windows are not cleaned, document conditions in the comments section. Document the time that the window was cleaned in the space provided. To clean the window:

- Remove the window pane from the frame.
- Inspect the hood and frame for spider webs.
- Use only Kimwipes and alcohol to clean both sides of the glass. Use plenty of cleaning fluid, change Kimwipes often, and use a light hand.
- Reinstall window pane after inspecting for smears, smudges, etc.
- Recheck alignment.
- Do not use canned air to clean windows or objective lens.

The objective in cleaning optical surfaces is to remove the abrasive dust particles and film without damaging the glass surface. Always remove the large particles first and progress toward the removal of films. Use a light touch, plenty of cleaning fluid, and frequent changes of cleaning paper. Clean with a circular rubbing motion.

INSPECT LENS

Remove the shelter window and look closely at the transmitter telescope lens from a number of angles. Note any accumulation of dust, dirt, smudges, or other foreign material on the lens. If any accumulation is noted, use the blower brush to clean the objective lens. Use a light touch. If an accumulation on the lens cannot be removed with the blower brush, call ARS for further instructions. Also, use the blower brush to remove dust from the body of the transmitter telescope. Clean the eyepiece with alcohol and Kimwipes. Use only the blower brush to clean the objective lens.

CORRECT ALIGNMENT

This entry verifies whether the alignment was corrected. If the alignment was corrected after the initial alignment documentation, circle "YES" and document the time it was corrected in the space provided. If the alignment was not corrected, circle "NO."

CLEAN SOLAR PANELS	Use glass cleaner and paper towels to clean dust and dirt from the solar panels. In the winter, sweep snow off the panels, but avoid scraping ice as damage to the panels could occur.
LAMP LED	Record the status (ON or OFF) of the lamp check LED located on the side of the control box. The LED status may be difficult to determine in direct sunlight. Shading the LED with your hand will make it easier to determine whether the LED is on or off. If the lamp voltage LED is on while the transmitter light is on, the lamp needs replacing. Procedures for changing lamps are described in Section 4.2.2. Before replacing the lamp, measure and document the lamp voltage as described below. This check is valid only when the instrument is in its auto on mode; if the instrument is turned on with the test switch, the LED will always turn on.
LAMP VOLTAGE	A calibrated voltmeter has been supplied for measuring the operational lamp voltage of the transmitter. The voltmeter should be connected to the lamp voltage "measurement pigtail" as indicated in Figure 4-3. After the lamp has been on for at least five minutes, check the voltage by switching the voltmeter to the 20 VDC range. Turn the voltmeter **OFF** after documenting voltage and lamp number on the log sheet.

4.1.2.3 Timing

CHECK TIMING	Document whether or not your watch is synchronized with NBS time by circling "YES" or "NO." Observe and document the exact time the transmitter light comes on and goes off in the spaces provided.

4.1.2.4 Special Servicing

RESET TIMING	Procedures for checking and resetting the transmitter internal auto-timer are described in Section 4.2.1. Document the results of a timing check before resetting the time. If the time is reset, document this on the log sheet. Timing checks should be made during each site visit.
CHANGE LAMP	Procedures for changing lamps are described in Section 4.2.2. If a lamp change is made, document it on the log sheet. The lamp number is located on a sticker attached to the back of the lamp.
RECHECK ALIGNMENT	Changing the lamp can result in telescope movement and misalignment. Always recheck alignment after a lamp change and make sure to return the flip mirror to the correct position before leaving the site.

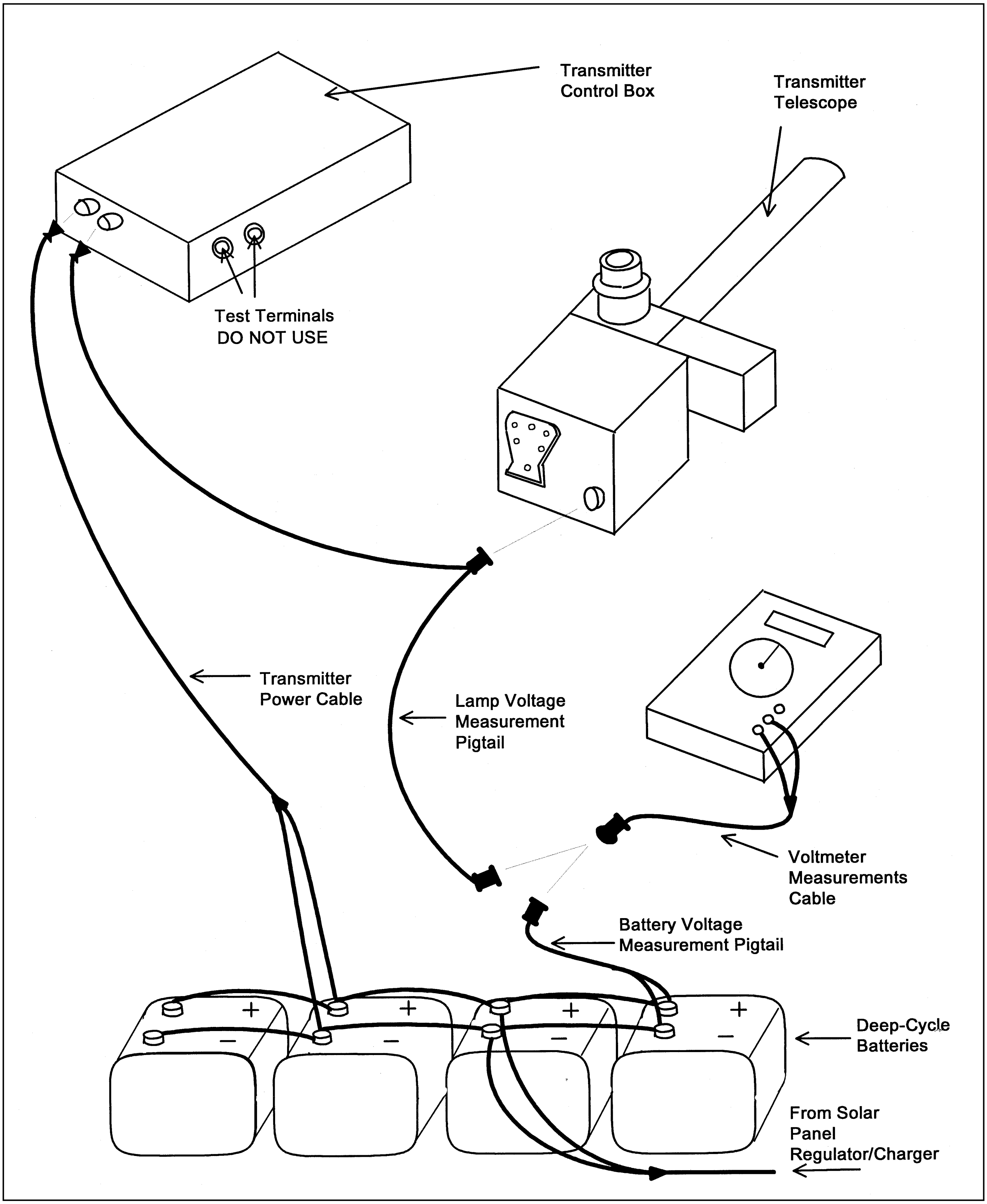

Figure 4-3. Transmitter Components Connection Diagram.

CHECK BATTERY VOLTAGE	At solar powered sites, it is important to verify that the solar charging system is operating properly. Use the on-site voltmeter to measure the voltage on the deep-cycle batteries when the charge regulator is "charging" and when "analyzing." Disconnect the voltmeter cable from the lamp voltage "measurement pigtail" and reconnect the voltmeter cable to the battery "measurement pigtail" (refer to Figure 4-3). Set the voltmeter switch to the 20 VDC setting. Document the "charging" and "analyzing" voltage readings on the log sheet. Set the voltmeter switch to "OFF" and reconnect the voltmeter cable to the lamp voltage measurement pigtail. Operation of the charge regulator is described in Section 4.2.4.
COMMENTS/ SUPPLIES NEEDED	Space for additional comments is provided at the bottom of the log sheet. This space should also be used to request additional servicing supplies.

4.1.3 Receiver Station - Routine Servicing

Before leaving the office, set your digital watch to the correct time by calling the Bureau of Standards recording at 303/499-7111 (Boulder, CO). The following information describes log sheet entries and servicing tasks required at the receiver station.

4.1.3.1 Initial Condition

OPERATIONAL CONDITION	A general overview of the shelter, instrument, and support equipment should be made to ensure that the system operated properly since the last servicing visit. Thoroughly document any noted inconsistencies.
RECEIVER DISPLAY READINGS	Record the raw reading ("A1" switch in **C** position) shown on the receiver computer display upon entering the shelter. Also record local time and toggle state.
SETTINGS	Record the position or numerical setting of each of the receiver computer front panel switches (Gain, Cal, Dist., A1, A2, Int and Cycle). Set the "A1" switch to the **B** position and record the display value and switch back to the **C** position.
SWITCH A1 READINGS	Use the orange conversion chart (Figure 4-4) to convert b_{ext} to visual range. Compare this value with the actual visibility conditions. If the reading does not correspond with the actual conditions, note the inconsistency in the comments section and call ARS.
DOCUMENT INITIAL ALIGNMENT	To check the alignment, turn the flip mirror knob fully clockwise against the stop to the "OFF" position. Document the position of the transmitter with respect to the circle on the data sheet with a "+." The light source would be at the intersection of the "+."

DOES THE CURRENT TRANSMISSOMETER READING MAKE SENSE?

CONVERT THE COMPUTER-DISPLAYED READING TO VISUAL RANGE USING THE CHART BELOW. DOES THIS VALUE AGREE WITH THE CURRENT VISIBILITY CONDITIONS?

IF NOT, CHECK

- FLIP MIRROR
- ALIGNMENT
- TIMING

IF THE PROBLEM CANNOT BE RESOLVED, CALL ARS AT 303-484-7941

COMPUTER DISPLAY B_{ext} (KM^{-1})	VISUAL RANGE (KILOMETERS)	VISUAL RANGE (MILES)
.010	391	243
.015	261	162
.020	196	122
.025	156	97
.030	130	81
.035	112	69
.040	98	61
.045	87	54
.050	78	49
.060	65	41
.070	56	35
.080	49	30
.090	43	27
.100	39	24
.200	20	12
.300	13	8
.400	10	6
.500	8	5
.600	7	4
.700	6	3
.800	5	3
.900	4	3
1.000	<4	<3

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Figure 4-4. Extinction (b_{ext}) to Visual Range Conversion Chart.

If the transmitter shelter is easily visible, do not interrupt a reading to make an alignment check. When viewing conditions are marginal, use the transmitter light source as an aid in alignment. The receiver can be placed in the "OFF" position for a short time immediately after the transmitter turns on, or following a toggle and reading update, without affecting a measurement. Document any interruption of a reading on the log sheet.

If an initial alignment check is impossible due to weather, haze, turbulence, or lighting conditions, return the flip mirror to the "ON" position -- Do not attempt to align. Record pertinent comments regarding alignment problems to the right of the circle on the log sheet.

CORRECTING ALIGNMENT

If the alignment has drifted so that the transmitter is not in the center of the reticle circle, adjust the alti-azimuth base controls to center the transmitter. Make sure the flip mirror knob is fully against the stop while aligning. Do this only after the initial alignment has been documented.

The circle depicted on the log sheet represents the reticle circle. The reticle circle must remain aligned on the transmitter for correct instrument operation.

INSTRUMENT NUMBER

The instrument number is located on stickers affixed to the receiver computer and telescope.

INITIAL WINDOW CLEANLINESS

Visually inspect the shelter window for water drop deposits, film, unusually heavy dust, and insects or pests that may reduce the transmission of light through the glass. Make comments when applicable. It is most important to inspect the glass directly in front of the receiver lens.

STRIP CHART OPERATION

At most sites the strip chart operates only when the DCP is not functioning properly.

4.1.3.2 Servicing

CLEAN WINDOW

The shelter window should be cleaned during every site visit. If for some reason the window is not cleaned, document its condition in the comments section. Document the time that the window was cleaned in the space provided. To clean the window:

- Remove the window pane from the frame.
- Inspect the hood and frame for spider webs.
- Use only Kimwipes and alcohol to clean both sides of the glass. Use plenty of cleaning fluid, change Kimwipes often, and use a light hand.

- Reinstall window pane after inspecting for smears. smudges, etc.
- Recheck alignment.
- Do not use canned air to clean windows or objective lens.

The objective in cleaning optical surfaces is to remove the abrasive dust particles and film without damaging the glass surface. Always remove the large particles first and progress towards the removal of films. Use a light touch, plenty of cleaning fluid, and frequent changes of cleaning paper. Clean with a circular, rubbing motion.

INSPECT LENS

Remove the shelter window and look closely at the receiver telescope objective lens from a number of angles. Note any accumulation of dust, dirt, smudges, or other foreign material on the lens. If any accumulation is noted, use the blower brush to clean the objective lens. Use a light touch. If an accumulation on the lens cannot be removed with the blower brush, call ARS for further instructions. Also, use the blower brush to remove dust from the body of the transmitter telescope. Clean the eyepiece with alcohol and Kimwipes. Use only the blower brush to clean the objective lens.

CORRECT ALIGNMENT

This entry verifies whether the alignment was corrected. If the alignment was corrected after the initial alignment documentation, circle "YES" and document the time it was corrected in the space provided. If the alignment was not corrected, circle "NO."

CLEAN SOLAR PANELS

Use glass cleaner and paper towels to clean dust and dirt from the solar panels. In the winter, sweep snow off the panels, but avoid scraping ice damage to the panels could occur.

4.1.3.3 Timing

CHECK TIMING

Record the exact time the transmitter light turns on and off, and the exact time the receiver toggle light changes state in the appropriate space. Record the updated receiver display reading.

The transmissometer system operates according to the timed sequence described below. It is possible to check the system timing of both the receiver and the transmitter from the receiver station.

HR:MI:SEC	Action
09:00:00	Transmitter turns **ON**
09:03:00	Receiver begins 10-minute average reading (cannot be observed)
09:13:20	Receiver finishes reading, toggle changes, front panel display updates
09:16:00	Transmitter turns **OFF**
10:00:00	Transmitter turns **ON**

The sequence repeats hourly.

The system clocks will drift over time. For correct operation, it is critical that the receiver take its reading well-centered within the lamp-on interval.

4.1.3.4 Special Servicing

RESET COMPUTER — Document whether or not a computer reset was performed during this site visit.

The computer is reset by turning the power switch **OFF** for at least one second and returning it **ON** (see Section 4.2.1). If the computer is reset, the timing must also be reset.

RESET TIME — Document whether or not a timing reset was performed during this site visit. A timing reset <u>must</u> be done each time the computer is reset.

CHANGE TRANSMITTER LAMP — Document whether or not the lamp was changed at the transmitter station. If the lamp was changed at the transmitter, the receiver computer calibration number (cal #) must also be changed.

CHANGE CALIBRATION NUMBER — Document whether or not the calibration number (cal #) was changed and record the new number.

MARK STRIP CHART — At most sites the strip chart operates only when there are problems with the data collection platform (DCP). If operating, the following information must be recorded on the chart at each site visit:

- Event markers or "ticks"
- Date and time
- Location
- Operator name
- Receiver computer display value
- Other information, such as:
    - Pens zeroed
    - New pens/paper
    - Computer reset
    - Alignment off/corrected
    - System timing off/corrected

When installing new chart paper, record the location, date and time started on the outside of the chart. The same information should be written at the end of the roll upon chart removal. The procedure for changing chart paper is described in the manufacturer's instruction manual.

CHART PAPER — Check the amount of chart paper remaining. A red line will appear on the right side of the chart paper when there is less than two days remaining on the chart.

CHART PENS — Make sure the pens are leaving a bold trace and track freely across the chart. The pens should be replaced when the trace becomes weak or intermittent. Pen replacement is described in the manufacturer's instruction manual.

BATTERY VOLTAGE — At solar powered sites, it is important to verify that the solar charging system is operating properly. Use the on-site voltmeter to measure the voltage on the deep-cycle batteries when the charge regulator is "charging" and when "analyzing". Disconnect the voltmeter cable from the lamp voltage "measurement pigtail" and reconnect the voltmeter cable to the battery "measurement pigtail" (refer to Figure 4-3). Set the voltmeter switch to the 20 VDC setting. Document the "charging" and "analyzing" voltage readings on the log sheet. Set the voltmeter switch to "OFF" and reconnect the voltmeter cable to the lamp voltage measurement pigtail. Operation of the charge regulator is described in Section 4.2.4.

The battery fluid level should be checked monthly. If the fluid level is below the top of the plates, refill it with distilled water. If fluid is added, this should be noted in the comments/supplies section of the log sheet. Detailed descriptions for the deep-cycle batteries servicing procedures are provided in Section 4.2.6.

COMMENTS/ SUPPLIES — Space for additional comments is provided at the bottom of the log sheet. This space should also be used to request additional servicing supplies.

4.2 INTERMITTENT SERVICING AND MAINTENANCE

This section presents detailed procedures to accomplish the following intermittent servicing and maintenance tasks:

- Checking and resetting system timing
- Transmitter lamp changes
- Strip chart servicing
- Solar power system servicing
- AC power system servicing

- Deep-cycle battery servicing
- Data collection platform (DCP) antenna servicing

The procedures described in the following subsections refer to specific instrument components. Detailed schematic diagrams and instrument component descriptions are provided for reference in TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*.

4.2.1 Checking and Resetting System Timing

When resetting the timing at both stations, reset the transmitter timing first.

CHECK TRANSMITTER TIMING

Set your digital watch by calling the National Bureau of Standards in Boulder, Colorado (303/499-7111).

The transmitter beam can be observed at the receiver station with the unaided eye or through the telescope. At the transmitter, the light can be seen at the back of the instrument through the lamp housing. Do not look into the transmitter telescope.

Observe the time the transmitter light turns either on or off. Document this on the appropriate log sheet.

CHECK RECEIVER TIMING

Observe the receiver computer toggle light and record the time it changes state (i.e., on to off, or off to on).

TIMING SEQUENCE

The transmissometer system should follow the following timing sequence:

HR:MI:SEC	Action
XX:00:00	Transmitter lamp turns on
XX:03:00	Receiver begins 10-min. average reading (cannot be observed)
XX:13:20	Receiver finishes reading, updates display and changes toggle state
XX:16:00	Transmitter lamp turns off
XX:00:00	Sequence repeats hourly

TIMING TOLERANCE

IMPORTANT -- When there is less than 45 seconds or more than 5 minutes between the toggle update and the lamp turnoff, the timing system needs resetting.

RESET TRANSMITTER TIMING

To reset transmitter timing:

- Set your digital watch to NBS time (see above) before going to the station.
- Arrive at the transmitter station at least five minutes before the hour.

- Leave the "ON/OFF" switch in the "ON" position (up), and the test switch in the OFF position (down). Test switches are on units with serial numbers 004 or higher.

- Remove the control box cover (four screws).

- Precisely at the top of the hour (any hour), push the time reset button all the way down, hold for 1/2 second, and release (see TI 4110-3350 *Transmissometer System Diagrams and Component Descriptions*).

- Upon release of the time reset switch, the transmitter lamp will turn on.

- Replace the control box cover.

- Verify that the transmitter turns off (lamp goes off) at 16 minutes past the hour.

- Document the time reset on the transmitter log sheet.

RESET RECEIVER TIMING

To set receiver timing:

- Set your digital watch to NBS time (303/499-7111) before going to the station.

- Arrive at the receiver station at least five minutes before the hour.

- At 2 minutes and 30 seconds after the hour (or 2 minutes and 30 seconds after the transmitter light turns on), turn the computer power switch **OFF** and leave the switch in the "OFF" position for at least one second and flip the switch back **ON**. For switch locations, see Section 8.0 (TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*).

- At precisely 3 minutes after the hour (or 3 minutes after the transmitter light turns on), hold the time reset switch in the "UP" position for 1/2 second. Let it return to its down or "ON" position.

- Verify that the reading updates and the toggle light changes state at approximately 13 minutes and 20 seconds after the hour.

- Document the time reset on the receiver log sheet.

4.2.2 Transmitter Lamp Changes

LAMP REMOVAL

IMPORTANT -- Lamps are removed by pulling them out; do not loosen the screws on the lamp housing plate. Since the lamp filaments are fragile, especially after use, the lamps should be removed and inserted very carefully and gently.

Refer to TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*, for the location of the items described.

To remove transmitter lamps:

- Arrive at the transmitter station 10-15 minutes before the top of the hour to allow time for removing "old" lamp and for cleaning "new" lamp before insertion.
- If the transmitter is in the "ON" mode and a reading is being taken, do not disrupt the reading -- wait until the transmitter has turned off.
- Do not attempt to change lamps if there is less than five minutes before the start of the hour.
- Take the new lamp out of the lamp case, handling it by the holder only. Do not touch the glass with your fingers.
- Clean the lamp with alcohol and Kimwipes. Carefully set the lamp aside in a safe place.
- Turn the transmitter power off at the control box.
- Remove the old lamp by pulling out on the lamp holder. Some lamps may have to be removed by gently prying around the lamp holder with the aid of a small flat-blade screwdriver. Do not loosen any screws on the lamp housing plate.
- Place the old lamp in the lamp case. Mark the date and time the lamp was removed on the transmitter operator log sheet.

LAMP INSERTION

To insert a new lamp:

- Insert the cleaned replacement lamp into the lamp socket.
- Be very careful to align the lamp contact pins with the holder sockets then firmly push the lamp all the way in. The lamp must be fully seated into the socket for proper instrument operation.
- **IMPORTANT** -- the lamp will not turn on unless proper contact is made.

- Turn the power switch to the **ON** (up) position and reset the timing at the top of the hour (see Section 4.2.1).

- Verify that the lamp comes "ON" under auto-control at the top of the hour.

- Take a lamp voltage reading and document on the operator log sheet (see Section 4.1.2 - Lamp Voltage).

- Document the lamp change on the operator log sheet.

CALIBRATION SETTING

Each lamp outputs a slightly different amount of light, requiring a new calibration number setting on the receiver computer with each lamp replacement. Each lamp has been pre-calibrated to determine the lamp-specific calibration number. ARS will call the site operator to request a lamp change and will provide the correct calibration number for each new lamp. Set the calibration number on the receiver computer using the thumb-wheel switches labeled "CAL."

POST CALIBRATIONS

Lamps removed from service will be post-calibrated at ARS after annual site visits. Extra care should be taken in handling and transporting these used lamps because the filaments become very brittle and fragile with use.

4.2.3 Strip Chart Servicing

OPERATIONAL CHECK

At least once a month, check the strip chart recorder to verify proper operation. Refer to TI 4330-4025, *Transmissometer Data Collection via Strip Chart Recorder*.

REPLACING CHART PAPER

Instructions for installation of chart paper can be found in the Primeline 6723 Instruction Manual on pages 2-8 through 2-10. By hand, advance the paper a few sheets before loading the magazine to make sure the paper is feeding correctly.

CLEANING CHART MAGAZINE

At each paper change, the chart paper roller should be cleaned with alcohol and Kimwipes. This will remove any paper dust and chart pen ink that may have accumulated. Use the blower brush to remove paper dust from the drive gear assembly.

CLEANING RECORDER

Use the blower brush to remove dust from the control panel and the top of the recorder.

REPLACING PEN

Instructions for changing pens can be found on page 2-10 of the Primeline 6723 Instruction Manual.

4.2.4 Solar Power System Servicing

SOLAR PANELS AND WIRING

To check the solar panels:

- Clean solar panels with the supplied glass cleaner and paper towels.

- Inspect the glass for cracks and scratches.
- Check mounting nuts and bolts for tightness.
- Visually inspect wiring for signs of damage due to rodents or chafing.
- If the panels are on a free-standing mount, check that the alignment perpendicular to true south has not been altered.
- Document results of these checks on the operator log sheets. Contact ARS if signs of damage are observed.
- Check M-8/M-16 solar panel regulator LED status indicators for proper operation (see below).

M-8/M-16 SOLAR PANEL REGULATOR

The M-8 and M-16 units include four LED status indicators. They are described below:

- PV READY will light when the solar panel voltage is high enough to charge the battery.
- ANALYZING will light when the controller has temporarily stopped the charging current to the battery to allow proper battery chemical mixing to prevent battery damage. In 30 to 60 seconds, the charging light will re-engage.
- CHARGING will light to indicate that the controller is allowing full charging current to flow to the battery.
- FINISHING will start to slowly flash as the battery reaches full charge. As the battery voltage rises, the flash rate will increase. This variable flash rate will indicate the rate of battery voltage swing and indirectly indicate the battery's state of charge.

4.2.5 AC Power System Servicing

SURGE PROTECTORS

Visually check the status of the surge protector indicator lights. Two versions of Northern Technologies' surge protectors protect instruments from potentially-damaging power surges. One model has two system warning lights, the other has three lights. The lights indicate the surge operating condition of the protector as described below:

Green Light: The surge protector is in good operating condition.

Yellow Light: The surge protector has sustained partial damage as the result of a power surge, but is still capable of providing protection.

Red Light: The surge protector has sustained a massive power surge and is no longer capable of providing protection.

If the red light on either model surge protector is lit, call ARS for a replacement unit.

POWER SUPPLY

A 10-amp power supply is used at the transmitter when AC power is available. A 5-amp power supply is used at the receiver when AC power is available. Check to see if power supply indicator light is on when power supply is turned on.

WIRING AND CONNECTORS

Periodically check wiring for damage and connectors for tightness.

4.2.6 Deep-Cycle Battery Servicing

BATTERY FLUID LEVEL

Battery fluid level should be checked monthly. The fluid level is visible through the plastic case of the battery and should be between the two indicator marks on the battery case. Batteries in the small version transmitter shelters may be difficult to check. In that case, a check of one battery would suffice.

If the battery fluid level is low, use only distilled water to bring the level up. Low battery fluid levels indicate a possible problem with the solar panel regulators. Call ARS if the batteries require fluid and check the batteries every site visit until directed otherwise.

Under normal operating conditions, battery fluid should only need to be added during annual field specialist site visits.

BATTERY CONTACTS

Visually inspect battery contacts for signs of excess corrosion or deposits. Wire brushes have been supplied to remove the deposits if needed. Under most conditions, terminals will only need cleaning once a year by field specialists. If terminals need cleaning, follow the directions listed below:

CLEANING BATTERY CONTACTS

- Notify ARS of the need to clean the terminals. Do not attempt this if you are unsure.
- Turn off power to the following instruments (do not disrupt a transmissometer reading):

  At Receiver Station

  - Receiver computer
  - Strip chart recorder
  - Also, disconnect solar panel regulator connection to Station (do not let "+" and "-" connections touch each other).

At Transmitter Station

- Transmitter control box

- Disconnect solar panel regulator connection to battery (do not let "+" and "-" connections touch each other).

- Make sure the wiring is labeled and is easily identifiable as to positive (+) and negative (-) leads.

- Draw a diagram depicting power lead attachments. (Positive interconnects to positive terminals, negative interconnects to negative terminals.)

- Remove and clean one contact surface at a time starting with all negative leads (-).

• **CAUTION** -- sparks will occur if battery leads touch metal objects or each other.

• Clean contacts with the supplied wire brush.

• Compare the battery system wiring with your diagram after you have finished and the wires are re-connected. (Positive interconnects to positive terminals, negative interconnects to negative terminals).

• Turn all instrumentation back **ON** and verify correct operation of each component. System timing may need to be reset when power is turned back ON (see Section 4.5).

• Document this servicing on the operator log sheets.

• Call ARS and advise them that the servicing has been completed.

VOLTAGE READING

Take a deep-cycle battery voltage reading at least once a month. Turn the voltmeter to the 20 VDC setting and connect the positive lead to the "+" terminal and the negative lead to the "-" terminal of the battery. Document the voltage reading on the log sheet and turn the voltmeter off.

4.2.7 Data Collection Platform (DCP) Antenna Servicing

ANTENNA INSPECTION

The DCP antenna should be visually inspected periodically. First, check that the mounting base is securely affixed to the shelter. Secondly, the driver, reflector, and directional elements should be securely attached and in position. Lastly and most important, the antenna alignment should be correct (southwesterly orientation with inclination angle of about 45°).

CABLE AND CONNECTOR INSPECTION	Inspect the antenna cable for rodent damage or chafing. The cable connector at the base of the antenna should be checked periodically for tightness.

4.3 PROBLEMS OR QUESTIONS

Call ARS immediately if any problems occur or if any questions arise. Many problems can be resolved through telephone consultation.

ARS may be reached at the following telephone numbers:

Regular: 970/484-7941
Fax: 970/484-3423

Detailed troubleshooting procedures to assist with telephone-directed problem resolution are presented in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

4.4 HANDLING LOG SHEETS

The site operator must complete a transmissometer operator log sheet for each transmitter and receiver site visit. Upon returning to the office, fax the completed sheets to ARS (Fax 970/484-3423).

Also mail the original log sheets to ARS:

Air Resource Specialists, Inc.
Attn: Data Coordinator
1901 Sharp Point Drive Suite E
Fort Collins, CO 80525

Any additional information or other pertinent supplemental documentation that the operator deems important can also be included with the log sheets.

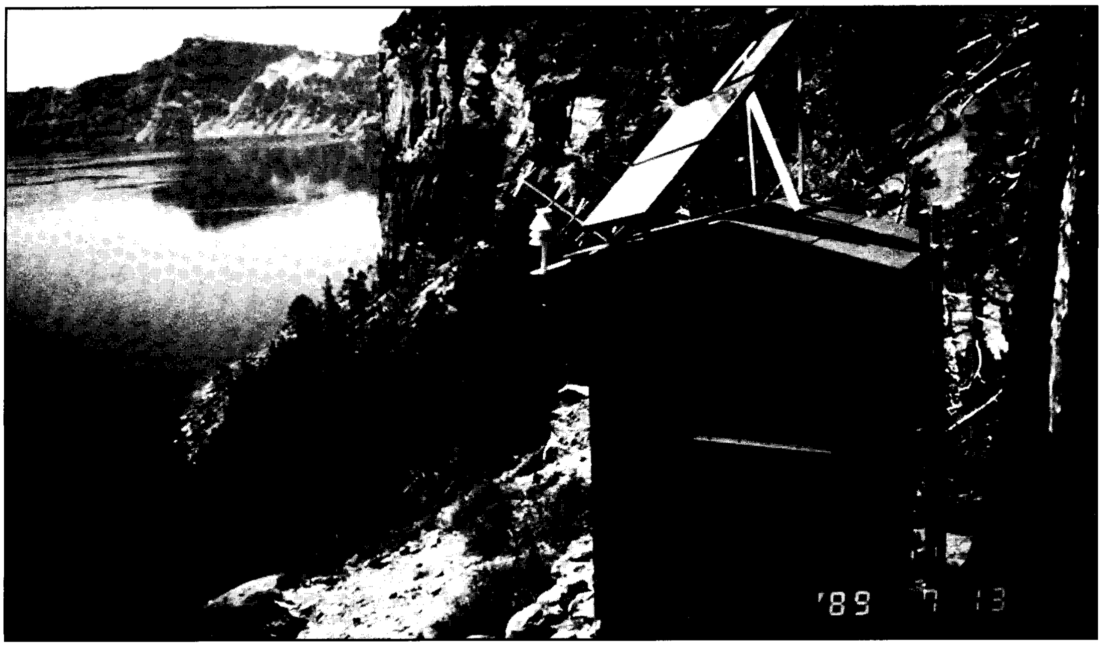
5.0 REFERENCES

Soletec Distribution, Primeline 6723 Instruction Manual, Sun Valley, CA.

APPENDIX A

NPS Visibility Monitoring Network
Optec LPV-2 Transmissometer
Operator's Guide

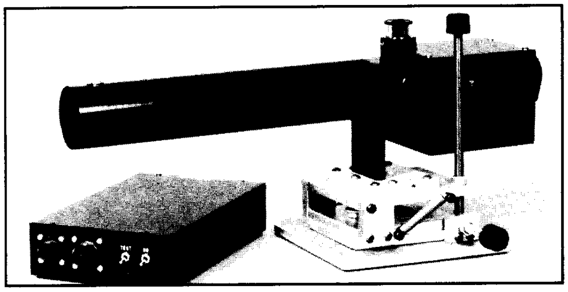
Air Resource Specialists, Inc.



NPS VISIBILITY MONITORING NETWORK
OPTEC LPV-2 TRANSMISSOMETER
OPERATOR'S GUIDE

Air Resource Specialists
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
(303) 224-9300

TRANSMITTER



Introduction

For correct operation, the transmitter must have the proper:

- alignment
- timing
- viewing mirror position
- window and optical cleanliness
- lamp regulation
- power supply

Servicing Frequency

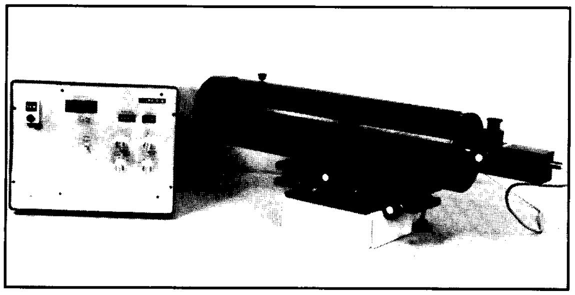
Both the transmitter and receiver stations should be visited weekly. The transmitter should be visited first. Correct operation of the entire system should be verified shortly thereafter at the receiver. Schedule your servicing visit to arrive at the transmitter shelter 10 minutes before the hour. Log Sheets must be completed during each site visit.

Regular Maintenance

The primary transmitter servicing tasks are listed below. For detailed descriptions of these tasks and Log Sheet entries, consult the operator's manual.

1. **Initial Inspection.** Prior to servicing the transmitter, note the general condition of the system and check the telescope alignment and the window and optical cleanliness.
2. **Alignment.** On the Log Sheet, document the initial position of the receiver shelter window with respect to the reticle circle with a "+". Correct the alignment and note the new position on the Log Sheet. Return the viewing mirror to the proper position.
3. **Clean Window.** Clean the window at every site visit. Remove the pane and clean it thoroughly with alcohol and Kimwipes. Visually inspect the telescope objective lens. If the objective lens is dusty, brush lightly with the photographic brush provided. If any smudges or other obstructions exist on the lens, call ARS. **Do not** clean the objective lens with alcohol. **Do not** use canned air on the window or lens. Re-check the alignment after window cleaning.
4. **Timing.** Verify that the lamp turns ON at the top of the hour and stays ON for the full 16 minutes. This can also be verified at the receiver.
5. **Lamp Check LED.** While the transmitter light is on under automatic control, determine the status of the lamp check LED on the side of the control box. The red LED light should remain OFF. If the LED is ON, call ARS. Do not check the LED light with the test switch.
6. **Power Supply Inspection.**
   - At sites with line power, check all surge protector indicator lights to determine if a surge has occurred. If indicator lights are red, call ARS.
   - At sites with lead-acid batteries, visually check the fluid level in the batteries and fill as needed with distilled water. Battery voltage measurements need only be done at the transmitter upon direction of ARS. Clean and inspect the condition of the solar panels.
7. **Final Check.** Verify proper alignment, then return the viewing mirror to the proper position. The knob should be turned fully counter-clockwise. No image should be visible in the eyepiece.
8. **Log Sheet.** Check that the Log Sheet is fully completed. The yellow copy remains in the shelter; mail the original to ARS.

RECEIVER



Introduction

For correct operation, the receiver must have the proper:

- alignment
- timing
- viewing mirror position
- window and optical cleanliness
- switch settings
- power supply

Servicing Frequency

Both the transmitter and receiver stations should be visited weekly. The transmitter should be visited first. Correct operation of the entire system should be verified shortly thereafter at the receiver. Schedule your servicing visit to arrive at the receiver shelter 10 minutes before the hour. Log Sheets must be completed during each site visit.

Regular Maintenance

The primary receiver servicing tasks are listed below. For detailed descriptions of these tasks and Log Sheet entries, consult the operator's manual.

1. **Initial Inspection.** Prior to servicing the receiver, note the general condition of the system and check the telescope alignment, the window and optical cleanliness, and the displayed reading. Convert the displayed reading to visual range by turning the A1 switch from C to B, and determine if the reading agrees with the actual conditions (refer to orange transmissometer reading sheet). Make sure that A1 switch is left in "C" position after check.
2. **Alignment.** On the Log Sheet, document the initial position of the transmitter light source with respect to the reticle circle with a "+". Correct the alignment and note the new position on the Log Sheet. Return the viewing mirror to the proper position.
3. **Clean Window.** Clean the window at every site visit. Remove the pane and clean it thoroughly with alcohol and Kimwipes. Visually inspect the telescope objective lens. If the objective lens is dusty, brush lightly with the photographic brush provided. If any smudges or other obstructions exist on the lens, call ARS. **Do not** clean the objective lens with alcohol. **Do not** use canned air on the window or lens. Re-check the alignment after window cleaning.
4. **Timing.** All times should be synchronized with the National Bureau of Standards (NBS) time. You can synchronize your digital watch to NBS time by calling the NBS recording at 303/499-7111. The system timing is as follows:

HR	MI	SE	Action
XX	00	00	Transmitter light ON
XX	03	00	Receiver starts reading
XX	13	20	Receiver finishes reading, toggle changes state and new reading is displayed.
XX	16	00	Transmitter light OFF

5. **Strip Chart.** Inspect the strip chart to verify that reasonable readings are being recorded. The number on the computer display should be transferred to the appropriate position on the strip chart paper. Mark the strip chart with a "hack" mark (orange button), and write the date, time, displayed computer reading, and your name on the chart. Zero channel A by pushing in the zero/record button and turning the knob until the black pen is over the left-most chart line. Put the zero/record button back in the *record* position.
6. **Power Supply Inspection.**
   - At sites with line power, check all surge protector indicator lights to determine if a surge has occurred. If indicator lights are red, call ARS.
   - At sites with lead-acid batteries, visually check the fluid level in the batteries and fill as needed with distilled water. Battery voltage measurements need only be done at the receiver upon direction of ARS. Clean and inspect the condition of the solar panels.
7. **Final Check.** Verify proper alignment, then return the viewing mirror to the proper position. The knob should be turned fully counter-clockwise. No image should be visible in the eyepiece.
8. **Log Sheet.** Check that the Log Sheet is fully completed. The yellow copy remains in the shelter; mail the original to ARS.

SPECIAL MAINTENANCE

Special maintenance tasks are discussed in detail in the operator's manual. Call ARS before performing special maintenance.

Timing Reset

When the system timing is correct, the receiver takes a 10-minute averaged reading centered within the 16-minute transmitter lamp-on time. If the receiver toggle light updates more than 5 minutes before the lamp turns OFF, or less than a minute before the lamp turns OFF, the system timing needs to be reset.

1. **Transmitter Timing.** Remove the control box cover. With the power switch ON, push the small reset button at the top of the hour. The light should come ON and stay ON for 16 minutes.
2. **Receiver Timing.** Turn the computer OFF, then ON to clear the system computer. The display should go to zeros. At three minutes after the hour (or three minutes after the transmitter light comes on), push the "reset clock" switch up momentarily, then release. At approximately 13 minutes and 20 seconds after the hour, the reading will update and the toggle light should come on.
3. **Setting Your Watch.** You can synchronize your digital watch to National Bureau of Standard's NBS time by calling the NBS recording at 303/499-7111 (Boulder, Colorado).
4. **Call ARS.** Notify ARS of the exact time of the timing reset by telephone and note the timing reset on the Log Sheet. If you are unsure of the procedure, call ARS for direction.

Lamp Changes

Prior to the scheduled lamp change date, ARS will provide the site operator with the next lamp number and its associated calibration number. Lamp changes should be done when visibility conditions are stable. Both the transmitter and receiver must be visited within as short a time as possible. Use extreme care when removing and storing used lamps. The used lamps are required for post-calibration of the system. Label the lamps with ON/OFF dates and times and record lamp changes on the Log Sheets.

Things to Avoid

1. **Lamp Changes.** The lamp is held into the rear of the transmitter by a friction fit and is removed by pulling it straight out of the transmitter body. Do not loosen any screws on the lamp alignment plate or the system will need re-calibration.
2. **Transmitter Focus.** Do not change the focus of the transmitter telescope or the system will need re-calibration.
3. **Radio Transmission.** Do not transmit with hand-held radios within 10 feet of either transmissometer component, or the timing may need to be reset.
4. **Computer Resets.** Avoid unnecessary computer resets (OFF/ON) as the timing may be disrupted.

Trouble-Shooting

The majority of transmissometer problems are caused by:

- misalignment
- incorrect system timing
- incorrect viewing mirror position
- inadequate power

Check for these potential causes and refer to the trouble-shooting section in the operator's manual before calling ARS.

Contact ARS

Please contact us if any questions or problems arise:

Carter Blandford, Jim Wagner, or Roger Tree
Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
303/224-9300

APPENDIX B

Example Completed LPV-2
Transmissometer Transmitter
Log Sheet

Air Resource Specialists, Inc.

Location GRBA

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
TRANSMITTER STATION

Date 15 MAR 93 Local Time 12:40 Operator(s) PFAFF

Weather Conditions OVERCAST WARM LIGHT BREEZE

Visibility Conditions FAIR (HUMID HAZE)

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? (YES) NO
   Comment
2. **ALIGNMENT:** Mark initial location of receiver shelter window with a "+".
   Initial Alignment Comments ON TARGET
   (+)
   IMPORTANT: Return flip mirror to proper (ON) position.
3. Instrument Number LPV- 605 Lamp Number 709
4. Initial Window Cleanliness (GOOD) MODERATE POOR
   Comment

SERVICING

1. Window Cleaned? (YES) NO If YES, time cleaned 12:42 If NO, why not?
2. Lens Inspected? (YES) NO Comment
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES (NO) If YES, time aligned
4. Solar Panels Cleaned? (YES) NO Comment
5. Lamp Check **IMPORTANT: Must be done when lamp is <u>ON</u> under automatic control.**
   a) LED (indicator light on side of control box) ON OFF (if ON , call ARS)
   b) Lamp Voltage Reading (switch voltmeter to 20 VDC range) 5.95 volts, for lamp number 709
   IMPORTANT: Switch voltmeter to "OFF" after taking voltage reading.

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES (NO)
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) 1 : 01 : 38
3. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) 1 : 17 : 38

SPECIAL SERVICING (upon ARS instruction)

1. Timing Reset? YES (NO) If YES, time reset
2. Lamp Changed? YES (NO) If YES, new lamp number time lamp changed
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Alignment rechecked after lamp change? YES NO
4. Battery Voltage (charging) 14.6 Battery Voltage (analyzing) 13.8

GENERAL COMMENTS/SUPPLIES NEEDED

Send the original copy of this form to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

Phone: 1-800-344-5423
FAX: 1-303-484-3423

(4_9.sam 3/94)

APPENDIX C

Example Completed LPV-2
Transmissometer Receiver
Log Sheet

Air Resource Specialists, Inc.

Location GRBA

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
RECEIVER STATION

Date 15 MAR 93 Local Time 14:45 Operator(s) PFAFF

Weather Conditions OVERCAST MILD BREEZY

Visibility Conditions GOOD (EXCELLENT, ACCORDING TO TRANSMISS.)

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? (YES) NO
   Comment
2. Receiver Display Reading 698 Local Time 14:45 Toggle ON (OFF)
3. Settings: Gain .500 Cal 736 Dist 3.91 A1 C A2 SD Int 10 Cycle 1H
   Switch A1 Readings: C 698 B .013
   Does the Bext represent actual conditions? (YES) NO Comment
   IMPORTANT: Return A1 Switch to "C" position after check.
4. **ALIGNMENT:** Mark initial location of transmitter light source with a "+".
   Initial Alignment (+) Comments TARGET IS VERY SLIGHTLY BELOW CENTER
   IMPORTANT: Return flip mirror to proper (ON) position.
5. Instrument Number LPV-005
6. Initial Window Cleanliness (GOOD) MODERATE POOR
   Comment ALMOST NO DUST
7. Strip Chart Operating? YES (NO) **(If operating, refer to SPECIAL SERVICING #4 below.)**

SERVICING

1. Window Cleaned? (YES) NO If YES, time cleaned 14:40 If NO, why not?
2. Lens Inspected? (YES) NO Comment VERY LITTLE DUST
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? (YES) NO If YES, time aligned 14:42
4. Solar Panels Cleaned? YES (NO) Comment

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES (NO)
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) 15 : 01 : 38
3. Receiver Toggle Update, Exact Time, (HR:MIN:SEC) 15 : 16 : 38
4. Updated Receiver Reading 693 Toggle ON OFF
   Does the updated Bext reading represent actual conditions? YES NO Comment
5. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) 15 : 17 : 38

SPECIAL SERVICING (upon ARS instruction)

1. Computer Reset? YES (NO) Timing Reset? YES (NO) If YES, time reset
2. Lamp changed at Transmitter Station? YES (NO)
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Receiver computer calibration (cal) number changed? YES (NO) If YES, new cal number entered
4. Strip Chart: Marked? YES (NO) Zeroed? YES (NO) Paper /Pens OK? YES NO
5. Battery Voltage (charging) 14.6 Battery Voltage (analyzing) 14.1

GENERAL COMMENTS/SUPPLIES NEEDED

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TROUBLESHOOTING AND EMERGENCY MAINTENANCE PROCEDURES FOR OPTEC LPV-2 TRANSMISSOMETER SYSTEMS (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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1.0	Modify figures for connecting components	March 1995	
1.1	Minor text changes.	August 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes on-site troubleshooting procedures to be followed when a malfunction of the Optec LPV-2 transmissometer system at an IMPROVE Protocol site is suspected. The purpose of on-site troubleshooting is to assure quality data capture and minimize data loss by performing operational checks on transmissometers, data acquisition systems, and support equipment that will either identify the probable source of a system malfunction, or verify proper system operation.

This TI is referenced from Standard Operating Procedure (SOP) 4110, *Transmissometer Maintenance (IMPROVE Protocol)* and serves as a guideline for:

- Transmitter system operational verification.
- Receiver system operational verification.
- Data collection platform (DCP) and support equipment operational verification.
- Strip chart recorder operational verification.
- Solar power (DC) system operational verification.
- Line power (AC) system operational check.

Due to variations in the site configurations of IMPROVE Protocol sites, portions of this TI may not apply to every transmissometer station.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and data coordinator concerning the schedule and requirements for specific troubleshooting procedures.
- Oversee and review specific troubleshooting procedure documentation completed by the site operator, field specialist, or data coordinator for accuracy and completeness.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, and data coordinator concerning the schedule and requirements for specific troubleshooting procedures.
- Train the site operator in troubleshooting procedures necessary for on-site resolution of instrument problems.

- Provide technical support to the site operator via telephone to assure identification and resolution of instrument problems.

- Document all technical support provided to the site operator.

- Resolve problems reported by the site operator.

2.3 DATA COORDINATOR

The data coordinator shall:

- Coordinate with the site operator, his/her supervisor, project manager, and field specialist concerning the schedule and requirements for specific troubleshooting procedures.

- Identify possible instrument malfunctions and contact the site operator to schedule troubleshooting visits.

- Verify that scheduled visits are performed and notify the site operator if he/she fails to make a scheduled visit.

- Provide technical support to the site operator via telephone to identify and resolve instrument problems.

- Document all technical support provided to the site operator.

- Review documentation completed by the site operator for accuracy and completeness.

- File all hard copy site documentation.

- Send supplies, tools, and replacement instrumentation necessary for instrument problem resolution to the site operator.

- Enter all correspondence with site operators and the results of all performed procedures into site-specific timelines.

2.4 INSTRUMENT TECHNICIAN

The instrument technician shall provide technical support to the data coordinator in identifying and interpreting instrument problems.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate with his/her supervisor, project manager, field specialist, and data coordinator concerning the schedule and requirements for specific troubleshooting procedures.

- Perform procedures described in this TI in response to direction provided by the data coordinator or field specialist.

- Thoroughly document all troubleshooting procedures on the LPV-2 Transmissometer Operator Log Sheets (see Figures 2-1 and 2-2) and mail the log sheets to the data coordinator.

- Report any noted inconsistencies immediately to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Equipment required to support troubleshooting includes:

- Keys for shelters and padlocks

- On-site transmissometer receiver tool kit that includes:

  - Medium and small flat-blade screwdriver
  - Medium and small Phillips-head screwdriver
  - Medium adjustable wrench
  - Pliers
  - Battery terminal cleaner
  - Wire cutters
  - Flashlight
  - Wire ties
  - AA batteries (four) for receiver computer
  - Pen or pencil
  - Strip chart recorder pens
  - Strip chart paper
  - Utility knife
  - Allen wrench set
  - Blower (photographic) brush
  - Signal mirror
  - AC circuit tester
  - compass
  - angle indicator

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Location________________________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
TRANSMITTER STATION

Date__________________ Local Time______________ Operator(s) ______________________________

Weather Conditions____

Visibility Conditions____

____

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment____
2. ALIGNMENT: Mark initial location of receiver shelter window with a "+".
   Initial Alignment Comments____________________________________
   ____
   ____
   IMPORTANT: Return flip mirror to proper (ON) position.
3. Instrument Number LPV-__________ Lamp Number___________________
4. Initial Window Cleanliness GOOD MODERATE POOR
   Comment____

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned ____________ If NO, why not? ______________________
2. Lens Inspected? YES NO Comment ______________________________________
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned ____________________
4. Solar Panels Cleaned? YES NO Comment ______________________________________
5. Lamp Check IMPORTANT: Must be done when lamp is <u>ON</u> under automatic control.
   a) LED (indicator light on side of control box) ON OFF (if ON , call ARS)
   b) Lamp Voltage Reading (switch voltmeter to 20 VDC range) __________ volts, for lamp number ______________
   IMPORTANT: Switch voltmeter to "OFF" after taking voltage reading.

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) _______:_______:_______
3. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) _______:_______:_______

SPECIAL SERVICING (upon ARS instruction)

1. Timing Reset? YES NO If YES, time reset ________________
2. Lamp Changed? YES NO If YES, new lamp number__________ time lamp changed____________
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Alignment rechecked after lamp change? YES NO
4. Battery Voltage (charging)______________________ Battery Voltage (analyzing)____________________

GENERAL COMMENTS/SUPPLIES NEEDED____

____

____

____

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Figure 2-1. LPV-2 Transmissometer Operator Log Sheet for Transmitter Station.

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Location______________________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
RECEIVER STATION

Date________________ Local Time____________ Operator(s) ______________________________
Weather Conditions______________________________
Visibility Conditions______________________________

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment______________________________
2. Receiver Display Reading ______________ Local Time ____________ Toggle ON OFF
3. Settings: Gain________ Cal________ Dist________ A1________ A2________ Int________ Cycle________
   Switch A1 Readings: C________ B________
   Does the Bext represent actual conditions? YES NO Comment ______________________
   IMPORTANT: Return A1 Switch to "C" position after check.
4. ALIGNMENT: Mark initial location of transmitter light source with a "+".
   Initial Alignment Comments______________________________
   IMPORTANT: Return flip mirror to proper (ON) position.
5. Instrument Number LPV-__________
6. Initial Window Cleanliness GOOD MODERATE POOR
   Comment ______________________________
7. Strip Chart Operating? YES NO (If operating, refer to SPECIAL SERVICING #4 below.)

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned __________ If NO, why not? ______________
2. Lens Inspected? YES NO Comment ______________________________
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned ______________
4. Solar Panels Cleaned? YES NO Comment ______________________________

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) ______:______:______
3. Receiver Toggle Update, Exact Time, (HR:MIN:SEC) ______:______:______
4. Updated Receiver Reading ______________ Toggle ON OFF
   Does the updated Bext reading represent actual conditions? YES NO Comment ______________
5. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) ______:______:______

SPECIAL SERVICING (upon ARS instruction)

1. Computer Reset? YES NO Timing Reset? YES NO If YES, time reset ______________
2. Lamp changed at Transmitter Station? YES NO
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Receiver computer calibration (cal) number changed? YES NO If YES, new cal number entered __________
4. Strip Chart: Marked? YES NO Zeroed? YES NO Paper /Pens OK? YES NO
5. Battery Voltage (charging)______________ Battery Voltage (analyzing)______________

GENERAL COMMENTS/SUPPLIES NEEDED______________________________

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Figure 2-2. LPV-2 Transmissometer Operator Log Sheet for Receiver Station.

- On-site transmissometer transmitter tool kit that includes:
  - Small flat-blade screwdriver
  - Pen or pencil
  - Flashlight
  - Blower (photographic) brush
  - Signal mirror
  - AA batteries (four) for the control box
- Battery tester
- Distilled water
- Watch
- *Site Operator's Manual for Transmissometer Monitoring Systems*
- LPV-2 Transmissometer Operator's Guide
- LPV-2 Transmissometer Operator Log Sheets (transmitter and receiver)
- Tenma digital voltmeters with cables (transmitter and receiver)
- Transmissometer component shipping cases
- Spare fuse kit, including:
  - 1-amp AGC glass fuse for transmissometer receiver computer
  - 5-amp AGC glass fuse for transmissometer transmitter (control box)
  - 0.5-amp fuse for strip chart recorder (AC line power external fuse)
  - 2-amp fuse for strip chart recorder (internal fuse for DC operation)
  - 20-amp AGC glass fuse for M-16 solar panel regulator (new orange style)
  - 3-amp AGC glass fuse for 5-amp power supply (for receiver station with AC line power)
  - 2.5-amp AGC glass fuse for 10-amp power supply (for transmitter station with AC line power)

If any tool(s) and/or equipment necessary to support troubleshooting procedures are not available, please contact ARS at 970/484-7941.

4.0 METHODS

This section includes two (2) major subsections:

4.1 General Information
4.2 Transmissometer and Support Equipment Troubleshooting

4.1 GENERAL INFORMATION

The majority of transmissometer problems are caused by:

- Misalignment.
- Incorrect system timing.
- Incorrect viewing mirror position.
- Inadequate power.

Many times operators can diagnose and solve instrument problems in the field, reducing costly site visits and minimizing data loss. Two good practices to follow in troubleshooting are: 1) start with the simple checks and progress towards the more complicated, and 2) break a system down into individually testable subsystems.

TROUBLE-SHOOTING

Many transmissometer system problems can be solved by checking items in the following categories:

- Obvious Sources:
  - The power is unplugged or not turned on.
  - The flip mirror(s) are not in the correct position (ON).
  - The transmitter, receiver, or both are misaligned.
  - System timing is not synchronized (refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
  - Incorrect instrument settings.
- Power Supply:
  - Battery voltage is not sufficient to run the system.
  - A fuse is blown in the receiver computer or in the transmitter control box.
  - Incorrect polarity exists on power leads.
  - Power connectors are not making good contact (pins).

- Solar panels are covered with snow or shaded by tree branches.

• Connectors:

- A connector is not plugged in, or is in the wrong input position.
- A connector is not making good contact.
- Connector pins or sockets are damaged.
- The cable/connector is damaged, resulting in broken wire or electrical short.

BEFORE CALLING FOR ASSISTANCE

Before reporting problems or requesting assistance in diagnosing an instrument problem, please do the following:

• Check problem areas listed above (Obvious Sources, Power Supply and Connectors).

• Follow procedures for troubleshooting the component in question (see following sections).

• Have documentation of your tests available.

• Have a site operator's manual available.

Please call promptly with suspected or observed instrument problems. If the person you need to speak with is not in, ask to be directed to another or leave a message, including your name, location, telephone number, and a brief description of the problem(s) or need(s).

4.2 TRANSMISSOMETER AND SUPPORT EQUIPMENT TROUBLESHOOTING

4.2.1 Transmitter Troubleshooting

INOPERABLE TRANSMITTER

If the transmitter will not operate check the following:

• The "ON/OFF" switch is in the "ON" position.

• The power cable contacts at the battery are not loose, corroded, or covered with excessive deposits.

• The connectors are firmly tightened at the control box and transmitter.

• The battery voltage is adequate (above 11 VDC).

• The fuse inside the control box is intact.

DAMAGED FUSE IN TRANSMITTER

To check the fuse inside the transmitter control box:

- Remove the screws on the top plate of control box (see Figure CONTROL BOX4-1, Transmitter Component Diagram).
- Refer to Figure 4-2, Transmitter Control Box for Location of Fuse.
- Replace damaged fuse with a 5-amp fuse.

CHOPPER FAILURE

If the lamp turns on and stays on, the problem may be that the chopper motor is not operating or the chopper blade may have fallen off the motor spindle. To determine if the chopper is operating properly, check the following:

- Remove the transmitter lamp housing access top cover (see Figure 4-1, Transmitter Component Diagram).
- Verify that the chopper blade (slotted disk) is still mounted on the motor shaft and is rotating (see Figure 4-3, Transmitter Lamp Chamber).
- If the chopper blade has detached, turn power to the system **OFF** and remove the chopper blade from the lamp chamber. Remove the lamp from the transmitter and place it in the lamp storage case. Remove the transmitter telescope and control box and place them in the gray suitcase for shipment to ARS. Telephone ARS for further instructions.

NOTE: It is not possible to determine if the chopper blade is attached by observing the transmitter through the telescope. Due to the speed at which the chopper rotates, both conditions will look the same.

CHOPPER ON/NO LIGHT

If the chopper blade turns on and stays on, but the lamp does not turn on check the following:

- Is the lamp burned out or has the filament been damaged? Use the voltmeter to measure the lamp voltage as described in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*. Voltmeter connections for measuring lamp voltage are shown in Figure 4-4. If the voltage is greater than 7.0 volts, or if the lamp check LED is "ON," the lamp filament is broken and the instrument should be turned off and the lamp should be removed. Telephone ARS for further instructions.

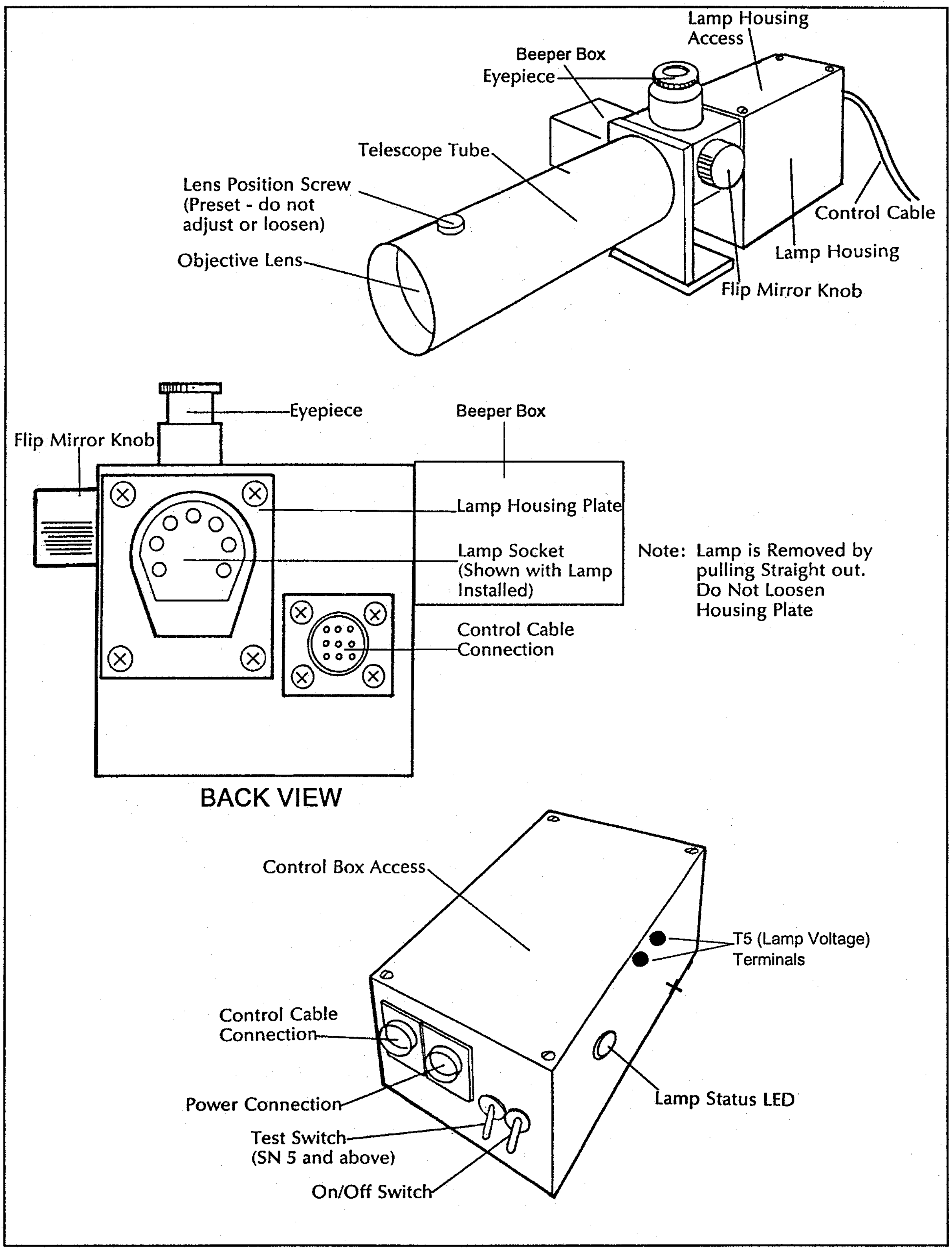

Figure 4-1. Transmitter Component Diagram.

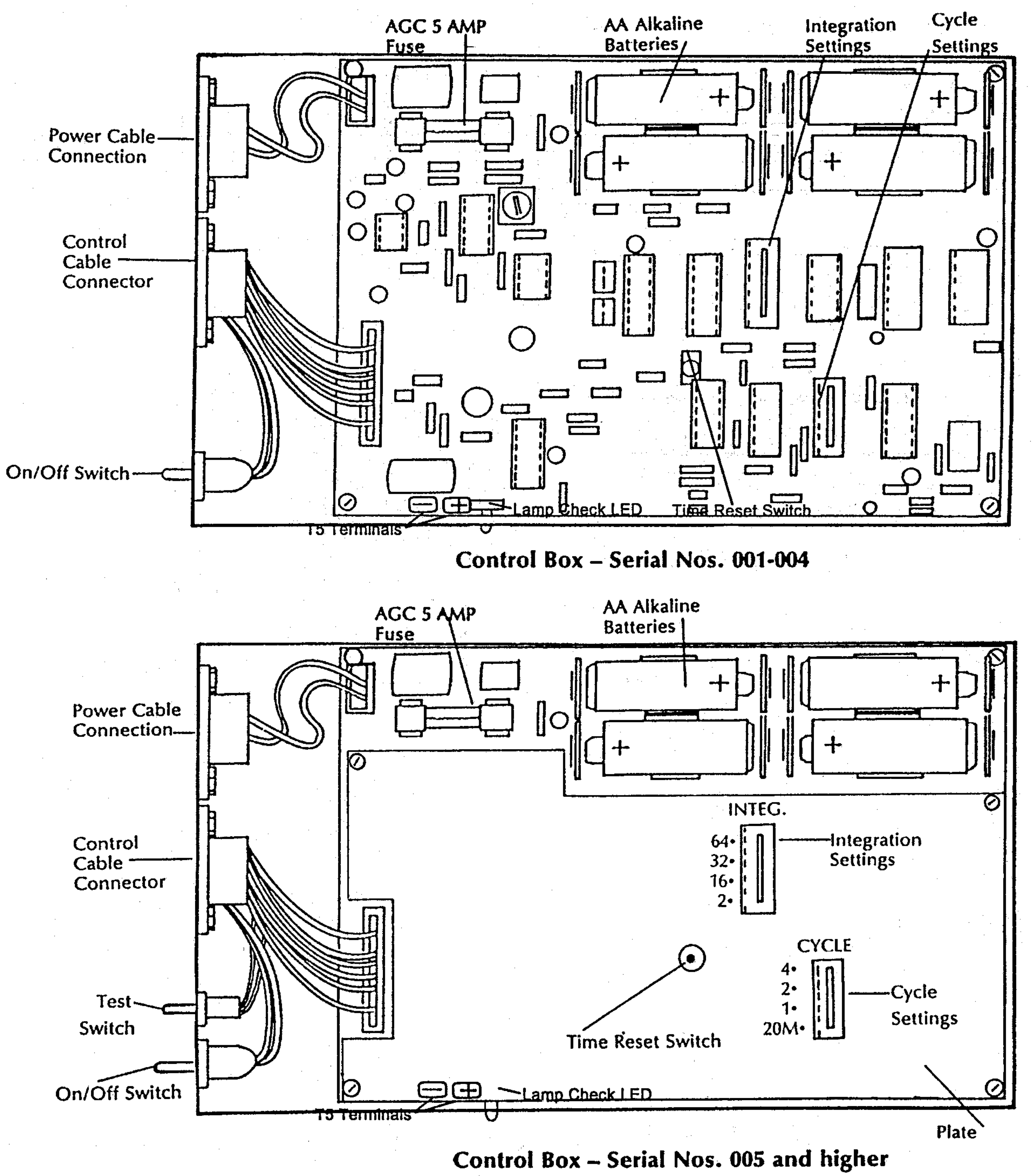

Figure 4-2. Transmitter Control Box for Location of Fuse.

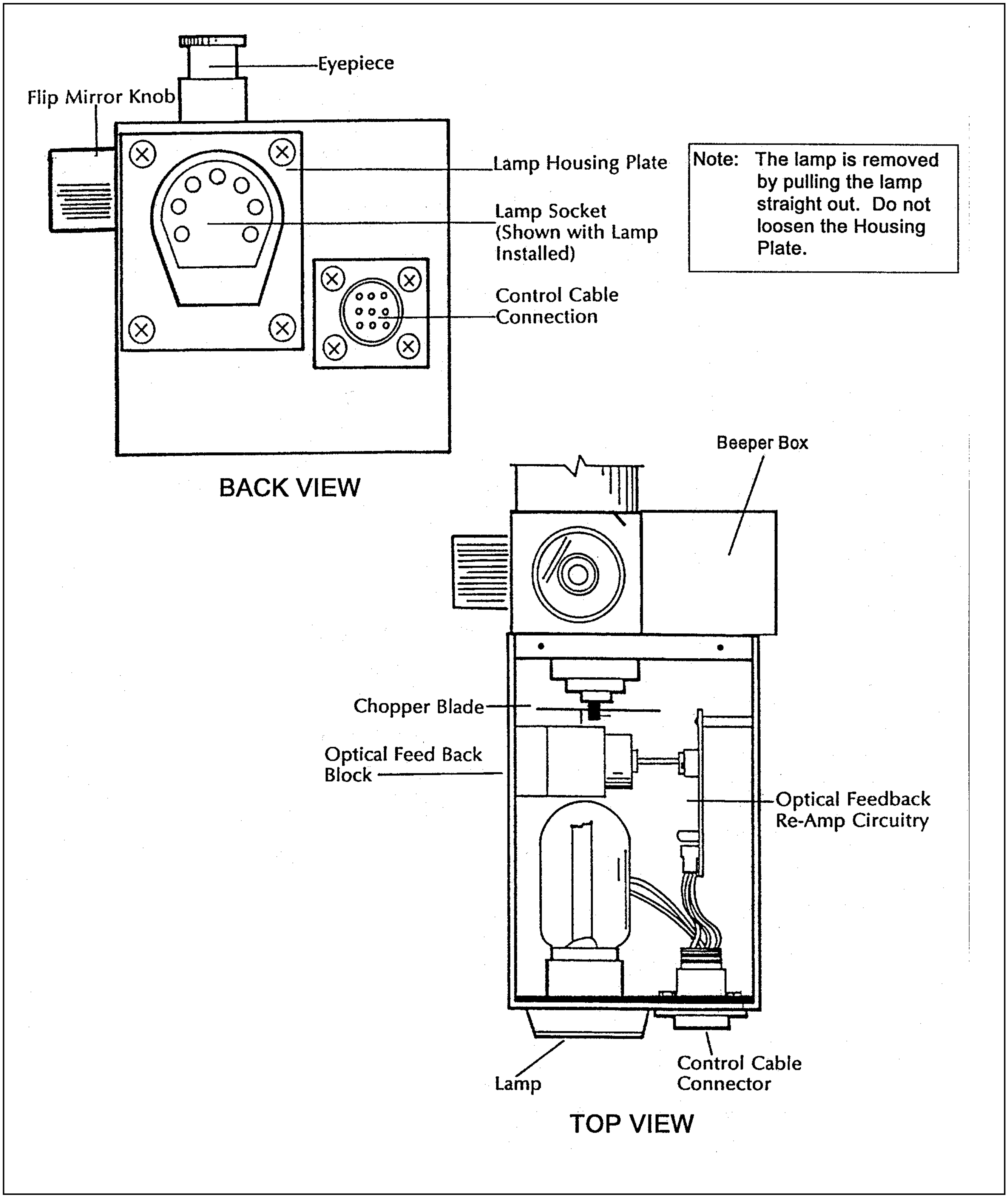

Figure 4-3. Transmitter Lamp Chamber.

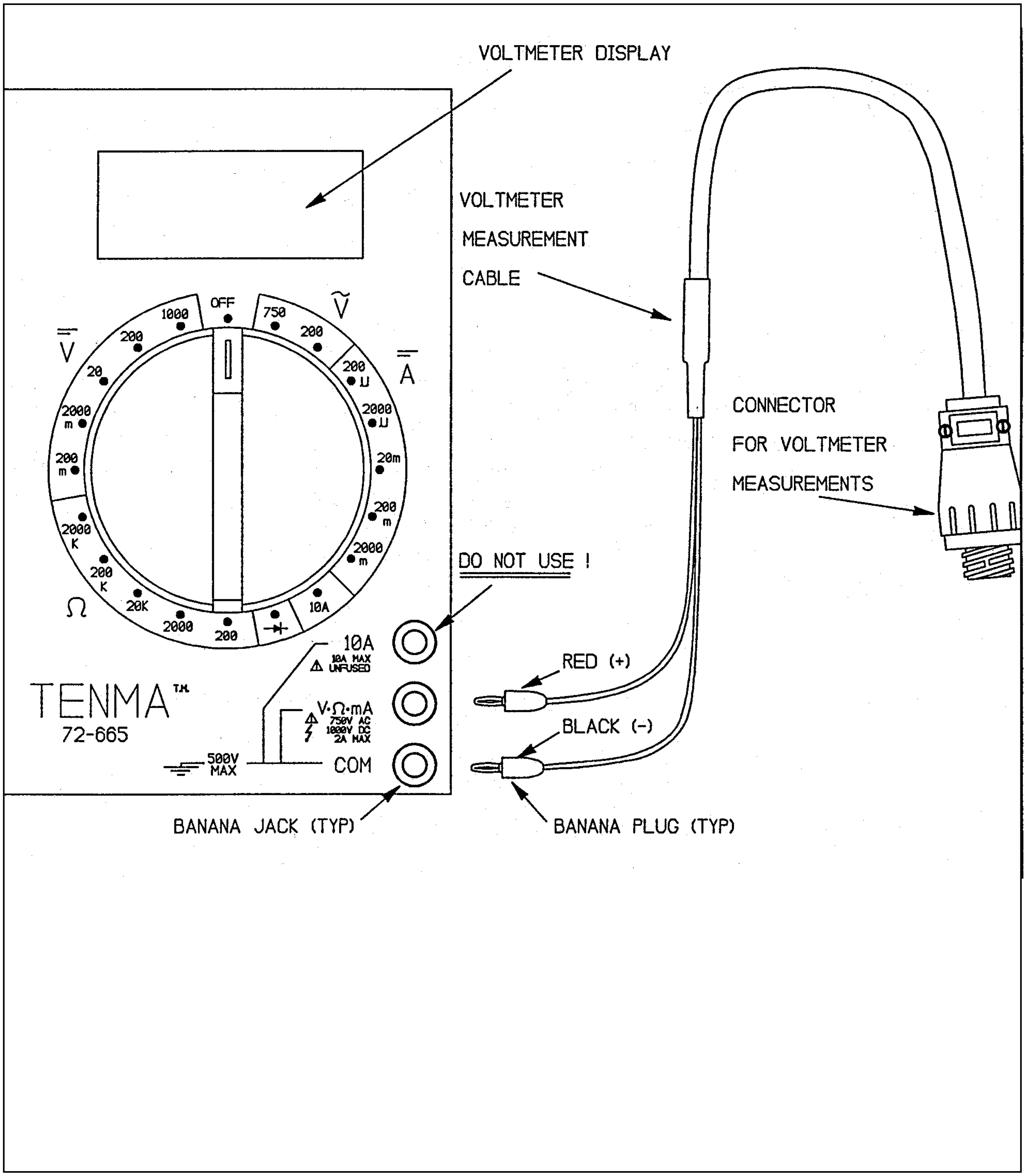

Figure 4-4. Voltmeter Connections for Measuring Lamp Voltage.

- Is the lamp fully seated and are the lamp pins making good contact in the lamp socket? After removing the transmitter lamp housing top cover (see Figure 4-1, Transmitter Component Diagram), look at the two wires that connect to the lamp socket. If either wire is not fully inserted into the socket, disconnect the power cable at the lamp housing and remove the lamp. From the inside of the lamp housing, press both wires firmly back into the lamp socket. Replace the lamp and retest the transmitter.

TRANSMITTER NOT ON FOR FULL 16 MINUTES

If the transmitter turns on at the correct time, but does not stay on for the full 16 minutes, check the supply power battery voltage while the transmitter is on. It should remain above 10.5 volts.

4.2.2 Receiver Troubleshooting

POWERING UP

When the receiver computer power is turned on, the computer will perform a series of internal checks and then set the front panel display to "001" (LPV-2, serial #1-4) or "000" (LPV-2, serial #5 and up). The toggle light should be off. If the display does not go to "000" or "001" upon powering-up, there is a system or component failure; call ARS for further directions. (See Figure 4-5 for a diagram of the receiver computer front panel.)

BLANK RECEIVER DISPLAY

If the receiver display is blank with the power switch "ON" (especially common after a power surge, lightning strike, or after reinstallation of the receiver computer after the computer has been recently shipped from ARS), check for loose computer cards in the receiver unit and for a damaged fuse in the receiver (see below).

LOOSE COMPUTER CARDS

The computer cards in the receiver unit may become loose during shipment. If the receiver display is blank, check the computer cards to make sure they are firmly seated (not loose).

Remove the four small screws (two on each side) from the sides of the receiver computer and lift the computer top cover off.

Using your thumbs, press down firmly (do not use excessive force) on each card to make sure it is firmly seated.

DAMAGED FUSE IN RECEIVER COMPUTER

With the receiver computer cover removed, check the fuse for damage. Refer to Figure 4-6, Receiver Computer Cards and Fuse Diagram, for location of the fuse. If the fuse is damaged, replace with a 1-amp fuse, replace the receiver computer top cover, and reset the receiver computer and system timing. Refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

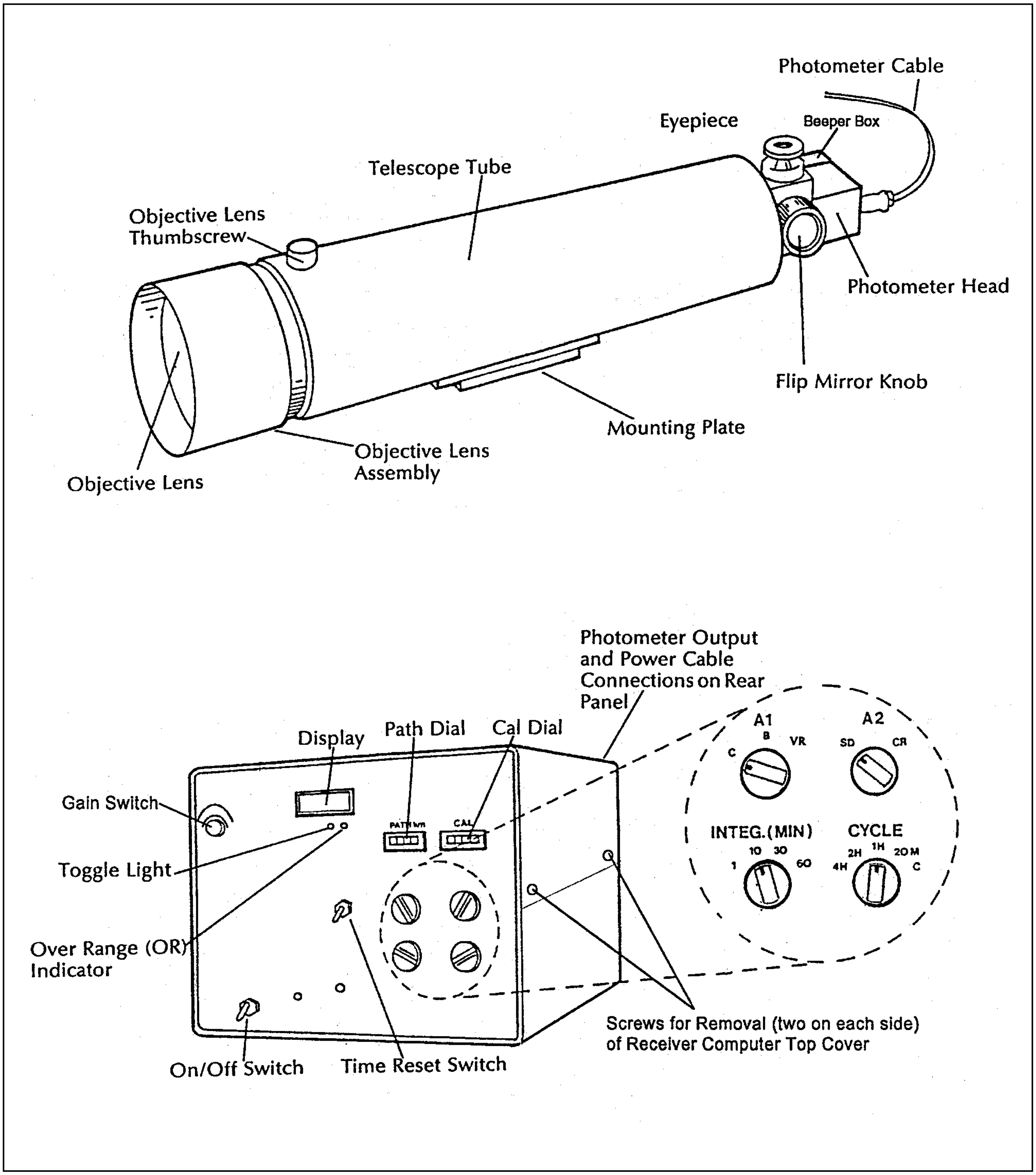

Figure 4-5. Receiver Component Diagram.

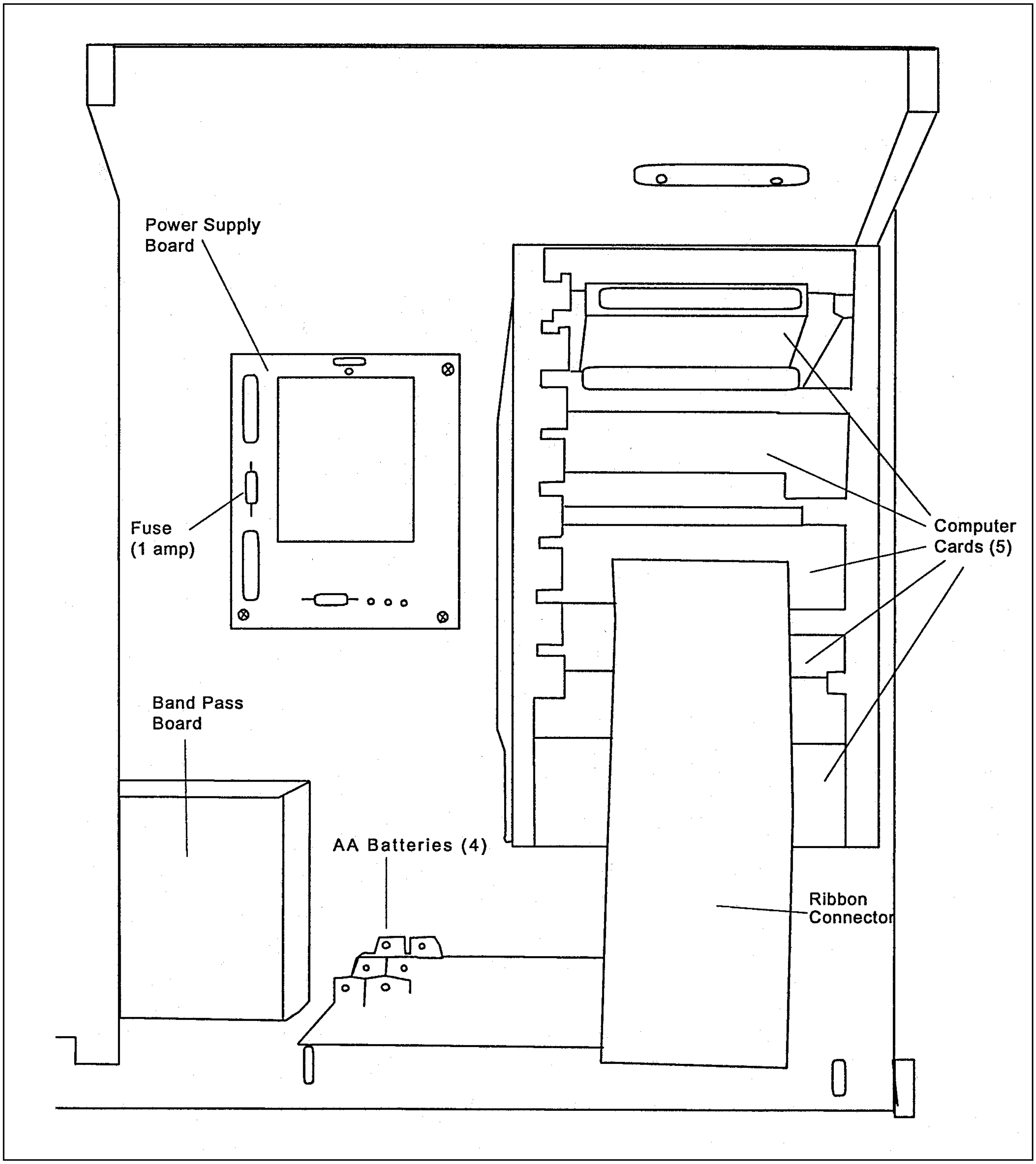

Figure 4-6. Receiver Computer Cards and Fuse Diagram.

TOGGLE LIGHT FLASHING

If during internal checks the computer finds a problem on the memory card, the toggle light will flash at approximately one second intervals upon powering up. If this occurs, call ARS for further directions.

TOGGLE DOES NOT UPDATE

If the toggle light does not change state at the correct time:

- Check the system timing (refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- The computer may be locked up. When this happens, both the toggle and the reading will stay the same until the computer is reset. Reset the computer (by turning the power **OFF** for one second and then turn the power switch back **ON**).
- After resetting the receiver computer, the system timing will need to be reset. (Refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- The computer may be malfunctioning. Call ARS for further direction.

VERIFICATION OF RECEIVER COMPUTER INTEGRITY

To determine if the receiver computer reading is being properly relayed via the terminal strip to the DCP, do the following:

- Locate the voltmeter (one has been supplied at each station).
- Refer to the terminal strip wiring diagram (Figure 4-7).
- Set the voltmeter to 20 VDC (third position to left of "OFF").
- Connect the negative probe (black) to the "A1 Grd." terminal (green wire - 4th hole down on left).
- Connect the positive probe (red) to the "A1 output" terminal (yellow wire - top left).
- Record the voltmeter reading on the LPV-2 Transmissometer Operator Log Sheet - Receiver Station (Figure 2-2).
- Set the "A1" switch to position **C** and record the receiver computer display reading, date, time, and any other pertinent information on the receiver station log sheet.

If a Model 570 DCP is in use at the site, an additional check may be done to confirm that the DCP data agree with the receiver and terminal strip data. Model 570 DCPs have an LED display that allows the user to read the values stored by the DCP for transmission to the GOES satellite. On the back of the DCP,

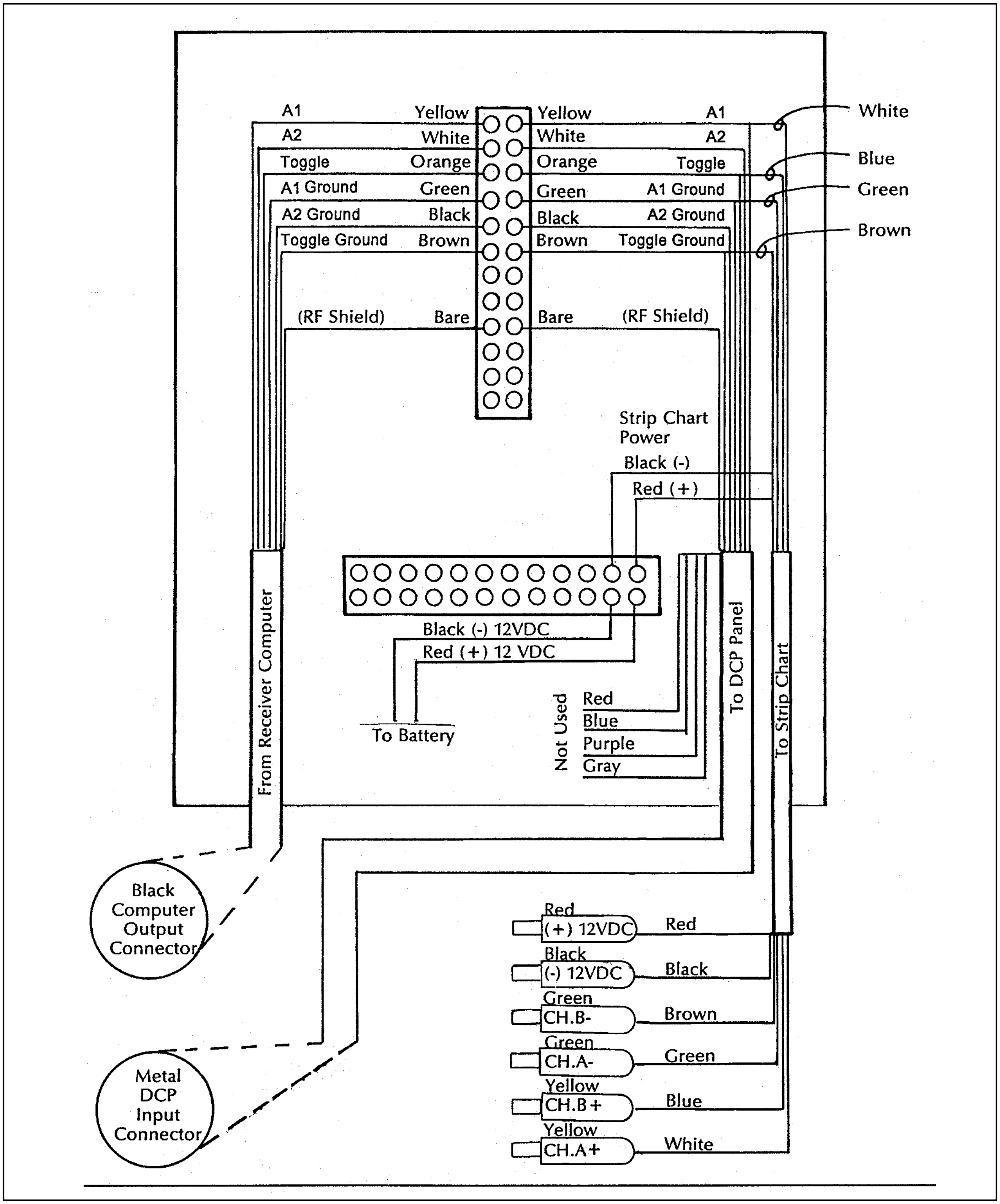

Figure 4-7. Terminal Strip Wiring Diagram.

below the LED display are three push-buttons labelled "ROLL-UP," "NEXT DIGIT," and "DISPLAY." Pressing the "DISPLAY" button causes the data display to advance through channels 1 - 10 showing the data value stored in each channel. The channel number appears on the far left of the display with the data for that channel appearing at the far right. The DCP channel 1 reading corresponds to the receiver computer display and the voltage measured at the terminal strip. Record the DCP channel 1 reading along with the date and time of the reading. For the DCP reading to correspond to the receiver computer display reading, both readings must be taken during a time window of approximately 43 minutes, beginning at 30 minutes after the top of the hour and ending with the next receiver computer update.

Call ARS to relate the recorded readings to the data coordinator or field specialist and to receive further instructions. Return the completed log sheet (white copy) to ARS as soon as possible.

4.2.3 DCP Troubleshooting

Three (3) different DCP models (Model 540A-1, Model 540A-2, and Model 570) currently are in use in the IMPROVE transmissometer network. Cable connections and display readings (570 only) may need to be checked if a DCP malfunction is suspected (refer to Figure 4-8, DCP Cable Connection and Display Diagram). If it is determined that the DCP is malfunctioning, it will need to be turned off and returned to ARS for repair. These procedures are provided in TI 4110-3375, *Replacing and Shipping Transmissometer System Components*.

DCP operation and operational parameters used for diagnosing data transmission problems are monitored daily by ARS. Should these parameters indicate a potential DCP problem, you will be contacted by the data coordinator or field specialist with a request to perform one or more of the following DCP system checks:

ANTENNA INSPECTION — Visually inspect the antenna to ensure that the driver, reflector, and directional elements (see Figure 4-9, DCP Antenna Component Diagram) are securely attached to their holders. The elements screw into the holders and should be hand-tightened so they are firmly seated against the holder.

ANTENNA ALIGNMENT — The site-specific antenna azimuth (compass heading) and elevation angle (degrees from horizontal) for IMPROVE sites are provided in Table 4-1, DCP Antenna Alignment for IMPROVE Sites. A compass should be used to check the approximate antenna azimuth. The elevation angle should be checked using the angle indicator supplied with the on-site tool kit. If either the azimuth or elevation angle are more than five degrees off from the values in Table 4-1, the antenna should be realigned to the specified values. The table will be updated as necessary (a shift in the satellite longitude may require a change in antenna azimuth and elevation).

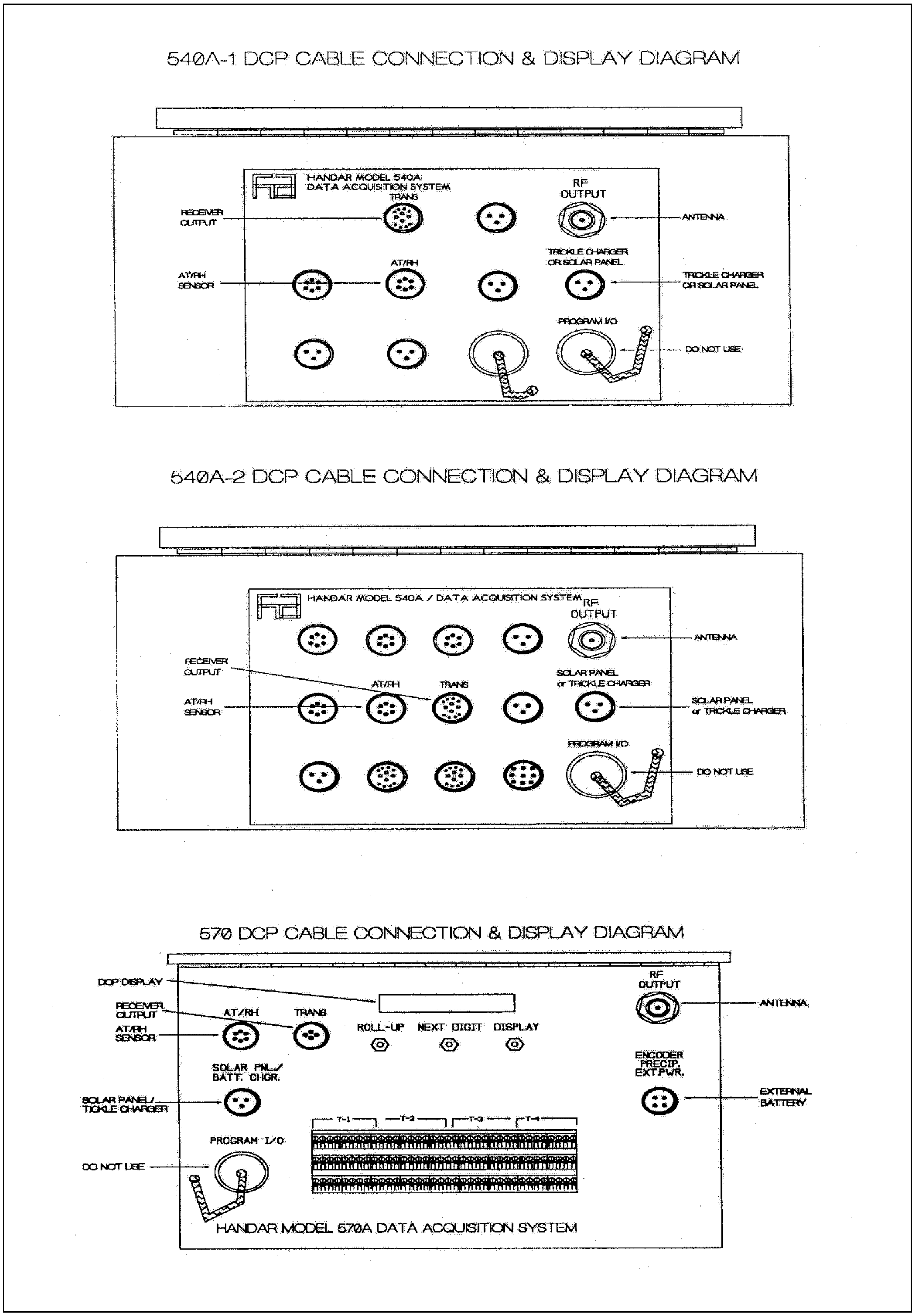

Figure 4-8. DCP Cable Connection and Display Diagram.

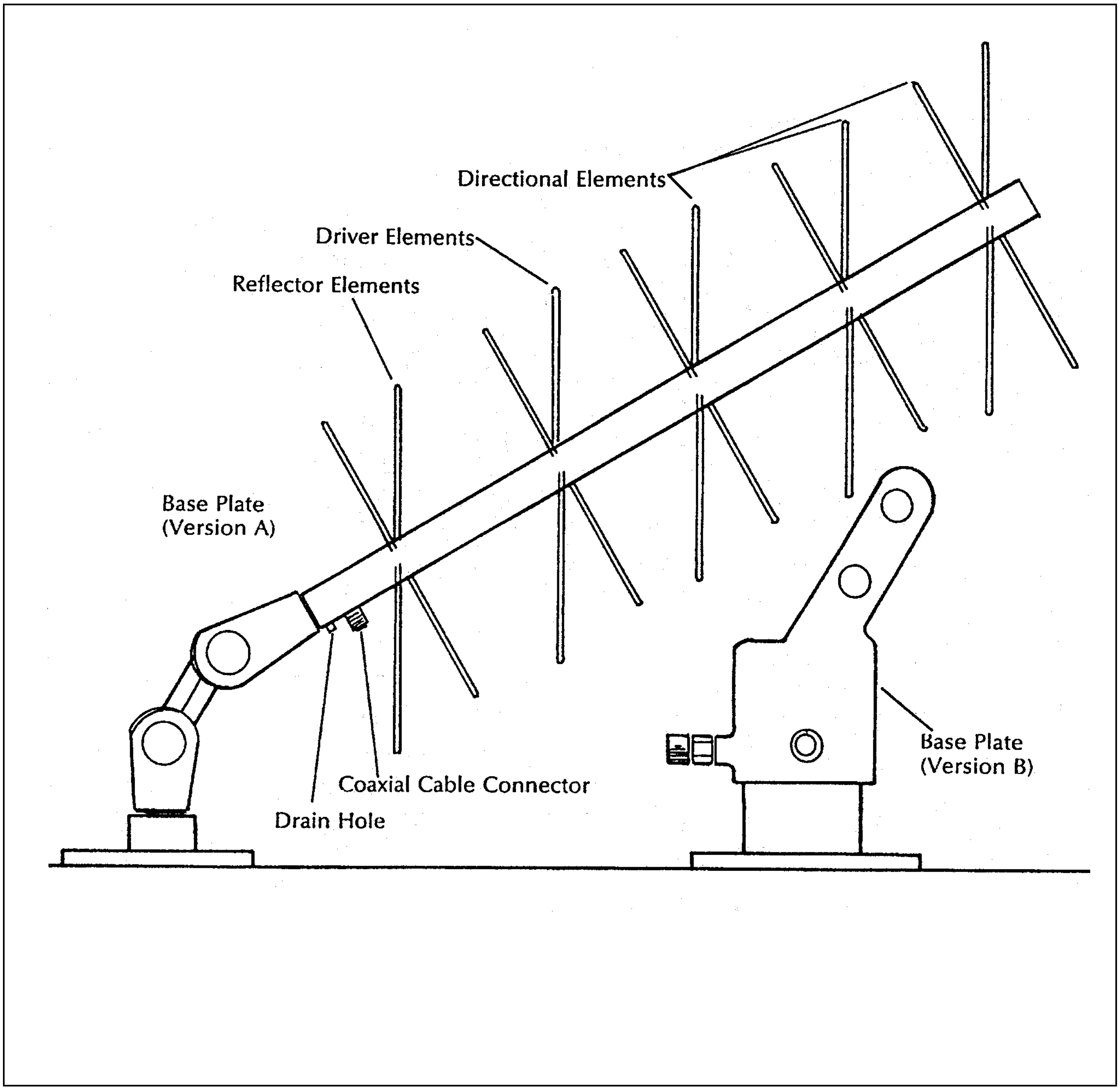

Figure 4-9. DCP Antenna Component Diagram.

Table 4-1

DCP Antenna Alignment for IMPROVE Sites

Site	Site Longitude		Site Latitude		Magnetic Declination	Satellite Longitude	True Bearing	Elevation Angle	Antenna Azimuth
BADL	101	54	43	47	9.6	139.5	228.06	27.18	218.46
BAND	106	16	35	47	10.8	139.5	228.25	35.69	217.45
BIBE	103	12	29	21	8.8	139.5	236.29	37.78	227.49
BRID	109	47	42	56	13.8	139.5	219.96	32.14	206.16
CANY	109	49	38	28	12.8	139.5	220.50	35.83	209.70
CHIR	109	23	32	1	11.3	139.5	227.57	40.60	216.27
GLAC	113	56	48	33	17.0	139.5	212.55	29.09	195.55
GRCA	112	0	36	0	13.0	139.5	221.53	39.14	208.53
GRCW	112	7	36	4	13.0	139.5	221.34	39.15	208.34
GRBA	114	13	39	0	14.3	139.5	216.89	37.80	202.59
GUMO	114	49	31	50	9.7	139.5	232.69	37.43	222.99
LYBR	73	8	43	9	-15.3	139.5	254.34	8.42	268.64
MACA	86	4	37	13	-2.2	139.5	245.84	20.18	248.04
PEFO	109	48	34	54	12.0	139.5	224.91	38.66	212.91
PINN	121	9	36	28	15.0	139.5	209.16	43.47	194.16
ROMO	105	35	40	22	11.3	139.5	226.00	32.00	215.00
SAGO	116	55	34	12	13.6	139.5	217.00	44.00	203.00
SHEN	78	26	38	31	-8.8	112.5	227.00	33.00	236.00

CABLE AND CONNECTOR INSPECTION

Inspect the DCP antenna cable for rodent damage or chafing. The antenna cable connectors should be checked for tightness at both ends. If the cable appears to be damaged, call ARS for a replacement cable.

4.2.4 Strip Chart Troubleshooting

Strip chart recorders are used only as backup data collection systems in the event of a DCP failure. The following is a list of the most common strip chart operational problems, resulting in lost data:

- The zero/record button is left in the "ZERO" position.
- The chart speed button is left in the "CM/MIN" position.
- The chart start/stop switch is left in the "STOP" position.
- Pen lifters are left in the "UP" position.
- The paper is loaded incorrectly, resulting in a jam.

If problems with the strip chart occur, take a minute to verify that the control switch and button settings match those listed on the strip chart settings sticker.

FUSES: AC OPERATION

If the strip chart does not function, the fuse may have blown. If the unit operates from AC line power, proceed with the following:

- Verify that AC power is available at the outlet that the strip chart recorder is plugged into. This check can be performed using the AC circuit tester provided in the on-site tool kit. Unplug the strip chart recorder from the outlet and plug the circuit tester into the same socket. If the circuit tester indicates that AC power is present at this outlet, continue with these procedures. Otherwise, refer to the AC power troubleshooting procedures described in Section 4.2.6, AC Power System Troubleshooting.
- Check that the power indicator switch on the back panel (Figure 4-10, Strip Chart Component Diagram,) is on the "AC LINE" position.
- Check the surge protector for correct operating status (see TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- Check the fuse located in the black holder on the back panel of the strip chart (Figure 4-10, Strip Chart Component Diagram).
- If the fuse has blown, turn the recorder power **OFF** -- also turn the chart drive **OFF**. Disconnect the green channel A(-) and channel B(-) plugs from the two jacks mounted on the back panel.

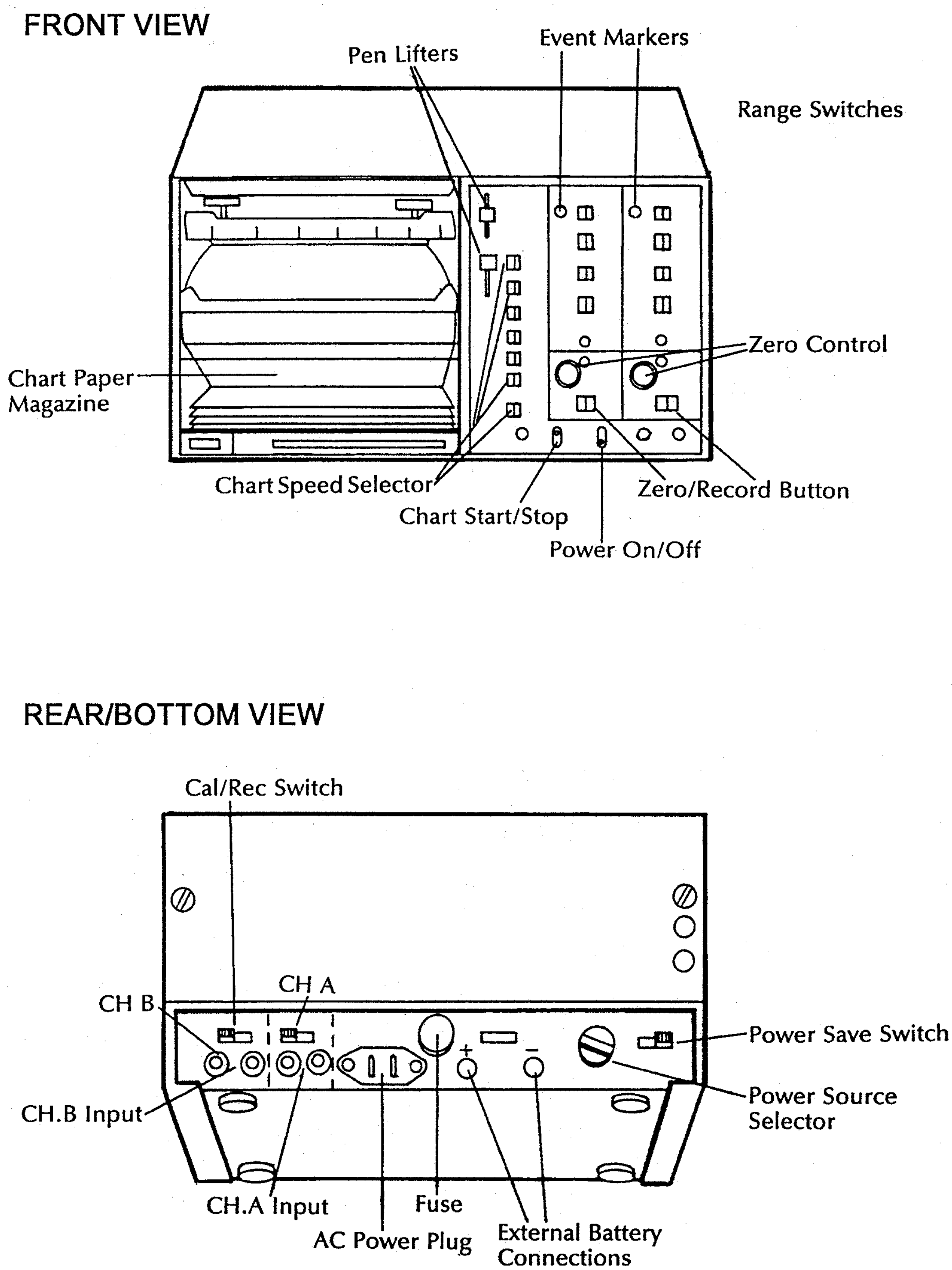

Figure 4-10. Strip Chart Component Diagram.

- Obtain a 0.5-amp replacement fuse from the spare fuses kit. Verify that the replacement fuse is the same as the blown fuse by reading the specifications stamped on the end of the fuse.

- Insert the replacement fuse and turn the recorder **ON**. If the "power on" indicator does not light, turn the unit **OFF** and recheck the fuse. If the fuse has blown, call ARS.

- If the "power on" indicator light remains on, reconnect the channel A(-) and channel B(-) plugs, one at a time, while observing the power indicator light.

- If the fuse blows ("power on" indicator light turns off) while connecting either input line, disconnect both the A(-) and B(-) plugs, turn the recorder power switch **OFF** and call ARS for further directions.

FUSES: DC OPERATION

If the strip chart does not function, an internal fuse may have blown. Fuses protecting recorders that operate from DC power will blow if the power leads are connected improperly (polarity reversed), if signal grounds are attached incorrectly, or if recorder components have failed.

The fuses for DC operation are located inside the recorder. The back panel fuse is not a part of the DC power circuit. To check the recorder operation:

- Check the power source selector switch on the back panel. The switch should be in the 12 V position.

- Check the power leads on the terminal strip and the battery for excessive corrosion or a bad connection.

- Use the voltmeter to check the voltage at the power input banana jacks on the recorder back panel. The voltage should be above 10 VDC.

- Before checking the fuse, turn the power switch **OFF** and disconnect the channel A(-) and channel B(-) leads.

- Take off the recorder cover by removing the six Phillips-head screws. Two screws are located on the top of the cover, the other four are located on the sides (two to a side near the bottom).

- Carefully remove the cover by first sliding it back slightly before pulling up.

- Inspect the fuse labeled "F301" located on the small circuit board on the left side of the recorder.

- If the fuse labeled "F301" is blown, replace it with a 2.0-amp fuse from the spare fuses kit. Verify that the replacement fuse is correct by comparing specifications stamped on the fuse.

- Before replacing the cover, turn the power switch back **ON** and observe the power indicator light. If the fuse blows again, turn the power switch **OFF**, reinstall the cover, leave the channel A(-) and B(-) leads disconnected, and call ARS for further directions.

- If the power indicator light remains **ON**, reconnect the channel A(-) and B(-) lines one at a time while observing the power indicator light and the fuse. If the fuse blows, disconnect the channel A(-) and B(-) input lines, turn the power switch **OFF**, reinstall the cover, and call ARS for further directions.

- If the problem cannot be corrected, call ARS for further directions.

4.2.5 Solar Power System Troubleshooting

Because solar panel power systems are wired in parallel, an individual, bad panel may not easily be identified aside from obvious physical damage; however, there is not much that can go wrong with a solar panel. The most common problems will be with the cables, regulators, or the deep-cycle storage batteries. If a problem with the solar panel power system is suspected, refer to the servicing and maintenance procedures described in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*. These sections fully describe the procedures for checking the status of the solar panels, M16 voltage regulators, and the deep-cycle storage batteries. After performing these checks, call ARS to relate the results and receive further instructions.

4.2.6 AC Power System Troubleshooting

CAUTION: Working with AC power can be dangerous! Extreme care must be used when troubleshooting any AC power system. Do not approach any system where cut or bare wires or standing water are present. If physical damage to any component of the AC power system (outlets, wiring, circuit breakers, etc.) is noted, leave the site immediately and contact ARS. If you have any concerns regarding your ability to safely troubleshoot the system, contact your unit electrician for assistance.

AC POWER STATUS

Verify that AC power is available at the outlet that the surge protector is plugged into. This check can be performed using the AC circuit tester provided in the on-site tool kit. Unplug the surge protector from the outlet and plug the circuit tester into the same socket. If the circuit tester indicates that AC power is not present at this outlet, check the status of the circuit breaker that provides power to the instrument shelter. If you do not know the location of this circuit breaker, contact your unit electrician.

TRIPPED CIRCUIT BREAKER

If the AC power status check performed above reveals that the circuit breaker has tripped, the problem may be due to a malfunction of a transmissometer component. To check for an instrument malfunction, proceed with the following:

- Disconnect the DC power supply (transmitter or receiver sites) and the DCP trickle charger (receiver sites only) from the surge protector.
- Reset the circuit breaker. If the breaker trips, consult an electrician.
- If the breaker does not trip, try to isolate the faulty component by reconnecting each component to the surge protector one at a time. Note the circuit breaker status as each component is reconnected. If the breaker trips when a component is plugged in, leave that component unplugged and continue the check; contact ARS with the results.
- If either the DCP trickle charger or the power supply are malfunctioning, leave the units unplugged and contact ARS for replacement components.

SURGE PROTECTOR

Check the status of the surge protector following the procedures described in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the individual components of an IMPROVE LPV-2 transmissometer system, including:

- An Optec LPV-2 transmissometer.
- Datalogging configuration.
- An ambient air temperature and relative humidity sensor.
- Shelters and related hardware.
- System power configuration.

The descriptions in this TI may be used to maintain and/or troubleshoot the transmissometer system. Components in the transmissometer system may change depending on site logistics, component availability, and construction. This technical instruction includes the following information:

- A brief description of component function
- Component model, manufacturer, and supplier
- System component diagrams
- Wiring diagrams
- Cable and connector description

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall ensure that the component descriptions in this TI are accurate, complete, and up-to-date.

3.0 REQUIRED EQUIPMENT AND MATERIALS

None.

4.0 METHODS

This section describes the system components and wiring of a transmissometer station and includes five (5) major subsections:

4.1 Optec LPV-2 Transmissometer
4.2 Datalogging Configuration
4.3 Ambient Air Temperature and Relative Humidity Sensor
4.4 Transmitter and Receiver Shelters
4.5 System Power Configuration

4.1 OPTEC LPV-2 TRANSMISSOMETER

This section provides an overview of the Optec LPV-2 transmissometer. Detailed component descriptions for the transmissometer are provided in the *Optec LPV-2 Long Path Visibility Transmissometer Technical Manual for Theory of Operation and Operating Procedures*(Optec, 1991). Refer to Table 4-1 for transmissometer component, model, manufacturer, and supplier information.

4.1.1 Transmitter Component Description

Refer to Figures 4-1, 4-2, and 4-3 for the location of the following components. The figures are presented at the end of the section.

TRANSMITTER TELESCOPE

FLIP MIRROR KNOB	The flip mirror knob changes the position of an internal mirror. When the knob is in its "fully clockwise" or "OFF" position, the image is directed to the eyepiece. When the knob is in its "fully counterclockwise" or "ON" position, the image is directed to the photodetector for measurement.
EYEPIECE	The eyepiece is used to check and reposition transmitter alignment. An image of the scene with the view transposed left to right will be visible when the flip mirror knob is rotated fully clockwise. The reticle markings are super-imposed over the scene as an aid to alignment. The transmitter must be aligned so that the receiver is always within the center circle.
	IMPORTANT--no readings are taken with the flip mirror in the "OFF" position. The beeper box will "beep" when the flip mirror is in the "OFF" position. It is to remind the operator to turn it to the"ON" position for instrument operation.
LENS POSITION SCREW	The lens position screw holds the objective lens in position.
	IMPORTANT--do not attempt to focus the transmitter. Repositioning the objective lens will change the transmitter light output, requiring a recalibration.
TELESCOPE TUBE	The telescope tube holds the objective lens at a constant distance (focus) from the lamp filament. The objective lens is used both to focus the image for alignment and to concentrate the outgoing light beam. The tube should always be mounted securely to the flip mirror assembly with the two Allen screws machined into the flip mirror block.
LAMP HOUSING	The lamp housing contains the lamp, chopper system, and the optical feedback block. To avoid the possibility of contaminating the optical surfaces with dust, the housing should only be opened if servicing/troubleshooting is required.

Table 4-1

Major Components of the
Transmissometer System

COMPONENT	MODEL	MANUFACTURER	SUPPLIER
Transmissometer	LPV-2	Optec	Optec
Data Collection Platform (DCP)	570A	Handar	Handar
DCP	540A-1	Handar	Handar
DCP Antenna	443A	Handar	Handar
Strip Chart Recorder	6723	Primeline	Soltec
AT/RH Sensor	MP-100F	Rotronics	Rotronics
Receiver Alti-Azimuth Base	REC-AZ	Optec	Optec
Transmitter Alti-Azimuth Base	XMTR	Von	Von
Mounting Post	36-ADJ	Von	Von
Surge Protector	PLS I	Northern Technologies	Northern Technologies
Trickle Charger	SBP	ARS	ARS
5-amp Power Supply	72-280	Tenma	MCM
10-amp Power Supply	RPS-1012A	Tenma	MCM
Solar Panels	MSX-56	Solarex	Remote Power
Solar Panels	SX-20	Solarex	Remote Power
Solar Panel Regulator	M-16	Bobier	Hutton Communications
Deep-Cycle Batteries	GR27	NAPA	NAPA

LAMP SOCKET — The type of optical system used in the transmitter to concentrate the light beam requires accurate positioning of the lamp filament. The machined lamp socket assures that each lamp is mounted in the same position.

LAMP HOUSING PLATE — The lamp housing plate accurately positions the lamp socket which, in turn, accurately positions the lamp and its filament.

IMPORTANT--the plate should never be loosened; movement of the lamp housing plate will require factory servicing of the instrument. Access to the lamp housing is from the top.

TRANSMITTER CONTROL BOX

ON/OFF SWITCH — The "ON/OFF" switch controls power to the control box ("ON" is when the switch is in the up position). The transmitter timekeeping circuitry runs from an internal battery and is not affected by the position of this switch. If power is applied to the transmitter when the auto-timer circuit is in the "OPERATE" mode, the lamp and chopper will come on. If the auto-timer is in the "WAIT" mode, the light will not come on.

TEST SWITCH — The "TEST" switch, present on units with serial numbers greater than four, is used to manually turn the transmitter "ON" without affecting the internal timekeeping circuitry. The lamp status LED will light when the "TEST" switch is in the "UP" or "TEST" position. Keep in mind that the transmitter will not turn off when the "TEST" switch is moved to the "OFF" position (if the internal auto-timer is in the "OPERATE" mode).

LAMP STATUS LED — The lamp status light indicates whether or not the lamp has aged or been damaged to the point where the optical feedback controller cannot keep the light output constant. The LED must be observed while the transmitter is "ON" under automatic control. If the LED is "ON," the lamp needs to be replaced. The LED will always light when the "TEST" switch is used.

T5 LAMP VOLTAGE CHECK SOCKETS — The T5 lamp voltage check sockets are used to check the voltage of the lamp being used. A voltmeter has been provided. The positive lead will connect to red socket and the negative lead will connect to the black socket - giving a lamp voltage reading. When requested to check the lamp voltage, make sure the voltmeter settings are for DC volts (greater than 2 and less than 20). Take a reading when the lamp is "ON" under automatic control and document the reading on the Transmitter Operator Log Sheet.

HANDHELD RADIO PRECAUTION — The transmitter circuitry, especially the internal auto-timer, can be adversely affected by strong radio signals. Do not transmit on a handheld radio within 10 feet of the transmitter. Avoid aiming the antenna at, or over the circuitry. Strong radio signals may reset the internal auto-timer, resulting in incorrect system timing.

TRANSMITTER CABLES AND CONNECTIONS

POWER CABLE CONNECTION — A black two-conductor power cable from a power supply or battery connects to this input plug. Pin 2 of the plug is for +12 VDC, Pin 3 is for power return (-). Refer to Figure 4-7 for power connector description. Reversing polarity or connecting a supply voltage greater than 17 VDC will cause the fuse inside the control box to blow.

CONTROL CABLE CONNECTION — The cable that carries power and signals from the control box to the transmitter telescope connects to these input plugs. Both ends of the cable are identical and are interchangeable. The connector is a "snap lock" type connector. When tightening the connector, a slight resistance will be felt just before the connector "snaps" into the "locked" position.

4.1.2 Receiver Component Description

Refer to Figures 4-4, 4-5, 4-6, and 4-7 for the location of the following components:

RECEIVER COMPUTER

ON/OFF SWITCH — The "ON/OFF" switch serves two purposes; it controls power to the computer, and acts as a computer reset. Upon powering up, the LCD display should, after a short period, display "000" to "001." If the computer should lock up, the "ON/OFF" switch can be used to reset the system. Resetting is accomplished by holding the switch in the "OFF" position for at least one second before turning "ON." Like the transmitter, the receiver's auto-timer circuitry is powered by internal batteries and is not affected by the "ON/OFF" switch. However, the system timing should be reset each time the computer power is cycled.

TIME RESET — The "TIME RESET" switch, when activated, resets the internal timer and defines the start times for the integration and cycle intervals. If settings on either the "INTEG" or "CYCLE" switches are changed, the internal timer must be reset. The "TIMER RESET" switch has no effect when the computer is set to the "CONTINUOUS" mode (INTEG = 1, CYCLE = C).

DISPLAY — The small LCD display, on the receiver computer front panel, displays readings as selected by the "A1" switch. The range of the display for the various readings is:

C **Raw Instrument Readings**. The range is from "000," indicating no light is visible to "999." Raw readings should always be less than the calibration number. The higher the raw readings, the cleaner the air.

B **Extinction Values (in km^{-1})**. The range is from ".000" indicating impossibly clean air to an extinction of ".999," which corresponds to a visual range of 3.92 km. For visual ranges less than 3.92 km, ".999" will continue to be displayed. Extinction values should not go below 0.007, which is the calculated theoretical minimum of .009 minus instrument and rounding error of .002. The lower the extinction value, the cleaner the air.

VR **Visual Range (km)**. The range of this setting is from 000 km, indicating no transmitter light was visible, to 999 km, an impossibly high value. The maximum possible visual range is 391 km. The higher the visual range, the cleaner the air.

A1 SWITCH

The "A1" switch selects the computer output to both the front panel display and to analog line #1 used by the dataloggers (i.e., data collection platform and strip chart recorder).

C Raw instrument readings in counts

B Extinction values in units of km^{-1}

VR Visual range in units of km

In "NORMAL OPERATING" mode, the "A1" switch should remain on the "C" (raw readings) setting.

A2 SWITCH

The "A2" switch selects the computer output to analog line #2 used by the dataloggers.

SD Standard deviation of the raw instrument readings

CR Raw readings count (the last of the 10 one-minute raw readings)

In "NORMAL OPERATING" mode the "A2" switch should remain on the "SD" (standard deviation) setting.

INTEG (MIN)

The "INTEG" switch selects the integration or averaging time period in minutes. The shortest possible time interval for a reading is one minute. A 10-minute averaged reading is, therefore, based upon 10 one-minute readings. A change in switch position requires that a time reset be made. For routine operation, this switch must remain on the "10" setting.

CYCLE

The "CYCLE" switch selects the time interval between the start of each reading. A setting of "C," for continuous, indicates there is no time delay or interval between readings. Other settings dictate time intervals of between 20 minutes and 4 hours. For example, a cycle time of 1 hour (1H) with an integration time of 10 minutes (10M), would provide a 10-minute average every hour. For routine operation, this switch must remain on the "1H" setting. A change in switch position requires that a time reset be made.

GAIN SWITCH

The "GAIN" switch determines the fraction of the received raw signal digitized by the analog to digital (A/D) converter for use in the computer. The gain should only be changed by trained service technicians.

OVER-RANGE (OR) INDICATOR

When the "OVER-RANGE" light is "ON," it indicates that the value sent from the computer to the display is too great for the display to handle. This may occur, for example, when a storm obscures the transmitter light. The receiver computer will then calculate an infinitely high extinction when the "A1" switch is in the "B" position, and output a very high (over-range) value to the display. This condition is indicated by the over-range (OR) light. The display will show "1000," its maximum value. The OR light will extinguish on its own after a within-range reading has been taken. For routine operation, the "A1" switch is in the “C” position and the OR light should not illuminate.

TOGGLE LIGHT

The toggle light indicates a reading update. At the end of the integration period, the toggle light will change state from "ON" to "OFF" or vice-versa. The toggle status is also output to the dataloggers. The toggle light has three important functions:

1. It indicates a computer lock-up or failure.

2. It can be used to differentiate a computer lock-up from consecutive, identical readings.

3. It provides the only visual indicator to reliably check the receiver auto-timer system.

PATH DIAL

The path dial is used to input the line-of-sight distance between the transmitter and the receiver into the computer. The distance is measured during installation with a laser range finder and is expressed in kilometers. An incorrect distance setting will not affect the raw readings, but will result in the calculation of erroneous extinction values.

CAL DIAL

A calibration (CAL) number is calculated for each lamp. Since all lamps are slightly different, a new calibration number must be dialed in for each replacement lamp. The CAL number represents the raw reading which would be obtained if the atmosphere had a theoretical 100% transmission. The CAL number should not be changed, unless directed by ARS field service technicians.

HANDHELD RADIOS PRECAUTION — The receiver computer circuitry, especially the internal auto-timer, can be adversely affected by strong radio signals. Do not transmit on a handheld radio within 10 feet of the computer. Avoid aiming the antenna at, or over, the computer. Strong radio signals may reset the timer circuit, resulting in an incorrect, out-of-sync system timing.

RECEIVER CABLES AND CONNECTIONS

POWER CABLE CONNECTION — A black two-conductor power cable from the power supply or battery connects to this input plug. "PIN 2" of the plug is for +12 VDC, "PIN 3" is for power return (-). Reversing polarity or connecting a supply greater than 17 VDC will cause the fuse inside the receiver computer to blow.

OUTPUT CABLE CONNECTION — The cable that carries signals from the receiver computer to the terminal strip connects to this input plug. The signals are differential - each signal has its own ground.

PHOTOMETER CONNECTION — The cable that carries signals from the photometer (detector head) to the receiver computer connects to this input plug.

RECEIVER TELESCOPE

FLIP MIRROR KNOB — The "FLIP MIRROR" knob is used to change the position of an internal mirror. When the knob is in the "fully clockwise" or "OFF" position, the image is directed to the eyepiece. When the knob is in the "fully counterclockwise" or "ON" position, the image is directed towards the photo-detector.

IMPORTANT--during alignment, the knob must be turned "fully clockwise" against the stop to the "OFF" position. If the knob is not positioned fully against the stop, incorrect alignment could occur. Once alignment is completed, the knob must be turned "fully counterclockwise" to the "ON" position. No readings will be taken if the flip mirror is left in the "OFF" position.

EYEPIECE — The eyepiece is used to check and reposition instrument alignment. As with the transmitter, an image of the scene with the view transposed left to right will be visible when the flip mirror knob is rotated "fully clockwise." Reticle markings are super-imposed on the scene for use in alignment. The transmitter light should be within the small inner circle.

OBJECTIVE LENS THUMBSCREW — The objective lens thumbscrew holds the objective lens assembly in place. The focus is set correctly during installation. Sometimes image degradation due to turbulence is mistaken as incorrect focus. Do not adjust the focus unless instructed by ARS. Receiver telescope focus adjustment will not affect the calibration.

OBJECTIVE LENS ASSEMBLY	The objective lens assembly on instruments with serial numbers 001-004 have aperture rings glued or taped in place over the end to allow a known amount of light collection by the telescope. These rings should always be firmly fixed in place. Later units have aperture rings built into the lens assembly.
OBJECTIVE LENS	The receiver telescope is equipped with an expensive objective lens. The delicate, coated, surface of this lens can easily be damaged or marked by incorrect cleaning. Field operators should avoid physically touching the lens; periodic cleaning of the surface with the blower brush is sufficient under normal circumstances.
TELESCOPE TUBE	The objective lens is held in place and the detector is shielded from stray light by a thick-walled telescope tube. A light-trapping baffle, mounted inside the tube, further protects the detector from stray light.
PHOTOMETER HEAD	The photometer head contains the photodiode detector, detector signal preamplification circuitry, filter, and the flip mirror. The photometer head must be securely attached to the telescope with the two Allen screws provided for this purpose.

4.2 DATALOGGING CONFIGURATION

This section provides an overview of the datalogging configuration used for collecting and disseminating data from an IMPROVE Protocol transmissometer system. Detailed component descriptions for the dataloggers and support equipment are provided in the Handar Data Acquisition System Operating and Service Manuals provided by Handar, Inc. and in the Primeline 6723 Instruction Manual provided by Soltec Distribution.

4.2.1 Terminal Strip Board and Wiring Description

A terminal strip is used as an interface between the transmissometer and the dataloggers. It provides an excellent place to troubleshoot the system. Refer to Figures 4-8 and 4-9 for the location of the following components.

TERMINAL STRIPS	Two terminal strips are mounted on the board. The vertical strip connects the transmissometer to the dataloggers. The horizontal strip is used to provide 12 VDC power to the strip chart (when needed) or to other equipment.
TRANSMIS-SOMETER SIGNALS	Transmissometer signals exit the receiver computer at the port marked "OUTPUT" and enter the left side of the vertically-mounted terminal strip. The signals are differential, each signal having its own ground.
DCP INPUT SIGNALS	The signal cable of the DCP exits the right side of the vertical terminal strip and enters the Handar 540A or 570A DCP at the port marked "TRANS."

STRIP CHART INPUT SIGNALS — The signal cable to the strip chart exits the right side of the vertical terminal strip where it shares terminal positions with the DCP wiring. The signals enter the back of the strip chart with labeled banana jacks. The 12 VDC power supply to the strip chart shares this cable and also enters the strip chart with labeled banana jacks.

CONNECTOR PINOUTS — Signal cabling and connectors are described in Table 4-2.

TERMINAL STRIP CABLES — Cables are fixed to the terminal strip board with strain reliefs. It is unlikely that a signal wire will come loose from the strip.

4.2.2 Data Collection Platform (DCP) Component Description

Refer to Figures 4-10, 4-11, and 4-12 for the location of the following components:

ON/OFF SWITCH — The main system "ON/OFF" switch is located next to the fuse holder near the hinge. Do not turn this switch "OFF" unless directed by ARS.

IMPORTANT--if power is turned "OFF," the internal program will be lost from memory and the unit will require reprogramming.

FUSES — Three fuses mounted in holders next to the "ON/OFF" switch protect the internal battery, an external battery (if used), and the program set power-output circuitry.

IMPORTANT--removal of internal battery fuse will wipe out the program and will require a site visit or replacement DCP.

BATTERY — The orange, 12 VDC, 20-amp-hour gel-cell battery secured in place at the end of the box or connected to the back panel of the 570 DCP as an external battery powers the DCP. Do not attempt to measure the battery voltage unless instructed by ARS. Shorting the positive battery terminal to the holder with the test lead could cause damage to the circuitry or wipe out the program.

DESICCANT INDICATOR — The desiccant indicator affixed to the battery holder monitors the effectiveness of the desiccant. When the desiccant is in good shape or "active," the color of the circle matches that of the rectangle. Both should be blue. When the desiccant is spent, the circle color will be pink. It is best to check the indicator immediately upon opening the DCP door as the color will change in approximately two minutes.

DOOR CLOSURE CLAMPS — All door closure clamps must be tightened to assure a good fit. Do no over tighten the clamps.

SUPPORT CARD — The support card contains the battery charging circuitry, system power supply, timer, and analog-to-digital converter. This card is always located in card slot number 9. Card slot number 1 is located closest to the battery.

Table 4-2

Transmissometer System
Cable and Connector Description

	FUNCTION	WIRE COLOR	WIRE COLOR	DCP INPUT PIN #	MET CARD PIN #	INPUT ADDRESS	POWER ADDRESS	FULL SCALE	DCP CH #
1	b_{ext} Signal	Yellow	Yellow	G	J2-8	6	8	1000	1
2	Raw Reading/ Stdev. Signal	White	White	B	J2-14	8	8	500	3
3	Toggle Signal	Orange	Orange	C	J1-12	9	8	001	2
4	b_{ext} Ground	Green	Green	J	J1-8				
5	Raw Reading/ Std. Ground	Black	Black	K	J2-10				
6	Toggle Ground	Brown	Brown	K	J2-10				
7	Not Used	----	----	----	----				
8	Not Used	----	----	----	----				
9	Shield	Bare	Bare	M	DCP Chassis /Grd.				

Comments:
1. Rec Output Cable - 6 ft. DCP Input Cable - 8 ft.; A1 determines Pin 1 output; A2 determines Pin 2 output.

2. Receiver outputs double ended; Handar DCP has common ground.

3. DCP input pins not listed above
Wire Color - Wires Not Used
A - Blue, J1-19 (5,B)
D - Grey, J1-6, (D,B)
E - Red, J1-15, (A,B)
F - Purples, J2-9, (F,B)
H - Not used

Leave extra wire at terminal strip end - do not trim.

CPU CARD — The CPU card contains the microprocessor, memory, and system firmware (operating system). This card is always placed in slot number 8 between the aluminum plates which act to shield it from interference.

MET CARD — The meteorological sensor card provides signal conditioning for sensor inputs. It is here the transmissometer extinction analog signal is converted to a format that is usable by the computer. For use in our system, this card is always placed in slot #6. Two multi-color ribbon connectors bring sensor signals from the input panel to the met cards. Most DCPs have two pairs of ribbon cables, some may have three pairs. The pair marked "TELEPHOTOMETER #1" or "TRANSMISSOMETER," should be used with the shorter of the two cables connected to the left met card cable input (battery at top). The black conductor is on both cables.

GOES TRANSMITTER — The GOES transmitter circuit board, located on the inside of the door, enables the DCP to transmit data at precise user-selected frequencies to the satellite. The transmitter has the ability to broadcast at 265 frequencies between 401.701 and 402.0985 mHZ in 1.5 kHZ steps. The 10-watt transmitter power output is +40 dBm.

PRIMARY CHANNEL SWITCHES — There are six square, red, dial switches located in the upper right corner (battery at top) of the GOES radio transmitter circuit board. The top three switches labeled "CHAN 1," are used to set the primary radio frequency at which the DCP will transmit. These switches should always be set to the channel noted on the DCP sticker. When the primary channel switches are set to 900, transmissions from the DCP are hardware inhibited. This function is used in the field to disable a DCP for shipping, or to ship a new DCP from ARS to the field.

SECONDARY CHANNEL — The "SECONDARY BROADCAST" channel, "CHAN 2," is not used in the transmissometer monitoring network. These switches should remain set to "000." The secondary channel is used in some monitoring networks to broadcast random transmissions when an emergency, such as a flood, occurs.

GRAY RIBBON CONNECTOR — The gray ribbon cable connecting the GOES radio to the CPU card should <u>never be unplugged</u>. The computer relies on clock signals generated by an oscillator on the GOES radio board for its operation.

IMPORTANT--disconnecting the gray ribbon cable will destroy the internal program requiring a site visit by ARS technicians or a replacement DCP.

4.2.3 DCP Antenna Component Description

The antenna used with the Handar 540A/570A DCP is a Cross-Yagi type with a gain of 10dB. The antenna has a half-power beam width of 47°, which means that critical alignment is not necessary. Refer to Figure 4-13 for the location of the following components:

BASE PLATE VERSION #A	The base plate used in many installations is chrome plated and adjustable in both the horizonal and vertical directions. The plate is usually mounted to the shelter with lag bolts or wood screws. The antenna bar screws to this base.
BASE PLATE VERSION #B	Another type of base plate in use is designed for post-mounting. With this type of mount, antenna alignment is a combination of the vertical component, adjusted with two bolts at the base of the antenna rod, and the rotational component adjusted with the two large Allen screws which clamp to the post.
DRAIN HOLES	At the base of the antenna bar, on all but the oldest units, are two holes which allow water that enters the bar to drain. These holes should remain uncovered and should be positioned towards the ground.
COAXIAL CABLE CONNECTOR	The coax cable from the DCP enters the antenna at this connector. The connector should be oriented towards the bottom of the bar if possible and should be screwed in tightly to avoid moisture penetrating the seal and degrading the signal. Refer to Figure 4-14 for diagram of cable connections.
DRIVER ELEMENTS	The driver elements, located in the second position from the bottom on the antenna, are the elements that do all the work. For the transmissions to be strong enough to reach the satellite reliably, all four elements must be in good shape, and securely fastened in their holders.
REFLECTOR ELEMENTS	These antenna elements function almost like a mirror behind a light bulb, increasing the signal strength.
DIRECTIONAL ELEMENTS	These antenna elements further increase the output power, as well as make the signal more directional.

4.2.4 Strip Chart Recorder Component Description

Refer to TI 4300-4025, *Transmissometer Data Collection Via Strip Chart Recorder*, for a description of the strip chart controls and connections shown in Figure 4-15.

4.3 AMBIENT AIR TEMPERATURE AND RELATIVE HUMIDITY SENSOR

Ambient air temperature and relative humidity are monitored with a Rotronics model MP-100F sensor. This sensor combines both measurements within one unit and is controlled by, and directly connected to, the DCP. Temperature is measured by a platinum RTD sensor, an electronic component whose resistance changes with temperature change. The relative humidity sensor measures humidity with a C-80 Hygromer, a device whose capacitance changes as its surface absorbs moisture. Refer to Figures 4-16 and 4-17 for a diagram of the sensor and cable, and of a sensor mounted to a receiver shelter.

SENSOR HOLDER	The sensor is mounted in a white, parallel, plate shield that acts to dissipate heat and to protect the sensor. The design assures that heat from the shield is not conducted to the sensor causing errant, high readings.
SAMPLING FREQUENCY	Air temperature (°F) and relative humidity (0%-100%) measurements are taken once per hour at the same time other measurements are made. Under routine monitoring procedures, all sensors are scanned at 30 minutes past each hour.

4.4 TRANSMITTER AND RECEIVER SHELTERS

Both the transmitter and receiver operate under ambient conditions, but require waterproof sheltering. Refer to Figure 4-18 for a diagram of the different types of shelters used, and to Figure 4-19 for a diagram of monitoring component placement in the shelters. Refer to TI 4050-3010, *Site Selection for Optec LPV-2 Transmissometer Systems*, for a brief description of the components and hardware used in the shelters.

One of the most important components in each shelter is the alti-azimuth base. They are used for holding the telescopes in place and for the alignment adjustment that is critical for proper transmissometer operation. Refer to Figure 4-20 for a diagram of both the transmitter and the receiver alti-azimuth bases with the location of their telescope hold down screws and their vertical and horizontal adjustment knobs. Refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures For LPV-2 Transmissometer Systems (IMPROVE Protocol)*, for a description of alignment correction procedures.

4.5 SYSTEM POWER CONFIGURATION

This section briefly describes the line power (AC) and the solar power (DC) components used for the LPV-2 transmissometer system. Detailed descriptions of each individual component are provided by the manufacturer and/or supplier of the respective component (see Table 4-1 for a listing of the major components, models, manufacturers, and suppliers).

4.5.1 <u>Line Power (AC) Component Description</u>

At some locations the receiver, transmitter, or both stations operate from an AC power line. As all instrumentation and data collection equipment have the capability of operating from DC power, AC power is used to supply a constant source of power (unless interrupted by power outage/surge) to the 5-amp (receiver) or the 10-amp (transmitter) power supply. An AC power system is comprised of the following components: a surge protector, a trickle charger, and a 5- or 10-amp power supply. The AC charging system can supply power to the power supply, and is unlike a solar system which can be affected by weather, however, the power supplies can be interrupted by a power outage or a power surge. Refer to Figures 4-21, 4-22, and 4-23 for the location of the following components.

SURGE PROTECTORS — At sites operating with line power (AC), Northern Technologies' surge protectors protect instruments from potentially damaging power surges. The models used have a "power on" switch and a system alert indicator light (red). If the red system alert light on either model surge protector is lighted, it means that the surge protector has sustained a massive power surge and is no longer capable of providing protection. Call ARS for a replacement unit if the red system alert light is lighted.

TRICKLE CHARGER — Used to charge the internal or external DCP battery.

POWER — A Tenma 5-amp power supply is used at the receiver to supply power to the receiver computer. A Tenma 10-amp power supply is used at the transmitter to supply power to the transmitter control box.

4.5.2 Solar Power (DC) Component Description

At some locations the receiver, transmitter, or both stations, are powered from a solar system with the following components: solar panels, solar panel regulators, deep-cycle batteries, and interconnection cabling. The number of solar panels is based on the estimated hours of sunlight available. Transmitter stations will require at least two panels approximately 1.5' x 3' in size. Most receiver stations can operate from one such panel. DCPs are powered by one small (1.5' x 2') solar panel. Refer to Figures 4-24, 4-25, 4-26, 4-27, and 4-28 for the location of the following components:

SOLAR PANELS — Solar panels produce electric current when illuminated with sunlight. Panels should be oriented towards true south, and are inclined to angles that are most efficient for winter operation (latitude plus 15 degrees). A coating of dust or dirt on the glass surface will reduce collecting efficiency; procedures to clean the panels are described in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

SOLAR PANEL OUTPUT — The solar panels used in the transmissometer systems produce approximately 18 volts when fully illuminated. Procedures to troubleshoot solar panel power systems are described in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

SOLAR PANEL REGULATOR — Electrical current produced by the solar panels is used to charge the deep-cycle batteries. A regulator prevents over-charging of the batteries during extended periods of sunny weather. The M-16 solar panel regulators are mounted inside the shelter (see Figure 4-27). Refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*, for description of M-16 solar panel regulator operation.

DEEP-CYCLE BATTERIES

Deep-cycle batteries power equipment at both receiver and transmitter stations that are equipped with solar power supplies. The batteries are connected in parallel with interconnect cables going from the positive to positive and from the negative to negative (terminals), respectively. Regular maintenance and troubleshooting procedures for the deep-cycle batteries are provided in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

INTERCONNECT WIRING

All power wiring used to interconnect solar panels and deep-cycle batteries should be labeled at the connectors. As a general rule, with red and black conductors, the red will be positive. As with all electrical or electronic conductors, it is very important to verify correct polarity before connecting to power; if unsure, call ARS for direction.

5.0 REFERENCES

Optec, Inc., 1991, Model LPV Long Path Visibility Transmissometer, Version 2, Technical Manual for Theory of Operation and Operating Procedures, July.

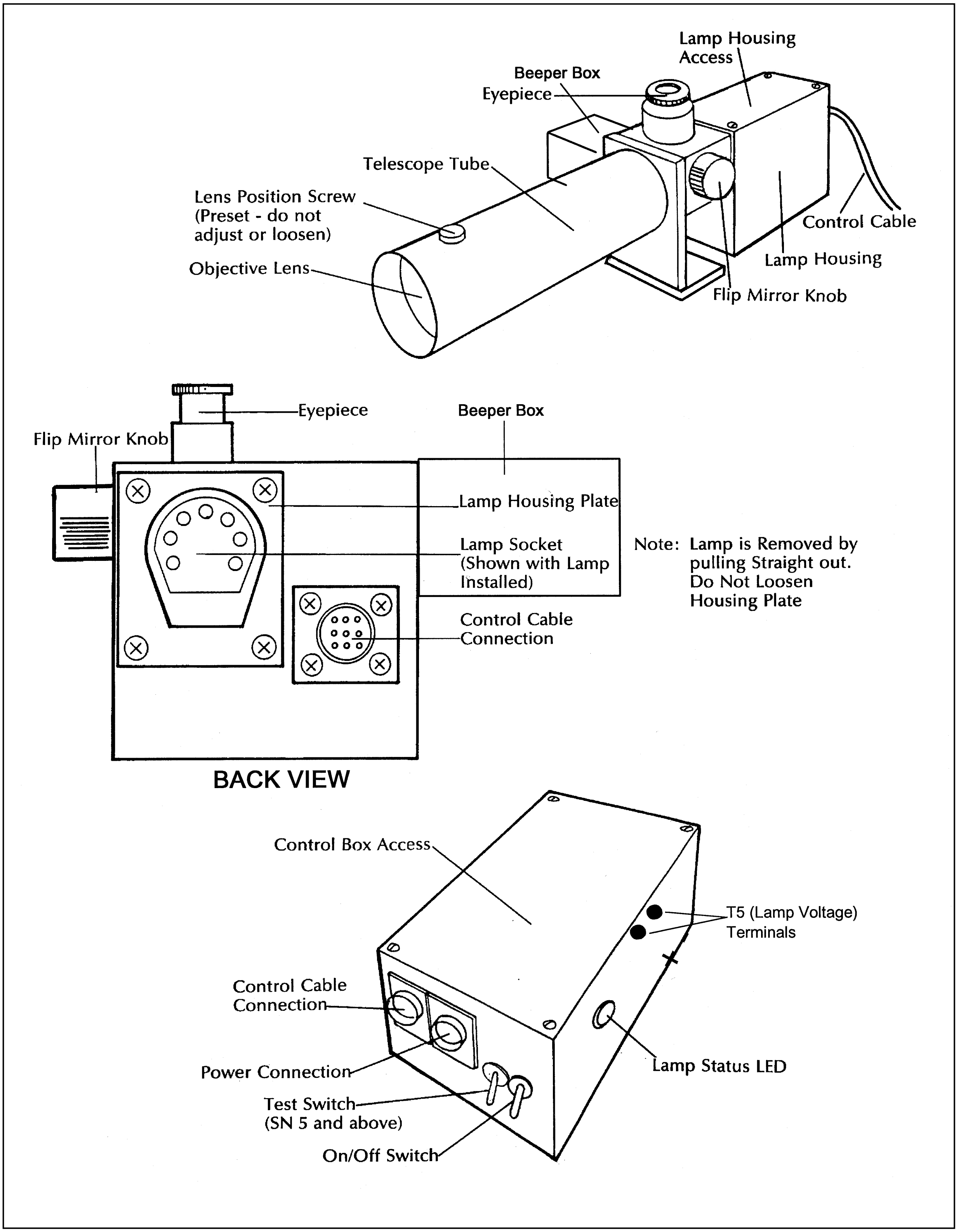


Figure 4-1. Transmitter Component Diagram.

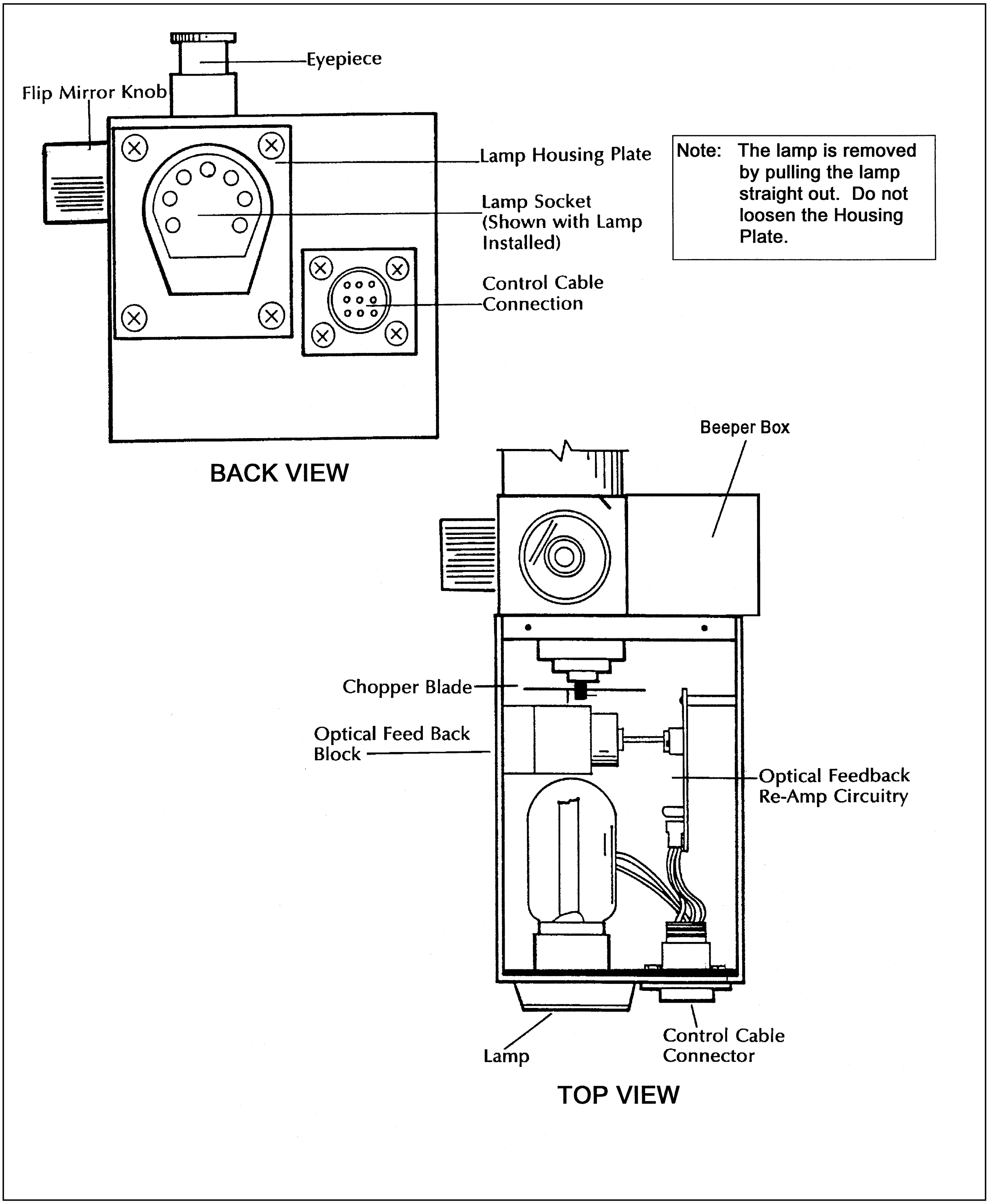


Figure 4-2. Transmitter Lamp Housing.

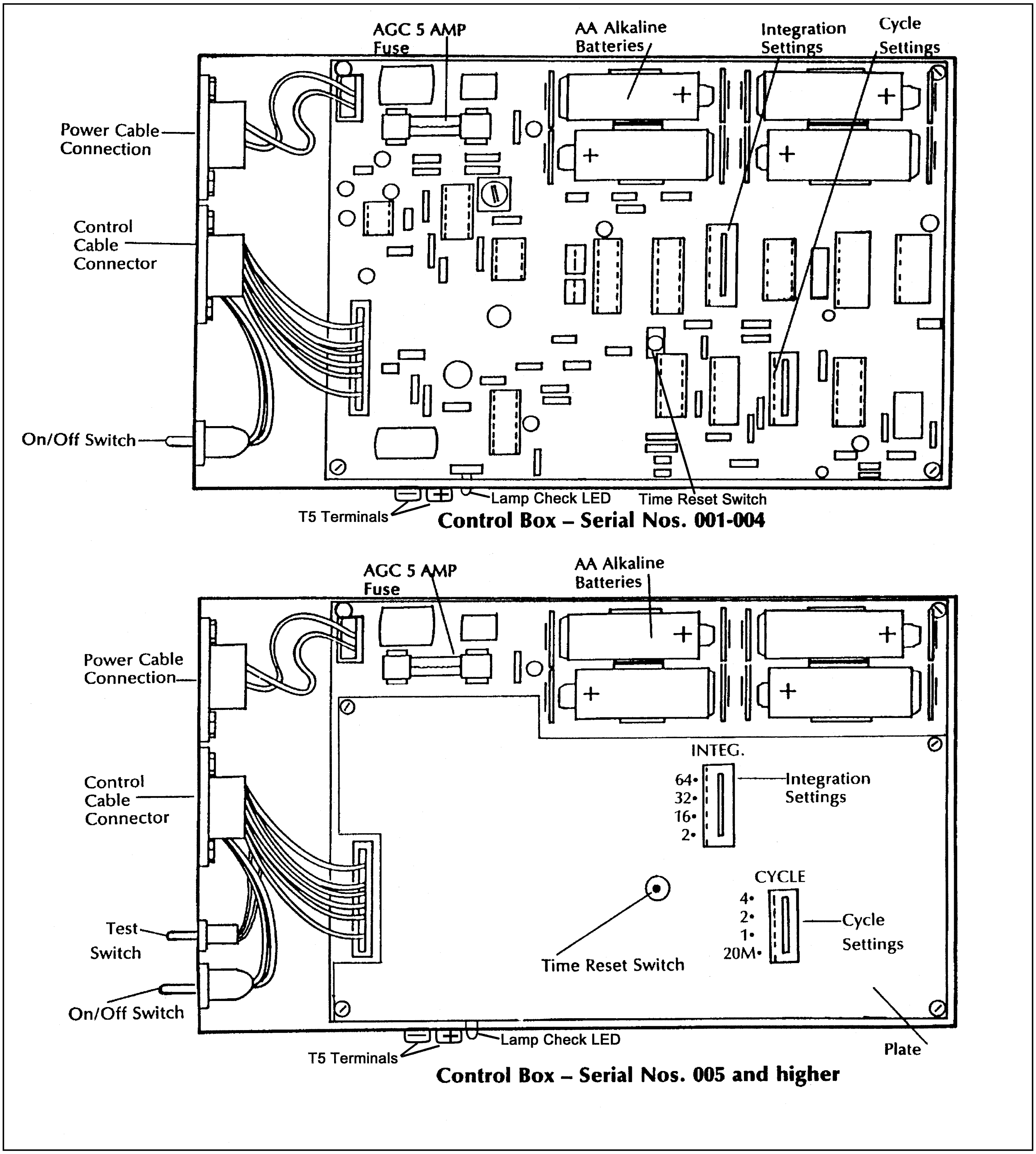


Figure 4-3. Transmitter Control Box Diagram.

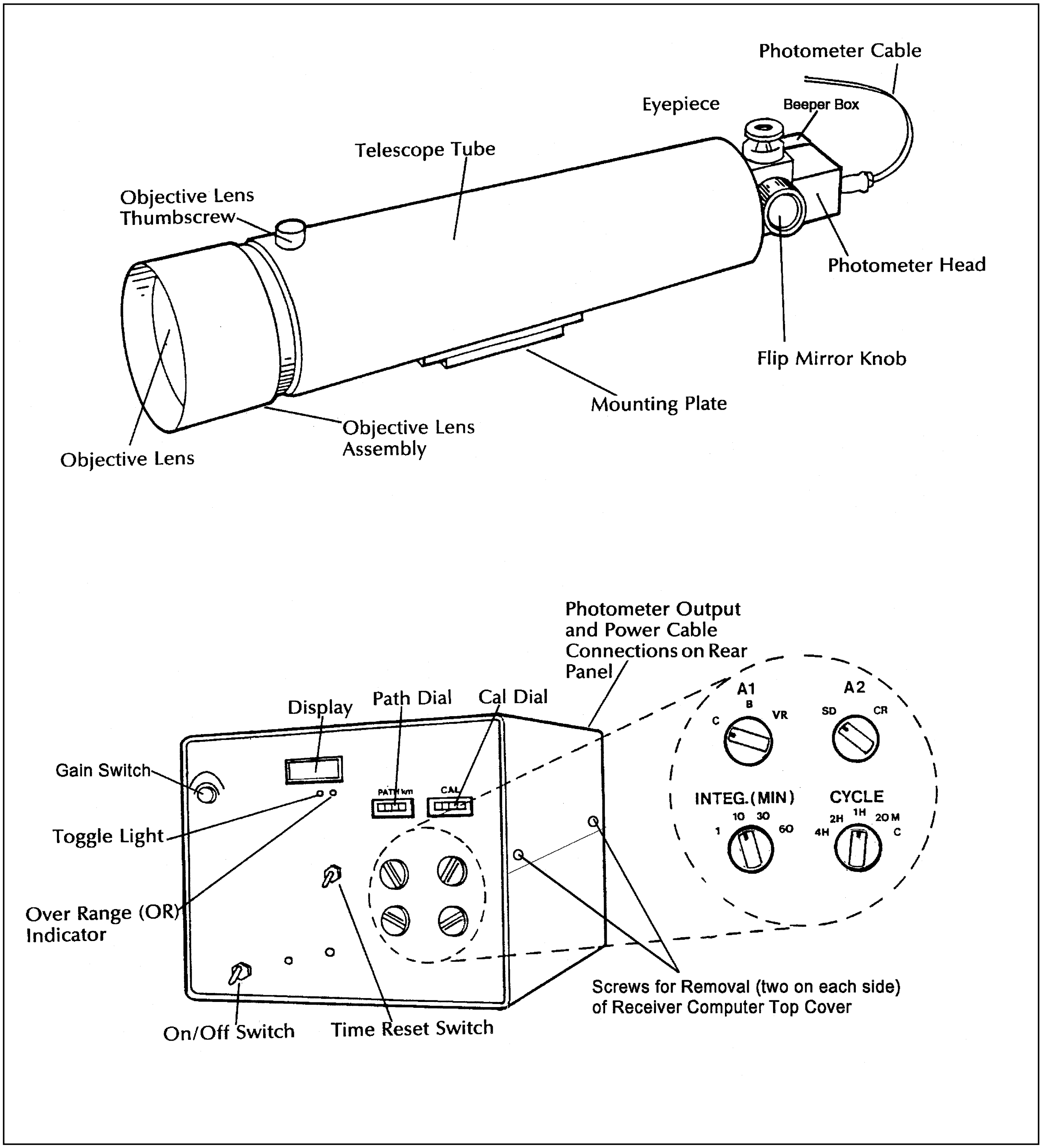


Figure 4-4. Receiver Component Diagram.

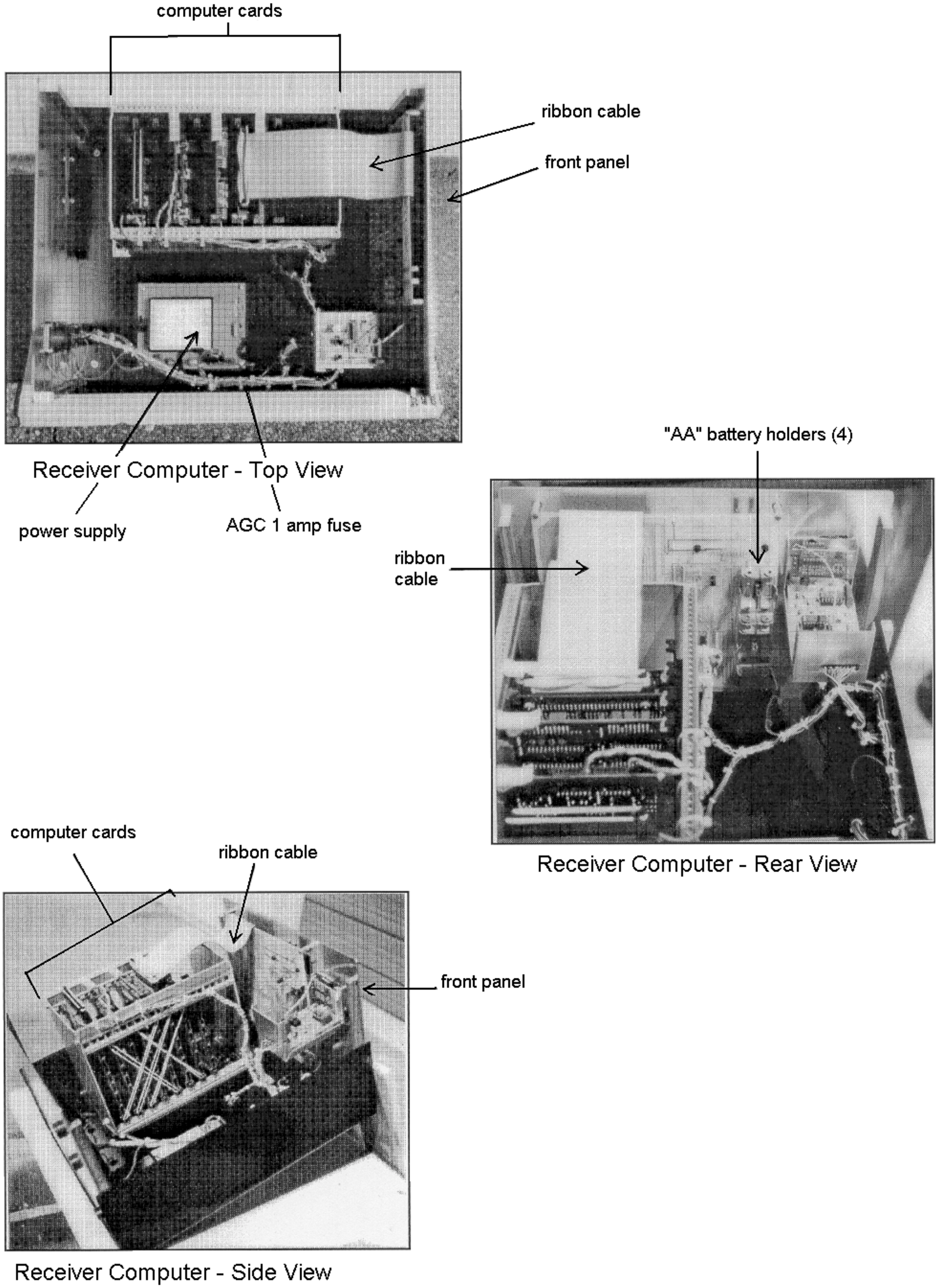


Figure 4-5. Receiver Computer Cards and Fuse Diagram.

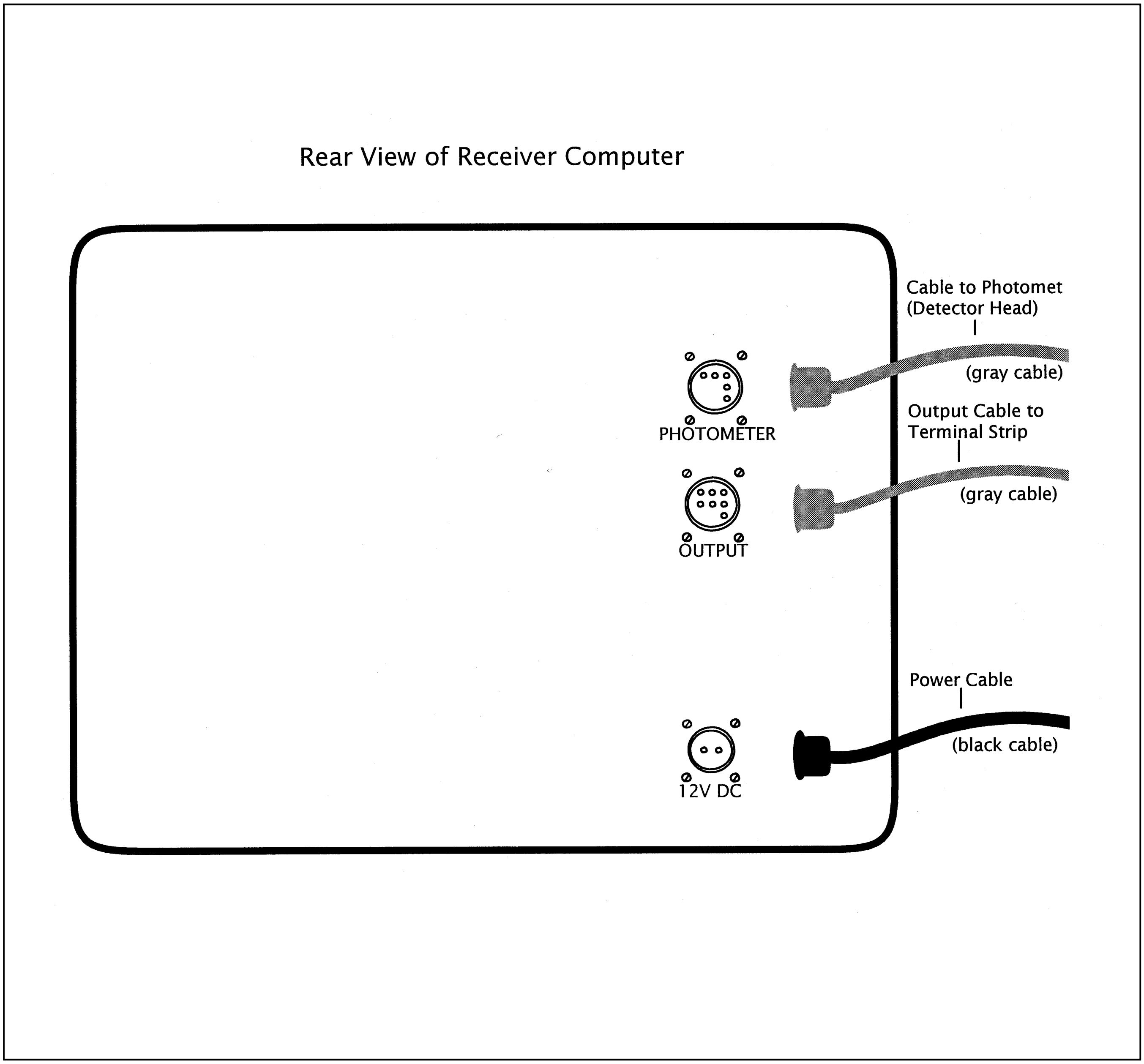
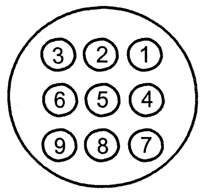


Figure 4-6. Receiver Computer Cable Connections Diagram.

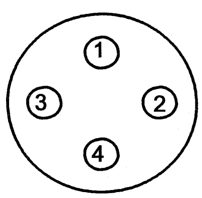
Receiver Computer

Output Connector



Pin No.	*Function*	*Wire Color*
1	A1 Switchable to: Raw Reading, B_{ext}, or VR	Yellow
2	A2 Switchable to: Raw Reading, Std. Deviation	White
3	Toggle Switch	Orange
4	A1 Ground	Green
5	A2 Ground	Black
6	Toggle Ground	Brown
7	Not Used	
8	Not Used	
9		Bare

Power Connector



Pin No.	*Function*	*Wire Color*
1	Not Used	
2	+12 Volt DC	Black (Ribbed)
3	Ground	Black
4	Not Used	

Figure 4-7. Receiver Computer Output and Power Connector Description.

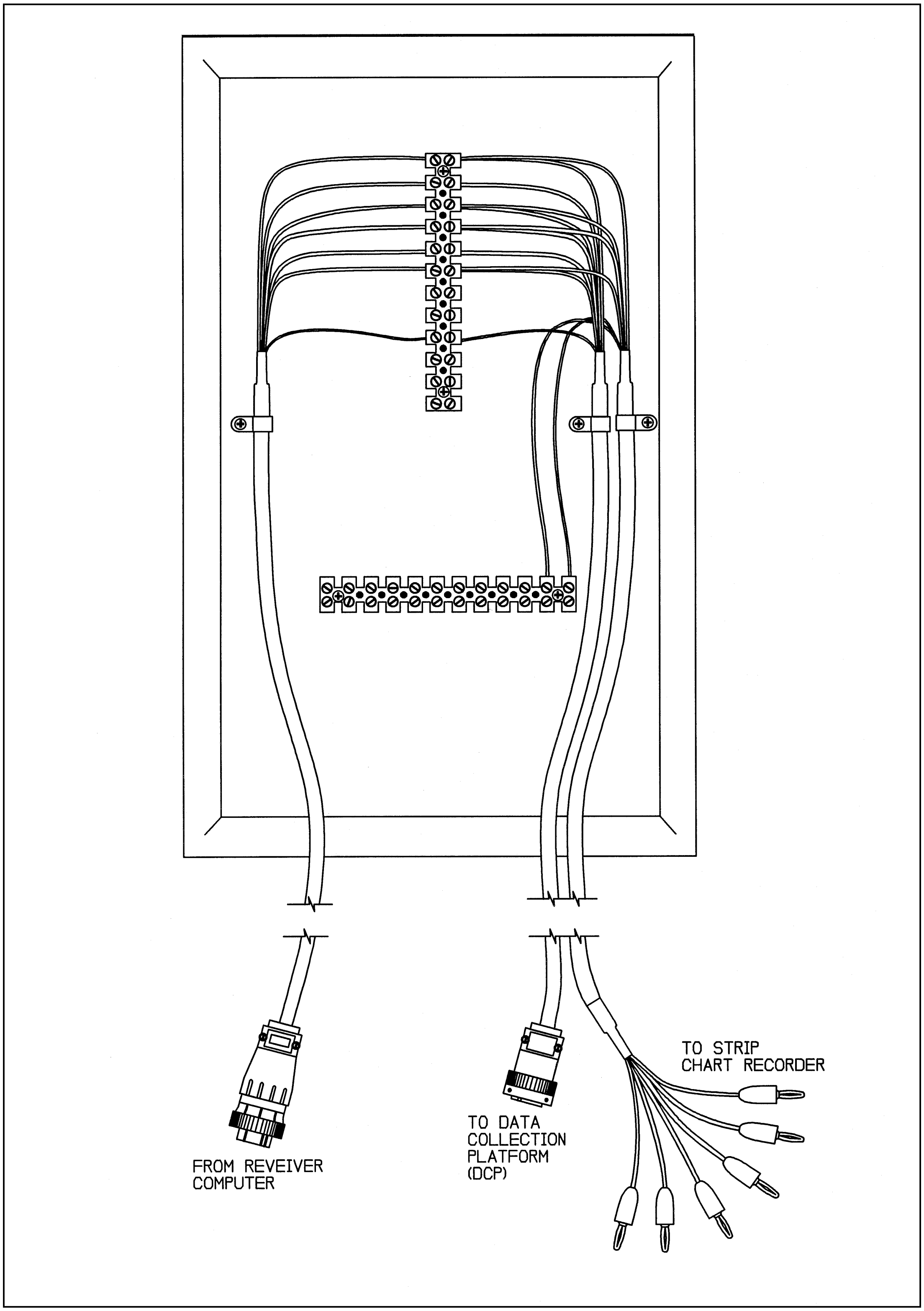


Figure 4-8. Terminal Strip Board With Cable Connectors Diagram.

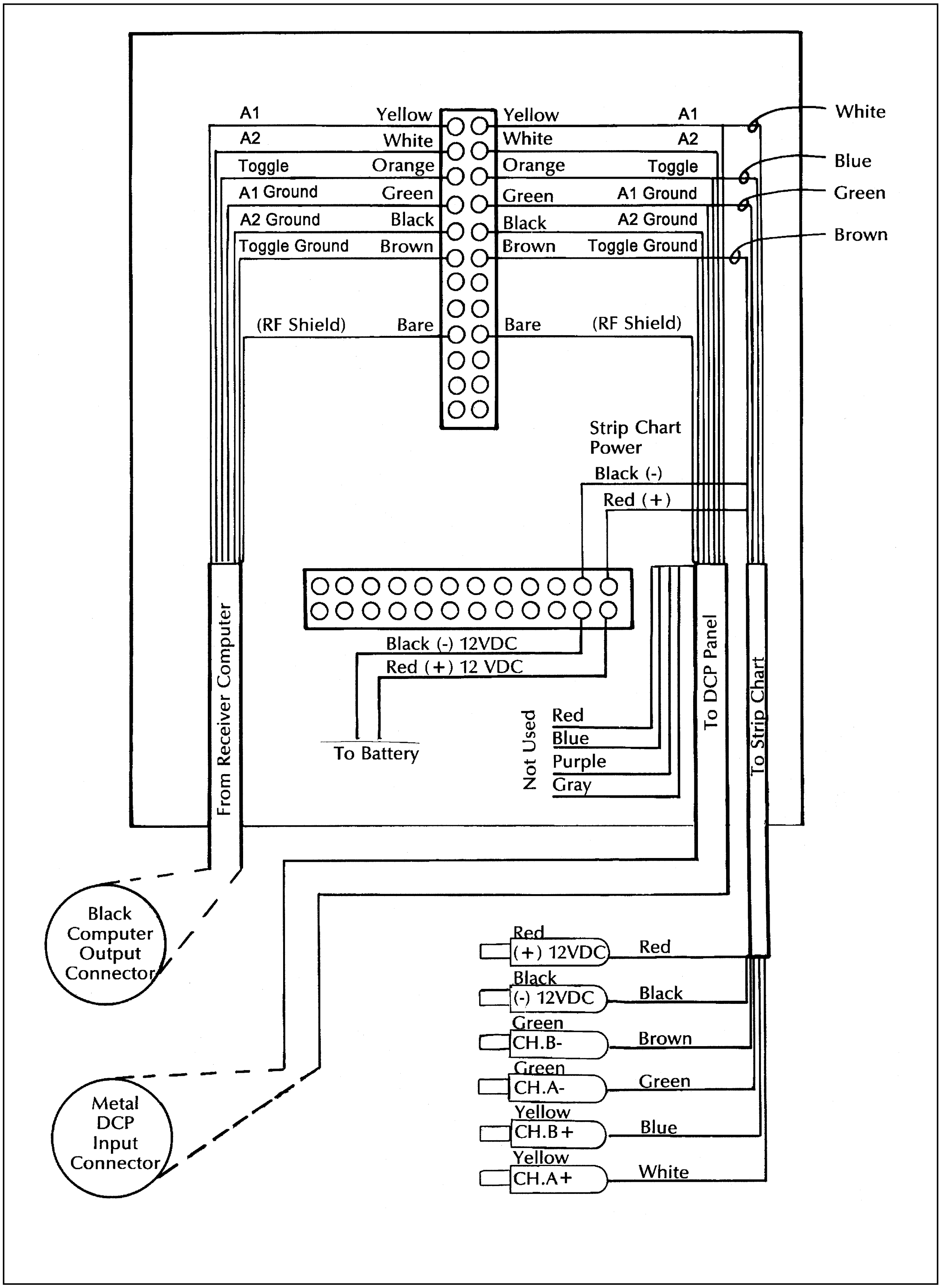


Figure 4-9. Terminal Strip Wiring Diagram.

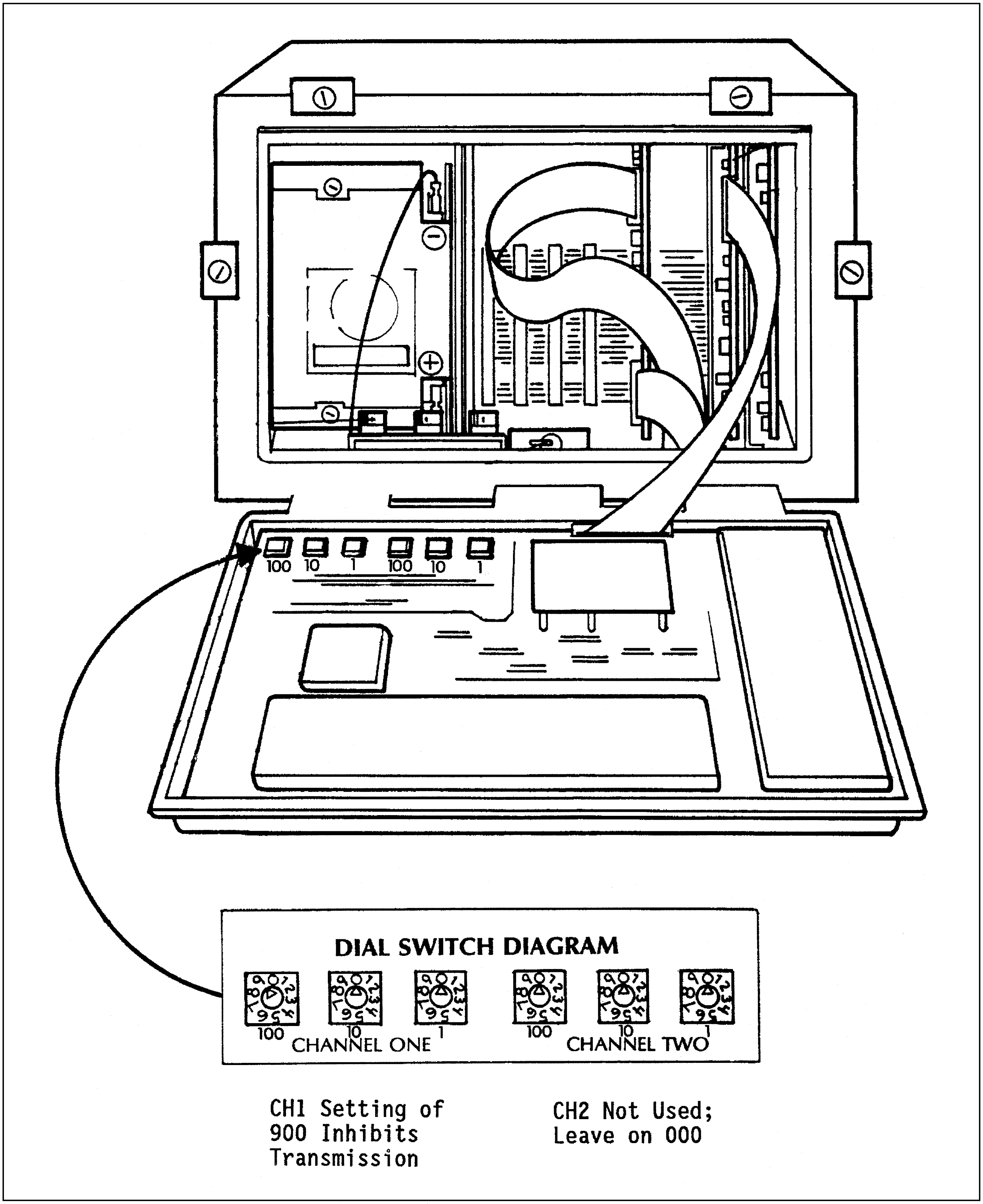
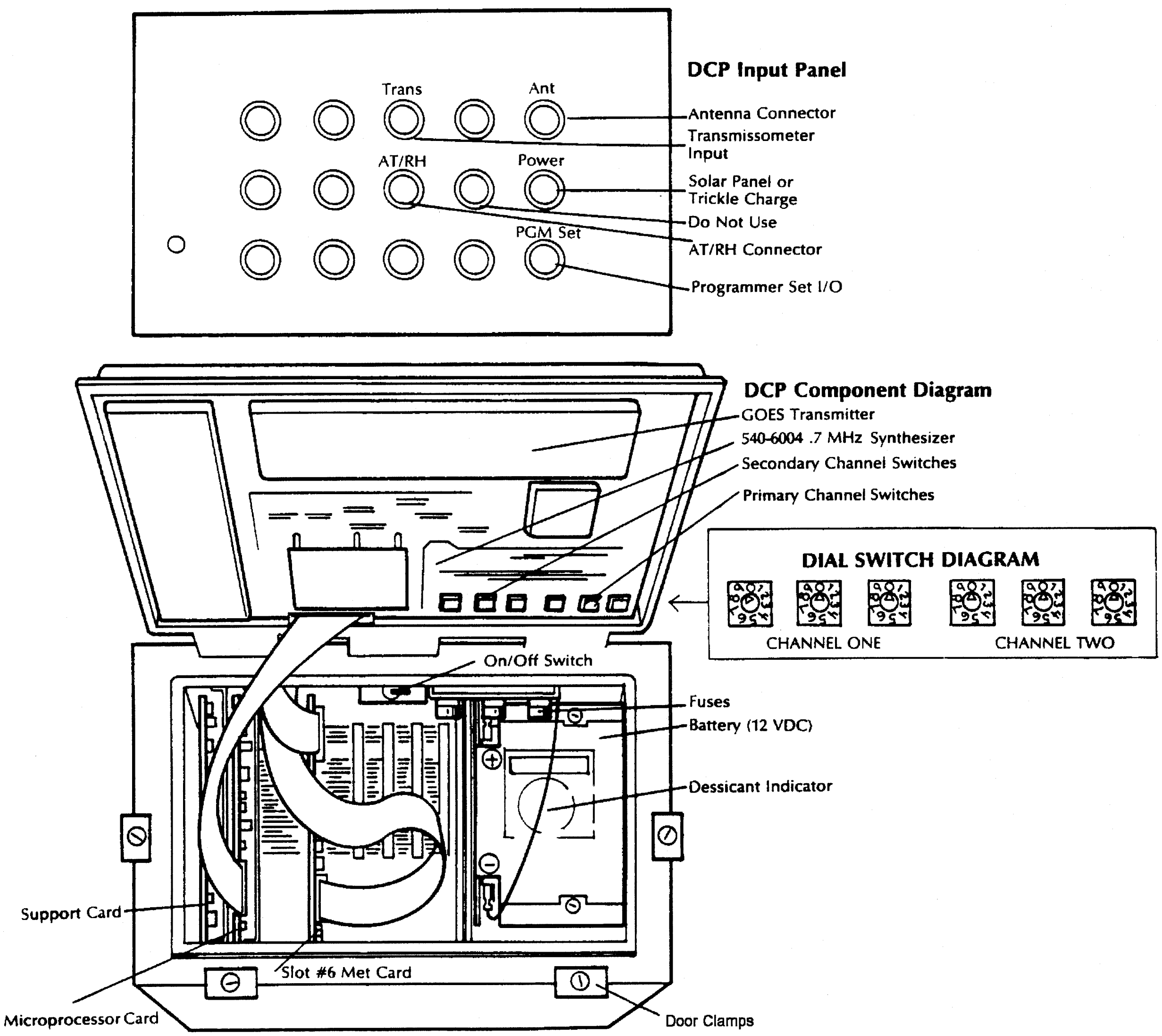


Figure 4-10. DCP Transmission Channel Switches Diagram.



Side View DCP Input Panel

IMPRORTANT--DCP panels may differ from the above unit.

Figure 4-11. DCP Component Diagram.

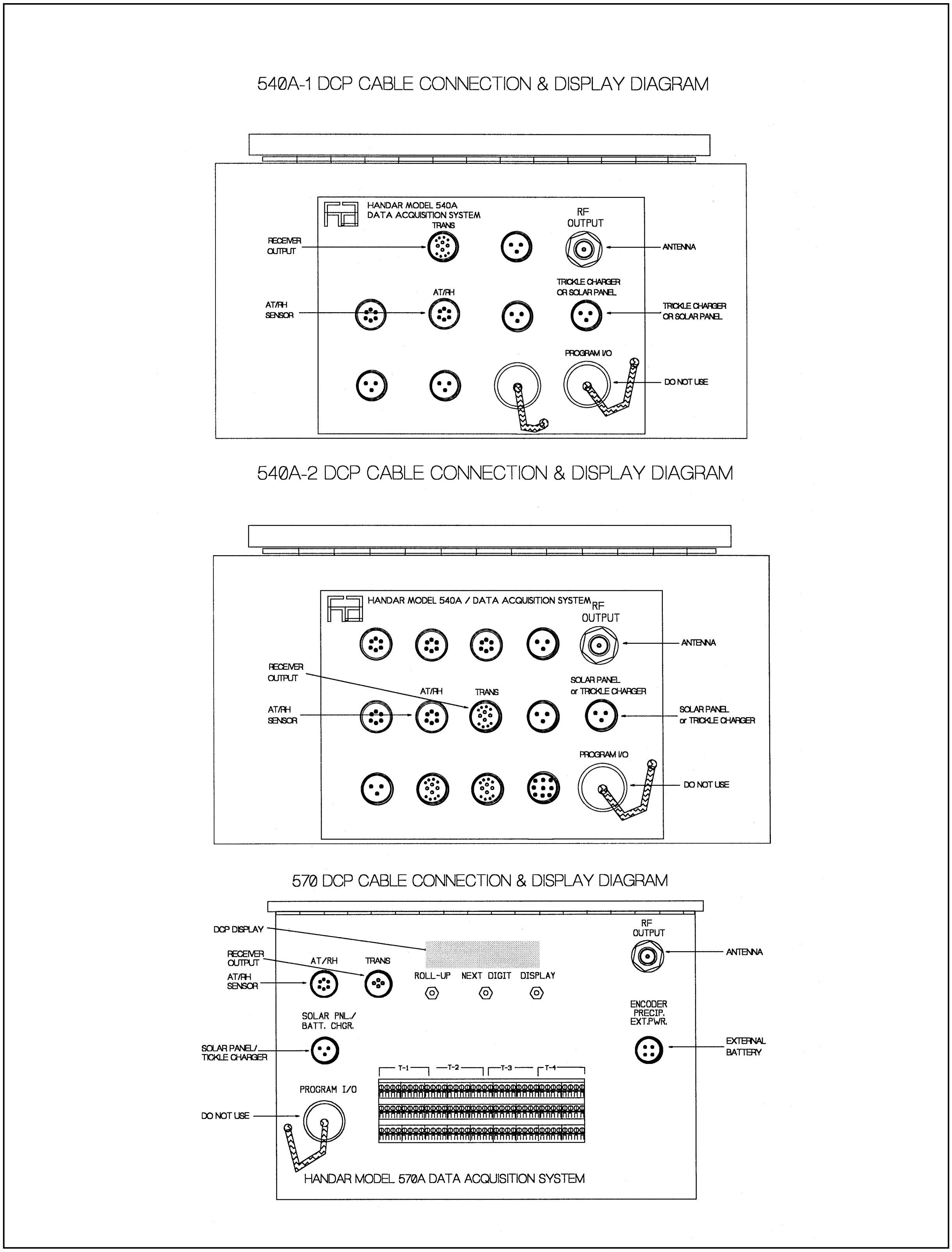


Figure 4-12. DCP Cable Connection and Display Diagram.

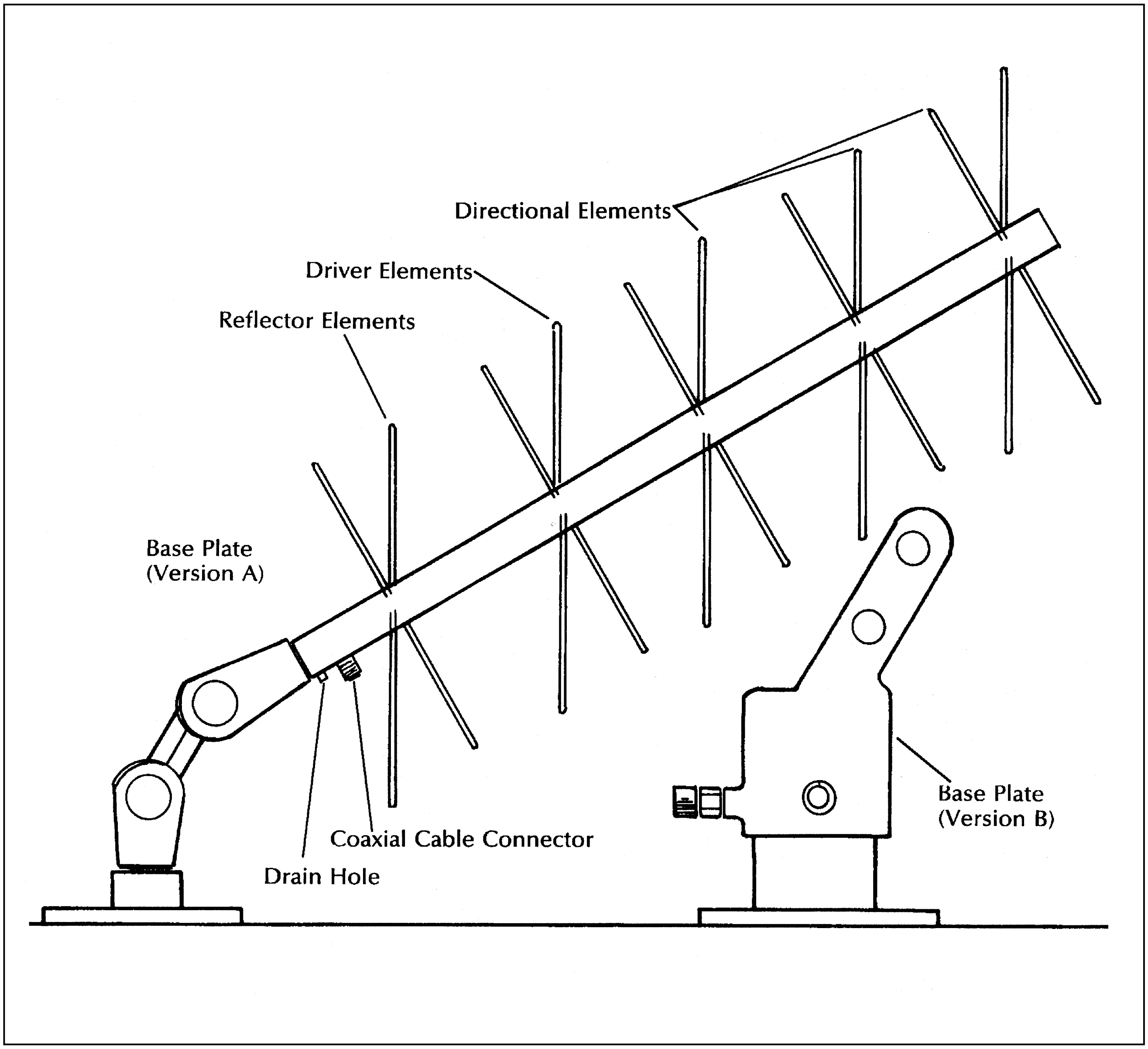


Figure 4-13. DCP Antenna Component Diagram.

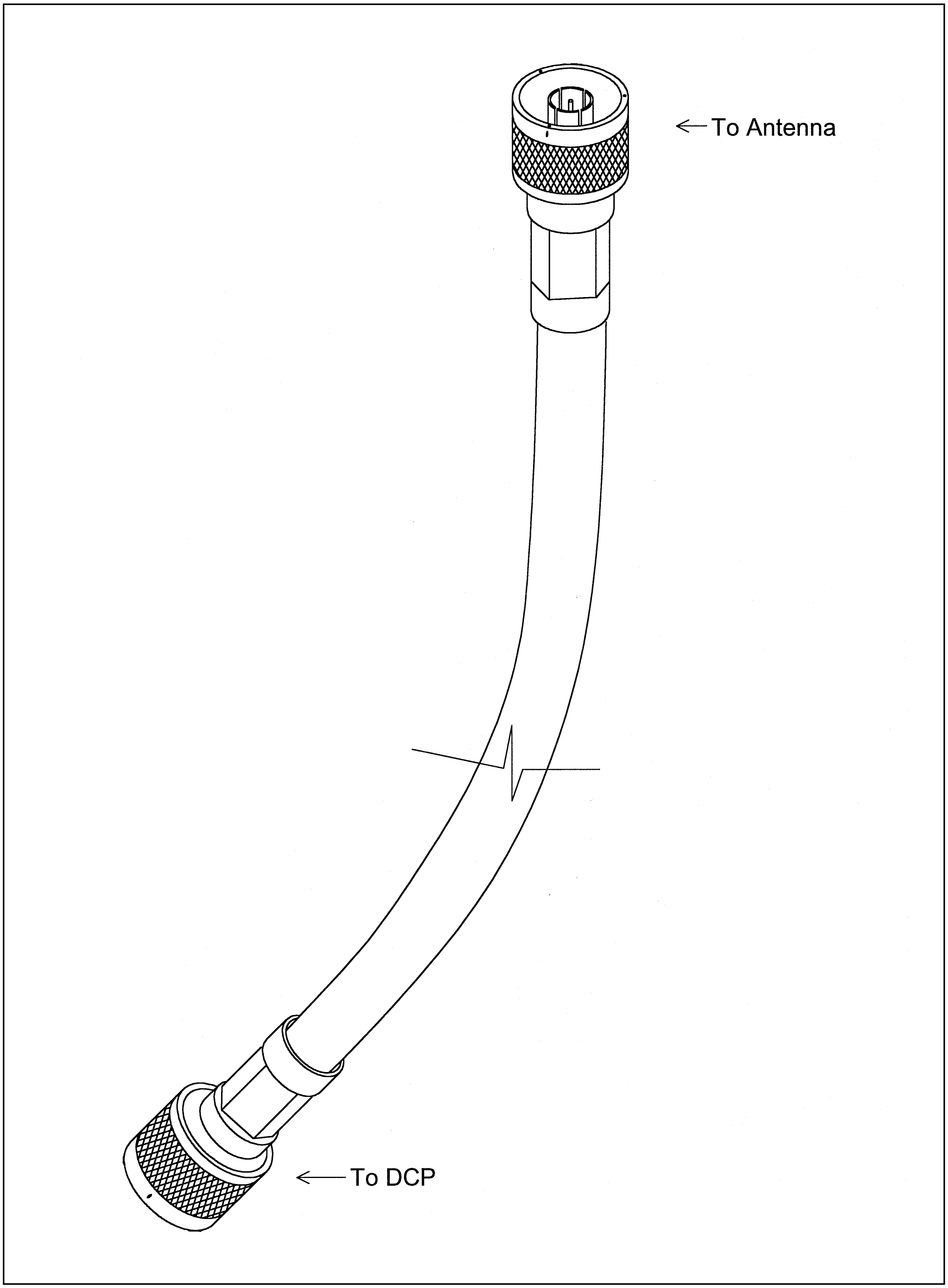


Figure 4-14. DCP Antenna Cable Connection Diagram.

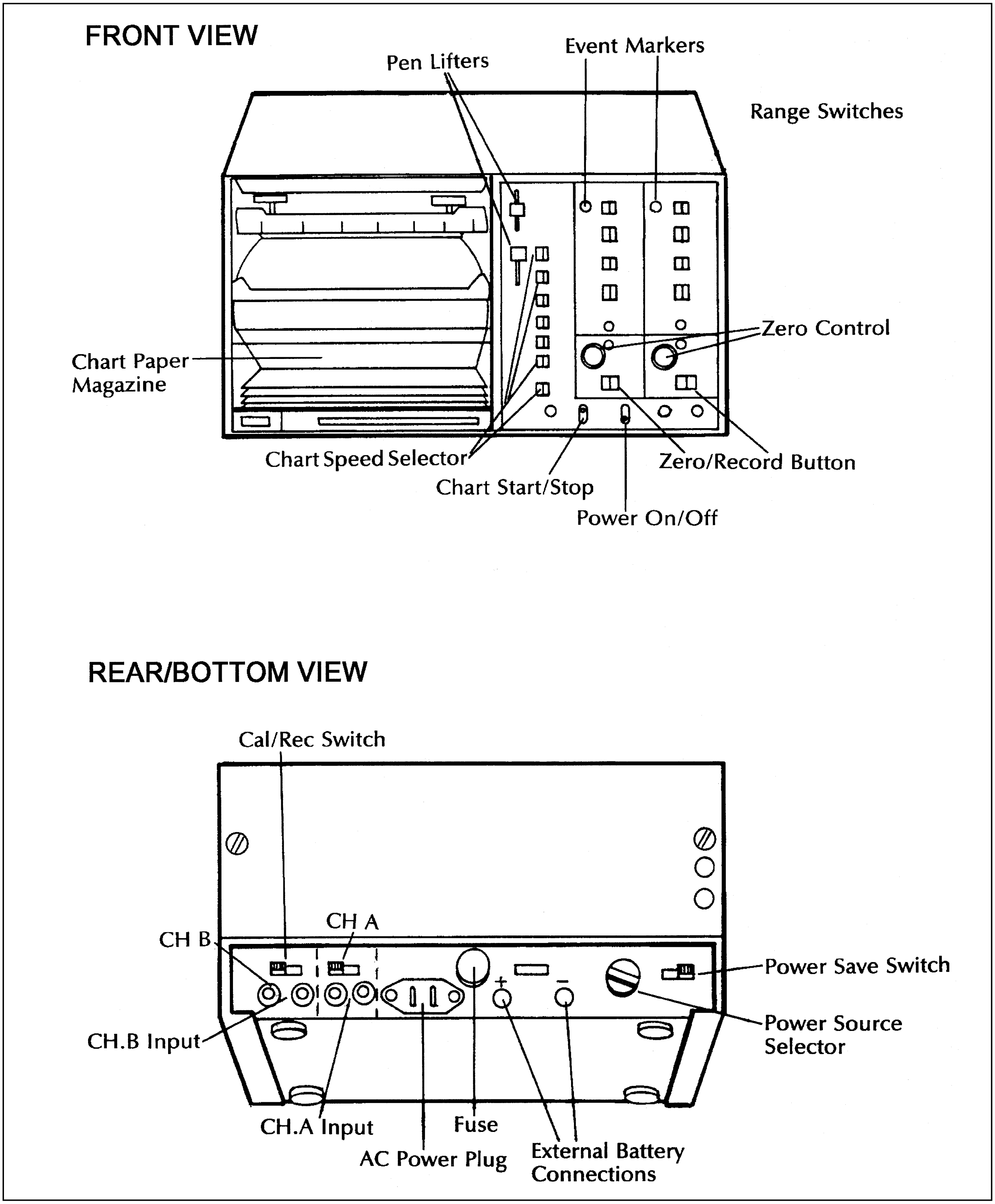


Figure 4-15. Strip Chart Component Diagram.

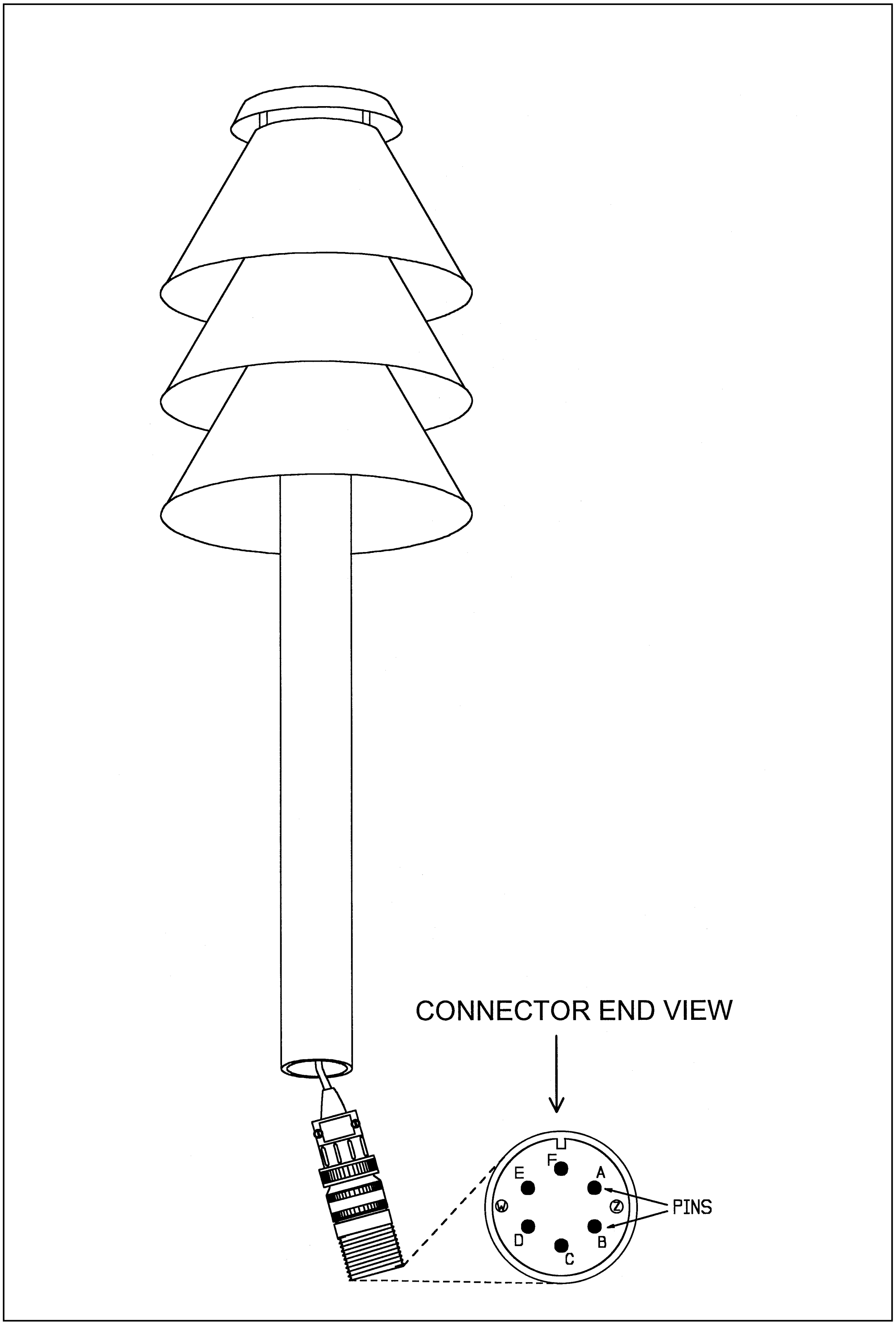


Figure 4-16. AT/RH Sensor and Cable Diagram.

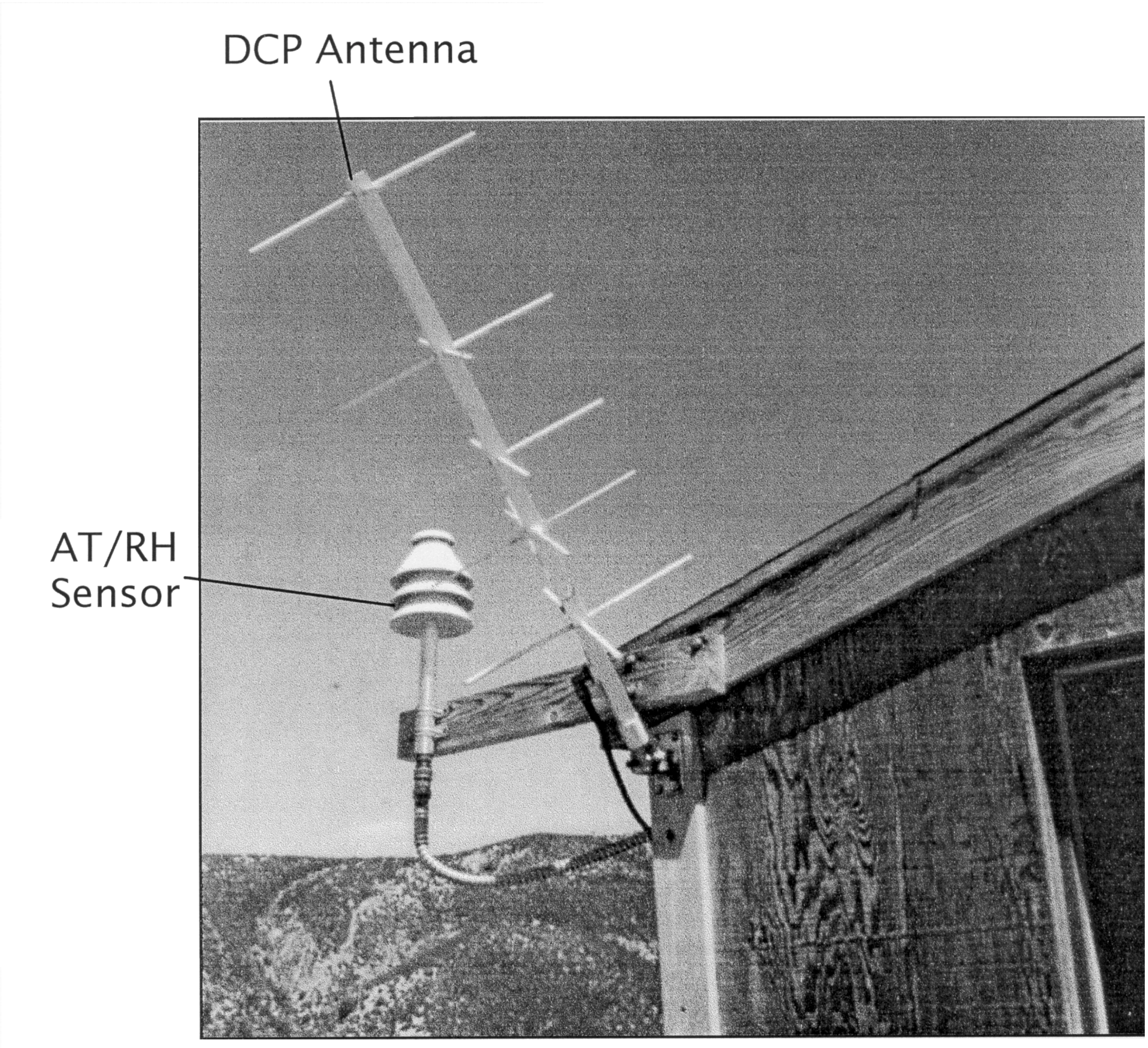


Figure 4-17. Mounted AT/RH Sensor and DCP Antenna.

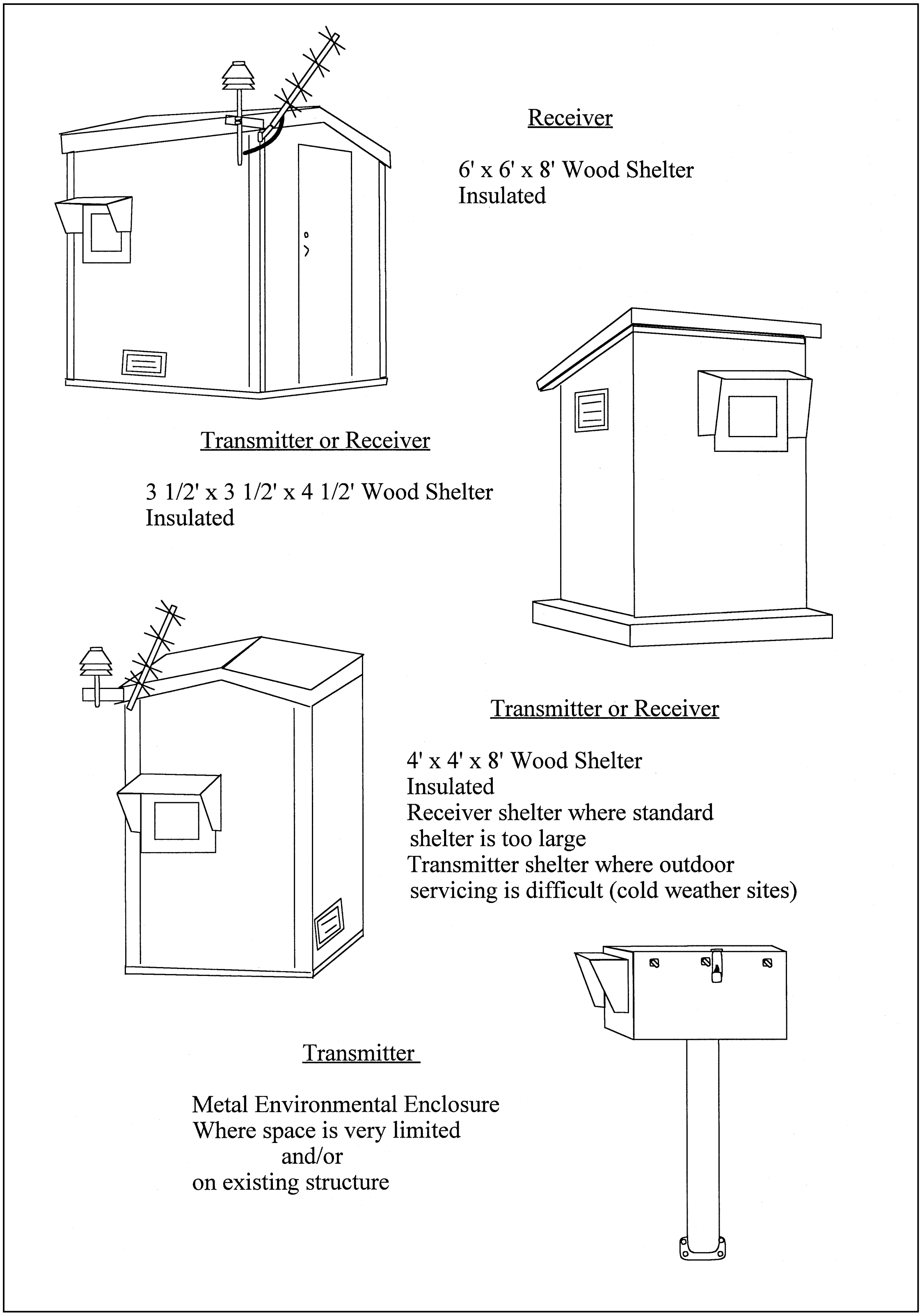


Figure 4-18. Transmissometer System Shelters Diagram.

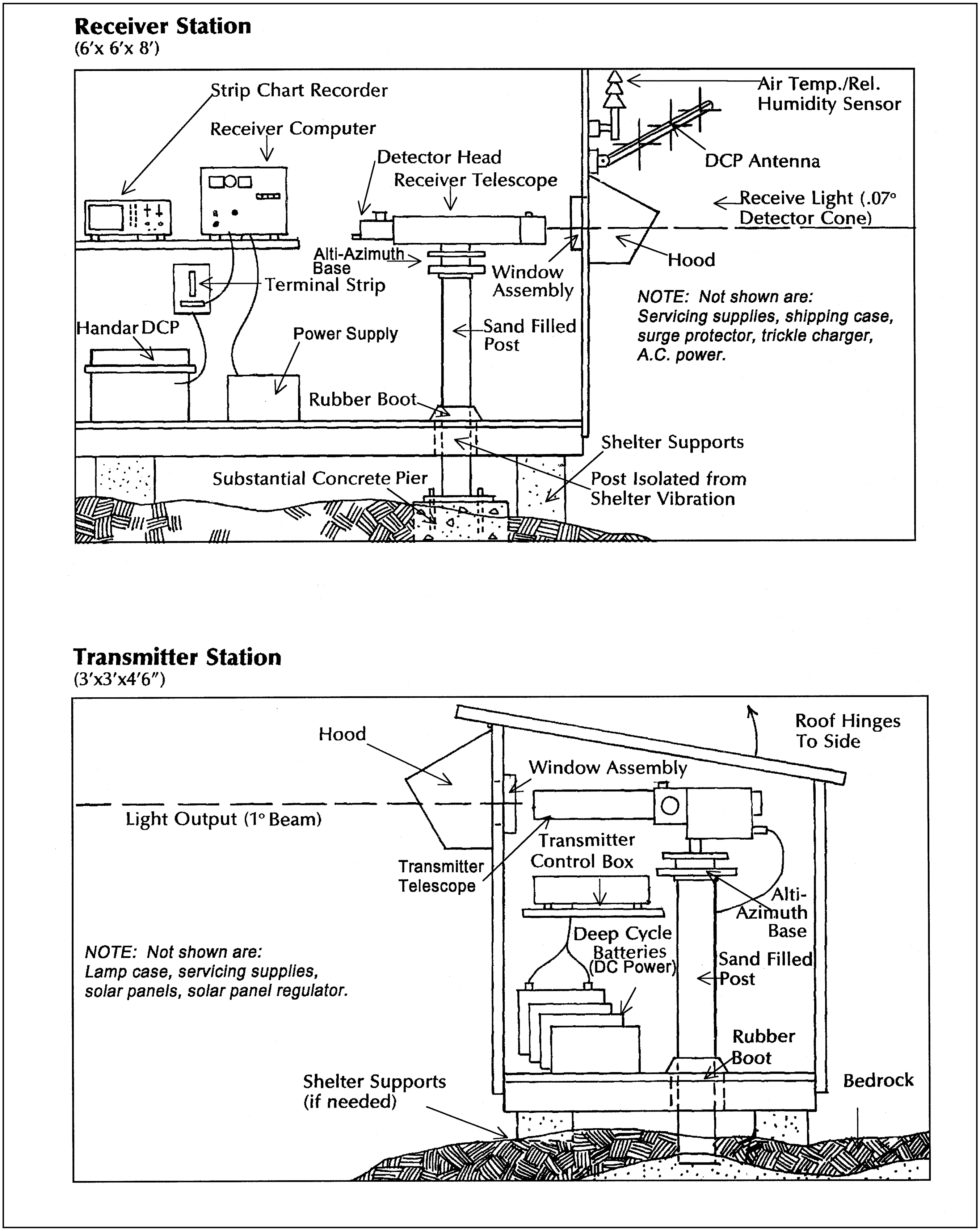
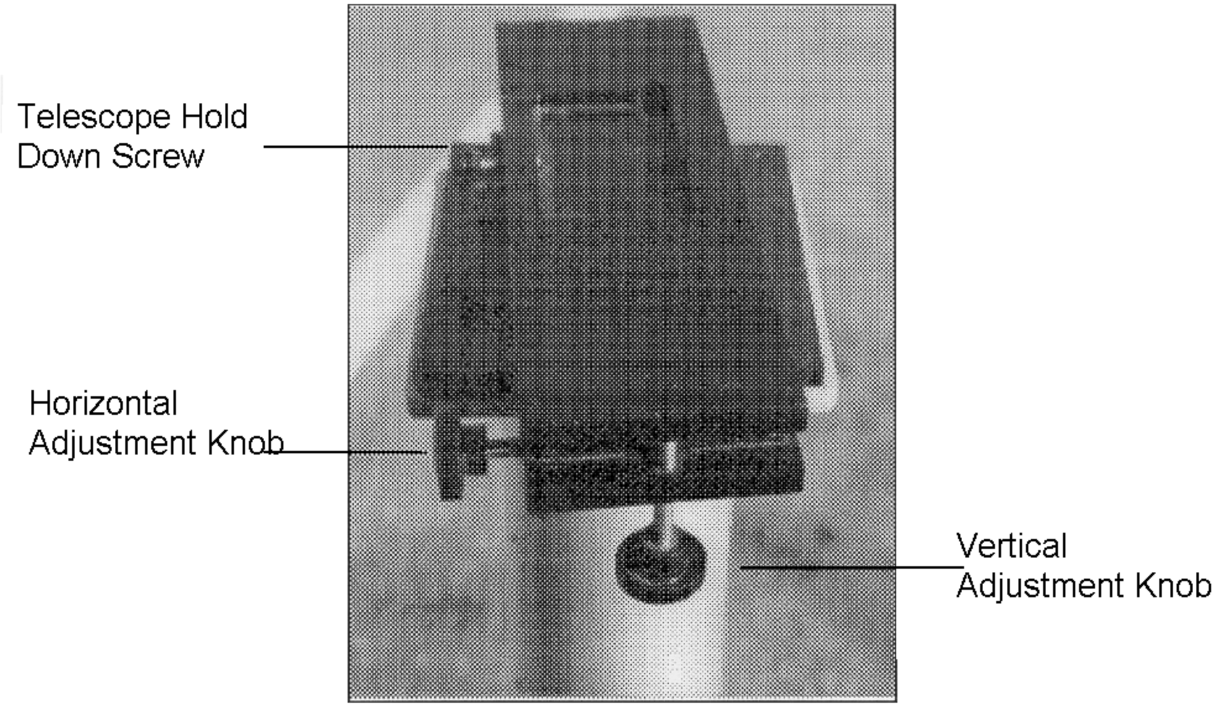
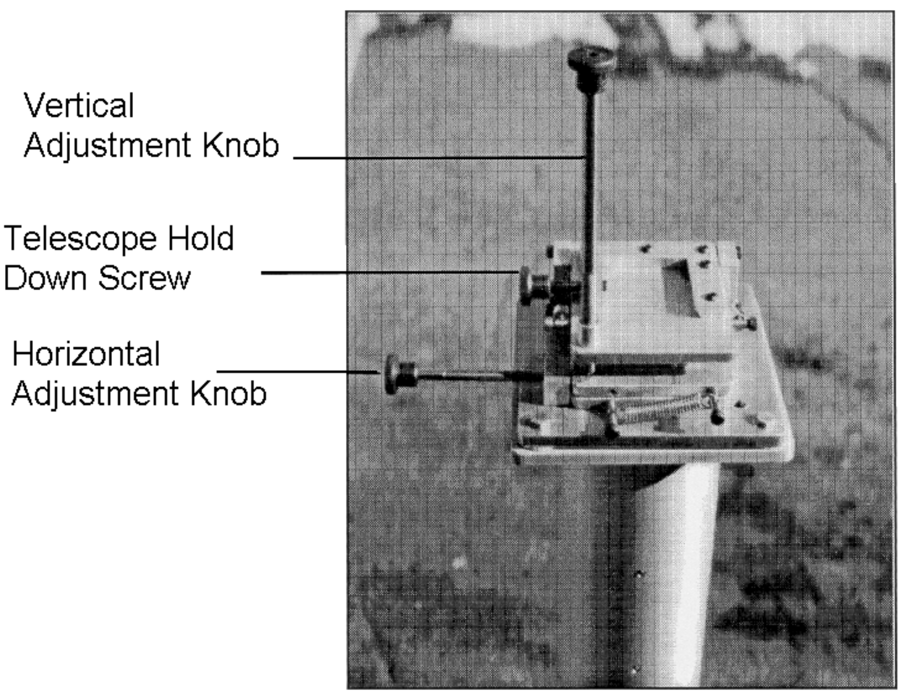


Figure 4-19. Monitoring Component Diagram (Receiver and Transmitter Shelters).



Receiver Alti-Azimuth Base



Transmitter Alti-Azimuth Base

Figure 4-20. Receiver and Transmitter Alti-Azimuth Bases.

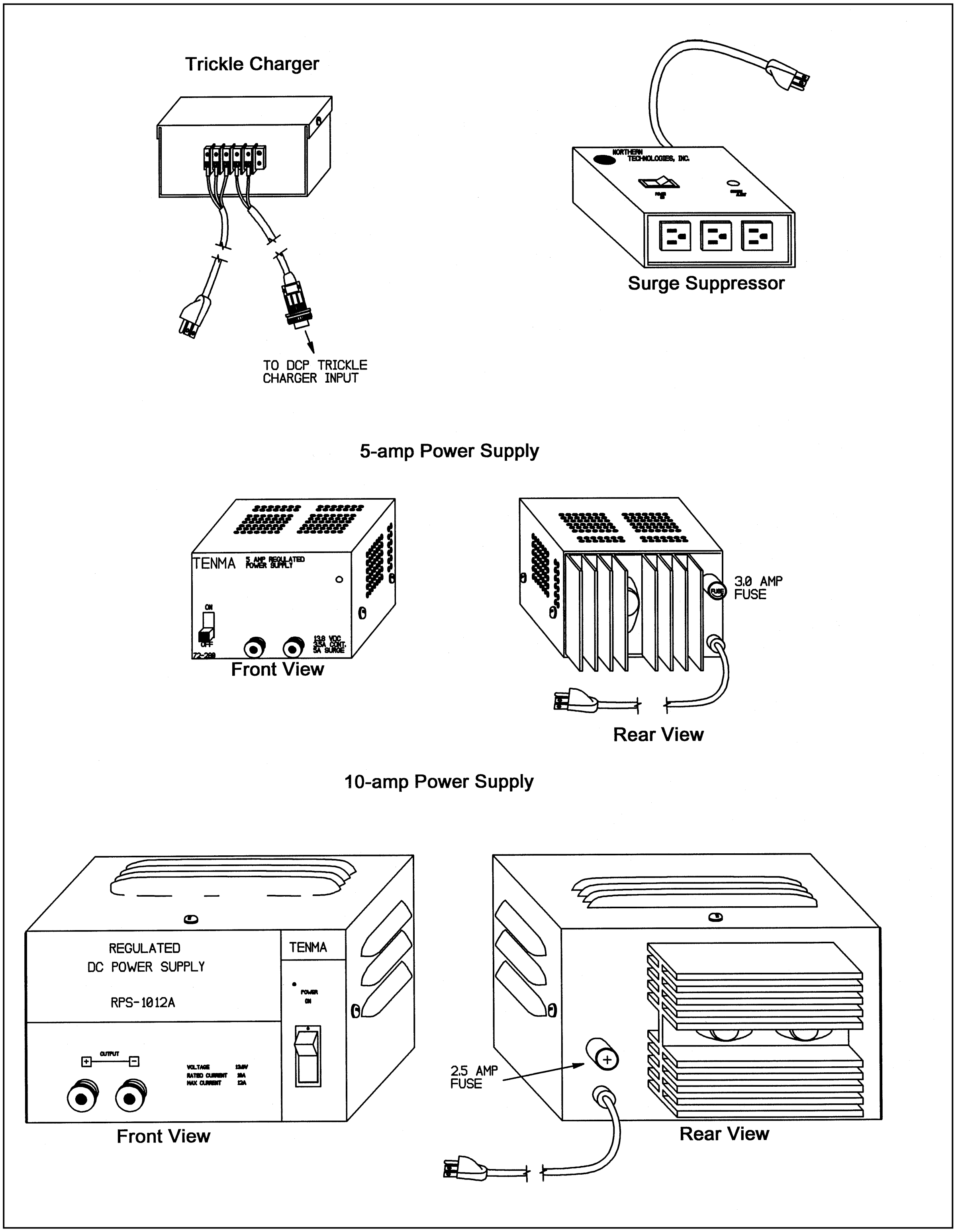


Figure 4-21. Line Power (AC) Components Diagram.

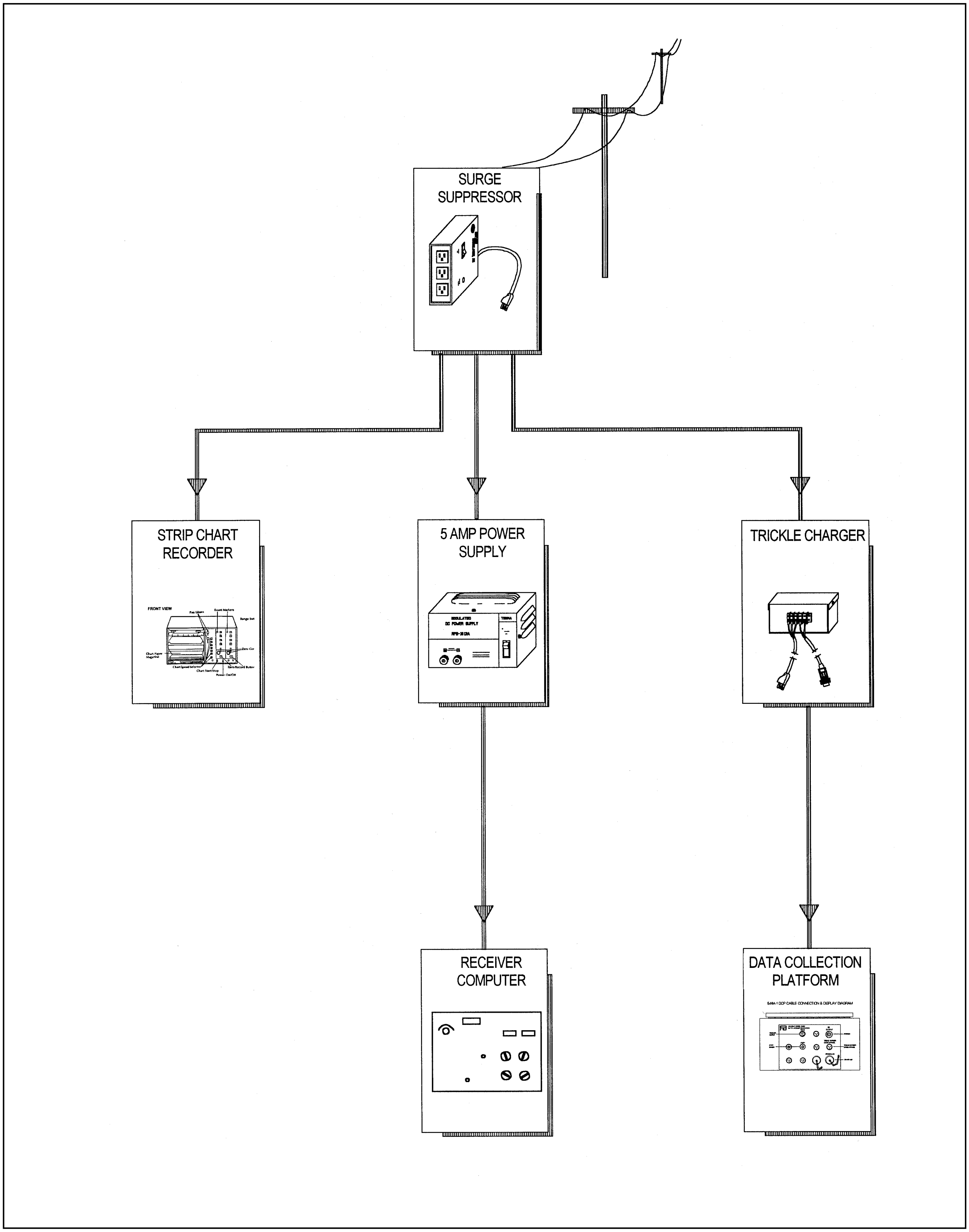


Figure 4-22. Receiver Station Line Power (AC) Configuration Diagram.

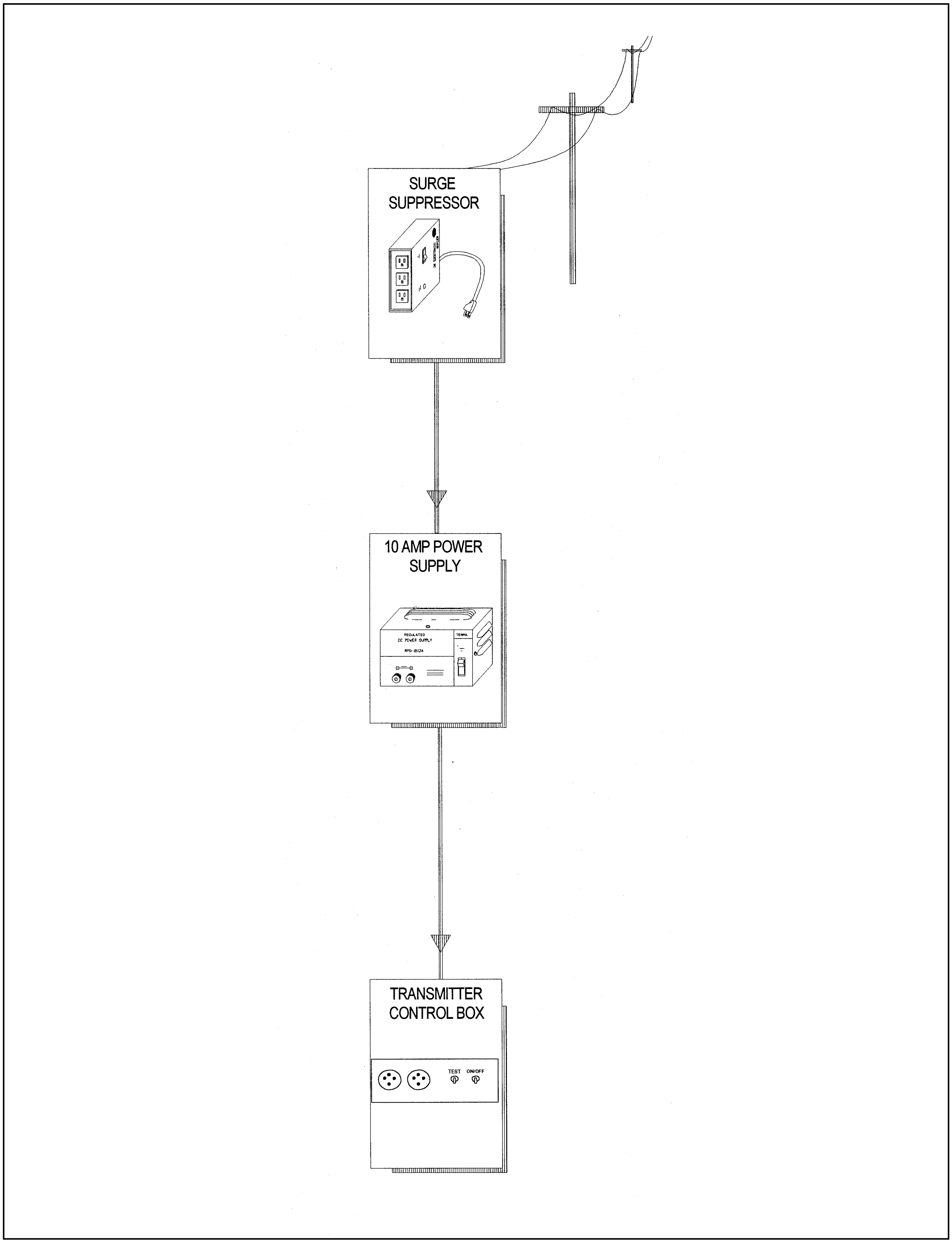


Figure 4-23. Transmitter Station Line Power (AC) Configuration Diagram.

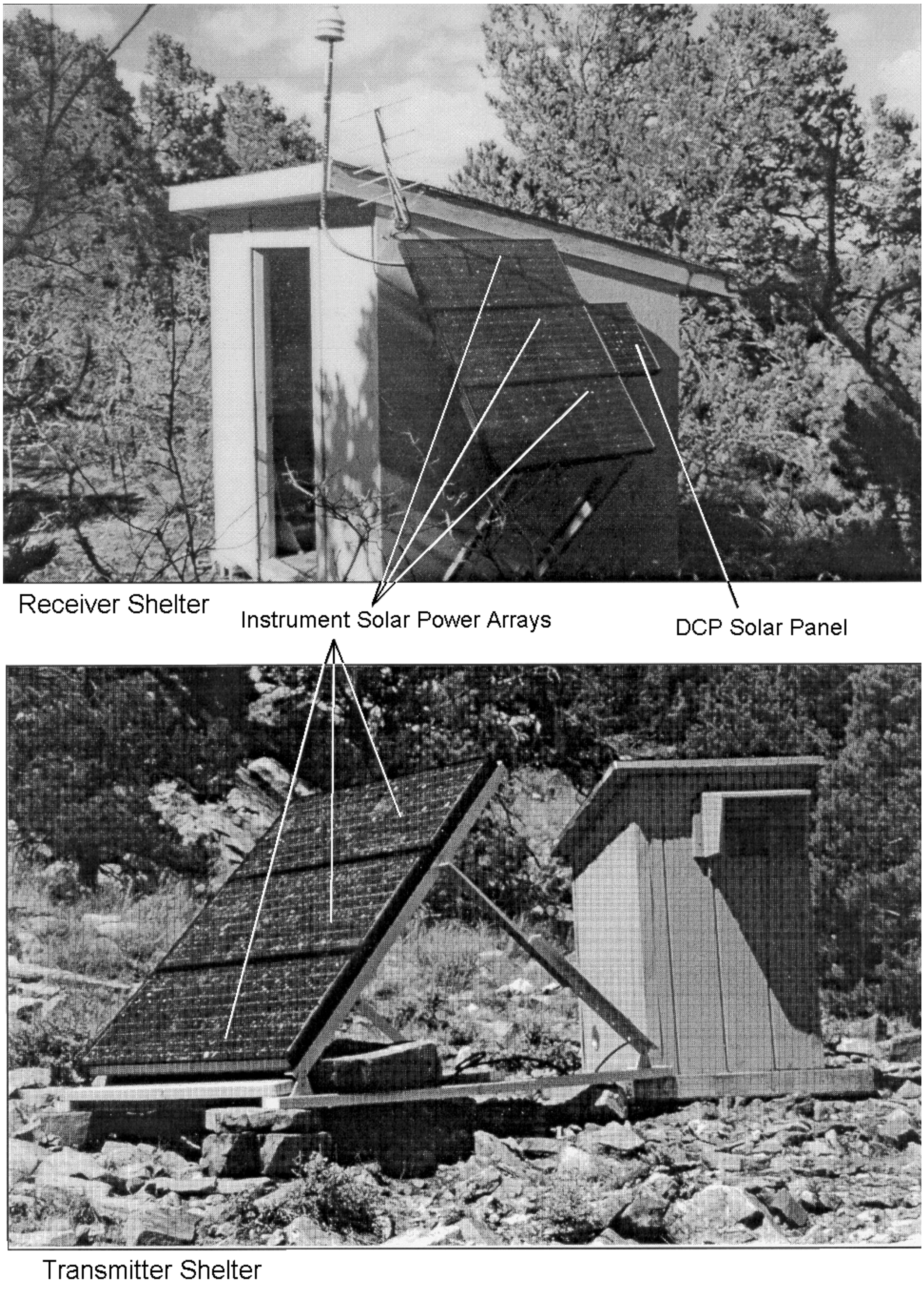


Figure 4-24. Solar Power Array Components (Receiver and Transmitter).

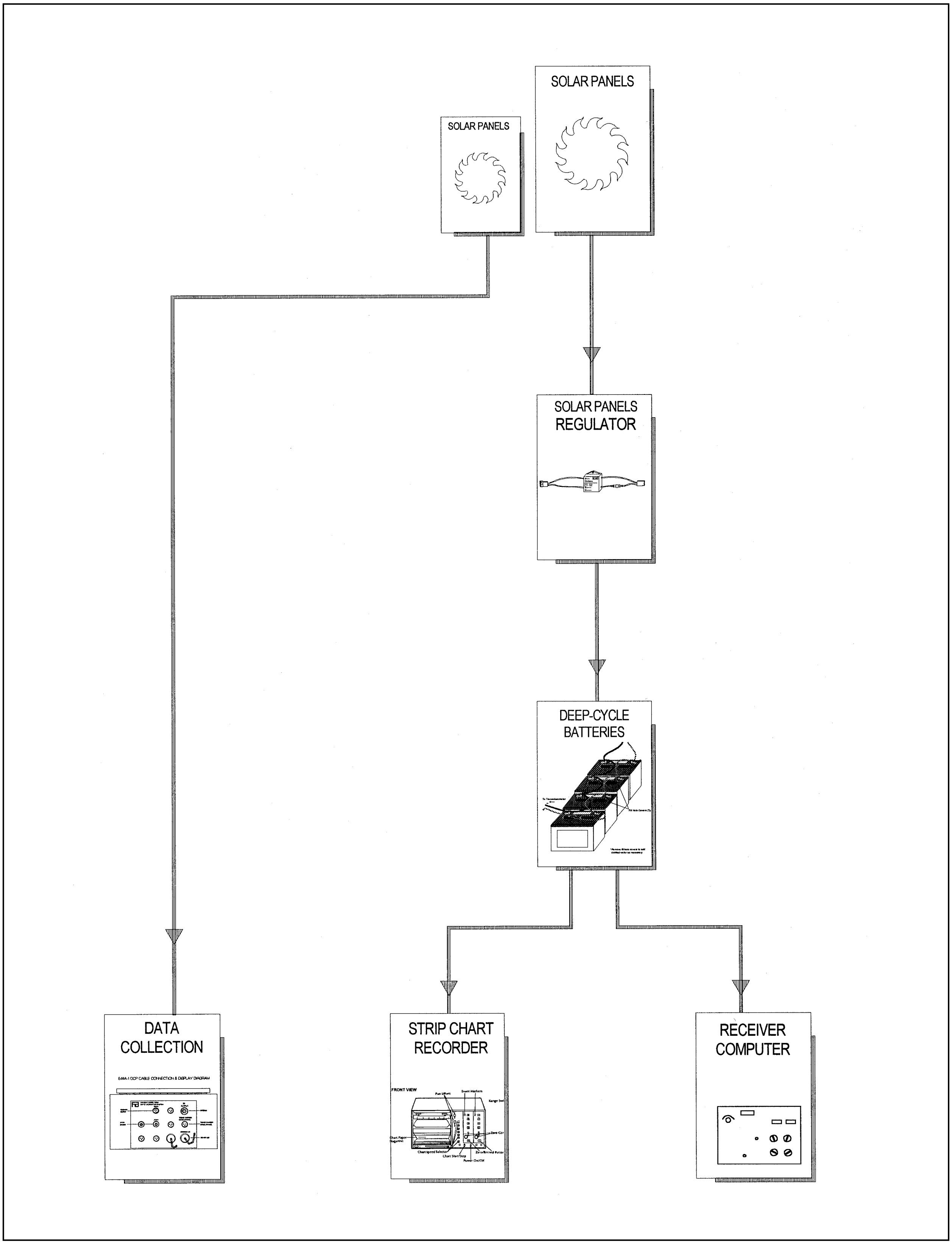


Figure 4-25. Receiver Station Solar Power (DC) Configuration Diagram.

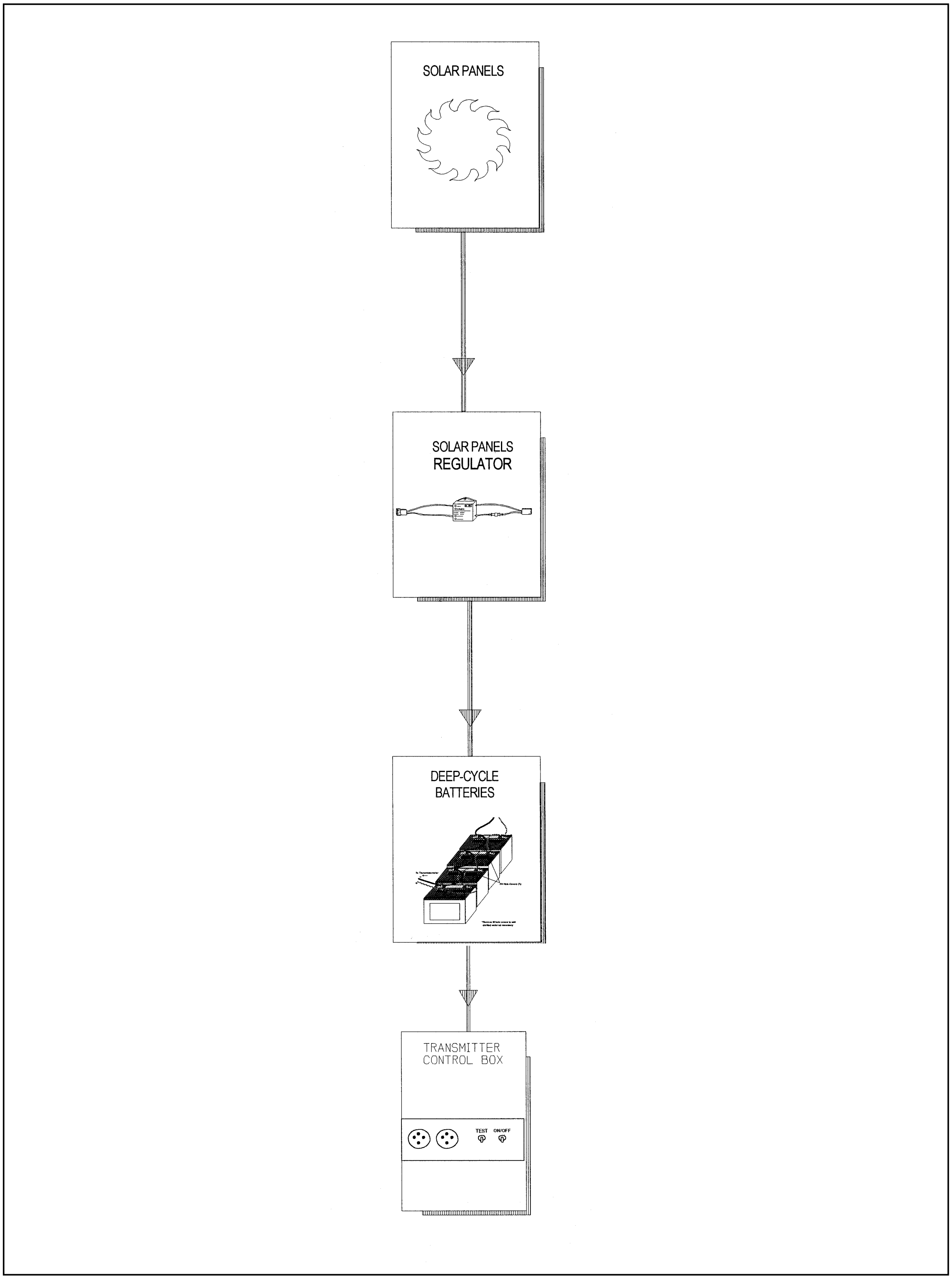


Figure 4-26. Transmitter Station Solar Power (DC) Configuration Diagram.

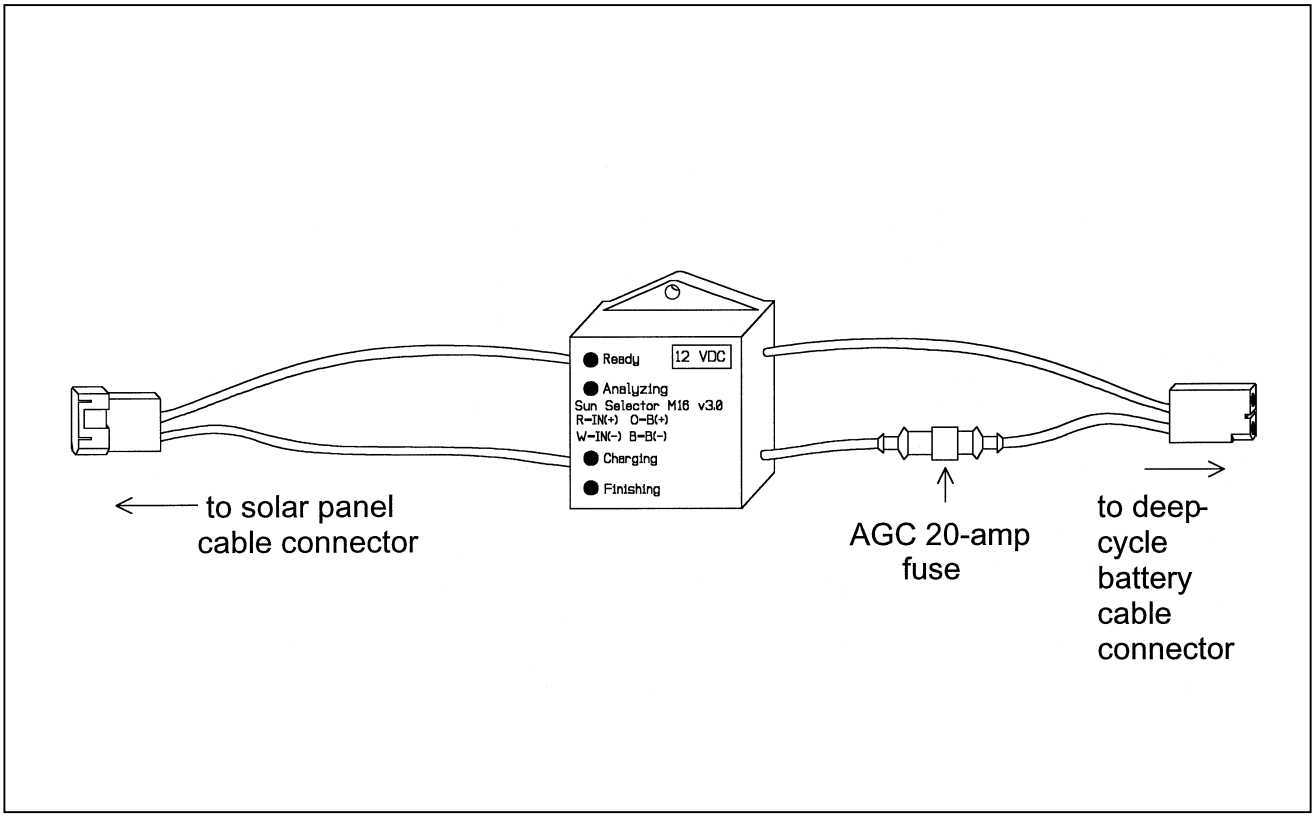


Figure 4-27. M-16 Solar Panel Regulator Diagram.

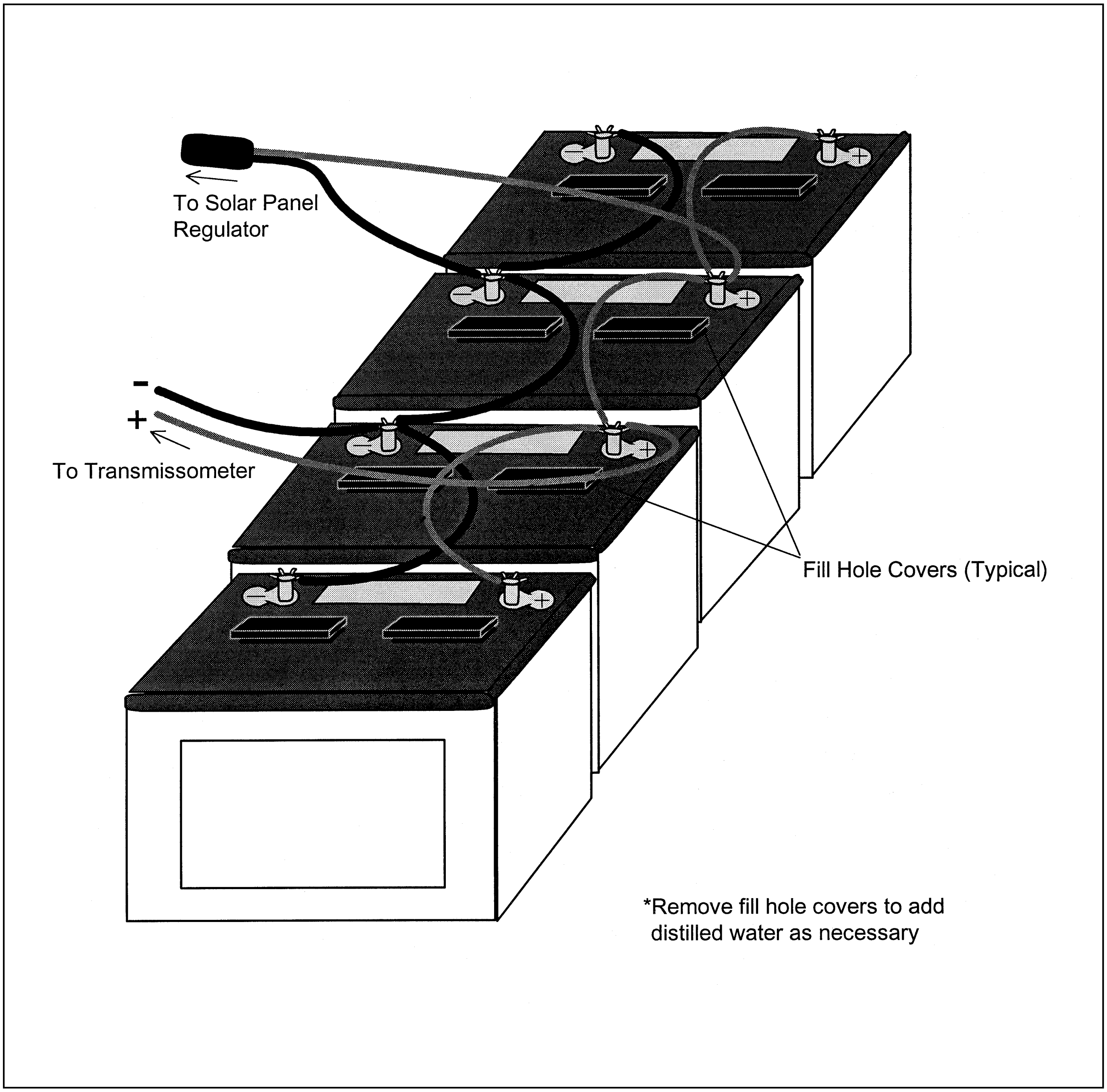


Figure 4-28. Deep-Cycle Battery and Interconnect Diagram.

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AUTHORIZATIONS		
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1.0	Modify/add component figures.	March 1995	
1.1	Minor text and formatting changes.	August 1996	

TABLE OF CONTENTS

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LIST OF FIGURES (CONTINUED)

Figure **Page**

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for removing, installing, and proper packing and shipping of transmissometer monitoring system components and support equipment at a field monitoring site.

This TI, as referenced in Standard Operating Procedure (SOP) 4110, *Transmissometer Maintenance (IMPROVE Protocol)*, specifically describes:

- Procedures for disconnecting power from instruments and support equipment.
- Procedures for physically removing instruments and support equipment from mounting hardware.
- Procedures for removing internal batteries (if necessary).
- Cables and other accessories to be packed and shipped with instruments and support equipment.
- Removal documentation requirements for instruments and support equipment.
- Procedures for physically installing replacement instruments and support equipment.
- Procedures for connecting power to instruments and support equipment.
- IMPROVE operational switch settings for instruments and support equipment.
- Procedures for verifying and documenting proper operation of replacement instruments and support equipment.
- Procedures for packing instruments and support equipment for shipment.
- Shipping methods and amount of insurance required for each item.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and data coordinator concerning the schedule and requirements for specific transmissometer component replacement and shipment procedures.
- Oversee and review specific transmissometer component replacement and shipment procedure documentation completed by the site operator, for completeness and accuracy.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, data coordinator, and project manager concerning the schedule and requirements for specific transmissometer component replacement and shipment procedures.
- Train the site operator in all phases of specific transmissometer component replacement and shipment procedures necessary for on-site resolution of instrument problems.
- Provide technical support to the site operator via telephone to assure proper transmissometer component replacement and shipment procedures.
- Document all technical support provided to the site operator.
- Resolve problems reported by the site operator.

2.3 DATA COORDINATOR

The data coordinator shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and project manager concerning the schedule and requirements for specific transmissometer component replacement and shipment procedures.
- Identify possible instrument malfunction then contact the site operator to schedule a visit for transmissometer component replacement and shipment procedure implementation.
- Review documentation completed by the site operator for completeness and accuracy.
- Verify that scheduled visits are performed and notify the site operator if he/she fails to make a scheduled visit.
- Provide technical support to the site operator via telephone to assure proper transmissometer component replacement and shipment procedures.
- Document all technical support provided to the site operator.
- Review and file all site documentation.
- Resolve problems reported by the site operator.
- Send supplies, tools, and replacement instrumentation necessary for instrument problem resolution to the site operator.
- Make the necessary arrangements for pick-up and return shipment of malfunctioning transmissometer components.
- Enter all correspondence with site operators and the results of all performed procedures into site-specific timelines.

2.4 SITE OPERATOR

The site operator shall:

- Coordinate with his/her supervisor, field specialist, data coordinator, and project manager concerning the schedule and requirements for specific transmissometer component replacement and shipment procedures.
- Perform all procedures described in this TI.
- Thoroughly document all performed transmissometer component replacement and shipment procedures on the LPV-2 Transmissometer Operator Log Sheet, and mail the log sheet to the data coordinator.
- Report any noted inconsistencies immediately to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment is generally required for transmissometer component replacement and shipment:

- Transmissometer component shipping cases, and cloth and plastic bags
- Large, medium, and small flat-blade screwdrivers
- Keys for shelters and padlocks
- Site Operator's Manual for Transmissometer Monitoring Systems
- LPV-2 Transmissometer Site Operator Log Sheet (transmitter and receiver)
- Pen or pencil
- Electrical tape
- Utility knife
- Allen wrench set
- Rubber bands
- Blower brush
- Cleaning cloth
- ARS shipping labels
- Packing tape

4.0 METHODS

This section includes three (3) major subsections:

4.1 Transmissometer and Support Equipment Removal
4.2 Transmissometer and Support Equipment Installation
4.3 Packing and Shipping

4.1 TRANSMISSOMETER AND SUPPORT EQUIPMENT REMOVAL

Follow the procedures described in this section for disabling and removing instrumentation and support equipment. Damage to instruments can occur upon installation or removal. When removing instruments, consider the following:

- Always leave the power switch in the "OFF" position when removing or installing instruments.

- Avoid touching connector pins or circuit boards; static electricity may damage sensitive components.

- Double-check connectors, power polarity, and instrument settings before applying power.

- Follow procedures in the order they are given.

- If you have questions, call the data coordinator before proceeding.

4.1.1 Removing the Transmitter

Take the gray, suitcase-style transmitter shipping case with you to the site, so that the instrument will be protected during transit. See Section 4.3 for packing and shipping instructions. Follow the procedures below when removing the transmitter:

DISCONNECT	Turn the control box power switch **OFF**.
	Disconnect the power cable (black) from the control box only. Coil the cable and set it next to the battery or the power supply.
	Disconnect the control cable (gray) from both the control box and the transmitter telescope. Coil and rubber band the cable and place it in the shipping case.
REMOVE	Place the control box in the shipping case after first enclosing in a plastic (or white cloth) bag.
	Remove the lamp from the transmitter. Document the lamp "off" date on the operator log sheet and store the lamp in the black lamp case (the lamp case remains on-site).

Cover the telescope and lamp chamber ends of the transmitter with plastic bags and secure the bags in place with rubber bands. Put the transmitter telescope in the white cloth bag. Place the transmitter telescope in the gray, suitcase-style shipping case.

DOCUMENT — Document removal of the instrument in the "General Comments" section of the LPV-2 Transmissometer Operator Log Sheet - Transmitter Station (see Figure 4-1).

4.1.2 Removing the Receiver

Take both wooden shipping cases and the gray suitcase-style case with you to the site, so that the instrument will be protected during transit. See Section 4.3 for packing and shipping instructions. Follow the procedures below when removing the receiver:

DISCONNECT — Turn the power to the receiver computer **OFF**.

Disconnect the receiver power, output, and photometer head cables from the computer and place them aside. Coil and band the photometer head cable.

REMOVE — Place the receiver computer in the white cloth bag provided and then in its wooden shipping case.

Remove the detector-head from the telescope with an Allen wrench included in the tool kit (refer to Figure 4-2). Put the detector-head first in a plastic bag and then in the white cloth bag; then place the unit in the gray, suitcase-style shipping case.

Cover both ends of the telescope with plastic bags secured with rubber bands. Place the telescope in the cloth bag provided, then place the unit in its wooden shipping case.

DOCUMENT — Document removal of the instrument in the "General Comments" section of the LPV-2 Transmissometer Operator Log Sheet - Receiver Station (see Figure 4-3).

4.1.3 Removing the DCP

Refer to Figure 4-4, DCP Datalogger Component Diagram, for the location of the switches and connectors discussed. Figure 4-4 depicts the dial switches in detail.

IMPORTANT: Before disconnecting the DCP antenna cable, some internal switch settings must be changed to inhibit transmissions. Failure to do so will damage the DCP.

Follow the procedures below when removing the DCP:

RESET — Loosen the clasps and open the hinged door of the DCP. Locate the six square, red, dial switches located on the circuit board on the inside of the door. Refer to close-up of dial switches in Figure 4-4.

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Location________________________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
TRANSMITTER STATION

Date__________________ Local Time______________ Operator(s) ______________________________

Weather Conditions____

Visibility Conditions____

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment____
2. ALIGNMENT: Mark initial location of receiver shelter window with a "+".
   Initial Alignment Comments____
   IMPORTANT: Return flip mirror to proper (ON) position.
3. Instrument Number LPV-__________ Lamp Number____________________
4. Initial Window Cleanliness GOOD MODERATE POOR
   Comment____

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned ____________ If NO, why not? ______________________
2. Lens Inspected? YES NO Comment ____
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned ____________________
4. Solar Panels Cleaned? YES NO Comment ____
5. Lamp Check IMPORTANT: Must be done when lamp is ON under automatic control.
   a) LED (indicator light on side of control box) ON OFF (if ON , call ARS)
   b) Lamp Voltage Reading (switch voltmeter to 20 VDC range) __________ volts, for lamp number ____________
   IMPORTANT: Switch voltmeter to "OFF" after taking voltage reading.

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) _______:_______:_______
3. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) _______:_______:_______

SPECIAL SERVICING (upon ARS instruction)

1. Timing Reset? YES NO If YES, time reset _______________
2. Lamp Changed? YES NO If YES, new lamp number__________ time lamp changed___________
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Alignment rechecked after lamp change? YES NO
4. Battery Voltage (charging)____________________ Battery Voltage (analyzing)____________________

GENERAL COMMENTS/SUPPLIES NEEDED____

Send the original copy of this form to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

Phone: 1-800-344-5423
FAX: 1-970-484-3423

xmtrlog.sam (8/96)

Figure 4-1. LPV-2 Transmissometer Operator Log Sheet - Transmitter Station.

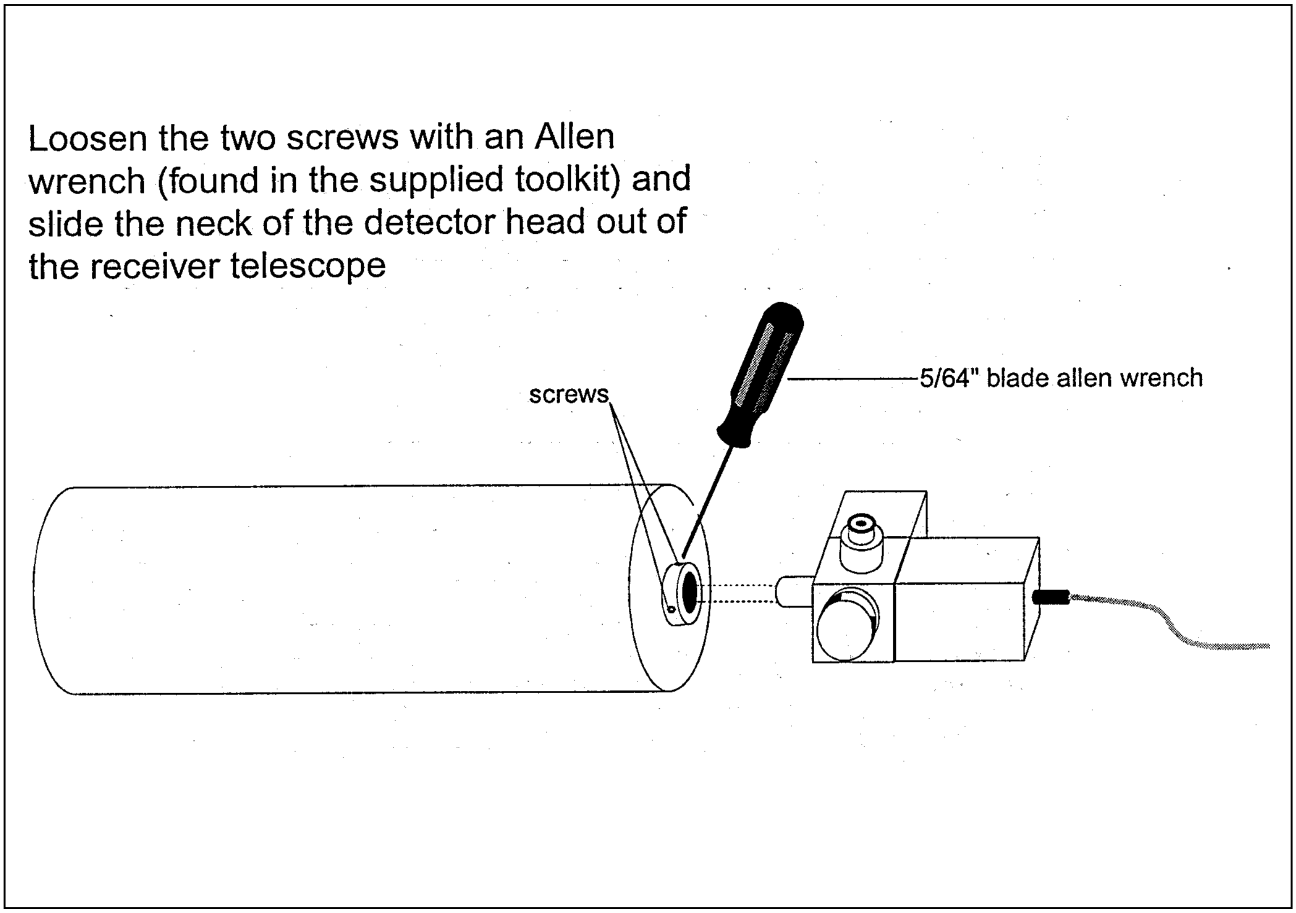

Figure 4-2. Removal of Receiver Detector Head.

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Location______________________________

LPV-2 TRANSMISSOMETER OPERATOR LOG SHEET
RECEIVER STATION

Date____________________ Local Time______________ Operator(s) ______________________________
Weather Conditions____
Visibility Conditions____

INITIAL CONDITION

1. Does the instrument generally appear to be working properly? YES NO
   Comment____
2. Receiver Display Reading __________________ Local Time _______________ Toggle ON OFF
3. Settings: Gain________ Cal________ Dist________ A1________ A2________ Int________ Cycle________
   Switch A1 Readings: C________ B________
   Does the Bext represent actual conditions? YES NO Comment ______________________
   IMPORTANT: Return A1 Switch to "C" position after check.
4. ALIGNMENT: Mark initial location of transmitter light source with a "+".
   Initial Alignment Comments____
   IMPORTANT: Return flip mirror to proper (ON) position.
5. Instrument Number LPV-__________
6. Initial Window Cleanliness GOOD MODERATE POOR
   Comment ____
7. Strip Chart Operating? YES NO (If operating, refer to SPECIAL SERVICING #4 below.)

SERVICING

1. Window Cleaned? YES NO If YES, time cleaned __________ If NO, why not? ______________
2. Lens Inspected? YES NO Comment ____
   IMPORTANT: Use only the blower brush to clean the telescope lens.
3. Alignment Corrected? YES NO If YES, time aligned __________________
4. Solar Panels Cleaned? YES NO Comment ____

TIMING

1. Is your watch synchronized with NBS (WWV) time? (303/499-7111) YES NO
2. Transmitter Light ON, Exact Time, (HR:MIN:SEC) ______:______:______
3. Receiver Toggle Update, Exact Time, (HR:MIN:SEC) ______:______:______
4. Updated Receiver Reading __________________ Toggle ON OFF
   Does the updated Bext reading represent actual conditions? YES NO Comment ______________
5. Transmitter Light OFF, Exact Time, (HR:MIN:SEC) ______:______:______

SPECIAL SERVICING (upon ARS instruction)

1. Computer Reset? YES NO Timing Reset? YES NO If YES, time reset __________________
2. Lamp changed at Transmitter Station? YES NO
   IMPORTANT: If lamp is changed, receiver computer calibration (cal) number must also be changed.
3. Receiver computer calibration (cal) number changed? YES NO If YES, new cal number entered __________
4. Strip Chart: Marked? YES NO Zeroed? YES NO Paper /Pens OK? YES NO
5. Battery Voltage (charging)__________________ Battery Voltage (analyzing)__________________

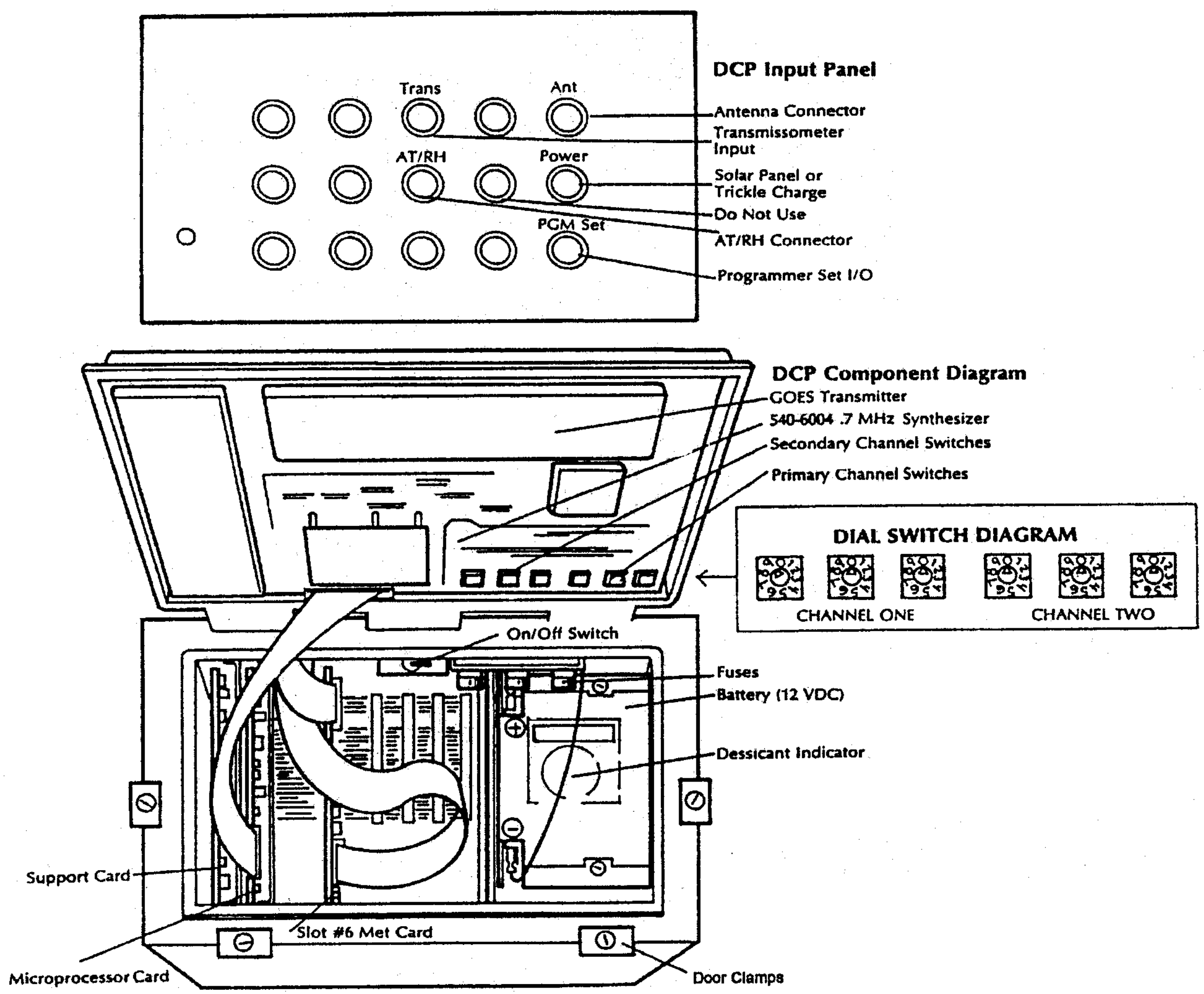
GENERAL COMMENTS/SUPPLIES NEEDED____

Send the original copy of this form to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Phone: 1-800-344-5423
FAX: 1-970-484-3423

recvrlog.sam (8/96)

Figure 4-3. LPV-2 Transmissometer Operator Log Sheet - Receiver Station.



Side View DCP Input Panel

IMPORTANT -- DCP panels may differ from the above unit

Figure 4-4. DCP Datalogger Component Diagram.

Using a small flat-blade screwdriver, reset the switches under "CHAN 1" to **9, 0, 0**. The switch immediately below the "100" on the circuit board should be set to **9**. The switches immediately below the "10" and the "1" on the circuit board should be set to **0**.

Close the DCP door and tighten the clasps.

DISCONNECT

Before disconnecting the connectors on the side of the DCP, note their locations and mark if necessary. Draw a wiring diagram if you think it will be helpful. Refer to Figure 4-5, DCP Cable Connection and Display Diagram.

Disconnect all cables from the DCP input panel and remove the DCP. Pack the unit for shipping in the supplied box.

DOCUMENT

Document the removal of the DCP in the "General Comments" section of the LPV-2 Transmissometer Operator Log Sheet - Receiver Station (see Figure 4-3).

4.1.4 Removing the Strip Chart Recorder

The strip chart recorder should be removed carefully, as both signal wires from the receiver computer and power from the battery (DC operation) are live. Refer to Figure 4-6, Strip Chart Component Diagram, and follow the procedures given below:

DISCONNECT

Turn the receiver computer power **OFF**.

Turn the strip chart recorder power **OFF**.

For AC-powered units, unplug the strip chart recorder at the surge protector.

For DC-powered units:

- Disconnect the "+" lead from the "EXT" battery connection on the back of the strip chart recorder and completely cover the metal portion of the banana jack with electrical tape.

  IMPORTANT: Do not let the "+" connector touch metal on the "-" lead as a large, potentially damaging spark will occur.

- Remove the "-" lead from the "EXT" battery connection on the back of the strip chart recorder and completely cover the metal portion of the banana jack with electrical tape.

REMOVE

Remove the yellow banana jack (+) leads of "CHA" and "CHB" inputs and tape each one as it is taken off.

Remove the green banana jack (-) leads of "CHA" and "CHB" inputs and tape each one as it is taken off.

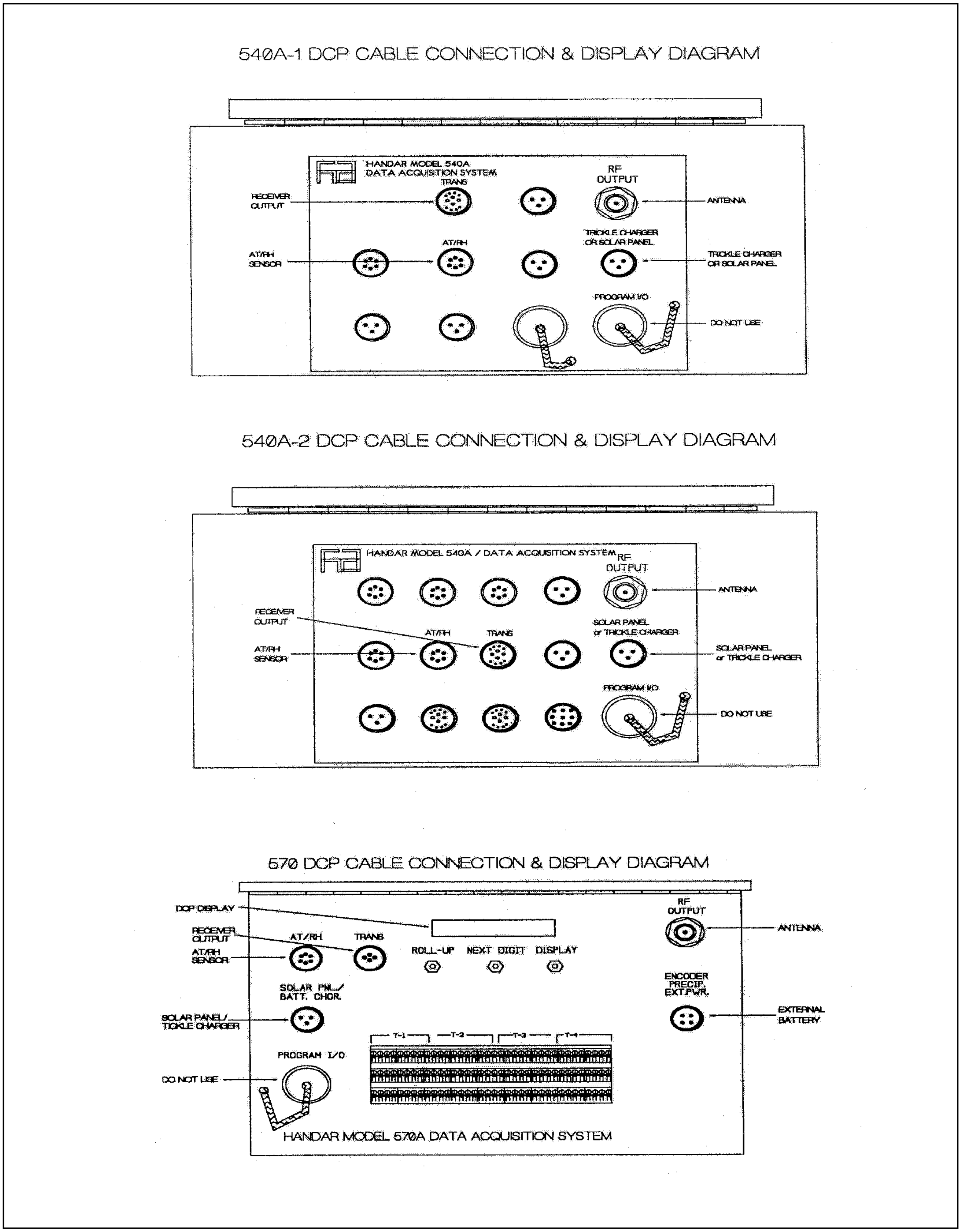


Figure 4-5. DCP Cable Connection and Display Diagram.

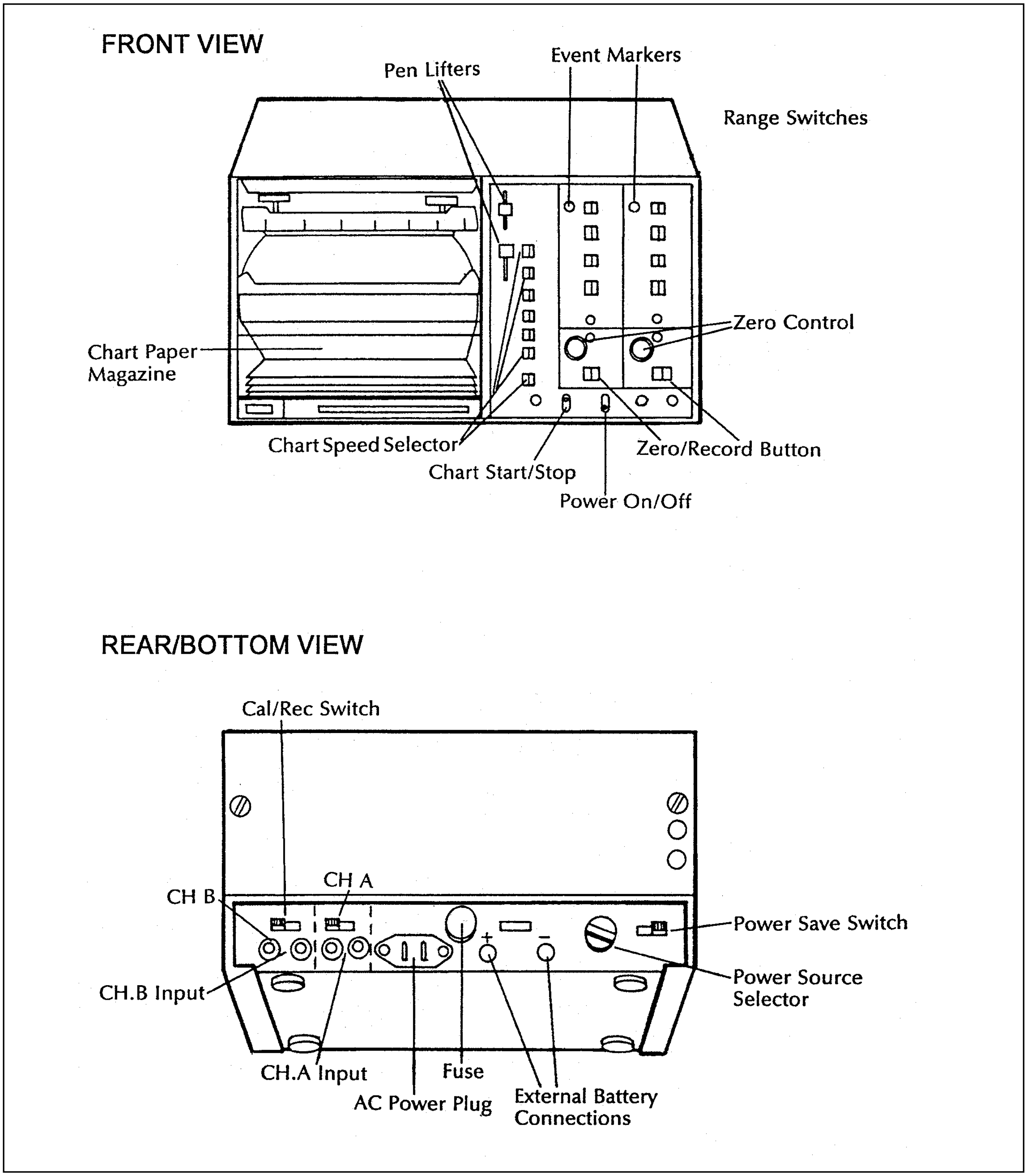


Figure 4-6. Strip Chart Component Diagram.

Place pen lifters for both channels in the "UP" position.

Write the date, time, and any other comments on the strip chart paper.

Remove the chart paper that contains data and mail the data to ARS.

Enclose the recorder in a plastic bag before placing it in the shipping box. Also coil the AC line-powered cord (if supplied) and place it in the shipping box.

DOCUMENT

Record the following information regarding chart removal and place inside the shipping box:

- Location name
- Date/time
- Operator name
- Brief description of chart recorder problems, if known

Document removal of the strip chart on the operator log sheet.

If the transmissometer is to continue operating, turn the receiver computer power "ON" and verify that the system timer is set correctly (refer to TI 3110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)* Section 4.2.1., Checking and Resetting System Timing.

4.1.5 Removing the Air Temperature/Relative Humidity Sensor

Follow the procedures below when removing the air temperature and relative humidity sensor:

DISCONNECT

Disconnect the air temperature/relative humidity cable at the connection below the sensor (see Figure 4-7, Air Temperature/Relative Humidity Sensor Component Diagram and Figure 4-8, AT/RH Sensor/DCP Cable Connection Diagram).

Cover the end of the cable connector with electrical tape. Allow the connector to hang down to prevent moisture from entering the connector.

REMOVE

Loosen the two clamps that hold the sensor in place and slide the sensor out.

Pack the sensor in the cardboard box for shipping.

DOCUMENT

Document the removal of this sensor on the receiver station operator log sheet.

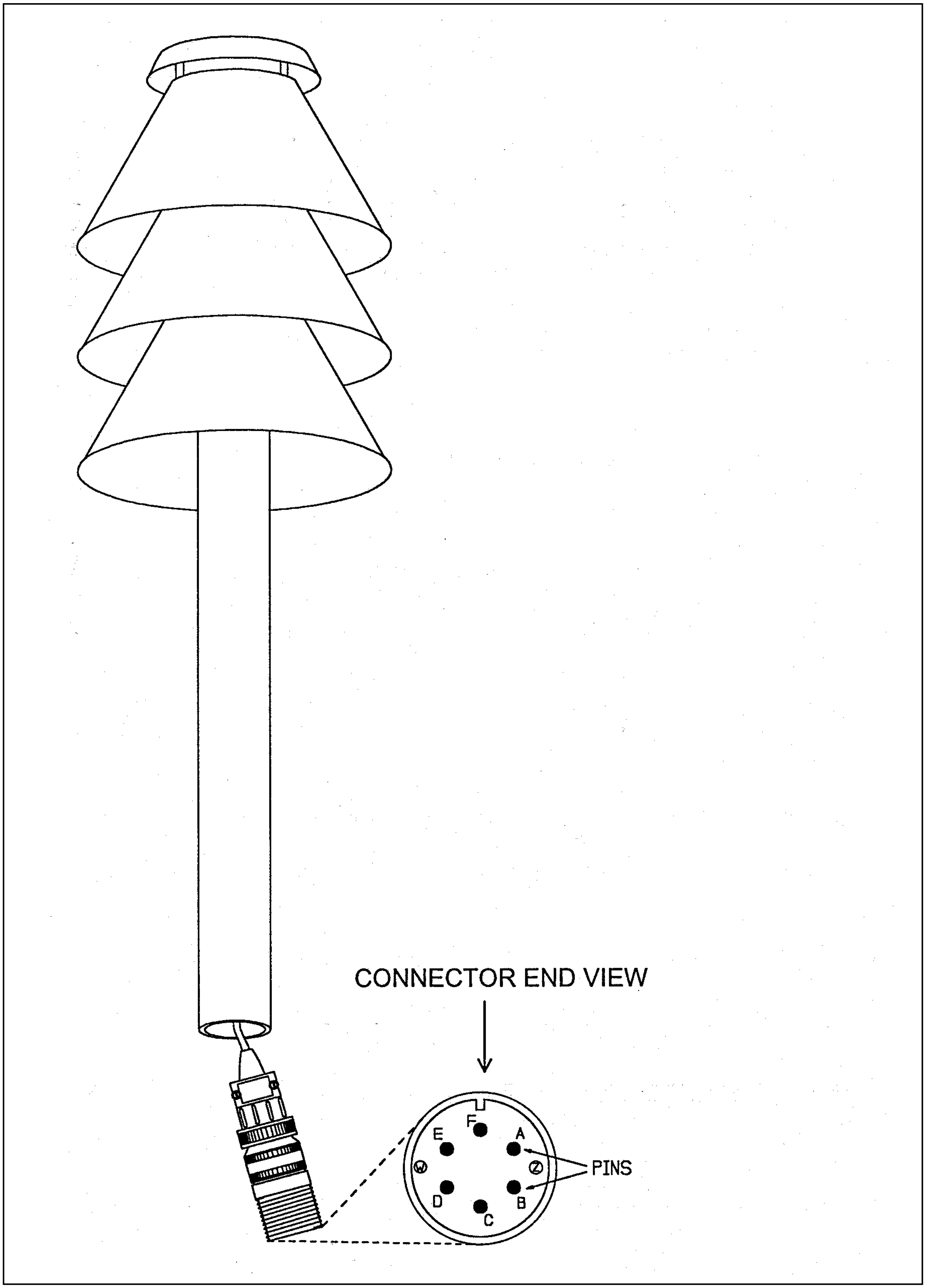


Figure 4-7. Air Temperature/Relative Humidity Sensor Component Diagram.

To Disconnect the AT/RH Cable:

- use pliers (channel-lock) to keep ① connection end from AT/RH cable from moving
- use hand (thumb and index finger) to disconnect connection from DCP cable. Rotate counterclockwise

To Connect the AT/RH Cable:

- line up ② connection from DCP cable with ① connection from AT/RH cable
- hand tighten only, rotating ② connection from DCP cable clockwise until secure

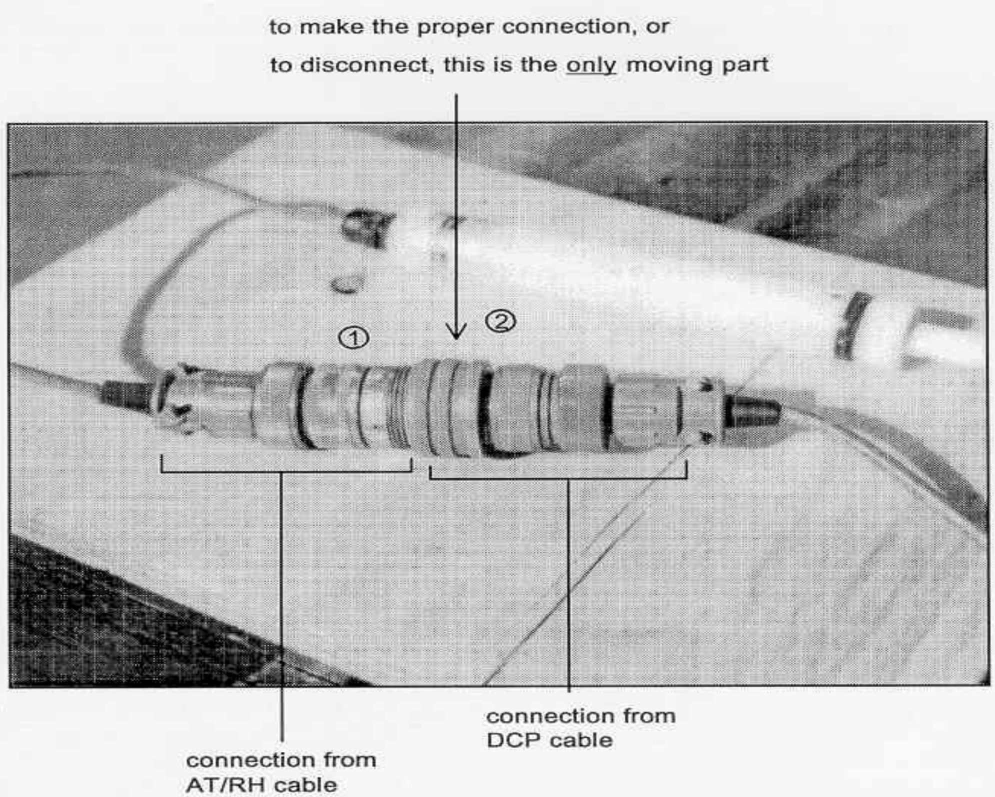


Figure 4-8. AT/RH Sensor/DCP Cable Connection Diagram.

4.2 TRANSMISSOMETER AND SUPPORT EQUIPMENT INSTALLATION

Replacement transmissometer components will be shipped directly to the site operator by ARS. Upon receipt of the shipment, the site operator should follow the component-specific procedures listed below.

4.2.1 Installing the Transmitter

Follow the procedures below when installing the transmitter:

INSTALL

Inspect shipping case(s) for signs of damage upon receiving the instrumentation. Remove the transmitter from the shipping case and remove the cloth and plastic bags from the instrument. Save all of the bags, rubber bands, etc., for return shipping.

Mount the transmitter on the alti-azimuth base and tighten the telescope hold-down screw. **DO NOT REFOCUS THE TRANSMITTER.**

Install the lamp number requested by ARS. Call ARS for additional instructions, if needed.

Clean the objective lens with the blower brush.

Install the control box. Make sure the on/off and test switches are in the "OFF" (down) position.

CONNECT

Connect the control cable to the instrument and the control box making sure to set the connectors properly. A small detent can be felt when the connectors are fully seated. Verify that the control cable connector attached to the instrument (transmitter telescope) includes the "measurement pigtail" as shown in Figure 4-9.

Connect the control box power cable. Check that the power cable is securely connected to the battery (DC power), or the power supply (AC power).

Turn the control box on/off switch **ON** and reset system timing (refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*, Section 4.2.1, Checking and Resetting System Timing).

DOCUMENT

Upon successful installation of the transmitter, complete the tasks listed on the transmitter station log sheet. Document the installation of the system and the lamp number placed into service on the transmitter station operator log sheet.

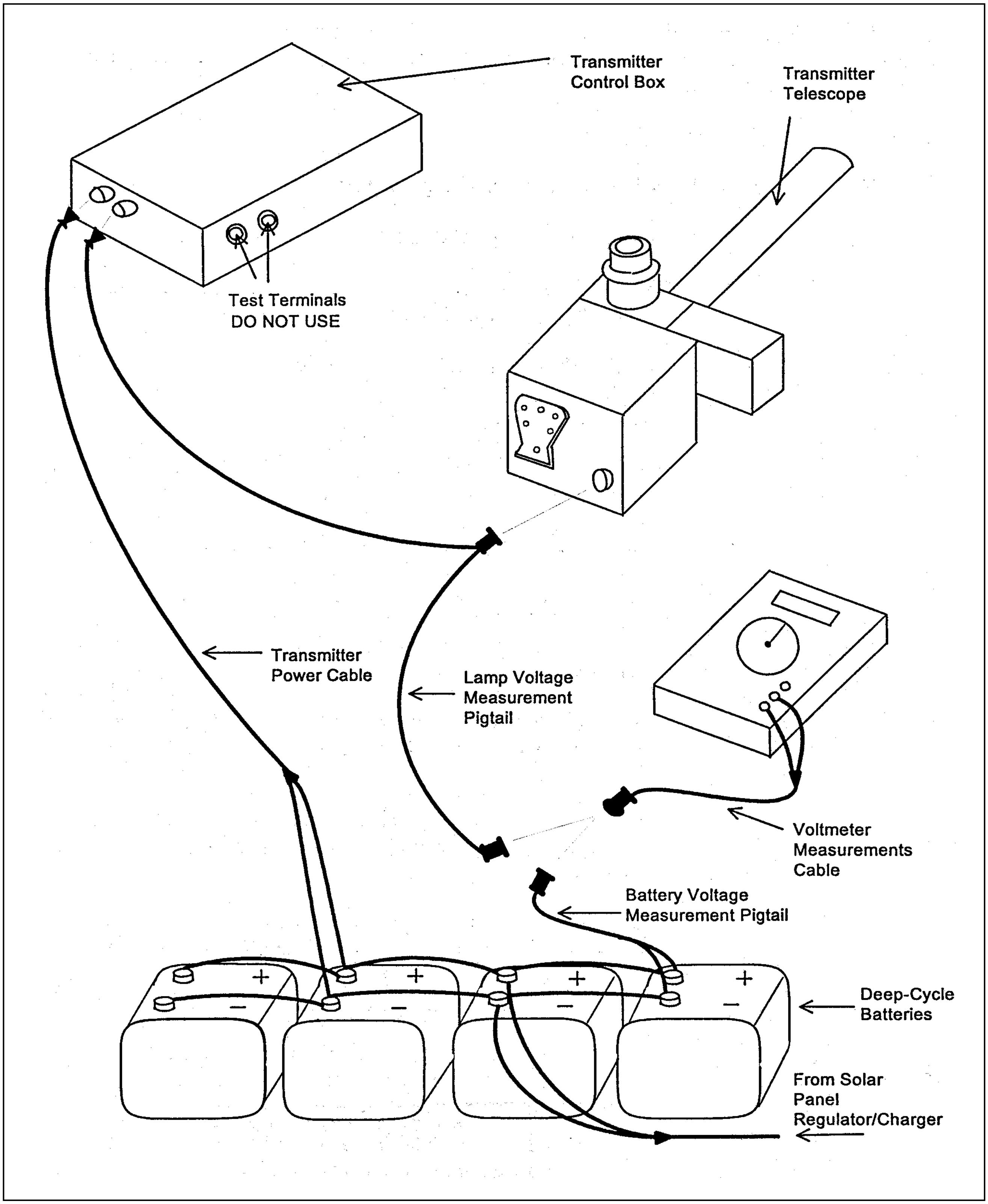


Figure 4-9. Transmitter Components Connection Diagram.

4.2.2 Installing the Receiver

Follow the procedures below when installing the receiver:

INSTALL

Remove the receiver telescope from the wooden shipping case. Remove the cloth and plastic bags from the instrument. Save all of the bags, rubber bands, etc. for return shipping.

Mount the telescope on the alti-azimuth base and tighten the telescope hold-down screw.

Clean the objective lens with the blower brush.

Mount the detector-head (photometer) to the telescope by tightening the two retaining Allen screws after fully seating the assembly. The sides of the eyepiece/detector-head assembly should be perpendicular to the ground.

Remove the receiver computer from the wooden shipping case, remove the cloth bag, and place the computer in its correct position. Ensure the power switch is **OFF**. Remove the four top-cover screws and take the top cover of the receiver computer off.

Touch the receiver computer case and any large, metal object (such as the unpainted portion of the monitoring post) to rid yourself of static electricity.

Push down on the computer cards carefully to make sure they are fully seated.

Push down on the ribbon connector and the small two-conductor connector located on the top cards.

Replace the computer cover and tighten the four screws. Connect the output cable from the terminal strip board, and the power cable from the battery or power supply, to the back panel of the receiver computer.

CONNECT

Plug the cable from the detector-head into the photometer input on the back panel of the receiver computer.

Turn the computer **ON**. The display should go to "000" or "001" and the toggle light should be off.

Align the telescope and leave the flip mirror "ON." To reset the computer, turn the computer **OFF** and back **ON** at 2 minutes and 30 seconds after the top of the hour. To reset system timing, toggle the reset switch at 3 minutes after the top of the hour. An updated reading and toggle change should occur at 13 minutes past the hour. Refer to TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)* Section 4.2.1, Checking and Resetting System Timing.

DOCUMENT

Upon successful installation of the system, complete the tasks listed on the receiver station log sheet. Document the installation of the system on the log sheet.

Store the shipping cases in the receiver station if there is enough room, otherwise store the shipping cases in an easily accessible location (i.e., at your office).

Call ARS and notify the data coordinator after the transmissometer has been installed.

4.2.3 Installing the DCP

Any replacement data collection platform (DCP) sent from ARS will be preprogrammed and in its "RUN" mode. It will start collecting data as soon as the sensor input cables are attached. Data will be transmitted after the antenna cable is attached and internal channel selection switches are set to the proper position. Refer to Figure 4-4, DCP Datalogger Component Diagram, for the location of described parts. Follow the procedures below when installing the DCP:

INSTALL

Notify the data coordinator before going into the field to install the DCP. The channel must be activated with the satellite service center prior to transmitting.

Locate the new DCP in the correct position within the shelter.

CONNECT

Connect the trickle charger or solar panel power cable to the correct position on the DCP panel. If a solar panel is used, the cable should be connected directly to the connector labeled "solar panel trickle charger." If AC power is used, the trickle charger should be plugged into the same connector.

Connect the antenna to the gold coaxial connector located on the upper right of the input panel.

Connect the sensor input cable from the terminal strip board to the connector labeled "TRANS."

Connect the air temperature/relative humidity sensor cable to the position labeled "air temperature/relative humidity."

Loosen the door clamps with a large, flat-blade screwdriver and open the DCP door.

Change the setting of transmission channel 1 from "900" (3 switches) to the channel requested by ARS. Channels used will be "009" for eastern sites and either "014," "038," or "002" for western sites.

Close the DCP door and re-tighten the clasps.

Check the antenna alignment, elements, and cable.

DOCUMENT Store the DCP shipping box, unless it is needed to return a malfunctioning DCP.

Document the DCP installation on the receiver station operator log sheet.

Notify the data coordinator when the installation is complete.

4.2.4 Installing the Strip Chart Recorder

Care must be taken when connecting DC power to the strip chart because the +12 VDC wire comes directly from the battery. To avoid damage to the recorder or the receiver computer, follow the procedures listed below:

IMPORTANT: Do not allow the "+" lead of the DC power cord to touch metal or the "-" lead, as a potentially damaging spark will occur.

INSTALL Place the strip chart in its normal position within the shelter.

CONNECT Make sure the strip chart settings match those listed on the strip chart sticker. See Figure 4-6, Strip Chart Component Diagram, for an illustration of strip chart setting locations.

Set the power source switch, located on the back panel, to the correct position: **AC LINE**, if AC line power is used, and **12 V**, if battery power (DC/solar panel) is used.

Leave the strip chart power switch **OFF**.

Turn the receiver computer power **OFF**.

Connect the green (-) and yellow (+) labeled sensor input banana jacks to the back of the strip chart recorder. The (-) leads attach to the black connectors, and the (+) leads attach to the red connectors under the appropriate channels.

If battery power is used, connect the red (+) lead of the power supply to "EXT" battery (+) before connecting the black (-) lead.

If AC line power is used, plug the power cord into the chart recorder and then into the surge protector.

Double-check the wiring before turning the power on.

Turn the power **ON**. The power indicator LED should light. If it does not, check the settings and wiring.

Service the strip chart as described in TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)* Section 4.2.3, Strip Chart Servicing.

DOCUMENT — Document the installation of the strip chart on the receiver station operator log sheet.

Call ARS to advise the data coordinator of the installation.

4.2.5 <u>Installing the Air Temperature/Relative Humidity Sensor</u>

Follow the procedures below when installing the air temperature and relative humidity sensor:

INSTALL — Slip the sensor into the mounting clamps; do not tighten at this time.

CONNECT — Attach the sensor input cable after inspecting for dust and debris within the connector. Use the blower brush to clean the connector, if needed. Wipe a cleaning cloth around the thread inside the connector if excess dust has collected there.

Tighten the sensor-mounting clamps.

DOCUMENT — Document the installation of the sensor on the receiver station operator log sheet.

Call ARS to advise the data coordinator of the installation.

4.3 PACKING AND SHIPPING

SHIPPING — Shipping cases have been provided for the transmissometer CASEScomputer, receiver telescope, and transmitter. The original manufacturer's box for the strip chart recorder has also been left on-site. Some sites have DCP shipping boxes; these can be sent from ARS if needed. Shipping containers for other equipment or instruments must be found locally (or will be provided by ARS upon request).

SHIPPING — Shipping costs should be charged to the air quality project's COSTSaccount. Other arrangements can be made if:

- UPS shipment is required and cannot be charged to the air quality account.
- There are problems meeting insurance requirements (government use of U.S. Mail).
- An air quality account does not exist.

Call ARS to discuss alternate plans for covering shipping costs.

SHIPPING MISCELLANEOUS

Use packing tape to seal the shipping cases. When shipping items in a cardboard box, use nylon filament packing tape to help strengthen the box. If the shipped items are not expected at ARS, or if an explanation on the return of the items would be valuable, enclose it in an envelope within the shipping case or box.

SHIPPING ADDRESS

Mail all items including correspondence and instruments to (or use ARS shipping labels):

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

Telephone: 970/484-7941 or 970/224-9300

Notify ARS when and with which shipper monitoring components were sent so a delivery date can be expected.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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TYPE	**TECHNICAL INSTRUCTION**
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AUTHORIZATIONS		
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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes annual laboratory servicing and preventative maintenance procedures for Optec LPV-2 transmissometers used in the IMPROVE network. The primary purpose of annual laboratory servicing is assure quality data capture by:

- Performing and documenting a post-field instrument inspection, functional test, and calibration on each transmissometer when it is returned from a field site.
- Performing and documenting the following annual transmissometer maintenance procedures:
  - Transmissometer disassembly and cleaning
  - Optics alignment checks and realignment
  - Chopper motor replacement
  - Instrument timing checks
  - Receiver computer gain measurements and calibration checks
  - Internal batteries replacement
  - Operational lamps replacement
  - Total system functional test
- Performing and documenting instrument upgrades and modifications as required.
- Performing a pre-field instrument calibration.

This TI, as referenced from Standard Operating Procedure (SOP) 4110, *Transmissometer Maintenance (IMPROVE Protocol)*, specifically describes transmissometer maintenance procedures to be performed during annual laboratory servicing of the Optec LPV-2 transmissometer systems.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Establish a servicing schedule to support annual replacement of transmissometers operating at field monitoring sites.
- Review servicing records prior to sending an instrument to a field monitoring site.
- Ensure that all instruments are serviced in accordance with the procedures described in this technical instruction.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform all laboratory servicing and maintenance procedures described in this TI.
- Document all servicing and maintenance work using the forms described in this TI.
- Maintain a file of all servicing records.
- Maintain the instrumentation laboratory spare parts inventory.

2.3 FIELD SPECIALIST

The field specialist shall:

- Perform transmissometer post-field and pre-field calibrations as specified in this technical instruction and in TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*.
- Provide technical support to the instrument technician in identifying and correcting instrument functional problems.

2.4 DATA COORDINATOR

The data coordinator shall provide the instrument technician with a description of any instrument problems suspected or identified during the time the instrument operated in the field.

3.0 REQUIRED INSTRUMENTATION, TOOLS, EQUIPMENT, AND MATERIALS

Specific instrumentation, tools, equipment, and materials required for transmissometer servicing include:

- Electronics laboratory instrumentation
- Optical laboratory equipment and instrumentation
- Specialized transmissometer servicing support equipment
- Cleaning and servicing supplies
- Hand tools
- Servicing forms and instrument manuals

3.1 ELECTRONICS LABORATORY INSTRUMENTATION

Specific instrumentation for the electronics laboratory includes:

- Digital voltmeter (4 1/2 digit display)

- Digital voltmeter (3 1/2 digit display, 3 amp current measurement capability)
- Dual channel oscilloscope (20 mHz bandwidth)
- Regulated power supply (12 VDC @ 10 amps)
- Adjustable regulated power supply (0-15 VDC @ 3 amps)

3.2 OPTICAL LABORATORY EQUIPMENT AND INSTRUMENTATION

Specific equipment and instrumentation for the optical laboratory includes:

- Optical bench and accessories including:
  - Optical bench (1 meter, low profile)
  - Detector head alignment fixture
  - Rod mount carriers (5)
  - Standard bench rods (4)
  - Vertical feed rod (1)
  - Beam diverter
- Controllable light source including:
  - Lamp monitor and control
  - Spectral irradiance head
  - Mask (0.020 inch pin-hole)
- Camera lens (135 mm) and holder
- Receiver computer emulator

3.3 SPECIALIZED TRANSMISSOMETER SERVICING SUPPORT EQUIPMENT

Specific support equipment for transmissometer servicing includes:

- Weighted detector head servicing fixture
- Transmitter bench stand
- Receiver computer output test fixture
- Reference detector head
- Chopper motor exchange stand

- Detector head emulator
- Celestron C11 Telescope Tripod with Optec alti-azimuth base
- Spotting scope
- IBM PC-compatible computer terminal (network access to PROCOMM communications software)
- CIMBUS computer servicing accessories including:
  - Serial communications interface card
  - PC board extender card

3.4 CLEANING AND SERVICING SUPPLIES

Specific supplies for cleaning and servicing a transmissometer system include:

- Electronics degreaser
- General purpose contact cleaner
- Flux remover
- Gold contact cleaner and lubricant (for gold edge connectors)
- Canned air
- Liquid window glass cleaner
- Isopropyl alcohol
- Heavy duty silicone lubricant
- Foam-tip swabs
- Paper towels
- Kimwipes (low linting tissue)
- Microfiber optical cleaning cloth and gloves
- Black silicone (room temperature vulcanizing)
- Electrical tape
- Pen or pencil
- Plastic bags (large and small)

- Cloth storage bags
- Rubber bands
- 6 V lithium batteries (2)
- AGC 5A fuse
- AGC 1A fuse

3.5 HAND TOOLS

Specific hand tools required for servicing a transmissometer system include:

- Small, medium, and large flat-blade screwdriver
- Small and medium Phillips-head screwdriver
- Small and medium adjustable wrench
- Allen wrench set
- Small wire cutter and stripper
- Pliers (standard, needle nose, and long nose)
- Nut driver set (1/4" - 1/2")
- Alignment tool (flat-blade tip)
- Contact extraction tool (for Amp Series 1 circular plastic connectors)
- T9 Torx driver
- Flexible pick-up tool
- Tape measure
- Soldering station

3.6 SERVICING FORMS AND INSTRUMENT MANUALS

The following servicing forms and checklists are required when performing annual servicing of the Optec LPV-2 transmissometer:

- Optec LPV-2 Transmissometer Post-Field Inspection Checklist
- Optec LPV-2 Transmissometer Post-Field Alignment Check Form
- Optec LPV-2 Transmissometer Servicing Checklist

- Optec LPV-2 Transmissometer Transmitter Lamp Voltage Measurements Record
- Optec LPV-2 Transmissometer Pre-Field Alignment Form
- Transmitter alignment target

The following instrument manuals and TIs are required for annual servicing of the Optec LPV-2 transmissometer:

- *Model LPV Long Path Visibility Transmissometer, Technical Manual for Theory of Operation and Operating Procedures*
- *CIMBUS Hardware Reference Manuals*
- TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*
- TI 4110-3400, *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

4.0 METHODS

This section includes three (3) major subsections:

4.1 Post-Field Inspection, Test, and Calibration
4.2 Annual Servicing
4.3 Pre-Field Calibration

Figure 4-1 is a flowchart showing the major procedures performed in each of these categories.

4.1 POST-FIELD INSPECTION, TEST, AND CALIBRATION

Each transmissometer returned from a field site for annual laboratory maintenance is inspected and tested prior to initiating any servicing procedures that could invalidate the instrument calibration. Post-field inspection and test is performed immediately after the instrument is received at ARS and includes:

- Initial inspection and functional tests.
- Detector uniformity check and post-field calibration.
- Post-field alignment check.

The procedures for performing these tasks are described in the following subsections.

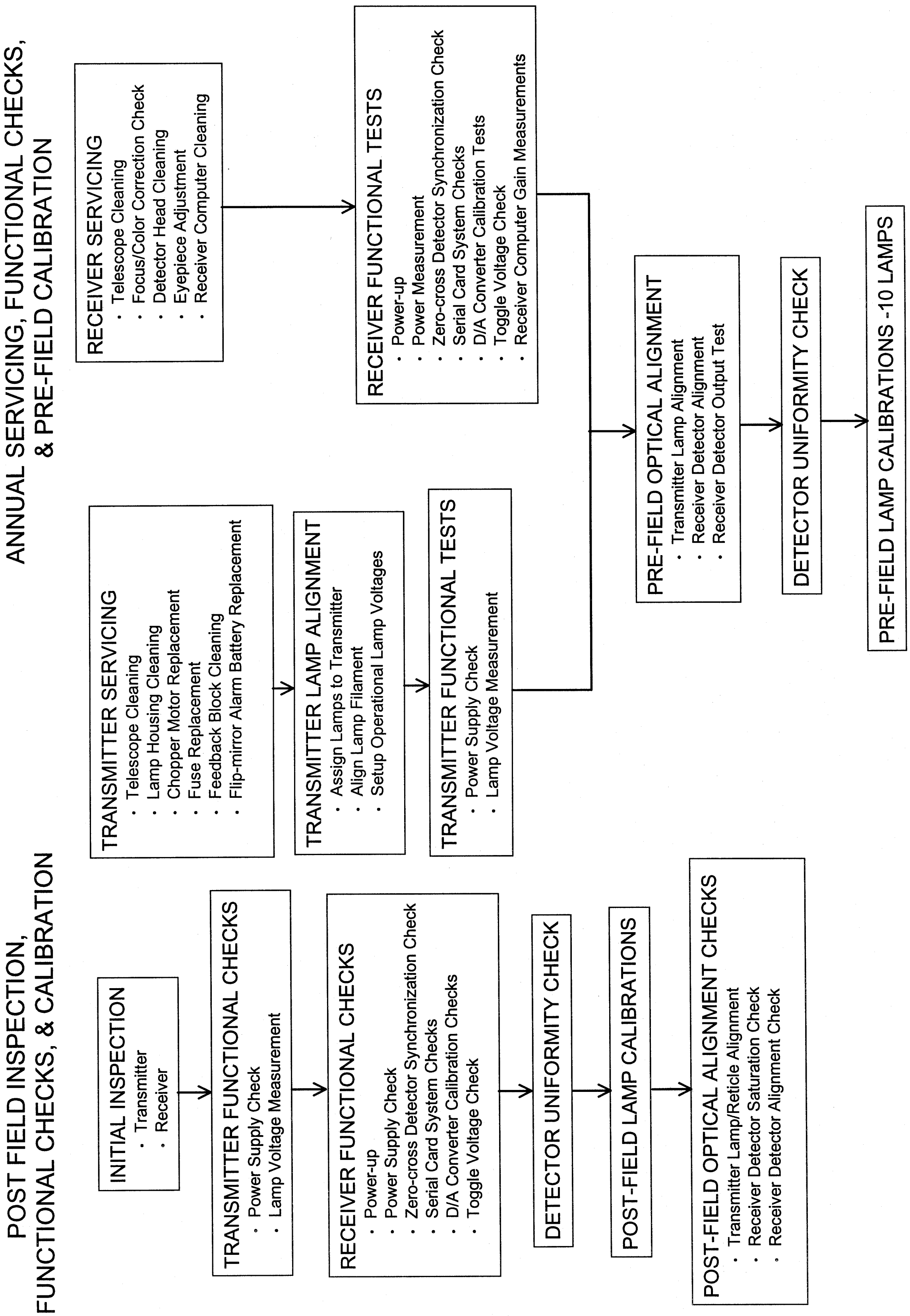

Figure 4-1. Flowchart of Transmissometer Annual Maintenance Procedures.

4.1.1 Initial Inspection and Functional Tests

The Optec LPV-2 Transmissometer Post-Field Inspection Checklist (Figure 4-2), is used by the instrument technician to document all initial inspection and functional test results. Initial inspection and test procedures are to be performed whenever and instrument is returned from the field. Procedures for performing and documenting the specified inspections and tests are described below.

4.1.1.1 Initial Inspection

GENERAL INFORMATION

Fill in the instrument number (LPV#), site abbreviation where the instrument last operated, date work was performed, and your name.

Note the reason the instrument was returned from the field. Describe any operational or functional problems noted by the site operator.

Examine the shipping cases for damage that might affect the instrument. Note the condition of the hinges and locks.

Note if the instrument components were packed in the protective plastic bags and cloth shipping bags.

Document the serial number and condition of each lamp returned with the instrument.

NOTE!! Do not clean the instrument or perform any service procedures during initial inspection.

TRANSMITTER INSPECTION

Check the transmitter telescope to see if the instrument was returned with a lamp installed. Note the lamp serial number.

Check the telescope Allen screws and the lamp base Torx screws for tightness.

Turn the flip mirror to the "ON" position and verify that the alarm is functioning.

Describe the "as returned" condition of all instrument components. Note cleanliness, cable and connector condition, and check for signs of battery leakage around the battery holders in the control box.

Measure the voltage of the AA backup batteries (should be approximately 6.0 volts).

OPTEC LPV-2 TRANSMISSOMETER
POST-FIELD INSPECTION CHECKLIST

Instrument Number: _______________
Site: ___________________________
Date: ___________________________
Technician: ______________________

Received for: ☐ Annual Servicing ☐ Unscheduled Maintenance
Reason for Unscheduled Maintenance: ____
____
____

Shipping Case Condition: ____
Protective Bags Used: ____

Lamps Received:	Lamp #	Condition	Lamp #	Condition	Lamp #	Condition
	______	__________	______	__________	______	__________
	______	__________	______	__________	______	__________
	______	__________	______	__________	______	__________
	______	__________	______	__________	______	__________
	______	__________	______	__________	______	__________

NOTE: *Do not service instrument during inspection.*

TRANSMITTER INSPECTION

Returned with Lamp Installed? ☐ Yes ☐ No Lamp #: _____________
Are Allen Screws in Transmitter Body Tight? ☐ Yes ☐ No
Flip Mirror Alarm Functioning: ☐ Yes ☐ No

Describe "As Returned" Condition of:
- Telescope Body ____
- Optics ____
- Cables/Connectors ____
- Control Box Circuit Board/Connectors __________________________
- Control Box Backup Batteries _________________________________

RECEIVER INSPECTION

Flip Mirror Alarm Functioning: ☐ Yes ☐ No
Receiver Computer Backup Batteries: ☐ Yes ☐ No
Receiver Telescope Aperture: ____________ mm

Describe "As Returned" Condition of:
- Telescope Body ____
- Optics ____
- Telescope Baffle ____
- Cable/Connectors ____
- Battery Holders ____
- CIMBUS Computer Connectors __________________________________
- CIMBUS Computer Cards ______________________________________

Receiver Computer Switch Settings:
- Gain __________________ Path __________________ Cal ___________________
- A1 ___________________ A2 ___________________
- Int ___________________ Cycle __________________

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Figure 4-2. Optec LPV-2 Transmissometer Post-Field Inspection Checklist.

TRANSMITTER FUNCTIONAL CHECK

Install Reference Lamp Prior to Performing These Checks:
Lamp Serial Number: ________________________________
Transmitter Current: _________________ Amps Lamp Voltage: ______________ Volts

Test Point Voltages: T1 _______ T2 _______ T3 _______ T4 _______ T5 _______

RECEIVER FUNCTIONAL CHECK

Receiver Computer Display
At Power Up (000 Expected): ____
One Minute Avg - Flip Mirror Up (000 Expected): ____

Receiver Power Tests

Input Voltage	+5V	+15V	-15V	TP1 High/Low	TP2 High/Low	A1 Output	Auto Reset	Receiver Current (Amps)
12V								
8V								
7V								
12V								

Comments: ____
____

Bandpass Board Synchronization Check: ☐ Pass ☐ Fail

Serial Card Tests

Function	Expected Result	Pass/Fail	Comment
Toggle	Toggle Lamp Blinking		
OR	OR Lamp Blinking		
Cal Switch	Actual Setting		
Path Switch	Actual Setting		
A1 Switch	C=0, B=1, VR=2		
A2 Switch	SD=0, CR=1		

D/A Converter Calibration Check

Function	Display	A1 (DVM)	A2 (DVM)
Zero			
Max			
Mid			

Toggle Voltage Test

Toggle	Voltage (No Load)	Voltage (With Load)
ON	______________________________	______________________________
OFF	______________________________	______________________________

Receiver Computer Gain Check

Emulator Switch Setting	RMS Input (mV)	A1 Output at Gain Switch Setting (mV)				
		100	300	500	700	900
2						
1						

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Figure 4-2. (Continued). Optec LPV-2 Transmissometer Post-Field Inspection Checklist.

RECEIVER INSPECTION

Turn the flip mirror to the "ON" position and verify that the alarm is functioning.

Measure the voltage of the AA backup batteries (should be approximate 6.0 volts).

Record the receiver telescope aperture size (engraved on the front of the telescope). If an aperture ring is installed on the instrument, note this and record the size of the aperture ring.

Describe the "as returned" condition of all instrument components. Note cleanliness, cable and connector condition, and check for signs of battery leakage around the battery holders on the receiver computer front panel.

Check the CIMBUS computer cards and cable connectors in the receiver computer. Verify that all cards are fully inserted into the card edge connectors and that all cable connections to the cards are secure.

RECEIVER COMPUTER SWITCH SETTINGS

Document the "as returned" setting for each of the receiver computer switches specified on the inspection checklist.

4.1.1.2 Transmitter Functional Check

TRANSMITTER POWER AND VOLTAGE MEASUREMENTS

All functional check measurements related to the transmitter are conducted with the instruments reference lamp installed. Record the lamp serial number.

Measure and record the transmitter operating current with the lamp on.

Measure and record the lamp voltage using the measurement pigtail on the control box cable.

Measure and record the T1, T2, T3, T4, and T5 test point voltages on the transmitter control box circuit board (see Figure 4-3, Transmitter Control Box Circuit Board Components Diagram).

4.1.1.3 Receiver Functional Check

RECEIVER COMPUTER SETUP

Connect the receiver detector head to the receiver computer and connect the receiver computer to a 0-12 VDC variable output power supply. Set the power supply output to 12 VDC. Set the "A1" switch to position **C** (raw readings), the "CYCLE" switch to **CONT** (continuous), and the "INTEG" switch to **1** (one minute).

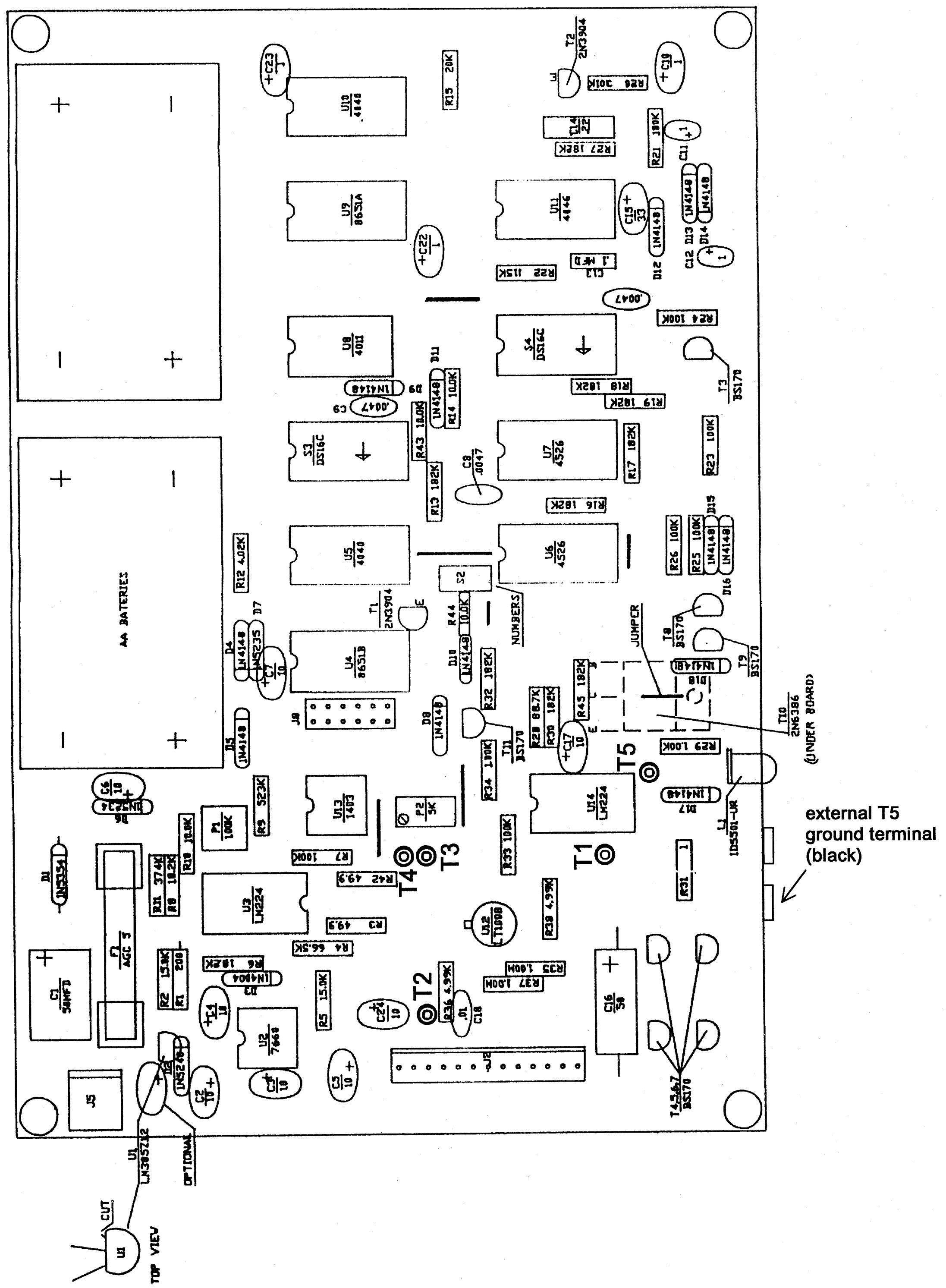


Figure 4-3. Transmitter Control Box Circuit Board Components Diagram.

Position the detector head so that it is "looking" at the transmitter lamp through a pin-hole mask. Adjust the detector head position so that the receiver computer will measure a one-minute raw readings average of 0.2 volts (200 on receiver computer display) or more.

Connect channel 1 and channel 2 of the oscilloscope to "TP1" and "TP2" of the auto reset circuit located on the receiver computer front panel board (see Figure 4-4, Receiver Computer Front Panel Circuit Board Components Diagram).

POWER-UP TEST

Turn the receiver computer **ON** and record the display reading immediately following the instruments power-up cycle.

ZERO INPUT TEST

Set the receiver telescope flip mirror to the "OFF" position (light blocked). Turn the receiver computer **OFF**, wait five (5) seconds and turn the receiver computer back **ON**. After one minute, the receiver computer will update the data on the front panel display. Since the flip mirror blocks all light from reaching the detector, the display should read "000." Record the display reading.

POWER SUPPLY AND AUTO RESET TEST

Place the receiver flip mirror in the "ON" position. With the power supply output set at 12 VDC, measure and record the receiver computer internal power supply outputs (+5 VDC, +15 VDC, -15 VDC). These voltages should be measured at the test points on the power supply board (see Figure 4-5, Power Supply Circuit Board Components Diagram). After the display updates, measure and record the "A1" output and the receiver operating current.

Reduce the external power supply voltage to 8.0 volts. After the next full one-minute update, record the "A1" output, the receiver power supply output voltages, and the "TP1" and "TP2" logic levels (high or low). This test confirms that the instrument will operate properly with a supply voltage as low as 8.0 volts.

Reduce the external power supply voltage to 7.0 volts. "TP1" and "TP2" should both go to a logic low. The receiver front panel display should be blank and the "A1" output should be zero. These conditions indicate that the receiver computer has ceased operation. Record the power supply output voltages, the "A1" output, and the "TP1" and "TP2" logic levels.

Increase the external power supply voltage to 12.0 volts. If the auto reset circuit is functioning properly, "TP1" and "TP2" will return to a logic high level immediately after the power supply voltage is increased. The "A1" output will be zero until the first update. After the update, the "A1" output will return to the value measured at the start of this test. At this time record the power supply output voltages, the "A1" output, and the "TP1" and "TP2" logic levels.

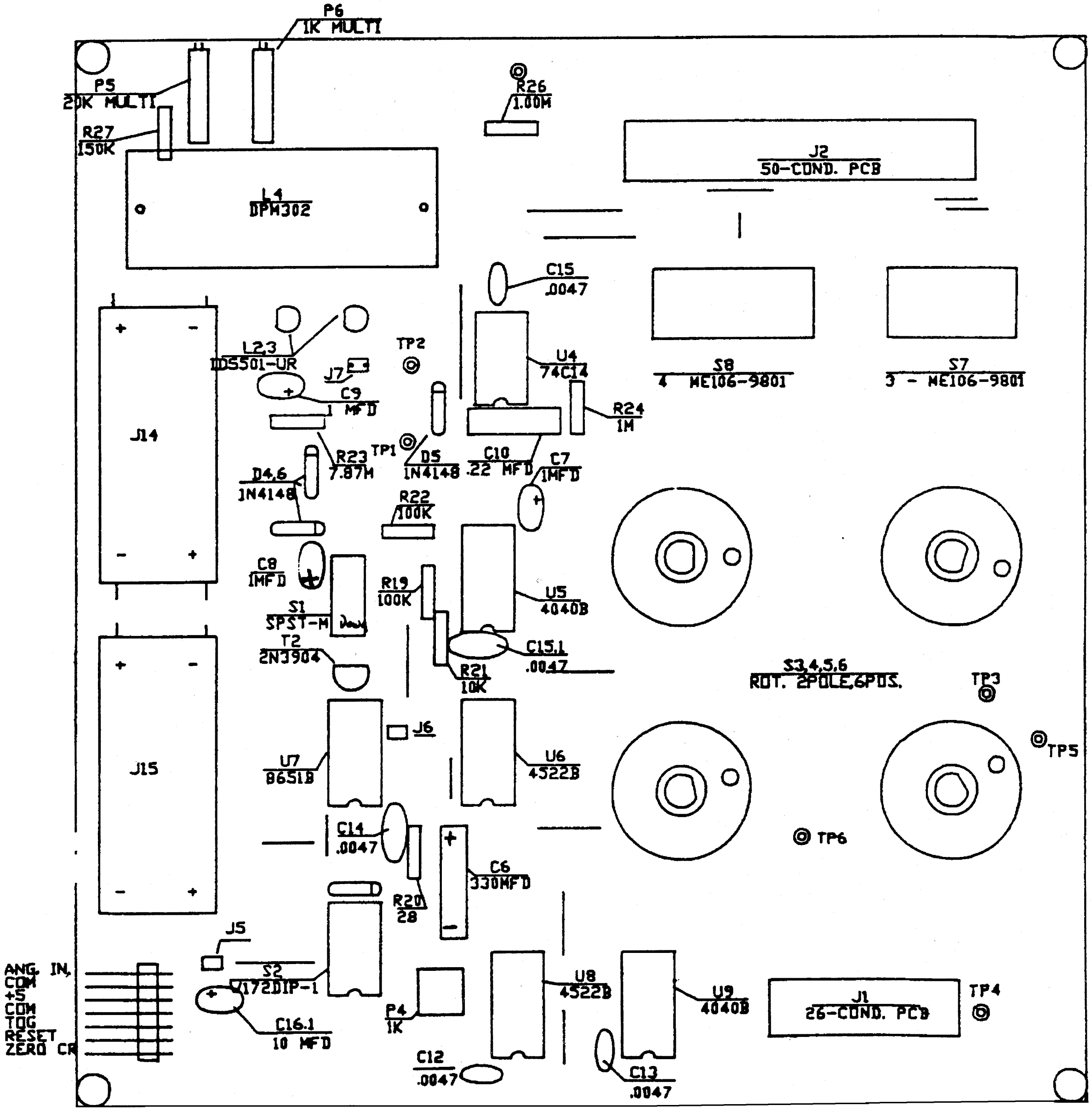


Figure 4-4. Receiver Computer Front Panel Circuit Board Components Diagram.

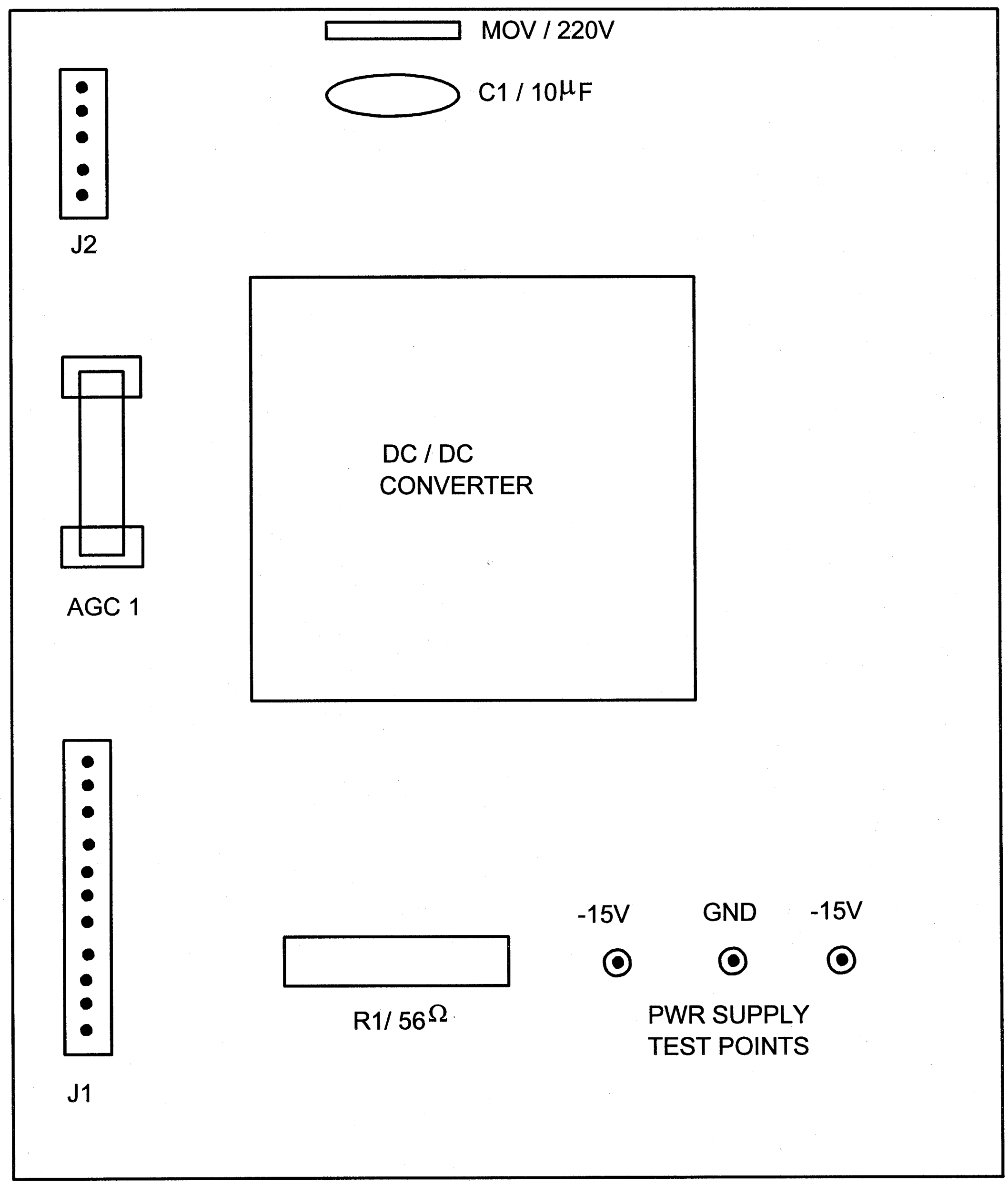


Figure 4-5. Power Supply Circuit Board Components Diagram.

ZERO-CROSS DETECTOR SYNCHRO-NIZATION CHECK	The purpose of this check is to determine if the receiver bandpass amplifier output is synchronized with the incoming transmitter signal. Connect channels 1 and 2 of the oscilloscope to test points "TP4" and "TP5" of the receiver computer bandpass board (see Figure 4-6, Bandpass Board Component Diagram). Synchronize the oscilloscope on channel 1. If the synchronization circuit is functioning properly, both the leading and trailing edges of the two waveforms will be in phase. If they are not in phase, mark the "FAIL" block and comment on the observed irregularity.

4.1.1.4 Serial Card Tests

SERIAL CARD TEST SETUP	Turn the receiver computer **OFF** and insert the CIMBUS serial card into slot #7 of the CIMBUS computer. Connect the serial card output to the serial port on the PC computer. PROCOMM software is used to communicate with the CIMBUS computer. Turn the receiver computer **ON** and enter **TEST** to initiate the receiver computer self-test program. The "TEST" program will execute a fixed sequence of test routines that will check all major receiver computer functions. When one test is completed, hit any key to move to the next test in the sequence. The Receiver Computer Front Panel, Figure 4-7, shows the receiver computer front panel digital display, switches, and status lamps. Record the result (Pass/Fail) for each test listed below on the inspection checklist. If instrument fails any portion of a test, briefly describe the observed failure(s) under "Comments."
TOGGLE TEST	The "TOGGLE" lamp, located on the receiver computer front panel will blink continuously.
OVER RANGE (OR) TEST	The over range (OR), located on the receiver computer front panel will blink continuously.
CAL SWITCH TEST	The "CAL" switch is a three (3) digit thumbwheel switch located on the receiver computer front panel. The number set into this switch will be displayed on the computer screen. The number displayed on the screen will update each time any digit on the switch is changed. Verify that all 10 positions (0-9) for each digit are translated properly by the receiver computer.
PATH SWITCH TEST	The "PATH" switch is a four (4) digit thumbwheel switch located on the receiver computer front panel. Follow the switch test procedures described above for the "CAL" switch.
A1 SWITCH TEST	The "A1" switch is a 3-position rotary switch located on the front panel of the receiver computer. Set the "A1" switch to each of the three positions (C,B,VR). The "TEST" program will continuously read the switch setting and display the setting as a number (0=C, 1=B, 2=VR) on the computer screen. Verify that the number displayed matches the switch setting for each switch position.

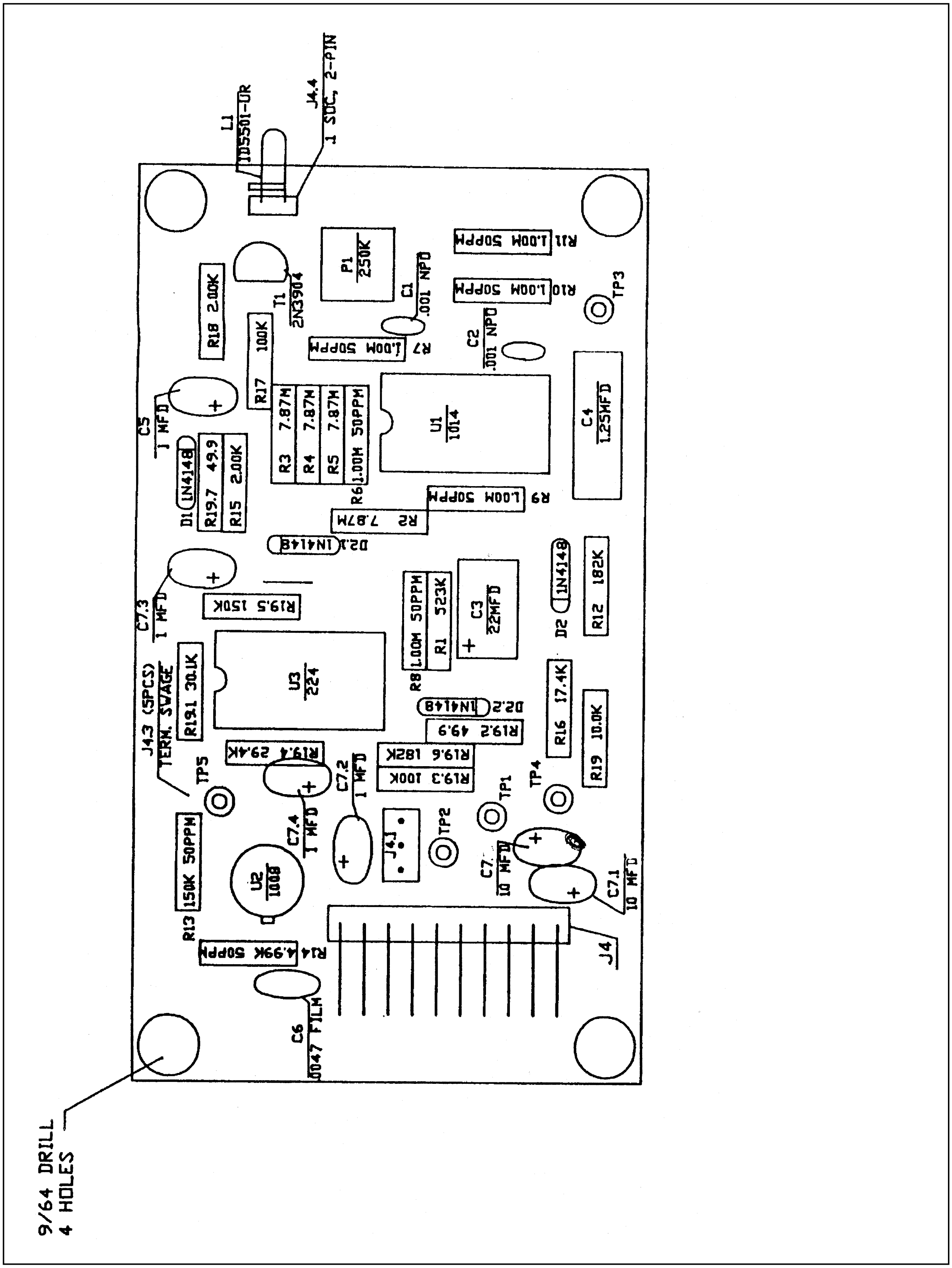


Figure 4-6. Bandpass Board Component Diagram.

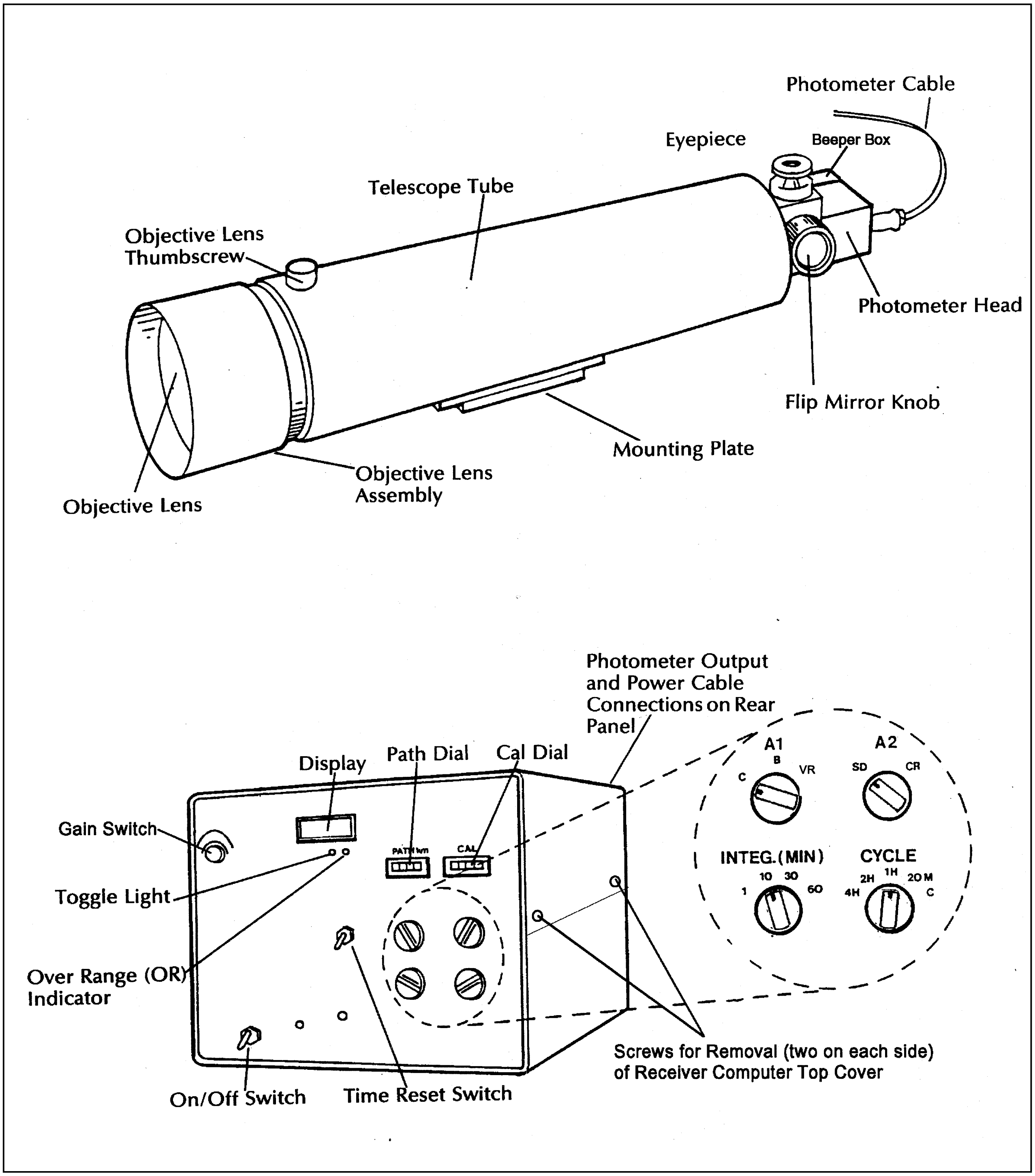


Figure 4-7. Receiver Computer Front Panel.

A2 SWITCH TEST

The "A2" switch is a two (2) position rotary switch located on the front panel of the receiver computer. Follow the procedures described above for testing the "A1" switch. The "A2" switch positions and the corresponding numbers displayed on the computer screen are "SD" (0) and "CR" (1).

ANALOG OUTPUT TEST

The receiver computer output test fixture includes a mating connector for the receiver computer output connector. This test fixture provides a switchable connection between the voltmeter and each of the receiver computer's two analog output signals (refer to Figure 4-8, Receiver Computer Output Test Fixture).

Turn the receiver computer **OFF** and remove the D/A converter board from the CIMBUS card cage. Insert the CIMBUS extender card in the D/A converter slot and plug the D/A converter into the extender card. Use the extension cables to make the connection from the wiring harness to the D/A connectors. Turn the receiver computer **ON**.

The "TEST" program provides three prompts indicating the test input applied to the D/A converters that generate the "A1" and "A2" output voltages. The test program also specifies the potentiometers to be adjusted for recalibration. It is important to not make any adjustments to the potentiometers during post-operational testing.

- ZERO - 0.00 volts
- MAX (Full scale) - 9.9975 volts
- MID (Half scale) - 4.9988 volts

The corresponding readings on the receiver computer display (for all "A1" switch positions) are as follows:

- ZERO - 000
- MAX (Full scale) - 1000
- MID (Half scale) - 500

Record the front panel display reading and the "A1" and "A2" output voltages for the specified switch settings.

4.1.1.5 Toggle Voltage Test

The receiver computer toggle output voltage is measured with and without an output load. The receiver computer output test fixture is used for this test. The "TOG-NL" (Toggle, no-load) position connects the toggle output directly to the voltmeter. The "TOG-L" (Toggle, with load) position connects a 4700 ohm resistor in parallel with the voltmeter input.

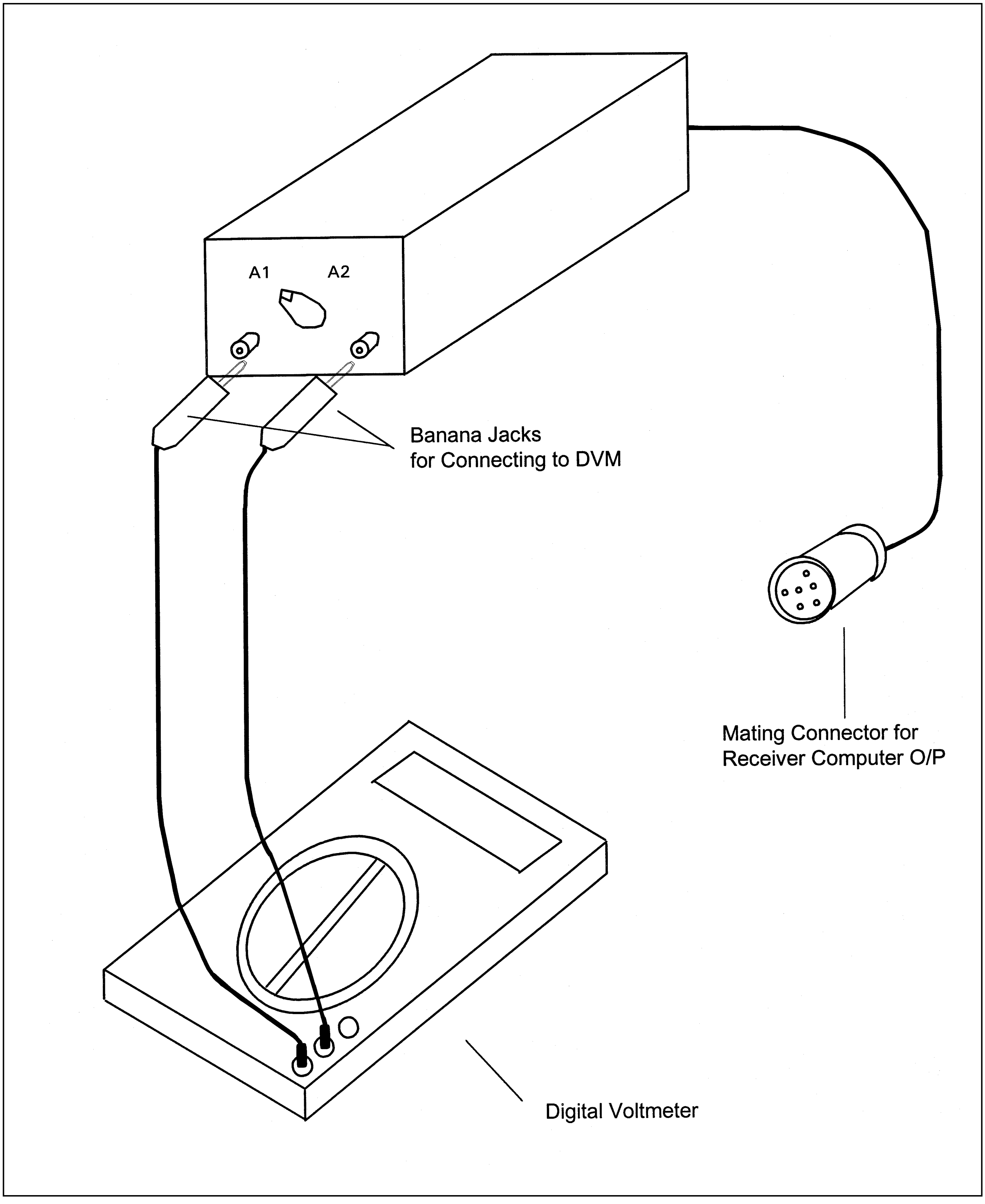


Figure 4-8. Receiver Computer Output Test Fixture.

Set the receiver computer for continuous operation ("CYCLE" switch on **C**) and one minute integrations ("INTEG" switch on **1**). Measure the toggle output voltage in both the "TOG-NL" and "TOG-L" positions with the toggle lamp "ON." Wait one minute for the toggle lamp to switch "OFF" and repeat the measurements. Record the measured voltages for each set of conditions.

4.1.1.6 Receiver Computer Gain Test

Disconnect the detector head output cable from the receiver computer and connect the detector head emulator in its place. The detector head emulator is powered by the receiver computer and generates a low level square wave signal that emulates the detector head output response under operational conditions. Connect the receiver computer output test fixture to the receiver computer output connector. Set the emulator switch to position "2" and measure the emulator output voltage using an rms voltmeter. With the receiver computer set for continuous operation and one-minute integrations, measure the receiver computer output for gain switch settings of "100," "300," and "500." Record the emulator output voltage and the three receiver computer output voltages. Reset the emulator switch to position "1" and repeat the above procedure for gain switch settings of "700" and "900."

4.1.2 <u>Detector Uniformity Check and Post-Field Calibration</u>

A post-field calibration is performed with the primary reference lamp, the on-site reference lamp, and all unbroken operational lamps returned with the instrument. Detailed instructions for performing and documenting post-field calibrations are provided in TI 4200-2100, *Calibration of LPV-2 Transmissometers (IMPROVE Protocol)*.

4.1.3 <u>Post-Field Alignment Check</u>

The purpose of the post-field alignment check is to identify any change in either the transmitter lamp alignment and/or the receiver detector alignment during the time the instrument was operating in the field. Post-field alignment checks are performed after the post-field calibration and prior to servicing the instrument and include:

- Transmitter alignment check
- Receiver detector saturation check
- Receiver detector alignment check
- Receiver output detector check

All alignment checks and measurements should be documented on the Optec LPV-2 Transmissometer Post-Field Alignment Check Form, Figure 4-9.

4.1.3.1 Transmitter Alignment Check

This procedure requires an unobstructed sight path of at least 50 feet and the following equipment:

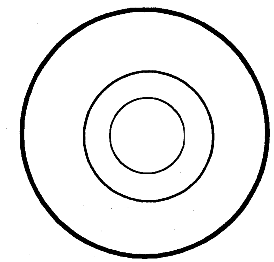
- Tripod with Optec alti-azimuth base
- Spotting scope mounted on a tripod

OPTEC LPV-2 TRANSMISSOMETER
POST-FIELD ALIGNMENT CHECK

Instrument Number:______________
Date:______________
Technician:______________

1. TRANSMITTER ALIGNMENT CHECK

Focus the transmissometer on the target (shown to the right of this paragraph) and tighten the objective lens securely. Adjust the transmitter so the beam is inside the large outer circle of the target. The target has two inner circles. The larger inner circle represents the outer limit for the reticle. The smaller inner circle represents the ideal reticle alignment and is indicated below. Draw the actual reticle position on the target.



TARGET

2. RECEIVER DETECTOR SATURATION CHECK

Test Detector - Camera Lens Aperture F/2.8 — Saturation Level:______________

Reference Detector - Camera Lens Aperture F/4 — Output Level:______________

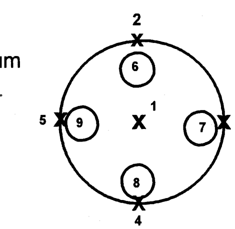
3. RECEIVER DETECTOR ALIGNMENT CHECK

FULL RETICLE LIGHT BEAM

Alignment Position	1	2	3	4	5	Maximum
Detector Output (V)	____	____	____	____	____	____

1/4 RETICLE LIGHT BEAM

Alignment Position	1	6	7	8	9
Detector Output (V)	____	____	____	____	____



ALIGNMENT POSITIONS

4. RECEIVER DETECTOR OUTPUT CHECK

Adjust Light Source Intensity for a Reference Detector Output of Approximately 7.0 Volts

Reference Detector Output at Alignment Position 1:______________

Test Detector Output at Full Reticle Maximum Position:______________

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Figure 4-9. Optec LPV-2 Transmissometer Post-Field Alignment Check Form.

- Transmitter alignment target (see Figure 4-10, Transmitter Alignment Target)

- DC Power Supply - 12 volts @ 5 amps

TRANSMITTER SETUP — Attach the transmitter alignment target to a wall at one end of the sight path. The center of the target should be at a height of approximately 42 inches. Attach the transmitter telescope to the tripod and set up the tripod 47 feet from the alignment target. Set up the spotting scope next to the transmitter telescope. Focus the transmitter telescope on the alignment target by adjusting the position of the objective lens. The objective lens is held in position by a set screw in the top of the telescope.

ADJUST ALIGNMENT — Connect the DC power supply to the transmitter control box and connect the control box to the transmitter telescope. Insert the reference lamp for the instrument being tested into the transmitter and turn the transmitter "ON." Use the spotting scope to observe the position of the transmitter light beam while adjusting the alti-azimuth base to center the light beam in the large outer circle of the alignment target. The transmitter reticle should align with the smaller of the two inner circles (refer to the target diagram on the Optec LPV-2 Transmissometer Post-Field Alignment Check Form, Figure 4-9). Alignment is acceptable if the reticle position is entirely within the larger of the two inner circles. Sketch the outline of the actual reticle position on the target diagram.

4.1.3.2 Receiver Detector Saturation Check

To determine the saturation level of the test instrument receiver detector, a variable intensity light source is focused on the detector. The detector output voltage is monitored as the light intensity is slowly increased. When the detector output voltage no longer increases with increasing light intensity, the saturation level has been reached.

This procedure requires the following test equipment:

- Optical bench

- Variable intensity light source

- Beam diverter

- 135 mm camera lens

- Detector head alignment fixture

- Receiver computer emulator

- Digital voltmeter (4 1/2 digit)

- Reference detector head

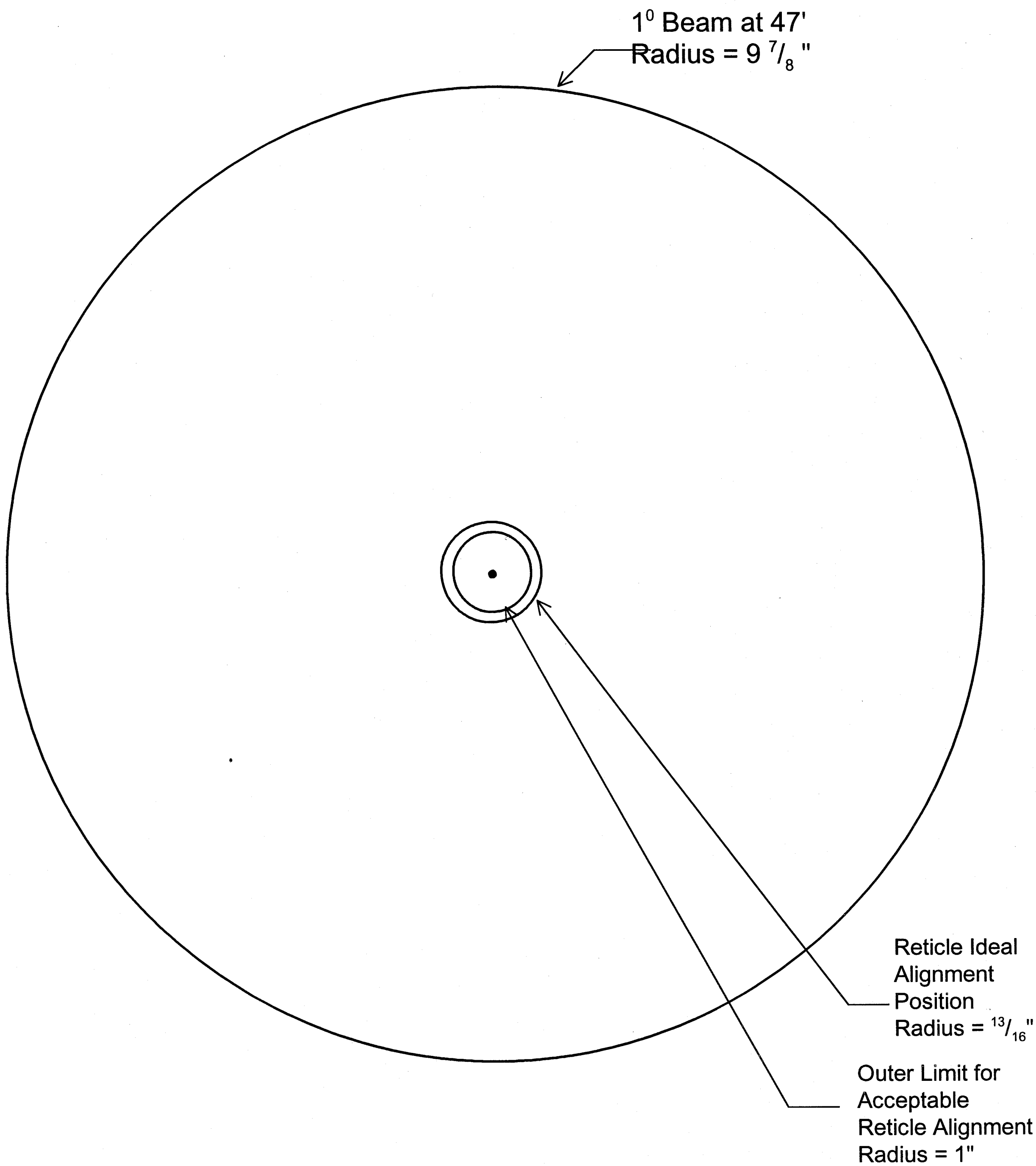

Figure 4-10. Transmitter Alignment Target.

INSTALL OPTICAL BENCH ACCESSORIES

Install the following optical bench accessories at the position shown:

- Variable intensity light source - 0.0 cm
- Beam diverter - 15.0 cm
- 135 mm camera lens - 37.5 cm
- Detector head alignment fixture - 55.5 cm

DETECTOR HEAD AND TEST EQUIPMENT SETUP

Set up the detector head and test equipment as follows:

- Install the detector head being tested on the detector head alignment fixture.
- Connect the detector head cable to the receiver computer emulator.
- Connect the digital voltmeter to the output of the receiver computer emulator.
- Remove the pin-hole mask from the light source filter holder.
- Set camera lens aperture at f/2.8
- Align the light beam at the center of the detector head.

MEASURE SATURATION LEVEL

Measure the saturation level of the transmissometer detector as follows:

- Slowly increase the light intensity to the point where the detector output voltage no longer increases. This voltage is typically in the range 13.0 to 14.5 volts DC. A saturation level lower than 11.5 volts indicates degradation of the detector response.
- Record this voltage (test detector saturation level) on the alignment check form.
- **NOTE: Do not change the intensity of the light source while performing the final steps of this procedure!**
- Remove the test instrument detector head from the alignment fixture and replace it with the reference detector head.
- Connect the reference detector head to the receiver computer emulator.
- Set the camera lens aperture at f/4.

- At this point, the digital voltmeter will be indicating the voltage output of the reference detector head. The reduced aperture will ensure that the reference detector is not saturated and permits a comparison of the relative light intensity required for detector saturation for all receiver detector heads.

- Record this voltage (reference detector output level) on the Optec LPV-2 Transmissometer Post-Field Alignment Check Form.

4.1.3.3 Receiver Detector Alignment Check

The receiver detector alignment check (part 3 of the Optec LPV-2 Transmissometer Post-Field Alignment Check Form) is performed in two stages. For the first stage, the size of the light beam projected onto the detector is adjusted to the diameter of the receiver reticle (full reticle light beam). The detector response is measured with the light beam centered in the reticle (position 1) and on the centered on the edge of the reticle at 0°, 90°, 180°, and 270° (positions 2-5). These alignment positions are shown on the drawing labelled "Alignment Positions" on the alignment form (Figure 4-9). The beam position is then scanned across the reticle to identify the position that provides the maximum output from the detector. Procedures for the second stage are similar to those described above with the light beam diameter adjusted to 1/4 of the reticle diameter (1/4 reticle light beam). Detector output measurements are obtained with the light beam centered in the reticle (position 1) and adjacent to the reticle at 0°, 90°, 180°, and 270° (positions 6-9). Document all measurements on the Optec LPV-2 Transmissometer Post-Field Alignment Check Form.

This procedure requires the following test equipment:

- Optical bench
- Variable intensity light source
- Beam diverter
- 135 mm camera lens
- Detector head alignment fixture
- Receiver computer emulator
- Digital voltmeter (4 1/2 digit)

OPTICAL BENCH SETUP

To perform the full reticle light beam alignment check, the optical bench should be setup with the following accessories installed at the position shown:

- Variable intensity light source - 0.0 cm
- Beam diverter - 15.0 cm
- 135 mm camera lens - 37.5 cm
- Detector head alignment fixture - 63.5 cm

DETECTOR HEAD AND TEST EQUIPMENT SETUP

Set up the detector head and test equipment as follows:

- Install the detector head being tested on the detector head alignment fixture.
- Connect the detector head cable to the receiver computer emulator.
- Connect the digital voltmeter to the output of the receiver computer emulator.
- Place the pin-hole mask in the light source filter holder.
- Set camera lens aperture at f/2.8.

ADJUST BEAM DIVERTER

Turn the light source "ON" and adjust the beam diverter to center the light beam in the detector head reticle. If the light beam is slightly out of focus, adjust the position of the detector head alignment fixture as needed to bring the light beam into focus.

RECORD OUTPUT VOLTAGES

Using the beam diverter to adjust the light beam position, align the full reticle light beam to alignment positions 1-5 as indicated on the alignment check form. Record the detector output voltage at each position. Then, align the light beam for maximum detector output voltage. Mark an "X" on the alignment positions diagram to indicate the position of the maximum output. Document the output voltage measured at this position (full reticle maximum detector output voltage) on the alignment check form.

CHANGE SETUP

Prior to performing the 1/4 reticle alignment check, the optical bench setup must be changed as follows:

- Position the 135 mm camera lens at 55.5 cm
- Position the detector head alignment fixture at 65.0 cm
- Set the camera lens aperture at f/4.

RECORD OUTPUT VOLTAGES

Align the 1/4 reticle light beam to alignment positions 1-5 as indicated on the alignment check form and record the detector output voltage at each position.

4.1.3.4 Receiver Detector Output Check

The receiver detector output check establishes a relative output relationship between the test detector head and the reference detector head. The light source intensity is adjusted to provide a specified output voltage from the reference detector. The test detector is then subjected to the same light source under the same conditions and its output voltage documented. Since instruments are serviced on an annual basis, this output check provides a history of the detector sensitivity.

The initial setup for the optical bench and test equipment is the same for this check as for the full reticle alignment check. Procedures for performing the output check are as follows:

- Center the light beam in the reference detector head reticle (align to alignment position 1).
- Adjust the light intensity for a detector output voltage of approximately 7.0 volts.
- Document the actual output voltage of the reference detector head.
- Replace the reference detector head with the test detector head.
- Without adjusting the light intensity, align the light beam to obtain the maximum output voltage from the test detector head. Document this voltage on the alignment check form.

4.2 ANNUAL SERVICING

Annual servicing of LPV-2 transmissometers includes a series of preventative maintenance and optical alignment tasks performed following completion of post-field inspection and functional checks, post-field lamp calibrations, and post-field alignment checks. Service forms required for annual servicing include:

- Optec LPV-2 Transmissometer Servicing Checklist.
- Optec LPV-2 Transmissometer Pre-Field Alignment Form.
- Optec LPV-2 Transmissometer Transmitter Lamp Voltage Measurements Record.

Specific tasks performed during annual servicing include:

- Transmitter servicing.
- Transmitter functional tests.
- Receiver servicing.
- Receiver computer functional tests.
- Transmitter/receiver optical alignment.

Detailed procedures for performing these tasks are described in the following subsections.

4.2.1 Transmitter Servicing and Functional Tests

Servicing of the LPV-2 transmitter includes:

- Cleaning of the control box, telescope and lamp housing, all optical components, and all electrical connections.
- Physical adjustment and alignment of optical components.

- Replacement of expendable electrical components.
- Alignment and voltage setup of transmitter lamps.
- Functional testing.

The Optec LPV-2 Transmissometer Servicing Checklist, Figure 4-11, is a four-page form used to document transmitter servicing tasks performed. Procedures for performing and documenting specific tasks are described below.

4.2.1.1 Transmitter Telescope and Lamp Housing

Document the completion of the following service tasks on page 1 of the Optec LPV-2 Transmissometer Servicing Checklist.

GENERAL INFORMATION	Complete the general information section of the service form. If the instrument is being serviced following failure or malfunction while operating in the field, check the box marked "other" and note the operational problem(s) in the "Comments" section.
TRANSMITTER SERVICING	Place the transmitter on the transmitter bench stand and clean the outside of the transmitter with window cleaner and paper towels.
	Remove the transmitter objective lens and clean the lens with an optical cleaning cloth.
	Remove the telescope tube by loosening the two set screws located in the top and side of the transmitter mounting plate at the rear of the telescope tube.
	Using Kimwipes held in the jaws of a flexible pickup tool, clean the inside of the transmitter telescope. Wipe back and forth to remove all contaminants. Use canned air to blow any remaining particles from the inside of the tube.
BAFFLE	Check that the baffle is securely mounted. If it is not, remount it using black RTV silicone.
	Measure and record the baffle distance (in inches) from the front of the tube.
REINSTALL TELESCOPE	Reinstall the telescope tube on the mounting plate. Firmly tighten both set screws.
	Reinstall the objective lens and firmly tighten the set screw.
EYEPIECE CLEANING AND ADJUSTMENT	Unscrew and remove the eyepiece lens. Clean both sides of the lens with an optical cleaning cloth.
	Clean the eyepiece tube with canned air and replace the lens (finger-tight).

OPTEC LPV-2 TRANSMISSOMETER
SERVICING CHECKLIST

Instrument Number: ____
Date: ____
Technician: ____

☐ Annual Servicing ☐ Other Comments: ____

____
____
____
____
____

TRANSMITTER SERVICING

Transmitter Telescope and Lamp Housing

Completed	See Comment	
☐	☐	Clean outside of transmitter
☐	☐	Remove and clean both sides of objective lens
☐	☐	Clean inside of telescope tube
☐	☐	Measure baffle distance from front of telescope - ______ inches
☐	☐	Replace objective lens and tighten securely
☐	☐	Clean both sides of eyepiece lens
☐	☐	Adjust the eyepiece
☐	☐	Remove the chopper (Mark date removed and Instrument # on old chopper motor).
☐	☐	Clean internal connectors & check tightness
☐	☐	Clean and lubricate the lamp bushing
☐	☐	Install feedback block filter retainer (if not already installed)
☐	☐	Clean and inspect the feedback block
☐	☐	Clean lamp chamber with canned air
☐	☐	Install new chopper motor/blade assembly (Mark installation date).
☐	☐	Affix green ON and red OFF labels to flip mirror knob
☐	☐	Clean and lubricate exterior connectors
☐	☐	Affix "Do Not Change Focus" sticker to telescope
☐	☐	Install new flip mirror alarm battery
☐	☐	Check body Allen screws - tighten as needed
☐	☐	Secure mirror knob - cover for storage with plastic and cloth bags

Comments: ____

____
____
____
____
____

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Figure 4-11. Optec LPV-2 Transmissometer Servicing Checklist.

Transmitter Control Box

Completed	See Comment	
☐	☐	Clean exterior of control box
☐	☐	Clean and lubricate exterior connectors
☐	☐	Check connectors, socketed ICs, and jumpers
☐	☐	Replace U3 and U14 (LM 124)
☐	☐	Clean and check battery holders
☐	☐	Clean and check internal connector tightness
☐	☐	Replace fuse F1 (AGC 5 amp fast blow)
☐	☐	Check labeling on test point T1-T5 and fuse. Re-label with permanent marker if required
☐	☐	Update revision sticker
☐	☐	Clean inside of control box and reinstall cover
☐	☐	Cover for storage with cloth bag
☐	☐	Install measurement pigtail on transmitter end of control box cable (if not already installed)
☐	☐	Clean cable connectors and coil cable for storage

Comments: ____
____

Transmitter Lamp Alignment

Completed	See Comment	
☐	☐	Refocus transmitter objective lens at infinity and tighten securely
☐	☐	Assign operational lamps to transmitter
☐	☐	Adjust lamp base plate for proper lamp filament alignment
☐	☐	Adjust feedback block position for proper lamp filament focus
☐	☐	Check clearance between lamps and feedback block
☐	☐	Setup operational lamp voltages

Comments: ____
____

TRANSMITTER FUNCTIONAL TEST

Install Reference Lamp Prior to Performing These Tests:
Lamp Serial Number: ________________________________
Transmitter Current: ___________________ Amps Lamp Voltage: ___________________ Volts

Test Point Voltages: T1 _______ T2 _______ T3 _______ T4 _______ T5 _______

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Figure 4-11. (Continued). Optec LPV-2 Transmissometer Servicing Checklist.

RECEIVER SERVICING

Receiver Telescope Servicing

Completed	See Comment	
☐	☐	Clean telescope exterior
☐	☐	Remove objective lens and clean both surfaces
☐	☐	Record aperture diameter (from aperture ring) - Aperture ________
☐	☐	Check baffle location (9-1/4")
☐	☐	Check wedge base for tightness
☐	☐	Clean inside of the telescope tube
☐	☐	Replace objective lens and re-focus at infinity
		Focus Quality: Good ☐ Fair ☐ Poor ☐
		Color Correction: Good ☐ Fair ☐ Poor ☐
☐	☐	Cover for storage with plastic and cloth bags

Comments: ____
____

Receiver Detector Head Servicing

Completed	See Comment	
☐	☐	Clean detector head exterior
☐	☐	Clean both sides of eyepiece lens
☐	☐	Adjust eyepiece
☐	☐	Clean connector
☐	☐	Affix the green ON and red OFF labels to flip mirror knob
☐	☐	Install new flip mirror alarm battery
☐	☐	Secure flip mirror knob in ON position
☐	☐	Cover for storage with plastic and cloth bags

Comments: ____
____

Receiver Computer Servicing

Completed	See Comment	
☐	☐	Clean outside of computer
☐	☐	Clean inside of computer with canned air
☐	☐	Remove computer cards and clean all connector contacts
☐	☐	Reinstall computer card connectors, and rubber band hold-downs
☐	☐	Clean bandpass board with canned air
☐	☐	Clean and check power module connector contacts
☐	☐	Check labeling on power supply test points and fuse type
☐	☐	Replace power supply fuse (AGC 1 amp fast blow)
☐	☐	Clean and lubricate exterior connectors

Comments: ____
____

Figure 4-11. (Continued). Optec LPV-2 Transmissometer Servicing Checklist.

RECEIVER COMPUTER FUNCTIONAL TESTS

Receiver Computer Display

At Power Up (000 Expected): ____________________

One Minute Avg - Flip Mirror Up (000 Expected): ____________________

Receiver Power Check

Input Voltage	+5V	+15V	-15V	TP1 High/Low	TP2 High/Low	A1 Output	Auto Reset	Receiver Current (Amps)
12V								
8V								
7V								
12V								

Bandpass Board Synchronization: ☐ OK Comment: ____________________

Serial Card Tests

Function	Expected Result	OK	Comment
Toggle	Toggle Lamp Blinking		
OR	OR Lamp Blinking		
Cal Switch	Actual Setting		
Path Switch	Actual Setting		
A1 Switch	C=0, B=1, VR=2		
A2 Switch	SD=0, CR=1		

D/A Converter Calibration

Function	Display		A1 Output (Volts)		A2 Output (Volts)	
	Expected	Actual	Expected	Actual	Expected	Actual
Zero	000		0.0000		0.0000	
Max	1000		9.9975		9.9975	
Mid	500					

Toggle Voltage Test

Toggle	Voltage (No Load)	Voltage (With Load)
ON	____________	____________
OFF	____________	____________

Receiver Computer Gain Check

Emulator Switch Setting	RMS Input (mV)	A1 Output at Gain Switch Setting (mV)				
		100	300	500	700	900
2						
1						

Comments: ____________________

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Figure 4-11. (Continued). Optec LPV-2 Transmissometer Servicing Checklist.

Adjust the eyepiece vertical position. Loosen the two set screws that hold the eyepiece in place. Align the bottom of the black band on the eyepiece with the top of the eyepiece holder and tighten the set screws.

LAMP HOUSING SERVICING

Place the transmitter on the chopper motor exchange stand and remove the lamp housing top and bottom cover plates.

Remove the chopper motor control wires at the transmitter input connector. An AMP pin extractor is required for this procedure.

Loosen the two set screws that hold the chopper motor in place and remove the chopper motor. NOTE: Do not install a replacement chopper motor at this point in servicing.

Clean the internal connectors with contact cleaner. Inspect the tightness of the connector pins. Tighten as required.

Clean the lamp bushing using electronic degreaser on a foam-tip swab followed by rubbing alcohol on a foam-tip swab.

Lubricate the inside surface of the lamp bushing with silicone lubricant on a foam-tip swab.

Clean the inside of the side plates with electronic degreaser and Kimwipes.

FEEDBACK BLOCK SERVICING

Remove the feedback block. This requires desoldering the photodetector from the photometer circuit board.

If the detector module is fastened to the feedback block with glue, the detector module should be removed and reinstalled after modification for use with the detector module retaining ring. Note under the "comments" section if the retaining ring modification was implemented.

Clean the feedback block optics with an optical cleaning cloth. Inspect the feedback block and note any hazing on the inside surfaces of the lenses.

Reinstall the feedback block and resolder the photodetector leads to the photometer circuit board.

CHOPPER MOTOR REPLACEMENT

Install a new chopper motor using the following procedures:

- The motor wires exit the back of the motor. The wire that exits nearest the green dot on the motor label should be marked with white shrink tubing.

- Insert the motor in the motor cavity with the motor positioned so the motor wires exit the motor cavity at the cutout.

- Tighten the two set screws that hold the chopper motor in place. The set screw on the right should be tightened first to ensure that the motor is positioned properly.

- Insert the marked motor wire into pin position 7 of the input connector. Insert the unmarked wire into pin position 8.

- Tape the motor wires to the front plate of the lamp housing so they do not interfere with the chopper blade.

- Replace the lamp housing bottom plate.

- Blow all dust and other particles out of the lamp chamber with canned air.

- Replace the lamp housing top plate.

FLIP MIRROR SERVICING

Check the "ON" (green) and "OFF" (red) labels on the flip mirror control knob. Replace if damaged or missing.

Replace the flip mirror alarm battery using the following procedures:

- Remove the four (4) screws that hold the end plate in place.

- Remove the set screw that holds the speaker screen in place.

- Remove the speaker screen and the sound tube.

- Slide the printed circuit board out of the alarm enclosure.

- Desolder the old battery. Obtain a new battery (BR-2325-2 HC) and solder it onto the circuit board.

- Slide the circuit board back into the enclosure, replace the sound tube and speaker screen, tighten the speaker screen set screw, and replace the end plate.

FINAL ITEMS

Clean the outside of the transmitter input connector with contact cleaner. Lubricate the plastic shell with silicone lubricant.

Affix a "DO NOT CHANGE FOCUS" label to the telescope tube immediately below the objective lens adjustment slot.

Tighten all body screws.

Secure the flip mirror in the "ON" position (alarm off) with a rubber band.

Cover the lamp housing and eyepiece with a large plastic bag. Cover the end of the telescope tube with a small plastic bag. Use rubber bands to hold the plastic bags in place.

Place the entire transmitter telescope and lamp housing in a clean white cloth transmitter storage bag.

4.2.1.2 Transmitter Control Box

Document the completion of the following service tasks on page 2 of the Optec LPV-2 Transmissometer Servicing Checklist.

EXTERIOR CLEANING	Clean the outside of the control box with window cleaner and paper towels.
	Clean all exterior connectors with contact cleaner. Apply silicone lubricant to the plastic connector shells.
INTERNAL INSPECTION, COMPONENT REPLACEMENT, AND CLEANING	Remove the control box cover plate and interior shield.
	Inspect all internal connectors, jumpers, and socketed components for proper location and tight connections. Clean the connectors with contact cleaner.
	Replace U3 and U14 (located on the control box circuit board - refer to Figure 4-3) with new LM124 ICs.
	Inspect the battery clips for cold solder joints and repair as needed. Clean the battery clip contacts with contact cleaner.
	Replace Fuse F1 (AGC 5A fast blow).
	Relabel test points and fuse type if needed.
	Update revision sticker.
	Spray the inside of the control box with canned air to remove dust and other particles.
	Replace the internal shield and cover plate.
	Place the control box in a clean white cloth storage bag.
CONTROL BOX CABLE	Check integrity of connectors on control box cable and measurement pigtail. Install a measurement pigtail if cable has not been modified.
	Clean connectors with contact cleaner.
	Coil cable for storage.

4.2.1.3 Transmitter Lamp Alignment and Voltage Setup

Document the completion of the following lamp alignment procedures on page 2 of the Optec LPV-2 Transmissometer Servicing Checklist. Lamp setup voltages should be documented on the Optec LPV-2 Transmissometer Transmitter Lamp Voltage Measurements Record, Figure 4-12.

LAMP ALIGNMENT

Loosen the objective lens set screw.

Align the transmitter telescope on a target at least one-quarter mile away. Adjust the position of the objective lens to bring the object into proper focus. Tighten the set screw securely.

To support annual operation of a transmissometer operating under the IMPROVE sampling protocol, (10-minute sample each hour) assign ten (10) lamps for use with this transmitter. Typically this will include the reference lamp previously assigned to this transmitter, any unused operational lamps previously assigned to this transmitter, and new lamps taken from stock. All new lamps must have been previously "burned in" as described in TI 4200-2110, *Transmissometer Lamp Preparation (Burn-in) Procedures*. Document the lamp numbers of the assigned lamps on the Optec LPV-2 Transmissometer Transmitter Lamp Voltage Measurements Record.

Place the lamp alignment disc over the front of the transmitter telescope. Insert the first assigned lamp into the transmitter and turn the transmitter on. If any part of the filament image projected onto the alignment disc is obscured, note the degree of misalignment.

Repeat the above procedure for all ten (10) of the assigned lamps.

Reinsert the lamp with the poorest alignment and realign the lamp using the following procedures.

- Loosen the four (4) screws that hold the lamp plate in place.
- Adjust the lamp plate position to center the projected filament image.
- Retighten the lamp plate screws.
- Recheck the alignment of the other lamps as described above.
- Repeat the above procedures until all lamps are properly aligned (full filament image projected onto alignment disc).

OPTEC LPV-2 TRANSMISSOMETER
TRANSMITTER LAMP VOLTAGE MEASUREMENTS RECORD

Instrument Number: ___________
Date: ________________________
Technician: __________________

LAMP VOLTAGE MEASUREMENTS

Lamp #	Setup Voltage		Pre-Cal Voltage	Install Voltage	Post-Cal Voltage
	Initial	Final			

TRANSMITTER TEST POINT VOLTAGES - LAMP #: ____________________

	T1	T2	T3	T4
SETUP				
PRE-CAL				
POST-CAL				

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Figure 4-12. Lamp Voltage Measurements Record.

FILAMENT FOCUS

The filament focus is controlled by the position of the feedback block. Adjust the filament focus using the following procedures.

- Place a piece of opaque material (such as a Kimwipe) against the objective lens.
- Insert the first lamp in the transmitter and turn the transmitter on.
- Loosen the set screw that holds the feedback block in place.
- Adjust the position of the feedback block to provide the sharpest projected filament image.
- Tighten the feedback block set screw and recheck the focus.
- Check the focus for the remaining lamps with this feedback block position.
- Repeat the above procedures until the focus is optimized for all assigned lamps.

FEEDBACK BLOCK/LAMP CLEARANCE

The position of the feedback block must allow all lamps to be fully inserted without touching the flat lens of the feedback block. Check the clearance between the lamps and the feedback block using the following procedures.

- Place a Kimwipe between the feedback block flat lens and each lamp as the lamp is inserted into the lamp plate.
- If the Kimwipe is pinched in place when the lamp has been fully inserted, loosen the feedback block set screw and move the feedback block forward (towards the front of the telescope) just enough to permit the Kimwipe to be removed.
- Tighten the set screw and repeat the above procedures with each lamp.

LAMP VOLTAGE SETUP

The lamp voltage control circuit must be set up so that the maximum initial lamp voltage for all operational lamps assigned to a specific transmitter does not exceed 5.6 volts. Since the lamp voltage control circuit automatically adjusts lamp voltage based on the lamp brightness measured by the feedback block, lamp voltage must be checked for each lamp. The lamp voltage is then adjusted to 5.6 volts using the lamp with the highest lamp voltage during the initial check. Document all lamp voltage measurements on the Optec LPV-2 Transmissometer Transmitter Lamp Voltage Measurements Record.

Procedures for performing the initial lamp voltage check are as follows:

- Connect the 4 1/2 digit digital voltmeter (DVM) to the lamp voltage measurement pigtail on the transmitter cable.
- Set the DVM on the 20 VDC scale (this should give a measurement resolution of 1 mV).
- Insert the first lamp into the transmitter and turn the transmitter control box "ON."
- After the lamp has operated for fifteen (15) seconds, record the lamp voltage as measured by the DVM (5.xxx volts).
- Turn the transmitter control box "OFF" and remove the lamp. Let the lamp cool before placing it back in the lamp case.
- Repeat the above procedures for each lamp assigned to this transmitter.

Procedures for the final setup of operational lamp voltages are as follows:

- Identify the lamp with the highest lamp voltage during the initial lamp voltage check.
- Insert this lamp into the transmitter and turn the transmitter control box "ON."
- Monitor the lamp voltage with the DVM as in the initial lamp voltage check.
- The lamp voltage is controlled by potentiometer P2 on the transmitter control box circuit board (Refer to Figure 4-3). Adjust P2 for a lamp voltage of 5.6 VDC.
- Check the lamp voltage after the lamp has operated for approximately six (6) minutes. If the lamp voltage is not equal to 5.6 volts, ±5 mV, readjust the lamp voltage to 5.6 VDC, turn the control box "OFF," let the lamp cool for five (5) minutes and repeat this step.
- When P2 has been adjusted so that the lamp with the highest initial check voltage is operating at a nominal voltage of 5.6 volts after six (6) minutes of operation, document the actual voltage and turn the control box "OFF."

- For each remaining lamp, insert the lamp in the transmitter, turn the control box "ON," and measure and record the lamp voltage after the lamp has operated for six (6) minutes. Be sure to let each lamp cool for several minutes before returning the lamp to the lamp case.

- When the reference lamp is being tested, the voltages at test points 1, 2, 3, and 4 should also be measured and recorded along with the final lamp voltage.

4.1.2.4 Transmitter Functional Test

TRANSMITTER POWER AND VOLTAGE MEASUREMENTS

All functional check measurements related to the transmitter are conducted with the reference lamp assigned to the instrument. Record the reference lamp serial number.

Measure and record the transmitter operating current with the lamp "ON."

Measure and record the lamp voltage using the measurement pigtail on the control box cable.

Measure and record the T1, T2, T3, T4, and T5 test point voltages on the transmitter control box circuit board (refer to Figure 4-3).

4.2.2 <u>Receiver Servicing and Functional Tests</u>

Servicing of the LPV-2 receiver includes:

- Cleaning of the receiver computer, telescope, detector head, all optical components, and all electrical connections.

- Inspection and evaluation of receiver optics quality.

- Physical adjustment and alignment of optical components.

- Replacement of expendable electrical components.

- Functional testing.

Completion of receiver servicing tasks is documented on page 3 of the Optec LPV-2 Transmissometer Servicing Checklist. Document results obtained during functional testing on page 4 of the servicing checklist. Procedures for performing and documenting specific tasks are described below.

4.2.2.1 Receiver Telescope Servicing

TELESCOPE EXTERIOR CLEANING

Clean the exterior of the receiver telescope with window cleaner and paper towels.

OBJECTIVE LENS CLEANING

Clean the objective lens assembly using the following procedures:

- The thumbscrew on the top of the telescope holds the objective lens assembly in place. The entire assembly is threaded to screw into the telescope tube. Remove the objective lens assembly by loosening the thumbscrew and unscrewing the assembly from the telescope tube.

- Remove the aperture ring by loosening the three Allen set screws that hold the ring in place.

- Put on a pair of cleaning gloves prior to removing the objective lens from the assembly. Carefully invert the assembly, letting the lens fall into your hand.

- Clean both sides of the lens with a cleaning cloth.

- Clean the lens seat and the aperture ring with window cleaner and paper towels.

- Reinsert the objective lens into the assembly, replace the aperture ring, and tighten the three Allen set screws that hold the aperture ring in place.

APERTURE DIAMETER

Record the aperture diameter inscribed on the front of the aperture ring.

BAFFLE

Check that the baffle is securely mounted. If it is not, remount it using black RTV silicone.

Measure the distance from the front of the telescope to the baffle. This distance should be 9 1/4 inches. If the distance is not 9 1/4 inches, record the measured distance in the comments section.

Tighten the screws that hold the wedge base in place.

TELESCOPE INTERIOR CLEANING

Using Kimwipes held in the jaws of a flexible pickup tool, clean the inside of the receiver telescope. Wipe back and forth to remove all contaminants. Use canned air to blow any remaining particles from the inside of the tube.

Reinstall the objective lens assembly in the telescope tube.

FOCUS QUALITY AND COLOR CORRECTION

Temporarily install the detector head for this receiver on the telescope.

Align the telescope on a target at least one-quarter mile away. adjust the position of the objective lens to bring the target into proper focus. Note the focus quality and color correction on the servicing form.

Tighten the thumbscrew that holds the assembly in place.

Remove the detector head from the receiver telescope.

FINAL ITEMS

Cover both ends of the telescope with large plastic bags, secure the plastic bags with rubber bands, and place the entire telescope in a clean white cloth receiver telescope bag.

4.2.2.2 Receiver Detector Head Servicing

EXTERIOR CLEANING

Clean the exterior of the receiver detector head with window cleaner and paper towels.

EYEPIECE CLEANING AND ADJUSTMENT

Unscrew and remove the eyepiece lens. Clean both sides of the lens with an optical cleaning cloth.

Clean the eyepiece tube with canned air and replace the lens (finger-tight).

Adjust the eyepiece vertical position. Loosen the two set screws that hold the eyepiece in place. Align the bottom of the black band on the eyepiece with the top of the eyepiece holder and tighten the set screws.

FLIP MIRROR SERVICING

Check the "ON" (green) and "OFF" (red) labels on the flip mirror control knob. If they are damaged or missing, they should be replaced.

Replace the flip mirror alarm battery using the following procedures:

- Remove the four (4) screws that hold the end plate in place.
- Remove the single set screw that holds the speaker screen in place.
- Remove the speaker screen and the sound tube.
- Slide the printed circuit board out of the alarm enclosure.
- Desolder the old battery. Obtain a new battery (BR-2325-2HC) and solder it onto the circuit board.
- Slide the circuit board back into the enclosure, replace the sound tube and speaker screen, tighten the speaker screen set screw, and replace the end plate.

FINAL ITEMS

Clean the connector on the detector head cable with contact cleaner. Lubricate the plastic shell with silicone lubricant.

Secure the flip mirror in the "ON" position (alarm off) with a rubber band.

Coil the detector head cable and tie together with a rubber band.

Place the detector head into a large plastic bag and secure with a rubber band. Then place it into a clean white cloth detector head bag.

4.2.2.3 Receiver Computer Servicing

RECEIVER COMPUTER CLEANING

Clean the outside of the receiver computer with window cleaner and paper towels.

Remove the top cover of the receiver computer. Use canned air to clean the interior of the receiver computer.

Disconnect all internal connectors and remove the CIMBUS computer cards from the receiver computer card cage.

Clean the gold connector pins on the CIMBUS computer cards with gold contact cleaning spray. Clean the gold connector pins in the CIMBUS card cage with the gold contact spray.

Clean all other receiver computer internal connections with contact cleaner.

Reinstall the CIMBUS computer cards in the card cage. Secure the cards using the rubber band hold downs.

Clean the bandpass circuit board with canned air. Clean connector contacts with contact cleaner and check the integrity of the connectors.

Clean the power supply module connector contacts with contact cleaner and check the integrity of the connectors.

Replace the power supply fuse (AGC 1A fast blow)

Inspect the battery clips on the front panel circuit board. Check for cold solder joints and repair as required. Clean the battery clips with contact cleaner.

4.2.2.4 Receiver Functional Tests

RECEIVER COMPUTER SETUP

Connect the receiver detector head to the receiver computer and connect the receiver computer to a 0-12 VDC variable output power supply. Set the power supply output to 12 VDC. Set the "A1" switch to position **C** (raw readings), the "CYCLE" switch to **CONT** (continuous), and the "INTEG" switch to **1** (one minute).

Position the detector head so that it is "looking" at the transmitter lamp through a pin-hole mask. Adjust the detector head position so that the one-minute raw readings measured by the receiver computer are greater than 0.2 volts (200 on the receiver computer display).

Connect channel 1 and channel 2 of the oscilloscope to "TP1" and "TP2" of the auto reset circuit located on the receiver computer front panel board (refer to Figure 4-4).

POWER-UP TEST

Turn the receiver computer on and record the display reading immediately following the instruments power-up cycle.

ZERO INPUT TEST

Set the receiver telescope flip mirror to the "OFF" position (light blocked). Turn the receiver computer **OFF**, wait five (5) seconds and turn the receiver computer back **ON**. After one minute, the receiver computer will update the data on the front panel display. Since the flip mirror blocks all light from reaching the detector, the display should read "000." Record the display reading.

POWER SUPPLY AND AUTO RESET TEST

Place the receiver flip mirror in the "ON" position. With the power supply output set at 12 VDC, measure and record the receiver computer internal power supply outputs (+5 VDC, +15 VDC, -15 VDC). These voltages should be measured at the test points on the power supply board (refer to Figure 4-5). After the display updates, measure and record the "A1" output and the receiver operating current.

Reduce the external power supply voltage to 8.0 volts. After the next full one-minute update, record the "A1" output. Record the receiver power supply output voltages, the "A1" output, and the "TP1" and "TP2" logic levels (high or low). This test confirms that the instrument will operate properly with a supply voltage as low as 8.0 volts.

Reduce the external power supply voltage to 7.0 volts. "TP1" and "TP2" should both go to a logic low. The receiver front panel display should be blank and the "A1" output should be zero. These conditions indicate that the receiver computer has ceased operation. Record the power supply output voltages, the "A1" output, and the "TP1" and "TP2" logic levels.

Increase the external power supply voltage to 12.0 volts. If the auto reset circuit is functioning properly, "TP1" and "TP2" will return to a logic high level immediately after the power supply voltage is increased. The "A1" output will be zero until the first update. After the update the "A1" output will return to the value measured at the start of this test. At this time record the power supply output voltages, the "A1" output, and the "TP1" and "TP2" logic levels.

BANDPASS BOARD ZERO-CROSS DETECTOR SYNCRO-NIZATION

The purpose of this test is to determine if the receiver bandpass circuit zero-cross detector output is synchronized with the incoming transmitter signal. Connect channels 1 and 2 of the oscilloscope to test points "TP4" and "TP5" of the receiver computer bandpass board. Synchronize the oscilloscope on channel 1. If the synchronization circuit is functioning properly, both the leading and trailing edges of the two waveforms will be in phase. If the waveforms are not synchronized, adjust potentiometer "P1" on the bandpass board (refer to Figure 4-6, Bandpass Board Component Diagram).

4.2.2.5 Serial Card Tests

SERIAL CARD TEST SETUP	Turn the receiver computer **OFF** and insert the CIMBUS serial card into slot #7 of the CIMBUS computer. Connect the serial card output to the serial port on the PC computer. PROCOMM software is used to communicate with the CIMBUS computer. Turn the receiver computer **ON** and enter **TEST** to initiate the receiver computer self-test program. The "TEST" program will execute a fixed sequence of test routines that will check all major receiver computer functions. When one test is completed, hit any key to move to the next test in the sequence. Figure 4-7 shows the receiver computer front panel digital display, switches and status lamps. Record the result (Pass/Fail) for each test listed below on the inspection checklist. If instrument fails any portion of a test, briefly describe the observed failure(s) under "Comments."
TOGGLE TEST	The "TOGGLE" lamp, located on the receiver computer front panel will blink continuously.
OVER RANGE (OR) TEST	The over range (OR), located on the receiver computer front panel will blink continuously.
CAL SWITCH CHECK	The "CAL" switch is a three (3) digit thumbwheel switch located on the receiver computer front panel. The number set into this switch will be displayed on the computer screen. The number displayed on the screen will update each time any digit on the switch is changed. Verify that all 10 positions (0-9) for each digit are translated properly by the receiver computer.
PATH SWITCH CHECK	The "PATH" switch is a four (4) digit thumbwheel switch located on the receiver computer front panel. Follow the switch test procedures described above for the "CAL" switch.
A1 SWITCH TEST	The "A1" switch is a three (3) position rotary switch located on the front panel of the receiver computer. Set the "A1" switch to each of the three positions (C,B,VR). The "TEST" program will continuously read the switch setting and display the setting as a number (C=0, B=1, VR=2) on the computer screen. Verify that the number displayed matches the switch setting for each switch position.

A2 SWITCH TEST

The "A2" switch is a two (2) position rotary switch located on the front panel of the receiver computer. Follow the procedures described above for testing the "A1" switch. The "A2" switch positions and the corresponding numbers displayed on the computer screen are "SD" (0) and "CR" (1).

D/A CONVERTER CALIBRATION

The receiver computer output test fixture includes a mating connector for the receiver computer output connector. This test fixture provides a switchable connection between the voltmeter and each of the receiver computers two analog output signals (refer to Figure 4-8, Receiver Computer Output Text Fixture).

Turn the receiver computer **OFF** and remove the D/A converter board from the CIMBUS card cage. Insert the CIMBUS extender card in the D/A converter slot and plug the D/A converter into the extender card. Use the extension cables to make the connection from the wiring harness to the D/A connectors. Turn the receiver computer **ON**.

The "TEST" program provides three prompts indicating the test input applied to the D/A converters that generate the "A1" and "A2" output voltages. The test program also specifies the potentiometers to be adjusted for recalibration (see Figure 4-13, CIMBUS D/A Converter Circuit Board Components Diagram, for the location of the adjustment potentiometers).

The calibration prompts and corresponding output voltages expected are:

- ZERO - 0.00 volts
- MAX (Full scale) - 9.9975 volts
- MID (Half scale) - 4.9988 volts

The corresponding readings expected on the receiver computer display (for all "A1" switch positions) are:

- ZERO - 000
- MAX (Full scale) - 1000
- MID (Half scale) - 500

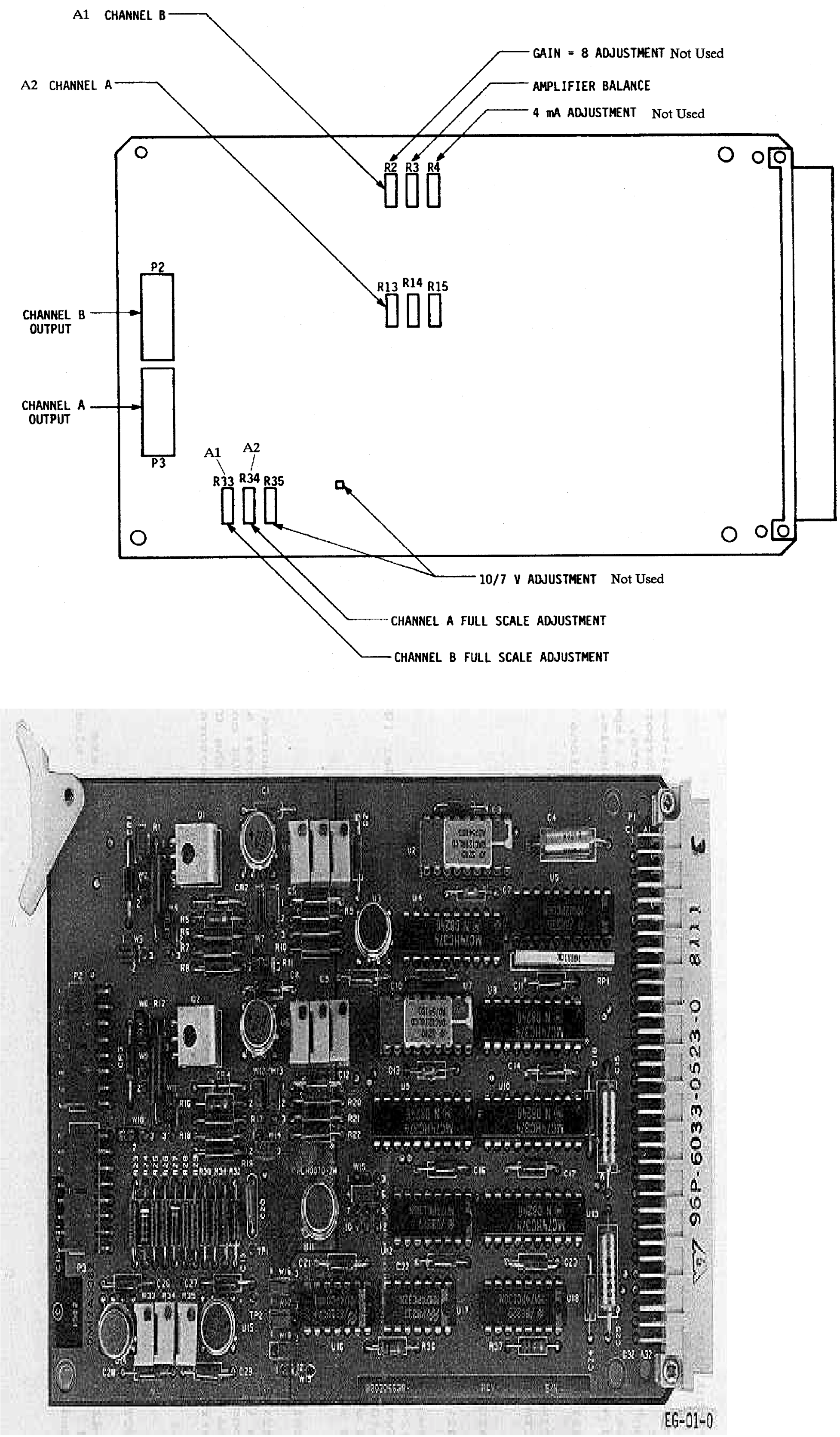


Figure 4-13. CIMBUS D/A Converter Circuit Board Components Diagram.

Procedures for recalibrating the receiver computer analog output channels are as follows:

- Go to the "ZERO" prompt in the "TEST" program.
- Set the test fixture switch to the "A1" position and adjust "R3" on the D/A card for an output of 0.000 VDC.
- Record the receiver computer display reading and the DVM reading on the servicing checklist.
- Set the test fixture switch to the "A2" position and adjust "R14" on the D/A converter board for an output of 0.000 VDC.
- Record the DVM reading on the servicing checklist.
- Go to the "MAX" prompt in the "TEST" program.
- Set the test fixture switch to the "A1" position and adjust "R33" on the D/A card for an output of 9.9975 ±.0005 VDC.
- Record the receiver computer display reading and the DVM reading on the servicing checklist.
- Set the test fixture switch to the "A2" position and adjust "R34" on the D/A card for an output of 9.9975 ±0.0005 VDC.
- Record the DVM reading on the servicing checklist.
- Adjust "P5" on the receiver computer front panel board (refer to Figure 4-4) for a receiver computer display reading of "1000."
- Go to the "MID" prompt in the TEST program.
- Set the test fixture switch to the "A1" position.
- Record the receiver computer display reading and the DVM reading on the servicing checklist.
- Set the test fixture switch to the "A2" position.
- Record the DVM reading on the servicing checklist.

4.2.2.6 Toggle Voltage Test

The receiver computer toggle output voltage is measured with and without an output load. The receiver computer output test fixture is used for this test. The "TOG-NL" (Toggle, no-load) position connects the toggle output directly to the voltmeter. The "TOG-L" (Toggle, with load) position connects a 4700 ohm resistor in parallel with the voltmeter input.

MEASURE VOLTAGES	Set the receiver computer for continuous operation ("CYCLE" switch on **C**) and one minute integrations ("INTEG" switch on **1**). Measure the toggle output voltage in both the "TOG-NL" and "TOG-L" positions with the toggle lamp "ON." Wait one minute for the toggle lamp to switch "OFF" and repeat the measurements. Record the measured voltages for each set of conditions.

4.2.2.7 Receiver Computer Gain Test

MEASURE EMULATOR OUTPUT VOLTAGE	Disconnect the detector head output cable from the receiver computer and connect the detector head emulator in its place. The detector head emulator is powered by the receiver computer and generates a low level square wave signal that emulates the detector head output response under operational conditions. Connect the receiver computer output test fixture to the receiver computer output connector. Set the emulator switch to position "2" and measure the emulator output voltage using an rms voltmeter.
MEASURE RECEIVER COMPUTER OUTPUT	With the receiver computer set for continuous operation and one-minute integrations, measure the receiver computer output for gain switch settings of "100," "300," and "500." Record the emulator output voltage and the three receiver computer output voltages. Reset the emulator switch to position "1" and repeat the above procedure for gain switch settings of "700" and "900."

4.2.3 <u>Transmitter/Receiver Optical Alignment</u>

Pre-field alignment of the transmissometer optics is required following annual servicing of the instrument and includes:

- Transmitter alignment.
- Receiver detector alignment.
- Receiver output detector check.

Pre-field alignment requires the same optical and electronic test equipment as specified for the post-field alignment checks (Refer to Section 4.1.3, Post-Field Alignment Checks). The basic procedures parallel the post-field alignment check procedures. The post-field procedures go only as far as measuring the parameters that can identify optical alignment problems that could affect data collected while the instrument was operating in the field. The pre-field alignment includes additional procedures for realigning the optics to optimize the instrument performance.

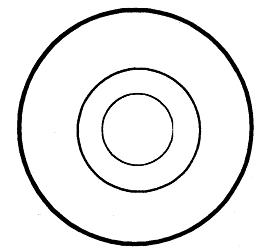
The Optec LPV-2 Transmissometer Pre-Field Alignment Form, Figure 4-14, is used for documenting all pre-field alignment checks and measurements.

OPTEC LPV-2 TRANSMISSOMETER
PRE-FIELD ALIGNMENT CHECK

Instrument Number:______________
Date:__________________________
Technician:_____________________

1. TRANSMITTER ALIGNMENT CHECK

Focus the transmitter on the target (shown to the right of this paragraph) and tighten the objective lens securely. Adjust the transmitter so the beam is inside the large outer circle of the target. The target has two inner circles. The larger inner circle represents the outer limit for the reticle. The smaller inner circle represents the ideal reticle alignment. Draw the actual reticle position on the target. If the reticle is not within limits, realign the transmitter. Draw the final reticle position on the target diagram.



TARGET

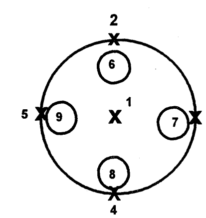
2. RECEIVER DETECTOR ALIGNMENT CHECK

FULL RETICLE ALIGNMENT

Alignment Position	1	2	3	4	5	Maximum
Pre-align Readings	______	______	______	______	______	______
Post-align Readings	______	______	______	______	______	______

1/4 RETICLE ALIGNMENT

Alignment Position	1	6	7	8	9
Pre-align Readings	______	______	______	______	______
Post-align Readings	______	______	______	______	______
Post-align Readings	______	______	______	______	______



ALIGNMENT POSITIONS

3. RECEIVER DETECTOR OUTPUT CHECK

Adjust Light Source Intensity for a Reference Detector Output of Approximately 7.0 Volts

Reference Detector Output at Alignment Position 1:____________________________

Test Detector Output at Alignment Position 1:_________________________

prefld.sam (8/96)

Figure 4-14. Optec LPV-2 Transmissometer Pre-Field Alignment Form.

4.2.3.1 Transmitter Alignment Check

This procedure requires an unobstructed sight path of at least 50 feet and the following equipment:

- Tripod with Optec alti-azimuth base
- Spotting scope mounted on a tripod
- Transmitter alignment target
- DC power supply - 12 volts @ 5 amps

EQUIPMENT SETUP

Attach the transmitter alignment target to a wall at one end of the sight path. The center of the target should be at a height of approximately 42 inches. Attach the transmitter telescope to the tripod and set up the tripod 47 feet from the alignment target. Set up the spotting scope next to the transmitter telescope. Focus the transmitter telescope on the alignment target by adjusting the position of the objective lens. The objective lens is held in position by a set screw in the top of the telescope.

ADJUST ALIGNMENT

Connect the DC power supply to the transmitter control box and connect the control box to the transmitter telescope. Insert the reference lamp for the instrument being tested into the transmitter and turn the transmitter "ON." Use the spotting scope to observe the position of the transmitter light beam while adjusting the alti-azimuth base to center the light beam in the large outer circle of the alignment target. The transmitter reticle should align with the smallest of the two inner circles (refer to the target diagram on the Optec LPV-2 Transmissometer Pre-Field Alignment Form). Alignment is acceptable if the reticle position is entirely within the larger of the two inner circles. If the reticle position is not within the larger of the two inner circles, realign the transmitter using the following procedures:

- Remove the telescope tube from the flip mirror housing by loosening the two (2) set screws on the top and side of the housing next to the telescope.
- Loosen the three (3) alignment screws located at the front of the flip mirror housing. These Allen screws extend through the housing to the lamp chamber. They should be loosened only enough to allow the flip mirror housing to be adjusted without slipping.
- Replace the telescope tube and align the light beam on the target.
- While looking through the eyepiece, adjust the flip mirror housing so that the reticle is aligned with the target.

- Check the light beam position on the target. If it is not aligned within the outer circle, adjust the lamp housing as required to place the light beam entirely within the circle.

- Recheck the reticle position. If the reticle is not properly aligned, readjust the flip mirror housing and the lamp housing as described in the previous two steps. Repeat this procedure until both the light beam and reticle are properly aligned.

- Remove the telescope, tighten the three alignment screws, and replace the telescope.

- Recheck the transmitter alignment to ensure that alignment was maintained as the instrument was reassembled. If the alignment is not within specifications, the entire alignment procedure must be repeated.

- When the alignment is finally within specifications, sketch the outline of the actual reticle position on the target diagram.

4.2.3.2 Receiver Detector Alignment

Receiver detector alignment (part 2 of the Optec LPV-2 Transmissometer Pre-Field Alignment Form) is performed in two (2) stages. For the first stage, the size of the light beam projected onto the detector is adjusted to the diameter of the receiver reticle (full reticle light beam). The detector response is measured with the light beam centered in the reticle (position 1) and centered on the edge of the reticle at 0°, 90°, 180°, and 270° (positions 2-5). These alignment positions are shown on the drawing labelled "Alignment Positions" on the pre-field alignment form. The beam position is then scanned across the reticle to identify the position that provides the maximum output from the detector. Procedures for the second stage are similar to those described above with the light beam diameter adjusted to 1/4 of the reticle diameter (1/4 reticle light beam). Detector output measurements are obtained with the light beam centered in the reticle (position 1) and adjacent to the reticle at 0°, 90°, 180°, and 270° (positions 6-9). All measurements are documented on the Optec LPV-2 Transmissometer Pre-Field Alignment Form.

This procedure requires the following test equipment:

- Optical bench
- Variable intensity light source
- Beam diverter
- 135 mm camera lens
- Detector head alignment fixture
- Receiver computer emulator
- Digital voltmeter (4 1/2 digit)

OPTICAL BENCH SETUP

To perform the full reticle light beam alignment check, the optical bench should be setup with the following accessories installed at the position shown:

- Variable intensity light source - 0.0 cm
- Beam diverter - 15.0 cm
- 135 mm camera lens - 37.5 cm
- Detector head alignment fixture - 63.5 cm

DETECTOR HEAD SETUP

Set up the detector head and test equipment as follows:

- Install the detector head being tested on the detector head alignment fixture.
- Connect the detector head cable to the receiver computer emulator.
- Connect the digital voltmeter to the output of the receiver computer emulator.
- Place the pin-hole mask in the light source filter holder.
- Set camera lens aperture at f/2.8

ADJUST BEAM DIVERTER

Turn the light source "ON" and adjust the beam diverter to center the light beam in the detector head reticle. If the light beam is slightly out of focus, adjust the position of the detector head alignment fixture as needed to bring the light beam into focus.

ALIGN RETICLE LIGHT BEAM

Using the beam diverter to adjust the light beam position, align the full reticle light beam to alignment positions 1-5 as indicated on the pre-field alignment form. Record the detector output voltage at each position. Then, align the light beam for maximum detector output voltage. Align the light beam to give the maximum detector output voltage and record this value on the alignment form. If the maximum is not at position 1, use the following procedures to align the reticle with the detector:

- Center the light beam in the receiver telescope reticle (position 1).
- Adjust the detector alignment to move the maximum towards position 1. The detector alignment is controlled by four set screws (top, bottom, and both sides) located directly behind the detector head eyepiece. Changes in vertical alignment are accomplished by adjusting the top and bottom screws as a pair (loosening one screw and tightening the other). Horizontal alignment changes are accomplished in the same manner with the set screws on the sides of the assembly.

- Check the location of the realigned maximum output.
- Repeat the above procedure until the maximum output occurs at position 1.
- When the maximum output is obtained at position 1, record the detector output for positions 1-5 and at the maximum.

CHANGE SETUP

Prior to performing the 1/4 reticle alignment check, the optical bench setup must be changed as follows:

- Position the 135 mm camera lens at 55.5 cm
- Position the detector head alignment fixture at 65.0 cm
- Set the camera lens aperture at f/4.

ALIGN RETICLE LIGHT BEAM

Align the 1/4 reticle light beam to the center of the reticle (position 1) and each of the four (4) alignment positions adjacent to the edge of the reticle (positions 6-9). Record the detector output voltage at each position. If the readings at opposite positions (6 and 8 or 7 and 9) differ by more than 2%, the detector alignment should be adjusted using the following half-power method procedures:

- Align the 1/4 reticle light beam at position 1 and note the detector output voltage at this position.
- Monitor the detector output while adjusting the beam diverter to move the light beam vertically towards position 2. When the detector output voltage decreases to 50% of the voltage measured in the previous step, record the light beam position.
- Adjust the light beam towards position 4 and again record the position of the light beam where the detector output voltage decreases to 50% of the position 1 value.
- If the two 50% positions are not equidistant from position 1, adjust the alignment of the detector following the procedures described in the full-reticle alignment procedures.
- Repeat the above three steps moving the light beam towards positions 3 and 5 to determine the 50% output positions along the horizontal axis.
- Repeat the 1/4 reticle alignment check, recording the detector output at position 1 and positions 6-9. If each of the voltages measured at positions 6-9 are not within 1% of the voltage measured at position 1, the half-power alignment procedure should be repeated.

4.2.3.3 Receiver Detector Output Check

The receiver detector output check establishes a relative output relationship with the reference detector head. The light source intensity is adjusted to provide a specified output voltage from the reference detector. The test detector is then subjected to the same light source under the same conditions and its output voltage documented. Since instruments are serviced on an annual basis, this output check provides a history of the detector sensitivity.

The initial setup for the optical bench and test equipment is the same for this check as for the full reticle alignment check. Procedures for performing the output check are as follows:

- Center the light beam in the reference detector head reticle (align to alignment position 1).
- Adjust the light intensity for a detector output voltage of approximately 7.0 volts.
- Document the actual output voltage of the reference detector head.
- Replace the reference detector head with the test detector head.
- Without adjusting the light intensity, align the light beam to position 1 in the test detector head. Document detector head output voltage on the alignment form.

4.3 PRE-FIELD CALIBRATION

A pre-field calibration must be performed prior to sending an instrument to the field. Detailed instructions for performing and documenting pre-field calibrations are provided in TI 4200-2100, *Calibration of LPV-2 Transmissometers (IMPROVE Protocol)*.

5.0 REFERENCES

Optec, Inc., 1991, Model LPV Long Path Visibility Transmissometer, Version 2, Technical Manual for Theory of Operation and Operating Procedures, July, Lowell, MI.

National Semiconductor Corp, 1983, CIM-660 Firmware Monitor User's Manual, August. Santa Clara, CA.

National Semiconductor Corp, 1982, CIM-801/-802/-804 CPU Board Hardware Reference Manual, May. Santa Clara, CA.

National Semiconductor Corp, 1984, CIM-110/-114/-118 and CIM-110C/-114C/-118C Universal Memory Expansion Boards Hardware Reference Manual, March, Santa Clara, CA.

National Semiconductor Corp, 1983, CIM-210/-210C Parallel I/O Board Hardware Reference Manual, June, Santa Clara, CA.

National Semiconductor Corp, 1984, CIM-415/-415C Analog Input Board Hardware Reference Manual, September, Santa Clara, CA.

National Semiconductor Corp, 1983, CIM-421/-441C Analog Output Board Hardware Reference Manual, March, Santa Clara, CA.

National Semiconductor Corp, 1984, CIM-203/-203C Serial I/O Board Hardware Reference Manual, March, Santa Clara, CA.

National Semiconductor Corp, 1984, CIM-602/604 Card Cages User's Manual, December, Santa Clara, CA.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4115**
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AUTHORIZATIONS		
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REVISION HISTORY			
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0.1	Changes to responsibilities.	April 1998	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general tasks performed during annual routine site visits to optical monitoring sites operated according to IMPROVE Protocol. Annual visits to optical monitoring sites are performed to assure quality data capture and minimize data loss by:

- Replacing all field monitoring instrumentation annually with fully refurbished and calibrated instrumentation.
- Ensuring that instrumentation removed from the field after one year of service is fully refurbished and calibrated.
- Ensuring that field support equipment (shelters, towers, power systems, system wiring, etc.) is in good condition and properly maintained.
- Verifying instrument performance in the field.
- Training site operator(s) in routine operations and system troubleshooting.

Two (2) types of optical monitoring instruments are currently operating in the IMPROVE visibility monitoring network:

- Ambient nephelometers (NGN-2)
- Transmissometers (LPV-2)

General tasks performed during an annual site visit are basically the same for both instruments. Detailed instrument-specific annual site visit procedures referenced by this SOP are as follows:

- TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*
- SOP 4710, *Transmissometer Field Audit Procedures*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each optical field site.

- Communicate to the field specialist, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Provide the Contracting Officer's Technical Representative (COTR) with a list of scheduled site servicing dates, ARS personnel who will visit each site, and names of the primary site contacts. Site operators and their supervisors must be notified either directly or through the COTR at least two weeks prior to a site visit.

- Review site visit documentation with the field specialist, data analyst, and instrument technician.

- Provide the field specialist with calibration numbers for the installation and reference transmissometers.

- Review on-site audit data to confirm correct system operation before the field specialist leaves the site.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the project manager and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Communicate to the instrument technician, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Ensure that all instrumentation (and associated calibrations), equipment, materials, and tools are properly prepared and are fully functional.

- Perform all procedures outlined in this TI.

- Make travel and shipping arrangements.

- Follow-up on resolution of any problems encountered on-site that could not be resolved during the site visit.

- Arrange for on-site purchase and delivery of equipment and/or materials that are best obtained locally.

- Hold a training session for site operators during the site visit.

- Review site documentation with the project manager, instrument technician, and data analyst.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Coordinate with the site operator, his/her supervisor, field specialist, project manager, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and project manager regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Perform all servicing, maintenance, modifications, and calibration of instrumentation prior to the site visit.

- Ensure that all instrumentation is in good operating condition prior to shipment.

- Communicate to the field specialist any equipment or instrument modification, or servicing requirements that must be performed on-site.

- Review site visit documentation with the field specialist, data analyst, and project manager.

2.4 DATA ANALYST

The data analyst shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and project manager regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, project manager, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Review site documentation with the project manager, field specialists, and instrument technician.

- Communicate to the field specialist during the site visit any problems evident in the collected data.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate with the project manager, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.
- Communicate to the instrument technician, data analyst, and field specialist any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.
- Be available for training during the site visit and arrange to have at least one backup operator also attend the training session.
- Assist the field specialist with the optical system replacement and other tasks that require assistance.

2.6 TECHNICAL ASSISTANT

The technical assistant shall:

- Verify and update the IMPROVE transmissometer inventory using on-site inventory information recorded during the annual visit.
- Prepare transmissometer on-site inventory report after updating the inventory.

3.0 REQUIRED EQUPMENT AND MATERIALS

The following subsections provide summary lists of equipment and materials required to perform routine on-site maintenance and servicing tasks during annual site visits to optical monitoring sites. Other system components or special tools may be required to perform non-routine field maintenance.

3.1 EQUIPMENT AND MATERIALS FOR NEPHELOMETER SITE VISITS

Specific instrumentation, equipment, tools, and materials generally required for a nephelometer annual site visit include the following (see TI 4115-3005 for a detailed list):

- A replacement nephelometer.
- A replacement datalogging and control subsystem.
- A replacement data collection platform (DCP) (if needed).
- A replacement AT/RH sensor.
- A digital voltmeter (DVM).
- An auditing AT/RH sensor.

- A replacement tank of calibration gas, calibration gas regulator, and uninterruptable power supply.
- A standard field service tool kit.
- An HP200LX Palmtop computer with programs required to communicate with and control the NGN-2 nephelometer, Campbell 21X datalogger, and the Blue Earth micro-controller.
- A telephone handset, line simulator, cables, and a cellular telephone for remote sites.
- Documentation cameras.
- A replacement rotameter (flowmeter).
- A replacement Campbell storage module.
- Nephelometer Servicing Site Visit Trip Report (Figure 4-1)
- Optec NGN-2 Nephelometer Field Installation Shipping Checklist (Figure 3-1)
- Post-maintenance nephelometer calibration data
- Miscellaneous site information (maps, contacts, directions, gates, locks, keys, etc.)
- A Site Operator's Manual containing all applicable technical instructions.
- Optec NGN-2 Technical Manual for Theory of Operation and Operating Procedures
- Log sheets

3.2 EQUPMENT AND MATERIALS FOR TRANSMISSOMETER SITE VISITS

Specific instrumentation, equipment, tools, and materials generally required for a transmissometer annual site visit include the following (see TI 4115-3000for a detailed list):

- A replacement transmissometer with calibrated lamps.
- A reference transmissometer with calibrated lamps.
- A replacement data collection platform (DCP) (if needed).
- A replacement AT/RH sensor.
- A digital voltmeter (DVM).
- An auditing AT/RH sensor.
- Replacement on-site receiver and transmitter DVMs (if needed).

- A replacement Campbell 21X datalogger.
- A standard servicing tool kit.
- A palmtop computer, capable of programming Handar 540A and 570A data collection platforms, with associated cable connectors.
- A calculator.
- Two 2-way radios.
- Documentation cameras.
- Replacement power supplies and surge protectors/suppressors.
- Replacement solar panel regulator(s) (if needed).
- Transmissometer Servicing Site Visit Trip Report (Figure 4-1)
- Optec LPV-2 Transmissometer Field Installation Shipping Checklist (Figure 3-1)
- Receiver and transmitter site transmissometer field audit forms.
- A Site Operator's Manual containing all applicable technical instructions.
- Log sheets.
- Optec LPV-2 Technical Manual for Theory of Operation and Operating Procedures

4.0 METHODS

Optical monitoring instruments at IMPROVE Protocol monitoring sites are removed from the field for laboratory servicing on an annual basis. Spare monitoring systems are installed as replacements for instruments and support equipment removed for laboratory servicing. Field specialists visit sites to perform this changeout of monitoring system components. As a part an annual site visit, a field specialist also performs a number of equipment checks and performance tests that provide information relating to the system's operation during the past 12 months, and verify that the replacement system has a high probability of operating successfully over the next 12 months. To further ensure successful operation and collection of high quality data, a comprehensive site operator training session, which includes a thorough review of routine operations and system troubleshooting procedures, is conducted by the field specialist.

General procedures included in an annual site visit are basically the same for nephelometers and transmissometers. This section outlines the general procedures for each type of instrument and includes two (2) subsections:

4.1 Nephelometer Annual Site Visits
4.2 Transmissometer Annual Site Visits

Detailed descriptions of annual site visit procedures for nephelometers and transmissometers are provided in TI 4115-3000 and TI 4115-3005.

4.1 NEPHELOMETER ANNUAL SITE VISITS

The nephelometer annual site visit includes the following procedures:

- Pre-visit preparation
- Pre-removal system inspection and equipment inventory
- Pre-removal system performance check and nephelometer calibration
- Removal and replacement of nephelometer, datalogging and control subsystem, and AT/RH sensor
- Post-installation system performance check and nephelometer calibration
- Post-installation system inspection and equipment inventory
- On-site training of the site operator
- Post-visit site operations review and inventory verification
- Archiving of all annual site servicing documentation

4.2 TRANSMISSOMETER ANNUAL SITE VISITS

The transmissometer annual site visit includes the following procedures:

- Pre-visit preparation
- Pre-removal system inspection and equipment inventory
- Pre-removal system operations and performance verification
- Removal and replacement of the AT/RH sensor
- Field audit and removal of the on-site transmissometer
- Installation and field audit of the replacement transmissometer
- Post-installation system operations and performance verification
- Post-installation system inspection and equipment inventory
- On-site training of the site operator
- Post-visit site operations review and inventory verification
- Archiving of all annual site servicing documentation

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**ANNUAL SITE VISIT PROCEDURES FOR OPTEC LPV-2 TRANSMISSOMETER SYSTEMS (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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REVISION HISTORY

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1.0	Trip report modifications	March 1995	
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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) outlines and describes the procedures involved in performing annual routine site visits to Optec LPV-2 transmissometer sites operated according to IMPROVE Protocol, with the primary purpose of ensuring quality data recovery and minimizing data loss from the transmissometer system. This TI is referenced in standard operating procedure (SOP) 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*.

The annual routine site visit includes:

- Scheduling the visit.
- Preparing and shipping equipment and instrumentation to the site.
- Documenting initial conditions.
- Verifying system operation (pre-removal).
- Removing the existing transmissometer and AT/RH sensor.
- Installing the replacement transmissometer and AT/RH sensor.
- Verifying replacement system operation (post-installation).
- Performing inspections, operational checks, maintenance, and/or replacing support equipment.
- Performing a field audit of existing and replacement transmissometers with a reference transmissometer.
- Testing window transmittance.
- Servicing, cleaning, and maintenance.
- Updating site inventories.
- Providing operator training.
- Preparing and return shipping of all instruments, tools, etc.
- Documenting all aspects of the site visit.

This TI outlines annual site visit procedures, except field audit and window transmittance procedures (refer to SOP 4710, *Transmissometer Field Audit Procedures*).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each transmissometer field site.

- Communicate to the field specialist, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Provide the Contracting Officer's Technical Representative (COTR) with a list of scheduled site servicing dates, ARS personnel who will visit each site, and names of the primary site contacts. Site operators and their supervisors must be notified either directly or through the COTR at least two weeks prior to a site visit.

- Provide the field specialist with calibration numbers for the installation and reference transmissometers.

- Review on-site audit data to confirm correct system operation before the field specialist leaves the site.

- Review site visit documentation with the field specialist, data analyst, and instrument technician.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the project manager and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each transmissometer field site.

- Communicate to the instrument technician, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Ensure that all instrumentation (and associated calibrations), equipment, materials, and tools are properly prepared and are fully functional.
- Perform all procedures outlined in this TI.
- Make travel and shipping arrangements.
- Follow-up on resolution of any problems encountered on-site that could not be resolved during the site visit.
- Arrange for on-site purchase and delivery of equipment and/or materials that are best obtained locally.
- Hold a training session for site operators during the site visit.
- Review site documentation with the project manager, instrument technician, and data analyst.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Coordinate with the site operator, his/her supervisor, field specialist, project manager, and data analyst regarding priority and scheduling of routine servicing trips.
- Coordinate with the field specialist and project manager regarding scheduling, preparation, calibrations, and assignment of instrumentation for each transmissometer field site.
- Perform all servicing, maintenance, modifications, and calibration of instrumentation prior to the site visit.
- Ensure that all instrumentation is in good operating condition prior to shipment.
- Communicate to the field specialist any equipment or instrument modification, or servicing requirements that must be performed on-site.
- Review site visit documentation with the field specialist, data analyst, and project manager.

2.4 DATA ANALYST

The data analyst shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and project manager regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, project manager, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Review site documentation with the project manager, field specialists, and instrument technician.

- Communicate to the field specialist during the site visit any problems evident in the collected data.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate with the project manager, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, data analyst, and field specialist any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Be available for training during the site visit and arrange to have at least one backup operator also attend the training session.

- Assist the field specialist with the transmissometer system replacement and other tasks that require assistance.

2.6 TECHNICAL ASSISTANT

The technical assistant shall:

- Verify and update the IMPROVE inventory using on-site inventory information recorded during the annual visit.

- Prepare an on-site inventory report after updating the inventory.

3.0 REQUIRED INSTRUMENTATION, TOOLS, EQUPMENT, AND MATERIALS

All required equipment and materials are listed on a checklist, which the field specialist completes when preparing for a site visit. Figure 3-1 presents the Optec LPV-2 Transmissometer Field Installation Shipping Checklist.

OPTEC LPV-2 TRANSMISSOMETER
FIELD INSTALLATION SHIPPING CHECKLIST

Site: ______________________
Date: ______________________

Packing List #: ______________________
Method of Shipping: ____________________

[√] TO TAKE	[√] WHEN PACKED	ON-SITE EQUIPMENT	QUANTITY	SERIAL #
		Transmissometer		
		AT/RH Sensor		
		M16 Voltage Regulator with Spare Fuses		
		Battery Interconnects (3 pair)		
		Surge Suppressors		
		DCP		
		DCP Support Equipment:		
		a. Trickle Charger		
		DVM		
		Control Box Stand		
		Windows:		
		a. Transmitter		
		b. Receiver		
		Terminal Strip Board		
		Power Cords		
		10 amp Power Supply		
		5 amp Power Supply		
		Cleaning Supplies		

AUDIT EQUIPMENT

		Reference Transmissometer		
		Campbell Datalogger		
		Tool Box		
		Palmtop Computer		
		Radio Sets		
		AT/RH Audit Kit		
		Aperture Ring		
		Fuse Kit		
		Audit DVM		

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Figure 3-1. Optec LPV-2 Transmissometer Field Installation Shipping Checklist.

3.1 INSTRUMENTATION

Instrumentation required during a routine site visit includes:

- A replacement transmissometer with calibrated lamps.
- A reference transmissometer with calibrated lamps.
- A replacement data collection platform (DCP) (if needed).
- A replacement AT/RH sensor.
- A digital voltmeter (DVM) (supplied by the field specialist).
- An auditing AT/RH sensor.
- Replacement on-site receiver and transmitter DVMs (if needed).

3.2 TOOLS

A complete tool kit is recommended as on-site tasks vary from instrument repair to minor shelter repairs or modifications. Non-standard tools often required include:

- A cordless drill with screw bits, drill bit set, and assorted (¾" – 1½") wood bits.
- A battery electrolyte tester.
- A crimp tool for solar panel regulator "quick-connectors."

3.3 EQUIPMENT

Equipment required during a routine site visit includes:

- A standard field servicing kit (spare components, chips, hardware, batteries, fuses, etc.).
- A palmtop computer, capable of programming Handar 540A and 570A data collection platforms, with associated cable connectors.
- A calculator.
- A Campbell 21X datalogger programmed to log transmissometer receiver computer outputs, with associated cable and connector (refer to SOP 4710, *Transmissometer Field Audit Procedures*).
- Two 2-way radios.

- Digital camera for documentation.

- A replacement 10 amp power supply for AC line power transmitter sites (if needed).

- A replacement 5 amp power supply for AC line power receiver sites (if needed).

- Replacement surge protector(s)/suppressor(s) for AC line powered sites (if needed).

- Replacement solar panel regulator(s) with quick-connectors for solar powered receiver and transmitter sites (if needed).

Typically, the deep-cycle batteries used at solar-powered sites should be replaced every two years. Since long-range transport of these batteries is difficult, it is best to order these batteries from a local dealer near the site prior to the site visit. NAPA Group 27 deep-cycle batteries are found to be the most reliable. Verify that the batteries are fully charged prior to installation. Battery interconnect cables should be replaced at this time.

3.4 MATERIALS

The following documentation forms and information sheets should be taken on each visit:

- Transmissometer Servicing Site Visit Trip Report (Figure 4-1)

- Receiver and transmitter site transmissometer field audit forms (see SOP 4710)

- Operational calibration memos for existing and replacement transmissometers (see TI 4200-2100)

- Audit calibration memo for the reference transmissometer (see TI 4200-2100)

- Spare receiver and transmitter station LPV-2 transmissometer operator log sheets (see TI 4110-3100)

- Optec LPV-2 Transmissometer Field Installation Shipping Checklist (Figure 3-1)

The site operator's manual on-site should contain the following for reference:

- SOP 4110, *Transmissometer Maintenance (IMPROVE Protocol)*

- TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

- TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

- TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*

- TI 4110-3375, *Replacing and Shipping Transmissometer Components*

- SOP 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*

- TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

- SOP 4710, *Transmissometer Field Audit Procedures*

- Optec LPV-2 Technical Manual for Theory of Operation and Operating Procedures

- Primeline manual

4.0 METHODS

This section describes annual site visit procedures for transmissometer systems, and includes 12 major subsections:

4.1 Pre-Visit Preparation
4.2 General Trip Information
4.3 Initial Conditions at Receiver Stations
4.4 Receiver System Operation
4.5 Receiver Station Initial Inventory
4.6 Receiver Station Servicing
4.7 Initial Conditions at Transmitter Stations
4.8 Transmitter Station Initial Inventory
4.9 Transmitter Station Servicing
4.10 Training Procedures and Documentation
4.11 Field Audit Procedures
4.12 Post-Visit Procedures

4.1 PRE-VISIT PREPARATION

Prior to travel to the site, the following preparations need to be made (for individual responsibilities refer to Sections 2.1 through 2.6):

- Schedule the site visit and notify the COTR.

- Schedule and perform instrument servicing, calibrations, and tests.

- Coordinate with site personnel to arrange for:

  - Site operator training (approximately 2-4 hours; schedule for the day <u>prior</u> to the field audit).
  - Assistance with the internal transmissometer audit and window transmittance tests (approximately 4-6 hours).
  - Any other assistance needed from on-site personnel.

- Organize all instruments, equipment, tools, and materials.
- Arrange for on-site procurement of equipment, tools, or materials.
- Verify transmissometer calibration numbers and lamp installation order.
- Investigate what site-specific problems need to be addressed on-site.
- Ship instruments, equipment, tools, and materials directly to the site or preferably airfreight all items to a major airport near the site to be held for pick-up by the field specialist.
- Arrange travel.

The field specialist should contact the site operators and their supervisor (if involved with the on-site transmissometer system servicing and maintenance) upon arrival at the site. The prearranged schedules for operator training, transmissometer field audit (reference instrument), window transmittance tests, and any other work the field specialist will need assistance with should be confirmed at this time.

The Transmissometer Servicing Site Visit Trip Report, Figure 4-1, must be used to document servicing tasks. This form generally follows the order in which procedures are performed and serves as a checklist for site conditions review, operational verifications and checks, and inventories. Procedures not included on the trip report are included in SOP 4710, *Transmissometer Field Audit Procedures*.

4.2 GENERAL TRIP INFORMATION

Refer to Figure 4-1, page 1 for the following:

SITE	Use either the full location name or the four-letter site abbreviation.
DATES	Record the calendar date duration of the entire servicing trip, including travel.
TECHNICIAN	Use the full name or the first initial and last name.
SITE VISIT OBJECTIVES	List the primary objectives of the site visit, especially any that are not standard for site visits.
TRIP SUMMARY	List the major actions taken for each day, including travel and locations. Any general comments pertaining to the trip should be noted in the comments section.

TRANSMISSOMETER SERVICING
SITE VISIT TRIP REPORT

Site: ______________________________

Technician: ______________________________ Dates: ______________________________

Site Visit Objectives: ______________________________

TRIP SUMMARY

Day/Date: Actions:

Comments:

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Figure 4-1. Transmissometer Servicing Site Visit Trip Report.

RECEIVER STATION – INITIAL CONDITIONS

Transmissometer LPV No. _______________ Does the instrument appear to be working properly: YES NO

Comment: ____

Receiver Display: C________ B________ VR________ Local Time_____:_____ Toggle ON OFF

Settings: Gain _______ Cal _______ Dist _______ A1 _______ A2 _______ Int _______ Cycle ______

○ Alignment: Mark initial location of transmitter light source with a "+".

Comments: ____

Window Cleanliness: good moderate poor Comments: ______________________

Lens Cleanliness: good moderate poor Comments: ______________________

Timing:

1. Is your watch synchronized with NBS (WWV) time? (303-499-7111) YES NO
2. Receiver update time (HR:MIN:SEC) ________:________:________

*** Note transmitter on/off times on Transmitter Station – Initial Conditions section ***

Alti-azimuth Base Operation: ____
AT/RH Sensor and Holder: ____
DCP Antenna Elements/Cable: _______________ Alignment Azimuth (°T) _______________ Incl. _________
Terminal Strip and Wiring: ____

Power System:
Power Supply ______________________ Output ____________V
Solar Panels ______________________ Output ____________V
Batteries ______________________ Output ____________V
Surge Protector Indicators ______________________
Regulator Operation ______________________
Wiring Condition ______________________

Shelter:
Hood/Window Frame Condition ______________________
Shelter Cleanliness ______________________
Shelter Condition ______________________
Vents: Size ________ No. ________ Filters ________ Foam Inserts ________

Comments: ____

____

Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

SYSTEM OPERATION VERIFICATION

☐ Pre-Removal ☐ Post-Installation

Digital Voltmeter MFR/Model/SN: ______________________________

AT/RH audit sensor MFR/Model/SN: ______________________________

Data Check: Date: ______________ Time: ______________

	Front Panel	Terminal Strip	DCP (570A Only)	Downloaded
A1 Switch (C)	________	________ VDC	CH1 ________	Data ________
(B)	________	________ VDC	________	Data ________
Toggle Lamp	ON OFF	________ VDC	CH2 ________	Data ________
A2 Switch (SD)		________ VDC	CH3 ________	Data ________
(CR)		________ VDC	________	Data ________

	Measured		
AT (DEG F or C)	________	CH4 ________	Data ________
RH (%)	________	CH5 ________	Data ________
DCP Battery (VDC)	________	CH10 ________	Data ________

b_{ext} Check: b_{ext} Calculated: ______________ From Raw Reading (C): ______________

b_{ext} (1/km) = -(ln T/Path Distance), T = C (A1 Raw Counts) / Cal. No.

Comments: ______________________________
____
____
____

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

RECEIVER STATION – INITIAL INVENTORY

	Changed	On-Site Mfr./Model/SN	Replacement Mfr./Model/SN
Transmissometer	☐	______	______
Alti-azimuth Base	☐	______	______
Data Collection Platform	☐	______	______
AT/RH Sensor	☐	______	______
Antenna	☐	______	______
Strip Chart	☐	______	______
Window	☐	______	______
Terminal Strip	☐	______	______
Batteries	☐	______	______
Power Supply	☐	______	______
Surge Protector	☐	______	______
Solar Panels	☐	______	______
	☐	______	______
	☐	______	______
DCP Solar Panel	☐	______	______
Regulator	☐	______	______

With Quick-connectors? YES NO

Voltmeter ______ ______ ______

Battery Replaced? YES NO Spare Battery? YES NO

Vandal Plate? YES NO Comment: ______

Tool Box YES NO

With Detector Head Allen Wrench	YES	NO
With Adjustable Wrench	YES	NO
With Medium Flathead Screwdriver	YES	NO
With Medium Phillips Screwdriver	YES	NO
With Signal Mirror	YES	NO

Fuse Kit YES NO Numbers and Types: ______

Supplies:

Kimwipes	______	Bottle Alcohol	______	Log Sheets	______
Window Cleaner	______	Blower Brush	______	Operator's Manual	______
Paper Towels	______	Distilled H_2O	______	b_{ext} SVR Sheet	______
		H_2O Dispenser	______		

Shipping Cases: Recvr. Computer _____ Transmitter _____ DCP _____ Recvr. Telescope _____

Storage Location(s): ______

______

Shelter Type/Size: ______

Shelter Key: ______ Spare Key Hidden: ______

Comments: ______

______

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

RECEIVER STATION - SERVICING

Receiver Replacement Date: ______________ Time: ____________ Receiver No.: ____________

AA Batteries Installed?	YES	NO
Computer Cards Seated?	YES	NO
Interconnect Cables:	OK	Replaced
Battery Terminals cleaned?	YES	NO
Power Cable	OK	Replaced
Battery Voltage Monitoring Cable	OK	Replaced

Miscellaneous Replaced Items: ______________________________

____

Antenna Alignment Connection: Azimuth (°T) ____________ Incl. ____________

Additional Power Supply Servicing/Checks: ______________________________

____

Supplement Tool Kit: ______________________________

Supplement Cleaning Supplies: ______________________________

Supplement Log Sheets/Update Operator's Manual: ______________________________

Shelter Cleaning: ______________________________

Additional Servicing Done: ______________________________

____

Follow-up Tasks Required: ______________________________

____

____

____

____

***** Complete and attach LPV-2 Transmissometer Operator Log Sheet – Receiver Station *****

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

TRANSMITTER STATION – INITIAL CONDITIONS

Lamp Number: _______________ Does the instrument appear to be working properly: YES NO

Comment: ____

○ Alignment: Mark initial location of receiver shelter window with a "+".

Comments: ____

Window Cleanliness: good moderate poor Comments: ______________________________

Lens Cleanliness: good moderate poor Comments: ______________________________

Lamp Check: **IMPORTANT:** Must be done when lamp is ON under automatic control.

a) LED (indicator light on side of control box) ON OFF

b) Lamp voltage with on-site DVM: ________ volts audit DVM: ________ volts

Timing:

1. Is your watch synchronized with NBS (WWV) time? (303-499-7111) YES NO
2. Transmitter Light ON, Exact Time (HR:MIN:SEC) ___________:___________:___________
3. Transmitter Light OFF, Exact Time (HR:MIN:SEC) ___________:___________:___________

Alti-azimuth Base Operation: ____

Lamp Voltage Monitoring DVM and Connections: ____

Power System:
- Power Supply ________________________________ Output ___________V
- Solar Panels ________________________________ Output ___________V
- Batteries ________________________________ Output ___________V
- Surge Protector Indicators ______________________________________
- Regulator Operation ______________________________________
- Wiring Condition ______________________________________

Shelter:
- Hood/Window Frame Condition ______________________________________
- Shelter Cleanliness ______________________________________
- Shelter Condition ______________________________________
- Vents: Size ________ No. ________ Filters ________ Foam Inserts ________

Comments: ____

____

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

TRANSMITTER STATION – INITIAL INVENTORY

	Changed	On-Site Mfr./Model/SN	Replacement Mfr./Model/SN
Alti-azimuth Base	☐	________	________
Window	☐	________	________
Solar Panels	☐	________	________
	☐	________	________
	☐	________	________
	☐	________	________
	☐	________	________
Power Supply	☐	________	________
Surge Protector	☐	________	________
Solar Panel Regulator	☐	________	________
Digital Voltmeter	☐	________	________

Measurement Pigtail Set? YES NO Comment: ________

Control Box Stand? YES NO Comment: ________

Vandal Plate? YES NO Comment: ________

Tool Box? YES NO Comment: ________

Small Flathead Screwdriver YES NO

Fuse Kit? YES NO Numbers and Types: ________

Supplies:

Kimwipes	________	Bottle Alcohol	________	Log Sheets	________
Window Cleaner	________	Blower Brush	________	Operator's Manual	________
Paper Towels	________	Distilled H_2O	________		
		H_2O Dispenser	________		

Shelter Type/Size: ________

Shelter Key: ________ Spare Key Hidden: ________

Comments: ________

____

____

____

____

____

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

TRANSMITTER STATION - SERVICING

Transmitter Replacement Date: ______________ Time: ____________ Transmitter No.: ______________

Lamp No. Put Into Service: ______________ Lamps On-Site: ____

AA Batteries Installed?	YES	NO
Interconnect Cables:	OK	Replaced
Battery Terminals cleaned?	YES	NO
Power Cable	OK	Replaced
Battery Voltage Monitoring Cable	OK	Replaced
Lamp Voltage Monitoring Cable	OK	Replaced

Miscellaneous Replaced Items: ____

____

____

Supplement Tool Kit: ____

Supplement Cleaning Supplies: ____

Supplement Log Sheets/Update Operator's Manual: ____

Shelter Cleaning: ____

Additional Servicing Done: ____

____

Follow-up Tasks Required: ____

____

____

____

____

***** Complete and attach LPV-2 Transmissometer Operator Log Sheet – Transmitter Station *****

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Figure 4-1. (Continued). Transmissometer Servicing Site Visit Trip Report.

4.3 INITIAL CONDITIONS AT RECEIVER STATIONS

Document the "as found" conditions of the following (refer to Figure 4-1, page 2):

INSTRUMENT NUMBER	Record the Optec instrument number from the receiver telescope, detector head, or computer. All components should have the same number, if not, carefully document the number of each individual component.
OPERATIONAL STATUS	Note if the instrument appears to be operating correctly. Comment on any observed inconsistency.
RECEIVER DISPLAY READING SETTINGS	Record the current display reading, also noting the local time and if the toggle light is on or off.
SWITCH A1 READINGS	Record the A1 display values for C, B, and VR A1 switch settings.
ALIGNMENT	Mark the initial location of the light source inside the reticle diameter on the form. If misaligned, record the severity of the misalignment by using the diameter of the reticle circle and the angle from the center of the reticle (i.e., alignment off by 0.4D @ 345°).
INITIAL WINDOW CLEANLINESS	Record degree of window cleanliness and type of uncleanliness.
LENS CLEANLINESS	Record degree of lens cleanliness and type of uncleanliness. If degree and/or type of uncleanliness is significant, do not clean. This will be incorporated into the post-calibration of the system at the ARS calibration facility.
TIMING	Record update time of the receiver and on/off times of the transmitter. Ensure that time is according to NBS (National Bureau of Standards) (WWV) time.
ALTI-AZIMUTH BASE OPERATION	Note operation and condition of the alti-azimuth base.
AT/RH SENSOR AND HOLDER	Note the condition of the AT/RH sensor and holder. Look for any accumulation of dirt, insects, or corrosion on the sensor or shield.

DCP ANTENNA ELEMENTS/ CABLE AND ALIGNMENT	Note the condition of the DCP antenna elements and cable. All elements should be tight and perpendicular to the shaft. The cable should be in good condition and all connectors secure. Note the alignment (azimuth and inclination) of the antenna.
TERMINAL STRIP AND WIRING	Check and record terminal strip and related wiring condition. All wires should be in good condition and all terminals secure.
POWER SYSTEM	At AC-powered sites, note the condition of the power supply and measure the power supply output voltage at the connectors. Also check the indicator lights on the surge protector.

At solar-powered sites, note the condition of the panels, support frame, and wiring. Panel output voltage is best measured by disconnecting the "quick-connector" at the solar panel regulator on the side coming in from the panels and measuring the output voltage at this point using the field specialist DVM. Lighting conditions on the panels should also be noted.

Note the battery condition (degree of terminal corrosion, electrolyte levels, etc.). Also record the output voltage. This is best measured at the power cable connection on the back of the receiver after disconnecting the connector.

At solar-powered sites, observe solar panel regulator operation to ensure that it is cycling properly. With adequate incident light on the solar panels to charge the batteries, proper Sun Selector M-16 Status Indicator LED cycling is as follows:

Ready: The ready LED will light when the solar panel voltage is high enough to charge the batteries.

Analyzing: The analyzing LED will light for 10-15 seconds before the charging light engages.

Charging: The charging LED will light when full charging current is flowing to the batteries. Charging continues for a maximum of 5 minutes per cycle or until the batteries have reached the maximum charging voltage. This LED cycles on and off opposite the analyzing LED.

Finishing: The finishing LED will start to flash as the battery voltage increases over 14.0 VDC.

Also refer to the Sun Selector M-8/M-16 Operation and Installation Sheet.

Note the condition of the power system wiring.

SHELTER — Note the condition of the hood and window frame.

Note the cleanliness of the shelter.

Note general condition of the shelter and any related maintenance needs.

Note the size and number of vent openings in the shelter and if there are filters and/or foam inserts in the vents.

4.4 RECEIVER SYSTEM OPERATION

The purpose of this check is to ensure agreement between receiver computer displayed readings, computer output voltages, and DCP transmitted data. An audit AT/RH sensor is used to check operation of the on-site AT/RH sensor. The pre-removal verification check is performed prior to any site servicing. The post-installation verification check is performed after the field audit has been completed.

At sites with 570A DCPs, the DCP stored transmissometer outputs, AT/RH measurements, and DCP battery voltage can be checked on the DCP display by scrolling through the channels using the display button. This can be done at any time after half past the hour when the inputs from the transmissometer computer and AT/RH sensor are scanned. Perform the operation verification check at least twice, preferably for consecutive hourly transmissometer readings.

Transmitted DCP data for the time of the operation verification checks should be verified from the field by calling the data analyst to obtain the DCP transmitted values. All transmissometer readings should be taken between 20 minutes after the hour and before the next hour, and a DCP reading must be taken between 31 minutes after the hour and before the next hour, to properly record the current hour's data.

The procedures for performing the operation verification check are detailed below (refer to Figure 4-1, page 3):

PRE-REMOVAL OR POST-INSTALLATION — Note if the check is for pre-removal or post-installation of an instrument.

DVM AND AT/RH — Record the make, model, and serial number of the digital voltmeter (DVM) and audit AT/RH sensor.

DATA CHECK — Record the date and local time.

A1 Switch. With the receiver computer displaying a valid reading, record the A1 display values for the A1 switch: Raw Reading (C) and b_{ext} (B). For each switch setting, also measure and record the voltage at the terminal strip. Refer to the terminal strip wiring diagram (TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*) for the corresponding terminal voltage points.

Toggle LED. Note the state (on/off) of the toggle light and measure the corresponding voltage at the terminal strip.

A2 Switch. Measure and record the voltages at the terminal strip for the reading (CR) and standard deviation (SD) A2 – switch positions.

AT/RH SENSOR — AT/RH measurements with the audit AT/RH sensor should be taken at half past the hour. This is when the DCP logs the on-site AT/RH sensor measurement.

b_{EXT} — Calculate the b_{ext} from the raw reading (C) using the following equations:

$$b_{ext}\,(1/\text{km}) = -(\ln T/\text{Path Distance}),\ T = C/\text{Cal. No.}$$

COMMENTS — Comment on any problems, conditions, etc. that were encountered during the operation verification check.

4.5 RECEIVER STATION INITIAL INVENTORY

Refer to Figure 4-1, page 4. Inventory of all items at the receiver site according to the inventory list on the servicing form. Also note any additional items on-site that do not appear on the inventory list.

4.6 RECEIVER STATION SERVICING

Servicing tasks and procedures at the receiver site are primarily replacement or operational checks of instruments and equipment. Shelter cleaning and supplementation of operator servicing materials is also done at this time. The individual tasks, procedures, and operational checks are as follows (refer to Figure 4-1, page 5):

RECEIVER REPLACEMENT — Remove the existing receiver. Install the replacement receiver and record the LPV number and the date and time installed.

Refer to TI 4110-3375, *Replacing and Shipping Transmissometer Components*, for procedures in removing and replacing the transmissometer receiver unit.

Note if the AA timing batteries were installed and if cables were replaced.

MISCELLANEOUS REPLACED ITEMS	Record replacement of any items not included above.
ANTENNA ALIGNMENT	If antenna alignment needs to be corrected, document the adjusted alignment azimuth and inclination. (refer to TI 4110-3375, *Replacing and Shipping Transmissometer Components*).
ADDITIONAL POWER SUPPLY SERVICING/ CHECKS	Document any additional servicing and/or checks that were performed on the power supply system.
SUPPLEMENT TOOL KIT	Document if the tool kit was supplemented with any tools, fuses, or miscellaneous items.
SUPPLEMENT CLEANING SUPPLIES	If the cleaning supplies were supplemented, document the type and number.
SUPPLEMENT LOG SHEETS/ UPDATE SITE OPERATOR'S MANUAL	Document the supplementation of log sheets and/or the updating of the Site Operator's Manual for Transmissometer Monitoring Systems.
SHELTER CLEANING	Note if the shelter was cleaned. Cleaning normally involves wiping down shelves, system components and mounts, sweeping out the shelter, and removing any trash.
ADDITIONAL SERVICING	Document any additional servicing tasks performed.
FOLLOW-UP TASKS	Document the need for any additional servicing/maintenance that is not performed during the site visit and if this is to be done by site or ARS personnel.

4.7 INITIAL CONDITIONS AT TRANSMITTER STATIONS

Document the "as found" condition of the following, (refer to Figure 4-1, page 6):

LAMP NUMBER	Record the lamp number currently in the instrument.
OPERATIONAL STATUS	Note whether or not the transmitter unit appears to be working correctly. If not, comment on any observed inconsistency.
ALIGNMENT	Mark the initial location of the receiver shelter window inside the reticle diameter on the form. If misaligned, record the severity of

the misalignment by using the diameter of the reticle circle and the angle from the center of the reticle (i.e., alignment off by 0.4 D @ 345°).

INITIAL WINDOW CLEANLINESS	Record degree of window cleanliness and type of uncleanliness.
LENS CLEANLINESS	Record degree of lens cleanliness and type of uncleanliness. If degree and/or type of uncleanliness is significant, do not clean. This will be incorporated into the post-calibration of the system at the ARS calibration facility.
LAMP CHECK	LED. When the lamp is on under automatic control, note if the LED indicator light on the side of the control box is on or off. Lamp Voltage Reading. Measure and record the lamp voltage using the on-site DVM and the lamp voltage measurement pigtail. Also measure the voltage with the field specialist's DVM to confirm correct operation of the on-site DVM.
TIMING	Note whether or not the watch has been synchronized with NBS (National Bureau of Standards) (WWV) time; if not, this can be done by calling 303-499-7111. Note the exact time (hours, minutes, seconds) that the transmitter light comes on. Also note the exact time the light turns off.
ALTI-AZIMUTH BASE OPERATION	Note operation and condition of the alti-azimuth base and if the transmitter telescope unit attaches securely to the base.
LAMP VOLTAGE MONITORING DVM AND CONNECTIONS	Note the operation and condition of the lamp voltage monitoring digital voltmeter and the cables and connectors.
POWER SYSTEM	At AC-powered sites, note the condition of the power supply and measure the power supply output voltage at the connectors. Also check the indicator lights on the surge protector. At the solar-powered sites, note the condition of the panels, support frame, and wiring. Panel output voltage is best measured by disconnecting the "quick-connector" at the solar panel regulator on the side coming in from the panels and measuring the output voltage at this point using the field specialist DVM. Lighting conditions on the panels should also be noted. At solar-powered sites, observe solar panel regulator operation to ensure that it is cycling properly. With adequate incident light on

the solar panels to charge the batteries, proper Sun Selector M-16 Status Indicator LED cycling is as follows:

Ready. The ready LED will light when the solar panel voltage is high enough to charge the batteries.

Analyzing. The analyzing LED will light for 10-15 seconds before the charging light engages.

Charging. The charging LED will light when full charging current is flowing to the batteries. Charging continues for a maximum of 5 minutes per cycle or until the batteries have reached the maximum charging voltage. This LED cycles on and off opposite the analyzing LED.

Finishing. The finishing LED will start to flash as the battery voltage increases over 14.0 VDC.

Also refer to the Sun Selector M-8/M-16 Operation and Installation Sheet.

Note the condition of the power system wiring.

SHELTER — Note the condition of the hood and window frame.

Note the cleanliness of the shelter.

Note general condition of the shelter and any related maintenance needs.

Note the size and number of vent openings in the shelter and if there are filters and/or foam inserts in the vents.

4.8 TRANSMITTER STATION INITIAL INVENTORY

Refer to Figure 4-1, page 7. Inventory all items at the transmitter site according to the inventory list on the servicing form. Also note any additional items on-site that do not appear on the inventory list.

4.9 TRANSMITTER STATION SERVICING

Servicing tasks and procedures at the receiver site are primarily replacement or operational checks of instruments and equipment. Shelter cleaning and supplementation of operator servicing materials is also done at this time. The individual tasks, procedures, and operational checks are as follows (refer to Figure 4-1, page 8):

TRANSMITTER REPLACEMENT	Remove the existing transmitter. Install the replacement transmitter and record the LPV number and the date and time installed. Refer to TI 4110-3375, *Replacing and Shipping Transmissometer Components*, for procedures in removing and replacing the transmissometer transmitter unit.
LAMPS	Record the lamp number that is put into service and also the lamp numbers that are left on-site.
TIMING BATTERIES AND CABLES	Note if the four (4) AA timing batteries were installed in the transmitter control box. Note if any cables were replaced.
MISCELLANOUS REPLACED ITEMS	Record replacement of any items not included above.
SUPPLEMENT TOOL KIT	Document if the tool kit was supplemented with any tools, fuses, or miscellaneous items.
SUPPLEMENT CLEANING SUPPLIES	If the cleaning supplies were supplemented, document the type and number.
SUPPLEMENT LOG SHEETS/ UPDATE SITE OPERATOR'S MANUAL	Document the supplementation of log sheets and/or the updating of the Site Operator's Manual for Transmissometer Monitoring Systems.
SHELTER CLEANING	Note if the shelter was cleaned. Cleaning normally involves wiping down shelves, system components and mounts, sweeping out the shelter, and removing any trash.
ADDITIONAL SERVICING	Document any additional servicing tasks performed.
FOLLOW-UP TASKS	Document the need for any additional servicing/maintenance that is not performed during the site visit and if this is to be done by on-site personnel or ARS personnel.

4.10 TRAINING PROCEDURES AND DOCUMENTATION

Scheduling of the operator training session should occur with the scheduling of the annual site visit and the transmissometer field audit. Typically, the training session is scheduled for the day prior to the field audit.

All site operators and backup operators should attend the training session, along with the site monitoring manager, if possible. When initially contacting site personnel, confirm that on-site copies of the site operator's manual (refer to Section 3.4) are on hand.

The following technical instructions should be reviewed by operators unfamiliar with the transmissometer system prior to the training session:

- TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*
- TI 4110-3375, *Replacing and Shipping Transmissometer Components*

Approximately 3-4 hours should be allotted for the training session. It is preferable to begin the training at the transmitter station and then proceed to the receiver station. If time constraints, weather, site accessibility, etc. make training at the transmitter station difficult or infeasible, transmitter training can be done at the receiver station or in a room using the reference transmitter unit.

Training topics include:

- Purpose of the monitoring program and the role of Air Resource Specialists, Inc.
- Theory of transmissometer system operation.

The following topics are addressed at both the transmitter and receiver stations using the information and procedures outlined in the technical instructions:

- TI 4110-3100, *Routine Site Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4110-3350, *Transmissometer Monitoring System Diagrams and Component Descriptions*
- TI 4110-3375, *Replacing and Shipping Transmissometer Components*

4.11 FIELD AUDIT PROCEDURES

The field audit of the transmissometer system is performed after site servicing and operator training have been completed. Procedures for performing the field audit are described in SOP 4710, *Transmissometer Field Audit Procedures*.

4.12 POST-VISIT PROCEDURES

The following post-visit procedures must be completed within one (1) week following the field specialists' return:

- Site visit review
- Inventory verification and update
- Archiving site visit documentation

4.12.1 Site Visit Review

The field specialist will meet with the project manager, data analyst, and instrument technician to review all annual site servicing and field audit documentation. Items to be discussed in this review include:

- On-site equipment or operations problems identified.
- Site operator evaluation.
- Audit results.
- Site-related routine servicing requirements.
- Observed factors that could influence transmissometer readings.
- Operations-related requests from the site operator or other on-site personnel.
- Miscellaneous follow-up needs.

4.12.2 Inventory Verification and Update

The IMPROVE equipment inventory is maintained by the technical assistant. Items from the on-site initial inventory (Figure 4-1, pages 4 and 7) that are included in the IMPROVE equipment inventory are:

- Receiver station equipment:
  - Alti-azimuth base
  - Data collection platform (DCP)
  - DCP antenna
  - DCP solar panel
  - AT/RH sensor
  - Solar panels

- Transmitter station equipment:

  - Alti-azimuth base
  - Solar panels

The technical assistant will verify that the on-site initial inventory property numbers match the corresponding property numbers in the IMPROVE inventory for all items listed above. For system components replaced during the annual site visit (Figure 4-1, pages 5 and 8), the technical assistant will update the IMPROVE inventory to reflect these changes. An on-site inventory report (See Figure 4-2 for an example) is prepared by the technical assistant after the inventory has been updated.

4.12.3 Archiving Site Visit Documentation

Upon completion of the site visit review and IMPROVE inventory verification/update, the data analyst archives all annual site servicing documentation. This documentation is filed in site-specific operations notebooks located in the ARS Data Collection Center. Specific annual site visit documentation archived includes:

- Transmissometer Servicing Site Visit Trip Report

- On-Site Inventory Report

- Field Installation Shipping Checklist

- Field audit documentation as specified in SOP 4710, *Transmissometer Field Audit Procedures*

INVENTORY REPORT FROM FILE CBIMPINV.VWS

FOR SITE BANDELIER

02/10/94 16:26:36

ITEM ID#	ITEM NAME	MAN'F	MODEL	SERIAL #	PROPERTY NO.
58	ANTENNA	HANDAR	443A	2106	2106
128	DCP	HANDAR	540A	168	168
262	SOLAR PANEL	SOLAREX	SX-20	K-140031TF	K-140031T
312	SOLAR PANEL	SOLAREX	SX-56	K-160018TF	K-160018T
221	STRIP CHT RECOR	PRIMELINE	6723	851754B122	851754B12
612	TRANSMIS RECEIV BASE	OPTEC	86230	LPVR	NPS-90207
436	TRANSMIS RECEIV COMPUTER	OPTEC	86210	LPVR011	NPS-90145
469	TRANSMIS RECEIV DET HEAD	OPTEC	86222	LPVR011	NPS-90144
501	TRANSMIS RECEIV TELESCOP	OPTEC	86222	LPVJ011	NPS-90146
648	TRANSMIS TRANSM BASE	VON			NPS-90127
532	TRANSMIS TRANSM CONTROLLE	OPTEC	86200	LPVT011	NPS-90143
564	TRANSMIS TRANSMITTER	OPTEC	86200	LPVT011	NPS-90142
1132	AT/RH SENSOR	ROTRONIC	MP-100MF	28329	28329

(site1_h)
Page number 1

Figure 4-2. Example On-Site Inventory Report.

Air Resource Specialists, Inc.
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Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**CALIBRATION OF OPTICAL MONITORING SYSTEMS (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4200**
DATE	**JULY 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
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PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Added responsibilities/equipment/methods.	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the steps for calibration of optical monitoring instruments operated according to IMPROVE Protocol. Optical monitoring instruments are calibrated periodically to verify an instrument's performance, assure quality data capture, and minimize data loss by measuring an instrument's output in response to well-defined and controlled operating conditions.

The two types of optical monitoring instruments currently operating in the IMPROVE visibility monitoring network are ambient nephelometers and transmissometers. Calibration of ambient nephelometers is required under any of the following circumstances:

- Upon acceptance testing of a new instrument.
- Upon installation in the field.
- Prior to any corrective action, service, or maintenance to any portion of the instrument that would change the instrument's response to specified input conditions.
- At weekly intervals.

Calibration of transmissometers is required under the following circumstances:

- Upon acceptance testing of a new instrument.
- Prior to installation in the field.
- Immediately following removal of the instrument from the field.
- Following any corrective action, servicing, or maintenance that could affect the instrument's operational performance.

Nephelometer and transmissometer calibration results are used to:

- Convert raw measurement values to appropriate engineering units.
- Evaluate the instrument's performance and estimate the precision and accuracy of the instrument for specific operational periods.

The following technical instructions (TIs) provide detailed information regarding specific calibration procedures:

- TI 4200-2000 *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*
- TI 4200-2100 *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*
- TI 4200-2110 *Transmissometer Lamp Preparation (Burn-in) Procedures*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that nephelometer calibrations are performed as required.
- Schedule transmissometer calibrations.
- Review all calibration results with the field specialist.
- Identify inconsistencies in calibration results and initiate corrective action as required.
- Review and approve all changes to calibration procedures.
- Review transmissometer lamp inventory and status records to ensure a sufficient number of burned-in lamps are available.
- Approve purchase orders for new lamps.

2.2 FIELD SPECIALIST

The field specialist shall:

- Perform all required field calibrations.
- Document calibration results on the appropriate form.
- Review all calibration results with the project manager.
- Identify inconsistencies in calibration results and initiate corrective action as required.
- Enter calibration results in the site-specific Quality Assurance Database.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform a nephelometer calibration during acceptance testing and laboratory maintenance.
- Maintain a printout of nephelometer calibration results.
- Enter the calibration results in the site-specific Quality Assurance Database.
- Prepare lamps for transmissometer calibration.
- Measure pre-calibration transmissometer lamp voltages.
- Assist the field specialist in analyzing inconsistencies in calibration results.

- Prepare purchase orders for new lamps.
- Perform lamp burn-in procedures.
- Maintain the lamp inventory and status records.
- Coordinate with Optec, Inc. for replacement of lamps.

2.4 SITE OPERATOR

The site operator shall:

- Perform a nephelometer calibration every week.
- Record the results of the nephelometer calibration on the NGN-2 Nephelometer/Meteorology Log Sheet.

3.0 REQUIRED EQUIPMENT AND MATERIALS

3.1 NEPHELOMETER CALIBRATION

Required equipment and materials to calibrate nephelometer systems include:

- Calibration span gas
- A pressure regulator and adjustable flowmeter
- Calibration gas hoses and fittings
- HP200LX palmtop computer with DATACOMM software
- NEPHCOM.DCF communication configuration file
- Site maintenance forms
- Calibration forms
- TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*
- TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*

3.2 TRANSMISSOMETER CALIBRATION

Prior to calibrating a transmissometer, the lamps to be used with a specific instrument must be burned-in, to stabilize the lamp's filament position and light output. Required equipment and materials for burn-in includes:

- A supply of lamps
- Lamp ID labels

- Lamp burn-in fixture
- Power supply (13.8 VDC @ 25 amps)
- Documentation forms
- KimWipe tissues
- TI 4200-2110, *Transmissometer Lamp Preparation (Burn-in) Procedures*

Calibration of LPV-2 transmissometers is performed at the Fort Collins Transmissometer Test Facility. Equipment and materials required at the test facility include:

- Tracking transmissometer (LPV-2 transmissometer installed to monitor light transmission measurements over a path parallel and adjacent to the calibration path)
- Tracking nephelometer (NGN-2 nephelometer installed to monitor ambient scattering measurements adjacent to the calibration path)
- Campbell 21X datalogger and solid state storage modules
- Serial printer
- Digital voltmeter (4 1/2 digit)
- Neutral Density Filters (NDFs)
- Assorted calibration apertures
- Power supplies (12 volts DC)
- Cleaning supplies (for windows and transmissometer optics)
- Calibration documentation forms
- TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*

Analysis and review of transmissometer calibration data requires the following:

- IBM-compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Campbell Scientific datalogger support software
- ARS calibration support software

4.0 METHODS

This section includes two (2) major subsections:

4.1 Nephelometer Calibrations
4.2 Transmissometer Calibrations

4.1 NEPHELOMETER CALIBRATIONS

Nephelometer calibration includes performing a clean air zero calibration and a span calibration. Calibration may be simple or complete:

- Simple calibration: A single zero and a single span value generally obtained by the site operator during routine servicing.
- Complete calibration: A series of zero and span values generally obtained during acceptance testing, installation, removal, laboratory servicing, or audit of the nephelometer by the field specialist or instrument technician.

4.1.1 Simple Calibration

Simple calibration of NGN-2 nephelometers occurs during any of the following checks:

- Site operator initiated zero and span checks performed weekly
- Remote, telephone modem initiated zero and span checks
- Field specialist initiated zero and span checks

Simple calibration of NGN-2 nephelometers includes:

- Clean air zero consisting of the average of 10 one-minute readings of particle-free air.
- Span consisting of the average of 10 one-minute readings of a span gas with known scattering properties.

The results of a simple calibration must be recorded on the appropriate documentation form and entered into the site-specific Quality Assurance Database.

4.1.2 Complete Calibration

Complete calibration of NGN-2 nephelometers are generally performed by the field specialist or instrument technician during servicing in the field or in the laboratory. Complete calibrations include:

- Twenty (20) 1-minute clean air zero readings
- Twenty (20) 1-minute span readings
- Recording of ambient temperature, relative humidity, and barometric pressure

The results of a complete calibration must be recorded on the appropriate calibration form and entered into the site-specific Quality Assurance Database.

4.1.3 Instrument Adjustment

Nephelometers must not be adjusted during calibration. Unadjusted calibration values are required for evaluating the performance and estimating the precision and accuracy of nephelometers. If the nephelometer cannot be calibrated, refer to the appropriate troubleshooting standard operating procedure and technical instruction.

4.2 TRANSMISSOMETER CALIBRATIONS

Transmissometer calibration includes pre-calibration preparation of lamps and the actual transmissometer calibration.

4.2.1 Lamp Preparation

Preparation of lamps prior to transmissometer calibration includes:

- Purchasing and visually inspecting lamps upon receipt
- Burning-in the lamps
- Visually inspecting burned-in lamps
- Documenting lamp voltage measurements of burn-in

4.2.2 Transmissometer Calibration

Transmissometer calibration includes pre-field and post-field calibration of an operational instrument, calibration of the audit instrument, and measuring window transmittances, including:

- Uniformity test of transmissometer receiver detector
- Calibration of transmissometer with the appropriate number of lamps for the defined operating period and sample frequency. Ten (10) lamps are calibrated for annual service intervals for instruments operating according to IMPROVE protocols.
- Measuring window transmittances
- Processing preliminary calibration data
- Documenting calibration configuration, weather and visibility conditions, and lamp voltage measurements on the calibration form
- Quality assurance review of calibration data
- Entry of calibration data in to the Transmissometer Calibration Database
- Calculation of site-specific calibration numbers for each lamp
- Maintenance of calibration documentation

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**CALIBRATION OF OPTEC LPV-2 TRANSMISSOMETERS (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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AUTHORIZATIONS		
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OTHER		

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1.0	Lamp calibration and aperture changes	March 1995	
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LIST OF FIGURES (CONTINUED)

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes calibration procedures for Optec LPV-2 transmissometers operated in accordance with IMPROVE Protocol. The purpose of transmissometer calibration is to assure quality data capture and minimize data loss by:

- Performing pre-field calibrations prior to installing an operational instrument at a field site.
- Performing post-field calibrations immediately after an instrument is removed from a field site.
- Performing pre-audit and post-audit calibrations on the audit transmissometer before and after it is used to perform a field audit of an operational transmissometer during an annual site servicing visit.
- Performing window transmittance measurements before and after the windows are installed in the IMPROVE network.

Calibration of LPV-2 transmissometers for operation in the IMPROVE network is performed at the Fort Collins Transmissometer Calibration and Test Facility. Pre-field calibration is required prior to installing an operational instrument at a network site and includes:

- A pre-field receiver detector uniformity check.
- Pre-field calibration of an annual supply of ten transmitter lamps (eight (8) on-site operational lamps, one (1) on-site reference lamp, and one (1) primary reference lamp).
- Completing the Optec LPV-2 Transmissometer Calibration Data Form.
- Calculation of a pre-field calibration number for each lamp calibrated and preparation of a site-specific calibration memo for the instrument prior to installing the instrument in the field.

Post-field calibration is required after an operational instrument has been removed from the network, but prior to any cleaning or servicing of the instrument. Post-field calibrations include:

- A post-field receiver detector uniformity check.
- Post-field calibration of all operational lamps, the primary reference lamp, and the on-site reference lamp.
- Completing the Optec LPV-2 Transmissometer Calibration Data Form.
- Calculating a lamp brightening factor for each post-calibrated lamp.

The audit transmissometer is used to perform on-site internal field audits of operational instruments during the annual site servicing visit (refer to Standard Operating Procedure (SOP) 4710, *Transmissometer Field Audit Procedures* and TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*). Audit instrument calibrations are performed prior to and after each use in the field. Calibration of the audit instrument includes:

- Pre-field and post-field receiver detector uniformity checks.
- Pre-field and post-field calibrations of a primary reference lamp, a traveling reference lamp, and four (4) field audit lamps.
- Completing the Optec LPV-2 Transmissometer Calibration Data Form.
- Calculating lamp-specific calibration numbers for use during the field audits.

Window transmittance is an operational factor that is used in determining lamp-specific calibration numbers. Window transmittance measurements include:

- Initial calibration measurements performed prior to using the windows at a site.
- Field verification measurements performed during the annual site visit (refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*).
- Final calibration measurements performed after the windows are removed from a site.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Schedule transmissometer calibrations.
- Review all calibration results with the field specialist.
- Identify inconsistencies in calibration results and initiate corrective action as required.
- Review and approve all changes to calibration procedures.

2.2 FIELD SPECIALIST

The field specialist shall:

- Perform all required field calibrations.
- Document calibration results on the appropriate calibration form.
- Review all calibration results with the project manager.

- Identify inconsistencies in calibration results and initiate corrective action as required.

- Enter calibration results into the instrument-specific Quality Assurance Database.

- Prepare a site-specific calibration memo for each instrument prior to installing the instrument in the field.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Prepare lamps for calibration following lamp burn-in procedures described in TI 4200-2100, *Transmissometer Lamp Preparation (Burn-in) Procedures*.

- Measure pre-calibration lamp voltages following procedures described in TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

- Notify the field specialist when laboratory servicing of a transmissometer has been completed and the instrument is ready for calibration.

- Assist the field specialist in analyzing inconsistencies in calibration results.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Calibration of LPV-2 transmissometers is performed at the Fort Collins Transmissometer Test Facility. Specific equipment and materials required at the test facility include:

- Tracking transmissometer (LPV-2 transmissometer installed to monitor light transmission measurements over a path parallel and adjacent to the calibration path)

- Tracking nephelometer (NGN-2 nephelometer installed to monitor ambient scattering measurements adjacent to the calibration path)

- Campbell 21X datalogger and solid state storage modules

- Serial printer

- Digital voltmeter (4 1/2 digit)

- Neutral density filters (NDFs)

- Assorted calibration apertures

- Power supplies (12 volts DC)

- Cleaning supplies (for windows and transmissometer optics)

- Calibration documentation forms

- TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*

- TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*

Analysis and review of transmissometer calibration data requires the following computer system hardware and software:

- IBM-compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Campbell Scientific datalogger support software
- ARS calibration support software

4.0 METHODS

To review descriptions of measurement techniques and system component functions of the LPV-2 transmissometer, refer to SOP 4110, *Transmissometer Maintenance (IMPROVE Protocol)*.

Calibration of the LPV-2 transmissometer determines the irradiance from the transmitter lamp that would be measured by the receiver if the optical sight path between the two units allowed 100% transmission. The LPV-2 transmissometer (all components) must be calibrated as a unit. Each lamp will have its own calibration number for use at a specific site with a specific transmissometer system. Receiver computers are individually calibrated during annual servicing (see TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*) and may be interchanged for emergency maintenance or for use with the audit instrument (see Section 4.3.7). Operation of an instrument with a receiver computer other than the receiver computer used at calibration requires recalculation of calibration numbers, but the instrument does not require recalibration. No other system component, including lamps, may be interchanged with another transmissometer without re-calibration.

All calibrations are performed at the Fort Collins Transmissometer Calibration and Test Facility. This facility, located at Colorado State University's Christman Field, includes sheltering and all support equipment required to conduct operational transmissometer calibrations. On-site instrumentation includes a datalogging system, a tracking transmissometer (to monitor relative changes in visibility along the calibration sight path during calibrations), meteorological instrumentation, electronic test equipment, and other support systems. The calibration path (the distance between transmitter and receiver during calibration) is 0.3 km. At this distance, the atmospheric transmission can be estimated with a high degree of accuracy for use in calculating the calibration number. A precision (2.74% transmission), high-quality, neutral-density filter installed on the transmitter and a 101.51 mm calibration aperture on the receiver telescope reduce the transmitted light intensity to a level well below the receiver detector saturation level. The increased light gathering capability of the receiver telescope operating near-full aperture (110.0 mm) reduces the effects of turbulence on the transmissometer calibration measurements. As a result, transmissometer calibrations can be performed over a wide range of visibility conditions.

Because lamp brightness is dependent on lamp voltage, the lamp voltage is measured in the laboratory prior to calibration, at the test site during calibrations, and in the laboratory following calibration. A shift in lamp voltage may indicate damage to the lamp or a malfunction of the lamp control circuitry. To facilitate lamp voltage measurements, the transmitter control cable for each instrument provides a 4-wire lamp connection at the transmitter lamp housing. Two wires provide power to the lamp directly from the transmitter control box. The other two wires (the measurement pigtail) provide a non-current carrying connection from the lamp connections to a voltmeter. This arrangement permits lamp voltage to be measured independent of the power cable voltage drop between the control box and the transmitter.

During annual laboratory servicing of the transmissometer, the receiver detector alignment is adjusted for maximum output (refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*). Detector alignment is performed on an optical bench which provides a short (18-20 inches) separation between the light source and the receiver detector. To ensure that the detector alignment is valid over a longer path, a detector uniformity test is performed at the field test site as the first step in performing any calibration.

This section includes four (4) major subsections:

4.1 Pre-Field Calibration
4.2 Post-Field Calibration
4.3 Audit Instrument Calibration
4.4 Window Transmittance Measurements

4.1 PRE-FIELD CALIBRATION

IMPROVE transmissometers are generally serviced and calibrated once per year. Pre-field calibration of a transmissometer is required prior to installing the instrument in the IMPROVE network and includes the following procedures:

- Burn-in of transmissometer lamps
- Measurement of pre-calibration lamp voltages
- Setup of instrumentation at the field calibration facility
- Measurement of receiver detector uniformity
- Calibration of ten (10) transmissometer lamps
- Measurement of pre-field lamp voltages
- Preliminary processing of calibration data
- Quality assurance review of calibration data
- Entry of calibration data into the Transmissometer Calibration Database
- Calculation of site-specific pre-field calibration numbers for each lamp
- Maintenance of pre-calibration documentation

The following subsections provide detailed instructions for performing the pre-field calibration procedures listed above.

4.1.1 Lamp Burn-in

All transmissometer lamps require a 72-hour burn-in cycle prior to being assigned to an operational instrument. The burn-in cycle is performed in the laboratory to stabilize the filament position and reduce the incidence of premature lamp failure in the operational network. Procedures for lamp burn-in are described in TI 4200-2110, *Transmissometer Lamp Preparation (Burn-in) Procedures*.

4.1.2 Pre-Calibration Lamp Voltages

Service procedures for the LPV-2 transmissometer (see TI 4110-3400, *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*) include lamp voltage measurements. Following instrument servicing, lamp voltages are measured after the lamp has operated for five minutes. These laboratory measurements are documented on the Transmissometer Lamp Voltage Measurements Log (Figure 4-1).

4.1.3 Calibration Instrumentation Setup

The Calibration Setup Checklist/Documentation Form (Figure 4-2) must be used to document the test site instrumentation configuration for all transmissometer calibrations. This form presents the major setup tasks in the order they are to be performed. All items are to be documented as they are completed. The following task descriptions are presented in the order they appear on the form.

CALIBRATION TYPE

Indicate the type of calibration(s) to be performed with this setup onfiguration.

TRANSMITTER SETUP

The transmitter setup procedures described below apply to both the calibration and tracking transmitters.

- Remove the transmitter shelter windows. All test site calibrations are performed with the windows removed.

- Clean the transmitter projection lens with Kimwipes and isopropyl alcohol. Use canned air to remove any remaining lint or dust particles.

- Remove the 2.74% neutral density filter (NDF) from the air-tight filter storage container. Clean both surfaces of the NDF with Kimwipes and alcohol and use canned air to remove any remaining lint or dust particles. Install the NDF on the transmitter telescope.

- A test lamp for use during calibration transmitter setup is provided in the calibration transmitter shelter. Install this lamp and record the lamp number on the setup form.

  The tracking transmitter lamp is normally left installed in the transmitter between calibrations. If the lamp is not installed, or if it burns out, a replacement lamp (stored in the tracking transmitter lamp case) should be installed. Record the lamp number for the lamp actually used on the setup form.

OPTEC LPV-2 TRANSMISSOMETER
TRANSMITTER LAMP VOLTAGE MEASUREMENTS RECORD

Instrument Number: _______________
Date: ___________________________
Technician: ______________________

LAMP VOLTAGE MEASUREMENTS

Lamp #	Setup Voltage		Pre-Cal Voltage	Install Voltage	Post-Cal Voltage
	Initial	Final			

TRANSMITTER TEST POINT VOLTAGES - LAMP #: _______________

	T1	T2	T3	T4
SETUP				
PRE-CAL				
POST-CAL				

Lampvolt.log (8/96)

Figure 4-1. Transmissometer Lamp Voltage Measurements Log.

Technician: ____________________ Date: ____________________
Tracking LPV #: ________________ Calibration LPV #: __________

CALIBRATION SETUP CHECKLIST/DOCUMENTATION FORM
OPTEC LPV-2 TRANSMISSOMETER

CALIBRATION TYPE

☐ Detector Uniformity
☐ Pre-Field/Site __________
☐ Post-Field/Site __________
☐ Audit Instrument
☐ Window Transmittance

TRANSMITTER SETUP

Calibration Transmitter
☐ Window Removed
☐ Transmitter Lens Cleaned
☐ Neutral Density Filter Cleaned and in Place
☐ Test Lamp #________ Installed
☐ Transmitter On and Aligned

Tracking Transmitter
☐ Window Removed
☐ Transmitter Lens Cleaned
☐ Neutral Density Filter Cleaned and in Place
☐ Tracking Lamp #________ Installed
☐ Transmitter On and Aligned

TRANSMITTER CONTROL BOX SWITCH SETTINGS

Switch Settings	Calibration Transmitter	Tracking Transmissometer
Cycle (STD = 1)	____________	____________
Integration (STD = 64)	____________	____________

RECEIVER SETUP

Calibration Receiver
☐ Window Removed
☐ Receiver Lens Cleaned

Aperture (detector uniformity)
- ☐ Full - STD for all telescopes
- ☐ Other - __________ mm

Aperture (calibration)
- ☐ 101.51 mm - STD for large telescopes
- ☐ Full - STD for small telescopes
- ☐ Other - __________ mm
- ☐ Telescope Focused and Aligned

Tracking Receiver
☐ Window Removed
☐ Receiver Lens Cleaned

Aperture:
- ☐ Standard (101.51 mm)
- ☐ Other __________mm

☐ Telescope Focused and Aligned

RECEIVER COMPUTER SWITCH SETTINGS

Switch Settings	Calibration Receiver	Tracking Receiver
Gain (STD = 100)	____________	____________
A1 (STD = C)	____________	____________
A2 (STD = CR)	____________	____________
Cycle (STD = Continuous)	____________	____________
Integration (STD = 1 Minute)	____________	____________

DATALOGGER SETUP

☐ Printer On
☐ Datalogger Operation Verified
☐ Storage Module #_____ in Place
☐ Storage Module Cleared
☐ Storage Module Operation Verified

Caldoc.frm (10/96)

Figure 4-2. Calibration Setup Checklist/Documentation Form.

- Turn on the 12 volt DC power supply and the transmitter control box. Verify that the lamp also turns on and that the chopper blade is turning. Align the transmitter telescope on the center of the corresponding receiver window.

TRANSMITTER CONTROL BOX SWITCH SETTINGS

The "CYCLE" and "INTEG" switches must be set for continuous operation prior to initiating a calibration. To access these switches, the cover of the control box must be removed. The locations of the two switches are shown in Figure 4-3, Transmitter Configuration Switch Locations (LPV-2 Transmissometer). The switch position labels on the "CYCLE" switch are in hours (except for the 20-minute position). The "INTEG" switch position labels are in minutes. Both switches are pc-board mounted dip switches and should be adjusted using the small plastic tipped adjustment tool in the transmitter shelter tool kit. The correct switch positions for continuous operation are indicated by the arrows in Figure 4-3. After the switches have been set, reset the transmitter control box by depressing the **RESET** switch.

RECEIVER SETUP

The receiver setup procedures described below apply to both the calibration and tracking receivers:

- Remove both receiver shelter windows.

- Clean the receiver telescope objective lens with Kimwipes and isopropyl alcohol. Use canned air to remove any remaining lint or dust particles.

- Detector uniformity checks are normally performed with the receiver telescope at full aperture. If the raw readings at full aperture are greater than 975, install the 101.51 mm calibration aperture prior to performing the detector uniformity check.

- Prior to initiating an instrument calibration, the 101.51 mm calibration aperture should be installed on the receiver telescope. If the calibration receiver telescope full aperture is less than 105 mm, a calibration aperture is not required.

- When a transmissometer is operating at a network site, the receiver telescope is focused at infinity. During calibration, the calibration receiver telescope focus should be adjusted to 0.3 km, the length of the sight path. To refocus the receiver telescope, loosen the thumbscrew that secures the objective lens and rotate the objective lens clockwise (viewed from the front of the telescope) until the transmitter lamp is sharply focused. The tracking receiver telescope is normally left focused at 0.3 km, but the focus should always be verified during receiver setup. After focusing, the receiver telescope should be aligned to place the transmitter lamp in the center of the alignment reticle.

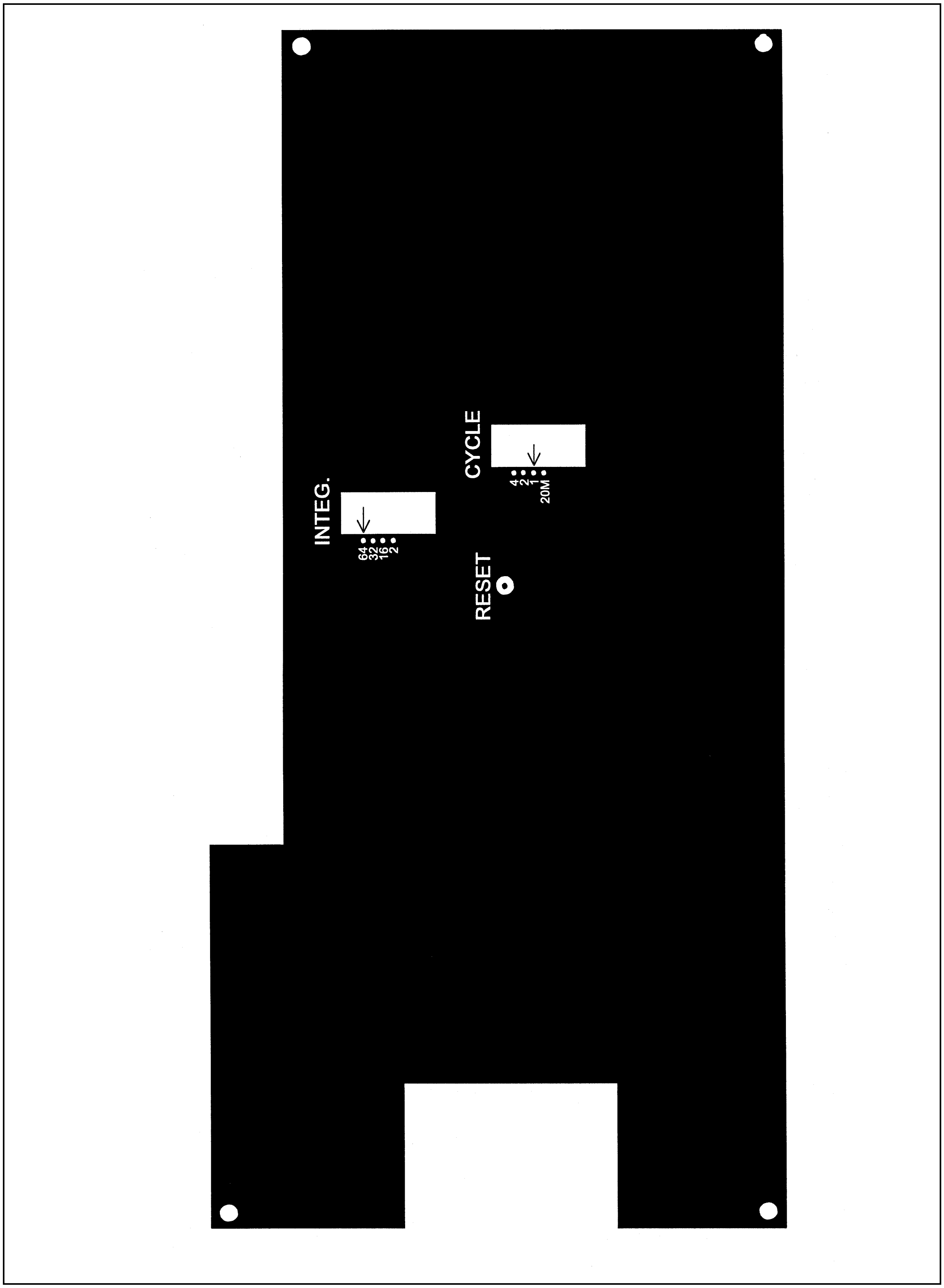


Figure 4-3. Transmitter Configuration Switch Locations (LPV-2 Transmissometer).

RECEIVER COMPUTER SWITCH SETTINGS

There are five front panel switches on the receiver computer that must be set and the settings documented prior to beginning a calibration. All IMPROVE network instruments should be calibrated with the switches set to the standard settings specified on the setup form. When calibrating non-IMPROVE instruments requiring non-standard switch settings, note the switch setting actually used on the setup form. The tracking instrument setup always uses the standard settings.

DATALOGGER SETUP

Calibration data (one-minute averaged raw readings from both the calibration receiver and the tracking receiver) are collected by a Campbell 21X datalogger and SM64 solid state storage module. An on-line printer provides a hard copy output (see Figure 4-4, Example Printout of Calibration Data) of the one-minute averaged data. Figure 4-5, Front Panel - SM64 Storage Module, shows the switch locations, connectors, and the status LED on the SM64 storage module and includes a listing of the switch positions for specific data storage functions. Proper operation of the datalogger components must be verified prior to performing a calibration.

- Turn the printer "ON" and verify that the printer is in the "ON-LINE" mode. Verify that the paper supply is adequate.

- The datalogger will date- and time-stamp each data record written to the storage module and printer. Verify that the time and date shown on the printer output are correct. If incorrect, reset the date and time following the procedures described in TI 4250-2000, *Servicing and Calibration of Campbell 21X Dataloggers*.

- The one-minute raw readings from columns #4 and #6 of the data printout (after dividing by 10 and rounding off to the nearest integer value) should agree (within ± 1 count) with the calibration receiver computer display. The raw readings from columns #5 and #7 should match the tracking receiver computer display in the same manner.

- Connect a storage module to the datalogger and record the storage module serial number on the setup form.

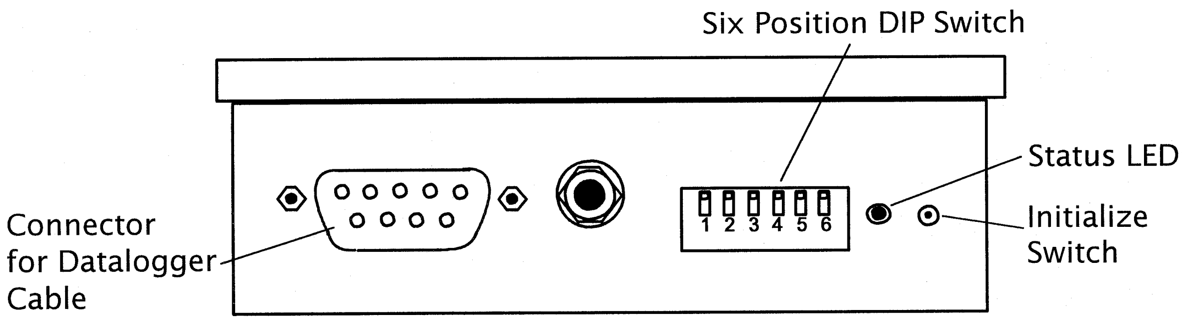
- Set the storage module front panel dip switches for "INITIALIZE" as specified in Figure 4-5. Initialize the storage module by pressing and releasing the **INITIALIZE** switch. About two seconds after the switch is released, the "Status LED" will light for a period of approximately two seconds, indicating that the module has been initialized.

- Reset the front panel dip switches for "DOWNLOAD DATA" as specified in Figure 4-5. At one-minute intervals, the "Status LED" will flash as data are transferred from the datalogger. This flashing action verifies that the datalogger and storage module are operating.

1/1/94
LPV-005 POST-FIELD CALIB.

01+0105.	02+0001.	03+1408.	04+0.0000	05+7795.4	06+0.0000	07+7796.3	
01+0105.	02+0001.	03+1409.	04+0.0000	05+7798.2	06+0.0000	07+7799.0	
01+0105.	02+0001.	03+1410.	04-2.7446	05+7795.4	06-1.3727	07+7796.9	
01+0105.	02+0001.	03+1411.	04+4015.3	05+7800.2	06+4017.6	07+7801.1	
01+0105.	02+0001.	03+1412.	04+6573.3	05+7778.3	06+6575.2	07+7779.1	
01+0105.	02+0001.	03+1413.	04+6590.4	05+7800.2	06+6592.4	07+7801.8	#667
01+0105.	02+0001.	03+1414.	04+6576.0	05+7800.9	06+6577.3	07+7801.8	REF. LAMP
01+0105.	02+0001.	03+1415.	04+6558.9	05+7813.2	06+6560.8	07+7814.1	
01+0105.	02+0001.	03+1416.	04+6591.1	05+7813.2	06+6592.4	07+7799.7	5.865V
01+0105.	02+0001.	03+1417.	04+6599.1	05+7798.2	06+6590.3	07+7799.0	
01+0105.	02+0001.	03+1418.	04+6613.1	05+7813.2	06+6614.4	07+7813.4	B_s = 0.035
01+0105.	02+0001.	03+1419.	04+6578.8	05+7810.5	06+6580.7	07+7812.0	
01+0105.	02+0001.	03+1420.	04+6595.9	05+7805.7	06+6597.9	07+7807.2	
01+0105.	02+0001.	03+1421.	04+6598.7	05+7796.1	06+6600.6	07+7796.9	
01+0105.	02+0001.	03+1422.	04+6598.7	05+7783.7	06+6578.7	07+7784.6	
01+0105.	02+0001.	03+1423.	04+6576.7	05+7816.0	06+6578.7	07+7816.9	
01+0105.	02+0001.	03+1424.	04+2938.5	05+7788.5	06+2939.6	07+7790.1	
01+0105.	02+0001.	03+1425.	04+7104.3	05+7808.4	06+7106.5	07+7809.3	
01+0105.	02+0001.	03+1426.	04+7092.7	05+7776.9	06+7094.1	07+7777.7	
01+0105.	02+0001.	03+1427.	04+5611.3	05+7805.7	06+5612.3	07+7807.2	
01+0105.	02+0001.	03+1428.	04+3153.5	05+7789.2	06+3155.2	07+7790.1	
01+0105.	02+0001.	03+1429.	04+7094.1	05+7815.3	06+7096.3	07+7816.2	
01+0105.	02+0001.	03+1430.	04+7084.5	05+7800.9	06+7086.7	07+7801.8	#668
01+0105.	02+0001.	03+1431.	04+7105.9	05+7790.6	06+7109.2	07+7792.8	6.036V
01+0105.	02+0001.	03+1432.	04+7109.8	05+7793.4	06+7110.7	07+7794.2	
01+0105.	02+0001.	03+1433.	04+7086.7	05+7818.7	06+7089.4	07+7818.9	B_s = 0.039
01+0105.	02+0001.	03+1434.	04+7099.0	05+7805.7	06+7101.8	07+7806.6	
01+0105.	02+0001.	03+1435.	04+7116.2	05+7803.7	06+7118.9	07+7804.5	
01+0105.	02+0001.	03+1436.	04+7121.0	05+7802.3	06+7123.7	07+7803.8	
01+0105.	02+0001.	03+1437.	04+7116.2	05+7817.4	06+7118.3	07+7818.9	
01+0105.	02+0001.	03+1438.	04+7105.9	05+7795.4	06+7108.0	07+7796.3	
01+0105.	02+0001.	03+1439.	04+7103.8	05+7812.6	06+7106.6	07+7813.5	

Figure 4-4. Example Calibration Data Printout.



SWITCH SETTINGS

Initialize Module	D	D	D	U	U	U
Collect Data	D	D	D	U	D	D
Download Data	U	D	U	U	D	D

Figure 4-5. Front Panel - SM64 Storage Module.

4.1.4 Receiver Detector Uniformity

Prior to performing a detector uniformity field check, the Calibration Setup Checklist/Documentation Form must have been completed in accordance with the procedures described in Section 4.1.3, Calibration Instrumentation Setup.

The detector uniformity check is performed by comparing: 1) lamp irradiance measurements obtained with the receiver telescope misaligned so that the transmitter lamp image appears at four specified locations near the outer edge of the receiver telescope alignment reticle, with 2) lamp irradiance measurements obtained with the receiver telescope properly aligned. The Detector Uniformity Field Check Form (Figure 4-6) includes a diagram indicating five alignment points. A measurement sequence consists of one-minute averaged raw readings from each position, beginning with position 1. This sequence of five 1-minute readings is repeated five times. The Campbell 21X datalogger is used as a voltmeter, providing increased resolution and accuracy over the receiver computer display. All data are recorded on the field check form. Specific procedures for performing the detector uniformity field check are as follows:

- Document the test configuration on the Detector Uniformity Field Check Form.
- Set the datalogger to monitor channel 5.
- Align the receiver telescope at position 1.
- Turn the receiver computer "ON" (initiating a one-minute measurement).
- After one minute, record on the field check form: 1) the one-minute averaged raw reading (as shown on the datalogger display) as the position 1 reading, and 2) the time (hours:minutes) the reading was taken.
- Turn the receiver computer "OFF," realign the receiver telescope at each successive position (2-5) and repeat the previous two steps.
- Perform the previous four steps (which comprise one complete measurement sequence) four additional times (providing five measurement sequences at each of the five telescope alignment positions).

Detector uniformity is determined by calculating the mean and standard deviation of the five 1-minute readings obtained at each alignment position and comparing the mean values for positions 2 through 5 to the mean value for position 1. The standard deviation values provide a measure of the stability of the visibility conditions during this test. Detector uniformity is considered acceptable when the mean values for positions 2 through 5 are equal to the position 1 mean value with a tolerance of +0.25% / -1.0%. These calculations are initially performed at the test site using a scientific calculator. The calculated means, standard deviations, and percent deviation of the mean values are recorded on the field check form. After returning to the office, the measurement data are entered into the a detector uniformity worksheet (included with the ARS calibration software) and the means and standard deviations described above are recalculated as a check on the manually calculated values.

Technician:________________

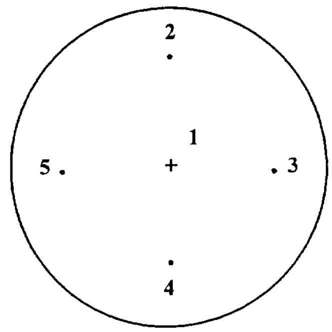
Date:____________
LPV#:____________

DETECTOR UNIFORMITY FIELD CHECK
OPTEC LPV-2 TRANSMISSOMETER

TEST CONFIGURATION

Lamp #: ________ Aperture: ________ Gain Setting: __________

Position	Reading	Time
1	________	:
2	________	:
3	________	:
4	________	:
5	________	:



Position	Reading	Time
1	________	:
2	________	:
3	________	:
4	________	:
5	________	:

Position	Reading	Time
1	________	:
2	________	:
3	________	:
4	________	:
5	________	:

Position	Reading	Time
1	________	:
2	________	:
3	________	:
4	________	:
5	________	:

Position	Reading	Time
1	________	:
2	________	:
3	________	:
4	________	:
5	________	:

Position	Mean	Standard Deviation
1	________	________
2	________	________
3	________	________
4	________	________
5	________	________

Position	Deviation from Position 1 Mean
2	________
3	________
4	________
5	________

COMMENTS:____

(4.37 1/94)

Figure 4-6. Detector Uniformity Field Check Form.

4.1.5 Lamp Calibration

Ten (10) uncalibrated transmissometer lamps (1 primary reference lamp, 1 on-site reference lamp, 6 operational lamps, and 2 spare lamps) are assigned to each transmissometer during annual laboratory servicing (see TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*). During calibration, the primary reference lamp is calibrated three times (at the beginning, in the middle, and at the end of the calibration). All other lamps are calibrated once.

Procedures for performing and documenting lamp calibrations are as follows:

COMPLETE SETUP FORM	Complete the Calibration Setup Checklist/Documentation Form as described in Section 4.1.3, Calibration Instrumentation Setup.
COMPLETE CALIBRATION DATA FORM	Use the Optec LPV-2 Transmissometer Calibration Data Form, Figure 4-7, to document test site weather and visibility conditions, preliminary support equipment measurements, calibration type, and lamp-specific calibration parameters.
PHOTOGRAPH SITE	Photographic documentation is required at the start and finish of a calibration. Three views are photographed from the northwest corner of the transmitter compound. Each view, the approximate bearing from the transmitter compound, and the lens used for photographing the view are presented in Figure 4-8, Test Site Photographic Documentation.
MEASURE TRANSMITTER VOLTAGES	Transmitter test point voltages are measured on the printed circuit board inside the calibration transmitter control box and documented on the lamp calibration data form. Connect the negative (ground) lead of the voltmeter to the negative (black) terminal of the external T5 jack located on the side of the transmitter control box (see Figure 4-9, Transmitter Control Circuit Component Layout). Note that the calibration instrument test point voltages are measured only during the first (reference lamp) calibration segment. The tracking instrument lamp voltage is measured during the first and last calibration segments.
RECORD PARAMETERS	Meteorological parameters are logged by the datalogger at the transmitter compound and should be recorded at the start, middle, and end of the calibration.
DOCUMENT LAMP HOURS	The tracking instrument lamp hours and lamp voltage should be documented at the start (during the first calibration segment) and finish (during the final calibration segment) of the calibration. Lamp hours are logged on a DC timer located in the tracking instrument transmitter shelter and connected to the transmitter control box. If a new lamp is installed in the tracking transmitter, the DC timer should be reset to zero.

Technician: ______________________ Date: __________________

Tracking LPV#:____________________ Calibration LPV #: _________

CALIBRATION DATA

OPTEC LPV-2 TRANSMISSOMETER

TEST SITE CONDITIONS

Weather ____

Visibility ____ Estimated b_{ext} __________________

☐ Initial Photo Documentation Completed Time_______:_______ ☐ Final Photo Documentation Completed Time_______:_______

METEOROLOGICAL PARAMETERS

	Air Temperature	Relative Humidity	Wind Speed	Wind Direction	Solar Radiation
START OF CALIBRATION					
MIDDLE OF CALIBRATION					
END OF CALIBRATION					

CALIBRATION INSTRUMENT - Transmitter Test Point Measurements

Reference Lamp #	TI	T2	T3	T4	T5
______	__________	__________	______	________	________

TRACKING INSTRUMENT - Transmitter Measurements

Tracking Lamp #___________ Lamp Hours: ON ________ OFF _________

Lamp Voltage: Start ______ Finish ________

CALIBRATION TYPE:

☐ Pre-Field ☐ Audit Instrument

☐ Post-Field ☐ Test Instrument

CALIBRATION TEST SEGMENTS LOG

☐ Lamp voltage datalogger connected to transmitter measurement pigtail

☐ Datalogger ground connected to negative T5 terminal on control box

Lamp #	Alignment	Start Time	End Time	Lamp Voltage	b_{scat}	Comments
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			
		:	:			

caldata.frm (2/95)

Figure 4-7. Optec LPV-2 Transmissometer Calibration Data Form.

Description: Toward Engineering Research Center centered on upper south end of Soldier Canyon Dam

Bearing 250°

Lens Size: 135 mm

Description: Toward north centered on horizon halfway between the Ideal Cement Plant and Rawhide Power Plant.

Bearing 10°

Lens Size: 50 mm

Description: Toward north centered on Rawhide Power Plant.

Bearing 15°

Lens Size: 135 mm

Figure 4-8. Test Site Photographic Documentation.

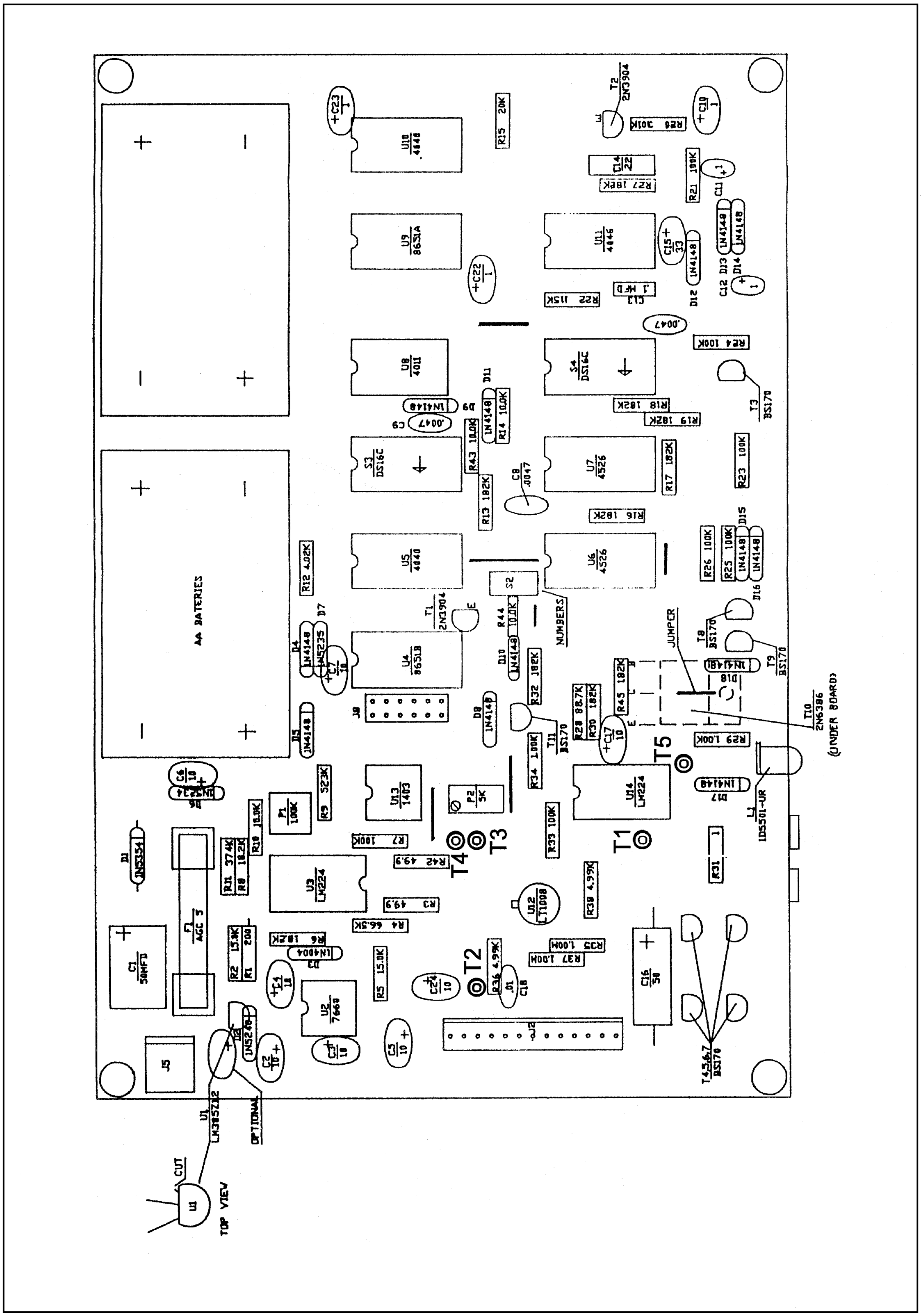


Figure 4-9. Transmitter Control Circuit Component Layout.

- Lamps are calibrated by serial number (ascending order). The lamp with the lowest serial number is always designated as the reference lamp and is used for repeat calibrations as defined by the type of calibration.

- Turn the transmitter power switch "OFF" prior to installing or removing a lamp.

MEASURE AND RECORD LAMP VOLTAGES

At the end of each calibration segment, measure and record the lamp voltage. Prior to initiating the first calibration segment, connect the lamp voltage datalogger to the transmitter cable measurement pigtail (located at the control box end of the transmitter cable). Connect the datalogger ground connection to the negative (black terminal of the external T5 jack located on the side of the transmitter control box). (See Figure 4-9, Transmitter Control Circuit Component Layout). Press ***6A** to display the lamp voltage on the datalogger. All lamp voltages are obtained using this measurement configuration and recorded on the calibration data form (Figure 4-7).

To initiate a calibration, remove the test lamp from the calibration transmitter (after turning the transmitter "OFF") and install the reference lamp for use. The reference lamp should be cleaned with the microfiber cleaning cloth located in the transmitter shelter. Measure and record the lamp voltage after the lamp has been operating for about five minutes. For each calibration segment (10-12 uninterrupted one-minute readings from a single lamp), perform and document the following procedures:

INSTALL LAMP

Visually inspect and clean each lamp before installing the lamp in the transmitter. Clean the lamp with the microfiber cleaning cloth located in the transmitter shelter. Inspect the lamp to make sure there are no spots on the bulb or damage to the filament. Be sure the lamp is fully inserted into the lamp socket. Check the telescope alignment and correct if necessary.

CAUTION! Transmissometer lamps are fragile and should be handled with great care. Dropping the lamp case or the lamp can result in a broken or damaged filament, even though the bulb does not appear broken.

TURN TRANSMITTER ON

Turn the transmitter power switch "ON" and document the calibration start time. Watch the lamp voltage as the lamp comes up to full power. Verify that the lamp voltage begins to stabilize near the standard operating voltage (approximately 5.5 volts). Each lamp should operate for approximately 15 minutes.

DOCUMENT LAMP VOLTAGE

The lamp voltage should be documented at the end of each calibration segment. Compare this lamp voltage with previously measured values as shown on the Transmitter Lamp Voltage Measurements Log included in the Instrument History Notebook. If the values differ by more than 30 mV, the lamp should be removed, reinserted, and the calibration segment restarted.

OBTAIN b_{SCAT}	Obtain the current test site b_{scat} reading from the datalogger at the NGN-2 nephelometer test area.
TURN TRANSMITTER OFF	After the lamp has operated long enough for the receiver to collect 10-12 uninterrupted one-minute readings, turn the transmitter power "OFF," document the end time, and check the telescope alignment. If the alignment is correct, remove the lamp from the transmitter. Let the lamp cool before reinserting the lamp into the lamp storage case. If the alignment is not correct, realign and retest the lamp.
DOCUMENT OBSERVATIONS	Document any unusual observations, changes in conditions, or other factors that might influence the calibration results.
REPEAT	Repeat these procedures for all lamps.
VERIFY OPERATION	At 45-minute intervals, verify receiver, datalogger, and printer operation.

4.1.6 Measurement of Pre-Field Lamp Voltages

When the calibrated instrument is returned to the laboratory, pre-field lamp voltages are measured for all lamps and recorded on the Lamp Voltage Measurement Record as described in Section 4.1.2, Pre-Calibration Lamp Voltages and TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*).

4.1.7 Preliminary Processing of Calibration Data

Prior to final review of the calibration data, the raw data must be transferred from the datalogger storage module to a computer data file and processed to present the data in a summarized format. Procedures for performing these tasks are as follows:

DOWNLOAD CALIBRATION DATA	Use the Campbell datalogger support software and the Campbell storage module interface to download calibration data from the Campbell SM64 storage module to a calibration data file. Prior to downloading from the storage module, the front panel switches must be configured for "DOWNLOAD" (refer to Figure 4-5, Front Panel - SM64 Storage Module). The naming convention for downloaded data files is "MMDDYYX.DAT" where MM denotes the month, DD the day, YY the year, and X, a letter indicating that this is the first (A), second (B), third (C), etc., calibration performed that day.
GENERATE CALIBRATION REPORT	Use the ARS calibration support software for preliminary processing of downloaded data files. This software reads each valid record from the data file and calculates the mean value, the 95% confidence interval (CI), and the ratio of the CI to the mean for raw readings measured by both the calibration and tracking instruments during each individual lamp calibration segment. A preliminary calibration report (see Figure 4-10, Example Test Site Calibration Report) is generated and includes:

TEST SITE CALIBRATION

Calibration Date: 12/14/93A
Operator: M. MILLS
Data File: 121493A.DAT
Cal type: PRE

Instrument: 014
Gain: 100
Aperture: 101.51
Path: 0.3
Bext: 0.020

Tracking Instrument Lamp No. 997 On 277.0 Off 280.0

Comments: 50F; WIND FROM SW @ 10-15 MPH

CALIBRATION RESULTS

Lamp No.	Volt.	Mean	CI/ mean	Ctrl Mean	Ctrl CI/Mn	T.Mn/ C.Mn	Comment
671	5.565	555.0	0.13	778.5	0.12	0.7130	REF LAMP, .025 BSCAT
954	5.851	552.9	0.09	778.9	0.07	0.7099	
955	5.533	552.8	0.15	777.2	0.21	0.7112	
963	5.808	550.1	0.13	779.2	0.14	0.7060	
970	5.806	540.5	0.08	778.7	0.08	0.6940	
671	5.570	558.4	0.10	776.8	0.12	0.7189	REF REPEAT, .028
972	5.869	552.0	0.15	776.8	0.16	0.7106	
973	5.637	533.8	0.21	773.6	0.22	0.6900	
974	5.738	545.0	0.13	770.4	0.10	0.7074	
975	5.795	556.7	0.19	770.9	0.16	0.7222	
976	5.730	539.8	0.21	773.0	0.26	0.6984	
671	5.566	555.9	0.17	771.9	0.24	0.7202	REF REPEAT, .031

Figure 4-10. Example Test Site Calibration Report.

- Calibration parameters
- Estimated b_{ext}
- Comments describing weather and visibility
- Calibration lamp voltages
- Calibration instrument - calculated mean raw readings and CI/mean for each calibration lamp
- Tracking instrument - calculated mean raw readings and CI/mean for tracking lamp during each calibration segment
- Ratio of the tracking instrument mean to the calibration instrument mean for each calibration segment

4.1.8 Quality Assurance Review of Calibration Data

After all calibration data have been collected and the Test Site Calibration Report generated, the field specialist and the project manager review the data to verify that all procedures have been followed, that specific measurement relationships are satisfied, and that the data appear reasonable. Specific procedures for performing this review are as follows:

REVIEW SETUP FORM	Review the Calibration Setup Checklist/Documentation Form. Verify that all required information has been properly documented.
REVIEW LAMP VOLTAGE LOG	Review the Transmissometer Lamp Voltage Measurements Log. Verify that lamp voltages recorded to date do not vary by more than 30 mV.
REVIEW DETECTOR UNIFORMITY CHECK	Review the detector uniformity check. Verify that the maximum deviation of peripheral alignment measurements from centered alignment measurements is +0.25% / -1.0%.
REVIEW CALIBRATION REPORT	Review the Test Site Calibration Report for the ten (10) lamp final calibration. The CI/mean is a measure of the stability of the visibility conditions over the time period during which each lamp was calibrated and should be less than 0.5% for both the calibration instrument and the tracking instrument. If the CI/mean is 0.5% or greater, the data are reviewed to determine if the high CI/mean is due to a single bad measurement. If the CI/mean exceeds 0.5% for several lamps, the calibration must be repeated. The ratio of the tracking mean to the calibration mean should not change by more than 1% for repeat calibrations of a specific lamp. This ratio is used to compare repeat calibrations performed over a wide range of visibility conditions.

4.1.9 Entry of Calibration Data Into the Calibration Database

When the quality assurance review of the calibration data is complete, the data from the ten (10) lamp final calibration are normalized and entered into the Transmissometer Calibration Database. ARS calibration support software is used in performing both of these functions.

The calibration data are normalized to account for small changes in test site visibility conditions through the calibration. The normalization process includes the following steps:

- The tracking instrument mean raw readings for each lamp calibration segment are averaged to provide one tracking instrument raw reading value, RAW_{cal}, to apply to the entire calibration.
- The ratio of the individual lamp tracking instrument mean raw readings to the calibration instrument raw readings is defined as K_{lamp}, the lamp calibration factor.
- The normalized mean raw reading, CR, is then:

$$CR = K_{lamp} * RAW_{cal}$$

Figure 4-11 is an example of a Normalized Calibration Raw Readings Report (Normalized Data Report).

Calibration data are entered into the calibration database via the entry screen for pre-field calibration data, shown as Figure 4-12. Each record includes all calibration-related information for a specific lamp. Lamp-specific calibration data to be entered into the database via this screen include:

- CALDATE - Enter the calibration date from the Normalized Data Report.
- EST b_{EXT} - Enter the estimated b_{ext} from the Normalized Data Report.
- LPV# - Enter the calibration transmissometer serial number from the Normalized Data Report.
- LAMP# - Enter the lamp number from the Normalized Data Report.
- LAMPVOLT - Enter the lamp voltage (measured during calibration) from the Normalized Data Report.
- CALRAW - Enter the normalized raw reading, CR, from the Normalized Data Report.
- CALPATH - Auto-entry (0.3000 km), calibration path length in kilometers.
- CALGAIN - Auto-entry (100), receiver computer gain switch position during calibration.
- CALAP - Auto-entry (101.51 mm), calibration aperture diameter in millimeters.
- NDF-T - Auto-entry (0.0274), transmittance value for the neutral density calibration filter.

NORMALIZED CALIBRATION RAW READINGS REPORT

LPV-005 (08/14/92) PRE-CAL Bext =.030

LAMP #	T5 VOLTS	RAWcal	RAWtrk	CAL/TRK	NORMcal(CR)
667	5.892	693.9	793.0	0.8750	697.6
668	5.885	715.6	796.0	0.8990	716.7
709	5.863	714.4	797.9	0.8954	713.8
710	5.856	704.5	798.9	0.8818	703.0
667	5.900	701.1	798.6	0.8779	699.9
711	5.876	715.8	797.3	0.8978	715.7
712	5.718	712.0	796.6	0.8938	712.5
713	5.851	702.4	795.1	0.8834	704.2
714	5.764	692.3	800.1	0.8653	689.8
667	5.889	695.0	798.3	0.8706	694.0
			797.2		

LPV-005 (01/01/94) POST-CAL Bext =.040

LAMP #	T5 VOLTS	RAWcal	RAWtrk	CAL/TRK	NORMcal(CR)
667	5.865	658.7	780.2	0.8443	658.7
668	6.036	710.4	780.5	0.9102	710.1
709	6.033	717.9	780.3	0.9200	717.8
710	5.993	705.7	780.1	0.9046	705.8
713	5.991	711.1	779.2	0.9126	712.0
714	5.815	669.7	780.1	0.8585	669.8
667	5.877	662.9	781.1	0.8487	662.1
			780.2		

Normalization of calibration raw readings based on tracking instrument mean raw readings.

Figure 4-11. Example Normalized Calibration Raw Readings Report.

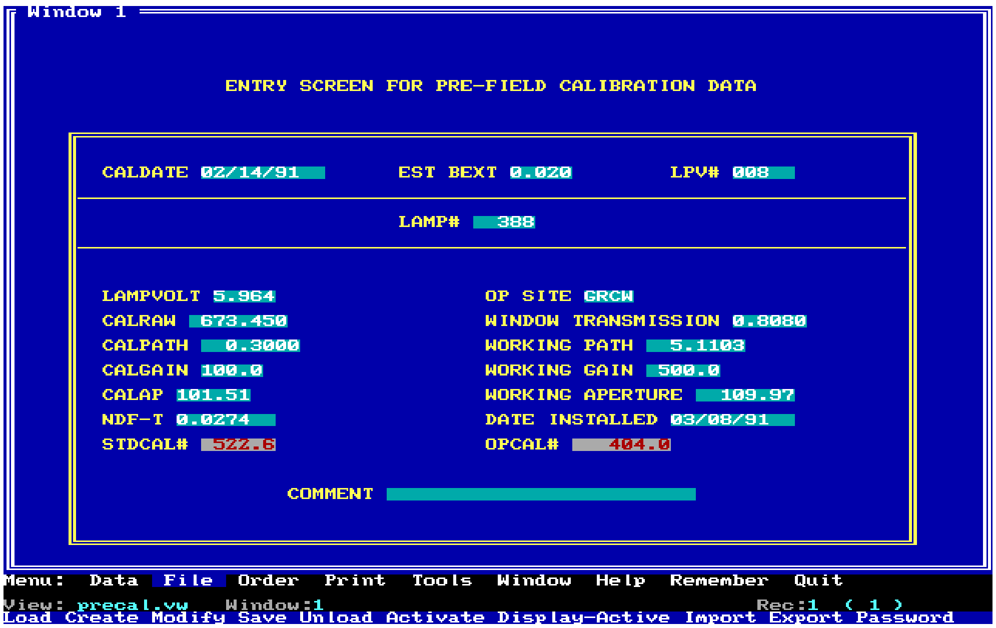


Figure 4-12. Entry Screen for Pre-Field Calibration Data.

- STDCAL# - The default values shown in parentheses are automatically entered into auto-entry fields when the cursor is moved into that field. When the cursor is moved to the "STDCAL#" field, the software will calculate a "standardized" calibration number for the lamp associated with this calibration record. The standardized calibration number assumes a working path length of 5.000 km, a working gain of 500, a working aperture of 110.00 mm, and a window transmittance of 1.0000 (no windows). The standardized calibration number is calculated using the following equation:

  $$\text{Calibration \#} = (CP/WP)^2 * (WG/CG) * (WA/CA)^2 * (1/FT) * WT * (1/T) * CR$$

  where

  CP = calibration path length, 0.300 km
  WP = working path length, 0.500 to 10.000 km
  (5.000 km for standardized calibration number)

  WG = working gain, nominal values are 100, 300, 500, 700, or 900
  (500 for standardized calibration number)
  CG = calibration gain, nominal values are 100, 300, 500, 700, or 900

  WA = working aperture, approximately 110.00 mm
  (110.00 for standardized calibration number)
  CA = calibration aperture, 101.51 mm

  FT = calibration filter (NDF) transmittance, 2.74% or 0.0274
  WT = total window transmittance for the operational system (typically 80% or 0.800) (1.000 for standardized calibration number)

  T = estimated atmospheric transmittance for the calibration path ($T=e^{-bext*CP}$)
  CR = normalized average of 10-12 readings over the calibration path

  The standardized calibration number is used in calculating lamp brightening and varies from instrument to instrument, but typically is in the range 400-475 for pre-field calibrations.

Fields shown on the data entry screen but not described above are site-related operational parameters that are entered when the instrument is assigned to a specific site in the IMPROVE network. The fields are discussed in the following section.

4.1.10 Calculation of Site-Specific Pre-Field Calibration Numbers

When a transmissometer is selected for installation at a specific IMPROVE network site, ARS calibration support software is used to enter site-specific operating parameters into lamp-specific data records for the instrument. Site-specific calibration numbers are calculated for each lamp and a calibration memo detailing the calibration parameters, site parameters, and calibration results is generated. Operational parameters are entered into the database via the Entry Screen for Pre-Field Calibration Data (see Figure 4-12). Specific information added to the database includes:

- OP SITE - Enter the four (4) letter abbreviation for the operational site.

- WINDOW TRANSMISSION - Measured window transmittance (both windows combined) is typically around 80% (0.800) with resolution of 0.1% (0.001). If new windows are being installed, enter the WT value measured at the test site (refer to Section 4.4, Window Transmittance Measurements). If the windows currently in use at the network site are to be used, use the WT value currently in use for these windows. Window transmittance measurements are performed on-site during each annual site visit as described in SOP 4710, *Transmissometer Field Audit Procedures*. The WT value in the database should be updated and the calibration numbers recalculated using the on-site WT measurement.

- WORKING PATH - Enter the site path length in kilometers, with a resolution of 0.1 meters (e.g., 5.4339 km). The site path length is precisely measured and documented as described in TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

- WORKING GAIN - Enter the receiver computer working gain (resolution to one (1) decimal place, e.g., 501.3) required to achieve calibration numbers greater than 600. The actual value of the receiver computer gain at each gain switch setting is measured during annual servicing of the transmissometer. Refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*).

- WORKING APERTURE - If the receiver telescope is being operated at full aperture, enter the aperture as documented during annual servicing (refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*). If a reduced aperture is required at a specific site, enter the aperture diameter as marked on the aperture ring.

- DATE INSTALLED - The installation date should be entered after the instrument is installed and operational parameters such as window transmission, working gain, and working aperture have been updated to reflect changes occurring at installation.

- OPCAL# - The computer software will calculate this number.

- COMMENT - Enter any comment appropriate to the calibration, if needed.

An example calibration memo is shown as Figure 4-13. The calibration numbers are calculated using the calibration equation described in Section 4.1.9.

4.1.11 Maintenance of Calibration Documentation

All calibration documentation is maintained in the ARS Data Collection Center. Following completion of all pre-field calibration procedures, the following documentation is transferred to the Data Collection Center:

- Transmissometer Lamp Voltage Measurements Log

- Calibration Setup Checklist/Documentation Form

- Detector Uniformity Field Check Form

TRANSMISSOMETER CALIBRATION MEMO

PATH SETTING: 5.79
GAIN SWITCH SETTING: 900

SITE: GRCA
LPV#: 016
DATE INSTALLED: 11/09/93

CALIBRATION SETUP VALUES

CAL DATE - 11/02/93

CP: 0.3000 km
CA: 101.51 mm
Bext: 0.035
FT: 0.0274

SITE CALIBRATION PARAMETERS

WP: 5.7904 km
WA: 110.00 mm
WG: 906.4
WT: 0.7992

LAMP#	LAMP VOLTAGE	RAW READING	COMPUTER CAL #	SITE CAL #	COMMENT
904	5.765	566.9	477.4	477	REFERENCE LAMP - RUN #1
904	5.772	571.0	480.9	481	REFERENCE LAMP - RUN #2
904	5.771	567.4	477.8	478	REFERENCE LAMP - RUN #3
905	5.772	573.7	483.1	483	OPERATIONAL LAMP #1
906	5.870	570.8	480.7	481	OPERATIONAL LAMP #2
907	5.692	576.8	485.7	486	OPERATIONAL LAMP #3
908	5.719	569.6	479.7	480	OPERATIONAL LAMP #4
909	5.876	576.5	485.5	485	OPERATIONAL LAMP #5
910	5.640	577.6	486.4	486	OPERATIONAL LAMP #6
911	5.768	576.3	485.3	485	SPARE LAMP #1
912	5.686	573.4	482.9	483	SPARE LAMP #2
913	5.630	573.8	483.2	483	ON-SITE REFERENCE LAMP

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Figure 4-13. Example Transmissometer Calibration Memo.

- Optec LPV-2 Transmissometer Calibration Data Form
- Test Site Calibration Data Report
- Normalized Calibration Raw Readings Report
- Transmissometer Calibration Memo
- Test site photographic documentation

Data Collection Center staff distribute calibration documentation as required.

4.2 POST-FIELD CALIBRATION

Post-field calibration of a transmissometer is required after the instrument is removed from the IMPROVE network and includes the following procedures:

- Setup of instrumentation at the field calibration facility
- Measurement of receiver detector uniformity
- Calibration of ten (10) transmissometer lamps
- Measurement of post-calibration lamp voltages
- Preliminary processing of calibration data
- Quality assurance review of calibration data
- Entry of calibration data into the Transmissometer Calibration Database
- Calculation of site-specific post-field calibration numbers for each lamp
- Calculation of lamp brightening factor for each post-field calibrated lamp
- Maintenance of post-calibration documentation

The following subsections provide detailed instructions for performing the post-field calibration procedures listed above. Many of the procedures required for performing post-field calibrations parallel pre-field calibration procedures described in Section 4.1.

4.2.1 Calibration Instrumentation Setup

Setup and documentation for all post-field calibrations are performed using the Calibration Setup Checklist/Documentation Form and follow the detailed procedures described in Section 4.1.3.

4.2.2 Receiver Detector Uniformity

Detector uniformity checks are an integral part of all post-field calibrations and are performed according to the detailed procedures described in Section 4.1.4.

4.2.3 Lamp Calibration

Post-field calibration of LPV-2 transmissometers is performed according to the detailed procedures for pre-field calibrations described in Section 4.1.5. Exceptions to these procedures are: 1) the number of lamps post-field calibrated, and 2) additional procedures for quantifying the affects of optical interference related to the transmissometer telescopes (receiver and/or transmitter). These exceptions are described below:

- Of the nine (9) transmissometer lamps initially sent to a field site, lamp breakage and failure often will reduce the number of lamps returned for post-calibration. All lamps returned with an operational instrument and the primary reference lamp must be post-field calibrated so that the lamp brightening characteristics can be measured and added to the lamp brightening database.

- If the initial inspection of the transmissometer (refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Monitoring Systems (IMPROVE Protocol)*) identifies smudges, cobwebs, or other optical interference that might introduce errors into the transmissometer measurements, the instrument is calibrated "as is" with the primary reference lamp, the on-site reference lamp, and one operational lamp. The interference is then removed and a full post-field calibration is performed. The effect of the optical interference can then be quantified and the operational data adjusted accordingly.

4.2.4 Measurement of Post-Calibration Lamp Voltages

When the post-field calibration is complete and the instrument is returned to the laboratory, post-field lamp voltages are measured for all lamps and recorded on the Transmissometer Lamp Voltage Measurements Log as described in TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*).

4.2.5 Preliminary Processing of Calibration Data

Prior to final review of the calibration data, the raw calibration data must be transferred from the datalogger storage module to a computer data file and processed to present the data in a summarized format. Procedures for performing these tasks are described in Section 4.1.7.

4.2.6 Quality Assurance Review of Calibration Data

After all calibration data have been collected, the field specialist and project manager review the data to verify that all procedures have been followed, that specific measurement relationships are satisfied, and that the data appear reasonable. Specific procedures for performing this review are as follows:

REVIEW SETUP FORM	Review the Calibration Setup Checklist/Documentation Form. Verify that all required information has been properly documented.
REVIEW LAMP VOLTAGE LOGS	Review Transmissometer Lamp Voltage Measurements Logs. Verify that lamp voltages for the primary and on-site reference lamps have not varied by more than 30 mV between calibrations.

REVIEW DETECTOR UNIFORMITY CHECK	Review the detector uniformity check. Verify that the maximum deviation of peripheral alignment measurements from centered alignment measurements is +0.25% / -1.0%.
REVIEW CALIBRATION REPORT	Review the Test Site Calibration Report. The CI/mean is a measure of the stability of the visibility conditions over the time period during which each lamp was calibrated and should be less than 0.5% for both the calibration instrument and the tracking instrument. If the CI/mean is 0.5% or greater, the data are reviewed to determine if the high CI/mean is due to a single bad measurement. If the CI/mean exceeds 0.5% for several lamps, the calibration must be repeated. The ratio of the tracking mean to the calibration mean should not change by more than 1% for repeat calibrations of a specific lamp. This ratio is used to compare repeat calibrations performed over a wide range of visibility conditions.

4.2.7 Entry of Calibration Data Into the Calibration Database

After the quality assurance review of the calibration data is complete, the data from the post-field calibration are normalized and entered into the Transmissometer Calibration Database. ARS calibration support software is used in performing both of these functions following the procedures described in Section 4.1.9. The normalized data are added to the database using the Entry Screen for Post-Field Calibration Data (see Figure 4-14). This data entry screen includes the same input fields as the entry screen described in Section 4.1.9.

4.2.8 Calculation of Site-Specific Post-Field Calibration Numbers

Post-field calibration numbers are calculated by ARS calibration support software after entering the site-specific operating parameters as described in Section 4.1.10. Post-field calibration numbers for the primary and on-site reference lamps and any unused lamps are expected to agree with the pre-field calibration numbers within 0.5%. Changes in the calibration number for lamps used operationally are dependent upon hours of operation and lamp-specific brightening. Procedures for determining the lamp brightening factor are described in Section 4.2.9.

4.2.9 Calculation of Lamp Brightening Factors

The transmitted light intensity of transmissometer lamps increases (brightens) with increased hours of lamp use. On a lamp-by-lamp basis, this brightening factor is calculated by comparing the pre-field and post-field calibration numbers and applying this change over the total number of lamp hours accumulated during field operation. Calculating a lamp brightening factor in this manner assumes a linear increase in lamp brightness. ARS has developed a lamp brightening database which includes the shift in lamp brightness (based on a comparison of pre-field and post-field calibration numbers) as a function of lamp-use hours. All post-calibrated lamp data are added to this database. Lamp brightening statistics can then be analyzed (using a set of lamps with specific lamp factors such as operating voltage or lamp manufacturer). A lamp brightening curve can then be defined for these lamps and a lamp drift correction factor applied to the operational transmissometer data. Refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)* for detailed procedures for applying the lamp brightening factor.

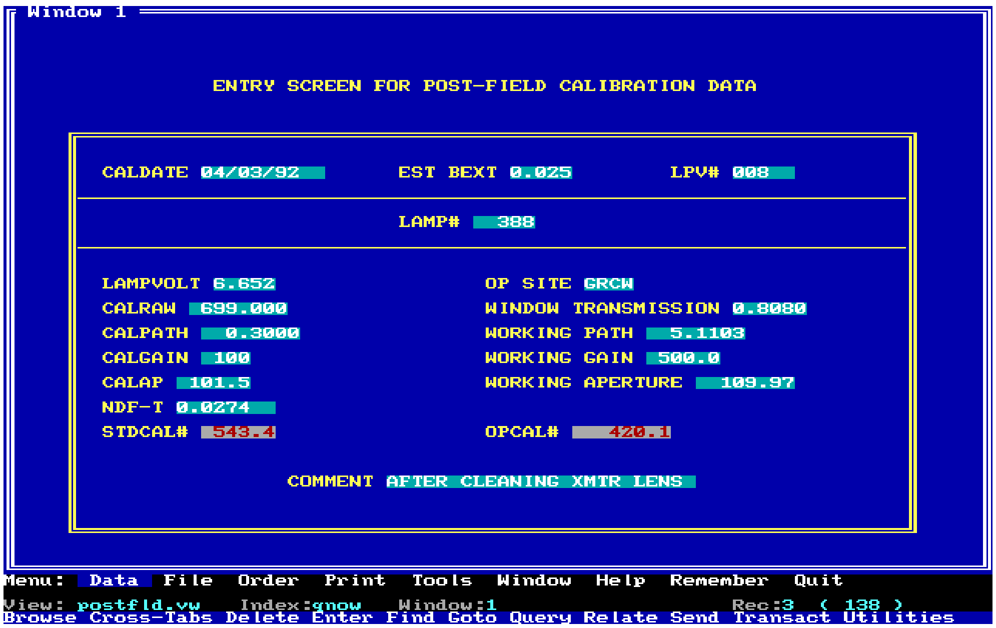

Figure 4-14. Entry Screen for Post-Field Calibration Data.

ARS calibration support software is used to access the calibration database and determine the lamp brightness increase. Standardized calibration numbers (see Section 4.1.9) from the pre-field and post-field calibration are used, along with the operational period for each lamp, to calculate the percent shift in lamp brightness and the lamp brightening factor (percent per 500 hours). A lamp brightening analysis report is generated for each post-calibrated instrument. Procedures for performing these functions are:

QUERY DATABASE	Using the Lamp Brightening Data Entry Screen (see Figure 4-15), query the database to select pre-field and post-field calibration records for a specific instrument post-field calibrated on a specific date.
ENTER DATE AND TIME	Enter the date and time for "LAMP ON" and "LAMP OFF." This information is available from the Data Collection Center - See TI 4300-4023, *Transmissometer Daily Compilation and Review of DCP Collected Data (IMPROVE Protocol)*. "TOTAL HOURS" and "LAMP BRIGHTENING FACTOR" are calculated automatically.
RETRIEVE VALUES	All precal and postcal values are automatically retrieved from the database. Precal to postcal changes in the calibration number and lamp voltage are calculated automatically.
	An example Lamp Brightening Analysis Report is shown as Figure 4-16.

4.2.10 Maintenance of Calibration Documentation

All calibration documentation is maintained in the ARS Data Collection Center. Following completion of all post-field calibration procedures, the following documentation is transferred to the Data Collection Center:

- Transmissometer Lamp Voltage Measurements Log
- Calibration Setup Checklist/Documentation Form
- Detector Uniformity Field Check Form
- Optec LPV-2 Transmissometer Calibration Data Form
- Test Site Calibration Data Report
- Normalized Calibration Raw Readings Report
- Lamp Brightening Analysis Report

Data Collection Center staff distribute calibration documentation as required.

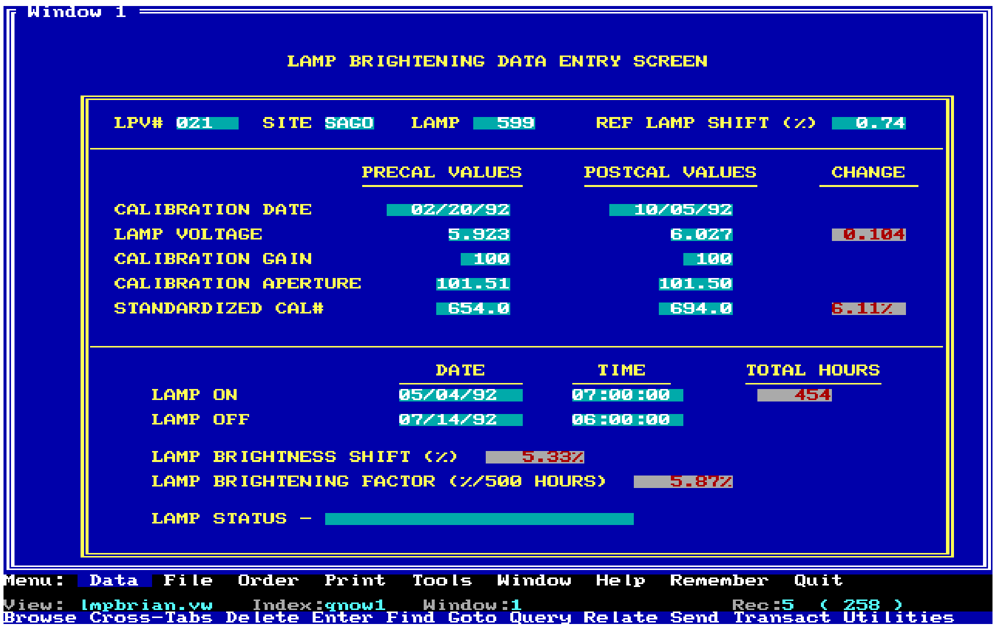

Figure 4-15. Lamp Brightening Data Entry Screen.

SITE ABBREVIATION: GRBA
INSTRUMENT SERIAL NUMBER: LPV# 005
PRE-FIELD CALIBRATION DATE: 08/14/92
POST-FIELD CALIBRATION DATE: 01/01/94

LAMP BRIGHTENING ANALYSIS REPORT
01/29/94

LAMP	PRECAL T5 VOLTS	CHNG (mv)	STD PRECAL#	STD POSTCAL#	CAL# CHANGE	LAMP SHIFT	DATE ON	DATE OFF	LAMP HOURS	LBF %/500 hrs	LAMP STATUS
667	5.892	5.865	540.1	514.4	-4.77%	0.00%				0.00%	PRIMARY REFERENCE LAMP
667	5.892	5.877	540.1	517.0	-4.28%	0.00%				0.00%	REF LAMP REPEAT
668	5.885	6.036	557.9	554.5	-0.60%	3.84%	08/20/92	11/13/92	544	3.53%	
709	5.863	6.033	555.6	560.5	0.88%	5.39%	01/20/93	04/26/93	615	4.38%	
710	5.856	5.993	547.2	551.1	0.72%	5.22%	11/13/92	01/20/93	434	6.01%	
713	5.851	5.991	548.1	556.0	1.43%	5.97%	04/26/93	07/19/93	537	5.55%	
714	5.764	5.815	536.9	523.0	-2.59%	1.77%	10/25/93	11/18/93	154	5.75%	ON-SITE REFERENCE LAMP

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Figure 4-16. Example Lamp Brightening Analysis Report.

4.3 AUDIT INSTRUMENT CALIBRATION

Calibration of the audit transmissometer is required prior to and following its use in performing a field audit, and includes the following procedures:

- Setup of instrumentation at field calibration facility
- Measurement of receiver detector uniformity
- Calibration of six (6) transmissometer lamps
- Preliminary processing of calibration data
- Quality assurance review of calibration data
- Entry of calibration data into the Transmissometer Calibration Database
- Calculation of site-specific audit calibration numbers for each lamp
- Maintenance of audit instrument calibration documentation

4.3.1 Calibration Instrumentation Setup

Setup and documentation for all audit instrument calibrations are performed using the Calibration Setup Checklist/Documentation Form and follow the detailed procedures described in Section 4.1.3.

4.3.2 Receiver Detector Uniformity

Detector uniformity checks are an integral part of all audit instrument calibrations and are performed according to the detailed procedures described in Section 4.1.4.

4.3.3 Lamp Calibration

Calibration of the LPV-2 audit transmissometer is performed according to the detailed procedures for pre-field calibrations described in Section 4.1.5. The only exception to these procedures is that six (6) lamps are calibrated for use with the audit instrument (a primary reference lamp, a traveling reference lamp, and four (4) audit lamps). The audit instrument is recalibrated following any field audit requiring shipment (air freight, UPS, Fed Ex, etc.) of the instrument.

4.3.4 Preliminary Processing of Calibration Data

Prior to final review of the calibration data, the raw calibration data must be transferred from the datalogger storage module to a computer data file and processed to present the data in a summarized format. Procedures for performing these tasks are described in Section 4.1.7.

4.3.5 Quality Assurance Review of Calibration Data

After all calibration data have been collected, the field specialist and project manager review data to verify that all procedures have been followed, that specific measurement relationships are satisfied, and that the data appear reasonable. Specific procedures for performing this review are as follows:

REVIEW SETUP FORM	Review the Calibration Setup Checklist/Documentation Form. Verify that all required information has been properly documented.
REVIEW LAMP VOLTAGE LOGS	Review Transmissometer Lamp Voltage Measurements Logs. Verify that lamp voltages for the primary and on-site reference lamps have not varied by more than 30 mV between calibrations.
REVIEW DETECTOR UNIFORMITY CHECK	Review the detector uniformity check. Verify that the maximum deviation of peripheral alignment measurements from centered alignment measurements is +0.25% / -1.0%.
REVIEW CALIBRATION REPORT	Review the Test Site Calibration Report. The CI/mean is a measure of the stability of the visibility conditions over the time period during which each lamp was calibrated and should be less than 0.5% for both the calibration instrument and the tracking instrument. If the CI/mean is 0.5% or greater, the data are reviewed to determine if the high CI/mean is due to a single bad measurement. If the CI/mean exceeds 0.5% for several lamps, the calibration must be repeated. The ratio of the tracking mean to the calibration mean should not change by more than 1% for repeat calibrations of a specific lamp. This ratio is used to compare repeat calibrations performed over a wide range of visibility conditions.
COMPARE READINGS	Compare lamp-specific raw readings obtained during this calibration with readings obtained with the same lamps in recent audit instrument calibrations.

4.3.6 Entry of Calibration Data Into the Calibration Database

After the quality assurance review of the calibration data is complete, data from the post-field calibration are normalized and entered into the Transmissometer Calibration Database. ARS calibration support software is used in performing both of these functions following the procedures described in Section 4.1.9. The normalized data are added to the database using the Entry Screen for Audit Instrument Calibration Data (see Figure 4-17). This screen includes the same calibration data input fields as the entry screen described in Section 4.1.9.

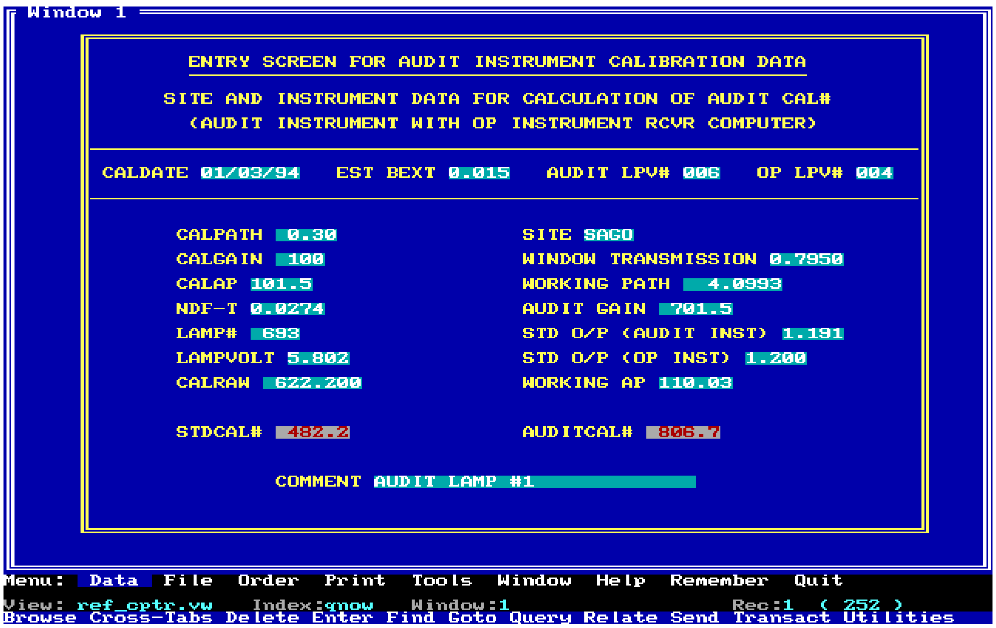

Figure 4-17. Entry Screen for Audit Instrument Calibration Data.

4.3.7 Calculation of Site-Specific Audit Instrument Calibration Numbers

Audit calibration numbers are calculated using ARS calibration support software. The Entry Screen for Audit Instrument Calibration Data (see Figure 4-17) is used to access the calibration database and display the calibration data entered in Section 4.3.6. Operational parameters are entered into the database via this screen. Specific information added includes:

- OP SITE - Enter the four (4) letter abbreviation for the operational site.
- WINDOW TRANSMISSION - Refer to procedures described in Section 4.1.10.
- WORKING PATH - Enter the sight path length in km, with a resolution of 0.1 meters (e.g., 5.4339 km). The sight path length is precisely measured and documented as described in TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems*. If a reduced aperture is required for operation of the audit instrument, enter the aperture diameter marked on the aperture ring.
- AUDIT GAIN - Enter the working gain for the instrument to be installed as the operational instrument. The gain value should be selected to ensure calibration numbers greater than 600. The gain value entered into this field should include one (1) decimal place (e.g., 501.3). The actual value of the receiver computer gain at each gain switch setting is measured during annual servicing of the transmissometer. Refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
- STD O/P (AUD INST) and STD O/P (OP INST) - The field audit procedures (refer to SOP 4710, *Transmissometer Field Audit Procedures*) specify that the audit transmissometer use the replacement instrument receiver computer during all phases of the audit. To account for differences in receiver computer measurement parameters, calculation of audit calibration numbers includes a relative gain correction factor based on receiver computer output measurements (Gain Switch set at 100) for a standard input signal (see TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*). These standardized receiver computer output values are documented in the instrument servicing records and typically range from 1.180 to 1.250.
- WORKING APERTURE - If the receiver telescope is being operated at full aperture, enter the aperture as documented during annual servicing (refer to the Transmissometer Servicing Checklist, TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*).

An Audit Calibration Numbers Report is generated for both the instrument to be removed and the instrument to be installed. An example Audit Instrument Calibration Numbers Report is shown as Figure 4-18. The calibration numbers are calculated using the calibration equation described in Section 4.1.9 and a multiplication factor based on the standardized receiver computer output measurements. The multiplier, K_{gain} is calculated using the following equation:

$$K_{gain} = STD_{opr} / STD_{aud}$$

where

STD_{opr} = Standardized receiver computer output - operational instrument
STD_{aud} = Standardized receiver computer output - audit instrument

AUDIT INSTRUMENT
CALIBRATION NUMBERS REPORT

Site: SAGO

AUDIT INSTRUMENT INFO

LPV#: 006
Cal Date: 01/03/94
Working AP: 110.03
EST Bext: 0.015
Std Output: 1.191

REPLACEMENT INSTRUMENT INFO

LPV#: 004
Working Path: 4.0993
Audit Gain: 701.5
Windows (WT): 0.7950
Std Output: 1.200

LAMP#	LAMP VOLTS	CALRAW	STD CAL#	AUDIT CAL#	LAMP STATUS / COMMENT
692	5.798	621.700	481.8	806.1	REFERENCE LAMP
692	5.799	621.100	481.4	805.3	REFERENCE LAMP
692	5.801	622.600	482.5	807.2	REFERENCE LAMP
693	5.802	622.200	482.2	806.7	AUDIT LAMP #1
722	5.810	633.100	490.7	820.8	AUDIT LAMP #2
768	5.912	635.300	492.4	823.7	AUDIT SPARE #1
838	5.912	641.400	497.1	831.6	AUDIT SPARE #2
839	6.063	648.400	502.5	840.7	TRAVELING REFERENCE LAMP

View: REF_CPTR
Report Definition: REF_AUD#
Report Printed 01/31/94 at 15:52:49

Figure 4-18. Example Audit Instrument Calibration Numbers Report.

4.3.8 Maintenance of Calibration Documentation

All calibration documentation is maintained in the ARS Data Collection Center. Following completion of all post-field calibration procedures, the following audit instrument documentation is transferred to the Data Collection Center:

- Transmissometer Lamp Voltage Measurements Log
- Calibration Setup Checklist/Documentation Form
- Detector Uniformity Field Check Form
- Optec LPV-2 Transmissometer Calibration Data Form
- Test Site Calibration Data Report
- Normalized Calibration Raw Readings Report
- Lamp Brightening Analysis Report
- Audit Calibration Numbers Report

Data Collection Center staff distribute calibration documentation as required.

4.4 WINDOW TRANSMITTANCE MEASUREMENTS

Calibration of a window for use in the IMPROVE transmissometer network requires measurement of light loss as transmitted light passes through the window. Initial measurements of window transmittance are performed at the test site and follow the basic measurement procedures described for other calibrations. Individual and combined transmittance is measured for the transmitter and receiver windows. The transmittance is determined by measuring the light received at the receiver with the window(s) in place and the window(s) removed. The ratio of the average readings with the windows in to the average readings with the windows out, is the window transmittance. Procedures for performing test site window transmittance measurements are as follows:

- Setup of instrumentation at field calibration facility
- Measurement of window transmittances
- Preliminary processing of calibration data
- Quality assurance review of calibration data
- Calculation of window transmittances

Window transmittance measurements are also performed during the annual site visit (refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*).

4.4.1 Calibration Instrumentation Setup

Setup and documentation for window transmittance measurements are performed using the Calibration Setup Checklist/Documentation Form and follow the detailed procedures described in Section 4.1.3.

4.4.2 Window Transmittance Measurements

All windows in the IMPROVE network are calibrated in pairs, one (1) transmitter window and one (1) receiver window. The procedures for performing and documenting window transmittance measurements are as follows:

DOCUMENT INFORMATION — Use the Window Transmittance Data Form (Figure 4-19) to document test site weather and visibility conditions, preliminary support equipment measurements, window serial numbers, and measurement data.

MEASURE WINDOW TRANSMITTANCES — Use the calibration transmitter with a test lamp to measure window transmittances.

- Do not initiate transmittance measurements until the lamp voltage has stabilized around 5.6 volts.
- Five measurement segments of 10-12 one-minute readings per segment are required for calibrating a pair of windows:

  Segment #1 Both windows out
  Segment #2 Transmitter window in
  Segment #3 Both windows in
  Segment #4 Receiver window in
  Segment #5 Both windows out

OBTAIN b_{SCAT} — Obtain the current test site b_{scat} reading from the datalogger located at the NGN-2 test area.

4.4.3 Preliminary Processing of Calibration Data

Prior to final review of the calibration data, the raw calibration data must be transferred from the datalogger storage module to a computer data file and processed to present the data in a summarized format. Procedures for performing these tasks are described in Section 4.1.7.

4.4.4 Quality Assurance Review of Calibration Data

After all calibration data have been collected, the field specialist and the project manager review data to verify that all procedures have been followed, that specific measurement relationships are satisfied, and that the data appear reasonable. Specific procedures for performing this review are as follows:

REVIEW SETUP FORM — Review Calibration Setup Checklist/Documentation Form. Verify that all required information has been properly documented.

Figure 4-19. Window Transmittance Data Form.

Technician: ____________ **Date:** ____________
Tracking LPV#: ____________ **Transmitter Window #:** ____________
Calibration LPV#: ____________ **Receiver Window #:** ____________

WINDOW TRANSMITTANCE DATA

TEST SITE CONDITIONS

Weather: ______________________________

Visibility: ______________________________

CALIBRATION INSTRUMENT - Transmitter Test Point Measurements

Test Lamp #: ________ **T1** ________ **T2** ________ **T3** ________ **T4** ________ **T5**

TRACKING INSTRUMENT - Transmitter Measurements

Tracking Lamp #: ________ **Lamp Hours:** **ON** ___:___ **OFF** ___:___

Lamp Voltage: **Start** ________ **Finish** ___

WINDOW TRANSMITTANCE TEST SEGMENTS LOG

	Alignment	Start Time	End Time	Lamp Voltage	b_{scat}	Comments
No Windows		:	:			
Transmitter Window		:	:			
Both Windows		:	:			
Receiver Window		:	:			
No Windows		:	:			
		:	:			
		:	:			

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REVIEW CALIBRATION REPORT

Review the Test Site Calibration Report.

The CI/mean is a measure of the stability of the visibility conditions over the time period corresponding to each measurement segment and should be less than 0.5% for both the calibration instrument and the tracking instrument. If the CI/mean is 0.5% or greater, the data should be reviewed to determine if the high CI/mean is due to a single bad measurement. If the CI/mean exceeds 0.5% for any segment, the calibration must be repeated.

Look for obvious inconsistencies. The raw readings should be approximately the same for segments #2 and #4 and segments #1 and #5. Raw readings for segments #2 and #4 should be about half-way between the segment #3 reading and the segment #1 or #5 reading.

4.4.5 Calculation of Window Transmittances

Data from the Test Site Calibration Report are used to calculate individual and combined window transmittances. A Window Transmittance Measurement Report is generated by the ARS calibration support software.

Raw readings and tracking mean to calibration mean ratios (see Section 4.1.7) for each measurement segment are entered into the calibration database using the Window Transmittance Measurements Data Entry Screen shown as Figure 4-20. Window transmittances are then calculated from raw readings and mean ratios. An example Window Transmittance Measurement Report is presented as Figure 4-21.

4.4.6 Maintenance of Window Transmittance Documentation

All window transmittance documentation is maintained in the ARS Data Collection Center. Following completion of window transmittance tests, the following documentation is transferred to the Data Collection Center:

- Window Transmittance Data Form
- Window Transmittance Measurements Report

Data Collection Center staff distribute window transmittance documentation as required.

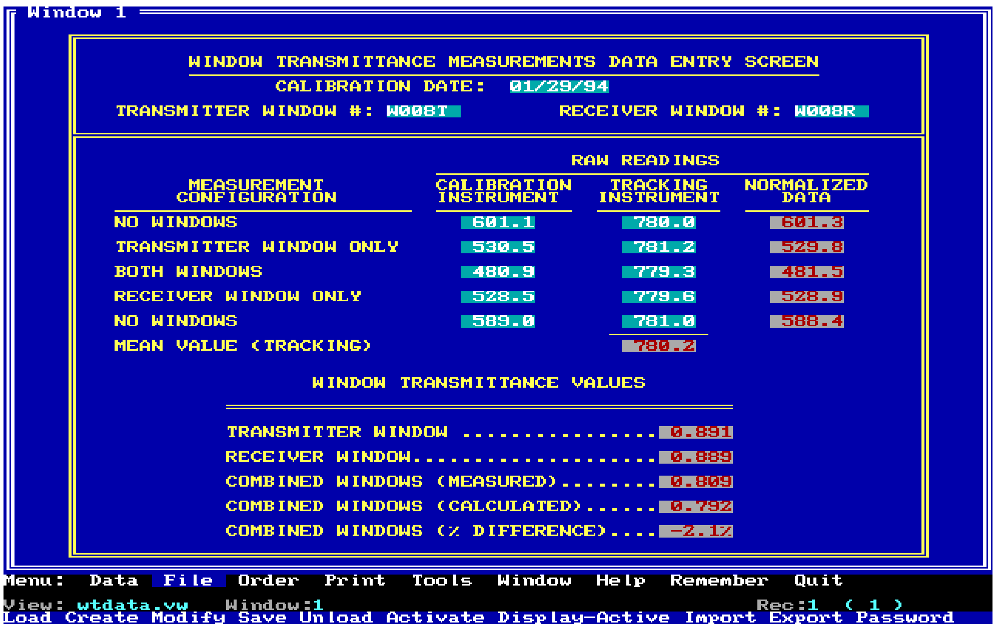

Figure 4-20. Window Transmittance Measurements Data Entry Screen.

WINDOW TRANSMITTANCE MEASUREMENTS DATA ENTRY SCREEN

CALIBRATION DATE: 01/29/94

TRANSMITTER WINDOW #: W008T **RECEIVER WINDOW #: W008R**

MEASUREMENT CONFIGURATION	RAW READINGS		
	CALIBRATION INSTRUMENT	TRACKING INSTRUMENT	NORMALIZED DATA
NO WINDOWS	601.1	780.0	601.3
TRANSMITTER WINDOW ONLY	530.5	781.2	529.8
BOTH WINDOWS	480.9	779.3	481.5
RECEIVER WINDOW ONLY	528.5	779.6	528.9
NO WINDOWS	559.0	781.0	558.4
MEAN VALUE (TRACKING)		780.2	

WINDOW TRANSMITTANCE VALUES

TRANSMITTER WINDOW 0.914

RECEIVER WINDOW 0.912

COMBINED WINDOWS (MEASURED) 0.830

COMBINED WINDOWS (CALCULATED) 0.833

COMBINED WINDOWS (% DIFFERENCE) 0.4%

Figure 4-21. Window Transmittance Measurements Report.

Air Resource
Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER LAMP PREPARATION (BURN-IN) PROCEDURES**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4200-2110**
DATE	**FEBRUARY 1994**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	James H. Wagner	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Change burn-in hours/update format	October 1996	

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

The purpose of this technical instruction (TI) is to describe the procedures for preparing a transmissometer lamp for calibration and operational use in the IMPROVE transmissometer network. The primary purpose of lamp preparation is to assure quality data capture through a transmissometer lamp burn-in procedure that will:

- Stabilize the operational characteristics of the lamps prior to performing pre-field lamp calibrations.
- Reduce infant mortality in operational lamps.

This TI describes all procedures required to perform and document transmissometer lamp preparation and burn-in and is referenced from Standard Operating Procedure (SOP) 4200, *Calibration of Optical Monitoring Systems*, and the following technical instructions:

- TI 4200-2100 *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*
- TI 4110-3400 *Annual Laboratory Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Review lamp inventory and status records to ensure that a sufficient number of burned-in lamps are available to support transmissometer field operations.
- Approve purchase orders for new lamps.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Prepare purchase orders for new transmissometer lamps.
- Inspect all new transmissometer lamps when received at ARS.
- Prepare lamp ID labels for all new lamps received and maintain the Transmissometer Lamp Log.
- Perform the lamp burn-in procedures described in this TI.
- Maintain the lamp inventory and status records.
- Ensure that all burned-in lamps are identified properly and stored in a manner that will protect them from damage.

- Coordinate with Optec, Inc. for replacement of lamps that are received damaged or that fail during burn-in.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific equipment and materials required for transmissometer lamp burn-in include:

- Supply of lamps
- Lamp ID labels
- Lamp burn-in fixture
- Power Supply (13.8 VDC @ 25 amps)
- Lamp Burn-in Documentation Form
- Lamp inventory and status records
- KimWipe tissues

4.0 METHODS

Transmissometer lamps are purchased from Optec, Inc., Lowell, Michigan. When a lamp order is received, all lamps are visually inspected and lamp ID labels placed on the base of each lamp. Lamps are then installed in the transmissometer lamp burn-in fixture (see Figure 4-1) for a burn-in cycle of 72 hours. The lamp burn-in fixture provides two (2) separate burn-in banks. Each burn-in bank permits up to six (6) lamps to be burned-in during a burn-in cycle. The burn-in control circuit switches power between the two banks at 15 minute intervals. With six lamps installed in each burn-in bank, each lamp is cycled through a 15 minute "on" period followed by a 15 minute "off" period twice an hour. This cycled burn-in technique closely replicates lamp operation in the field. The 72 hour burn-in cycle provides 144 lamp "on" cycles which is equivalent to 144 hours (6 days) of field operation. Once a lamp has been burned-in, the ID label is marked to indicate that the lamp is ready to be assigned to an operational instrument.

This section includes (2) major subsections:

4.1 Lamp Receiving and Preparation
4.2 Lamp Burn-in

4.1 LAMP RECEIVING AND PREPARATION

Specific procedures for receiving and preparing lamps for burn-in are described in the following subsections.

4.1.1 <u>Documentation for Lamps Received</u>

Optec inscribes a lamp serial number on each lamps' plastic base. Lamps are then individually packed in small boxes labelled with the lamp serial number. The individual boxes are packed into a larger box for shipment. Receiving procedures include:

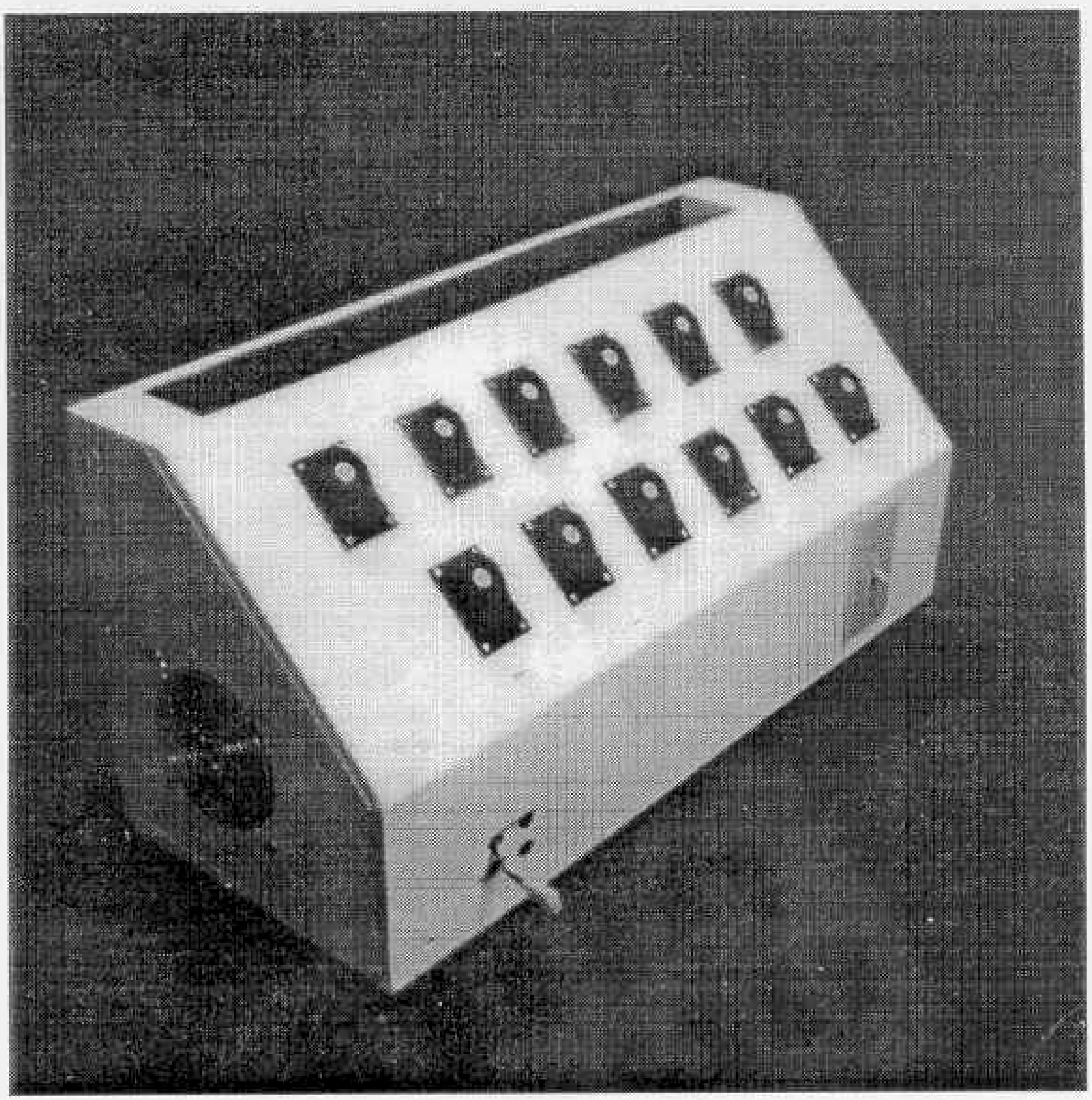

Figure 4-1. Transmissometer Lamp Burn-in Fixture.

CONFIRM NUMBER OF LAMPS	Confirm that the number of lamps received matches the number of lamps shipped (as documented on the packing list).
RECORD SERIAL NUMBERS	Using the Lamp Receiving Log (Figure 4-2), record the serial numbers (from the label on the lamp boxes) of all lamps received.

4.1.2 Visual Inspection of Lamps

Lamp inspection procedures include:

PREPARE LABEL — The lamp serial number inscribed on the lamp base is difficult to see when the lamp is installed in a field instrument. Using the Lamp Receiving Log, prepare an ID label (1/2" diameter adhesive backed) with the lamp serial number for each lamp received.

VERIFY SERIAL NUMBER — Remove each lamp from its shipping box and verify that the serial number inscribed on the base matches the serial number on the box. Apply the ID label to the base as shown in Figure 4-3.

INSPECT LAMP — As each lamp is removed, the lamp should be visually inspected. Lamp condition should also be documented on the Lamp Receiving Log. Typical flaws or lamp damage (examples shown in Figure 4-4) include the following:

- Cracked or broken filament
- Abnormalities in the shape, texture, clarity, or thickness of the glass bulb
- Missing or damaged gold sleeves on lamp power pins
- Bent, broken, or missing power pins

PLACE LAMP IN STORAGE — After a lamp has been visually inspected and the inspection results documented on the Lamp Receiving Log, place the lamp in the lamp storage drawer, ensuring that the plastic lamp holder is lined with a KimWipe tissue to prevent damage to the lamp bulb.

4.2 LAMP BURN-IN

Specific procedures for burning in lamps include:

CLEAN LAMPS — Select 12 lamps for burn-in. Clean each lamp with a microfiber optical cleaning cloth and insert into the 12 lamp sockets built into the Lamp Burn-in Fixture.

RECORD SERIAL NUMBERS — Record the lamp serial numbers on the Lamp Burn-in Log Form (Figure 4-5).

TRANSMISSOMETER LAMP RECEIVING LOG

Reference Purchase Order Number: ________
Date Received: _______________

Quantity Received (Packing List): __________
Quantity Received (ARS Count): ___________

Lamp #	Condition	Lamp #	Condition

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Figure 4-2. Transmissometer Lamp Receiving Log.

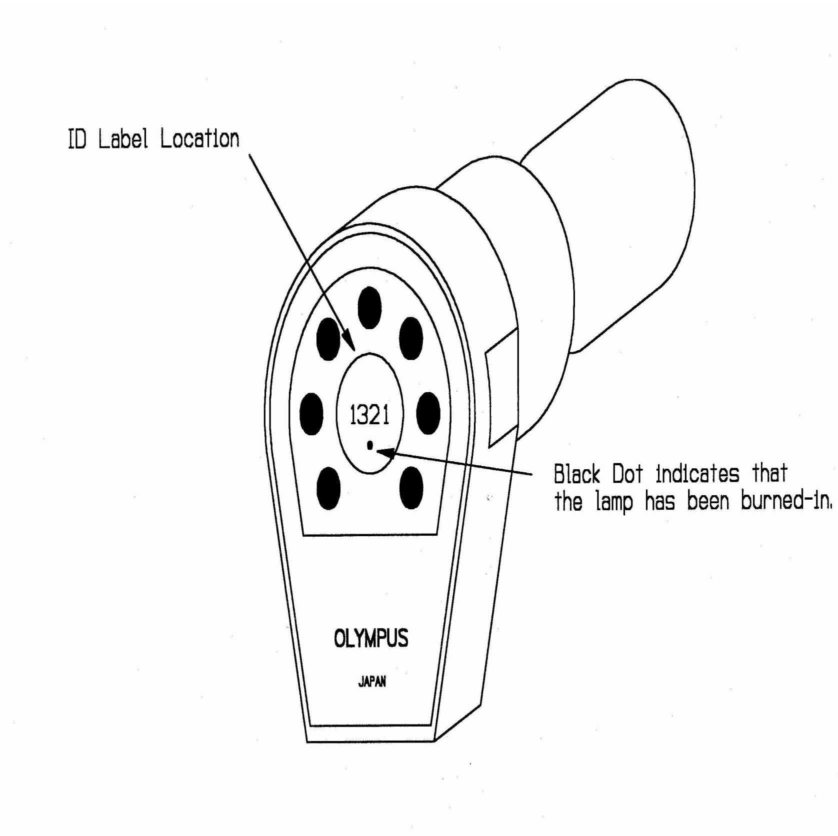

Figure 4-3. Placement of Lamp ID Label on Lamp Base.

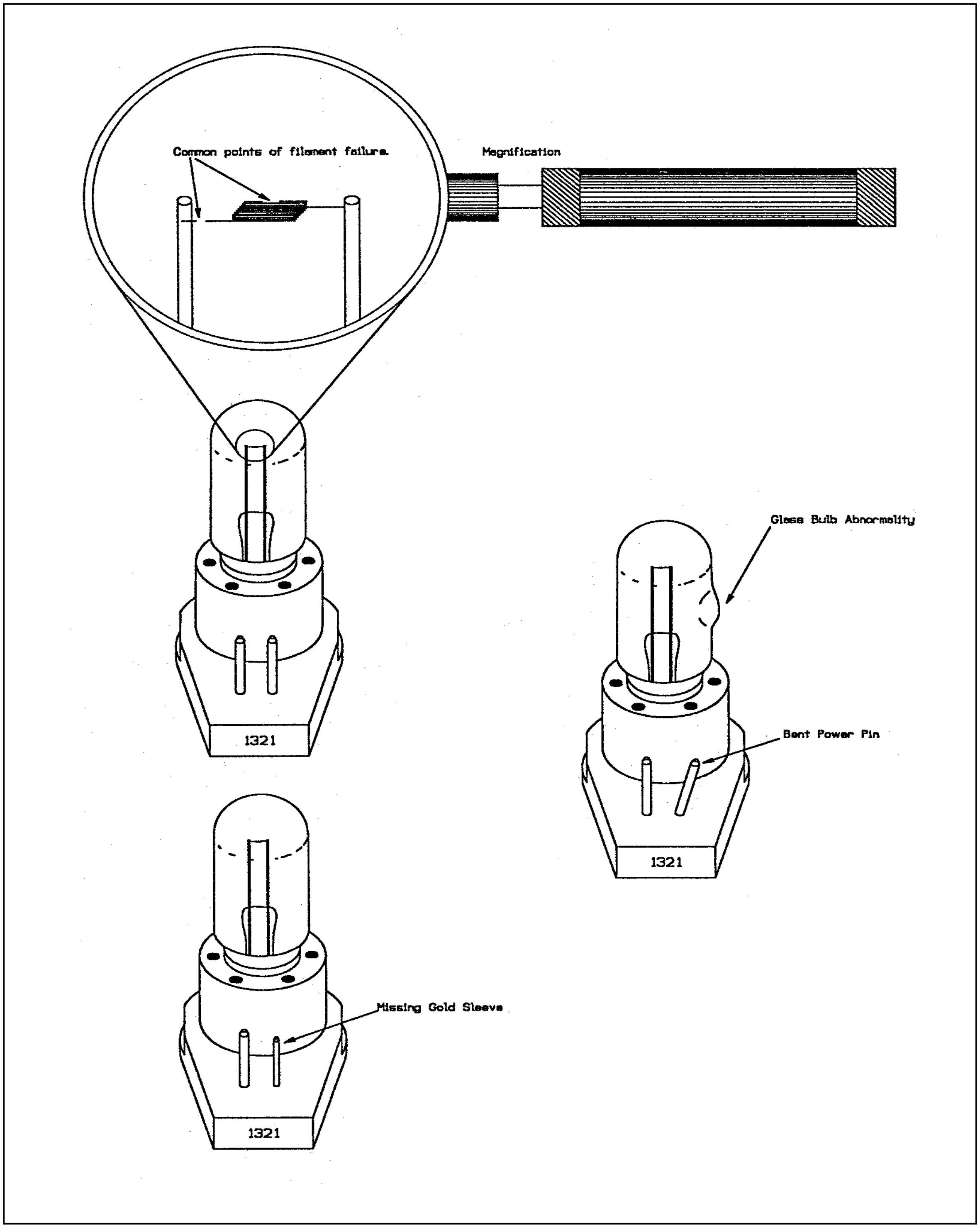

Figure 4-4. Lamp Flaws to Look For During Lamp Inspection.

LAMP BURN-IN LOG SHEET

START BURN-IN: DATE: ____________ TIME: ____________
BURN-IN COMPLETE: DATE: ____________ TIME: ____________

SOCKET #	LAMP #	BURN-IN COMPLETED YES	NO	ID LABEL MARKED	COMMENTS
1		☐	☐	☐	
2		☐	☐	☐	
3		☐	☐	☐	
4		☐	☐	☐	
5		☐	☐	☐	
6		☐	☐	☐	
7		☐	☐	☐	
8		☐	☐	☐	
9		☐	☐	☐	
10		☐	☐	☐	
11		☐	☐	☐	
12		☐	☐	☐	

OPERATION VERIFIED		
DATE	TIME	TIMER HOURS

FAILED LAMPS		
LAMP #	RETURNED TO OPTEC	REPLACEMENT RECEIVED

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Figure 4-5. Lamp Burn-in Log Form.

CONNECT POWER SUPPLY	Connect the 13.8 VDC power supply to the burn-in fixture.
TURN ON	Turn the power supply on and document the burn-in start time on the Lamp Burn-in Log Form. Reset the burn-in cycle timer to zero.
DOCUMENT HOURS	Periodically, verify that all lamps in both banks are cycling properly. Use the Lamp Burn-in Log Form to document the accumulated hours reading (from the burn-in cycle timer) at the time operation is verified.
TURN POWER OFF	When the burn-in timer indicates 72 accumulated hours of operational time, turn the power supply off and record the burn-in finish time on the Lamp Burn-in Log Form.
COOL LAMPS	Let the lamps cool in the burn-in fixture for 20 minutes.
MARK LABELS	Use a black felt tip pen to mark the ID labels with a dot to indicate that the lamp has been burned-in.
INSPECT LAMP	Remove each lamp from the burn-in fixture, inspecting the lamp for: • Cracked or broken filament. • White film (milky appearance) on the inside surface of the bulb (indicates an air leak in the bulb - see the photograph of Figure 4-6).
STORE LAMP	Return the lamps to the storage drawer.

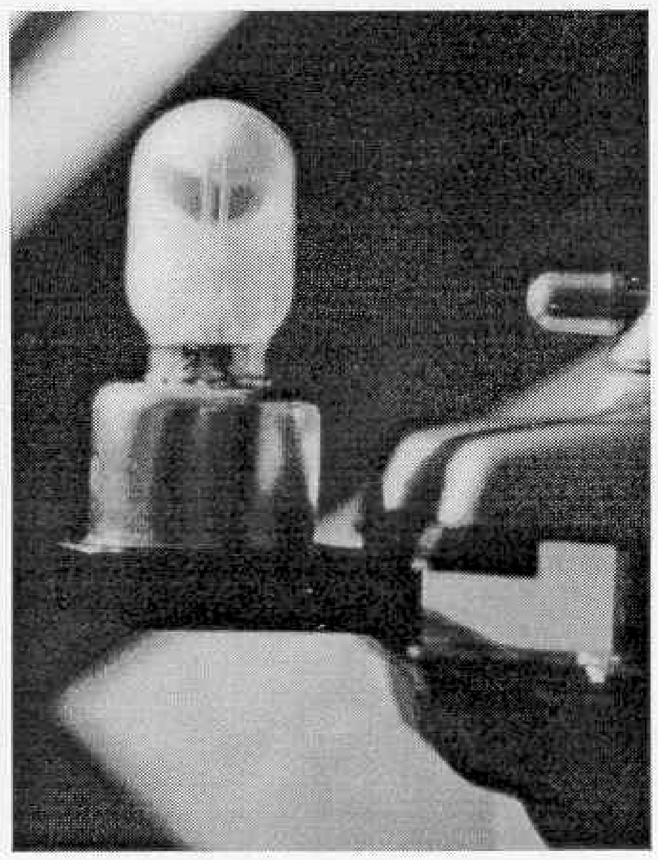

Figure 4-6. Transmissometer Lamp With Air Leak.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SERVICING AND CALIBRATION OF OPTICAL MONITORING DATALOGGERS**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4250**
DATE	**MARCH 1994**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
ORIGINATOR	James H. Wagner	
PROJECT MANAGER	James H. Wagner	
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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Add responsibilities and equipment.	May 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general procedures for servicing and calibrating dataloggers used with optical monitoring systems. Accurate and reliable operation of on-site dataloggers is critical to collection of high quality optical monitoring data. Regular servicing, performance testing, and calibration of dataloggers is performed to assure quality data capture and minimize data loss by:

- Performing functional checks and performance tests annually.
- Performing preventive maintenance servicing annually.
- Recalibrating the datalogger when performance tests indicate the unit is not operating within specifications.
- Documenting all servicing, repairs, and calibrations performed.

The following technical instructions (TIs) provide detailed information regarding specific datalogger servicing and calibration procedures:

- TI 4250-2000 *Servicing and Calibration of Campbell 21X Dataloggers*
- TI 4250-2010 *Servicing and Calibration of the Handar 540A/570A DCP*
- TI 4250-2020 *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*

Campbell 21X dataloggers are used as the primary datalogger for the IMPROVE nephelometer network, transmissometer calibration, and transmissometer field audits. Handar 540A/570A DCPs are used as the primary datalogger in the IMPROVE transmissometer network. Primeline 6723 strip chart recorders are used as backup dataloggers in the IMPROVE transmissometer network.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that performance testing is conducted on all data dataloggers annually.
- Ensure that fully serviced, calibrated, and field ready dataloggers are available as backups for units operating in the field.
- Ensure that all dataloggers that do not operate within factory specifications are returned to the manufacturer for factory servicing and recalibration.
- Ensure that all servicing and calibration is performed and documented according to procedures described in the datalogger-specific servicing and calibration TIs.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform all servicing and calibration of optical monitoring dataloggers.
- Coordinate with the manufacturer for return of dataloggers that fail to operate within factory specifications.
- Document and archive all datalogger servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a datalogger is removed from the field.
- Provide the instrument technician with a description of the field problems observed with the datalogger.

2.4 FIELD SPECIALIST

The field specialist shall:

- Perform strip chart recorder checks annually.
- Provide the instrument technician with a description of problems observed during annual site visit testing.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following subsections provide summary lists of test equipment and materials required to service and calibrate optical monitoring dataloggers.

3.1 CAMPBELL 21X DATALOGGER

- Calibrated voltage source
- Campbell Scientific datalogger communications software (SMCOM)
- Campbell Scientific SC532 Peripheral Interface Module
- ARS Campbell 21X datalogger test program (21X_TEST.DLD)
- Digital voltmeter
- Waveform generator
- Frequency counter
- Campbell Scientific, Inc. *21X Micrologger Operator's Manual* and *21X Prompt Sheet*

- Reference thermometer (°C)
- Replacement components as required
- Battery pack
- Battery charger
- Desiccant packets
- Standard electronics laboratory small tools
- TI 4250-2000, *Servicing and Calibration of Campbell 21X Dataloggers*

3.2 HANDAR 540A/570A DCP

- Calibrated voltage source
- RF Wattmeter with 50 ohm RF load
- Digital voltmeter
- Reference AT/RH sensor
- Handar, Inc. *Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set*
- Handar, Inc. *570A Data Acquisition System Operating and Service Manual*
- Handar "TERM" program
- IBM PC-compatible computer
- Spare circuit boards as required
- 12 volt battery
- Desiccant packets
- Standard electronics laboratory small tools
- TI 4250-2010, *Servicing and Calibration of the Handar 540A/570A DCP*

3.3 PRIMELINE 6723 STRIP CHART RECORDER

- Regulated 12 VDC power supply
- Calibrated voltage source
- Digital voltmeter

- Frequency counter
- Standard electronics laboratory small tools
- Soltec Distribution, *Primeline 6723 Instruction Manual*
- Stopwatch
- Replacement components (fuses, chart pens, chart paper)
- Cleaning supplies (window cleaner, alcohol, foam tip swabs)
- TI 4250-2020, *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*

4.0 METHODS

This section includes three (3) subsections:

4.1 Campbell 21X Datalogger Servicing Procedures
4.2 Handar 540A/570A DCP Servicing Procedures
4.3 Primeline 6723 Strip Chart Recorder Servicing Procedures

4.1 CAMPBELL 21X DATALOGGER SERVICING PROCEDURES

Campbell 21X dataloggers are used as the primary datalogger for the IMPROVE nephelometer network, transmissometer calibration, and transmissometer field audits. Servicing procedures for the Campbell 21X datalogger are described in detail in TI 4250-2000, *Servicing and Calibration of Campbell 21X Dataloggers*. Servicing procedures include:

- Internal memory check
- Analog input check
- Analog output check
- Pulse counter check
- Panel temperature check
- Internal battery servicing
- Archiving Campbell 21X datalogger service records

4.2 HANDAR 540A/570A DCP SERVICING PROCEDURES

The Handar 540A/570A DCP is the primary datalogger in the IMPROVE transmissometer network. Servicing procedures for the Handar 540A/570A DCP are described in detail in TI 4250-2010, *Servicing and Calibration of the Handar 540A/570A DCP*. Servicing procedures include:

- Post-field inspection and performance checks

- Routine laboratory servicing
- DCP programming
- Pre-field performance testing
- Archiving Handar 540A/570A DCP service records

4.3 PRIMELINE 6723 STRIP CHART RECORDER SERVICING PROCEDURES

The Primeline 6723 strip chart recorder is used as the backup recorder in the IMPROVE transmissometer network. Servicing procedures for the Primeline 6723 strip chart recorder are described in detail in TI 4250-2020, *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*. Servicing procedures include:

- Post-field inspection and performance checks
- Routine servicing
- Pre-field calibration and testing
- Archiving Primeline 6723 strip chart recorder service records

5.0 REFERENCES

Campbell Scientific, Inc., 1993, 21X Micrologger Operator's Manual. July.

Campbell Scientific, Inc., 1993, 21X Prompt Sheet.

Handar, Inc., 1982, Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set. June.

Handar, Inc., 1988, 570A Data Acquisition System Operating and Service Manual. March.

Soltec Distribution, Primeline 6723 Instruction Manual.

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AUTHORIZATIONS

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for servicing and verifying calibration of Campbell 21X dataloggers. This TI, as referenced in Standard Operating Procedure (SOP) 4250, *Servicing and Calibration of Optical Monitoring Dataloggers*, specifically describes procedures for:

- Testing datalogger memory functions
- Checking the accuracy of all analog voltage input channels
- Checking the accuracy of the analog output ports
- Checking the accuracy of the pulse input port
- Checking the accuracy of the panel temperature measurement
- Checking the condition of the internal battery
- Replacing the internal battery
- Archiving datalogger servicing records

Campbell 21X dataloggers are primarily used by ARS as the:

- Primary datalogger at NGN-2 nephelometer monitoring sites (Refer to TI 4300-4006, *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*).
- Primary datalogger for transmissometer calibration (Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*).
- Primary datalogger for field audit of transmissometers (Refer to SOP 4710, *Transmissometer Field Audit Procedures*).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that all Campbell 21X dataloggers are serviced at least annually.
- Verify that calibration checks are performed on all Campbell 21x dataloggers at least annually.
- Verify that all Campbell 21X dataloggers are operating within factory specifications prior to being shipped to the field.
- Verify that all Campbell 21X dataloggers that do not operate within factory specifications are returned to Campbell Scientific for factory servicing and recalibration.

- Ensure that all datalogger servicing is documented and archived in accordance with the procedures described in this TI.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform and document all calibration checks.
- Coordinate with Campbell Scientific for return and recalibration of Campbell 21X dataloggers that fail to operate within factory specifications.
- Prepare purchase orders for factory servicing and recalibration of Campbell 21X dataloggers.
- Replace the Campbell 21X internal battery as required.
- Archive all datalogger servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a 21X is being removed from the field.
- Provide the instrument technician with a description of the field problems observed with the 21X.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific instrumentation, tools, equipment, and materials required to service the Campbell 21X datalogger and to verify the datalogger calibration are:

- Calibrated voltage source - Datel Model DVC-350A or equivalent
- Campbell Scientific datalogger communications software (SMCOM)
- Campbell Scientific SC532 Peripheral Interface Module
- ARS Campbell 21X datalogger test program (21X_TEST.DLD)
- Digital voltmeter (4 1/2 digits)
- Waveform generator - Wavetek Model 185 or equivalent
- Frequency counter - Tenma Model 72-375 or equivalent
- Campbell Scientific, Inc. *21X Micrologger Operator's Manual* and *21X Prompt Sheet*
- Laboratory reference thermometer (°C)

- Replacement components as required
- Medium screwdrivers (flat-blade and Phillips-head)
- Battery charger
- Replacement sealed lead acid battery pack
- Two (2) dry half-unit DESI PAK desiccant packets

4.0 METHODS

Campbell 21X dataloggers should be serviced according to the following schedule:

- Prior to installation at a field monitoring site
- On an annual schedule (for units not used at field sites)
- Any time the operation or accuracy of the datalogger appears to be suspect

Calibration of the Campbell 21X datalogger is required any time calibration checks indicate that the datalogger is not operating within factory specifications.

This section includes six (6) subsections:

4.1 Internal Memory Check
4.2 Analog Input Checks
4.3 Analog Output Checks
4.4 Pulse Counter Check
4.5 Panel Temperature Test
4.6 Internal Battery Servicing
4.7 Archiving Datalogger Service Records

Procedures for performing the internal memory check are documented on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1) and are described in the following sections.

RECORD GENERAL INFORMATION	Record the datalogger serial number and the current date. The initials of the technician performing the inspection should also be recorded.

4.1 INTERNAL MEMORY CHECK

The Campbell 21X datalogger will perform an internal memory check on power-up. This check indicates the status of each memory chip on the datalogger's CPU board. Procedures for performing the internal memory check are documented on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1) and are as follows:

TURN DATALOGGER ON	Turn the datalogger **ON**. The datalogger display will read "HELLO."

CAMPBELL 21X DATALOGGER
SERVICING DOCUMENTATION FORM

Date: ______________________________
Datalogger S/N: ____________________
Technician: ________________________

INTERNAL MEMORY CHECK

Memory Status = 11:111111? ☐Yes ☐No Status __:______

ANALOG INPUT CHECK

Input Voltage (mV)	Datalogger Readings (mV) CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
0.000								
2.500								
5.000								

ANALOG OUTPUT CHECK

CAO PORT #	CORRECT OUTPUT (mV)	ACTUAL OUTPUT (mV)
#1	2500±1	
#2	5000±1	

PULSE COUNTER CHECK

Waveform Generator Frequency ____________________ Hz
Datalogger Counts ________________________________

PANEL TEMPERATURE CHECK

Ambient Temperature - Lab Reference _______________ °C
Datalogger Panel Temperature ______________________ °C

INTERNAL BATTERY SERVICING

Battery Voltage ____________________________ Volts
Battery Installation Date _____________________
Battery Replaced ☐Yes ☐No
Desiccant Replaced☐Yes ☐No Comment ________________________________

Factory servicing or calibration required ☐Yes ☐No
Describe Servicing required ____
____
____

Figure 4-1. Campbell 21X Datalogger Servicing Documentation Form.

After a few seconds delay, the memory check results will be displayed. If all memory is installed and operating, the display will read "11:111111." The eight (8) characters in the display represent the eight (8) memory sockets numbered from left to right. A "1" indicates a good chip is in the corresponding socket. A "0" indicates the socket is empty or an error was detected in the chip. The five (5) left-most characters of the display represent the 8K ram chips. The three (3) right-most characters of the display are the 8K PROMs.

If the memory check results indicate that one or more memory chips are faulty, return the instrument to Campbell Scientific for repair.

4.2 ANALOG INPUT CHECKS

CONNECT VOLTAGE CALIBRATOR — Connect the Datel voltage calibrator to the datalogger using the datalogger "analog inputs" test cable. This cable provides a connection from the voltage output of the calibrator to each of the eight (8) analog input channels of the datalogger.

DOWNLOAD TEST PROGRAM — Download the datalogger test program (21X_TEST.DLD) to the datalogger to be tested using the Campbell Scientific datalogger communications software (SMCOM) and the Campbell Scientific SC532 Peripheral Interface Module.

RUN TEST PROGRAM — Press ***0** on the datalogger to compile and run the test program.

SET VOLTAGES — Set the calibrator to the input voltages specified on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1). All input voltages are specified in millivolts. All datalogger readings should be recorded as millivolts.

RECORD DISPLAY READINGS — Enter ***6** on the datalogger and record the datalogger display reading (storage locations 01 - 08) for each of the eight analog channels at each of the three input voltages specified on the Campbell 21X Datalogger Servicing Documentation Form.

If the datalogger readings for any of the analog channels differ from the specified values by more than ± 5.0 millivolts, return the datalogger to Campbell Scientific for recalibration.

4.3 ANALOG OUTPUT CHECKS

The test program sets up a continuous DC voltage output on both analog output ports (CAO 1 and CAO 2).

MEASURE OUTPUT VOLTAGE — Measure the output voltage at CAO ports 1 and 2 with a calibrated and certified 4 ½ digit voltmeter. Record these measurements (in millivolts) on the Campbell 21X Datalogger Servicing

Documentation Form. The correct reading for each port is shown, along with the manufacturers' specified accuracy, on the Campbell 21X Datalogger Servicing Documentation Form.

If the datalogger readings for either CAO port differ from the specified values by more than ± 5.0 millivolts, return the datalogger to Campbell Scientific for recalibration.

4.4 PULSE COUNTER CHECK

CONNECT GENERATOR TO FREQUENCY COUNTER	Connect the waveform generator to pulse input channel #1.
SETUP WAVEFORM GENERATOR	Setup the waveform generator for a square wave output with a frequency of 1000 Hz and an amplitude of 1 volt(rms).
RECORD COUNTS	The test program will count pulses from the waveform generator for a period of 10 seconds. Record the number of counts in the pulse counter channel at storage location 09 (press ***6 9** on the datalogger). Based on an input frequency of 1000 Hz, a datalogger count of 10,000 should be displayed. If the datalogger reading for the pulse counter channel differs from the specified value by more than ± 5 counts, return the datalogger to Campbell Scientific for recalibration.

4.5 PANEL TEMPERATURE CHECK

RECORD AMBIENT TEMPERATURE	Read the ambient temperature in the laboratory with the laboratory reference thermometer. Record this temperature (°C) on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1).
RECORD PANEL TEMPERATURE	Read the datalogger panel temperature at storage location 10 (press ***6 10** on the datalogger) and record the reading on the Campbell 21X Datalogger Servicing Documentation Form. If the datalogger panel temperature measurement differs from the laboratory reference thermometer reading by more than ± 1.7 °C, return the datalogger to Campbell Scientific for recalibration.

4.6 INTERNAL BATTERY SERVICING

RECORD BATTERY VOLTAGE	Read the internal battery voltage at storage location 11 (press ***6 11** on the datalogger). Record this reading on the Campbell 21X Datalogger Servicing Documentation Form.

RECHARGE BATTERY — If the battery voltage is less than 11.76 volts, connect the datalogger to the battery charger. Recharge the battery for eight (8) hours.

REPLACE BATTERY — Disconnect the datalogger from the battery charger and recheck the battery voltage (press ***6 11** on the datalogger). If the battery voltage is still less than 11.76 volts, replace the battery as described below:

- Turn the power switch **OFF**.
- Remove the two front panel screws and carefully raise the front panel away from the datalogger case.
- Disconnect the used battery from the charging circuit and remove from the datalogger case.
- Install a fresh battery. Mark the installation date on the battery.
- Remove the datalogger desiccant packets and replace with two (2) dry half unit DESI PAK desiccant packets.
- Replace the front panel.
- Turn the power switch **ON** and recheck the battery voltage.

4.7 ARCHIVING DATALOGGER SERVICE RECORDS

All service records for Campbell 21X dataloggers are maintained by the instrument technician. The records are archived by datalogger serial number in three-ring notebooks located in the ARS instrumentation laboratory.

5.0 REFERENCES

Campbell Scientific, Inc., 1993, 21X Micrologger Operator's Manual. July.

Campbell Scientific, Inc., 1993, 21X Prompt Sheet.

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for servicing and calibration testing of Handar 540A/570A Data Collection Platforms (DCPs). This TI, as referenced in Standard Operating Procedure 4250, *Servicing and Calibration of Optical Monitoring Dataloggers*, specifically describes procedures for:

- Performing post-field inspections
- Performing post-field timing and performance checks
- Performing routine laboratory servicing and cleaning
- Checking and performing laboratory modifications
- Programming the DCP
- Performing pre-field operational tests
- Documenting all servicing tasks
- Archiving servicing, repair, and calibration records

Handar 540A/570A DCPs are used as the primary dataloggers in the IMPROVE transmissometer network.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that all Handar 540A/570A DCPs are serviced at least annually.
- Verify that calibration, timing, and transmission checks are performed on all Handar 540A/570A DCPs at least annually.
- Verify that all Handar 540A/570A DCPs are operating within factory specifications prior to being shipped to the field for use at an operational monitoring site.
- Verify that all Handar 540A/570A DCPs that do not operate within factory specifications are returned to Handar for factory servicing and recalibration.
- Ensure that all DCP servicing is documented and archived in accordance with the procedures described in this TI.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform and document all servicing, modifications, calibration checks, and operational tests.

- Coordinate with Handar for return, servicing, and recalibration of 540A/570A DCPs that fail to operate within factory specifications.

- Prepare purchase orders for factory servicing and recalibration of Handar 540A/570A DCPs.

- Replace the Handar 540A/570A internal battery as required.

- Archive all DCP servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a DCP is being removed from the field.

- Provide the instrument technician with a description of the field problems observed with the DCP.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific instrumentation, tools, equipment, and materials required to service and test the Handar 540A/570A DCP are as follows:

- Calibrated voltage source - Datel Model DVC-350A or equivalent

- RF wattmeter - Bird Model 43 with #250D power element and 50 ohm RF load or equivalent

- Digital voltmeter (4 1/2 digits)

- Handar, Inc. *Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set*

- Handar, Inc. *570A Data Acquisition System Operating and Service Manual*

- Handar "TERM" program (DCP communication and interface software)

- IBM PC-compatible computer

- Spare circuit boards as required

- Replacement internal 12 volt battery

- Two (2) packs desiccant

- Reference AT/RH sensor (Rotronics GT-L or equivalent)

- Rotronics AT/RH Sensor (Model MP-100F, wired for use with the Handar 540A/570A DCP)

- Electronic contacts cleaning fluid
- Medium screwdrivers (flat-blade and Phillips-head)

4.0 METHODS

Handar 540A/570A DCPs should be serviced according to the following schedule:

- Prior to installation at a field monitoring site
- On an annual schedule
- Any time the operation or accuracy of the datalogger appears to be suspect

Factory servicing and calibration of the Handar 540A/570A DCP is required when timing and performance checks indicate that the DCP is not operating within factory specifications.

This section includes five (5) major subsections:

4.1 Post-Field Inspection and Performance Checks
4.2 Routine Laboratory Servicing
4.3 DCP Programming
4.4 Pre-Field Performance Testing
4.5 Archiving Handar 540A/570A DCP Service Records

4.1 POST-FIELD INSPECTION AND PERFORMANCE CHECKS

When a DCP is returned from a field site, the external and internal physical condition is visually inspected prior to performing any performance tests or laboratory servicing. If the DCP is received with the power switch in the "ON" position and there are no loose circuit boards, disconnected or damaged connectors, or other apparent problems that might affect the operation of the DCP, performance tests that evaluate DCP timing, A/D converter operation, transmission power, and the DCP program are performed. Results and comments related to inspection and performance testing are fully documented on the Post-Field Inspection Checklist - Handar 540A/570A DCP (Figure 4-1).

4.1.1 General Information

RECORD GENERAL INFORMATION	Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
IDENTIFY DCP MODEL	Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).
NOTE REASON FOR RETURN	Note whether the DCP was returned for annual servicing (no observed operational problems in the field) or for unscheduled maintenance (unit malfunctioning). If returned for unscheduled maintenance, describe the observed field symptoms.

POST-FIELD INSPECTION CHECKLIST
HANDAR 540A/570A DCP

DCP S/N: ______________________________
Site: ______________________________
Date: ______________________________
Technician: ______________________________

DCP Model: ☐540A1 ☐540A2 ☐570A
Received for: ☐Annual Servicing ☐Unscheduled Maintenance
Reason for unscheduled maintenance ______________________________
____
____

PHYSICAL INSPECTION - EXTERNAL

Describe "as returned" condition of the following:

DCP Case ______________________________
Case Latches ______________________________
Connectors/Contacts ______________________________
Display (570A Only) ______________________________
Door Seal ______________________________

PHYSICAL INSPECTION - INTERNAL

Describe "as returned" condition of the following:

Power switch ☐On ☐Off
GOES Radio Channel 1 ☐900 ☐Other ______________________________
GOES Radio Channel 2 ☐000 ☐Other ______________________________
Circuit Boards, Hold Down Bracket, Connectors ______________________________
Battery and Hold Down Bracket ______________________________
Battery Voltage ________________ Volts

DCP TIMING CHECKS

Program in Memory ☐Yes ☐No
DCP ID [I] ______________________________
DCP Time [J] __ __ : __ __ : __ __ WWV Time __ __ : __ __ : __ __
DCP Time to Next Scan [S] __ __ : __ __ : __ __
DCP Time to Next Transmit [T] __ __ : __ __ : __ __

DCP A/D CONVERTER CHECKS

Test Input Ch. 1,2,3	DCP Channel # (Output)					
	CH1	CH2	CH3	CH4	CH5	CH10
0.000 Volts	________	________	________	________	________	________
4.950 Volts	________	________	________	________	________	________
Lab AT/RH				________	________	

TRANSMISSION TEST

Forced Transmit RF Power Output ____________________ Watts

Figure 4-1. Post-Field Inspection Checklist - Handar 540A/570A DCP.

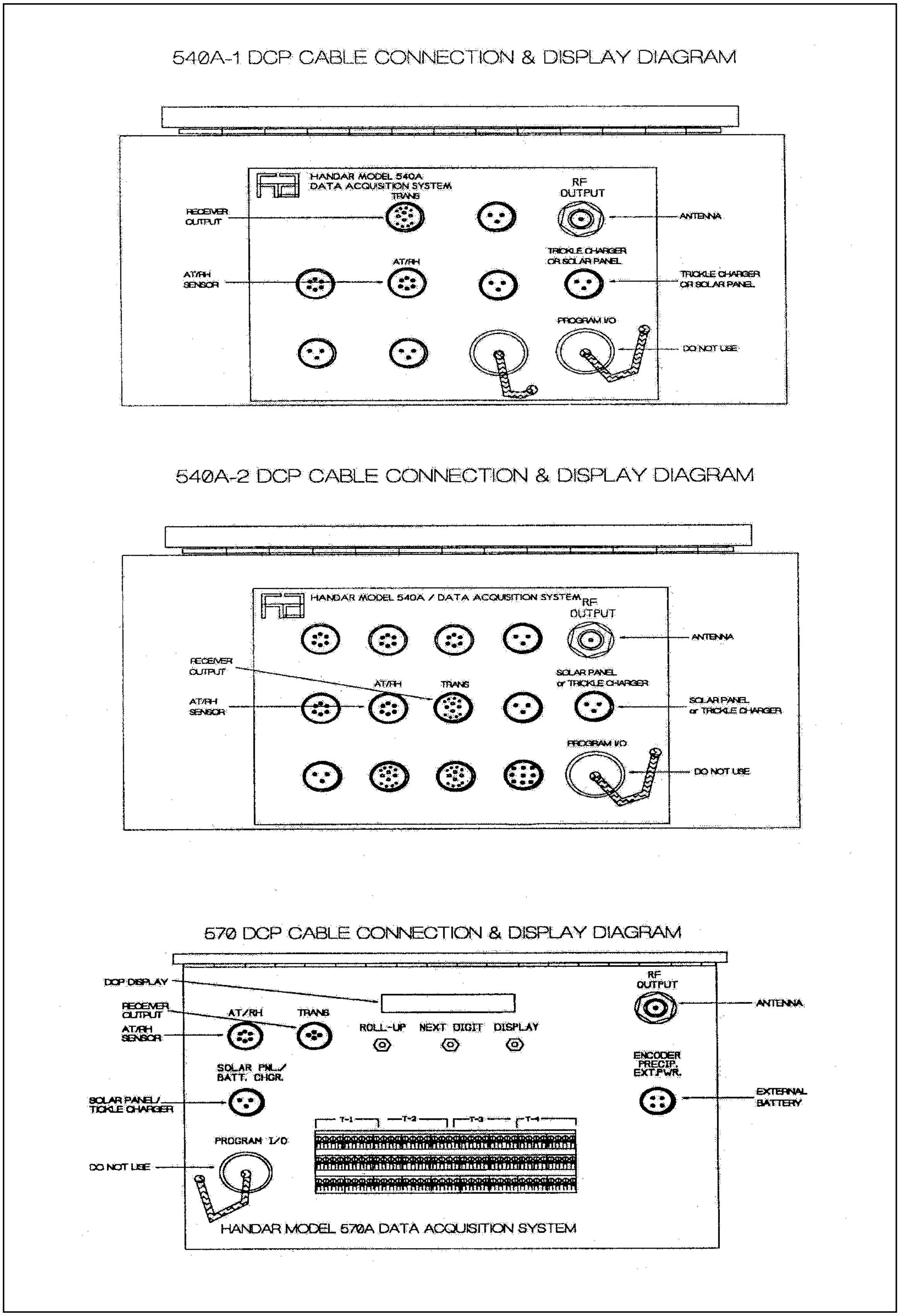


Figure 4-2. Front Panel Configurations - Handar 540A/570A DCP.

4.1.2 Physical Inspection - External

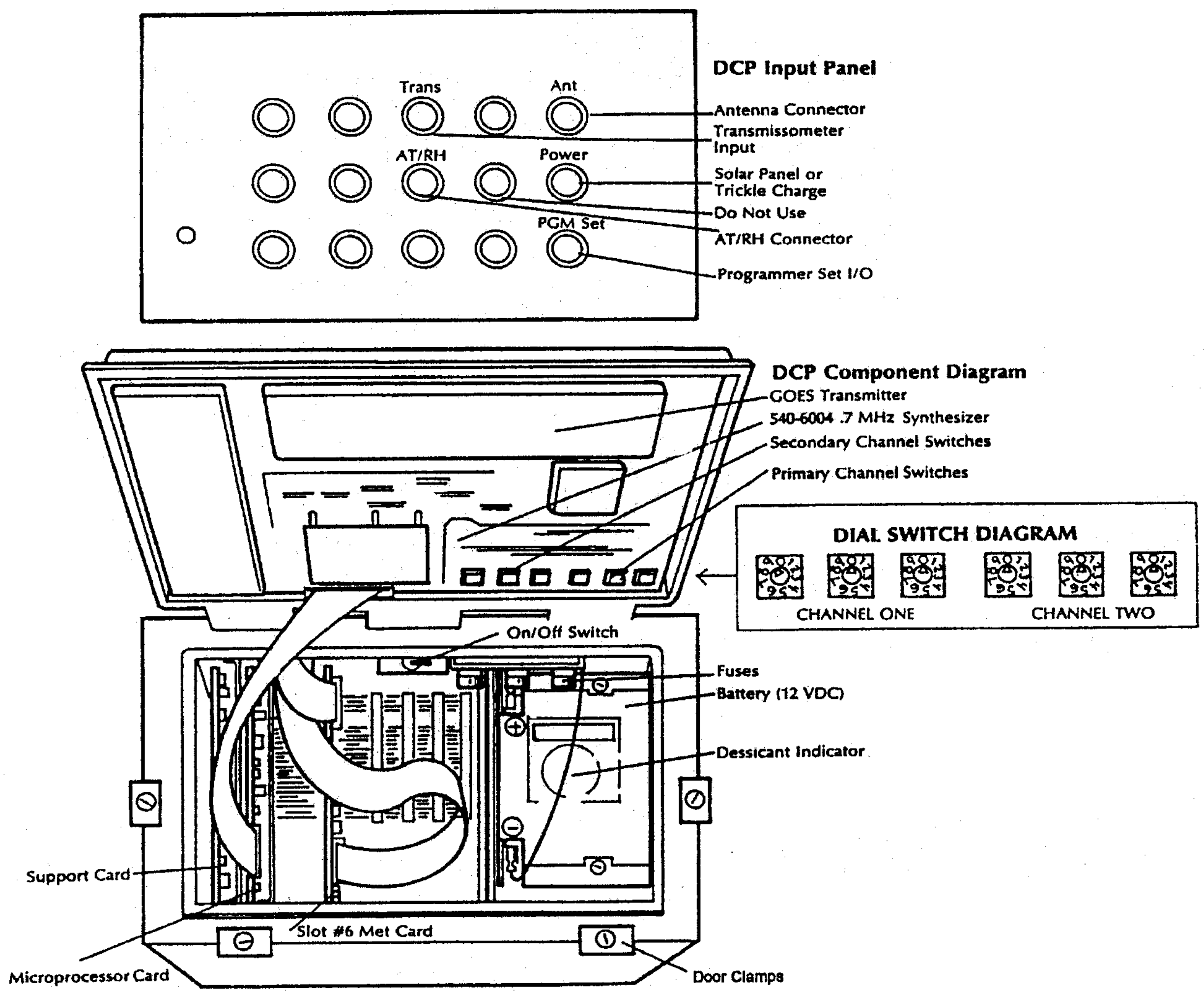
INSPECT CASE	Inspect the outside of the DCP case thoroughly. Look for signs of external damage (dented, scraped, or gouged surfaces). Examine the latches and external connectors. Describe any damage or general deterioration noted.
RECORD DISPLAY	If the DCP is a model 570A, step through the display, recording the readings displayed for each channel.
INSPECT SEAL	Open the cover on the DCP and inspect the seal between the cover and the case. Look for loose sections of seal, tears, and worn spots.

4.1.3 Physical Inspection - Internal

NOTE POWER	Note whether the power switch is "ON" or "OFF" (see Figure 4-3 for switch location).
NOTE CHANNEL SETTINGS	Note the settings of the GOES primary channel (#1) and secondary channel (#2) switches (see Figure 4-3 for switch locations). The GOES primary channel selection switch should be set to "900" (inhibits transmission). The GOES secondary channel selection switch should be set to "000" (channel unused). If the switches are not set properly, they should be reset to these channel numbers before proceeding with this inspection.
INSPECT DCP INTERIOR	Inspect the interior of the DCP, checking that all circuit boards are firmly seated, all hold-down brackets are in place and secure, and all cables and connectors are undamaged and in place. Describe any improper conditions.
MEASURE BATTERY VOLTAGE	Measure the internal battery voltage. If it is less than 11.8 volts, connect a current limited power supply set at 16 volts and 500 ma to the DCP Solar Panel/Battery Charger input for a period of 24 hours. If the battery voltage does not reach a minimum voltage of 13.8 volts, it must be replaced during servicing.
CHECK INSTALLATION DATE	Check the installation date on the battery. If the battery is more than 5 years old, it must be replaced during servicing, regardless of the battery's state of charge.

4.1.4 DCP Timing Checks

PROGRAM MEMORY	**NOTE!** If the DCP power switch was off, or has been turned off for any reason, the program and timing will have been lost from the DCP memory and this section of the post-field inspection should be omitted.
EXECUTE PROGRAM	Execute the Handar DCP communications program "TERM" from the IBM PC-compatible computer.



Side View DCP Input Panel

IMPORTANT -- DCP panels may differ from the above unit

Figure 4-3. DCP Component Diagram.

SWITCH BAUD RATE	When the "TERM" setup screen (see Figure 4-4) is displayed on the computer screen, press **F2** to switch to the correct baud rate (300 baud).
CONNECT COMPUTER TO DCP	Connect the serial port of the computer to the DCP programming port (see Figure 4-2 for location) using the DCP programming cable. After the connection is complete, the "TERM" programming screen (Figure 4-5) should be displayed on the computer screen.
NOTE DISPLAY	If the program is still in memory, the computer display should be as shown in Figure 4-5.
	If the computer display appears as in Figure 4-6, the program has been lost from memory and the DCP performance and timing checks should be terminated. Exit the "TERM" program and turn the DCP off before initiating the servicing procedures. Be sure and document that the program was no longer in memory.
SYNCHRONIZE TIME	Verify that your watch is synchronized with WWV by calling the NIST WWV time transmission telephone (303/499-7111).
ENTER PARAMETERS	Obtain DCP ID and timing information by entering into the DCP the boldface character that precedes each of the following parameters: • **I** Station ID • **J** DCP time • **S** Time remaining before next scan • **T** Time remaining before next transmission
RECORD VALUES	Record each of the values from the ID and timing checks and the correct (WWV) time when the DCP time check, [J], was performed.
COMPARE TIMES	Compare the DCP times to the correct time to determine the timing drift relative to previous measurements (at installation or from recent transmissions - Refer to TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*.

4.1.5 DCP A/D Converter Checks

CONNECT VOLTAGE SOURCE	Connect a calibrated voltage source to the input of data channels 01, 02, and 03 of the DCP.
CONNECT AT/RH SENSOR	Connect a calibrated Rotronic AT/RH sensor to the DCP's AT/RH input connector.

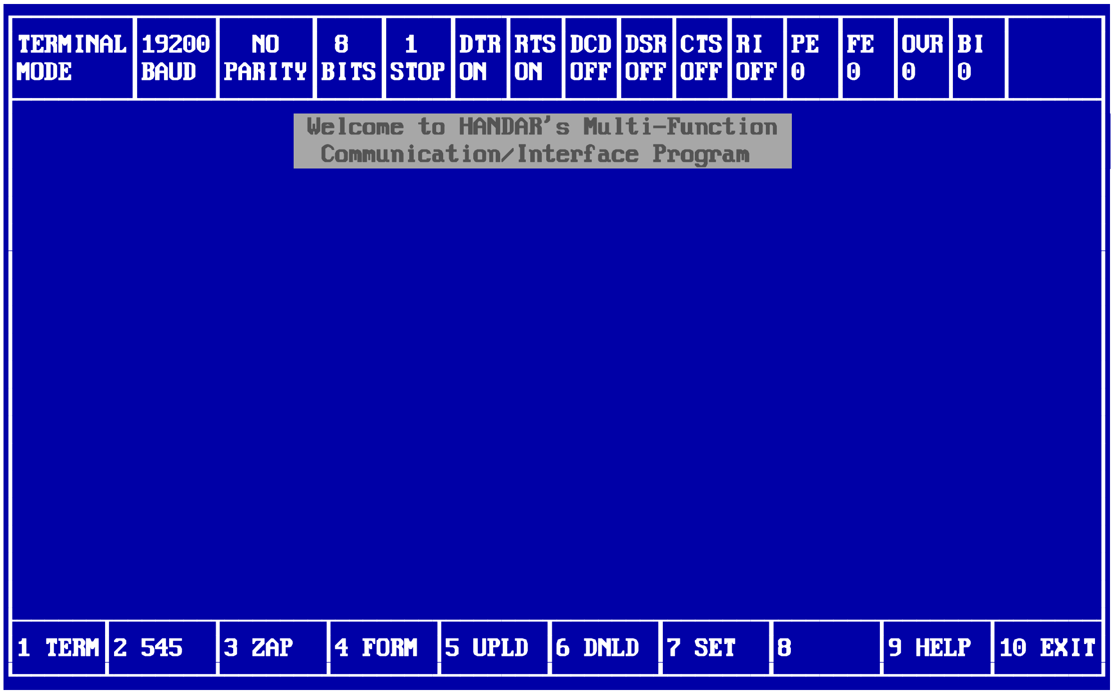


Figure 4-4. **TERM** Setup Screen.

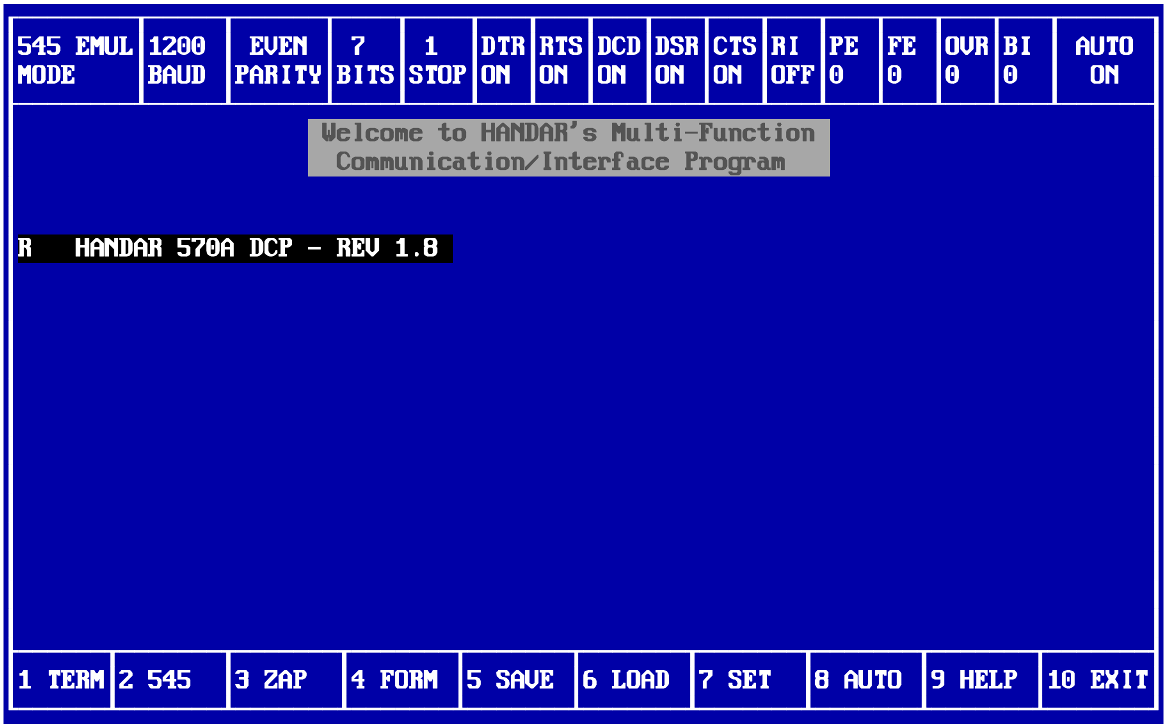


Figure 4-5. "TERM" DCP Programming Screen (Program in DCP Memory).

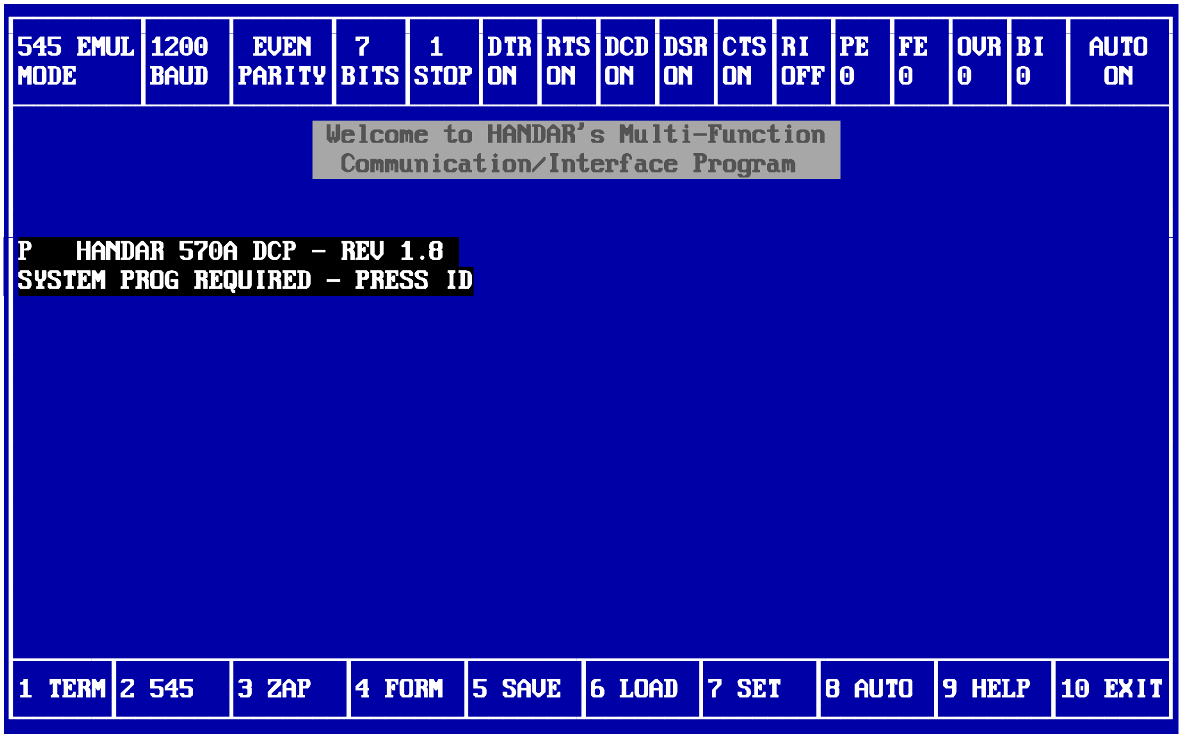


Figure 4-6. **TERM** DCP Programming Screen (No Program in DCP Memory).

SWITCH MODES

Switch the DCP from "RUN" mode to "PROGRAM" mode by entering **?**.

The computer display will read "R Enter (1) = Service (2) = All." Enter **2** to select "ALL."

SET OUTPUT

Set the output of the calibrated voltage source to 0.000 volts.

OBTAIN READINGS

Obtain DCP readings for data channels 01, 02, and 03 using the following procedure:

- Enter **M** (access data channel 01 - transmissometer raw readings).
- Enter **$** (execute a forced scan).
- Record the DCP reading for data channel 01.
- Enter **V** (scroll down to data channel 02 - transmissometer toggle signal).
- Enter **$** (execute a forced scan).
- Record the DCP reading for data channel 02.
- Enter **V** (scroll down to data channel 03 - transmissometer standard deviation).
- Enter **$** (execute a forced scan).
- Record the DCP reading for data channel 03.

With a 0.000 volt input, DCP data channels 01, 02, and 03 should all read "000."

SET OUTPUT VOLTAGE

Set the output of the calibrated voltage source to 4.950 volts.

OBTAIN READINGS

Obtain DCP readings for data channels 01-05 and 10 using the DCP procedures described above for obtaining DCP readings for data channels 01, 02, and 03.

OBTAIN AT/RH

Obtain current laboratory measurements of ambient temperature and relative humidity using the Rotronic GT-L hand held AT/RH sensor. Record these values on the inspection checklist (DCP A/D Converter Checks section) under channel 04 and channel 05, respectively.

NOTE READINGS

With a 4.950 volt input, DCP data channels 01 and 03 should read "495." DCP data channel 02 should read "001."

COMPARE READINGS — The DCP data channel 04 reading (Rotronics AT output signal) must be adjusted by subtracting 100 from the reading obtained during the test. Compare this adjusted reading with the temperature measurement obtained with the hand held sensor. The two values should then match within ± 2 F°.

Compare the DCP data channel 05 reading (Rotronics RH output signal) with the RH measurement obtained with the hand held sensor. The two values should agree within ± 3%.

Compare the DCP data channel 10 reading (DCP internal battery voltage) with the internal battery voltage measured during the DCP internal physical inspection. The two values should agree within ± 0.005 volts.

4.1.6 Transmission Test

CONNECT WATTMETER — Connect an RF wattmeter (with a 200-500 mHz, 25-watt power element) to the "RF Output" connector located on the front panel of the DCP. A 50 Ohm, 25-watt load resistor should be connected to the output of the wattmeter.

SET CHANNEL SWITCHES — Set the GOES primary channel select switches to the channel number assigned to the ID programmed for the DCP under test.

INITIATE TRANSMISSION — With the DCP in "PROGRAM" mode, initiate a transmission by entering **#**.

RECORD READING — The wattmeter should read 10 ± 2 watts. Record the observed reading on the Post-Field Inspection Checklist - Handar 540A/570A DCP (Figure 4-1).

RESET SWITCHES — Reset the GOES primary channel select switches to **900**.

4.2 ROUTINE LABORATORY SERVICING

Record and document all information and procedures on the Routine Servicing Checklist - Handar 540A/570A DCP (Figure 4-7).

RECORD GENERAL INFORMATION — Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.

IDENTIFY DCP MODEL — Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).

NOTE REASON FOR RETURN — Note whether the DCP was returned for annual servicing (no observed operational problems in the field) or for unscheduled maintenance (unit malfunctioning). If returned for unscheduled maintenance, describe the observed field symptoms.

ROUTINE SERVICING CHECKLIST
HANDAR 540A/570A DCP

DCP S/N: ___________________________
Date: ______________________________
Technician: _________________________

DCP Model: ☐540A1 ☐540A2 ☐570A

Received for: ☐Annual Servicing ☐Unscheduled Maintenance

Reason for unscheduled maintenance ____

____

____

SETUP

☐ GOES Primary Channel Select Switches Set to 900

☐ GOES Secondary Channel Select Switches Set to 000

EXTERNAL CLEANING

☐ Front Panel Connector Contacts Cleaned

☐ Connector Mounting Screws Tightened

BATTERY REPLACEMENT

Internal 12-Volt Battery Replaced ☐ Yes ☐ No

INTERNAL CLEANING

☐ Plug in Circuit Board Connector Contacts Cleaned

☐ Backplane Connector Contacts Cleaned

☐ Inside of DCP Cleaned

570A MODIFICATIONS

Toggle Input ☐ Modified During Servicing ☐ Previously Modified

AT/RH Interface ☐ Modified During Servicing ☐ Previously Modified

540A MODIFICATION

AT/RH Interface ☐ Modified During Servicing ☐ Previously Modified

Figure 4-7. Routine Servicing Checklist - Handar 540A/570A DCP.

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to 900" and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with servicing of the DCP.
CLEAN EXTERNAL CONTACTS	Spray the contacts on all external (front panel) connectors with contact cleaner.
CHECK MOUNTING SCREWS	Check the mounting screws for all front panel connectors. Loose screws should be tightened.
REPLACE BATTERY	If the battery is more than five (5) years old (as indicated by the installation date marked on the battery), or if the battery failed the battery test during inspection, the battery must be replaced. Battery replacement procedures are as follows: • Turn the power switch **OFF**. • Disconnect any external power source (battery or battery charger) from the DCP. • Disconnect the DCP internal battery connectors. • Remove the circuit board hold-down bracket. • Remove the battery hold-down bracket. • Lift the battery out of the DCP case. • With a permanent marker, write the installation date on the new battery. • Place the new battery in the DCP case. • Replace the battery hold-down bracket.
CLEAN CIRCUIT BOARD	Check the power switch. If it is not "OFF," turn it **OFF**. Remove the DCP plug-in circuit boards. Clean printed circuit board's edge connector contacts and the ribbon cable connector contacts with contact cleaner.
CLEAN BACKPLANE CONNECTORS	Clean the backplane connectors with contact cleaner. Clean the contacts on the ribbon cable connectors with contact cleaner.

CLEAN INTERIOR OF DCP

Clean the inside of the DCP with compressed air.

MODIFY 570A TOGGLE INPUT VOLTAGE DIVIDER

If this is a Handar 570A DCP, the transmissometer toggle input (DCP data channel 02) voltage divider must be modified to ensure that the voltage divider always exceeds 3.0 volts when the toggle input is at a logic "high" level. Modify the toggle input voltage divider located on the 12-bit A/D Converter (ADC) board using the following procedures:

- Remove the component platform in socket U17 of the ADC board (see Figure 4-8 for the location of U17).
- Examine resistor R17-6 located between pins 6 and 11 of the component platform (the resistor location on the component platform is shown in Figure 4-8). If the modification has been implemented, this resistor value will be 4.02K Ohms. If it is not 4.02K, remove the existing resistor (1.00K) and replace it with a 4.02K resistor.
- Replace the component platform in socket U17 of the ADC board.

MODIFY 570A FOR AT/RH SENSOR

If this is a Handar 570A DCP, the AT/RH sensor interface circuit on the ADC board must be modified to accept the Rotronics MP100-F AT/RH sensor. To modify the sensor interface circuit, remove the component platform from socket U7 of the ADC board (refer to Figure 4-8 for the location of U7).

MODIFY 540A FOR AT/RH SENSOR

If this is a Handar 540A DCP, the AT/RH sensor interface circuit on the Met board must be modified to accept the Rotronics MP100-F AT/RH sensor. To modify the sensor interface circuit, remove resistor R8 (see Figure 4-9 for the location of R8).

REINSTALL CIRCUIT BOARDS

If this is a Handar 570A DCP, reinstall the ADC board in slot #1.

If this is a Handar 540A DCP, reinstall the circuit boards in the slots numbered as follows:

- Slot #6 Met board
- Slot #8 Microprocessor board
- Slot #9 Support board

Replace the circuit board hold-down bracket.

Reconnect the ribbon cables.

Reconnect the DCP internal battery connectors to the battery.

Turn the power switch **ON**.

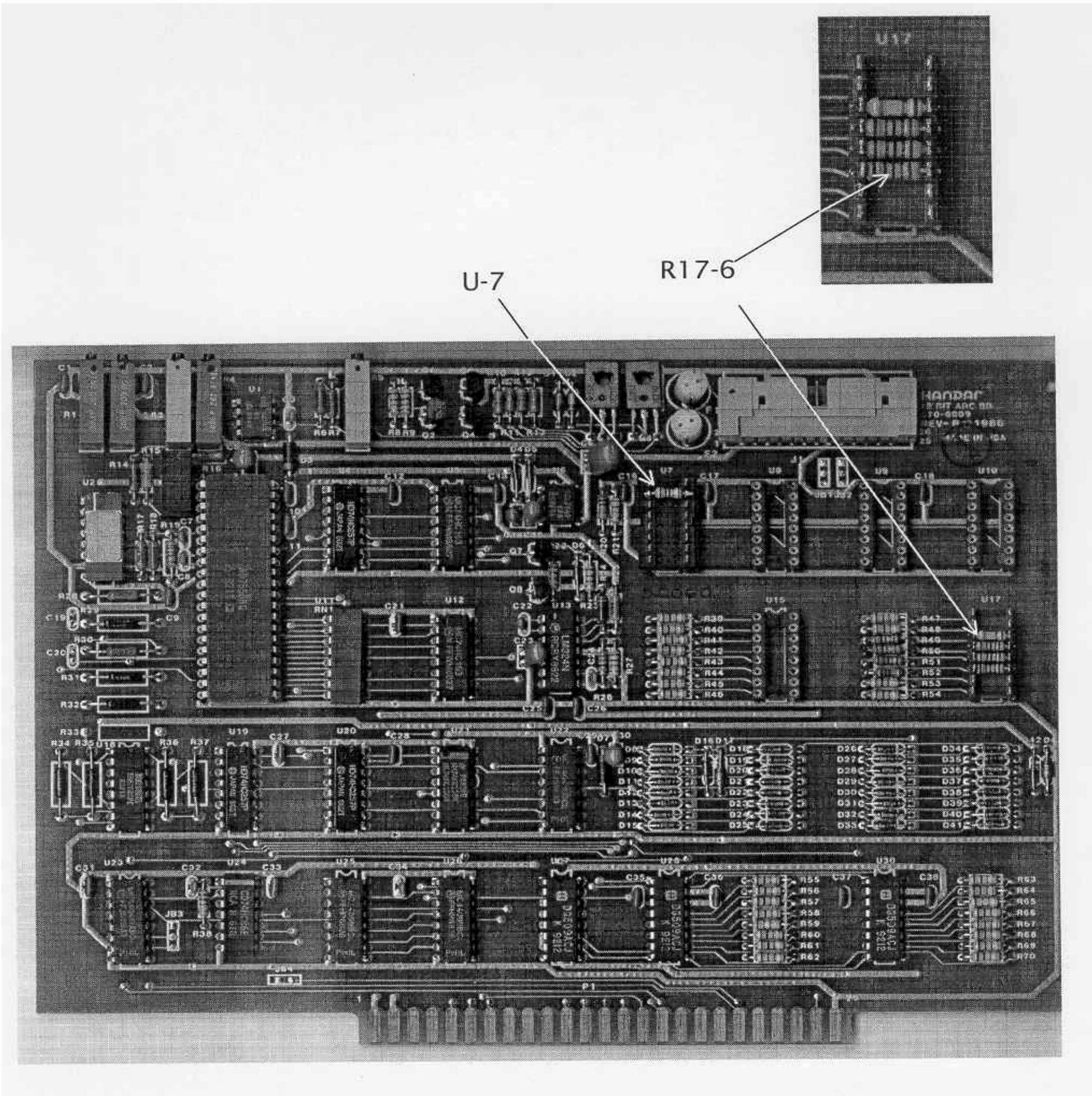


Figure 4-8. Handar 570A ADC Board - Component Locations.

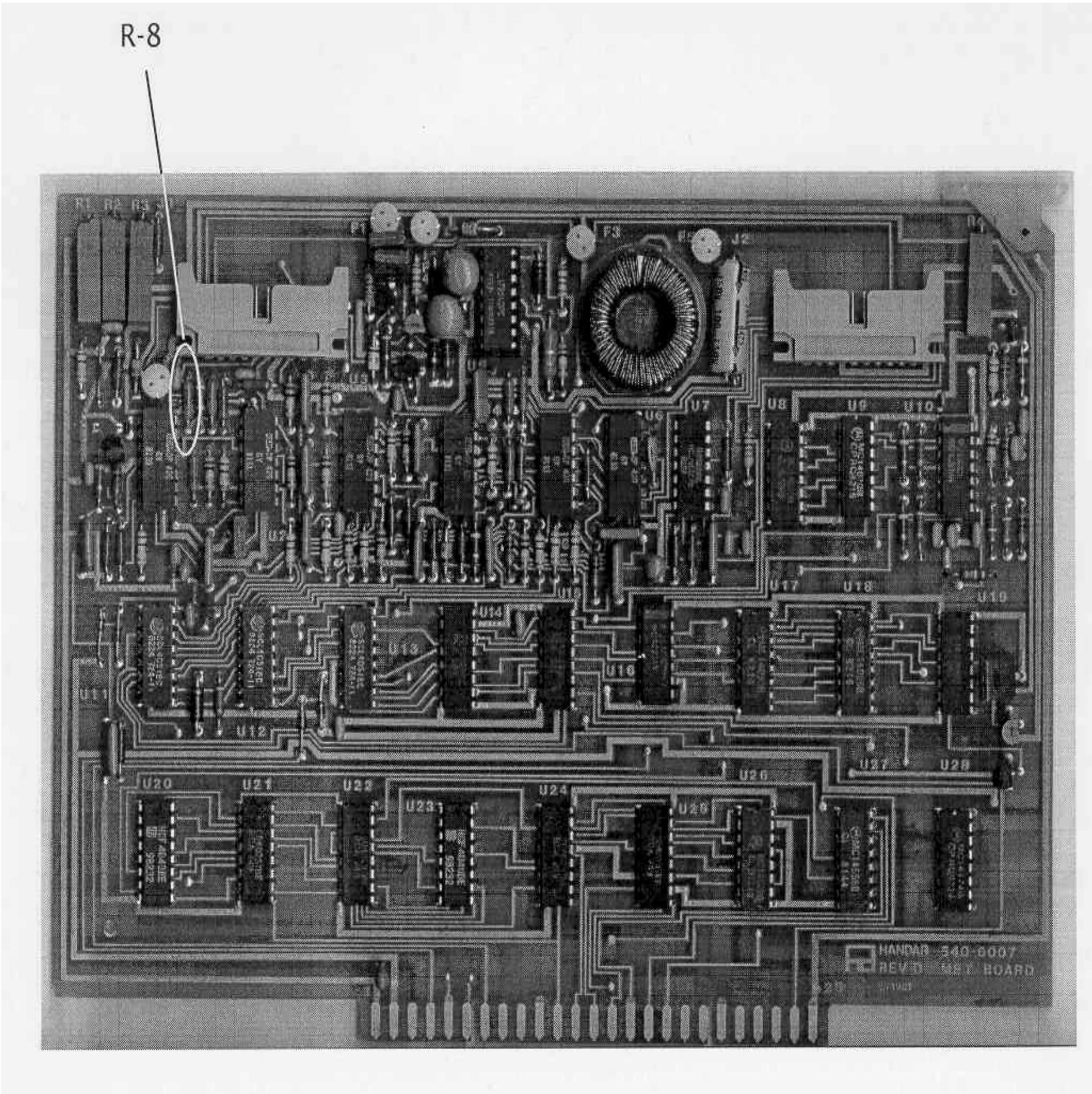


Figure 4-9. Handar 540A Met Board - Component Locations.

4.3 DCP PROGRAMMING

The Handar 540A/570A DCP operational configuration is established through a user program that performs the following functions:

- Defines the external sensors and signal inputs to be used
- Specifies the data acquisition channels associated with each sensor or input
- Defines processing options
- Selects reporting modes and formats
- Sets scanning, reporting, and transmission schedules

Basic concepts relating to the data acquisition functions of the Handar 540A/570A DCP are described in detail in Section 6.1 of the Handar *570A Data Acquisition System Operating and Service Manual*.

For DCPs used with the IMPROVE transmissometer network, the most recent version of the standard DCP configuration program is available as an ASCII file, either 540ROT.DCP (Refer to Appendix A for a complete listing of the 540ROT.DCP configuration program) or 570ROT.DCP (Refer to Appendix B for a complete listing of the 570ROT.DCP configuration program), depending on the type of DCP to be programmed. The standard program file is first downloaded to the DCP.

After downloading, the program in the DCP is edited to include the site-specific operating parameters (see Table 4-1 for a list of station IDs, GOES channel assignments, and transmit times for all IMPROVE transmissometer sites) listed below:

- Station ID
- Transmit time

GOES channel selection is controlled by the DCP channel selection switches, not by the DCP configuration program.

Procedures for downloading the standard DCP configuration program are as follows:

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to "900" and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with programming of the DCP.
SYNCHRONIZE TIME	Verify that your watch is synchronized with WWV by calling the NIST WWV time transmission telephone (303/499-7111).
DELETE DCP MEMORY	Ensure that there is no program stored in the DCP memory by turning the power switch to **OFF**, then turning it back to **ON** (refer to Figure 4-3 for switch location).

Table 4-1

DCP ID Assignments
IMPROVE Transmissometer Network

DCP-ID	CHAN	LOCATION	TIME *	RATE **
FA43DOBE	014W	Fort Collins (Test)	0200	X3
FA43F652	014W	Grand Canyon (In-Canyon)	0202	X3
FA441794	014W	Glacier	0204	X3
FA44C1FC	014W	Rocky Mountain	0215	X3
FA44D28A	014W	Grand Canyon (South Rim)	0216	X3
FA44E710	014W	Great Basin	0217	X3
FA44F466	014W	Canyonlands	0218	X3
FA450618	014W	Chiricahua	0219	X3
FA42D244	014W	Yosemite	0220	X3
FA4306D6	038W	San Gorgonio	0219	X3
FA4315A0	038W	Badlands	0220	X3
FA4356AA	038W	Big Bend	0224	X3
FA436330	038W	Petrified Forest	0225	X3
FA437046	038W	Guadalupe Mountains	0226	X3
FA4380C2	038W	Bandelier	0227	X3
FA43A62E	038W	Bridger	0229	X3
FA42C132	009E	Shenandoah	0232	X3

* GOES FIRST TRANSMISSION TIME (GMT)

** GOES TRANSMISSION INTERVAL (X3 = 3 HOUR INTERVAL)

EXECUTE PROGRAM

Execute the Handar DCP communications program "TERM" from the PC computer.

When the "TERM" setup screen (see Figure 4-4) is displayed on the computer screen, press **F2** to switch to the correct baud rate (300 baud).

Connect the serial port of the PC computer to the DCP programming port (see Figure 4-2 for location) using the DCP programming cable. After the connection is complete, the "TERM" programming screen of Figure 4-6 should be displayed on the computer screen.

Initiate the program download by pressing the **F6** key.

The next screen prompt displayed is "LOAD PS PROG->DCP." Press **ENTER** in response to this prompt.

The screen prompt "ENTER NAME OF PROGRAM FILE:" is then displayed. Enter **540ROT.DCP** to program a Handar 540 DCP. To program a Handar 570A DCP, enter **570ROT.DCP**.

While the program is loading, the message "P LOADING PROGRAM" will be displayed. Upon completion of the download, the message "P DONE" will be displayed. The "P" at the beginning of a display message indicates that the DCP is in the "PROGRAM" mode. An "R" at the beginning of a message indicates that the DCP is in the "RUN" mode.

EDIT PARAMETERS

Procedures for editing the site-specific parameters are as follows:

Editing commands (the boldfaced character) used in these procedures are as follows:

- **I** Station ID
- **J** DCP time
- **S** Time remaining before next scan
- **T** Time remaining before next transmission
- **M** Data channel select
- **N** Define Sensor Type
- **K** Program GOES/Radio
- **V** Scroll Down
- **U** Scroll Up

- **$** Forced Scan
- **#** Forced Transmit (GOES Radio)

Enter **I** to edit the station ID. The download program initially assigns ID "FA43F652" to the DCP. The display message will be "P ID FA43F652."

Enter an unused test ID (e.g., **FA43D0BE**). Note that all ID characters are hexadecimal numbers (0-9 and A-F). The letter "O" is not allowed. The display message will be "P ID FA43D0BE."

Enter **K** to program the GOES functions. The display message will be "P GOES PRI XMT MODE 01."

Enter **V** to scroll down to the next prompt, "P 1ST GOES XMT TIME 02:30:00."

Enter the "first transmit time" assigned to the selected station ID. For ID FA43D0BE, the first transmit time is "02:00:00." Enter **020000** (the colons are added by the DCP). The display message will be "P 1ST GOES XMT TIME 02:00:00."

Enter **V** to scroll down to the next prompt, "P PRI XMT INTERVAL 03:00:00." This is the proper transmit interval for all IMPROVE transmissometer sites. Editing is not required.

Enter **V** to scroll down to the next prompt, "P GOES SEC XMT MODE 00." This is the proper secondary transmit mode for all IMPROVE transmissometer sites. Editing is not required.

Enter **J** to set the DCP time and date. The display message will be "P STATION TIME 23:27:45." (The actual time displayed in the message is not important).

All DCP times are Greenwich Mean Time (GMT). Enter the time at the top of the next minute (e.g., if the current GMT time is 14:32:28, enter **14:33:00**) and press **ENTER** at the top of the minute. The display message will be "P STATION TIME 14:33:00."

Enter **V** to scroll down to the next prompt, "P YEAR (XX) 88."

Enter the last 2 digits of the current year (e.g., **94**). The display message will be "P YEAR (XX) 94."

Enter **V** to scroll down to the next prompt, "P DCP JULIAN DATE 326."

Enter the correct Julian date (e.g., for January 28, enter **028**). The display message will be "P DCP JULIAN DATE 028."

Enter **M** to select DCP channel 01. The display message will be "P CHANNEL 01."

Enter **N** to edit the sensor configuration. The display message will be "P01 SENSOR TYPE 10."

Enter **V** to scroll through the sensor configuration until you reach the "start of measurement prompt", "P01 START OF MEAS 23:30:00."

The start of measurement time should be programmed for 30 minutes after the current hour (e.g., if the current time is 17:04:29, enter **17:30:00**). A second prompt asking "CHANGE ALL CHANNELS? (1=Y, 2=N) will be displayed.

Enter **1**, setting the start of measurement time for all channels to 17:30:00. The display message will be "P01 START OF MEAS 17:30:00."

This completes programming of the Handar 540A/570A DCP.

4.4 PRE-FIELD PERFORMANCE TESTING

Pre-field performance testing of the Handar 540A/570A DCP includes laboratory performance testing and a 7-day field test at the Fort Collins Transmissometer Calibration and Test Facility. Laboratory performance testing verifies proper programming and calibration of the DCP. Field testing exposes the DCP to a varying operational environment, testing the ability of the DCP to maintain accurate timing and calibration over a wide range of operating conditions. Document all performance checks and results on the Laboratory Performance Testing Form - Handar 540A/570A DCP (see Figure 4-10).

4.4.1 General Information

RECORD GENERAL INFORMATION	Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
IDENTIFY DCP MODEL	Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).

4.4.2 Laboratory Performance Testing

Laboratory performance testing repeats the DCP performance and timing checks and the transmission test performed during the post-field inspection and performance checks. It also adds a run mode timing check. Procedures for conducting laboratory performance testing are:

- Perform DCP timing checks as described in Section 4.1.4.
- Perform DCP A/D converter checks as described in Section 4.1.5.
- Perform the DCP transmission test as described in Section 4.1.6.

LABORATORY PERFORMANCE TESTING
HANDAR 540A/570A DCP

DCP S/N: ___________________________
Date: ______________________________
Technician: _________________________

DCP Model: ☐540A1 ☐540A2 ☐570A

DCP TIMING CHECKS

Program in Memory ☐Yes ☐No
DCP ID [I] _____________________
DCP Time [J] __ __ : __ __ : __ __ WWV Time __ __ : __ __ : __ __
DCP Time to Next Scan [S] __ __ : __ __ : __ __
DCP Time to Next Transmit [T] __ __ : __ __ : __ __

DCP A/D CONVERTER CHECKS

Test Input Ch. 1,2,3	DCP Channel # (Output)					
	CH1	CH2	CH3	CH4	CH5	CH10
0.000 Volts	________	________	________	________	________	________
4.950 Volts	________	________	________	________	________	________
Lab AT/RH				________	________	

TRANSMIT TEST

Forced Transmit RF Power Output _____________ Watts

RUN MODE TIMING CHECKS

☐ Primary Channel Select Switches Set to 900
☐ Secondary Channel Select Switches Set to 000
☐ DCP in Run Mode

Assigned ID __________________
Next Scheduled Scan Time __ __ : __ __ : __ __
Next Scheduled Transmit Time __ __ : __ __ : __ __

DCP ID [I] ___________________
DCP Time [J] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __

DCP Time to Next Scan [S] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __
Next Scan Time (WWV Time + Time to Next Scan) __ __ : __ __ : __ __

DCP Time to Next Transmit [T] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __
Next Transmit Time (WWV Time + Time to Next Transmit) __ __ : __ __ : __ __

Figure 4-10. Laboratory Performance Testing Form - Handar 540A/570A DCP.

4.4.3 Run Mode Timing Checks

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to "900" and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with laboratory testing of the DCP.
RECORD PARAMETERS	Enter **Y** to place the DCP in the "RUN" mode.
	Enter **I** to display the station ID. Verify that the ID displayed is the ID programmed into the DCP.
	At the top of the minute (using GMT as the reference), enter **J** to display the station time. Record GMT and station time. If the station time differs from GMT by more than 2 seconds, reset the station time (see Section 4.3, DCP Programming).
	Enter **S** to obtain the time remaining before the next scan. Record GMT at the time the "S" command was entered and the time remaining as reported by the DCP. Adding the time remaining to the recorded GMT should give the next scheduled scan time (normally set for 30 minutes after the hour).
	Enter **T** to obtain the time remaining before the next transmission. Record GMT at the time the "T" command was entered and the time remaining as reported by the DCP. Adding the time remaining to the recorded GMT should give the next scheduled transmission time (see Table 4-1 for a list of station IDs and their assigned transmission times).

4.4.4 Field Testing of the Handar 540A/570A DCP

INSTALL	Transport the DCP to field test site and install the unit in the DCP transmissometer receiver shelter.
CONNECT TRICKLE LOCATION	Connect the on-site trickle charger to the DCP (see Figure 4-2 for the DCP connector location).
CONNECT ANTENNA	Connect the GOES antenna (mounted on the outside of the receiver shelter and previously aligned) to the DCP RF output connector.
SET GOES SWITCHES	Open the DCP case and set the GOES primary channels selection switches to the channel assigned to the ID of the DCP under test (see Table 4-1).
CONNECT WATTMETER	Connect an RF wattmeter (with a 200-500 mHz, 25-watt power element) between the "RF Output" connector located on the front panel of the DCP and the DCP antenna cable.

Set the power element of the wattmeter for the forward direction.

Monitor the wattmeter reading as the first transmit time approaches. When the transmitter turns on (as indicated by a sharp increase in the wattmeter reading), note the peak power reading in the forward direction. Reverse the direction of the power element and note the peak reading of the reflected power.

The forward direction wattmeter reading should be 10 ± 2 watts. The reflected power reading should be less than two watts.

Disconnect the wattmeter and reconnect the antenna to the DCP.

Place two fresh desiccant packs inside the DCP. Close the DCP and tighten all latches to ensure a tight seal.

The transmitted data are reviewed daily, verifying that the transmit time, frequency deviation, and power level all meet factory specifications (Refer to TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*).

If the transmitted data review indicates timing, frequency deviation, or power related problems, the field test should be terminated and the DCP returned to the laboratory. The instrument technician will then coordinate with Handar to arrange for repair and/or recalibration of the DCP.

If the DCP operates within factory specifications throughout the seven day test period, the DCP is returned to the laboratory and turned off until it is needed in the IMPROVE transmissometer network.

All field test data printouts are archived with the DCP service records as described in Section 4.5.

4.5 ARCHIVING HANDAR 540A/570A DCP SERVICE RECORDS

Service records for Handar DCPs are maintained by the instrument technician and archived by DCP serial number in three-ring notebooks located in the ARS instrumentation laboratory.

5.0 REFERENCES

Handar, Inc., 1988, 570A Data Acquisition System Operating and Service Manual, March.

Handar, Inc., 1982, Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set, June.

APPENDIX A

HANDAR 540A DCP CONFIGURATION PROGRAM - 540ROT.DCP

P ID	FA43D0BE
P STATION TIME	15:47:38
P YEAR (XX)	94
P DCP JULIAN DATE	055
P GOES PRI XMT MODE	01
P 1ST GOES XMT TIME	02:00:00
P PRI XMT INTERVAL	03:00:00
P GOES SEC XMT MODE	00
P TEL #:AREA CODE	1-303
P TEL #:LOCAL	224-9300
P MODEM XMT FORMAT	00
P 1ST DIAL TIME	00:00:00
P DIAL INTERVAL	00:00:00
P TEL EMG XMIT 1=0N	00
P AUTO DUMP? 1=Y 0=N	00
P CHANNEL NO.	01
P01 SENSOR TYPE	10
P01 CARD SLOT #	06
P01 SENSOR INPUT ADRS	6
P01 SENSOR PWR ADRS	8
P01 SENSOR PWR ADV	00:00:02
P01 *FULL SCALE	1000
P01 ZERO SCALE	0000
P01 MEAS INTERVAL	01:00:00
P01 START OF MEAS	16:30:00
P01 LEVEL 1 MEAS TYPE	001
P01 XMIT 2 OR 3 BYTES?	03
P01 HIGH LIMIT	NO LIMIT
P01 LOW LIMIT	NO LIMIT
P01 HIGH DIFF LIMIT	NO LIMIT
P01 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	02
P02 SENSOR TYPE	10
P02 CARD SLOT #	06
P02 SENSOR INPUT ADRS	9
P02 SENSOR PWR ADRS	8
P02 SENSOR PWR ADV	00:00:02
P02 *FULL SCALE	001
P02 ZERO SCALE	000
P02 MEAS INTERVAL	01:00:00
P02 START OF MEAS	16:30:00
P02 LEVEL 1 MEAS TYPE	001
P02 XMIT 2 OR 3 BYTES?	03
P02 HIGH LIMIT	NO LIMIT
P02 LOW LIMIT	NO LIMIT
P02 HIGH DIFF LIMIT	NO LIMIT
P02 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	03
P03 SENSOR TYPE	10
P03 CARD SLOT #	06
P03 SENSOR INPUT ADRS	8
P03 SENSOR PWR ADRS	8
P03 SENSOR PWR ADV	00:00:02
P03 *FULL SCALE	500
P03 ZERO SCALE	000
P03 MEAS INTERVAL	01:00:00
P03 START OF MEAS	16:30:00
P03 LEVEL 1 MEAS TYPE	001
P03 XMIT 2 OR 3 BYTES?	03
P03 HIGH LIMIT	NO LIMIT
P03 LOW LIMIT	NO LIMIT
P03 HIGH DIFF LIMIT	NO LIMIT
P03 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	04
P04 SENSOR TYPE	10
P04 CARD SLOT #	06
P04 SENSOR INPUT ADRS	C
P04 SENSOR PWR ADRS	8
P04 SENSOR PWR ADV	00:00:02
P04 *FULL SCALE	0978
P04 ZERO SCALE	0081
P04 MEAS INTERVAL	01:00:00
P04 START OF MEAS	16:30:00
P04 LEVEL 1 MEAS TYPE	001
P04 XMIT 2 OR 3 BYTES?	03
P04 HIGH LIMIT	NO LIMIT
P04 LOW LIMIT	NO LIMIT
P04 HIGH DIFF LIMIT	NO LIMIT
P04 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	05
P05 SENSOR TYPE	04
P05 CARD SLOT #	06
P05 SENSOR PWR ADV	00:00:02
P05 HUMIDITY CHAN (1,2)	01
P05 *FULL SCALE	500
P05 ZERO SCALE	000
P05 MEAS INTERVAL	01:00:00
P05 START OF MEAS	16:30:00
P05 LEVEL 1 MEAS TYPE	001
P05 XMIT 2 OR 3 BYTES?	03
P05 HIGH LIMIT	NO LIMIT
P05 LOW LIMIT	NO LIMIT
P05 HIGH DIFF LIMIT	NO LIMIT
P05 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	06
P06 SENSOR TYPE	10
P06 CARD SLOT #	06
P06 SENSOR INPUT ADRS	5
P06 SENSOR PWR ADRS	8
P06 SENSOR PWR ADV	00:00:02
P06 *FULL SCALE	000
P06 ZERO SCALE	000
P06 MEAS INTERVAL	01:00:00
P06 START OF MEAS	16:30:00
P06 LEVEL 1 MEAS TYPE	001
P06 XMIT 2 OR 3 BYTES?	03
P06 HIGH LIMIT	NO LIMIT
P06 LOW LIMIT	NO LIMIT
P06 HIGH DIFF LIMIT	NO LIMIT
P06 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	07
P07 SENSOR TYPE	10
P07 CARD SLOT #	06
P07 SENSOR INPUT ADRS	D
P07 SENSOR PWR ADRS	8
P07 SENSOR PWR ADV	00:00:02
P07 *FULL SCALE	000
P07 ZERO SCALE	000
P07 MEAS INTERVAL	01:00:00
P07 START OF MEAS	16:30:00
P07 LEVEL 1 MEAS TYPE	001
P07 XMIT 2 OR 3 BYTES?	03
P07 HIGH LIMIT	NO LIMIT
P07 LOW LIMIT	NO LIMIT
P07 HIGH DIFF LIMIT	NO LIMIT
P07 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	08
P08 SENSOR TYPE	10
P08 CARD SLOT #	06
P08 SENSOR INPUT ADRS	A
P08 SENSOR PWR ADRS	8
P08 SENSOR PWR ADV	00:00:02
P08 *FULL SCALE	000
P08 ZERO SCALE	000
P08 MEAS INTERVAL	01:00:00
P08 START OF MEAS	16:30:00
P08 LEVEL 1 MEAS TYPE	001
P08 XMIT 2 OR 3 BYTES?	03
P08 HIGH LIMIT	NO LIMIT
P08 LOW LIMIT	NO LIMIT
P08 HIGH DIFF LIMIT	NO LIMIT

P08 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	09
P09 SENSOR TYPE	10
P09 CARD SLOT #	06
P09 SENSOR INPUT ADRS	8
P09 SENSOR PWR ADRS	8
P09 SENSOR PWR ADV	00:00:02
P09 *FULL SCALE	00.0
P09 ZERO SCALE	00.0
P09 MEAS INTERVAL	01:00:00
P09 START OF MEAS	16:30:00
P09 LEVEL 1 MEAS TYPE	001
P09 XMIT 2 OR 3 BYTES?	03
P09 HIGH LIMIT	NO LIMIT
P09 LOW LIMIT	NO LIMIT
P09 HIGH DIFF LIMIT	NO LIMIT
P09 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	10
P10 SENSOR TYPE	12
P10 MEAS INTERVAL	01:00:00
P10 START OF MEAS	16:30:00
P10 LEVEL 1 MEAS TYPE	001
P10 XMIT 2 OR 3 BYTES?	03
P10 HIGH LIMIT	NO LIMIT
P10 LOW LIMIT	NO LIMIT
P10 HIGH DIFF LIMIT	NO LIMIT
P10 LOW DIFF LIMIT	NO LIMIT

APPENDIX B

HANDAR 570A DCP CONFIGURATION PROGRAM - 570TROT.DCP

P ID	FA43D0BE
P STATION TIME	22:46:25
P YEAR (XX)	94
P DCP JULIAN DATE	047
P GOES PRI XMT MODE	01
P 1ST GOES XMT TIME	02:00:00
P PRI XMT INTERVAL	03:00:00
P GOES SEC XMT MODE	00
P TEL #:AREA CODE	0-000
P TEL #:LOCAL	000-0000
P MODEM XMT FORMAT	00
P 1ST DIAL TIME	00:00:00
P DIAL INTERVAL	00:00:00
P TEL EMG XMIT 1=0N	00
P AUTO DUMP? 1=Y 0=N	00
P VOICE OUTPUT MODE	00
P TOUCH TONE PASSWD	0
P CHANNEL NO.	01
P01 SENSOR TYPE	10
P01 SENSOR NAME TAG	10
P01 CARD SLOT #	01
P01 ADC INPUT MODE	2
P01 ADC INPUT NUMBER	08
P01 ADC SCALE (5.0E-X)	0
P01 ADC OUTPUT NUMBER	0
P01 SENSOR PWR ADV	00:00:02
P01 *FULL SCALE	1000
P01 ZERO SCALE	0000
P01 MEAS INTERVAL	01:00:00
P01 START OF MEAS	17:30:00
P01 LEVEL 1 MEAS TYPE	001
P01 XMIT 2 OR 3 BYTES?	03
P01 HIGH LIMIT	NO LIMIT
P01 LOW LIMIT	NO LIMIT
P01 HIGH DIFF LIMIT	NO LIMIT
P01 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	02
P02 SENSOR TYPE	10
P02 SENSOR NAME TAG	10
P02 CARD SLOT #	01
P02 ADC INPUT MODE	1
P02 ADC INPUT NUMBER	06
P02 ADC SCALE (5.0E-X)	0
P02 ADC OUTPUT NUMBER	0
P02 SENSOR PWR ADV	00:00:02
P02 *FULL SCALE	001
P02 ZERO SCALE	000

P02 MEAS INTERVAL	01:00:00
P02 START OF MEAS	17:30:00
P02 LEVEL 1 MEAS TYPE	001
P02 XMIT 2 OR 3 BYTES?	03
P02 HIGH LIMIT	NO LIMIT
P02 LOW LIMIT	NO LIMIT
P02 HIGH DIFF LIMIT	NO LIMIT
P02 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	03
P03 SENSOR TYPE	10
P03 SENSOR NAME TAG	10
P03 CARD SLOT #	01
P03 ADC INPUT MODE	1
P03 ADC INPUT NUMBER	14
P03 ADC SCALE (5.0E-X)	0
P03 ADC OUTPUT NUMBER	0
P03 SENSOR PWR ADV	00:00:02
P03 *FULL SCALE	999
P03 ZERO SCALE	000
P03 MEAS INTERVAL	01:00:00
P03 START OF MEAS	17:30:00
P03 LEVEL 1 MEAS TYPE	001
P03 XMIT 2 OR 3 BYTES?	03
P03 HIGH LIMIT	NO LIMIT
P03 LOW LIMIT	NO LIMIT
P03 HIGH DIFF LIMIT	NO LIMIT
P03 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	04
P04 SENSOR TYPE	10
P04 SENSOR NAME TAG	10
P04 CARD SLOT #	01
P04 ADC INPUT MODE	1
P04 ADC INPUT NUMBER	04
P04 ADC SCALE (5.0E-X)	0
P04 ADC OUTPUT NUMBER	2
P04 SENSOR PWR ADV	00:00:02
P04 *FULL SCALE	0978
P04 ZERO SCALE	0078
P04 MEAS INTERVAL	01:00:00
P04 START OF MEAS	17:30:00
P04 LEVEL 1 MEAS TYPE	001
P04 XMIT 2 OR 3 BYTES?	03
P04 HIGH LIMIT	NO LIMIT
P04 LOW LIMIT	NO LIMIT
P04 HIGH DIFF LIMIT	NO LIMIT
P04 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	05

P05 SENSOR TYPE	10
P05 SENSOR NAME TAG	10
P05 CARD SLOT #	01
P05 ADC INPUT MODE	1
P05 ADC INPUT NUMBER	12
P05 ADC SCALE (5.0E-X)	0
P05 ADC OUTPUT NUMBER	2
P05 SENSOR PWR ADV	00:00:02
P05 *FULL SCALE	500
P05 ZERO SCALE	000
P05 MEAS INTERVAL	01:00:00
P05 START OF MEAS	17:30:00
P05 LEVEL 1 MEAS TYPE	001
P05 XMIT 2 OR 3 BYTES?	03
P05 HIGH LIMIT	NO LIMIT
P05 LOW LIMIT	NO LIMIT
P05 HIGH DIFF LIMIT	NO LIMIT
P05 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	06
P06 SENSOR TYPE	10
P06 SENSOR NAME TAG	10
P06 CARD SLOT #	01
P06 ADC INPUT MODE	1
P06 ADC INPUT NUMBER	05
P06 ADC SCALE (5.0E-X)	0
P06 ADC OUTPUT NUMBER	0
P06 SENSOR PWR ADV	00:00:02
P06 *FULL SCALE	000
P06 ZERO SCALE	000
P06 MEAS INTERVAL	01:00:00
P06 START OF MEAS	17:30:00
P06 LEVEL 1 MEAS TYPE	001
P06 XMIT 2 OR 3 BYTES?	03
P06 HIGH LIMIT	NO LIMIT
P06 LOW LIMIT	NO LIMIT
P06 HIGH DIFF LIMIT	NO LIMIT
P06 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	07
P07 SENSOR TYPE	10
P07 SENSOR NAME TAG	10
P07 CARD SLOT #	01
P07 ADC INPUT MODE	1
P07 ADC INPUT NUMBER	13
P07 ADC SCALE (5.0E-X)	0
P07 ADC OUTPUT NUMBER	0
P07 SENSOR PWR ADV	00:00:02
P07 *FULL SCALE	000

P07 ZERO SCALE	000
P07 MEAS INTERVAL	01:00:00
P07 START OF MEAS	17:30:00
P07 LEVEL 1 MEAS TYPE	001
P07 XMIT 2 OR 3 BYTES?	03
P07 HIGH LIMIT	NO LIMIT
P07 LOW LIMIT	NO LIMIT
P07 HIGH DIFF LIMIT	NO LIMIT
P07 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	08
P08 SENSOR TYPE	10
P08 SENSOR NAME TAG	10
P08 CARD SLOT #	01
P08 ADC INPUT MODE	1
P08 ADC INPUT NUMBER	07
P08 ADC SCALE (5.0E-X)	0
P08 ADC OUTPUT NUMBER	0
P08 SENSOR PWR ADV	00:00:02
P08 *FULL SCALE	000
P08 ZERO SCALE	000
P08 MEAS INTERVAL	01:00:00
P08 START OF MEAS	17:30:00
P08 LEVEL 1 MEAS TYPE	001
P08 XMIT 2 OR 3 BYTES?	03
P08 HIGH LIMIT	NO LIMIT
P08 LOW LIMIT	NO LIMIT
P08 HIGH DIFF LIMIT	NO LIMIT
P08 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	09
P09 SENSOR TYPE	10
P09 SENSOR NAME TAG	10
P09 CARD SLOT #	01
P09 ADC INPUT MODE	1
P09 ADC INPUT NUMBER	15
P09 ADC SCALE (5.0E-X)	0
P09 ADC OUTPUT NUMBER	0
P09 SENSOR PWR ADV	00:00:02
P09 *FULL SCALE	00.0
P09 ZERO SCALE	00.0
P09 MEAS INTERVAL	01:00:00
P09 START OF MEAS	17:30:00
P09 LEVEL 1 MEAS TYPE	001
P09 XMIT 2 OR 3 BYTES?	03
P09 HIGH LIMIT	NO LIMIT
P09 LOW LIMIT	NO LIMIT
P09 HIGH DIFF LIMIT	NO LIMIT
P09 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	10
P10 SENSOR TYPE	12
P10 SENSOR NAME TAG	12
P10 MEAS INTERVAL	01:00:00
P10 START OF MEAS	17:30:00
P10 LEVEL 1 MEAS TYPE	001
P10 XMIT 2 OR 3 BYTES?	03
P10 HIGH LIMIT	NO LIMIT
P10 LOW LIMIT	NO LIMIT
P10 HIGH DIFF LIMIT	NO LIMIT
P10 LOW DIFF LIMIT	NO LIMIT

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SERVICING AND CALIBRATION OF PRIMELINE 6723 STRIP CHART RECORDERS**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4250-2020**
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AUTHORIZATIONS		
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for servicing, calibrating, and functional testing of Primeline 6723 strip chart recorders. The Primeline 6723 recorder is used as a backup data collection system in the IMPROVE transmissometer network. The recorders are used as backup dataloggers and operate only when the Handar 540A/570A DCP data collection system malfunctions. This TI, as referenced in Standard Operating Procedure 4250, *Servicing and Calibration of Optical Monitoring Dataloggers*, specifically describes procedures for:

- Performing post-field inspections
- Performing routine laboratory servicing and cleaning
- Calibrating the recorder
- Documenting all servicing tasks
- Archiving servicing, repair, and calibration records

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that chart speed and calibration checks are performed on all Primeline 6723 recorders during the annual site servicing visit.
- Verify that all Primeline 6723 recorders are operating within factory specifications prior to being shipped to the field for use at an operational monitoring site.
- Ensure that all strip chart recorder servicing is documented and archived in accordance with the procedures described in this TI.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform and document all servicing, calibration checks, and operational tests.
- Archive all strip chart recorder servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a strip chart recorder is being removed from the field for routine (three-year cycle) or emergency (field malfunction) servicing.
- Provide the instrument technician with a description of the field problems observed with the recorder.

2.4 FIELD SPECIALIST

The field specialist shall:

- Perform chart speed and calibration checks on the Primeline 6723 strip chart recorder during the annual site visit (see TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*).
- Provide the instrument technician with a description of strip chart recorder problems observed during annual site visit testing.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific instrumentation, tools, and materials required to service, calibrate, and test the Primeline 6723 strip chart recorder are:

- Regulated 12 VDC power supply
- Calibrated voltage source - Datel Model DVC-350A or equivalent
- Digital voltmeter (resolution 50-microvolts or better)
- Frequency counter (resolution 20-microseconds or better)
- Stopwatch
- Standard set of small electronics laboratory tools
- Soltec Distribution, *Primeline 6723 Instruction Manual*
- Electronic contacts cleaning fluid
- Window glass cleaner
- Alcohol and foam swabs
- Strip chart paper
- Spare strip chart pens (red and black)

4.0 METHODS

Primeline 6723 strip chart recorders should be serviced according to the following schedule:

- Prior to installation at a field monitoring site
- Following removal of the recorder from a field monitoring site
- Any time the operation or accuracy of the recorder appears to be suspect

Appendix A of this TI includes the *Primeline 6723 Instruction Manual*. This manual provides detailed procedures for performing operational checks and adjustments, calibration checks, and instrument calibration. The instruction manual will be referenced throughout this section for these procedures.

This section includes three (3) major subsections:

4.1 Post-Field Inspection and Performance Checks
4.2 Routine Laboratory Servicing and Calibration
4.3 Archiving Primeline 6723 Service Records

4.1 POST-FIELD INSPECTION AND PERFORMANCE CHECKS

When a strip chart recorder is returned from a field site, a visual inspection and operational check is conducted prior to performing routine laboratory servicing and calibration. Results and comments related to the inspection and performance testing are fully documented on the Post-Field Inspection Checklist - Primeline 6723 Strip Chart Recorder (Figure 4-1).

4.1.1 General Information

RECORD GENERAL INFORMATION	Record the recorder serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
NOTE REASON FOR RETURN	Note whether the recorder was returned for scheduled servicing (no observed operational problems in the field) or for unscheduled maintenance (unit malfunctioning). If returned for unscheduled maintenance, describe the observed field symptoms.

4.1.2 Physical Inspection

INSPECT CASE	Inspect the recorder case thoroughly. Look for signs of external damage (dents, scratches, marks, or other signs of rough handling or shipping). Describe any damage or general deterioration noted.
INSPECT CONTROL KNOBS	Inspect the control knobs. Verify that all knobs and switches are in good condition and operate with positive action. Describe any problems noted.
INSPECT CONNECTORS	Inspect the connectors on the rear panel of the recorder. Describe any observed damage.
INSPECT FRONT COVER AND PAPER TRAY	Inspect the front cover and paper tray. Check for smooth operation and that both remain stationary when moved to the normal operating position.
INSPECT SLIDE WIRES	Inspect the slide wires for dirt, lint, or other contamination that would restrict movement of the pen holders. Also look for signs of wear on slide wires.

POST-FIELD INSPECTION CHECKLIST
PRIMELINE 6723 STRIP CHART RECORDER

Recorder S/N: ____________________________
Site: ____________________________________
Date: ___________________________________
Technician: ______________________________

Returned for: ☐ Scheduled Servicing
☐ Unscheduled Maintenance

Reason for unscheduled maintenance: ____
____
____

PHYSICAL INSPECTION

Recorder Case: ____
Control Knobs: ____
Rear Panel Connectors: ____
Front Cover: ____
Paper Tray: ____
Slide Wires: ____
Slide Bar: ____

OPERATIONAL CHECKS

OK	OUT OF SPECIFICATION	
☐	☐	Pen drive mechanism
☐	☐	Slip mechanism
☐	☐	Pen drive wire tension
☐	☐	Gear backlash
☐	☐	Pen lift check

Figure 4-1. Post-Field Inspection Checklist - Primeline 6723 Strip Chart Recorder.

INSPECT SLIDE BARS — Inspect the slide bars for signs of wear.

4.1.3 Operational Checks

PERFORM CHECKS — Refer to the Primeline 6723 Instruction Manual (Appendix A) for the following:

- Pen drive mechanism test - Section 3-1, Paragraph (1)
- Slip mechanism check - Section 3-1, Paragraph (2)
- Pen drive wire tension check - Section 3-1, Paragraph (3)
- Gear backlash - Section 3-1, Paragraph (4)
- Pen lift check - Section 3-1, Paragraph (5)

4.2 ROUTINE LABORATORY SERVICING AND CALIBRATION

All Primeline 6723 strip chart recorders must be fully serviced and calibrated prior to being installed at a field monitoring site. The Routine Servicing and Calibration Checklist - Primeline 6723 Strip Chart Recorder (Figure 4-2) is used to ensure that all procedures are performed and calibration results are documented.

4.2.1 General Information

RECORD GENERAL INFORMATION — Record the recorder serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.

4.2.2 Cleaning, Calibration, and Adjustments

INSTRUMENT CLEANING — Clean the case and window with glass cleaner or mild soap.

Clean the paper roller with alcohol and foam swabs.

Clean the slide bars with alcohol and foam swabs.

Clean the slide wires with contact cleaner.

Clean the potentiometer as described in the Primeline 6723 Instruction Manual, Section 4, Paragraph 2.

PEN DRIVE MECHANISM TEST AND ADJUSTMENTS — Refer to the Primeline 6723 Instruction Manual (Appendix A) for the following:

- Motor starting voltage - Section 3-1, Paragraph (1)
- Slip mechanism - Section 3-1, Paragraph (2)

ROUTINE SERVICING AND CALIBRATION CHECKLIST
PRIMELINE 6723 STRIP CHART RECORDER

Recorder S/N: ____________________
Site: ______________________________
Date: ____________________________
Technician: _______________________

INSTRUMENT CLEANING

- ☐ Case and front cover cleaned
- ☐ Paper roller cleaned
- ☐ Slide bars cleaned
- ☐ Slide wires cleaned
- ☐ Potentiometer cleaned

PEN DRIVE MECHANISM TEST AND ADJUSTMENTS

- ☐ Motor starting voltage
- ☐ Slip mechanism
- ☐ Pen drive wire tension
- ☐ Gear backlash
- ☐ Pen lift

SERVO-AMPLIFIER TEST AND ADJUSTMENT

OK	ADJUSTED	
☐	☐	Test point voltage
☐	☐	Dead-band adjustment
☐	☐	Damping

CALIBRATION

OK	ADJUSTED	
☐	☐	Zero balance
☐	☐	Full scale accuracy (AC operation)
☐	☐	Full scale accuracy (DC operation)
☐	☐	Variable adjust
☐	☐	Linearity
☐	☐	50-mV calibration

CHART SPEED CONTROLLER ADJUSTMENT

OK	ADJUSTED	
☐	☐	4 cm/min chart speed
☐	☐	16 cm/min chart speed

Figure 4-2. Routine Servicing and Calibration Checklist - Primeline 6723 Strip Chart Recorder.

- Pen drive wire tension - Section 3-1, Paragraph (3)
- Gear backlash - Section 3-1, Paragraph (4)
- Pen lift test - Section 3-1, Paragraph (5)

SERVO-AMPLIFIER TEST AND ADJUSTMENT

Refer to the Primeline 6723 Instruction Manual (Appendix A) for the following:

- Test point voltage checks - Section 3-2, Paragraph (1)
- Dead-band adjustment - Section 3-2, Paragraph (2)
- Damping - Section 3-2, Paragraph (3)

CALIBRATION

Refer to the Primeline 6723 Instruction Manual (Appendix A) for the following:

- Zero balance - Section 3-2, Paragraph (4)
- Full scale calibration - Section 3-2, Paragraph (5)
- Full scale accuracy check - Section 3-2, Paragraph (6). This check is initially performed with the recorder operating on AC (line) power. The check is then repeated with the recorder operating on DC (12 volts) power.
- Variable adjust (input scaling) check - Section 3-2, Paragraph (7)
- Linearity - Section 3-2, Paragraph (8)
- 50-millivolt calibration - Section 3-2, Paragraph (9)

CHART SPEED CONTROLLER ADJUSTMENT

With channel "A" pen in the down position, turn chart drive switch to **ON**.

Turn chart drive switch to **OFF** when the channel "A" pen is on an even cm line.

Set chart speed switch for a speed of 4 cm/min.

Using a stopwatch, verify that the actual chart speed is 4 cm/min.

Repeat this procedure, checking the chart speed at 16 cm/min.

If either chart speed test is not within factory specifications (± 1%), the chart speed oscillator frequency must be adjusted - refer to the Primeline 6723 Instruction Manual, Section 3-3, Paragraph (2).

4.3 ARCHIVING PRIMELINE 6723 SERVICE RECORDS

Service records for Primeline 6723 strip chart recorders are maintained by the instrument technician. The records are archived by recorder serial number in three-ring notebooks located in the ARS instrumentation laboratory.

5.0 REFERENCES

Soltec Distribution, Primeline 6723 Instruction Manual.

APPENDIX A

PRIMELINE 6723 INSTRUCTION MANUAL

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**COLLECTION OF OPTICAL MONITORING DATA (IMPROVE PROTOCOL)**
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NUMBER	**4300**
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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines collection of optical visibility monitoring data from sites operated according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

The IMPROVE Program has partitioned visibility-related characteristics and measurements into three groups: optical, scene, and aerosol. This SOP pertains to the optical group and encompasses the following:

- Optical properties pertaining to the ability of the atmosphere to scatter or absorb light passing through it
- Physical properties of the atmosphere described by the atmospheric extinction coefficient (b_{ext}), absorption coefficient (b_{abs}), scattering coefficient (b_{scat}), and scattering phase function, an angular dependence of the scattering
- Optical characteristics integrating the effects of atmospheric aerosols and gases
- Optical extinction measurements made with transmissometers
- Optical scattering measurements made with nephelometers

Data are generally logged on-site by one of four data logging approaches:

- Satellite data collection platforms (DCPs) (Handar 540/570 or Synergetics)
- Campbell Scientific 21XL dataloggers
- Telephone modems
- Primeline strip chart recorders

This SOP serves as a guide to assure high quality data collection from transmissometer and nephelometer stations operated according to IMPROVE Protocol by:

- Assuring complete, error-free data downloads from Wallops Island or directly from the individual stations via telephone modem.
- Assuring complete, error-free data downloads from sites with Campbell Scientific data storage modules.
- Reducing data from strip chart recorders at transmissometer sites.
- Processing data to reformat raw, downloaded data to Level-A validation.
- Reviewing data and examining error files for details regarding monitoring system performance, datalogger problems, or data acquisition problems.

Because most stations are remote, daily data review is critical to the identification and resolution of field problems.

At sites with a DCP or Campbell Scientific datalogger and telephone modem, data are collected daily. At sites with a Campbell Scientific datalogger and storage module, or at sites where back-up strip chart recorders must be used, data are collected at approximately two-week intervals.

Separate technical instructions (TIs) are developed for the following cases:

- TI 4300-4000 *Data Collection via DCP (IMPROVE Protocol)*
- TI 4300-4002 *Nephelometer Data Collection via Telephone Modem (IMPROVE Protocol)*
- TI 4300-4004 *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*
- TI 4300-4006 *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*
- TI 4300-4023 *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*
- TI 4300-4025 *Transmissometer Data Collection via Strip Chart Recorder*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Review data collection procedures with the data coordinator to identify and correct problems.
- Review editing of instrument constants files with the data coordinator.
- Coordinate with the NESDIS for allocation of DCP assignments.

2.2 DATA COORDINATOR

The data coordinator shall:

- Update all constants files pertaining to data collection and review with the project manager.
- Set up and initiate the automatic data collection program(s).
- Check the status of the automatic data collection and review data daily to assure the integrity of the monitoring systems and to achieve complete, error-free data collection.
- Perform periodic data collection via data storage module or strip chart reduction for sites without DCP or modem communication.

- Provide technical support to the site operator via telephone.
- Enter any information relating to the collection of the data and operation of the specific monitoring system into the site-specific Quality Assurance Database.
- Review Level-A files with the project manager to identify instrument problems.
- Ship supplies, tools, and replacement instrumentation to the site operator.
- Digitize and convert strip chart recorder data into transmissometer format.

2.3 FIELD SPECIALIST

The field specialist shall:

- Train the site operator in strip chart recorder operation and maintenance.
- Provide technical support to the site operator via telephone.

2.4 SITE OPERATOR

The site operator shall:

- Operate and maintain strip chart recorders.
- Document strip chart recorder operation.
- Report instrument collection inconsistencies to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data collection occurs on IBM-PC compatible systems. Refer to the individual TIs for the monitoring system-specific computer system requirements. Required computer system components are as follows:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Internal or external Hayes compatible modem configured for COM port #2
- Microsoft Windows 3.0/3.1
- Software for collection DCP data via Wallops Island
- Software for processing of optical data collected via DCP
- Software for telephone modem collection
- Campbell Scientific software for processing optical data:
    - TELCOM Version 1.0 or later

- SPLIT Version 1.0 or later
- SMCOM Version 1.0 or later
- TERM Version 1.0 or later

• Campbell Scientific SC532 storage module interface

• NGN_PULL software Version 3.0 or later (ARS)

• Jandel Scientific Sigma Scan software for digitizing strip charts

• Jandel Scientific digitizing table

Information on the Campbell Scientific software is detailed in the *Campbell Scientific PC208 Datalogger Support Software Instruction Manual*.

4.0 METHODS

This section includes two (2) major subsections:

4.1 Optical Monitoring Station Configurations
4.2 Collection of Optical Monitoring Data

These subsections describe the station configurations and data collection methods for each configuration. Collection of optical monitoring data is dependent on the configuration of individual sites. Transmissometer and nephelometer sites are generally configured differently.

4.1 OPTICAL MONITORING STATION CONFIGURATIONS

Optical monitoring stations are configured based on the following:

• Transmissometer stations are generally configured with a DCP and strip chart recorder.

• Nephelometer stations are generally configured with a Campbell Scientific datalogger, telephone modem, storage module, or optionally, a DCP.

4.1.1 Transmissometer Stations

Transmissometers measure the ability of the atmosphere to transmit light. These measured light transmission properties can be represented in terms of the atmospheric extinction coefficient (b_{ext}).

IMPROVE transmissometer sites generally include:

• A transmitter station with shelter, transmitter telescope, transmitter control box, and battery-backed power supply.

• A receiver station with shelter, receiver telescope, receiver computer, battery-backed power supply.

- A data collection platform (DCP).
- An optional strip chart recorder.
- A collocated air temperature and relative humidity sensor (naturally aspirated).
- A solar powered operation (at some sites).

The following data are collected via DCP from transmissometer sites operated according to IMPROVE Protocol:

- Ten-minute average raw transmissometer transmission values that are later converted to atmospheric extinction coefficient.
- Standard deviation of the 10 one-minute raw transmission values that make up the 10-minute average transmission value.
- Hourly, single reading ambient air temperature and relative humidity.

Strip charts serve as the backup logger at transmissometer sites. Strip charts are only used in the event of DCP failure. The strip chart recorder from transmissometer sites operated according to IMPROVE Protocol collects 10-minute average raw transmissometer transmission values that are later converted to atmospheric extinction coefficient.

4.1.2 Nephelometer Stations

Nephelometers measure the ability of the atmosphere to scatter light. These measured light scattering properties can be represented in terms of the atmospheric scattering coefficient (b_{scat}).

IMPROVE nephelometer sites generally include:

- An NGN-2 nephelometer mounted on a three-meter tower along with datalogger and power supply support system.
- A Campbell Scientific 21XL datalogger.
- A Campbell Scientific storage module.
- An optional telephone modem.
- An optional DCP.
- A collocated air temperature and relative humidity sensor (force aspirated).
- A solar powered operation (at some sites).

The following data are collected via telephone modem and storage module from nephelometer sites operated according to IMPROVE protocol:

- Five-minute nephelometer serial data stream

- Five-minute nephelometer analog channels A1 and A2
- Five-minute ambient air temperature and relative humidity
- Hourly codes summarizing the past hour's operation of the nephelometer and support system.

The following data are collected via DCP from nephelometer sites operated according to IMPROVE Protocol:

- Ten-minute nephelometer analog channels A1 and A2
- Hourly codes summarizing the past hour's operation of the nephelometer and support system.
- Last clean air and span calibrations
- Hourly, single-reading ambient air temperature and relative humidity

4.2 COLLECTION OF OPTICAL MONITORING DATA

The method used to collect optical monitoring data depends on the type of site (transmissometer or nephelometer) and the site-specific configuration (telephone modem, storage module, DCP or strip chart). The following subsections describe data collection procedures for the above listed station configurations.

4.2.1 Collection of Transmissometer Data via DCP

Specific transmissometer data collection procedures are detailed in TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*. Collection of transmissometer data via DCP includes:

- Updating the current list of sites in the site information file.
- Updating the next time to download data in the Wallops information file.
- Configuring the computer used for automatic data acquisition that downloads the data from Wallops the following day.
- Reviewing all downloaded data file for communication errors or indications of monitoring, logging and data collection problems.
- Initiating data collection programs if automatic data collection failed.
- Executing the STRIP_T program which removes invalid characters and reformats the raw file.
- Executing the APPEND_T program to add the raw data to site-specific Level-A files.
- Resolving identified system inconsistencies according to TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

4.2.2 Collection of Transmissometer Data via Strip Chart Recorder

Strip chart recorder data are only used as a backup logging method at sites where DCP system failures occur, and are only used until the malfunctioning DCP can be repaired or replaced. Specific procedures are detailed in TI 4300-4025, *Transmissometer Data Collection via Strip Chart Recorder*. Collection of transmissometer data via strip chart recorder includes the following:

- Obtaining strip charts.
- Digitizing the strip chart trace.
- Scaling the digitized values to yield raw transmission values.
- Transferring raw transmission data from the strip chart file into the site-specific Level-A file.
- Changing the validity code in the site-specific Level-A file to reflect the use of an alternate datalogger.

4.2.3 Collection of Nephelometer Data via Telephone Modem

Collection of nephelometer data via telephone modem from sites configured with a Campbell Scientific datalogger is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4002, *Nephelometer Data Collection via Telephone Modem (IMPROVE Protocol)*. Collection of nephelometer data via modem includes the following:

- Updating the current list of sites.
- Updating the next time to download data.
- Initiating the automatic download timer.
- Polling each telephone modem station daily using the Campbell Scientific TELCOM program for all data since the last download.
- Dividing each downloaded data file into three parts using the Campbell Scientific SPLIT program:
    - Nephelometer serial data, ambient temperature, and relative humidity
    - Nephelometer analog data, ambient temperature, and relative humidity
    - Hourly nephelometer status code and support system status code
- Reformatting and appending each site's nephelometer serial data to site-specific Level-A plottable data files.
- Creating a daily nephelometer log file that contains a summary of the performance of all of the sites downloaded.

- Resolving identified system inconsistencies according to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.2.4 Collection of Nephelometer Data via DCP

Collection of nephelometer data via DCP is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4004, *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*. Collection of nephelometer data via DCP includes the following:

- Updating the current list of sites.

- Extracting each site's data from the stripped daily download file into site-specific daily data files compatible with data obtained via telephone modem.

- Dividing each reformatted data file into three parts using the Campbell Scientific SPLIT program:

  - Nephelometer analog data, ambient temperature, and relative humidity

  - Hourly nephelometer status code and support system status code

- Reformatting and appending each site's nephelometer analog data to site-specific Level-A plottable data files.

- Creating a daily nephelometer log file that contains a summary of the performance of all of the sites downloaded.

- Resolving identified system inconsistencies according to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.2.5 Collection of Nephelometer Data via Campbell Scientific Storage Module

Collection of nephelometer data via Campbell Scientific storage module is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4006, *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*. Collection of nephelometer data via storage module includes the following:

- Updating the current list of sites.

- Downloading data from the storage module using the Campbell Scientific SMCOM program into site-specific files compatible with data obtained via telephone modem.

- Dividing each downloaded data file into three parts using the Campbell Scientific SPLIT program:

  - Nephelometer serial data, ambient temperature, and relative humidity

  - Nephelometer analog data, ambient temperature, and relative humidity

  - Hourly nephelometer status code and support system status code

- Reformatting and appending each site's nephelometer serial data to site-specific plottable data files.
- Creating a nephelometer log file that contains a summary of the performance of all of the sites downloaded.
- Resolving identified system inconsistencies according to TI 4100-3100.

5.0 REFERENCES

Campbell Scientific, Inc., 1989, Campbell Scientific PC208 Datalogger Support Software Instruction Manual, February.

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the collection of data logged by data collection platforms (DCPs) at transmissometer, nephelometer, and meteorological sites operated according to IMPROVE Protocol. The purpose of this TI is to assure quality data capture and minimize data loss by:

- Monitoring DCP operating parameters, including: transmission time, DCP battery voltage, signal strength, and transmission frequency deviation.
- Identifying and resolving problems affecting transmissometer and nephelometer systems, meteorological sensors, data acquisition and control systems, and support equipment.

This TI, as referenced from Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol),* specifically describes:

- General information about data collection via DCP and data acquisition via the National Environmental Satellite Data and Information Service (NESDIS) downlink facility in Camp Springs, Maryland, via the satellite downlink station at Wallops Island, Virginia.
- Automatic and manual data acquisition procedures.
- Daily data handling of DCP data.
- Verification of DCP transmission parameters.
- Procedures for updating the NESDIS Platform Description Tables (PDTs).

Troubleshooting procedures for DCPs are described in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with NESDIS for the allocation of DCP assignments for data collection.
- Review data acquired via DCP to detect and resolve problems.

2.2 DATA COORDINATOR

The data coordinator shall:

- Verify that automatic data collection via DCP is successful and perform manual data collection if unsuccessful.
- Review DCP-transmitted data to determine if the DCP and monitoring equipment are functioning properly.

- Provide technical support to the site operator via telephone to assure high quality data capture from the DCP and monitoring equipment.

- Update NESDIS DCP platform description tables (PDTs) via telephone modem.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Equipment and materials generally required for data collection via DCP includes the following:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk

- Internal or external Hayes compatible modem configured for COM port #2

- Crosstalk-4 PC communications software

- WALLOPS4 PC interface software (ARS)

- User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1

- Wallops Island log book

- Julian calendar

- Plain ASCII text editor such as WordStar

4.0 METHODS

This section includes six (6) major subsections:

4.1 General Information
4.2 Automatic Data Collection
4.3 Manual Data Collection
4.4 DCP Transmission Quality Check
4.5 Daily DCP Data Handling
4.6 Updating NESDIS Platform Description Tables (PDTs)

4.1 GENERAL INFORMATION

Data logged on data collection platforms (DCPs) are processed by several entities before being available for downloading via modem. Monitoring stations with DCPs undergo the following data downloading sequence:

- The DCP logs transmissometer, nephelometer, and/or meteorological data at pre-programmed intervals.

- At three-hour intervals, the DCP transmits the past three hours' data and its internal battery voltage to the GOES satellite.

- The GOES satellite retransmits the data to the NOAA/NESDIS downlink facility at Wallops Island, Virginia.

- The data are made available via the dissemination facility at Camp Springs, Maryland.

- The data are downloaded via telephone modem to ARS.

4.1.1 GOES Satellite System

The following general information summarizes how satellite data collection works:

SATELLITE USE	Use of the Geostationary Orbiting Earth Satellite (GOES) is free to government agencies. Authorization and operation to use the satellite system is directed by the National Environmental Satellite Data and Information Service (NESDIS), a branch of the National Oceanic and Atmospheric Administration (NOAA).
DCP ASSIGNMENTS	NESDIS assigns each DCP a one-minute data transmit time slot every three hours and a unique DCP identification code. Platform Description Tables (PDTs) describe the location and other operational parameters of each DCP. The PDTs must be updated via modem to reflect the status of all operational DCPs.
SATELLITE SYSTEM CAPACITY	Relay of data from DCPs to the downlink facility is a minor portion of the satellite's job. Its primary function is to provide weather-related data and images to aid in weather forecasting. Each satellite is capable of utilizing 233 frequencies for a total capacity of over 12,000 DCPs per hour. The data transmission rate is 100 baud (bits per second). The majority of the DCPs in use throughout the United States help support early warning flood monitoring systems.

4.1.2 Data Collection Platforms (DCPs)

DCPs manufactured by Handar and Synergetics are used at IMPROVE optical monitoring sites. Transmissometer sites are generally configured with Handar DCPs and nephelometer sites are generally configured with Synergetics DCPs. Both types of DCPs have the following features:

- Low power, programmable, microprocessor based system

- Analog sensor inputs

- Real-time clock

- GOES compatible radio transmitter

The dissemination facility makes the following data available via telephone modem a short time after the DCP transmits its data:

- Data logged by the DCP
- Transmission date and time
- DCP signal strength and deviation from the specified frequency
- Quality of the DCP transmission

DCP transmission parameters are used to evaluate the performance of the DCP and to resolve DCP-related problems quickly.

4.2 AUTOMATIC DATA COLLECTION

Automatic data collection via DCP includes the following steps:

- Log onto the ARS_NET2 network at a designated DCP data collection computer.
- Type **LOGIN BATCH**. Enter **OH** for project code and **2** (server number for an IMPROVE2 auto pull job).
- Update the DCP data collection identification file "WALDCP.DAT."
- Check the date and time of the next automatic batch job and change if necessary.
- Start the batch software.
- Verify the success of the data collection.

The following detailed procedures describe automatic data collection of DCP data:

LOG ONTO NETWORK

Log onto ARS_NET2 on the data handling computer using your assigned user name and password.

UPDATE THE "WALDCP.DAT" FILE

The "WALDCP.DAT" file includes DCP and site-specific information required to download data via modem. The file includes:

- Site abbreviation
- DCP identification number
- DCP transmission time
- DCP transmission period

An example "WALDCP.DAT" file is provided as Figure 4-1.

Site|Site_id | Ch.|Time|Interval

ACAD,FA42914E,009E,0227,X3
BADL,FA4315A0,038W,0220,X3
BAND,FA4380C2,038W,0227,X3
BIBE,FA4356AA,038W,0224,X3
BRID,FA43A62E,038W,0229,X3
CANY,FA44F466,014W,0218,X3
CHIR,FA450618,014W,0219,X3
GRBA,FA44E710,014W,0217,X3

Format:
Site Abbrv, DCP Iden, DCP Channel and Satellite, Transmit Time and Interval

---

Figure 4-1. Example "WALDCP.DAT" DCP Definition File for WALLOPS4 Software.

Update the "WALDCP.DAT" file to include all operational DCPs, using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\WALDCP.DAT**.

CHECK THE BATCH JOB DATE AND TIME

The batch software runs the data collection software at a predetermined date and time. The list of programs the batch software is scheduled to run is included in the batch queue. The batch queue may be edited to add or delete scheduled batch jobs. The following procedures detail how to edit the batch queue:

- To examine the batch queue enter **BATCH #Q**.
- To delete a job in the batch queue enter **BATCH #D @XXXX**, where "XXXX" is the number of the batch job.
- To add a new batch job for DCP data collection enter **F:\USERS\WALLOPS\NEWBATCH HH:MM NN/DD/YY**, where "HH" is the hour, "MM" is the minute, "NN" is the month, "DD" is the day, and "YY" is the year the batch job is next scheduled to run.

START THE BATCH SOFTWARE

Start the automatic batch software by entering **LOGIN BATCH**.

The result of a successful batch run is a file with the name "GALYYDDD.DAT" where "YY" is the year and "DDD" is the Julian day.

EXIT THE BATCH SOFTWARE

The batch software must be running to perform automatic data collection. To exit the PS-BATCH software enter **X** at the PS BATCH prompt.

4.3 MANUAL DATA COLLECTION

Data may be collected manually via telephone modem from the data dissemination facility as follows:

- Log onto the network.
- Run the WALLOPS4 software.
- Enter the site, DCP identification, date, and time at the WALLOPS4 software prompts.

The following procedures detail manual data collection of DCP data:

LOG ONTO NETWORK

Log onto the ARS_NET2 network on the data collection computer using your assigned user name and password.

START THE WALLOPS4 SOFTWARE

The WALLOPS4 software performs all functions of the user interface for manual data collection. To start the WALLOPS4 software, enter **WALLOPS4** at the DOS prompt. Choose one of the following available download options (detailed in Figure 4-2):

- **S** Download one site.
- **D** Download all sites.
- **T** Download all sites at specific beginning and ending time interval.

ENTER THE FILE NAME

If the **D** or **T** option is chosen, enter the file name for the manual data pull using the "GALYYDDD.DAT" format where "YY" is the year and "DDD" is the Julian day.

ENTER THE SITE ABBREVIATION

If **<S>** is chosen, enter the four-character site abbreviation. The site must exist in the "WALDCP.DAT" file. Figure 4-3 shows the WALLOPS4 site entry display.

EXAMINE THE DCP PARAMETERS

Verify that the DCP parameters displayed are correct for DCP data desired. Figure 4-4 shows the parameter verification display.

ENTER THE DATE AND TIME

Enter the date and time of the start of the interval desired. Figure 4-5 shows the date and time entry display. The download will proceed upon entering **Y** at the prompt. Figure 4-6 shows the display during the download process.

4.4 DCP TRANSMISSION QUALITY CHECK

The data satellite downlink facility analyzes DCP transmissions for transmission strength and quality. The data coordinator should check the downloaded data file for correct DCP operation as follows:

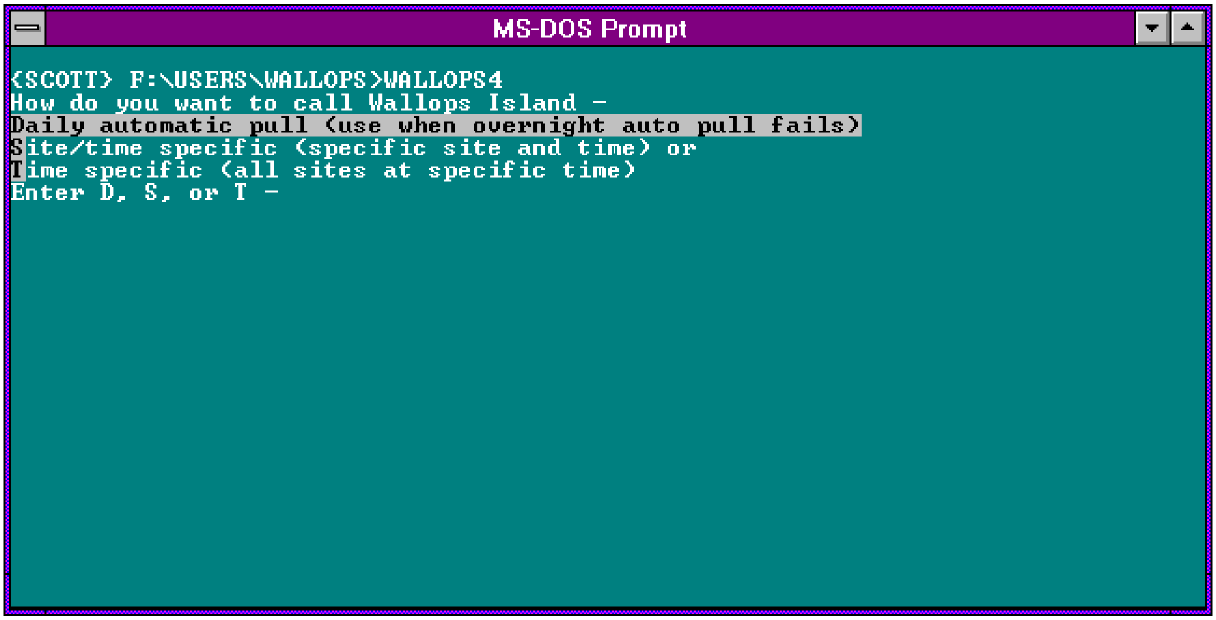

Figure 4-2. Starting WALLOPS4 Software.

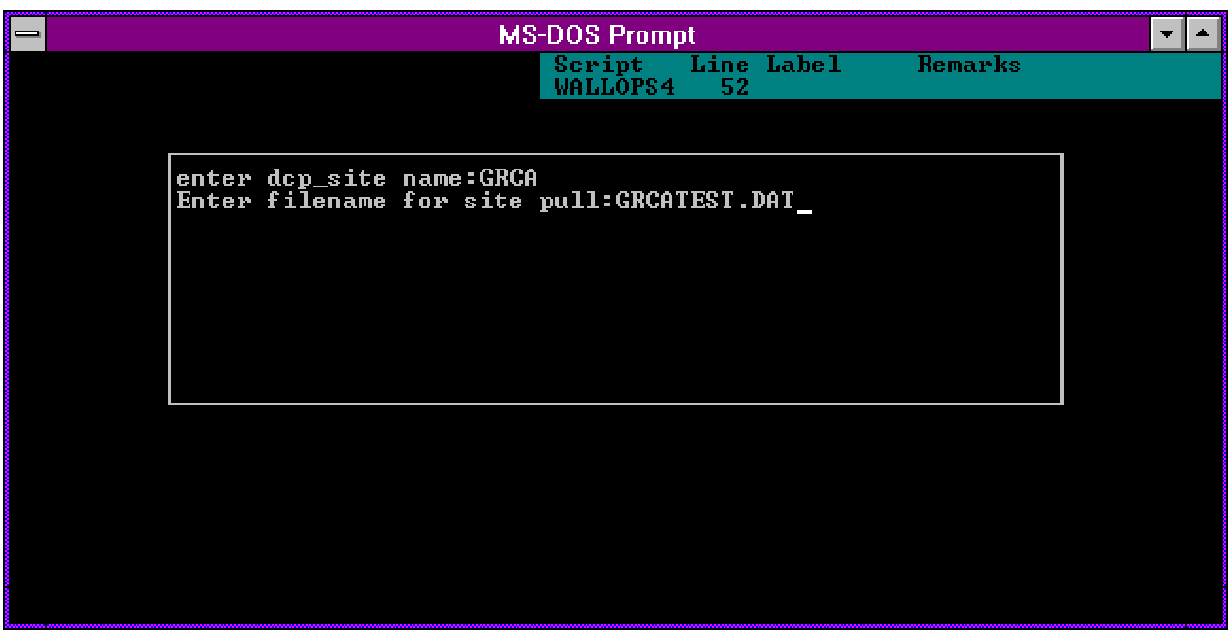

Figure 4-3. Entering Site Abbreviation and File Name in WALLOPS4 Software.

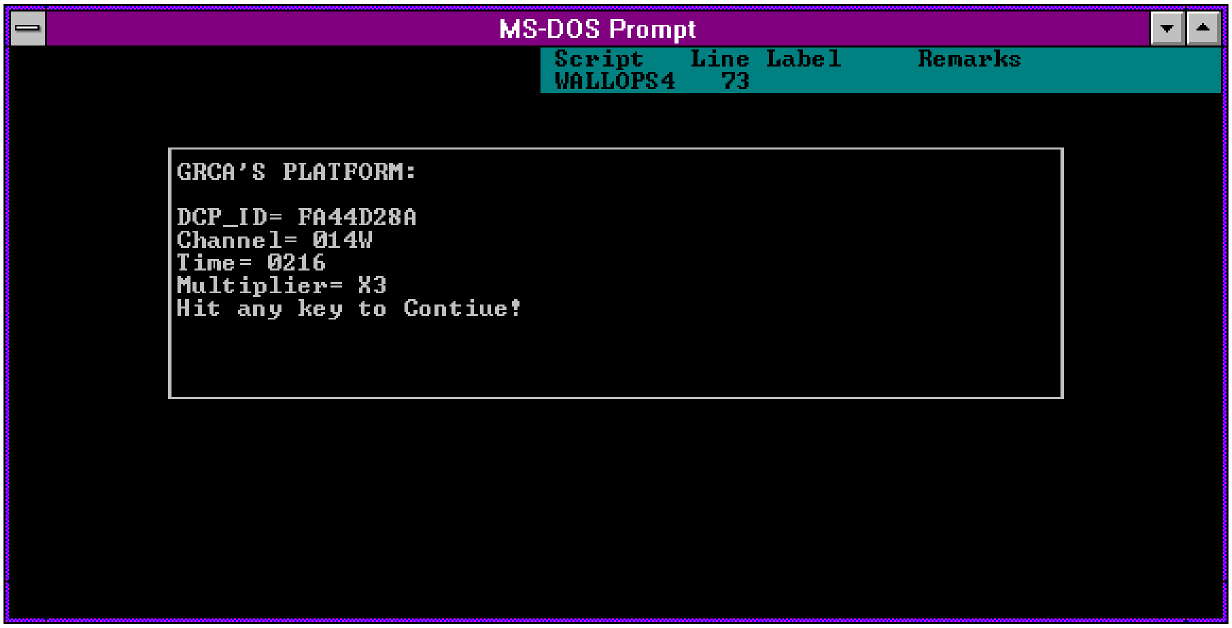

Figure 4-4. Verifying Download Parameters in WALLOPS4 Software.

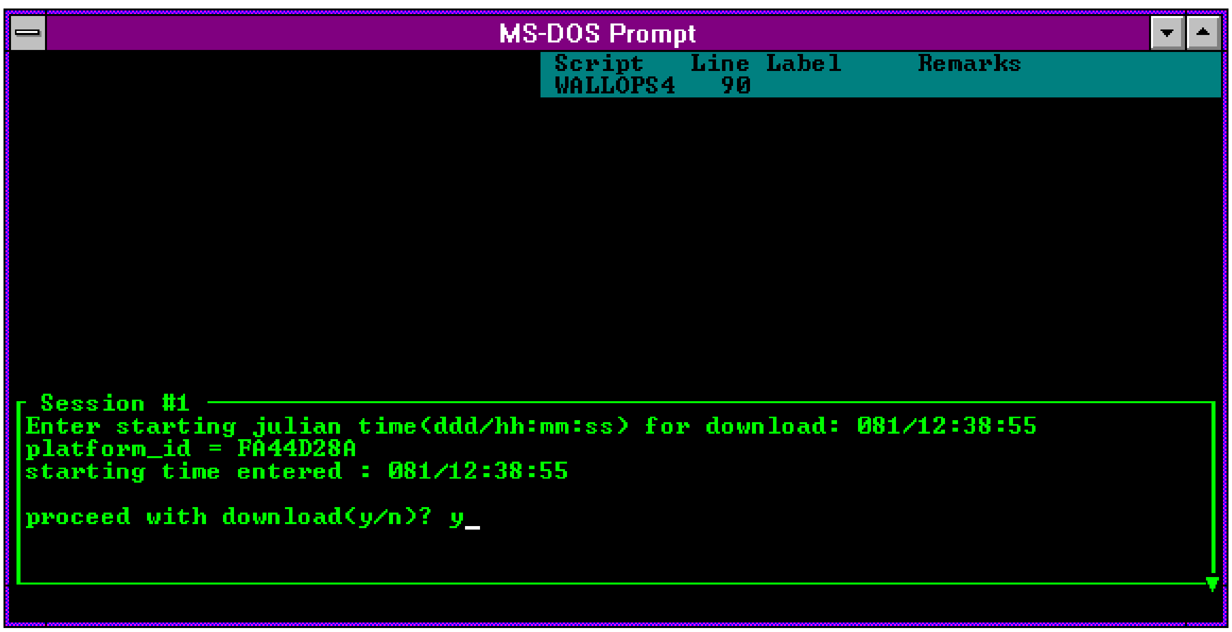

Figure 4-5. Starting the Download in WALLOPS4 Software.

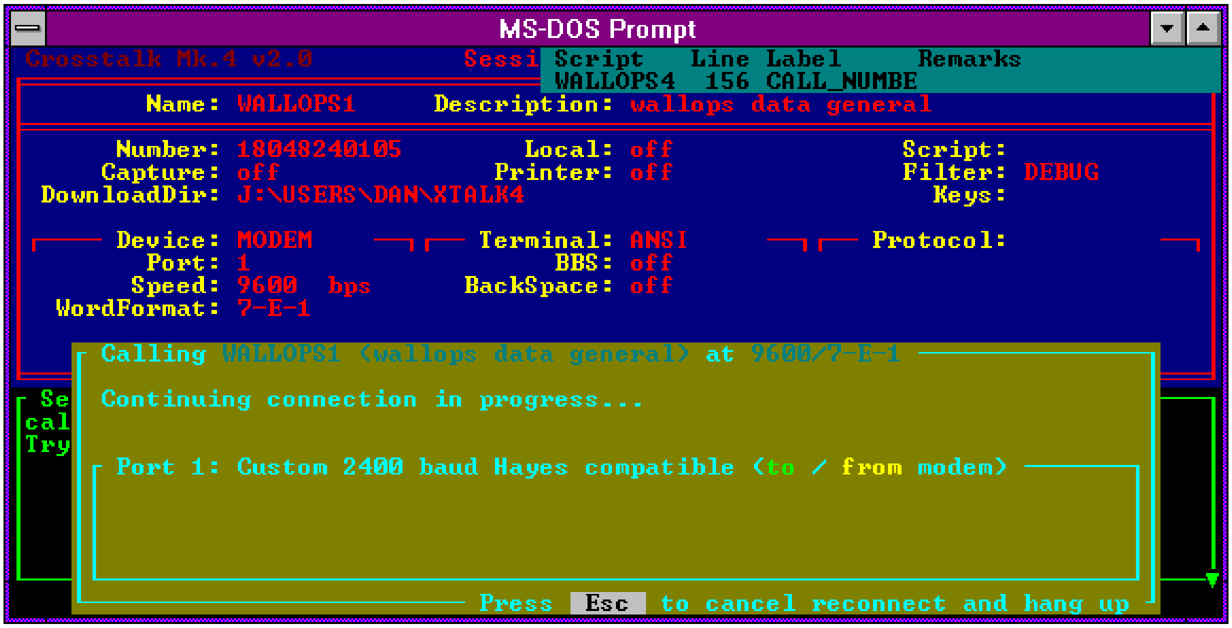

Figure 4-6. Downloading Data Display in WALLOPS4 Software.

- Edit the downloaded data file.
- Check the messages and news information at the beginning of the file.
- Check each DCP data transmission regarding:
  - DCP address.
  - Transmission time (year, Julian day, hour, minute, and second).
  - Failure code.
  - DAMS data quality measurements (signal strength, frequency deviation, modulation index, and modulation quality).
  - DCP transmission channel.
  - Message length.
  - Transmissometer, nephelometer, or meteorological data transmission format.

The following procedures detail the DCP transmission quality check:

EDIT THE DOWNLOADED FILE	Edit the downloaded file using any plain ASCII editor such as WordStar. The WordStar command is **WS FILENAME**. "FILENAME" is the downloaded data file, usually of the format "GALYYDDD.DAT," where "YY" is the year, and "DDD" is the Julian date.
CHECK MESSAGES AND NEWS	The downloaded data file may contain information about data dissemination processes, solar eclipses, data archiving, etc. This information may provide clues to failed DCP transmissions or poor quality data.
CHECK DCP TRANSMISSIONS	Each DCP transmission has associated quality assurance information added to the downloaded data file. Figure 4-7 details the information for a Handar DCP and Figure 4-8 details the information for a Synergetics DCP. Figure 4-9 details the ranges of acceptable values for the DCP transmission information. If any parameter is out of range, refer to TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.
CHECK DATA FORMAT	Each type of monitoring station (transmissometer, nephelometer, or meteorological) logs different data and transmits a different data format. Figures 4-7 and 4-8 detail the data transmission formats for transmissometer and nephelometer stations, respectively. If the transmitted data are not in the correct format, refer to TI 4110-3000, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, or TI 4100-3100, *Routine Site Operator Maintenance Procedures for NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

Example Data	Row Description
FA42914E93085112729G38+1HN009EFF00143	Identification and quality
0501 001 004 0137 090 000 000 000 00.0 13.8	First hourly data
0495 000 004 0138 088 000 000 000 00.0 13.8	Second hourly data
0496 001 003 0138 086 000 000 000 00.0 13.8	Third hourly data
1 2 3 4 5 6 7 8 9 10	Data column

Column	Description
1	Raw transmission average (counts)
2	Receiver computer toggle
3	Standard deviation of the raw transmission (counts)
4	Ambient temperature (°F) (+ 100)
5	Ambient relative humidity (%)
6-9	Not used
10	DCP battery voltage (VDC)

Identification and transmission quality:

Characters	Example	Description
1-8	FA42914E	DCP identification
9-10	93	Year of transmission
11-13	085	Julian date of transmission
14-15	11	Hour of transmission
16-17	27	Minute of transmission
18-19	29	Second of transmission
20	G	Failure code
21-22	38	Signal strength
23-24	+1	Modulation frequency deviation from normal
25	H	Modulation quality
26	N	Modulation index
27-29	009	Satellite channel
30	E	Satellite (East or West)
31-32	FF	IFPD (Intermediate Frequency Presence Detector)
33-37	00143	Message length

Figure 4-7. Handar DCP Transmissometer Data Format.

```
Example Data
FA40643E93085122318G43-1NN002W4C00432# 1  1716
# 2   114   173   210   224   383   407   297   302
# 2   383   140   135   140   125   132   138   128
# 2   141   155
# 3   498   498   498   498   498   498   498   498
# 3   498   498   498   498   498   498   498   498
# 3   498   498
# 4   524   423   324
# 5    50    50    50
# 6    -1    -1    -1
# 7   209   209   209
# 8  1020  1020  1020
# 9    96    92   102
#10   960   954   926
#11  1388
```

Description
Identification and quality

Data Group Number	Description
#1	Synergetics operation status
#2	10-minute nephelometer analog A1 readings
#3	10-minute nephelometer analog A2 readings
#4	Nephelometer time when 21X datalogger time is xx:30
#5	Hourly nephelometer code summary
#6	Hourly support code summary
#7	Last clean air calibration (counts) (x10)
#8	Last span calibration (counts) (x10)
#9	Ambient temperature at top of hour (°C) (x10)
#10	Ambient relative humidity at top of hour (%) (x10)
#11	DCP battery voltage (VDC) (x100)

Identification and transmission quality:

Characters	Example	Description
1-8	FA40643E	DCP identification
9-10	93	Year of transmission
11-13	085	Julian date of transmission
14-15	12	Hour of transmission
16-17	23	Minute of transmission
18-19	18	Second of transmission
20	G	Failure code
21-22	43	Signal strength
23-24	-1	Modulation frequency deviation from normal
25	N	Modulation quality
26	N	Modulation index
27-29	002	Satellite channel
30	W	Satellite (East or West)
31-32	4C	IFPD (Intermediate Frequency Presence Detector)
33-37	00432	Message length

Figure 4-8. Synergetics DCP Nephelometer Data Format.

PARAMETER	RANGE	INTERPRETATION
SIGNAL STRENGTH	32 to 57	Signal strength should never exceed 50. Normal strength is 44 to 48. A signal strength less than 43 or greater than 49 indicates a possible malfunction or improper installation. Reliable data can be received with a signal strength as low as 37 if no other signal problems exist.
FREQUENCY	±0 to ±A	50 Hz increments. Reliable data should be possible between -8 and +8 (-449 to +449 Hz). Frequency drift due to temperature (+200 Hz) and Aging (+400 Hz/year) can cause a platform to drift outside the +500 HZ range very quickly. ±250 Hz is a safe range for normal operations.
MODULATION INDEX	N,H,L	N is normal. H (High); messages may be truncated or lost due to loss of demodulator lock. Signal strength readings may indicate too low. L (Low); high error rate, missing messages, and signal strength readings may read too high.
MODULATION QUALITY	N,F,P	N is normal. F indicates malfunction or misalignment, error rate between 10^{-4} and 10^{-6}. P indicates malfunction or misalignment, error rate worse than 10^{-4}.

Figure 4-9. DCP Transmission Quality Description.

4.5 DAILY DCP DATA HANDLING

Daily DCP data handling includes automatic removal of invalid characters from the downloaded file and reformatting the downloaded file into a form usable by processing software. Specifically, DCP data handling includes:

- Updating the "SITEINFO" file.
- Running the STRIP_T program to remove invalid characters and reformat the downloaded data file.
- Examining the stripped file to determine the beginning and ending dates and times for the interval of the file.
- Recording the interval in the Wallops Island log book.
- Examining the "ERROR.DAT" file for incomplete transmissions.
- Examining the "MESSAGE.DAT" file for information included in the header of the downloaded data file.

EDIT AND UPDATE THE "SITEINFO" FILE

The site list information file (SITEINFO) includes information for the current transmissometer and nephelometer sites, including associated DCP ID, site abbreviation, GMT time offset to Local Standard Time (LST), and number of lines in the DCP transmission. The information in the "SITEINFO" file is used by the STRIP_T and APPEND_T programs to define which DCP IDs are valid and to which site they are assigned. The "SITEINFO" file is located in the F:\USERS\WALLOPS directory. The "SITEINFO" file must be updated to reflect changes to DCP-related site configurations. The following procedures describe editing of the "SITEINFO" file:

- Edit the "SITEINFO" file using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\SITEINFO**.
- The file format for "SITEINFO" is detailed in Figure 4-10.
- Add, delete, or change the lines in the file to reflect the currently operating DCP-equipped stations.
- Update the number of stations in the first line of "SITEINFO" to reflect the number of stations listed in the file.
- Save the "SITEINFO" file. The WordStar command is **ALT F S**.

```
23
FA42914E,ACADH,4,3,ACADIA,OK,BEXT
FA4315A0,BADLH,7,3,BADLANDS,OK,BEXT
FA4380C2,BANDT,7,3,BANDELIER,OK,BEXT
FA4356AA,BIBEH,6,3,BIGBEND,OK,BEXT
FA43A62E,BRIDH,7,3,BRIDGER,OK,BEXT
FA44220E,BRMEO,7,6,BRYCECANYON,OK,NONE
FA44F466,CANYH,7,3,CANYONLANDS,OK,BEXT
FA450618,CHIRH,7,3,CHIRICAHUA,OK,BEXT
FA441794,GLACT,7,3,GLACIER,OK,BEXT
FA44E710,GRBAH,8,3,GREATBASIN,OK,BEXT
FA44D28A,GRCAH,7,3,GRANDCANYON(SOUTHRIM),OK,BEXT
FA43F652,GRCWH,7,3,GRANDCANYON(IN-CANYON),OK,BEXT
FA42F4A8,GRCMM,7,11,GRANDCANYONMET,OK,NONE
FA437046,GUMOH,6,3,GUADALUPE,OK,BEXT
FA4393B4,MEVEH,7,3,MESAVERDE,OK,BEXT
FA436330,PEFOH,7,3,PETRIFIEDFOREST,OK,BEXT
FA43203A,PINNH,8,3,PINNACLES,OK,BEXT
FA44C1FC,ROMOH,7,3,ROCKYMOUNTAIN,OK,BEXT
FA4306D6,SAGOH,8,3,SANGORGONIO,OK,BEXT
FA42C132,SHENH,4,3,SHENANDOAHLONGPATH,OK,BEXT
FA43B558,YELLH,6,3,YELLOWSTONE,OK,BEXT
FA42D244,YOSEH,8,3,YOSEMITE,OK,BEXT
FA40643E,MACAN,4,14,MAMMOTHCAVESNEPH,OK,NONE
```

Format:

The first line is the number of DCP definitions in the file.

All other lines:

DCP Identification
Site abbreviation and site type
Hourly offset to GMT
Number of lines in each transmission
Site name
Always OK if active; TEST if not active
Always b_{ext} if transmissometer; NONE if nephelometer

Site types:

T Transmissometer sites with Handar AT/RH sensor
H Transmissometer sites with Rotronics AT/RH sensor
N Nephelometer sites
O Bryce Canyon meteorological site

Figure 4-10. Example SITEINFO File for Daily Data Processing.

RUN STRIP_T

The STRIP_T program performs the following functions:

- Strips the downloaded data file of invalid characters.
- Saves the logon and file header information in the "MESSAGE.DAT" file.
- Saves incomplete transmissions in the "ERROR.DAT" file.
- Reformats the downloaded data file and sorts it by transmission date and time (GALYYDDD.TMP file).

  The downloaded data file must be run through STRIP_T before daily data processing of transmissometer or nephelometer data can proceed. The STRIP_T program is started by:

  - Changing to the F:\USERS\WALLOPS directory.
  - Entering **STRIP_T** to start the program.

RECORD START AND END TIMES

The stripped downloaded data file is sorted by transmission data and time. Examine the first and last transmissions in the "GALYYDDD.TMP" file and record them in the Wallops Island logbook.

EXAMINE ERROR FILE

The "ERROR.DAT" file in F:\USERS\WALLOPS contains incomplete transmissions from the downloaded data file. Examine this file for error messages. If error(s) exist, the data file contains incomplete transmissions that must be corrected.

The following procedures describe how to edit the "GALYYDDD.DAT" file that generated an error in the "ERROR.DAT" file:

- Edit the "GALYYDDD.DAT" file using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\GALYYDDD.DAT**.
- Each transmissometer data transmission format contains three lines of data following the header line as follows:

```
FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8
0470 000 003 0139 023 000 000 000 00.0 13.1
```

- Add, delete, or change the lines in the data file so that the transmission format is complete. For example: the error is "FA44D28A93110011630, 2 lines does not = 3 lines," and the transmission in the "GALYYDDD.DAT" file looks like -

```
FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8
```

Add a third line with 999's so the transmission looks like -

```
FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8
9999 999 999 9999 999 999 999 999 9999 9999
```

Once errors are corrected, run STRIP_T again and reexamine the "ERROR.DAT" file. Do not proceed to the next processing stage until the "ERROR.DAT" file is free of errors. (See TI 4300-4023, *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)* or TI 4300-4004, *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*).

EXAMINE MESSAGE FILE

The "MESSAGE.DAT" file in F:\USERS\WALLOPS contains the header information from the downloaded data file. Print out a copy of "MESSAGE.DAT" daily and file the printout in the message archive file.

PERFORM DAILY DATA COMPILATION AND REVIEW

Once the primary data collection is complete, the next phase in daily data handling includes compilation and review of the collected data. Refer to the following data-specific TIs:

TI 4300-4004: *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*

TI 4300-4023: *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*

4.6 UPDATING NESDIS PLATFORM DESCRIPTION TABLES (PDTs)

The NESDIS program information tables must be updated when any change in an operational parameter (location, etc.) occurs. Figure 4-11 details the contents of a typical PDT. Refer to the User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1 for details on updating PDTs.

5.0 REFERENCES

Integral Systems, Inc., 1990, User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1, September.

PARAMETER	DESCRIPTION
OWNER_ID	Owner user ID (must be in UDT)
PRIME_TYPE	Primary Type: S: Self-timed I: Interrogate R: Random D: Dual
PRIME_CHAN	Primary CHANNEL: 1 - 266 (must be in CDT)
PRIME_SCD	Primary GOES spacecraft assigned: E: East, W: West
SECND_ADDR	Secondary address or Null
SECND_TYPE	Secondary type: R: Random I: Interrogate, or Null Note: Valid PRIME/SECND types are S/I, S/R
SECND_CHAN	Secondary channel: 0 - 266 (must be in CDT if > 0)
SECND_SCID	Secondary GOES spacecraft assigned: E: East, W: West, or Null
TRIGGER_MODE	Trigger mode: S: Special, T: Test, or Null Note: if not Null then: (a) PRIME_TYPE must be R (b) SECND_ADDR (trigger id) required FIRST_XMT Time of first interrogation for I type platforms in HMMSS format
XMT_PERIOD	Time period between transmissions (S/D) Time period between interrogations (I) in HHMMSS format
XMT_WINDOW	Maximum transmission window size in MMSS (S/D)
XMT_RATE	Data transmission rate in bps (100/300/1200)
MAX_RETRIES	Maximum number of interrogation retries (I)
DATA_FORMAT	DCPRS data format: A: ASCII, B: Binary
PRIME_PREAMBLE	DCPRS preamble type: L: Long, S: Short
SECND_PREAMBLE	DCPRS preamble type: L: Long, S: Short, or Null
LOC_CODE	Three-character location code
LOC_REGION	Location category: A: United States, B: Canada, C: South America, O: Other
LOC_NAME	Location name (31 characters)
LATITUDE	Latitude in DDMMSS
LONGITUDE	Longitude in DDMMSS
MIN_ELEVATION	Minimum elevation angle of platform (in DD)
CATEGORY	Platform category: Fixed: Fixed-buoy, D: Drifting-buoy A: Aircraft, S: Ship B: Balloon, L: Land-based O: Other

Figure 4-11. DCP Platform Description Table (PDT) Description.

Air Resource
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Fort Collins, CO 80525
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Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DAILY COMPILATION AND REVIEW OF DCP-COLLECTED DATA (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor text modifications	June 1996	

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1.0 PURPOSE AND APPLICABILITY

The purpose of this technical instruction (TI) is to describe the daily compilation and review of DCP transmissometer and meteorological data from an Optec LPV-2 transmissometer station operated according to IMPROVE Protocol. The primary purpose of daily compilation and review is to assure quality data capture and minimize data loss by:

- Extracting each site's DCP transmissometer and meteorological data from the stripped daily data file downloaded from the NOAA/NESS data dissemination facility at Wallops Island, Virginia. This file is obtained according to Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)* and TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*.

- Reformatting and appending the data to site-specific Level-A plottable data files.

Because most stations are remote and have limited operator visits, early identification of system problems during daily data review is critical to initiating timely corrective actions that minimize data loss.

This TI is a guide to:

- Updating the following transmissometer control files:

  - "SITEINFO," the DCP site description file.

  - "XXXX_L," the site-specific lamp calibration files.

  - "TPROCESS.CON," the data processing control file.

- Operation of the APPEND_T program.

- File formats of the transmissometer constants files, stripped downloaded data file, and site-specific Level-A plottable files.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Review editing of transmissometer constants files with the data coordinator.

- Review the daily transmissometer data compilation to Level-A files with the data coordinator to assure timely and accurate daily processing.

2.2 DATA COORDINATOR

The data coordinator shall:

- Update all transmissometer constants files and review with the project manager.

- Manually initiate the daily data append program.

- Review the Level-A files to identify instrument problems with the project manager.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Transmissometer data compilation procedures require the following computer hardware and software:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk

- Internal or external Hayes compatible modem configured for COM port #2

- APPEND_T software (ARS)

- Plain ASCII text editor such as WordStar

4.0 METHODS

Transmissometer data collected via DCP are processed daily to reformat and append the data to site-specific Level-A files. The Level-A files may then be reviewed and plotted. Review of transmissometer data is detailed in TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*.

Automatic and manual collection of DCP data is handled in accordance with TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*. Daily processing of DCP transmissometer data consists of the following steps:

- Updating the "SITEINFO" file containing the list of currently operating sites.

- Updating the site-specific lamp calibration files, "XXXX_L" (where "XXXX" is the site abbreviation).

- Executing the APPEND_T program.

The following procedures detail the steps for daily processing of transmissometer data:

LOGON TO NETWORK	Logon to network on the transmissometer data handling computer using your assigned user name and password.
UPDATING THE "SITEINFO" FILE	The site list information file "SITEINFO" includes the currently operating transmissometer and nephelometer sites with their associated DCP ID, site abbreviation, GMT time offset to Local Standard Time (LST), and number of lines in the DCP transmission. Information in the "SITEINFO" file is used by the STRIP_T and APPEND_T programs to define which DCP IDs are valid and to which site they are assigned. The "SITEINFO" file is located on the network in the "F:\USERS\WALLOPS" directory. The "SITEINFO" file must be updated to reflect changes to DCP-related site configurations. The following procedures describe editing of the "SITEINFO" file:

- Edit the "SITEINFO" file using any plain ASCII editor such as WordStar. The file format for "SITEINFO" is detailed in Figure 4-1. The WordStar command is **WS F:\USERS\WALLOPS\SITEINFO**.
- Add, delete, or change the lines in the file to reflect the currently operating DCP-equipped stations.
- Update the number of stations in the first line of "SITEINFO" to reflect the number of stations listed in the file.
- Save the "SITEINFO" file. The WordStar command is **Alt-F S**.

UPDATING THE SITE-SPECIFIC LAMP FILES

The site-specific lamp files include the following site-specific information:

- Lamp installation and removal dates and times
- Lamp serial numbers and calibration numbers
- Path distance and Rayleigh coefficient
- Lamp calibration curve set information

The information in the lamp files is required to calculate the atmospheric extinction coefficient (b_{ext}) from the raw transmission values collected via DCP. The lamp files must be edited with the most current information available regarding lamps. Each site has its own lamp file with file name "XXXX_L," where "XXXX" is the site abbreviation. The following procedures detail the steps for editing individual lamp files:

- Locate lamp files that are on the network in the "F:\USERS\SITE.CON" directory.
- Edit an individual lamp file using any plain ASCII editor. The WordStar command is **WS F:\USERS\SITE.CON\XXXX_L**, where "XXXX" is the site abbreviation. The file format for lamp files is detailed in Figure 4-2.
- Edit the fields in the lamp file to reflect current information regarding the site. Commas must be included between fields.
- Save the lamp file. The WordStar command is **Alt-F S**.

Line Number	SITEINFO File Contents
1	14
2	FA42914E,ACADH,4,3,ACADIA,OK,BEXT
3	FA4315A0,BADLH,7,3,BADLANDS,OK,BEXT
4	FA4380C2,BANDT,7,3,BANDELIER,OK,BEXT
5	FA4356AA,BIBEH,6,3,BIG BEND,OK,BEXT
6	FA43A62E,BRIDH,7,3,BRIDGER,OK,BEXT
7	FA44220E,BRMEO,7,6,BRYCE CANYON,OK,NONE
8	FA44F466,CANYH,7,3,CANYONLANDS,OK,BEXT
9	FA450618,CHIRH,7,3,CHIRICAHUA,OK,BEXT
10	FA441794,GLACT,7,3,GLACIER,OK,BEXT
11	FA44E710,GRBAH,8,3,GREAT BASIN,OK,BEXT
12	FA44D28A,GRCAH,7,3,GRAND CANYON (SOUTH RIM),OK,BEXT
13	FA43F652,GRCWH,7,3,GRAND CANYON (IN-CANYON),OK,BEXT
14	FA42F4A8,GRCMM,7,11,GRAND CANYON MET,OK,NONE
15	FA437046,GUMOH,6,3,GUADALUPE,OK,BEXT

Line Number Descriptions

1	Number of sites described in this file
2-	One line per site in the format described below

SITEINFO Line Format

DCP ID, site abbreviation and type, GMT time offset to LST, number of data lines per transmission, expanded name, status, type of data

Field	Description
DCP ID	8-Character DCP identification tag.
Site abbreviation and type	4-Character site abbreviation plus 1-character site type: T = Transmissometer with Handar AT/RH sensor H = Transmissometer with Rotronics AT/RH sensor N = Nephelometer O = Bryce Canyon meteorological station M = Grand Canyon Tonto Plateau meteorological station
GMT time offset to LST	Number of hours between Greenwich Mean Time (GMT) (the time programmed into the DCP) and Local Standard Time (LST) (the time used to tag the data).
Number of data lines	Each transmission should contain x number of data lines (not counting the DCP ID header line).
Expanded name	This appears at the top of the raw data plots.
Status	OK or TEST to indicate whether to process the data from this DCP (OK = no, TEST = yes).
Type of data	For transmissometers, this is always b_{ext}, otherwise it is NONE.

There should be one line for every DCP-configured site.

Figure 4-1. Example "SITEINFO" File and Description.

Line Number Contents of XXXX_L File

```
1     GRAND CANYON NATIONAL PARK (SOUTH RIM, GRCA)
2     CONSTANTS FILE
3     WESTERN
4     02/24/93
5                            INST LAMP   CAL  ON/   LAMP    LAMP                     LAMP CAL
6     YYMMDD  JD   HRMM  NUM  NUM   NUM  OFF   FACTOR  OFFSET DISTANCE RAYLEIGH Curve Set COMMENT
7     !!!!!!--!!!--!!!!--!!!--!!!!--!!!--!!!--!!!!!!---!!!!--!!!!!!!---!!!!!!!--!!!!!!!----------
8     861201, 335,    0, 001, 1005, 609,  ON,     -99,     0,  5.7904,  0.00935,       5,
9     870217,  48, 1200, 001, 1005, 609,  ON,     -99,     0,  5.7904,  0.00935,       3, +500 HRS OF OPERATION
10    870401,  91,  500, 001, 1006, -99,  ON,     -99,     0,  5.7904,  0.00935,       5,
11    870618, 169, 1200, 001, 1006, -99,  ON,     -99,     0,  5.7904,  0.00935,       3, +500 HRS OF OPERATION
12    870707, 188,  500, 002, 1007, 224,  ON,     -99,     0,  5.7904,  0.00935,       5,
13    870717, 198,  500, 002, 1007, 224, OFF,     -99,     0,  5.7904,  0.00935,       5,
14    870728, 209,  400, 002, 1007, 224,  ON,     -99,     0,  5.7904,  0.00935,       5,
15    871106, 310,  500, 007, 1008, 217,  ON,     -99,     0,  5.7904,  0.00935,       5,
```

Line Number	Description
1	Site name
2	Information
3	WESTERN or EASTERN
4	Date this file was last edited
5-7	Headers
8-	Lamp calibration information

Field	Description
YYMMDD	Year, month and day
JJJ	Julian date
HRMN	Hour and minute
INST NUM	Instrument number
LAMP NUM	Lamp number
CAL NUM	Calibration number or -99 for invalid lamp
ON/OFF	Lamp status during this interval
LAMP FACTOR	Lamp correction factor in percent per 500 hours or -99 for default
LAMP OFFSET	Number of hours the lamp has been used prior to this installation
DISTANCE	Path distance in kilometers
RAYLEIGH	Rayleigh coefficient in km^{-1}
LAMP CAL CURVE SET	Lamp calibration curve set (defined in TPROCESS.CON file) to use with this lamp
COMMENT	Comment concerning this line in the file

Important: The fields must be separated by a comma! (No commas in the comment field).

Figure 4-2. Example Lamp Calibration File (XXXX_L).

UPDATING "TPROCESS.CON" FILE

The "TPROCESS.CON" file contains information that is used during seasonal processing of transmissometer data. Information in the file may also be used to calculate a corrected b_{ext} value in the Level-A files as raw data are appended using the APPEND_T program. The "TPROCESS.CON" file should be updated when a site is installed, removed, or when calibration parameters change. The following procedures detail the steps for editing the "TPROCESS.CON" file:

- Locate the "TPROCESS.CON" file on the network in the "F:\USERS\SITE.CON" directory.

- Edit the file using any plain ASCII editor. The file format for "TPROCESS.CON" is detailed in Figure 4-3. The WordStar command is **WS F:\USERS\SITE.CON\TPROCESS.CON**.

- Edit the fields in "TPROCESS.CON" to reflect current information regarding the site. Commas must be included between fields.

- Save the "TPROCESS.CON" file. The WordStar command is **Alt-F S**.

RUNNING THE APPEND_T PROGRAM

The APPEND_T program extracts individual transmissometer data from the daily stripped DCP download file and appends the site-specific Level-A files. During the append process, extinction is calculated from raw transmission values and is included in the site-specific files. The following procedures detail the steps to appending daily data:

- Run the APPEND_T program.

- Enter the name of the daily stripped download file. The file name will be of the form "GALYYJJJ.TMP," where "YY" is the year and "JJJ" is Julian date.

- The program will append the data to site-specific Level-A files with file names of the form "XXXX_T," where "XXXX" is the site abbreviation.

- The APPEND_T program screen will be continuously updated with the status of the append process.

REVIEW THE SITE-SPECIFIC LEVEL-A FILES

The data in the site-specific Level-A files may be reviewed and plotted in accordance with TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*. Figure 4-4 details the file format for the site-specific Level-A files.

Line	Contents of TPROCESS.CON

```
1    TPROCESS.CON
2    Transmissometer Data Processing Constants File
3    Last Updated:
4    02/27/93
5    Last Update by: Jim
6
7    Lamp Calibration Uncertainty Curves, (Power Y=a0*hrs^a1)
8    Number of curve sets, COMMENT
9    Curve set number,curve name,a0,a1,r, COMMENT
10   ----------------------------------------------------
11   1,<--- This is the number of curve sets
12   ************************************
13   High lamp voltage - last bin removed
14   implemented 01/07/93
15   for processing Spring 91 - Summer 92
16   ************************************
17   1,MEAN, 0.058466,0.684934,0.999970
18   1,UPPER,0.059746,0.764626,0.999694
19   1,LOWER,0.168204,0.331265,0.951433
20   --------------------------------------------------------------------------------------------------
21       |  Constant bext Filters   |         |          |         |Cal.     |Uncal    |Cal      |             |Relative
22       |    First |  Second      |WX       |WX        |WX       |Lamp     |Lamp     |Num      |Temperature  |Humidity
23   Site|Thresh Num|Thresh Num    |Uncer    |Delta     |Max      |Uncer    |Uncer    |Uncer    |Min Max Del  |Min  Max  Delta
24   --------------------------------------------------------------------------------------------------
25   ACAD,  -0.001, 10,  0.050,  3,    0.018,0.010,     -0.050, 0.005,     0.02,     0.005,    -50, 60, 10,   1,100,30
26   BADL,  -0.001, 10,  0.050,  3,    0.018,0.010,     -0.050, 0.005,     0.02,     0.005,    -50, 60, 10,   1,100,30
27   BAND,  -0.001, 10,  0.050,  3,    0.018,0.010,     -0.050, 0.005,     0.02,     0.005,    -50, 60, 10,   1,100,30
```

Line Number	Description
1-10	Information about this file
11	Number of curve sets listed below in this file
12-16	Description of the first curve set
17-19	Coefficients for the first curve set
	*Repeat lines 12-16 and 17-19 for the number of curve sets defined in line 11.
20-24	Field headers
25-	Site-specific data processing constants

Field	Description
Site	Site abbreviation
Constant b_{ext} Filters	When there are NUM or more of the same b_{ext} value greater than THRESH, they are invalidated during seasonal processing.
WX Uncertainty Cutoff	Uncertainty cutoff used in the weather removal algorithm (km^{-1}).
WX Delta Cutoff	Delta cutoff used in the weather removal algorithm (km^{-1}).
WX Maximum Cutoff	Maximum cutoff used in the weather removal algorithm (km^{-1}).
Lamp Uncertainties	Not used.
Calibration Number Uncertainty	Percent uncertainty in the calibration number.
Temperature MIN/MAX/DELTA	Minimum and maximum acceptable temperatures (°C). Temperature variations of more than DELTA are recorded in an error file during seasonal processing.
Relative Humidity MIN/MAX/DELTA	Minimum and maximum acceptable relative humidity values (%). Relative humidity variations of more than DELTA are recorded in an error file during seasonal processing.

Figure 4-3. Example "TPROCESS.FILE" and Description.

Field:	Site	YYMMDD	JJJ	HHMM	b_{ext}	Raw	SD	AT	RH	Code
	GRCA	921201	336	000	6	461	7	28	14	9
	GRCA	921201	336	100	6	460	5	30	13	9
	GRCA	921201	336	200	6	461	7	29	12	9
	GRCA	921201	336	300	6	460	7	33	5	9
	GRCA	921201	336	400	7	457	7	28	23	0
	GRCA	921201	336	500	8	454	5	31	11	0
	GRCA	921201	336	600	6	460	9	36	3	9
	GRCA	921201	336	700	7	458	7	34	6	0

Field	Description
Site	4-Character site abbreviation
YYMMDD	Year, month and day
JJJ	Julian date
HHMM	Hour and minute
b_{ext}	b_{ext} (km^{-1} x 1000)
Raw	Mean of the 10 1-minute raw transmission values
SD	Standard deviation of the 10 1-minute raw transmission values
AT	Ambient air temperature (F°)
RH	Ambient relative humidity (%)
Code	b_{ext} validity code:

0 = Valid
1 = Operator error
2 = Instrument malfunction or removed
3 = Data reduced from alternate data logger
6 = b_{ext} overrange
9 = b_{ext} less than Rayleigh
A = Alignment problem
L = Lamp suspect
S = Suspect data

Code 0,2,6,8 and 9 may be placed by the APPEND_T program. These codes may later be updated during processing.

Figure 4-4. Example Level-A Transmissometer File and Description.

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1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 303-484-7941
Fax: 303-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DATA COLLECTION VIA STRIP CHART RECORDER**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4300-4025**
DATE	**JANUARY 1994**

AUTHORIZATIONS		
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PROGRAM MANAGER	David L. Dietrich	
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

The purpose of this technical instruction (TI) is to describe procedures necessary for the collection of transmissometer data via strip chart recorder. The primary purpose of transmissometer data collection via strip chart recorder is to assure continued data capture and minimize data loss when the primary data collection method (i.e. data collection platform (DCP)), fails. This secondary or backup data collection process includes:

- Performing operational and preventative maintenance checks, as needed, on the strip chart recorder to assure proper operational condition
- Verifying proper transmissometer operation
- Verifying proper strip chart recorder control, switch, and button settings
- Identifying data points on strip chart recorder paper for conversion to data base file
- Operation of digitizing tablet for data measurement

This TI is referenced from SOP 4300, Collection Of Optical Monitoring Data (IMPROVE Protocol), and serves as a guideline to facilitate the following:

- Strip chart recorder operation verification
- Transmissometer system operation verification
- Documentation of data parameters on strip chart recorder paper
- Documentation of data parameters on transmissometer log sheets
- Removal and shipment of strip chart recorder paper
- Digitizing strip chart recorder data
- Conversion of digitized data into site-specific transmissometer data files

Due to variation in the site configuration of IMPROVE Protocol sites, portions of this technical instruction may not apply to every transmissometer station.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the field specialist and data coordinator concerning the desired strip chart recorder instrument settings for collection of transmissometer data when the primary data collection method (DCP) fails.
- Oversee and review converted strip chart recorder data for accuracy and completeness prior to the data being entered into site-specific transmissometer data files.

2.2 FIELD SPECIALIST

The field specialist shall:

- Train the site operator in all phases of strip chart recorder maintenance and operation procedures.
- Provide technical support to the site operator via telephone to assure proper transmissometer data collection from the strip chart recorder.
- Document all technical support provided to the site operator.
- Resolve problems reported by the site operator.

2.3 DATA ANALYST

The data analyst shall:

- Identify possible DCP malfunction and contact the site operator to verify proper transmissometer and strip chart recorder operation.
- Provide technical support to the site operator via telephone, to assure proper transmissometer data collection from the strip chart recorder.
- Document all technical support provided to the site operator.
- Resolve problems reported by the site operator.
- Review documentation completed by the site operator for accuracy and completeness.
- Ship supplies, tools, and replacement instrumentation necessary for instrument problem resolution to the site operator.
- Enter all correspondence with site operators and the results of all performed procedures into site-specific timelines.
- Digitize the strip chart's transmissometer data.
- Convert digitized data into transmissometer format.
- Enter converted digitized transmissometer data into site-specific data files.

2.4 SITE OPERATOR

The site operator shall:

- Perform all procedures described in this TI.

- Thoroughly document all transmissometer and strip chart recorder operation verification information on the Transmissometer Site Operator Log Sheet and mail the log sheet to the data coordinator.

- Report any noted inconsistencies immediately to the data analyst or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The equipment generally required for collection of transmissometer data via strip chart recorder includes:

- Primeline 6723 strip chart recorder
- Strip chart recorder paper (Chart No. ZM1-01-12-15M)
- Strip chart recorder pens (red and black)
- Digitizing tablet with power supply, cable, and digitizing mouse
- Medium Phillips-head screwdriver
- Non-stick tape
- ARS strip chart recorder data conversion software
- Pen or pencil
- Primeline 6723 instruction manual

4.0 METHODS

This section includes three (3) major subsections:

4.1 Strip Chart Recorder Operation Verification
4.2 Transmissometer System Operation Verification
4.3 Digitizing and Converting Strip Chart Recorder Data

The procedures described in these sections refer to specific instrument components. Detailed schematic diagrams and instrument component descriptions are provided for reference in TI 4110-3350, Transmissometer Monitoring System Diagrams and Component Descriptions. Many of the procedures described in Section 4.1 refer to routine maintenance procedures that are detailed in TI 4110-3100, Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol). Many of the procedures described in Section 4.2 refer to transmissometer system operation verification procedures that are detailed in TI 4110-3300, Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol).

4.1 STRIP CHART RECORDER OPERATION VERIFICATION

This subsection describes verification checks on the strip chart recorder and describes procedures for documentation on the strip chart recorder paper.

The strip chart recorder is the backup data collection instrument for transmissometer data. At most sites the strip chart recorder operates only when there are problems with the data collection platform (DCP). When data is not transmitted by the DCP, the site operator is notified and requested to verify proper strip chart recorder operation. Refer to Figure 4-1, Strip Chart Component Diagram, for the location of the following items:

CHART PAPER MAGAZINE	The entire chart paper magazine is removable, enabling easy paper installation. Blank paper is stored at the back of the magazine, while paper with recorded data folds into a storage area at the front.
CHART PAPER	Check to make sure that there is an adequate supply of chart paper remaining. A red line will appear on the right side of the chart paper when there is less than two days remaining on the chart. If unsure that there is at least a week of chart paper remaining, install a new roll of strip chart paper. Instructions for installation of chart paper can be found in the Primeline 6723 instruction manual, pages 2-8 through 2-10. By hand, advance the paper a few sheets before loading the magazine to make sure that the paper is feeding correctly.
CHART PENS	Check to make sure that the pens are leaving a bold trace and track freely across the chart paper. The pens should be replaced when the trace becomes weak or intermittent. Chart recorder pens slip into holders, as described on page 2-10 of the Primeline 6723 instruction manual. It is important that the pens be inserted securely into the mounts. Note that the pen positions, as they mark on the chart paper, are offset slightly. This is important when looking at the strip chart data.
PEN LIFTERS	Pen lifters raise the pens off the chart paper to prohibit recording or to make installation of new pens easier. **IMPORTANT** -- pen lifters should be in the fully down position for routine operation.
EVENT MARKERS	Event markers are momentary-on push buttons, that when depressed, make a "tick" mark on the strip chart paper. These tick marks are used to accurately record events such as field operator servicing visits. Tick marks on the strip chart paper should always have a time and date written next to them. When making tick marks, depress the event markers 4 or 5 times rapidly to make a good, positive mark.
RANGE SWITCHES	Range switches should be set to the values listed on the strip chart settings sticker. For most locations, CHA should be set to the **10-volt** position and CHB to the **50-volt** position. The 50-volt setting is a combination of the "10-VOLT" push-button and the "ZERO CONTROL" knob pulled out to the **X5** position.

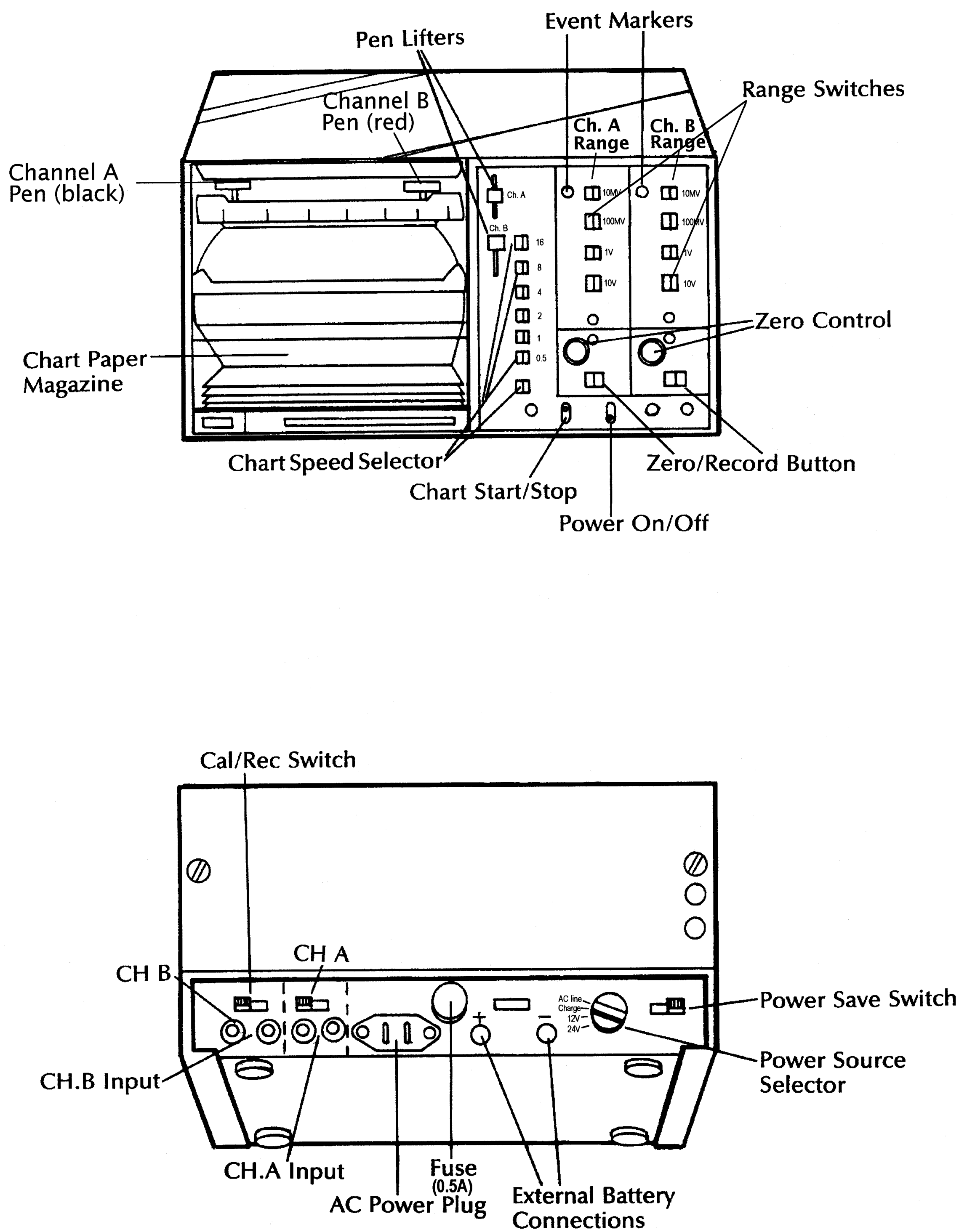

Figure 4-1. Strip Chart Component Diagram.

ZERO CONTROL KNOB	The "ZERO CONTROL" knob provides the following functions: 1) It positions the pens to the correct **zero** position on the chart paper. (The **zero** position can only be adjusted when the "ZERO/RECORD" button is in the **zero** position.) 2) It expands the range settings by a factor of five. For example, a range switch setting of **10** becomes **50-volts** full scale when the "ZERO CONTROL" knob is pulled out.
ZERO RECORD BUTTON	The "ZERO/RECORD" button adjusts the pens to their correct **zero** position when used in conjunction with the "ZERO CONTROL" knob. **IMPORTANT** -- the button must be in its record position for routine operation.
POWER ON/OFF SWITCH	The power "ON/OFF" switch controls the supply of power to the recorder regardless of the power supply used.
CHART START/STOP SWITCH	This switch stops movement of the chart paper. It does not inhibit the pens from changing position as input voltages change. With the slow chart speed used in the transmissometer monitoring system, it is possible to write strip chart documentation on the "moving" chart paper. This switch should remain in the **start** position when the strip chart recorder is operational. **IMPORTANT** -- no data will be recorded when the switch is in the **stop** position.
CHART SPEED SELECTOR	The speed at which the chart paper passes the recording pens is selected by these switches. The speed is determined by a combination of the setting chosen from the upper six switches, and the setting of the lower switch. These switches should remain in the positions listed on the strip chart settings sticker. For routine monitoring, the button marked "0.5" should be depressed and the bottom button should be in the **out** or **CM/HR** position.
CHA INPUT	The analog voltage representing the transmissometer extinction signal inputs the strip chart recorder at CHA on the back panel. The banana jacks on the strip chart cable are labeled: the CHA positive lead connects to the plug marked "+" and the negative lead connects to "-".
CHB INPUT	The analog voltage, representing toggle state (on or off), inputs the strip chart recorder at CHB on the back panel.
CAL/REC SWITCH	The "CAL/REC" (calibrate/record) switch puts the recorder in either the "TEST" or "OPERATE" mode. If the switch is placed in the **CAL** position, an internally-generated 50-millivolt voltage is sent to the channel. This known reference voltage is used to check or verify correct recorder operation. For routine monitoring, the switch should remain in the **record** position.

	IMPORTANT -- no data is recorded when the switch is in the **CAL** position.
FUSE	The fuse contained within the fuse holder is used only when the recorder is operated from AC power. Spare fuses are supplied with the servicing equipment.
EXTERNAL BATTERY CONNECTOR	If DC battery power is used to operate the strip chart recorder, the power jacks connect at the position labeled "EXT battery" on the back panel. Care must be taken to observe correct polarity.
POWER SOURCE SELECTOR	The power source switch selector position must match the type of power supplied. When battery power is used, the switch must be set to 12-volts, not 24-volts. When the AC power is used, the switch must be set to **AC line**.
POWER SAVE SWITCH	The power save switch reduces power consumption when only one channel of data (CHA) is to be collected. If the pen on Channel B fails to respond to signals or changes in control switch settings, check the position of the switch. This switch must remain in the **off** position.

4.1.1 Documentation on Strip Chart Recorder Paper

When the data collection platform (DCP) is not operating or is operating improperly, the strip chart recorder becomes the only source of data from the transmissometer. Once proper strip chart recorder operation is verified, the following information must be recorded on the chart paper at each site visit:

- Event markers or "ticks"
- Date and time
- Location
- Operator name
- Receiver computer display value
- Toggle "on" or "off"
- Other information such as:
  - Pens zeroed
  - Replacement pens/paper
  - Computer reset
  - Alignment off/corrected
  - System timing off/corrected

The transmissometer receiver computer outputs its A1 channel and toggle readings to the strip chart recorder. During normal operation, the receiver computer A1 switch is in the **C** (raw reading) position and the strip chart recorder Channel A (black pen) range setting is in the **10-volt** position. In order to get better resolution of data readings on the strip chart paper when the DCP is not operating, the receiver computer A1 switch should be in the **B** (b_{ext}) position and the strip chart recorder Channel A range setting should be in the **1-volt** position. See Figure 4-2, Example of Strip Chart Data, for an example of b_{ext} readings on strip chart paper with Channel A range setting on 1-volt.

It is very important that the documentation on the strip chart recorder paper is thorough (especially the date, time, and current reading), and that the transmissometer data is being "transferred" to the proper position on the chart paper. For example, an b_{ext} reading of .028 should be easily distinguishable from a b_{ext} reading of .030 on the strip chart paper.

4.1.2 Removal of Strip Chart Recorder Paper and Shipment to ARS

When removing the strip chart paper, record the location, date, and time of last data on the outside of the chart paper. The same information should be written at the beginning of the roll of chart paper when installing. The procedure for changing chart paper is described on pages 2-8 through 2-10 of the Primeline 6723 Strip Chart Recorder Manufacturer's Instruction Manual.

Once the strip chart paper has been document and removed from the recorder, it should be mailed to Air Resource Specialists, Inc. (ARS) with corresponding transmissometer log sheet documentation. The correct mailing address for ARS is:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

Call ARS immediately if any problem arises with strip chart recorder operation, documentation, chart paper replacement, or shipment of chart paper and log sheets. Primary contacts at ARS are:

Carter Blandford
Dave Beichley
Jim Wagner

ARS may be reached at the following telephone numbers:

Regular: (303) 484-7941
FAX: (303) 484-3423

4.2 TRANSMISSOMETER SYSTEM OPERATION VERIFICATION

This subsection describes verification checks on the transmissometer system log sheet documentation procedures.

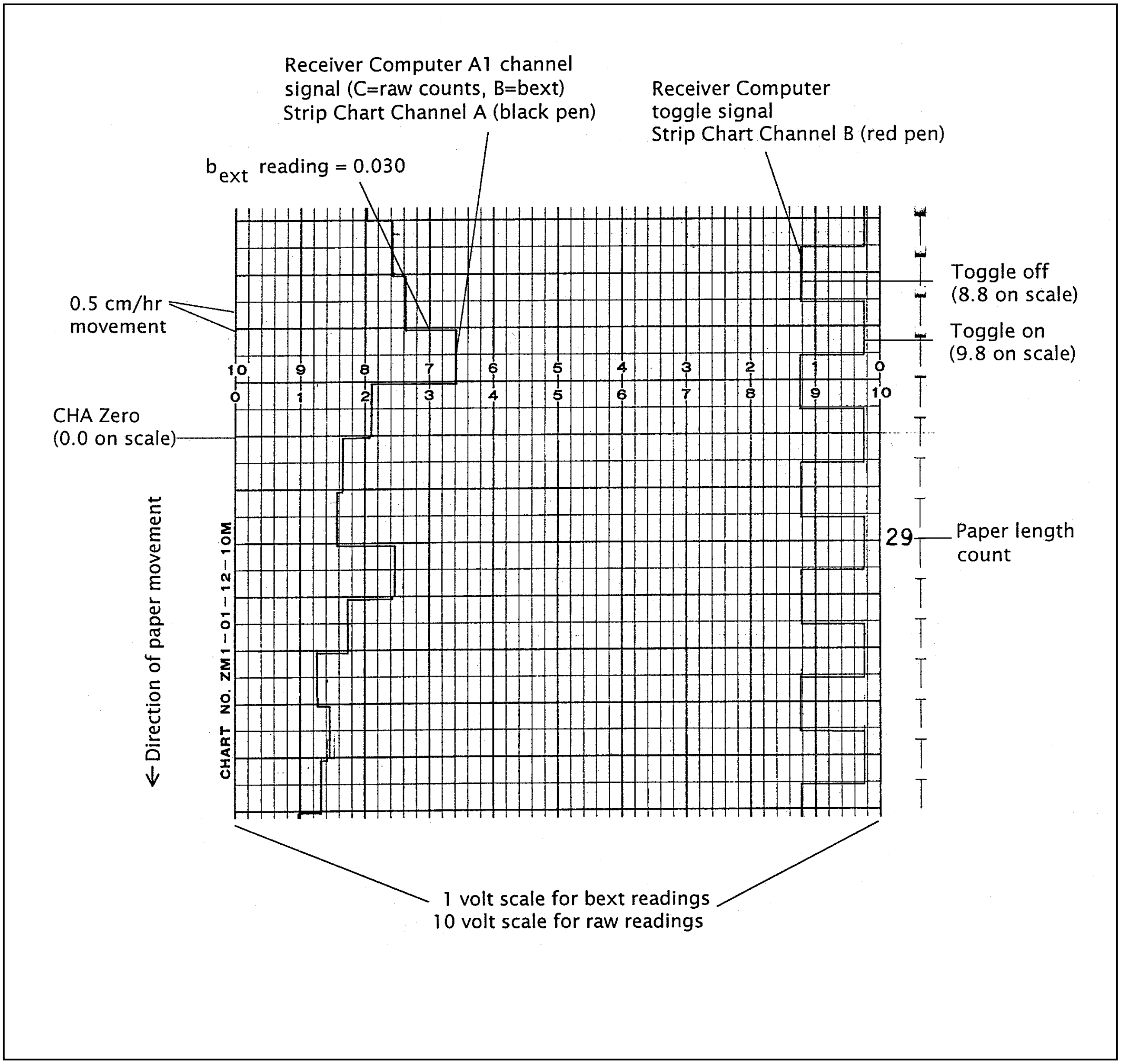

Figure 4-2. Example of Strip Chart Data.

For data collected from the strip chart recorder to be considered valid, the transmissometer system operation must also be verified. Frequent site visits (twice a week instead of weekly) are necessary for weather and visibility comparisons with the transmissometer data. When the DCP is not transmitting data from the transmissometer station, there is no air temperature or relative humidity data to relate the transmissometer readings with.

The site operator must verify proper transmissometer system operation by documenting the following on the site operator log sheets:

- System timing - lamp "on" and "off" times and receiver display update time
- Toggle operation
- Receiver computer display reading accuracy (does the reading make sense?)
- Current and recent weather and visibility conditions
- Receiver computer switch settings
- Lamp number and lamp voltage readings
- Optical cleanliness (shelter windows and telescopes)
- Alignment location/correction
- Power supply and/or deep-cycle battery operation/maintenance
- Solar panel and regulator operation

The above documentation and operation verification information is referred to in TI 4110-3100, Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol), and in TI 4110-3300, Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol).

4.3 DIGITIZING AND CONVERTING STRIP CHART RECORDER DATA

This subsection describes procedures for identifying data points, date and time reference points on strip chart recorder paper, and procedures for converting strip chart data into site-specific transmissometer Level-A data files.

When the strip chart paper containing data to be converted is received at ARS (along with the associated transmissometer log sheets), the data analyst must identify the beginning date, time, and data reading on the strip chart paper with the help of site operator documentation on both the chart paper and log sheets. Once the start date, time, and data reading is identified, the strip chart paper can be attached (using non-stick tape) to the digitizing tablet for data identification. The data analyst uses the digitizing tablet to scan the data points on the strip chart paper and input the data into an ASCII/TEXT file on the ARS computer network system.

For the data analyst to convert the strip chart data into valid transmissometer data, the following information is needed:

- Strip chart Channel A range setting (1-volt or 10-volt)
- Lamp number from transmissometer transmitter for data in question
- Calibration number for lamp being used
- Site path distance (km) of site using the strip chart data

By using the above information and ARS strip chart data conversion software, the digitized data can be converted into raw readings and b_{ext} readings that can be manually entered into the site-specific Level-A (XXXX_T) file. Refer to TI 4300-4023, Transmissometer Daily Compilation and Review of DCP-Collected Data, for an example and description of a Level-A transmissometer file.

To scan the data points on the strip chart paper, perform the following:

- Use the digitizing tablet's mouse to locate the boundaries of the strip chart paper's length (identifying the "x" scale - time in 24-hour format).
- Use the digitizing tablet's mouse to locate the boundaries of the strip chart paper's width (identifying the "y" scale - 1-volt or 10-volt).
- Using the digitizing tablet's mouse, click on each hours' data reading by following the black pen marks opposite the red pen toggle marks (a one-hour reading for each toggle change). (See Figure 4-2).

The result of this scan will be the First Stage digitized ASCII/TEXT file (see Figure 4-3). Once the raw numbers have been identified, they can be associated with a specific date, time, and b_{ext} reading using the documentation information provided by the site operator on the strip chart paper. Using ARS strip chart data conversion software, the First Stage ASCII/TEXT file can then be converted to a Second Stage ASCII/TEXT file with date, time, b_{ext}, and raw readings (must use calibration number and site path distance to calculate a raw reading from the b_{ext} reading). See Figure 4-4 for an example of a Second Stage ASCII/TEXT file.

Before the b_{ext} and raw readings can be manually inserted into the site-specific Level-A (XXXX_T) file, they must be rounded off to the nearest whole number (see Figure 4-5). Once the b_{ext} and raw readings numbers have been rounded off, the digitized strip chart data can be manually inserted into the proper Level-A file using any plain ASCII editor. To manually insert the final strip chart data file into the Level-A file, perform the following:

- Locate the missing data period in the Level-A file (site-specific Level-A data files are in F:\USERS\TRANS\XXXX_T, where XXXX is the site abbreviation).
- Insert columns 3 and 4 from the final ASCII/TEXT file (see Figure 4-5) into the proper column positions and into the correct date and time positions of the XXXX_T file.
- Manually insert a code of 3 (data reduced from strip chart recorder) into the code column of the XXXX_T file for every strip chart reduced data entry.

	1	2	3	4	5	6	7
1	13.44725	3.89400	13.00000	--			
2	14.51350	3.95009	--	--			
3	15.44824	3.96600	--	--			
4	16.53336	4.00692	--	--			
5	17.47107	4.00158	--	--			
6	18.45543	4.00393	--	--			
7	19.52918	3.52553	--	--			
8	20.52801	2.85970	--	--			
9	21.53478	**********	--	--			
10	22.44322	***********	--	--			
11	23.45813	***********	23.00000	--			
12	24.51312	***********	--	2.00000			
13	25.55793	***********	--	--			
14	26.50285	***********	--	--			
15	27.51361	0.42116	--	--			
16	28.55919	***********	--	--			
17	29.53740	***********	--	--			
18	30.55167	***********	--	--			
19	31.46562	***********	--	--			
20	32.47193	3.79105	--	--			
21	33.49115	2.36362	--	--			
22	34.46910	3.01281	--	--			
23	35.50277	***********	--	--			
24	36.44289	3.72777	--	--			
25	37.49520	1.51310	--	--			
26	38.52862	***********	--	--			
27	39.41033	***********	--	--			
28	40.44518	***********	--	--			
29	41.53187	0.42877	--	--			
30	42.51135	2.92060	--	--			
31	43.49480	1.79701	--	--			
32	44.57633	0.22858	--	--			
33	45.49841	3.01188	--	--			
34	46.50510	3.23649	--	--			
35	47.50374	3.48245	23.00000	--			
36	48.43491	3.61505	--	3.00000			
37	49.39043	3.63485	--	--			
38	50.44734	3.64868	--	--			
39	51.45123	3.69311	--	--			
40	52.45694	***********	--	--			
41	53.50633	3.03475	--	--			
42	54.48326	2.96301	--	--			
43	55.44315	3.48316	--	--			

KEY

Column 1 = X value (hour measurement) going length-wise on strip chart paper

Column 2 = Y value (b_{ext} or raw reading measurement) going width-wise on strip chart paper

Column 3 = Hour scale (24-hour format)

Column 4 = Day scale (0-23 hours equals one day)

Figure 4-3. Example of First Stage ASCII/TEXT File From Strip Chart Paper.

	1	2	3	4	5	6	7
1	13.4473	3.8940	13	12/04/92	15.93	389.00	
2	14.5135	3.9501	14	12/04/92	13.55	395.00	
3	15.4482	3.9660	15	12/04/92	12.77	397.00	
4	16.5334	4.0069	16	12/04/92	11.21	401.00	
5	17.4711	4.0016	17	12/04/92	11.60	400.00	
6	18.4554	4.0039	18	12/04/92	11.60	400.00	
7	19.5292	3.5255	19	12/04/92	31.02	353.00	
8	20.5280	2.8597	20	12/04/92	63.73	286.00	
9	21.5348	0.0394	21	12/04/92	727.19	4.00	
10	22.4432	0.0472	22	12/04/92	692.51	5.00	
11	23.4581	0.0491	23	12/04/92	692.51	5.00	
12	24.5131	0.0439	0	12/05/92	727.19	4.00	
13	25.5579	0.0388	1	12/05/92	727.19	4.00	
14	26.5029	0.0545	2	12/05/92	692.51	5.00	
15	27.5136	0.4212	3	12/05/92	361.81	42.00	
16	28.5592	0.0684	4	12/05/92	640.23	7.00	
17	29.5374	0.0602	5	12/05/92	664.18	6.00	
18	30.5517	0.0557	6	12/05/92	664.18	6.00	
19	31.4656	0.0677	7	12/05/92	640.23	7.00	
20	32.4719	3.7911	8	12/05/92	19.98	379.00	
21	33.4912	2.3636	9	12/05/92	93.59	236.00	
22	34.4691	3.0128	10	12/05/92	55.78	301.00	
23	35.5028	0.0542	11	12/05/92	692.51	5.00	
24	36.4429	3.7278	12	12/05/92	22.46	373.00	
25	37.4952	1.5131	13	12/05/92	162.98	151.00	
26	38.5286	0.0748	14	12/05/92	640.23	7.00	
27	39.4103	0.0704	15	12/05/92	640.23	7.00	
28	40.4452	0.0677	16	12/05/92	640.23	7.00	
29	41.5319	0.4288	17	12/05/92	358.16	43.00	
30	42.5114	2.9206	18	12/05/92	60.50	292.00	
31	43.4948	1.7970	19	12/05/92	135.68	180.00	
32	44.5763	0.2286	20	12/05/92	455.38	23.00	
33	45.4984	3.0119	21	12/05/92	55.78	301.00	
34	46.5051	3.2365	22	12/05/92	44.34	324.00	
35	47.5037	3.4825	23	12/05/92	33.24	348.00	
36	48.4349	3.6151	0	12/06/92	27.11	362.00	
37	49.3904	3.6349	1	12/06/92	26.68	363.00	
38	50.4473	3.6487	2	12/06/92	25.83	365.00	
39	51.4512	3.6931	3	12/06/92	24.13	369.00	
40	52.4569	0.0501	4	12/06/92	692.51	5.00	
41	53.5063	3.0348	5	12/06/92	57.75	303.00	
42	54.4833	2.9630	6	12/06/92	58.39	296.00	
43	55.4432	3.4832	7	12/06/92	33.24	348.00	

KEY

Column 1 = Value (hour measurement) going length-wise on strip chart paper

Column 2 = Y value (b_{ext} or raw reading measurement) going width-wise on strip chart paper

Column 3 = Hour scale (24-hour format)

Column 4 = Date identification (month/date/year)

Column 5 = b_{ext} reading (calculated using calibration number, site path distance, and raw reading

Column 6 = Raw reading (calculated using calibration number, site path distance, and b_{ext} reading)

Figure 4-4. Example of Second Stage ASCII/TEXT File From Strip Chart Paper.

1	2	3	4
0	12/03/92	27	369
1	12/03/92	27	368
2	12/03/92	28	366
3	12/03/92	28	365
4	12/03/92	28	267
5	12/03/92	28	366
6	12/03/92	28	367
7	12/03/92	28	367
8	12/03/92	27	369
9	12/03/92	26	371
10	12/03/92	25	374
11	12/03/92	23	377
12	12/03/92	23	378
13	12/03/92	21	382
14	12/03/92	20	385
15	12/03/92	20	386
16	12/03/92	20	386
17	12/03/92	20	384
18	12/03/92	20	384
19	12/03/92	20	385
20	12/03/92	23	377
21	12/03/92	24	375
22	12/03/92	25	374
23	12/03/92	24	375
0	12/04/92	24	375
1	12/04/92	24	375
2	12/04/92	24	375
3	12/04/92	24	376
4	12/04/92	23	378
5	12/04/92	22	380
6	12/04/92	23	379
7	12/04/92	23	377
8	12/04/92	23	379
9	12/04/92	23	379
10	12/04/92	22	381
11	12/04/92	22	381
12	12/04/92	18	389

KEY

Column 1 = Hour scale (24-hour format)

Column 2 = Date identification (month/year)

Column 3 = b_{ext} reading (rounded off to nearest whole number)

Column 4 = Raw reading (counts)

Figure 4-5. Example of Final ASCII\TEXT File From Strip Chart Paper.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 303-484-7941
Fax: 303-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DATA REDUCTION AND VALIDATION (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4400-5000**
DATE	**JANUARY 1994**

AUTHORIZATIONS		
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Add discussion regarding Olympus lamps	March 1995	

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1.0 PURPOSE AND APPLICABILITY

The purpose of this technical instruction (TI) is to describe the steps of transmissometer data reduction and validation, to assure quality data, and ensures that data are placed in a format consistent with IMPROVE protocol. This TI is referenced in SOP 4400, Optical Monitoring Data Reduction and Validation (IMPROVE Protocol).

A transmissometer directly measures the irradiance of a light source after the light has traveled over a finite atmospheric path. The transmittance of the path is calculated by dividing the measured irradiance at the end of the path with the calibrated initial intensity of the light source. The average extinction of the path is calculated using Bouger's law from the transmittance and length of the path. It is attributed to the average concentration of all atmospheric gases and ambient aerosols along the path.

This TI presents the detailed steps used to ensure high quality data reduction and validation from transmissometer stations operated according to IMPROVE Protocol:

- Processing data daily to convert the raw data to Level-A validation format
- Reviewing data visually and examining any error files for details on monitoring system performance
- Processing data through Level-0 validation to search for questionable or physically unrealizable data
- Processing data through Level-1 validation to calculate uncertainty values and identify values affected by weather or optical interferences

Because most stations are remote, daily data review is critical to the identification and resolution of problems.

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Review finalized data with the project manager to ensure quality and accurate data reduction.
- Coordinate with the Contracting Officer's Technical Representative (COTR) for desired method of data reduction required of the IMPROVE program.

2.2 PROJECT MANAGER

The project manager shall:

- Review and verify calibration results for each instrument.
- Review and finalize data with data analysts and field specialists.

2.3 DATA ANALYSTS

The data analysts shall:

- Run all processing programs required to generate preliminary seasonal summary plots.
- Review data with the project manager and field specialists.

2.4 FIELD SPECIALISTS

The field specialists shall:

- Review data with the project manager and data analysts.
- Provide input as to the cause of instrument problems and specific siting characteristics.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reduction and validation occurs on IBM-PC compatible systems. The required computer system components are as follows:

- IBM compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Software for processing raw transmissometer data:
  - Microsoft Windows 3.0/3.1
  - WordStar 5.1 or any ASCII editor
  - File viewing utility
  - ARS plotting and seasonal processing software
- Hewlett-Packard HP LaserJet II or 4 printer

4.0 METHODS

This section includes three (3) subsections:

4.1 Daily Reduction and Validation Procedures
4.2 Monthly Reduction and Validation Procedures
4.3 Seasonal Reduction and Validation Procedures

These subsections describe the processing procedures applied to transmissometer data to obtain extinction, SVR, and deciview data in IMPROVE Protocol format.

4.1 DAILY REDUCTION AND VALIDATION PROCEDURES

Data collected at each monitoring site are recovered daily from satellite data collection platforms (DCPs). Along with extinction, ambient temperature and relative humidity are also monitored. The data represent one ten-minute average value for each hour. The measurement interval begins three minutes after the hour and ends at thirteen minutes after the hour.

For times when the transmissometer system operated but DCP transmissions were not received, strip charts are available as backup. Data for missing DCP periods are manually reduced from the strip charts and added to the raw transmissometer files. (See TI 4300-4025, Transmissometer Data Collection via Strip Chart Recorder).

Once the data are appended into site-specific Level-A files (see TI 4300-4023, Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)), the data analysts review each Level-A file (XXXX_T where XXXX is the four letter site abbreviation) using the file viewing utility "DR" (directory read). The Level-A files are located in the F:/USERS/TRANS directory of the ARS computer network. Each XXXX_T file is reviewed to determine if the transmissometer is functioning properly. Corrective action is taken when an instrument malfunction or data problem is detected. Data analysts contact the site operator by telephone and initiate troubleshooting procedures (see TI 4110-3300, Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)).

4.2 MONTHLY REDUCTION AND VALIDATION PROCEDURES

Raw data plots are generated bi-monthly from the XXXX_T files. Data from operator log sheets are checked against data collected via data collection platform (DCP) to identify inconsistencies and errors. Information from the log sheets and comments from the bi-monthly plots are entered into the Quality Assurance (QA) Database. All hard copy log sheets are chronologically filed by site.

4.2.1 Bi-Monthly Data Plots

Level-A transmissometer data are plotted bi-monthly using ARS plotting software. The plots are displayed on the large corkboard outside the data collection center (DCC) and are reviewed by the project manager, data analysts, and field specialists on a monthly basis. Inconsistent or suspicious data are identified and troubleshooting procedures are initiated (see TI 4110-3300, Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)).

4.2.2 Comments on Plots

As completed log sheets from transmissometer sites are received, the pertinent information (visibility conditions, alignment, system timing, instrument problems, etc.) is manually transferred to the bi-monthly plots. Figure 4-1 is an example bi-monthly data plot with comments. This procedure helps to identify the exact time of lamp changes, alignment corrections, and other actions done by the site operator affecting instrument operation. The data analysts can then use this information to correctly update the lamp and code files for Level-A verification (see Section 4.3.1).

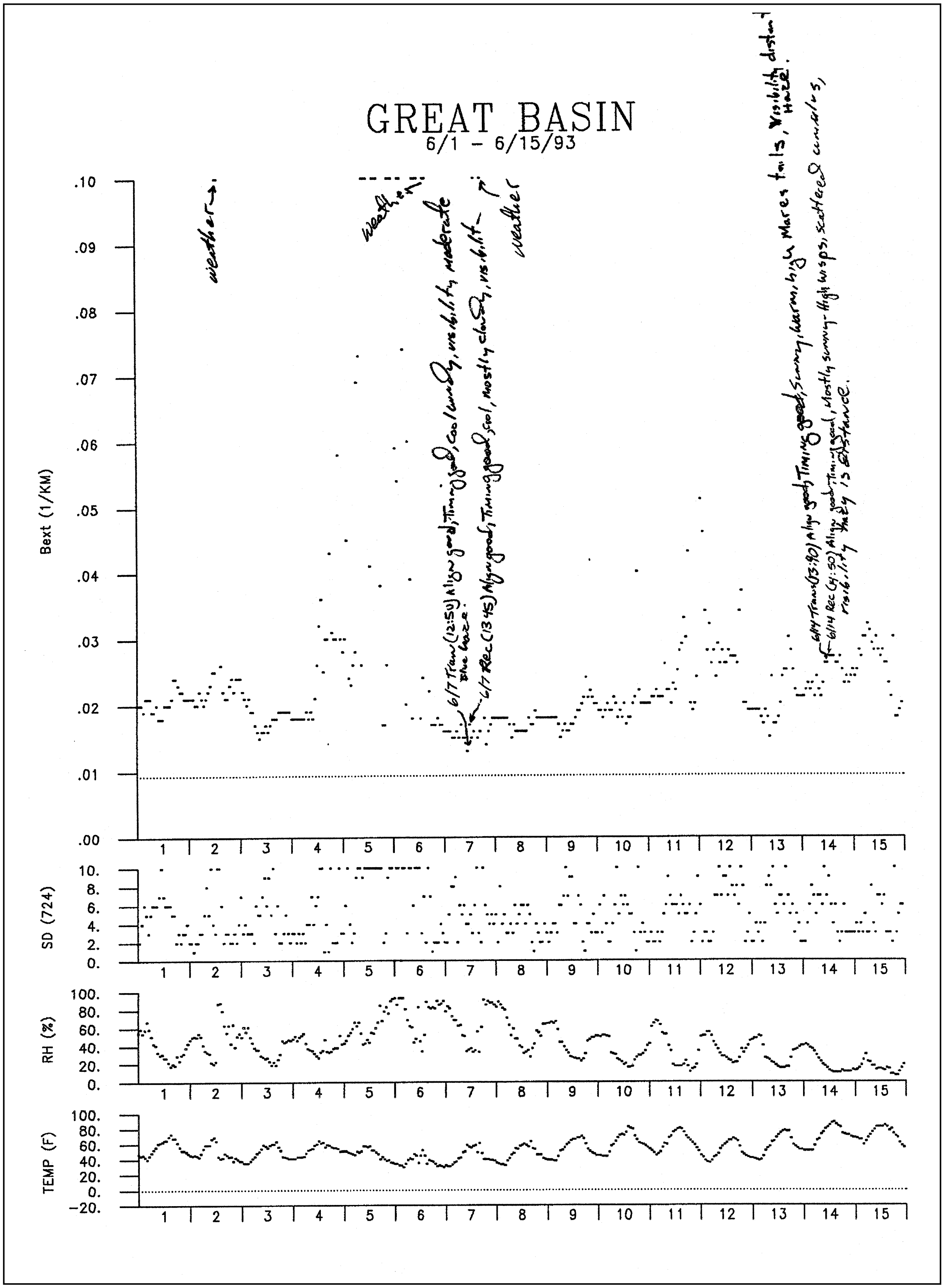

Figure 4-1. Example Bi-Monthly Data Plot With Comments.

4.3 SEASONAL REDUCTION AND VALIDATION PROCEDURES

Data analysts create a seasonal data file for each site. Standard meteorological seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Processing begins with the raw transmissometer files and consists of three levels of data verification: Level-A, Level-0, and Level-1. Processing that defines each level is presented in Figure 4-2, Transmissometer Data Processing Flow Chart, and described in the following subsections.

4.3.1 Level-A Verification

Raw files are converted to Level-A verification format. Reduction at this level includes updating constants files:

- Lamp files (XXXX_L) where XXXX is the site abbreviation
- Code files (XXXX_C) where XXXX is the site abbreviation
- Processing file (TPROCESS.CON)

Refer to TI 4300-4023, Transmissometer Daily Compilation and Review of DCP Collected Data (IMPROVE Protocol), for a description of the procedures to be followed when updating the site-specific lamp files and the processing file (XXXX_L and TPROCESS.CON).

UPDATING THE SITE-SPECIFIC CODE FILES

The site-specific code files include the following information:

- Beginning and ending dates and times that identify invalid data
- Codes indicating reason for invalid data
- Comments describing specific reason for invalid data

The information in the code files is required to identify known periods of invalid data. The block of data that is coded invalid will not be used in the seasonal or annual report(s). The code files must be edited with the most current information available regarding instrument and support equipment operation. Each site has its own code file with the file name XXXX_C, where XXXX is the site abbreviation.

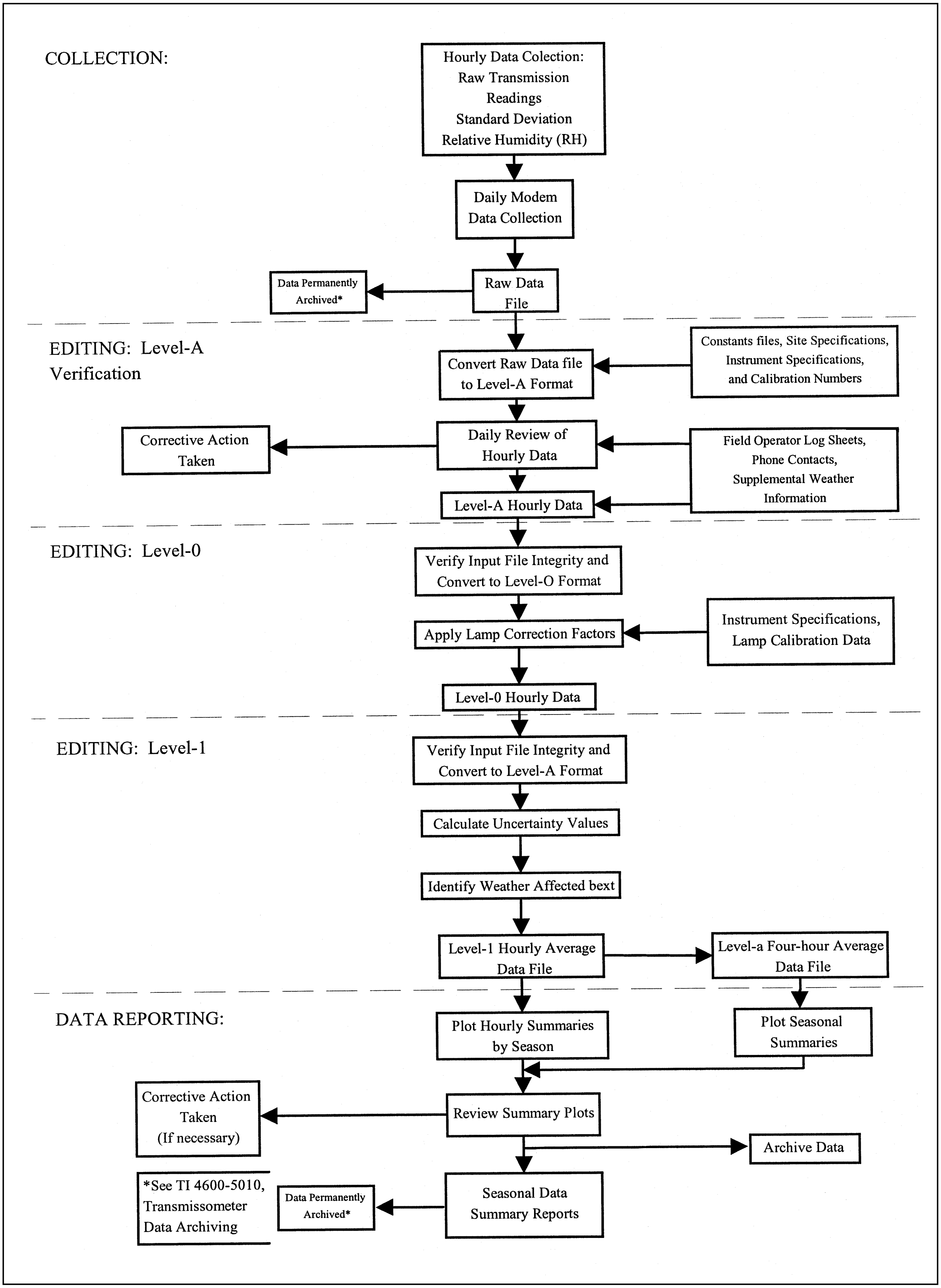

Figure 4-2. Transmissometer Data Processing Flow Chart.

The following procedures detail the steps for editing individual code files:

- Locate code files which are on the computer network in the F:\USERS\SITE.CON directory.

- Edit an individual code file using any plain ASCII editor. The WordStar command is: **WS F:\USERS\SITE.CON\XXXX_C**, where XXXX is the site abbreviation. The file format for code files is detailed in Figure 4-3.

- Edit the fields in the code file to reflect current information regarding the instrument and support equipment operation. Commas must be included between fields.

- Save the code file; the WordStar command is: **Alt-F S**.

Once the site-specific lamp files, code files, and the processing file are all updated with the most current information available regarding lamps, instrument and support equipment operation, and calibration parameters, seasonal processing can be initiated.

Level-A processing software performs the following functions for each site:

- Generates Level-A formatted seasonal data files which include only the data records for the season to be processed.

- Recalculates b_{ext} from the raw readings, using calibration information in the lamp files.

- Removes periods in the raw file when the b_{ext} exceeds a number of consecutive times specified. In effect, this removes periods of constant b_{ext}.

- Adds codes specified in the code files to the raw files. This saves time from entering long strings of codes manually.

Transmissometer validity codes reflecting instrument operation are manually added to the raw files. These can be obtained from operator log sheets or other operator communications. Transmissometer validity codes used at this level include:

0 = Valid
1 = Invalid: Site operator error
2 = Invalid: System malfunction or removed
3 = Valid: Data reduced from an alternate logger
6 = Valid: b_{ext} data exceeds maximum (overrange)
8 = Missing: Data acquisition error
9 = Valid: b_{ext} data below Rayleigh (underrange)
A = Invalid: Misalignment
L = Invalid: Defective lamp
S = Invalid: Suspect data
W = Invalid: Unclean optics

Line Number	Contents of XXXX_C File

```
1     GRAND CANYON NATIONAL PARK (SOUTH RIM, GRCA)   UPDATE:  9/08/93
2     CODE DESCRIPTION FILE
3
4
5     START START START  START  START END   END   END    END
6     YEAR  MONTH  DAY  JULIAN  TIME  MONTH DAY  JULIAN  TIME
7                        DATE                     DATE        CODE COMMENT
8     -------------------------------------------------------------------
9     86,    12,    1,   335,    0,   12,   17,  351,    0,   8,
10    86,    12,   18,   352,   21,   12,   21,  355,   16,   1,   FLIP MIRROR
11    86,    12,   28,   362,    2,   12,   31,  365,    6,   1,
12    86,    12,   31,   365,    7,   12,   31,  365,   23,   8,
13    87,     1,    1,     1,    0,    1,    3,    3,   12,   8,
14    87,     1,    6,     6,   19,    1,    9,    9,   15,   1,
15    87,     1,   23,    23,   13,    1,   24,   24,   12,   2,   POWER OUTAGE
16    87,     2,   18,    49,   22,    2,   19,   50,    0,   8,
```

Line Number	Description
1	Site name - Date this file was last updated
2	Information
3	Blank
4	Blank
5-8	Headers
9-xx	Data code information

Field	Description
START YEAR	Year containing data to be coded out
START MONTH	Beginning month containing data to be coded out
START DAY	Beginning day for data to be coded out
START JULIAN DATE	Beginning julian date for data to be coded out
START TIME	Beginning hour (24-hour format) of data to be coded out
END MONTH	Ending month for data to be coded out
END DAY	Ending day for data to be coded out
END JULIAN DATE	Ending julian date for data to be coded out
END TIME	Ending hour (24-hour format) of data to be coded out
CODE	Code indicating reason for data to be coded out *
COMMENT	Comment concerning this line in the file

Important: The fields must be separated by a comma! (No commas in the comment field).

* Refer to description of Transmissometer validity codes (page 7)

Figure 4-3. Example Code File (XXXX_C).

A -99 in any data field indicates missing or invalid data.

The maximum $b_{ext,max}$ occurs when the transmittance falls below 5%. The $b_{ext,max}$ is calculated when data are appended using:

$$b_{ext,\max} = \frac{-\ln(0.05)}{r} \tag{1}$$

where r = path distance.

4.3.2 Level-0 Verification

Data and validity codes are checked for inconsistencies using a screening program. The same validity codes used at Level-A apply at Level-0.

All b_{ext} data are corrected for lamp drift. This value is based on the calculated average drift of a number of lamps. The algorithm for calculating the drift-related offset applied to each b_{ext} value is:

Let t_1 = 16 number of minutes per hour the lamp is on.
t_2 = 60 number of minutes in an hour.
t_3 = number of lamp-on hours for current lamp.
L = number of hours the lamp resides in the transmitter.
r = path length.

The lamp-on time (t_3) for the current lamp is:

$$t_3 = L \times t_1 / t_2 \tag{2}$$

The lamp drift correction factor (F_{drift}) is a function of the lamp-on hours (t_3) defined by the following curve for Olympus lamps operating at a nominal voltage of 5.9 VDC:

$$F_{drift}(\%) = 0.270 \times t_3^{0.4405} \tag{3}$$

The lamp drift corrected transmittance (T_{corr}) is:

$$t_{corr} = [1 + (F_{drift} / 100)] \times T \tag{4}$$

where T is the measured transmittance. The drift corrected b_{ext} is:

$$b_{ext,\,corr} = -\ln(\frac{1}{T_{corr}}) / r \tag{5}$$

where r = path distance.

Level-0 data files are kept active on hard disk, backed up on cassette tape daily, and archived on cassette tape seasonally.

4.3.3 Level-1 Verification

Level-1 verification includes two processing steps:

- Calculation of uncertainty values for all data
- Identification of b_{ext} values affected by weather or optical interferences

A key to the Level-1 data file, including validity codes for b_{ext} data, is presented as Figure 4-4.

A screening program is used to again check all data and validity codes for inconsistencies. The data are then reduced to four-hour average values of extinction (b_{ext}), standard visual range (SVR), and haziness (dv). The time periods of the four-hour average values are:

03:00	0000 - 0359 hours
07:00	0400 - 0759 hours
11:00	0800 - 1159 hours
15:00	1200 - 1559 hours
19:00	1600 - 1959 hours
23:00	2000 - 2359 hours

The four-hour average b_{ext} and average dv, along with the average relative humidity, average temperature, and the transmissometer validity code are recorded and kept in the database.

4.3.3.1 Calculation of Uncertainties

Transmissometer Uncertainties

Operationally the basic equation used to calculate path transmittance in the network is:

$$T = I_r / (F_{lamp} \times I_{cal}) \qquad (6)$$

where:

$\boldsymbol{T}$	=	Transmittance of atmosphere of path $\boldsymbol{r}$
$\boldsymbol{I_r}$	=	Intensity of light measured at $\boldsymbol{r}$
$\boldsymbol{I_{cal}}$	=	Calibration value of transmissometer
$\boldsymbol{F_{lamp}}$	=	Variability function of lamp output

The relative uncertainty ($\boldsymbol{U_x}$) of any measured parameter $\boldsymbol{x}$ is defined as:

$$U_x = \sigma_x / \bar{x} \qquad (7)$$

Field Number

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GRCA	900702	183	700	28	1	4	0	18	10	300	0	17	1	0	38	3	0	134
GRCA	900702	183	800	-99	-99	0	4	18	10	300	4H	-99	-99	0	-99	-99	0	-99

Field	**Description**
1	Site abbreviation
2	Date in year/month/day format
3	Julian Date
4	Time using a 24-hour clock in hour/minute format
5	b_{ext} x 1000 (km^{-1})
6	b_{ext} uncertainty x 1000 (km^{-1})
7	Number of readings in average
8	Number of readings not in average due to weather
9	Uncertainty threshold x 1000 (km^{-1})
10	Δ threshold x 1000 (km^{-1})
11	Maximum threshold x 1000 (km^{-1})
12	b_{ext} validity code [1]
13	Temperature (°C)
14	Temperature uncertainty (°C)
15	Temperature validity code [2]
16	Relative humidity (%)
17	Relative humidity uncertainty (%)
18	Relative humidity validity code [2]
19	Haziness (dv x 10)

[1] b_{ext} validity codes:

0 = Valid
1 = Invalid: Site operator error
2 = Invalid: System malfunction or removed
3 = Valid: Data reduced from alternate logger
4x = Weather: a letter code representing specific conditions as noted below:

Condition	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
RH > 90%	x		x		x		x		x		x		x		x
b_{ext} > maximum threshold		x	x			x	x			x	x			x	x
b_{ext} uncertainty > threshold				x	x	x	x					x	x	x	x
Δ b_{ext} > delta threshold								x	x	x	x	x	x	x	x

Z Weather observation between 2 other weather observations.

Threshold values may be different for each site. See Appendix A.

8 = Missing: Data acquisition error
9 = Invalid: b_{ext} below Rayleigh
A = Invalid: Mis-alignment
L = Invalid: Defective Lamp
S = Invalid: Suspect Data
W = Invalid: Unclean optics

[2] Meteorology validity codes:

0 = Valid
1 = Invalid: Site operator error
2 = Invalid: System malfunction or removed
3 = Valid: Data reduced from alternate logger
5 = Invalid: Data > maximum or < minimum
8 = Missing: Data acquisition error

A -99 in any data field indicates missing or invalid data.

Figure 4-4. Key to the Level-1 Transmissometer Data File.

where

$\bar{x}$ = arithmetic mean of all $\boldsymbol{x}$ measurements
δ_x = precision of measurements $\boldsymbol{x}$ defined as

$$\sigma_x = \left[\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 \right]^{1/2} \tag{8}$$

Using propagation of error analysis the relative uncertainty of the path transmittance can be calculated from the relative uncertainties of the measured variables as:

$$U_T = (U_{Ir}^2 + U_{Ical}^2 + U_{lamp}^2)^{1/2} \tag{9}$$

where

U_T = relative uncertainty of T
U_{Ir} = relative uncertainty of I_r
U_{Ical} = relative uncertainty of I_{cal}
U_{lamp} = relative uncertainty of F_{lamp}

To understand the uncertainty of a transmittance measurement requires a thorough investigation of the precision of each of the following:

- Precision in calibration to determine I_{cal}
- Precision in the measurement of I_r
- Precision in the measurement of F_{lamp}

Relative Uncertainty of I_{cal} - The precision in calibration value I_{cal} can be determined by investigating the calibration equation. I_{cal} is the value that would be measured by the transmissometer detector if the atmospheric path was a vacuum. I_{cal} incorporates the path distance $\boldsymbol{r}$, transmittance of all windows in the path, and size of working aperture used. I_{cal} is determined from:

$$I_{cal} = (CP/WP)^2 \times (WG/CG) \times (WA/CA)^2 \times WT \times (1/FT) \times (1/T) \times CR \tag{10}$$

Using propagation of uncertainty analysis the relative uncertainty in I_{cal} can be shown to be:

$$U_{cal} = (2U_{CP}^2 + 2U_{WP}^2 + U_{CG}^2 + 2U_{WA}^2 + 2U_{CA}^2 + U_{WT}^2 + U_{FTt}^2 + U_{CR}^2)^{1/2} \tag{11}$$

Path distances are measured using a laser range finder. Calibration apertures are measured with a precision micrometer. Gain settings are measured with a precision voltmeter. Window and neutral density filter (NDF) transmittances are measured with a reference transmissometer by differencing techniques, thus they do not require absolute calibration. The standard deviation of the raw readings (CR) are calculated at each calibration. The typical working values, measurement precision, and relative uncertainties of these values are:

Parameter		Value	Precision	Relative Uncertainty
CP	Calibration Path	0.3 km	1 x 10-6 km	3.3 x 10-6
WP	Working Path	5.0 km	1 x 10-6 km	2.0 x 10-7
CG	Calibration Gain	100	1 x 10-2	1.0 x 10-4
WG	Working Gain	500	1 x 10-2	2.0 x 10-5
CA	Calibration Aperture	100 mm	1 x 10-2 mm	1.0 x 10-4
WA	Working Aperture	110 mm	1 x 10-2 mm	9.1 x 10-5
WT	Window Transmittance	0.810	0.001	1.2 x 10-3
FT	NDF Transmittance	0.274	-0.001	3.6 x 10-3
T	CP Transmittance	0.975	0.003	3.1 x 10-3
CR	Raw Readings	900	2.0	2.2 x 10-3

Combining the above values into the uncertainty equation leads to a typical relative uncertainty for $\boldsymbol{I}_{\mathbf{cal}}$: $\boldsymbol{U}_{\mathbf{Ical}}$ = 0.005.

Relative Uncertainty of $\boldsymbol{I}_{\mathbf{r}}$ - Under ambient operating conditions the irradiance measured by the transmissometer receiver will fluctuate due to:

- Atmospheric optical turbulence causing scintillation
- Atmospheric optical aberrations causing beam wander
- Varying meteorological conditions along the path: rain, snow, fog
- Insect swarms causing beam interference

The precision of each ten-minute irradiance measurement is calculated by the receiver computer as the standard deviation of the ten one-minute average irradiance measurements. The measured standard deviation is a direct estimation of atmospheric optical interference. Typical values of $\boldsymbol{I}_{\mathbf{r}}$ and various operational precision estimates that have been observed in the monitoring network are listed below.

Ambient Extinction (km^{-1})	I_r Value	No Optical Interferences		Optical Interference	
		Precision	Relative Uncertainty	Precision	Relative Uncertainty
0.010	200	1	0.0050	20	0.100
0.020	190	1	0.0053	20	0.105
0.030	180	1	0.0056	20	0.111
0.050	163	1	0.0061	20	0.123
0.100	127	1	0.0079	20	0.158
0.500	17	1	0.0580	20	1.117

Working Path = 5.0 km, I_{cal} = 210

As can be seen the relative uncertainty of the measured intensity is a function of the extinction of the path. For typical extinction measurements free from optical interference in the network, the average relative uncertainty in I_r is approximately: $U_{Ir} = 0.0055$

Relative Uncertainty of F_{lamp} - The major source of uncertainty in the transmissometer data is lamp drift correction. The transmitter employs an optical feedback loop designed to maintain constant irradiance within the 10nm bandwidth of the receiver filter/detector module. However, comparison of pre and post lamp calibrations show that the transmitter lamp output increases (brightens) with increased hours of lamp use. Tests have shown that the brightening is definitely a function of the lamp rather than the feedback circuit or filter. It is important to note that a 1% increase in irradiance over a path length of approximately five kilometers (the Grand Canyon sight path for example) results in the apparent extinction being decreased by 0.002 km^{-1} (20% of Rayleigh!!); i.e., the instrument measurement indicates the air to be cleaner than it actually is.

The method initially used to handle this bias was to compare the pre and post lamp calibrations and generate a lamp brightening factor that would be applied to the raw irradiance prior to calculating path transmittance. Early results from 1987 suggested a fairly stable 2% per 500 hour brightening rate through the first 500 hours of lamp use. Site operator lamp changes were scheduled at three month intervals (approximately 575 hours of lamp "on" time). The systems were returned to Fort Collins annually for routine servicing. Prior to servicing the instrument, lamp brightening would be verified by post-calibrating all lamps. This method resulted in delays of over a year before final data were available. Additionally, due to instrument failure, instrument damage, or lamp breakage, it is not always possible to post-calibrate all lamps used operationally. Therefore, a constant 2% per 500 hours correction factor was applied to all lamps to facilitate data collection, processing, and reporting. This lamp drift correction factor was based on post-calibrations of the first 10 lamps from the three systems used in the WHITEX study.

During 1992, a re-examination of all available post-calibration data showed that the lamp brightening factors were not as well-behaved as early post-calibrations had indicated. In January 1993, development of revised processing procedures that more accurately estimate transmissometer lamp drift correction was completed. Lamp brightening percentages and lamp "on" hours for all systems and lamps post-calibrated at the Fort Collins, Colorado transmissometer calibration facility are entered into a lamp brightening database. The data in this database are used to create statistics on lamp brightening. Lamp brightening percentages for post-calibrated lamps are sorted into time bins based on lamp operational hours. The mean and standard deviation of operational hours and percent lamp brightening were calculated for each bin. Power law functions are fitted to these data to define a statistically based mean lamp brightening and the one sigma upper and lower bounds. Applying the mean function to the raw transmissometer irradiance readings corrects for lamp brightening. The precision of the correction is calculated from the upper and lower bounds for the number of hours on the lamp at the time of the reading.

If, upon post-calibration, a system exhibits abnormally high or low lamp brightening, previously reported extinction data are flagged for further review. The lamp brightening database is continually updated as additional lamps are post-calibrated. Periodically, the lamp brightening statistics are reanalyzed to provide a more accurate description of the lamp drift correction and the precision associated with this correction.

Variations in lamp brightening characteristics for a given lamp design may occur due to variations in manufacturing processes between manufacturers. All lamps used with the LPV-2 transmissometer are purchased from the transmissometer manufacturer, Optec, Inc. Optec purchases standard lamps from the lamp manufacturer and precisely aligns the filament of each lamp prior to delivering the lamps for operational use. From 1986 through March 1993, all lamps supplied by Optec were purchased from Micro-Optics, Inc. Beginning in April 1993, lamps supplied by Optec have been purchased through a new distributor, Lamp Technology, Inc. These lamps are manufactured by Olympus and are considered to be of higher quality than the Micro-Optics lamps. A second factor that influences lamp brightening is the lamp operating voltage. Prior to 1990, IMPROVE operating procedures specified a nominal lamp operating voltage of 5.6 VDC. In 1990, the nominal lamp operating voltages was increased to 5.9 VDC. As a result of these changes, all operational lamps were placed in one of the following three categories:

- Low voltage Micro-Optic lamps, 5.6 VDC (1986 - 1989)
- High voltage Micro-Optic lamps, 5.9 VDC (1990 - March 1993)
- High voltage Olympus lamps, 5.9 VDC (April 1993 - present)

Using the revised processing procedures described above, statistically based lamp brightening functions were derived from post-calibration data for lamps in each of these three operational categories.

Low Voltage Micro-Optic Lamps (1986 - 1989)

Figure 4-5 is an analysis of lamp brightening data for Micro-Optic lamps pre-calibrated prior to 1990. These lamps were calibrated for a nominal operating voltage of 5.6 VDC. For low voltage lamps, the lamp drift correction applied for the first 500 hours of accumulated lamp time is a linear approximation to the mean brightening curve of Figure 4-5 (3.08% per 500 hours). Beyond 500 hours, the lamp drift correction is a constant offset equal to the correction at 500 hours (3.08%). The precision of the brightening measurements for the low voltage lamps has been approximately 3.1%. The relative uncertainty in $\boldsymbol{F_{lamp}}$ for a low voltage lamp at 500 hours is: $\boldsymbol{U_{lamp}}$ = 0.030.

High Voltage Micro-Optic Lamps (1990 - March 1993)

In early 1990, the nominal lamp operating voltage was increased to 5.9 VDC. An analysis of the lamp brightening data for Micro-Optics lamps calibrated at this higher operating voltage is presented in Figure 4-6. For these lamps, the lamp drift correction applied during the first 700 hours of accumulated lamp time follows the mean brightening curve of Figure 4-6. The equation for calculating lamp brightening using this curve is:

$$Lamp\ \ Brightening\,(\%) = a_o \times t^{a_1} \qquad (12)$$

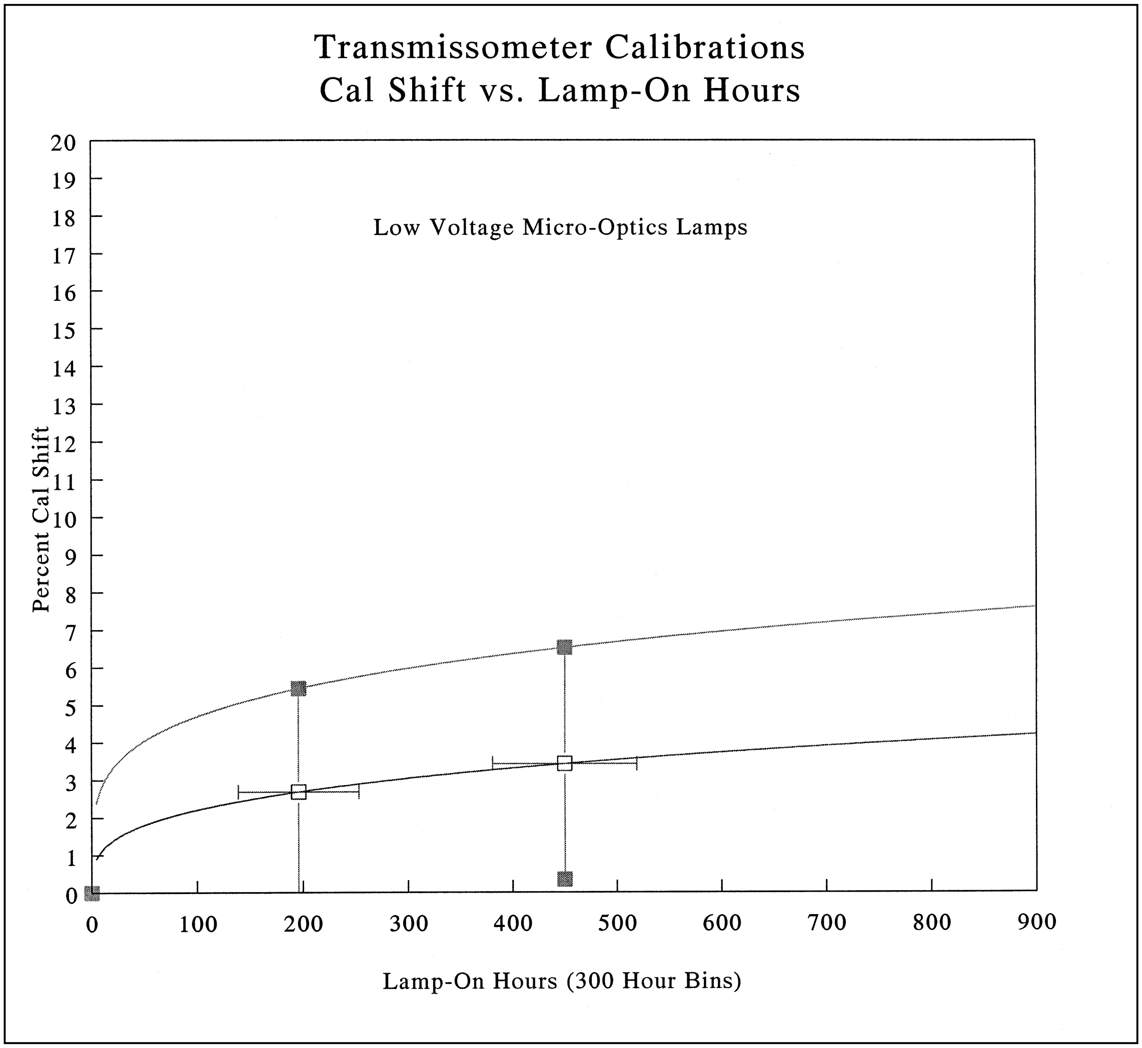

Figure 4-5. Lamp Brightening Curve - Low Voltage Micro-Optics Lamps.

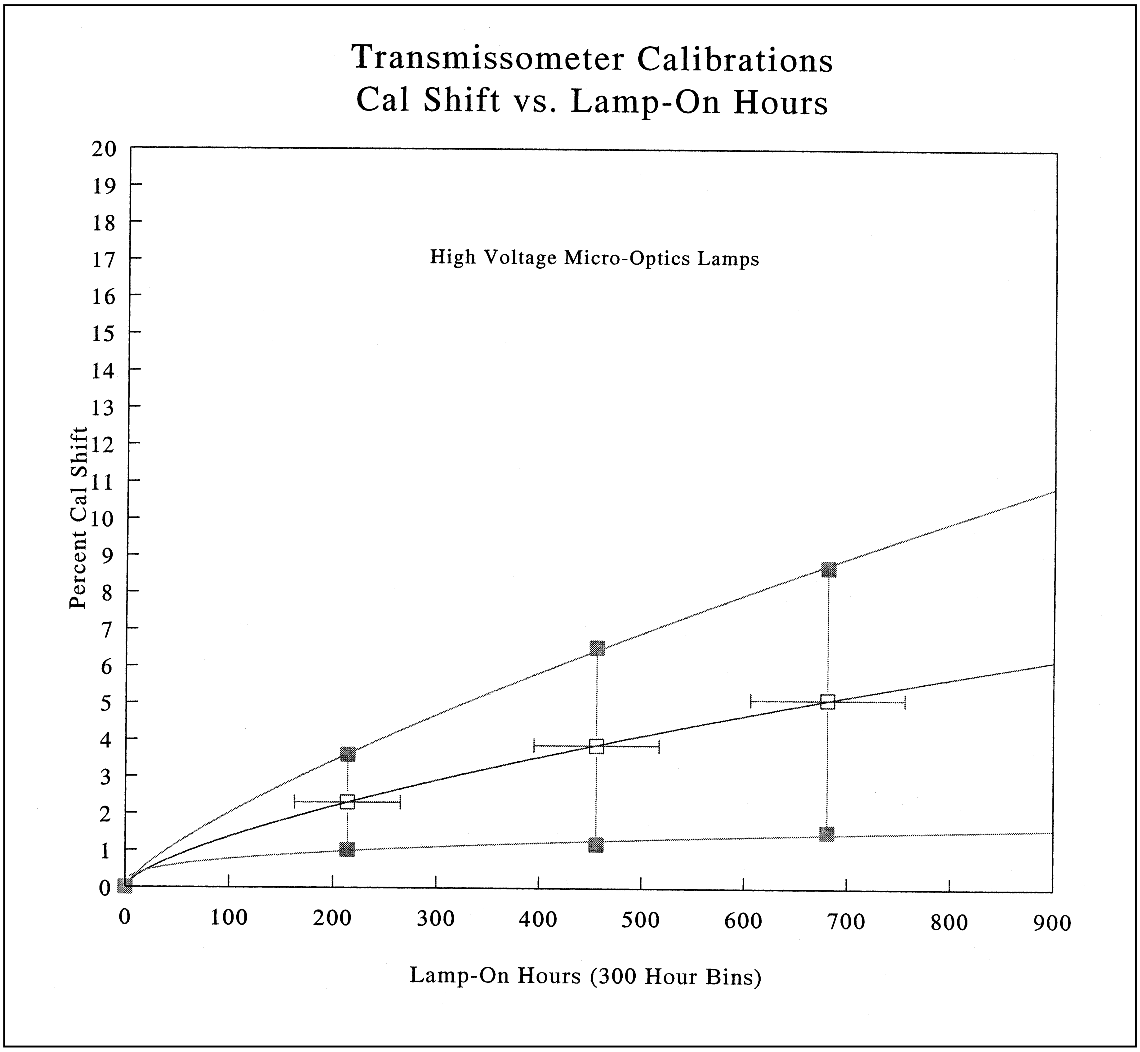

Figure 4-6. Lamp Brightening Curve - High Voltage Micro-Optics Lamps.

where:

t = accumulated lamp "on" time (hours)
a_0 = 0.0585
a_1 = 0.6849

Beyond 700 hours, the lamp drift correction is constant at the 700 hour value (5.19%). The precision of the brightening measurements for the high voltage Micro-Optics lamps has been approximately 2.7%. The relative uncertainty in F_{lamp} for a high voltage lamp at 500 hours is: U_{lamp} = 0.026

High Voltage Olympus Lamps (April 1993 - Present)

Beginning in April 1993, all replacement lamps calibrated for use in the IMPROVE network have been Olympus lamps with a nominal operating voltage of 5.9 VDC. Figure 4-7 is an analysis of lamp brightening data for the post-calibrated Olympus lamps. The lamp drift correction for the Olympus lamps follows the mean brightening curve of Figure 4-7. The equation for calculating lamp brightening is of the same form as the equation given for the high voltage Micro-Optic lamp (Equation 12) with:

t = accumulated lamp "on" time (hours)
a_0 = 0.2700
a_1 = 0.4405

Current IMPROVE network operations procedures specify that eight (8) pre-calibrated lamps be provided with each replacement transmissometer installed during an annual site servicing visit. This permits lamp changeouts at two-month intervals, ensuring that operational lamps will generally accumulate less than 500 hours of "on" time. Therefore, a separate high-hours lamp drift correction is not required.

Until additional Olympus lamps have been post-calibrated, the relative uncertainty in F_{lamp} calculated for the high voltage Micro-Optics lamps will also be used with the high voltage Olympus lamps (U_{lamp} = 0.026).

Relative Uncertainty in Path Transmittance

From the above analysis, the relative uncertainty in path transmittance can be calculated for each ten-minute transmittance measurement by the transmissometer. The typical values are:

Condition	Relative Uncertainty (U_T)
No Optical Interference	0.02
Optical Interference	0.20

Precision of Extinction Estimates From Transmittance Measurements

The average extinction b_{ext} of the transmissometer optical path (r) is calculated from the transmittance measurement (T) by:

$$b_{ext} = -\ln(T)/r \tag{13}$$

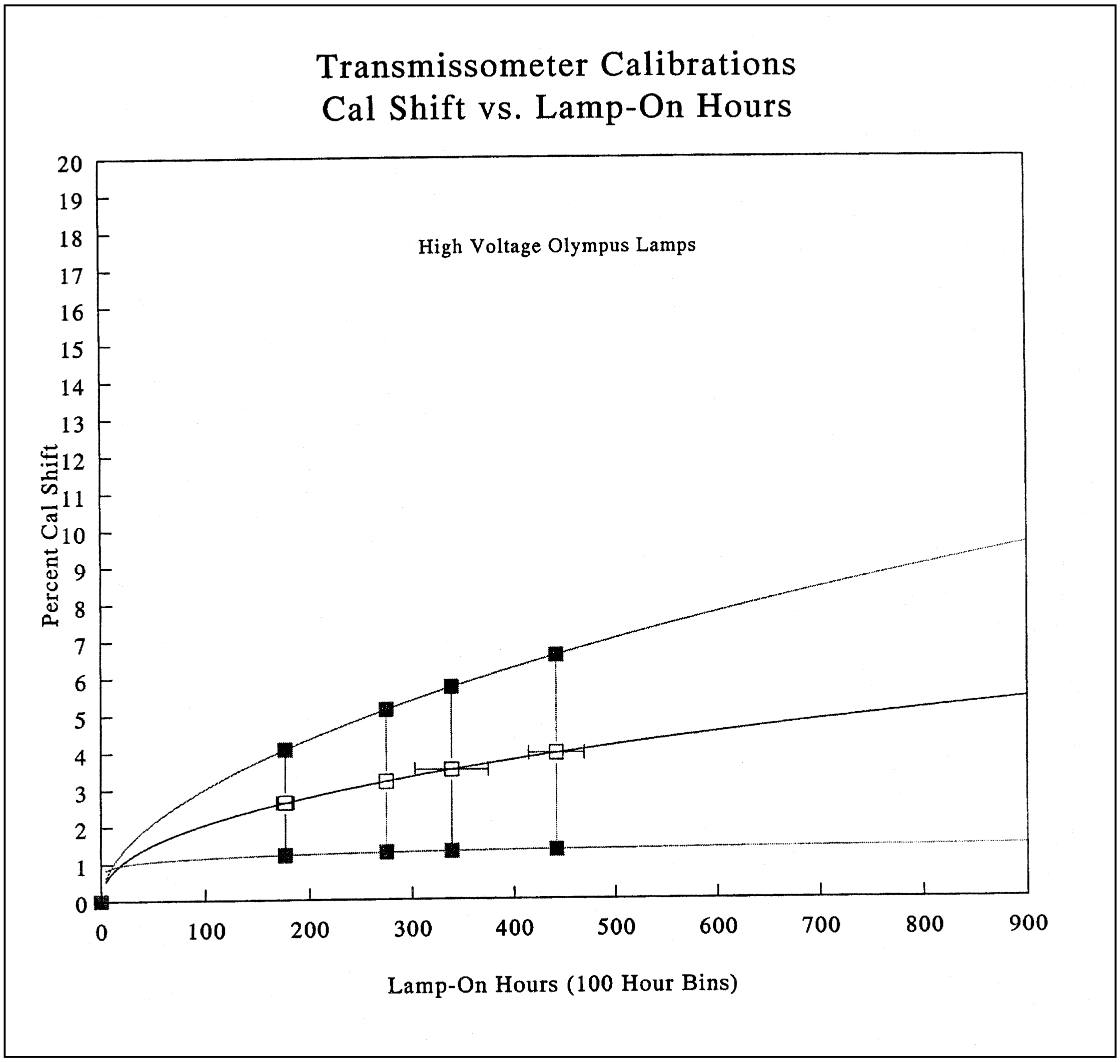

Figure 4-7. Lamp Brightening Curve - High Voltage Olympus Lamps.

Since the path length $\boldsymbol{r}$ is measured to an extremely high precision, the precision in $\boldsymbol{b_{ext}}$ can be approximated from propagation of error analysis as:

$$\sigma_{bext} = \pm U_T / r \tag{14}$$

The relative uncertainty in transmittance leads to an additive uncertainty in extinction that depends on the path length of the transmittance measurement. Table 4-1 lists the average uncertainty of b_{ext} estimates for typical sight paths in the monitoring network when no optical interferences are present along the path.

Table 4-1

Typical Uncertainty in b_{ext} for
Selected Monitoring Locations

Location	Path (km)	Precision (km^{-1})
Tonto	7.20	0.004
Grand Canyon	5.79	0.005
Acadia	3.67	0.007
Yosemite	2.71	0.100
Shenandoah	0.68	0.398

Bias In Extinction Calculations

The calibration equation assumes clean glass surfaces of constant transmittance. Any change in the window transmittance results in a bias added to the calculated extinction. If the window transmittance decreases the calculated extinction will increase, if it increases the calculated extinction will decrease. As with the precision, the bias is a function of the relative change in window transmittance and path distance:

Bias = (relative change in window transmittance)/r (15)

The possibility exists for errors to arise from changes in the transmittance of the windows due to:

- Pitting of the windows by wind blown dirt
- Staining of the windows by pollution
- Dirt collecting on the window surface due to dust, rain, snow
- Fogging of the windows at high humidities
- Improper servicing resulting in smudging of the windows
- Removal of the windows due to breakage

National Park Service (NPS) transmissometer data collected during 1991 was used to investigate the bias associated with varying window transmittance. Field operators are instructed to visit both the receiver and transmitter weekly. One of their duties is to observe the windows carefully and clean them regularly. These actions are noted on field log sheets. The NPS data base was scanned to locate the indicated times when the windows of the transmissometer systems were cleaned. The previous three hours and the following three hours of data were extracted for each cleaning. Servicing periods when the measured irradiance was constant before the windows were cleaned and also remained constant (independent of the previous three hours) after cleaning were identified. Three hundred thirty-five (335) servicings were selected that met these requirements. The average change in window transmittance was calculated from the difference between the mean irradiance values before and after servicing from this data set. The mean change was found to be 0.1%. This is misleading due to the fact that the servicing of the windows can have three possible effects:

- No change in window transmittance - the windows were perfectly clean before and after servicing.
- The window transmittance increased - the windows were dirty and servicing cleaned them.
- The window transmittance decreased - the windows were clean and servicing made them dirty.

The first condition leads to no change in window transmittance thus no bias. The second condition would indicate that b_{ext} values measured before the servicing were biased too high. The third condition would result in b_{ext} values measured after window cleaning biased to high. Thus, in practice, unless the window is removed or a window with a higher transmittance is substituted, the bias due to a change in window transmittance is in one direction: increasing the calculated extinction either before or after the servicing. If second and third conditions have about the same magnitude and occur at about the same frequency, a simple comparison of mean radiance differences before and after servicing will come out as a zero percent change. Therefore, a better indication of this bias is a calculation using the absolute value of the difference in mean radiances measured before and after servicing. When this is done, the mean change in window transmittance for the NPS network was 1.5%.

Typical bias estimates in b_{ext} for a 1.5% change in window transmittance at selected monitoring locations are listed in Table 4-2.

Table 4-2

Typical Bias in b_{ext} for
Selected Monitoring Locations

Location	Path (km)	Bias (km^{-1})
Tonto	7.20	0.002
Grand Canyon	5.79	0.003
Acadia	3.67	0.004
Yosemite	2.71	0.006
Shenandoah	0.68	0.022

Air Temperature and Relative Humidity Uncertainty

The uncertainties and limits for meteorological data collected are obtained from the manufacturer's literature. The values used are listed below:

U_{temp} = 1°C

U_{RH} = 2% (Rotronics MP100F Sensor)

Maximum temperature = 60°C

Minimum temperature = -50°C

Maximum relative humidity = 100%

Minimum relative humidity = 0%

4.3.3.2 Identification of Meteorological and Optical Interferences That Affect the Calculation b_{ext} From Transmittance Measurements

The transmissometer directly measures the irradiance of a light source after the light has traveled over a finite atmospheric path. The average extinction coefficient of the sight path is calculated from this measurement and is attributed to the average concentration of atmospheric gases and ambient aerosols along the sight path. The intensity of the light, however, can be modified not only by intervening gases and aerosols, but also by:

- The presence of condensed water vapor in the form of fog, clouds, and precipitation along the sight path
- Condensation, frost, snow, or ice on the shelter windows
- Reduction in light intensity by insects, birds, animals, or vegetation along the sight path, or on the optical surfaces of the instrumentation or shelter windows
- Fluctuations in light intensity both positive and negative due to optical turbulence, beam wander, atmospheric lensing, and miraging caused by variations in the atmospheric optical index of refraction along the sight path

A major effort was undertaken to develop an algorithm to identify transmissometer extinction data that may be affected by the interferences described above. This algorithm contains five major tests:

1) Relative Humidity
2) Maximum Extinction
3) Uncertainty Threshold
4) Rate of Change of Extinction
5) Isolated Data Points

Due to the large volume of extinction data collected by transmissometers as compared to aerosol monitors, the algorithm has been designed to be a conservative filter on the extinction data. That is, if an hourly extinction measurement indicates the slightest possibility of meteorological or optical interference by failing any one of the above tests, it is flagged with identifier codes in the Level-1 data file. The following describes each of the five tests:

Relative Humidity

When the relative humidity measured at the transmissometer receiver is greater than 90%, the corresponding transmissometer measurement is flagged as having a possible interference. The 90% level has been chosen due to the following considerations:

- The relative humidity is only measured at the receiver location and not at any other position along the sight path.
- A 1.5°C change in dew point temperature results in a 10% change in relative humidity.
- The atmosphere is continuously undergoing both systematic and random variations in its spatial and temporal properties.
- The typical precision of relative humidity measurements is ±2%.

The above considerations all indicate that inferring a precise knowledge of the meteorological conditions along a sight path at high relative humidity from a single point measurement is very difficult. When the relative humidity is above 90% at one end of the path, small random temperature or absolute humidity fluctuations along the path can lead to condensation of water vapor causing meteorological interferences. Thus, in accordance with the conservative philosophy expressed above, the 90% relative humidity limit was selected for this test.

Maximum Threshold

For every transmissometer sight path, a maximum b_{ext} can be calculated that corresponds to a 5% transmittance for the path. All sight paths were selected, such that based on historical visibility data, this maximum b_{ext} occurs less than 1% of the time. When the measured b_{ext} is greater than this threshold value, it is assumed that meteorological or optical interferences, not ambient aerosols, are causing the high extinction. All measurements greater than the calculated site-specific maximum threshold are flagged in the data file.

Uncertainty Threshold

The normal operating procedure for the transmissometer is to take ten one-minute measurements of transmitter irradiance each hour, and report the average and standard deviation of the ten values. A mean hourly extinction and associated uncertainty is then calculated as described in Section 4.3 from these measurements. In remote, rural areas, the ambient aerosol concentration typically varies quite slowly with time constants on the order of a few hours rather than minutes. This leads to the expectation of relatively constant extinction during the ten minutes of receiver measurements and a low standard deviation of measured transmitter irradiance. If only one of the ten irradiance values varies more than 20% from the mean, the uncertainty in b_{ext} will increase dramatically. The presence of any meteorological or optical interferences along the sight path will lead to large standard deviations in lamp irradiance, thus large uncertainties in b_{ext}. With the conservative assumption of constant b_{ext} during any ten minute measurement period, any increase in the uncertainty of b_{ext} above a selected threshold flags the measurement as affected by one of these interferences. The uncertainty threshold is determined for each sight path and is included in each Level-1 data file for reference.

Rate Of Change Of Extinction (Delta Threshold)

Transmissometer data collected before September 1, 1990, did not include standard deviation of measured irradiance values. For data collected before this date, another test was developed to identify periods of interferences associated with rapidly fluctuating irradiance measurements. This test consists of comparing the hourly average extinction to the preceding and following hours, and calculating a rate of change in each direction. If the absolute value of this rate of change is greater than some assigned Delta threshold, the hourly b_{ext} value is flagged as being affected by interferences. Delta thresholds have been determined for each sight path by analyzing extinction data collected after September 1990, which have corresponding uncertainty thresholds to determine appropriate Delta thresholds for the sight path. The Delta threshold is typically not as low as the uncertainty threshold, due to the possibility of larger hourly variations in b_{ext} as compared to variations during ten minutes of measurements. Each sight path has its own Delta threshold and it is listed in the Level-1 data file for reference.

Isolated Data Points

This test is performed after the above four thresholds are applied to the hourly extinction data. It is used to identify data points that have passed the above thresholds, but are located between hourly b_{ext} data that have failed the above thresholds. The conservative assumption is, if data before and after the isolated hour indicates interferences, the hour in question probably is also affected by interferences. This data is also flagged as weather-affected.

4.3.4 Supplemental Visibility Indices

4.3.4.1 Standard Visual Range

Standard visual range (SVR) can be interpreted as the farthest distance that a large, black feature can be seen on the horizon. It is a useful visibility index that allows for comparison of data taken at various locations.

$$SVR = \frac{3.912}{(b_{ext} - b_{ray} + 0.01\,km^{-1})} \tag{16}$$

SVR is calculated to normalize all visual ranges to a Rayleigh scattering coefficient of 0.01 km^{-1} or an altitude of 1.524 km (5000 ft.). The Rayleigh scattering coefficient, b_{ray}, for the mean sight path altitude is subtracted from the calculated extinction coefficient, b_{ext}, and the standard Rayleigh scattering coefficient of 0.01 km^{-1} is added back. The value 3.912 is the constant derived from assuming a 2% contrast detection threshold. The theoretical maximum SVR is 391 km.

4.3.4.2 Deciview

An easily understood visibility index has been recently developed to uniformly describe visibility impairment. The scale of this visibility index, expressed in deciview (dv), is linear with respect to perceived visual changes over its entire range, analogous to the decibel scale for sound.

Neither visual range nor extinction coefficient is linear to perceived visual scene changes caused by uniform haze. For example, a 5 km change in visual range or a 0.01 km^{-1} change in extinction coefficient can result in a scene change that is either imperceptible or very obvious, depending on the baseline visibility conditions.

The newly-developed visibility index's dv scale is linear to humanly-perceived changes in visual air quality. A one dv change is about a 10% change in extinction coefficient, which is a small but perceptible scenic change under many circumstances. Since the deciview scale is near zero for a pristine atmosphere (dv=0 for Rayleigh conditions at about 1.8 km elevation) and increases as visibility is degraded, it measures perceived haziness. Expressed in terms of extinction coefficient (b_{ext}) and visual range (vr):

$$haziness(dv) = 10\ln\left(\frac{b_{ext}}{0.01\,km^{-1}}\right) = 10\ln\left(\frac{391\,km}{vr}\right) \qquad (17)$$

The name deciview was chosen because of the similarity of the decibel scale in acoustics. Both use 10 times the logarithm of a ratio of a measured physical quantity to a reference value to create scales that are approximately linear with respect to changes as perceived by human senses.

Ideally, a just noticeable change (JNC) in scene visibility should be approximately a one or two dv change in the deciview scale (i.e., a 10% to 20% fractional change in extinction coefficient) regardless of the baseline visibility level. Similarly, a change of any specific number of dv should appear to have approximately the same magnitude of visual change on any scene.

The dv scale provides a convenient, numerical method for presentation of visibility values. Any visibility monitoring data that are available in visual range or extinction coefficient are easily converted to the new visibility index expressed in deciview.

Use of the dv scale is an appropriate way to compare and combine data from different visibility perception and valuation studies. When results from multiple studies are presented in terms of a common perception index, the effects of survey approach and other factors influential to the results can be evaluated.

4.4 SEASONAL SUMMARY PLOTS

Seasonal summary plots are generated using the WIN_TSUM software. The following procedures describe the operation of the WIN_TSUM software:

EXECUTE WIN_TSUM SOFTWARE	Execute the WIN_TSUM software from the Windows Program Manager. The WIN_TSUM display will appear as shown in Figure 4-8.
EDIT THE SUBMIT FILE	The submit file defines the Level-1 validated data files and associated parameters used to generate the plots. Figure 4-9 details the format of the submit file. The following procedures are used to edit the submit file:

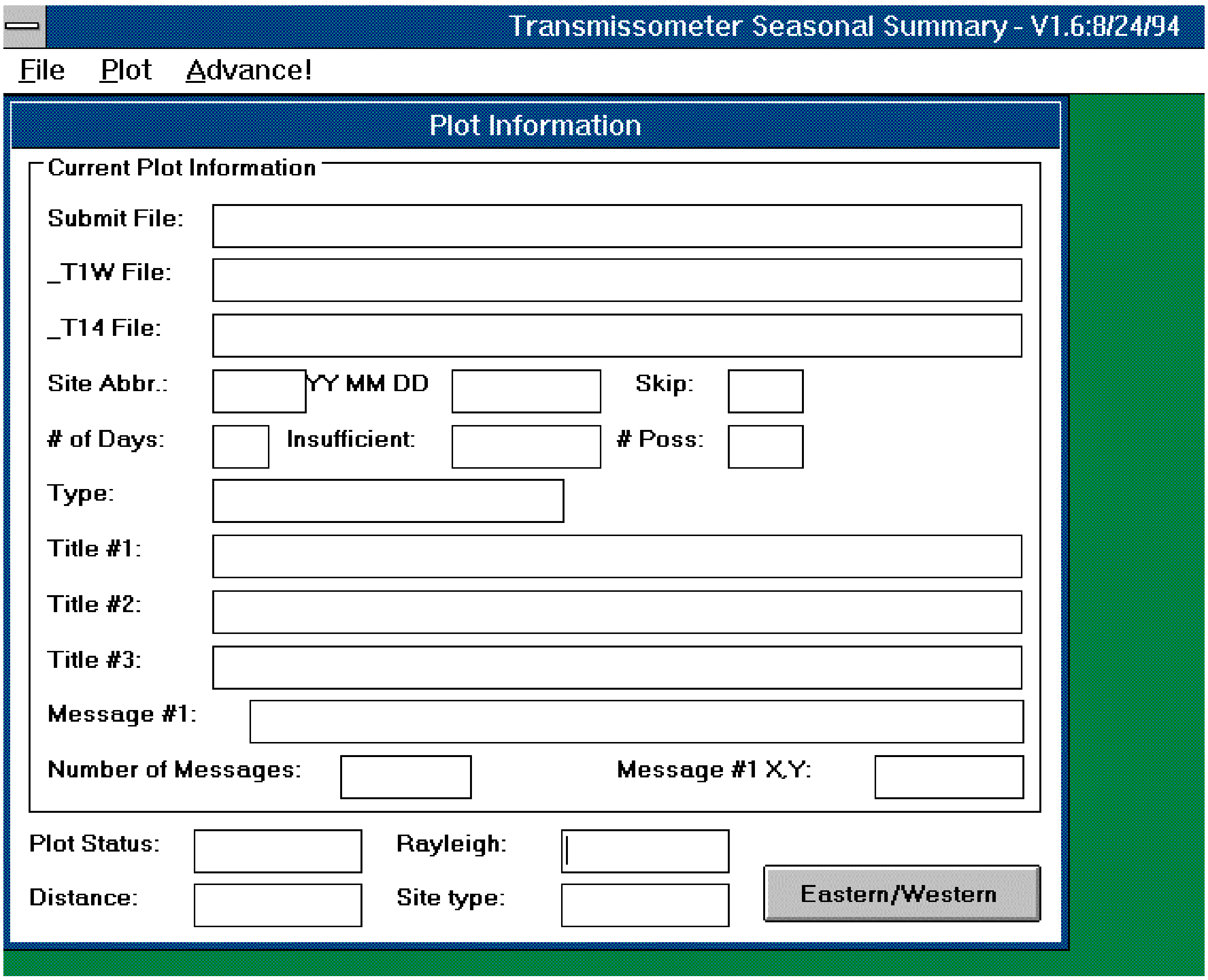

Figure 4-8. WIN_TSUM Software Display.

BADL_T1W.933	Level-1 validated file
BADL_T14.933	Level-1 validated file
BADL	Site code
93,6,1	Year, month, and day of start of plot
92	Number of days to read from file
0	Number possible hours, 0=all
0	Plot type, 0 = final, 2 = preliminary
BADLANDS NATIONAL PARK, SOUTH DAKOTA	Main title
Transmissometer Data Summary	Second title
Summer Season: June 1, 1993 - August 31, 1993	Third title
TIMING	Timeline plot comment
4.50,0.60	Location of comment ("from lower left")
BAND_T1W.933	Next site ...
BAND_T14.933	
BAND	
93,6,1	
92	
0	
0	
BANDELIER NATIONAL MONUMENT, NEW MEXICO	
Transmissometer Data Summary	
Summer Season: June 1, 1993 - August 31, 1993	
-99,-99	

Figure 4-9. Example Submit File for WIN_TSUM Seasonal Summary Plot Software.

- Click on **File**. Click on **Edit Submit File**. The Windows Notepad program will be initiated.

- Open an existing submit file or create a new one in Notepad.

- Save the submit file and exit Notepad.

GENERATE PLOTS

The plots defined in the submit file can be plotted to the screen or to any Windows-compatible printer attached to the system. The following procedures are used to generate the plots:

- Choose the submit file to use by clicking **File** and then choose **Submit File**. Select the submit file to use from the file selection box.

- Generate the plots defined in the submit file by clicking **Plot** and then **Plot All Plots**.

4.4.1 Review of Level-1 Seasonal Summary Plots

Seasonal summary plots of Level-1 validated data are reviewed by the data analysts and project manager to identify the following:

- Data reduction and validation errors
- Instrument operational problems
- Lamp or calibration problems

Problems identified in the Level-1 seasonal summary plot review are resolved by editing the lamp, code, and/or constants files to identify additional valid or invalid data and performing the Level-0 and Level-1 validation procedures again.

When the Level-1 seasonal summary plots have passed the review process, the raw through Level-1 validated data and associated lamp, code, and constants files are archived. (Refer to TI 4600-5010, Transmissometer Data Archiving (IMPROVE Protocol)).

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTICAL MONITORING DATA REPORTING**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4500**
DATE	**OCTOBER 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Gloria S. Mercer	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Revised nephelometer reporting units.	February 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedures (SOP) is a guide to the written reporting of optical visibility monitoring data from sites operating according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

IMPROVE Program goals include timely reporting of collected data in presentation formats that further the understanding of the visual resource and support effective management decisions. The program encompasses:

- Establishing baseline conditions and long-term trends of visual air quality in Class I wilderness areas, and monitoring progress toward the national visibility goals.
- Obtaining high quality visibility data that can be used in planning, permit review, and policy decision processes by using instrumentation capable of measuring quantities that can be directly related to those perceived by the human eye.
- Establishing a database that will assist in the scientific investigation of visibility and validation of computer models designed to predict visibility impairment.
- Determining the existing sources of visibility impairment, detecting new problems and developments early, and determining the sensitivity of individual vistas and Class I areas to varying concentrations of pollutants.

The program has partitioned visibility-related characteristics and measurements into three groups: optical, scene, and aerosol. This SOP pertains to the optical group and encompasses the following:

- Reporting the measurement of basic electro-optical properties of the atmosphere, independent of specific vista characteristics.
- Reporting data in various comprehensive graphics forms.
- Reporting optical extinction measurements made with transmissometers (represented in a variety of units including haziness in dv, extinction in km^{-1}, and standard visual range in km).
- Reporting optical scattering measurements made with nephelometers (represented as scattering in km^{-1}).

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). The following technical instructions (TIs) provide detailed information regarding reporting data collected by optical instruments:

- TI 4500-5000 Nephelometer Data Reporting (IMPROVE Protocol)
- TI 4500-5100 Transmissometer Data Reporting (IMPROVE Protocol)

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements).
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
- Coordinate with the secretary for report preparation.
- Review final reports for completeness and accuracy before distribution.

2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

2.4 SECRETARY

The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.
- Prepare final, approved reports for photocopying and distribution.
- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data for each optical monitoring instrument type (nephelometer or transmissometer) are released in separate data reports. Data reports are prepared in a format that conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the seasonal and/or annual report are defined by the contracting agency COTR. This section includes four (4) subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Other Reporting
4.4 Distribution

4.1 SEASONAL DATA REPORTING

Seasonal reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Optical data are presented in the following formats for each reporting season:

- Overview of monitoring program goals and objectives, and a description of the monitoring networks.
- Comprehensive discussion of data collection, reduction, and processing procedures.
- Brief overview of site configuration(s) and description of instrumentation.
- Map of all site locations and site abbreviations.
- Table of monitoring instrumentation history at each site.
- Table of site specifications and operating period for each site during the reporting season.
- Seasonal data summary plot for each site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.
- Detailed explanation of data presentations included in the summary plots.
- Discussion of events and circumstances influencing data recovery, specific for each site.

- Data recovery and cumulative frequency distribution table, including data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The table includes dv, b_{ext}, and SVR values for transmissometers and b_{scat} (filtered data and unfiltered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.2 ANNUAL DATA REPORTING

Annual reporting is completed within three months after the end of the last season to be reported. Optical data are presented in the following formats for each annual reporting period:

- Overview of monitoring program goals and objectives, and a history of the program.

- Comprehensive discussion of data collection, reduction, and processing procedures.

- Brief overview of site configuration(s) and description of instrumentation.

- Map of all site locations and site abbreviations.

- Table of site specifications and operating period for each site and season during the annual reporting period.

- Seasonal data summary plots for each season and site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.

- Annual data summary plots for each site. The plots contain three data presentations: 1) a bar graph depicting the monthly median air quality values, 2) a monthly cumulative frequency summary table including data recovery statistics. The table displays dv and b_{ext} for transmissometers and b_{scat} (for filtered data and all data) values for nephelometers, and 3) an annual frequency of occurrence graph based on hourly data.

- Detailed explanation of data presentations included in the seasonal and annual data summary plots.

- Data recovery and cumulative frequency distribution tables for each season of the reporting period. The tables include data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The tables include dv, b_{ext}, and SVR values for transmissometers and b_{scat} (unfiltered data and filtered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.3 OTHER REPORTING

Contracting agencies will periodically request additional data reports. Cases or events of special scientific, legal, or political importance to the NPS or other cooperating agencies may occur during the term of the project. New techniques, hardware, software, or other technical advances may also occur that will be applicable to the visibility monitoring program. Additional data reporting or analyses may be required to address these special circumstances and will be executed according to project-specific direction.

4.4 DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DATA REPORTING (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4500-5100**
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AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Gloria S. Mercer	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Define elevation angle in site configuration.	March 1995	
1.0	Changes to reporting presentations.	February 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the procedures and methods for preparing written reports of Optec LPV transmissometer data collected according to IMPROVE Protocol. This TI is referenced from SOP 4500, *Optical Monitoring Data Reporting*, and specifically describes:

- Reporting frequency and contents of seasonal transmissometer reports.
- Reporting contents of annual transmissometer reports.
- Report distribution requirements.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements.
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
- Coordinate with the secretary for report preparation.
- Review final reports for completeness and accuracy before distribution.

2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

2.4 SECRETARY

The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.

- Prepare final, approved reports for photocopying and distribution.
- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). A separate data report is prepared for each instrument type; transmissometer data reports contain only transmissometer data. Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the reports are defined by the contracting agency COTR. This section includes the following three (3) main subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Report Distribution

4.1 SEASONAL DATA REPORTING

Seasonal transmissometer reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Seasonal reports contain the five (5) major sections listed below:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Transmissometer Data Summaries
4.0 References
A.0 Appendix A - Transmissometer Data Collection and Processing Procedures

The information and data presentation formats included in each section of the seasonal report are summarized in the following subsections.

4.1.1 <u>Introduction</u>

The introduction contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks.

4.1.2 Data Collection and Reduction

Data collection and reduction is presented in two subsections, Site Configuration and Data Reduction.

4.1.2.1 Site Configuration

Transmissometer system components and basic system operation are briefly discussed in each seasonal report. Measurement principles and data collection specifications are also described. Detailed descriptions of system components and operation are presented in TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems*.

Figures and tables in this section include:

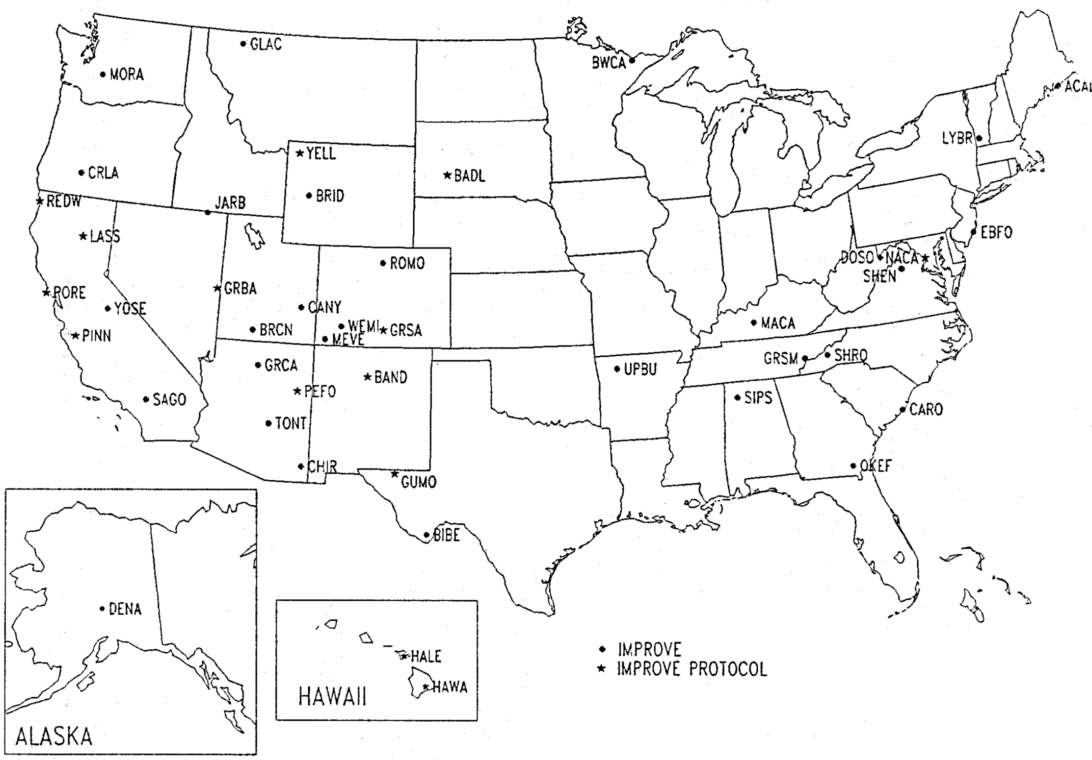
- Map of the United States depicting the location of all IMPROVE and IMPROVE Protocol monitoring network sites. An example map is presented as Figure 4-1.
- Monitoring History Summary Table - The table lists for each monitoring site the name, type of instrumentation, and period of operation for each instrument type (see Table 4-1).
- Site Specifications Summary Table - The table lists for each monitoring site complete site specifications. Site specifications include site name and abbreviation, latitude and longitude of both the receiver and transmitter, elevation of both the receiver and transmitter, the sight path distance between the two components, azimuth, and elevation angle (receiver to transmitter) of the sight path. the table also includes the number of readings taken each day, and the operating period during the season (see Table 4-2).

4.1.2.2 Data Reduction

Each seasonal report contains a brief discussion of data collection, reduction, and processing procedures. The discussion includes daily data review, file format, and monthly and seasonal analytical processing and reduction procedures and assumptions (including discussion of levels of validation, calculation of uncertainties, and identification of meteorological and optical interferences). Reduced data are presented in various units of measurement, including haziness (dv), extinction (b_{ext}), and standard visual range (SVR). More detailed discussions of collection and reduction procedures are presented in an appendix to each report (see Section 4.1.5). Refer to SOP 4300, *Collection of Optical Data (IMPROVE Protocol)*, and TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of procedures.

4.1.3 Transmissometer Data Summaries

Data are presented in various forms in seasonal reports. Each mode of presentation is accompanied by an explanation of the presentation; the following two (2) subsections are included in each seasonal report and detail each data presentation.



IMPROVE SITES

SITE ABRV.	SITE NAME
1. ACAC	ACADIA NP
2. BIBE	BIG BEND NP
3. BWCA	BOUNDARY WATERS CANOE AREA W
4. BRCN	BRYCE CANYON NP
5. BRID	BRIDGER W
6. CANY	CANYONLANDS NP
7. CARO	CAPE ROMAIN NWR
8. CHIR	CHIRICAHUA NM
9. CRLA	CRATER LAKE NP
10. DENA	DENALI NP
11. DOSO	DOLLY SODS W
12. EBFR	EDWIN B FORSYTHE NWR
13. GLAG	GLACIER NP
14. GRCT	GRAND CANYON NP
15. GRSM	GREAT SMOKY MOUNTAINS NP
16. JARB	JARBIDGE W
17. LYBW	LYE BROOK W
18. MACA	MAMMOTH CAVE NP
19. MEVE	MESA VERDE NP
20. MORA	MOUNT RAINIER NP
21. OKEF	OKEFENOKEE NWR
22. ROMM	ROCKY MOUNTAIN NP
23. SAGO	SAN GORGONIO W
24. SHES	SHENANDOAH NP
25. SHRO	SHINING ROCK W
26. SIPS	SIPSEY W
27. TONT	TONTO NM
28. UPBU	UPPER BUFFALO W
29. WEMI	WEMINUCHE W
30. YOSW	YOSEMITE NP

NON-IMPROVE SITES TO BE OPERATED ACCORDING TO IMPROVE PROTOCOL

SITE ABRV.	SITE NAME
1. BADL	BADLANDS NP
2. BAND	BANDELIER NM
3. GRBA	GREAT BASIN NP
4. GRSA	GREAT SAND DUNES NM
5. GUMO	GUADALUPE MOUNTAINS NP
6. HALE	HALEAKALA NP
7. HAWA	HAWAII VOLCANOES NP
8. LASS	LASSEN VOLCANIC NP
9. NACA	NATIONAL CAPITAL-CENTRAL
10. PEFO	PETRIFIED FOREST NP
11. PINN	PINNACLES NM
12. PORE	POINT REYES NS
13. REDW	REDWOOD NP
14. YELL	YELLOWSTONE NP

SITE NAME KEY

NP	National Park	NWR	National Wildlife Refuge
NM	National Monument	W	Wilderness
NS	National Seashore		

Figure 4-1. Example Visibility Network Location Map.

Table 4-1

Example Monitoring History Summary Table

NETWORK	SITE NAME	TELERADIOMETER				CAMERA				TRANSMISSOMETER		NEPHELOMETER	
		MANUAL		AUTO		MANUAL		AUTO					
		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
IMPROVE	Acadia NP			10/79	02/86	01/80	10/84	04/85		11/87	06/93	06/93	
IMP Pro.	Badlands NP							08/87		01/88			
IMP Pro.	Bandelier NM	07/78	09/84			06/79	02/85	07/87		10/88			
IMPROVE	Big Bend NP	08/78	02/86			09/81	06/86	06/86		12/88			
IMPROVE	Boundary Waters Canoe Area W							10/85				05/93	
IMPROVE	Bridger W							09/86		07/88			
IMPROVE	Bryce Canyon NP	06/78	11/83	12/83	02/86	01/79	11/83	04/84					
IMPROVE	Canyonlands NP	09/78	02/86			07/82	01/87	01/87		12/86			
IMPROVE	Cape Romain NWR												
IMPROVE	Chiricahua NM	06/81	02/86			06/81	06/86	06/86		02/89			
IMPROVE	Crater Lake NP	07/82	09/82			08/82	09/82	06/85		09/88	09/91		
IMPROVE	Denali NP							06/88					
IMPROVE	Dolly Sods W							09/85				05/93	
IMPROVE	Edwin B. Forsythe NWR							05/92				04/93	04/94
IMPROVE	Glacier NP	06/83	05/85	06/85	11/85	07/82	06/85	06/85		02/88			
IMPROVE	Grand Canyon NP (South Rim)	07/78	10/83	12/83	02/86	10/79	11/83	11/83		12/86			
IMPROVE	Grand Canyon NP (In-Canyon)									12/89			
IMP Pro.	Great Basin NP	06/82	02/86			06/82	06/86	06/86		08/92			
IMP Pro.	Great Sand Dunes NM							07/87					
IMPROVE	Great Smoky Mountains NP			12/83	02/85			01/84				03/90	
IMP Pro.	Guadalupe Mountains NP			02/82	02/86	06/83	05/84	06/84		11/88			
IMP Pro.	Haleakala NM							07/87					
IMP Pro.	Hawaii Volcanoes NP							10/86					
IMPROVE	Jarbidge W							09/86				04/93	
IMP Pro.	Lassen Volcanic NP	07/82	11/83			08/82	10/83	06/87					
IMPROVE	Lye Brook W							05/87				08/93	04/94
IMPROVE	Mammoth Cave NP							03/92				03/93	
IMPROVE	Mesa Verde NP	07/78	02/86			09/79	06/86	06/86		09/88	06/93		
IMPROVE	Mount Rainier NP							06/85				06/90	
IMP Pro.	National Capital-Central							12/88					
IMPROVE	Okefenokee NWR							04/92	11/92			02/93	
IMP Pro.	Petrified Forest NP							07/86		04/87			
IMP Pro.	Pinnacles NM							08/86		03/88	06/93		
IMP Pro.	Point Reyes NS							06/87					
IMP Pro.	Redwood NP							06/87					
IMPROVE	Rocky Mountain NP	06/80	05/85			07/85	09/85	07/85		11/87			
IMPROVE	San Gorgonio W							08/86		04/88			
IMPROVE	Shenandoah NP	05/80	10/85			05/80	10/86	10/86		12/88			
IMPROVE	Shining Rock W												
IMPROVE	Sipsey W							11/88					
IMPROVE	Tonto NM							04/89		04/89	09/91		
IMPROVE	Upper Buffalo W							11/88				02/93	
IMPROVE	Weminuche W							08/86	08/93				
IMP Pro.	Yellowstone NP	06/81	06/82			09/81	06/82	09/86		07/89	06/93		
IMPROVE	Yosemite NP	09/82	07/83	01/84	10/85	09/82	09/83	09/84		08/88			

NETWORK KEY

IMPROVE - IMPROVE site
IMP Pro. - Non-IMPROVE site to be operated according to IMPROVE Protocol

SITE NAME KEY

NP - National Park
NM - National Monument
NS - National Seashore
NWR - National Wildlife Refuge
W - Wilderness

Table 4-2

Example Transmissometer Site Specifications Summary Table

SITE NAME	SITE ABRV	RECEIVER LOCATION			SIGHT PATH					OBS. PER DAY	OPERATING PERIOD DURING SUMMER 1993
		LAT (°N)	LONG (°W)	ELEV (M)	TRANSMITTER LOCATION	ELEV (M)	DIST (KM)	AZIM (°)	ELEV ANGLE (°)		
ACADIA NP	ACAD	44°22'29"	68°15'35"	134	44°21'05" 68°13'40"	466	3.67	134	5.19	24	03/01/93 - 05/31/93
BADLANDS NP	BADL	43°47'15"	101°54'12"	806	43°46'05" 101°56'50"	805	4.15	239	-0.01	24	03/01/93 - 05/31/93
BANDELIER NM	BAND	35°47'05"	106°15'39"	2011	35°48'47" 106°17'51"	2143	4.58	315	1.65	24	03/01/93 - 05/31/93
BIG BEND NP	BIBE	29°20'38"	103°12'24"	1082	29°23'12" 103°12'45"	1033	4.74	353	-0.59	24	05/11/93 - 05/31/93
BRIDGER W	BRID	42°55'41"	109°47'15"	2390	42°58'21" 109°46'13"	2568	5.08	11	2.01	24	03/01/93 - 05/31/93
CANYONLANDS NP	CANY	38°27'50"	109°49'18"	1806	38°28'35" 109°44'58"	1774	6.43	73	-0.29	24	03/01/93 - 05/31/93
CHIRICAHUA NM	CHIR	32°00'35"	109°23'18"	1567	32°00'52" 109°19'27"	2235	6.12	84	6.20	24	03/01/93 - 05/31/93
GLACIER NP	GLAC	48°33'29"	113°56'15"	968	48°31'45" 113°59'37"	975	5.27	232	0.08	24	------
GRAND CANYON NP (SOUTH RIM)	GRCA	35°59'47"	111°59'30"	2256	36°00'30" 111°55'55"	2170	5.79	81	-0.85	24	03/01/93 - 05/31/93
GRAND CANYON NP (IN-CANYON)	GRCW	36°03'59"	112°07'00"	2145	36°06'23" 112°05'35"	755	5.11	25	-15.78	24	03/01/93 - 05/31/93
GREAT BASIN NP	GRBA	38°59'30"	114°12'40"	2130	39°01'13" 114°14'30"	2365	3.91	315	3.44	24	05/22/93 - 05/31/93
GUADALUPE MOUNTAINS NP	GUMO	31°49'56"	104°48'34"	1616	31°49'04" 104°51'23"	1317	4.86	249	-3.53	24	05/14/93 - 05/31/93
MESA VERDE NP	MEVE	37°13'07"	108°29'36"	2245	37°15'27" 108°29'49"	2450	4.29	355	2.74	24	03/01/93 - 05/31/93
PETRIFIED FOREST NP	PEFO	34°53'54"	109°47'45"	1690	34°56'01" 109°44'55"	1710	5.94	47	0.19	24	03/01/93 - 05/31/93
PINNACLES NM	PINN	36°28'22"	121°08'47"	448	36°30'14" 121°10'59"	428	4.80	317	-0.24	24	03/01/93 - 05/31/93
ROCKY MOUNTAIN NP	ROMO	40°21'38"	105°34'50"	2536	40°23'12" 105°37'50"	2932	5.27	305	4.31	24	03/01/93 - 05/31/93
SAN GORGONIO W	SAGO	34°11'36"	116°54'48"	1710	34°09'45" 116°56'07"	1731	4.10	211	0.29	24	03/01/93 - 05/31/93
SHENANDOAH NP	SHEN	38°30'49"	78°25'55"	1079	38°31'03" 78°26'13"	1077	1.64	317	-0.16	24	03/01/93 - 05/31/93
TONTO NM	TONT	33°37'15"	111°02'10"	738	33°38'56" 111°06'26"	786	7.20	115	0.38	24	03/01/93 - 05/31/93
YELLOWSTONE NP	YELL	44°58'08"	110°41'29"	1836	44°56'45" 110°38'48"	1951	4.28	125	1.54	24	03/01/93 - 05/31/93
YOSEMITE NP	YOSE	37°42'47"	119°42'14"	1608	37°42'06" 119°43'47"	1370	2.71	242	-5.04	24	03/01/93 - 05/31/93

SITE NAME KEY

NP National Park
NM National Monument
W Wilderness

4.1.3.1 Data Summary Description

A Seasonal Transmissometer Data Summary plot is prepared for each site that operated during the reporting season. An example Seasonal Transmissometer Data Summary is presented as Figure 4-2. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Transmissometer Data Summaries include the following five data presentations:

- **4-Hour Average Variation in Visual Air Quality (Excluding Weather-Affected Data)** - Plot of four-hour averaged b_{ext}, SVR, and dv geometric mean values (without weather-influenced observations) for each day of the reporting season. A mean value is calculated for each four-hour period from the valid transmissions for that day. Gaps in the plot indicate that data were missing, weather-influenced, or failed edit procedures. For example, values are not calculated if the transmissometer was mis-aligned. The left axis of the graph is labeled as haziness (dv) and the right axis as b_{ext} and SVR. Note that SVR and b_{ext} are inversely related. For example, as the visual air quality improves, SVR values increase and b_{ext} values decrease. A Rayleigh atmosphere is defined by an SVR of 391 km and a b_{ext} of approximately 0.01 km^{-1}. A dirty atmosphere is represented by low SVR values and high b_{ext} values. The haziness scale is linear to changes in perceived air quality. A one dv change is about a 10% change in b_{ext}, and increases as the air becomes dirtier.

- **Relative Humidity** - Timeline of four-hour averaged relative humidity measurements. This allows rapid determination of the effect of increasing relative humidity on measured b_{ext} and SVR. Long periods of relative humidity near 100% usually result in corresponding periods of high b_{ext} (low SVR), and are likely associated with precipitation events. This assumption can only be verified by reviewing simultaneous photographic data.

- **Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{ext}, SVR, and haziness values, both with and without weather-influenced data. The 10% to 90% values are plotted in 10% increments. The 10%, 50%, and 90% cumulative frequency values for b_{ext} are listed to the right of the plot and haziness to the left of the plot. SVR values are listed in the corresponding cumulative frequency summary table. Note that SVR and b_{ext} are inversely related; for example, as the air becomes cleaner, b_{ext} values decrease and SVR values increase.

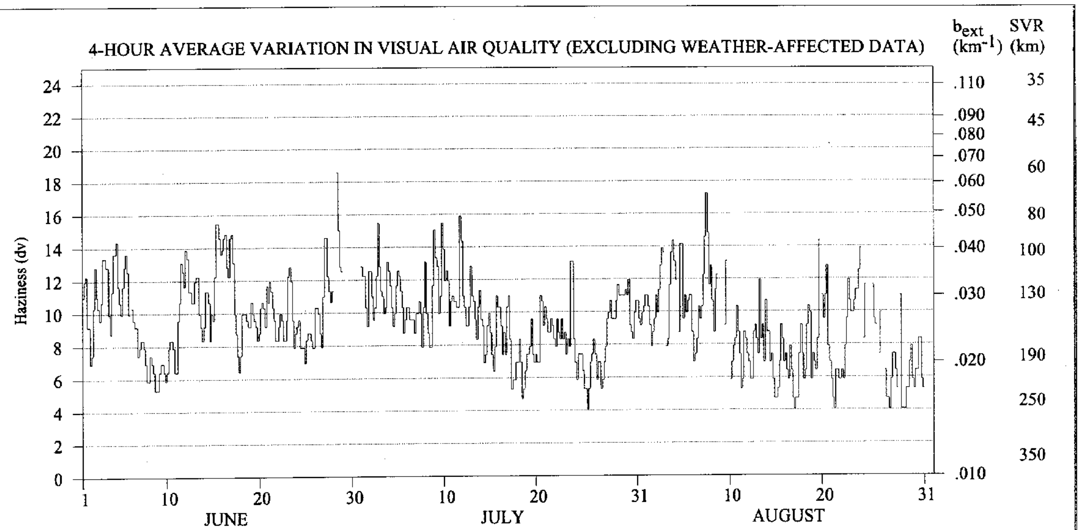
  For b_{ext}, the 10%, 50%, and 90% values can be interpreted as:

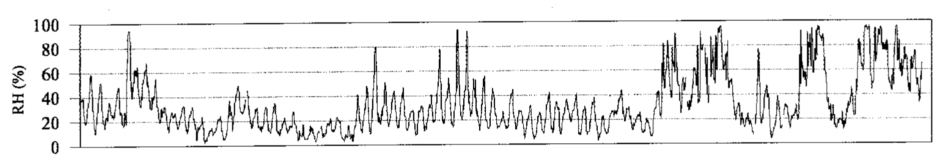
Value	Interpretation
10%	10% of the time the b_{ext} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{ext} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{ext} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

GRAND CANYON NATIONAL PARK (SOUTH RIM), ARIZONA

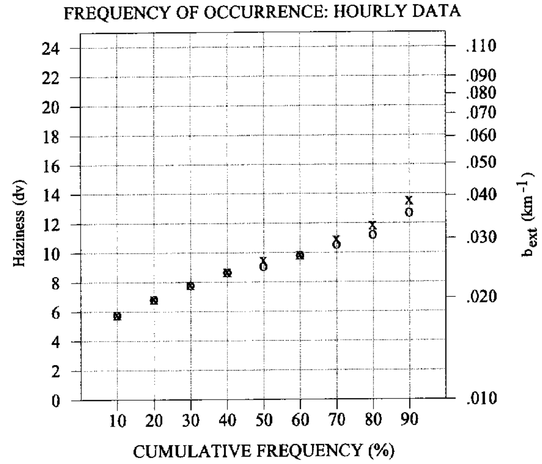
Transmissometer Data Summary

Summer Season: June 1, 1993 - August 31, 1993





FREQUENCY OF OCCURRENCE: HOURLY DATA



CUMULATIVE FREQUENCY SUMMARY

	Excluding Weather [o]			Including Weather [x]		
%	dv	b_{ext}	SVR	dv	b_{ext}	SVR
10	5.9	.018	210	5.9	.018	210
20	6.9	.020	189	6.9	.020	189
30	7.9	.022	173	7.9	.022	173
40	8.8	.024	159	8.8	.024	159
50	9.2	.025	153	9.6	.026	147
60	9.9	.027	141	9.9	.027	141
70	10.6	.029	132	11.0	.030	128
80	11.3	.031	124	11.9	.033	116
90	12.8	.036	107	13.6	.039	99

VISIBILITY METRIC (EXCLUDING WEATHER)

	dv	b_{ext}	SVR
Mean of cleanest 20%	5.8	.018	213
Mean of all data	9.3	.026	155
Mean of dirtiest 20%	13.1	.037	105

TRANSMISSOMETER DATA RECOVERY	NUM	%
Total Possible Hourly Averages In The Time Period	2208	100
Valid Hourly Averages Including Weather-Affected Data	2137	97
Valid Hourly Averages Excluding Weather-Affected Data	1962	89
Percent Of All Valid Hourly Averages Not Affected By Weather		92

L:01/25/96 T:01/23/96 W:08/22/94 1:37 p P:02/06/96 V1.8:5/4/95

Figure 4-2. Example Seasonal Transmissometer Data Summary.

For SVR, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the SVR was greater than or equal to the 10% value;
50%	Median value; 50% of the SVR observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the SVR was greater than or equal to the 90% value (10% of the time it was less than or equal to the 90% value).

For deciview, the 10%, 50%, and 90% values are linear with respect to b_{ext} changes. A one dv change is approximately a 10% change in b_{ext}. Clean days are characterized by low haziness values (small dv) and dirty days are characterized by high haziness values (large dv).

- **Visibility Metric (Excluding Weather)** - This table presents mean values excluding weather for dv, b_{ext}, and SVR. The best, worst, and average conditions using the arithmetic means of the 20th percentile least impaired visibility, the 20th percentile most impaired visibility, and for all data for the season are presented.

- **Data Recovery Statistics**

  Total Possible Hourly Averages in the Time Period - The total possible category is calculated by subtracting the number of hourly averages included in periods when the instrument was removed due to conditions unrelated to system performance (construction, site relocation, etc.) from the theoretical maximum number of hourly average periods possible during a season.

  Valid Hourly Averages Including Weather-Affected Data - The number of all valid hourly averages collected during a season. The percentage represents the number of valid hourly averages compared to the total possible hourly averages.

  Valid Hourly Averages Excluding Weather-Affected Data - The number of valid hourly averages (excluding any data affected by weather) collected during a season. The percentage represents the number of valid hourly averages compared to the total possible hourly averages.

  Percent of All Valid Hourly Averages Not Affected by Weather - This percentage collection efficiency represents the number of valid hourly averages (excluding any data affected by weather) compared to the number of all valid hourly averages.

4.1.3.2 Events and Circumstances Influencing Data Recovery

Each seasonal report contains a brief discussion of events and circumstances that influence data recovery. Operational status throughout the reporting period is presented for each site in an operation summary table. The table lists for each site, site name and abbreviation, the actual time period during the season that each site collected data, data collection losses or problem description, and problem resolutions. An example Operation Summary Table is presented as Table 4-3. An analysis summary table is also prepared (for all data and for all data excluding weather events) based on actual monitoring periods. The table lists for each site, site name and abbreviation, the number of seasonal hourly averages possible, the number and percentage of hourly averages usable, and the cumulative frequency distribution (10%, 50%, and 90% dv, b_{ext}, and SVR values). An example Analysis Summary Table is presented as Table 4-4.

4.1.4 <u>References</u>

References are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the seasonal report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by Air Resource Specialists, Inc. (ARS).

4.1.5 <u>Appendix A - Transmissometer Data Collection and Processing Procedures</u>

Each seasonal report contains an appendix that fully details transmissometer data collection and processing procedures. The following subsections, which are presented in the appendix, discuss these procedures.

4.1.5.1 On-Site Data Logging and Transmission

Transmissometer data transmittal from the site to ARS facilities is discussed. The data are transferred through data collection platforms (DCPs) to the GOES satellite, to ARS via telephone modem. A description of data collection procedures is included in SOP 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*.

4.1.5.2 Daily Data Collection and Review

Detailed data collection and daily review procedures performed at ARS facilities are described. This discussion includes the steps involved in reviewing data files for extraneous information, searching for problems that require corrective action, verifying the date and time of the transmitted data, and applying preliminary validity codes. Refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of data reduction procedures.

4.1.5.3 Monthly and Seasonal Data Processing Procedures

Detailed discussions of the various processing and validation levels performed during each season are presented. Figure 4-3 presents the transmissometer data processing flow chart. Discussion includes file formats, validity codes applied during the various stages of processing (validation levels), theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{ext} from transmittance measurements.

Table 4-3

Operational Summary Table

SITE NAME	SITE ABBRV	DATA COLLECTION PERIOD	DATA COLLECTION LOSSES/ PROBLEM DESCRIPTION	PROBLEM RESOLUTIONS/COMMENTS
BADLANDS NATIONAL PARK	BADL	06/01/93 - 08/31/93	Timing malfunction at transmitter 8/20-8/24	Power surge; site operator reset timing.
BANDELIER NATIONAL MONUMENT	BAND	06/01/93 - 08/31/93		
BIG BEND NATIONAL PARK	BIBE	06/01/93 - 08/31/93		
BRIDGER WILDERNESS	BRID	06/01/93 - 08/31/93		
CANYONLANDS NATIONAL PARK	CANY	06/01/93 - 08/31/93		
CHIRICAHUA NATIONAL MONUMENT	CHIR	06/01/93 - 08/31/93		
GLACIER NATIONAL PARK	GLAC	06/01/93 - 08/31/93		
GRAND CANYON NATIONAL PARK	GRCA	06/01/93 - 08/31/93		
	GRCW	06/01/93 - 08/31/93	Alignment and power problems at transmitter 8/8-8/22	Site operator corrected alignment, replaced fuse and batteries in transmitter control box, and reset system timing.
GREAT BASIN NATIONAL PARK	GRBA	06/01/93 - 08/31/93	Lamp malfunction 7/19-7/30	Site operator replaced lamp.
GUADALUPE MOUNTAINS NATIONAL PARK	GUMO	06/01/93 - 08/31/93	Transmitter power problem 7/1-7/20	Transmitter turned off to recharge batteries.
PETRIFIED FOREST NATIONAL PARK	PEFO	06/01/93 - 08/31/93	DCP solar panel cable severed; power loss 6/1-6/11	ARS personnel visited site to repair cables and replace DCP.
ROCKY MOUNTAIN NATIONAL PARK	ROMO	06/01/93 - 08/31/93	Transmitter chopper motor malfunction 7/12-7/21 Receiver timing malfunction 8/19-8/24	Transmitter removed for repair. Site operator reset receiver computer and timing.
SAN GORGONIO WILDERNESS	SAGO	06/01/93 - 08/31/93		
SHENANDOAH NATIONAL PARK	SHEN	06/01/93 - 08/31/93		
YOSEMITE NATIONAL PARK	YOSE	06/01/93 - 08/31/93	Tree branches obscuring transmitter beam 6/8-6/30	ARS personnel visited site and pruned branches.

Table 4-4

Example Analysis Summary Table
Data Recovery and Cumulative Frequency Distribution

ALL DATA

SITE NAME	SITE ABBRV	DATA RECOVERY		CUMULATIVE FREQUENCY DISTRIBUTION								
		HOURLY AVERAGES POSSIBLE	HOURLY AVERAGES USABLE	Haziness (dv)			b_{ext} (km^{-1})			SVR (km)		
				10%	50%	90%	10%	50%	90%	10%	50%	90%
BADLANDS NATIONAL PARK	BADL	2208	2075 (94%)	6.4	12.2	23.0	.019	.034	.100	213	117	39
BANDELIER NATIONAL MONUMENT	BAND	2208	2173 (98%)	8.3	10.6	15.3	.023	.029	.046	166	133	84
BIG BEND NATIONAL PARK	BIBE	2208	2114 (96%)	9.6	14.8	20.3	.026	.044	.076	153	90	52
BRIDGER WILDERNESS	BRID	2208	1991 (90%)	7.9	10.6	13.9	.022	.029	.040	171	131	96
CANYONLANDS NATIONAL PARK	CANY	2208	2112 (96%)	9.9	12.2	14.6	.027	.034	.043	144	114	90
CHIRICAHUA NATIONAL MONUMENT	CHIR	2208	2191 (99%)	8.3	12.5	21.7	.023	.035	.088	167	111	44
GLACIER NATIONAL PARK	GLAC	2208	2155 (98%)	9.9	14.8	23.8	.027	.044	.108	148	90	36
GRAND CANYON (SOUTH RIM) NATIONAL PARK	GRCA	2208	2137 (97%)	5.9	9.6	13.6	.018	.026	.039	210	147	99
GRAND CANYON (IN-CANYON) NATIONAL PARK	GRCW	2208	2154 (98%)	11.6	13.4	17.7	.032	.038	.059	122	103	66
GREAT BASIN NATIONAL PARK	GRBA	2208	1938 (88%)	8.3	10.3	13.6	.023	.028	.039	165	137	99
GUADALUPE MOUNTAINS NATIONAL PARK	GUMO	2208	1906 (86%)	8.3	11.9	18.1	.023	.033	.061	170	119	64
PETRIFIED FOREST NATIONAL PARK	PEFO	2208	1895 (86%)	8.8	11.6	15.9	.024	.032	.049	162	121	80
ROCKY MOUNTAIN NATIONAL PARK	ROMO	2208	2060 (93%)	7.9	11.0	43.1	.022	.030	.741	169	126	5
SAN GORGONIO WILDERNESS	SAGO	2208	2199 (100%)	11.9	19.6	34.1	.033	.071	.303	118	55	13
SHENANDOAH NATIONAL PARK	SHEN	2208	2201 (100%)	22.0	33.6	55.9	.090	.287	2.68	44	14	1
YOSEMITE NATIONAL PARK	YOSE	2208	1472 (67%)	9.2	13.6	16.9	.025	.039	.054	157	100	72

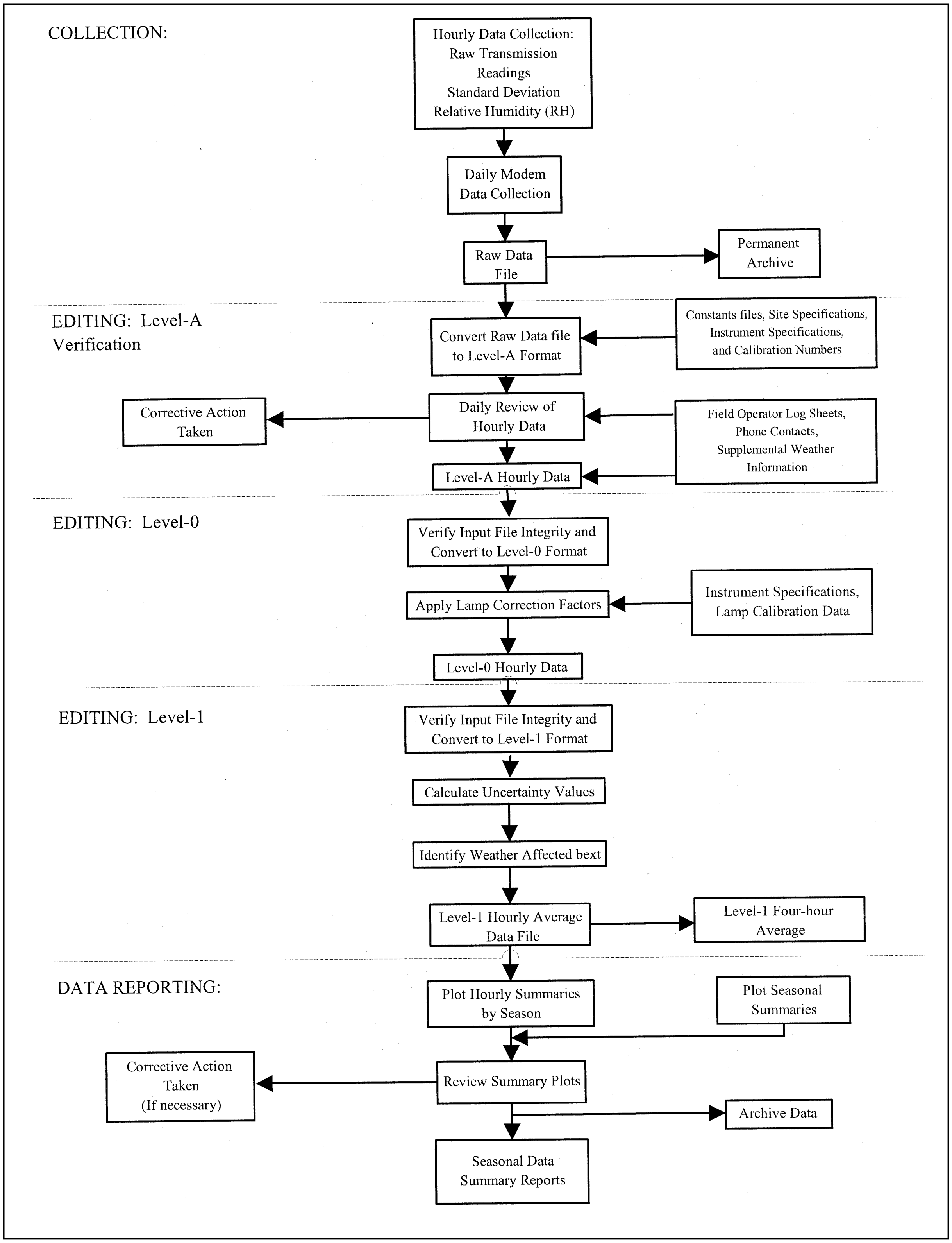


Figure 4-3. Transmissometer Data Processing Flow Chart.

4.1.5.4 Supplemental Visibility Indices

A final discussion regarding transmissometer data processing contains a definition of supplemental visibility indices (standard visual range and deciview).

4.2 ANNUAL DATA REPORTING

Annual reports contain seven (7) major sections:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Site Configuration
4.0 Data Summary Description
5.0 Transmissometer Data Summaries
6.0 Summary
7.0 References

The information and data presentation formats included in each section are summarized in the following subsections.

4.2.1 Introduction

The introduction section contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks. It also includes a map of the United States, depicting locations of all transmissometer monitoring sites (see Figure 4-1).

4.2.2 Data Collection and Reduction Procedures

Each annual report contains detailed transmissometer data collection and processing procedures, identical to the appendix included in seasonal reports (refer to Section 4.1.5). Discussion includes data collection methods, data file review, data validation, application of validity codes, processing through various validation levels, and discussion of file formats, theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{ext} from transmissometer measurements.

4.2.3 Site Configuration

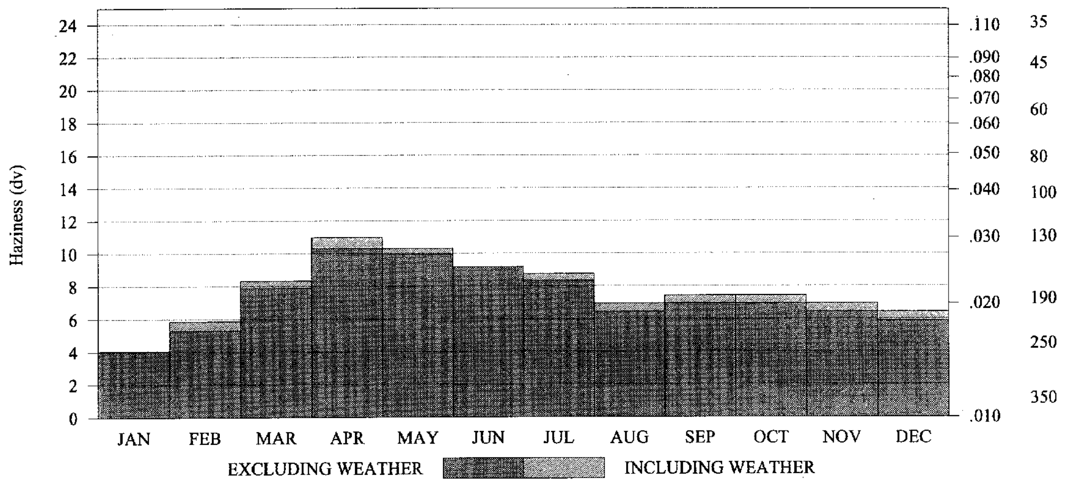
The site configuration section contains a brief discussion of instrumentation at each transmissometer site and basic principles of operation. A site specifications summary table is presented (see Table 4-2).

4.2.4 Data Summary Description

Each annual report contains a data summary description section describing seasonal and annual data summaries. Refer to Section 4.1.3 for a detailed discussion of seasonal summaries. Annual data summaries are prepared for each site that operated during the reporting period, and are based on a calendar year instead of season. An example Annual Transmissometer Data Summary is presented as Figure 4-4. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Annual Transmissometer Data Summaries include three data presentations:

GRAND CANYON NATIONAL PARK (SOUTH RIM), ARIZONA
Annual Transmissometer Data Summary
All Data: January 1, 1994 - December 31, 1994

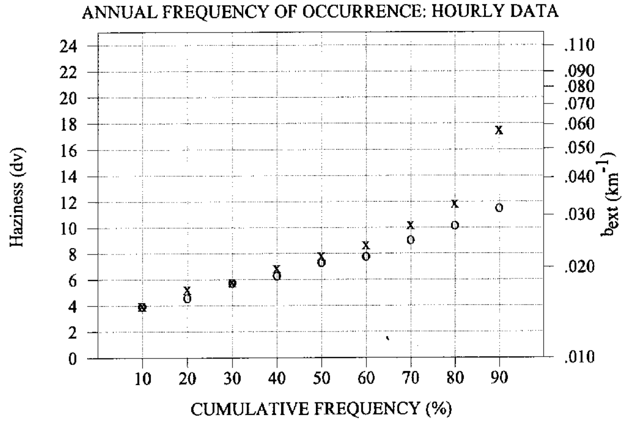
MONTHLY MEDIAN VISUAL AIR QUALITY



MONTHLY CUMULATIVE FREQUENCY SUMMARIES

		EXCLUDING WEATHER						INCLUDING WEATHER						DATA RECOVERY STATISTICS						
		10%		50%		90%		10%		50%		90%		POSS.	COLLECTED		VALID:IN. WX.		VALID:EX. WX.	
MONTH	YEAR	bext	dv	bext	dv	bext	dv	bext	dv	bext	dv	bext	dv	NUM	NUM	%	NUM	%	NUM	%
JAN	1994	0.012	1.8	0.015	4.1	0.022	7.9	0.012	1.8	0.015	4.1	0.044	14.8	744	744	100	743	100	637	86
FEB	1994	0.014	3.4	0.017	5.3	0.021	7.4	0.014	3.4	0.018	5.9	0.675	42.1	672	657	98	657	98	446	66
MAR	1994	0.018	5.9	0.022	7.9	0.030	11.0	0.018	5.9	0.023	8.3	0.082	21.0	744	735	99	735	99	603	81
APR	1994	0.018	5.9	0.028	10.3	0.040	13.9	0.018	5.9	0.030	11.0	0.246	32.0	720	717	100	717	100	554	77
MAY	1994	0.022	7.9	0.027	9.9	0.036	12.8	0.022	7.9	0.028	10.3	0.038	13.4	744	744	100	744	100	680	91
JUN	1994	0.018	5.9	0.025	9.2	0.036	12.8	0.018	5.9	0.025	9.2	0.036	12.8	720	714	99	555	77	534	74
JUL	1994	0.014	3.4	0.023	8.3	0.033	11.9	0.014	3.4	0.024	8.8	0.043	14.6	744	742	100	499	67	426	57
AUG	1994	0.015	4.1	0.019	6.4	0.028	10.3	0.015	4.1	0.020	6.9	0.031	11.3	744	744	100	536	72	460	62
SEP	1994	0.015	4.1	0.020	6.9	0.027	9.9	0.015	4.1	0.021	7.4	0.039	13.6	720	709	98	679	94	545	76
OCT	1994	0.016	4.7	0.020	6.9	0.031	11.3	0.016	4.7	0.021	7.4	0.037	13.1	744	727	98	722	97	629	85
NOV	1994	0.014	3.4	0.019	6.4	0.027	9.9	0.015	4.1	0.020	6.9	0.107	23.7	720	714	99	714	99	566	79
DEC	1994	0.015	4.1	0.018	5.9	0.026	9.6	0.015	4.1	0.019	6.4	0.675	42.1	744	744	100	744	100	531	71
ALL DATA		0.015	4.1	0.021	7.4	0.032	11.6	0.015	4.1	0.022	7.9	0.058	17.6	8760	8691	99	8045	92	6611	75

ANNUAL FREQUENCY OF OCCURRENCE: HOURLY DATA



ANNUAL CUMULATIVE FREQUENCY SUMMARY

%	Excluding Weather [o] dv	b_{ext}	SVR	Including Weather [x] dv	b_{ext}	SVR
10	4.1	.015	250	4.1	.015	250
20	4.7	.016	235	5.3	.017	222
30	5.9	.018	210	5.9	.018	210
40	6.4	.019	199	6.9	.020	189
50	7.4	.021	181	7.9	.022	173
60	7.9	.022	173	8.8	.024	159
70	9.2	.025	153	10.3	.028	137
80	10.3	.028	137	11.9	.033	116
90	11.6	.032	120	17.6	.058	67

FOR A GIVEN % OF THE TIME THE HAZINESS IS LESS THAN OR EQUAL TO THE CORRESPONDING dv VALUE.

D:10/03/95 2:52 p P:02/20/96

V1.03:09/06/94

Figure 4-4. Example Annual Transmissometer Data Summary.

- **Monthly Median Visual Air Quality** - Plot of median monthly b_{ext}, SVR, and dv values both with and without weather-affected data. The left axis of the graph is labeled as haziness (dv) and the right axis as b_{ext} and SVR. Note that SVR and b_{ext} are inversely related. For example, as the visual air quality improves, SVR values increase and b_{ext} values decrease. A Rayleigh atmosphere is defined by an SVR of 391 km and a b_{ext} of approximately 0.01 km^{-1}. A dirty atmosphere is represented by low SVR values and high b_{ext} values. The haziness scale is linear to changes in perceived air quality. A one dv change is about a 10% change in b_{ext}, and increases as the air becomes dirtier.

- **Monthly Cumulative Frequency Summaries, All Data** - Table of cumulative frequency distribution average b_{ext} and dv values both with and without weather-influenced data. The 10% to 90% values are presented in 10% increments. Also included are data recovery statistics (total possible readings, number of collected readings, and number of valid (both with and without weather-affected data).

- **Annual Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{ext}, SVR, and haziness values, both with and without weather-influenced data. The 10% to 90% values are plotted in 10% increments. The 10%, 50%, and 90% cumulative frequency values for b_{ext} are listed to the right of the plot and haziness to the left of the plot. SVR values are listed in the corresponding cumulative frequency summary table. Note that SVR and b_{ext} are inversely related; for example, as the air becomes cleaner, b_{ext} values decrease and SVR values increase.

  For b_{ext}, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the b_{ext} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{ext} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{ext} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

  For SVR, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the SVR was greater than or equal to the 10% value;
50%	Median value; 50% of the SVR observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the SVR was greater than or equal to the 90% value (10% of the time it was less than or equal to the 90% value).

For deciview, the 10%, 50%, and 90% values are linear with respect to b_{ext} changes. A one dv change is approximately a 10% change in b_{ext}. Clean days are characterized by low haziness values (small dv) and dirty days are characterized by high haziness values (large dv).

4.2.5 Transmissometer Data Summaries

The data summary section presents first the seasonal summary plots, then the annual summary plots. Data recovery and cumulative frequency distribution tables follow, containing a summary of values for each season (see Table 4-4).

4.2.6 Summary

The summary section provides a synopsis of the transmissometer network, including changes in operational techniques, and a general conclusion of the monitoring year in review.

4.2.7 References

Identical to the seasonal reports, references are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the annual report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by ARS.

4.3 REPORT DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report; for example, 15 seasonal reports and 5 annual reports are delivered to the NPS.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTICAL MONITORING DATA ARCHIVES**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4600**
DATE	**SEPTEMBER 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Betsy Davis-Noland	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor text changes	December 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) is a guide to the archiving and maintenance of optical visibility monitoring data. The purpose of this SOP is to assure that the following data and information are secure and available:

- Nephelometer data
- Transmissometer data
- Associated meteorological data
- Supporting documentation

These archives are a historical record of both raw and processed data files and provide information that supports the documentation of existing conditions and trends in monitored areas. Duplicate archive tapes of digital data are stored off-site to prevent data loss.

The following technical instructions (TIs) provide detailed information regarding specific archive procedures:

- TI 4600-5000 *Nephelometer Data Archives (IMPROVE Protocol)*
- TI 4600-5010 *Transmissometer Data Archives (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that archives are accessible, orderly, complete, and current.
- Inform the data archivist when data have been finalized and reported and are ready to be archived.
- Ensure that duplicate archives are properly stored off-site.

2.2 DATA COORDINATOR

The data coordinator shall:

- Archive raw transmissometer data on a monthly basis.
- Inform the data archivist of files to be archived on a monthly basis.
- Maintain supporting hard copy documentation.

2.3 DATA ARCHIVIST

The data archivist shall:

- Obtain and compile ASCII data files to be archived as directed by the project manager or data coordinator.
- Perform periodic archives.
- Prepare and maintain data archive files and records.
- Provide a list of archived file names to the project manager or data coordinator.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Required equipment and materials include computer equipment and software, digital data, and supporting documentation as discussed in the following subsections. Data Archive Request Forms are also needed to document the archiving process.

3.1 COMPUTER EQUIPMENT AND SOFTWARE

Optical visibility monitoring digital data archives are performed on IBM-PC compatible systems. Required computer system components and software include:

- An IBM compatible 386/486 computer system with VGA display and minimum 80 megabyte hard disk, and a 3.5" diskette drive, connected to the ARS computer network
- 3.5" diskettes
- GigaTrend's SL Digital Audio Tape (DAT) Drive
- 4mm DAT cartridges
- GigaTrend's ServerDat archiving/backup software
- ServerDat and WordPerfect software
- Hewlett Packard Laserjet 4 Printer
- Three-ring notebook
- Plastic storage pouches and storage boxes
- Storage cabinet

3.2 DIGITAL DATA

ASCII files, as specified on the Data Archive Request Form, must be available in a designated network on-line directory. All optical data will be handled as ASCII files.

3.3 SUPPORTING HARD COPY DOCUMENTATION

Supporting hard copy documentation for optical data is divided into two categories, site-based and instrument-based. All supporting documentation is archived on a continual basis. Equipment and materials for maintaining supporting documentation archives include:

- Three-ring notebooks
- Manila file folders
- Hanging file folders
- Standard file cabinets

4.0 METHODS

Archiving of raw digital data is performed on a monthly basis. Archiving of all raw and processed digital data is performed after data have been finalized and reported (generally seasonally for nephelometer data and annually for transmissometer data). All files are in ASCII format. Files are stored in their original formats (non-compressed) on magnetic tape and at least two copies of each archive tape are created. One tape is stored at ARS, the other(s) are stored off-site. Hard copies of supporting documentation are archived on a continual basis and stored in-office.

Procedures for archiving optical data are discussed in the following two (2) major subsections:

4.1 Nephelometer Data Archives
4.2 Transmissometer Data Archives

4.1 NEPHELOMETER DATA ARCHIVES

4.1.1 Nephelometer Digital Data Archives

Table 4-1 outlines the nephelometer monthly and seasonal archive process. Raw data files (site-specific daily files collected by telephone modem, DCP, or downloaded from storage modules) are archived monthly. File types to be archived seasonally include:

- Processed data files for each site; Level-A (XXXX_N), Level-0 (XXXX_N0), and Level-1 (XXXX_N11)
- Submit files for plotting data
- Constants file (NPROCESS.CON)
- Calibration files (QA files) for each instrument
- Code files (XXXX_C) for each site
- Data processing and plotting program executable and source code files

Specific nephelometer archive procedures are detailed in TI 4600-5000, *Nephelometer Data Archives (IMPROVE Protocol)*.

Table 4-1

Archiving Procedures for Nephelometer and Associated Digital Data
and Supporting Information

NEPHELOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Nephelometer Digital Data				
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (site-specific daily files collected by telephone modem, DCP, or downloaded from storage modules)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Seasonal Archive of Nephelometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported (within 90 days after the end of a season)	•Processed data files; Level-A (XXXX_N), Level-0 (XXXX_N0) and Level-1 (XXXX_N11) files •Submit files for plotting data • Constants file (NPROCESS.CON) •QA calibration files (SSS_N.QA) •QA database files (XXXX_C) •Data processing and plotting program executable and source code files (NGN_PULL, NGN_PLOT, NGN_SEAS, NGN_NSUM, NGN_QA)	Magnetic tape	•One copy at ARS •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Site servicing trip reports •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Weekly plots •Seasonal plots •Annual plots •Seasonal summary history forms •Seasonal uncertainty printouts	Hard copies	•On file at ARS or ARS storage

4.1.2 Nephelometer Supporting Hard Copy Documentation Archives

Supporting hard copy documentation is archived on a continual basis. Nephelometer monitoring support documentation includes the following:

- Site specifications
- Site servicing trip reports
- Monitoring timelines
- Data coordinator/site operator correspondence
- Site operator log sheets
- Instrument calibration and audit reports
- Instrument maintenance logs
- Weekly, seasonal, and annual data plots
- Seasonal summary history forms
- Seasonal uncertainty printouts

Specific nephelometer archive procedures are detailed in TI 4600-5000, *Nephelometer Data Archives (IMPROVE Protocol)*.

4.2 TRANSMISSOMETER DATA ARCHIVES

4.2.1 Transmissometer Digital Data Archives

Table 4-2 outlines the transmissometer monthly and seasonal archive process. Raw data files (daily Wallops files) are archived monthly. File types to be archived seasonally include:

- Processed data files for each site; Level-A (XXXX_T), Level-0 (XXXX_T0), and Level-1 (XXXX_T11, XXXX_T1W, and XXX_T14)
- Submit files for plotting data
- Constants file (TPROCESS.CON)
- Lamp calibration files (XXXX_L) for each instrument
- Code files (XXXX_C) for each site
- Data processing and plotting program executable and source code files

Specific transmissometer archive procedures are detailed in TI 4600-5010, *Transmissometer Data Archives (IMPROVE Protocol)*

Table 4-2

Archiving Procedures for Transmissometer and Associated Digital Data and Supporting Information

TRANSMISSOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Transmissometer Digital Data				
Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	3.5" diskette	•One copy at ARS (DCC)
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Periodic Archive of Transmissometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported	•Processed data files; Level-A (XXXX_T), Level-0 (XXXX_T0) and Level-1 (XXXX_T11, XXXX_T1W, and XXXX_T14) files •Submit files for plotting data • Constants file (TPROCESS.CON) •Lamp calibration files (XXXX_L) •Code files (XXXX_C) •Data processing and plotting program executable and source code files (WALLOPS4, STRIP_T, APPEND_T, PROCESS.BAT, WIN_TSUM)	Magnetic tape	•Two copies at ARS (Archive Storage Cabinet and DCC) •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Bi-monthly plots •Seasonal plots •Annual plots •Seasonal summary history forms	Hard copies	•On file at ARS or ARS storage

4.2.2 Transmissometer Supporting Hard Copy Documentation Archives

Supporting hard copy documentation is archived on a continual basis. Transmissometer monitoring support documentation includes the following:

- Site specifications
- Monitoring timelines
- Data coordinator/site operator correspondence
- Site operator log sheets
- Instrument calibration and audit reports
- Instrument maintenance logs
- Bi-monthly, seasonal, and annual plots
- Seasonal summary history forms

Specific transmissometer archive procedures are detailed in TI 4600-5010, *Transmissometer Data Archives (IMPROVE Protocol)*.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DATA ARCHIVES (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4600-5010**
DATE	**JANUARY 1994**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	J. Carter Blandford	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Monthly archive and tape naming procedures	March 1995	
1.1	Minor text and formatting changes	December 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) is a guide to archiving transmissometer-based optical visibility monitoring data. The purpose of this TI is to assure that data and supporting information are secure and available. This TI is referenced by SOP 4600, *Optical Monitoring Data Archives*.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that archives are accessible, orderly, complete, and current.
- Issue a Data Archive Request Form to the data archivist when data have been finalized and reported.
- Document and distribute duplicate archive tapes to off-site locations.

2.2 DATA COORDINATOR

The data coordinator shall:

- Archive, on at least a monthly basis, all raw transmissometer and associated meteorological data files to 3.5" PC-compatible diskettes.
- Issue a Data Archive Request Form to the data archivist on a monthly basis.
- Maintain archives of supporting hard copy documentation on a continual basis.

2.3 DATA ARCHIVIST

The data archivist shall:

- On at least a monthly basis, archive all raw transmissometer and associated meteorological data files to magnetic tape.
- Archive finalized and reported data (processed data and associated files to magnetic tape).
- Obtain and compile data files to be archived as described on the Data Archive Request Form.
- Perform archives as described in this TI.
- Maintain data archive files and records.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Required equipment and materials include computer equipment and software, digital data, and supporting documentation as discussed in the following subsections. Data Archive Request Forms are also needed to document the archiving process.

3.1 COMPUTER EQUIPMENT AND SOFTWARE

Optical visibility monitoring digital data archives are performed on IBM-PC compatible systems. Required computer system components and software include:

- An IBM compatible 386/486 computer system with VGA display and minimum 80 megabyte hard disk and a 3.5" diskette drive, connected to the ARS computer network
- 3.5" diskettes
- GigaTrend's SL Digital Audio Tape (DAT) Drive
- 4mm DAT cartridges
- GigaTrend's ServerDat archiving/backup software
- ServerDat and WordPerfect software
- Hewlett Packard Laserjet 4 Printer
- Three-ring notebook
- Plastic storage pouches and storage boxes
- Storage cabinet

3.2 DIGITAL DATA

ASCII files of transmissometer data (raw, Level-A, Level-0, or Level-1) as specified on the Data Archive Request Form, must be available in a designated network on-line directory. All transmissometer data will be handled as ASCII files.

3.3 SUPPORTING HARD COPY DOCUMENTATION

Supporting hard copy documentation for transmissometer monitoring is divided into two categories, site-based and instrument-based. All supporting documentation is archived on a continual basis. Equipment and materials for maintaining supporting documentation archives include:

- Three-ring notebooks
- Manila file folders
- Hanging file folders
- Standard file cabinets

4.0 METHODS

Table 4-1 outlines archiving procedures for transmissometer and associated digital data and supporting information. Details of each archive procedure are described in the following four (4) major subsections:

4.1 Monthly Archive of Transmissometer Digital Data
4.2 Periodic Archive of Transmissometer Digital Data
4.3 Digital Data Archiving
4.4 Supporting Hard Copy Documentation Archiving

4.1 MONTHLY ARCHIVE OF TRANSMISSOMETER DIGITAL DATA

Raw data files (files downloaded daily from Wallops Island) are archived on a monthly basis. At the beginning of each month (after the bi-monthly plots are completed), the raw data files are copied from the ARS computer network are archived on 3.5" diskettes and on magnetic tape. The data coordinator maintains the 3.5" diskette archive and the data archivist maintains the magnetic tape archive. Procedures for each archive type are discussed in the following subsections.

4.1.1 Monthly Archive of Transmissometer Data Files to 3.5" Diskettes

Copy raw data files to 3.5" diskettes using the following procedures:

- Insert a blank, formatted 3.5" diskette into drive "A:" on an ARS network workstation.
- Change to the "F:\USERS\WALLOPS" directory.
- It is convenient to create individual daily files in 10-day increments by using a wildcard command in the Julian date field of the file name. For example, to create daily files for Julian dates 300 to 309 (October 27 to December 5), type **COPY F:\USERS\WALLOPS\GAL9330?.DAT A:** at the DOS prompt. This will copy files GAL93300 to GAL93309.DAT to "A:" drive. The naming format for raw data files is "GALYYDDD.DAT," where "YY" is the year and "DDD" is the Julian date.
- Label the 3.5" diskette to include all files archived. The 3.5" diskette holds 1.44 megabytes, or approximately 45 raw daily data files of average size.

4.1.2 Monthly Archive of Transmissometer Data Files to Magnetic Tape

Archiving the raw data files to magnetic tape involves appending save sets to the most recent tape until the tape is full. A duplicate of each archive tape is also created and delivered to the project manager for off-site storage. Raw data file archive tapes stored at ARS are labeled GAL_1_1, GAL_2_1, etc.; the duplicate tapes are labeled GAL_1_2, GAL_2_2, etc.

Monthly archiving to magnetic tape is a two-part process, as detailed in Section 4.3. First, the data coordinator issues a Data Archive Request Form to the data archivist. Second, with the information provided on the form, the data archivist archives the requested data set.

Table 4-1

Archiving Procedures for Transmissometer and Associated Digital Data and Supporting Information

TRANSMISSOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Transmissometer Digital Data				
Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	3.5" diskette	•One copy at ARS (DCC)
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Periodic Archive of Transmissometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported	•Processed data files; Level-A (XXXX_T), Level-0 (XXXX_T0) and Level-1 (XXXX_T11, XXXX_T1W, and XXXX_T14) files •Submit files for plotting data • Constants file (TPROCESS.CON) •Lamp calibration files (XXXX_L) •Code files (XXXX_C) •Data processing and plotting program executable and source code files (WALLOPS4, STRIP_T, APPEND_T, PROCESS.BAT, WIN_TSUM)	Magnetic tape	•Two copies at ARS (Archive Storage Cabinet and DCC) •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Bi-monthly plots •Seasonal plots •Annual plots •Seasonal summary history forms	Hard copies	•On file at ARS or ARS storage

4.2 PERIODIC ARCHIVE OF TRANSMISSOMETER DIGITAL DATA

As illustrated in Table 4-1, a series of processed data, submit, constants, calibration, database, and executable files are archived on magnetic streamer tape periodically, following final data processing. Periodic transmissometer data archiving is a two-part process, similar to monthly archiving. First, the project manager issues a Data Archive Request Form to the data archivist. Second, with the information provided on the form, the data archivist archives the requested data set.

Processed data files (Level-A, Level-0, and Level-1) are located on the ARS computer network, on "G:\USERS\TRANS\NETWORK\YYS" (where "YY" is the year and "S" is the season, e.g., 933 signifies third season (summer) of 1993). The naming convention for these files is:

Type	Naming Convention	Description
Level-A	XXXX_T	XXXX = Site code T = Transmissometer data
Level-0	XXXX_T0	XXXX = Site code T = Transmissometer data 0 = Level-0 data
Level-1	XXXX_T11	XXXX = Site code T = Transmissometer data 1 = Level-1 data 1 = Hourly data
	XXXX_T1W	W = Weather removed data
	XXXX_T14	4 = Four-hour averaged data

Other supporting files to be archived include:

Type	Naming Convention	Description
Submit files	SEASSUM.SBM	Plotting information
Constants file	TPROCESS.CON	Site specifications
Lamp calibration files	XXXX_L	Instrument-specific lamp information
Code files	XXXX_C	Quality assurance validity and precision codes
Data processing source code and executable files	WALLOPS4 STRIP_T APPEND_T PROCESS.BAT WIN_TSUM	Data acquisition files Reformatting files Appending files Validation program files Seasonal summary plot program files

Refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*, and TI 4300-4023, *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)* for detailed discussions on each data file type.

The periodic archiving procedure is identical to monthly archiving of daily files (see Section 4.1). A Data Archive Report is produced and disposition of tapes and archive records parallel monthly archiving procedures.

4.3 DIGITAL DATA ARCHIVING

Digital data archiving involves first completing a Data Archive Request Form, then having the data archivist perform the archiving.

4.3.1 Data Archive Request Form

The data coordinator (for monthly archiving) or project manager (for periodic archiving after data have been validated and reported) issues a Data Archive Request Form to the data archivist. Figure 4-1 is an example Data Archive Request Form. The following information should be completed by the person requesting the archive:

- Current date
- Name of person to receive the data archive request (the data archivist)
- Name of person who initiated the data archive request (the data coordinator or project manager)
- Project name or account codes
- Data period (e.g., Summer 1993 through Spring 1994)
- Number of archive tape copies required
- A general description of the data (e.g., "digital data files for reported transmissometer monitoring from the Summer 1993 through Spring 1994 seasons for the IMPROVE project")
- Note if a new archive tape is to be created or if an existing tape is to be appended or overwritten
- Disposition of the tapes
- Names of the specific files to be archived using an attached directory listing of the files if needed

The data archivist will archive the data within two weeks after receiving the Data Archive Request Form and will complete the form with the following information:

- Archive date
- Number of archive tapes made

Air Resource Specialists, Inc.

DATA ARCHIVE REQUEST

Date: ______________________________ Project/Study: ______________________________

To: ______________________________ Period: ______________________________

From: ______________________________ # of tape copies: ______________________________

General Data Description: ______________________________

New Tape ______ or Label of Tape to Append: ______________________________

Disposition: ______________________________

Files to be archived (include full path) or attach listing:

To Be Completed by Data Archivist

Archive date: ________________ # of tapes per copy: ___________ # of copies: _______

Tape Label(s): ______________________________

Disposition: ______________________________

Notes: ______________________________

archive.req 12/94

Figure 4-1. Data Archive Request Form.

- Tape label names
- Disposition of the tapes
- Additional notes concerning the archive

4.3.2 Archiving Procedure

4.3.2.1 The ServerDat Program

The data archivist obtains and compiles all files to be archived, then performs the archive as the following steps detail:

1) If using a new tape, initialize it before proceeding with the archive. To initialize a 4mm DAT tape, hold the **EJECT** button while inserting the tape into the GigaTrend SL tape drive. Release the button when the left LED flashes. When the orange LED lights, press the **EJECT** button again. When the initialization is complete, the tape will automatically eject.

2) If using a tape that has previously been used or initialized, insert the 4mm DAT archive tape into the GigaTrend SL tape drive.

3) From any ARS network work station, enter the ServerDat program by typing **SD** at the DOS prompt.

4) Select **SCHEDULE ATTENDED JOBS** from the "Main Menu."

5) Select **BACK UP TO TAPE** from the "Attended Operations Menu."

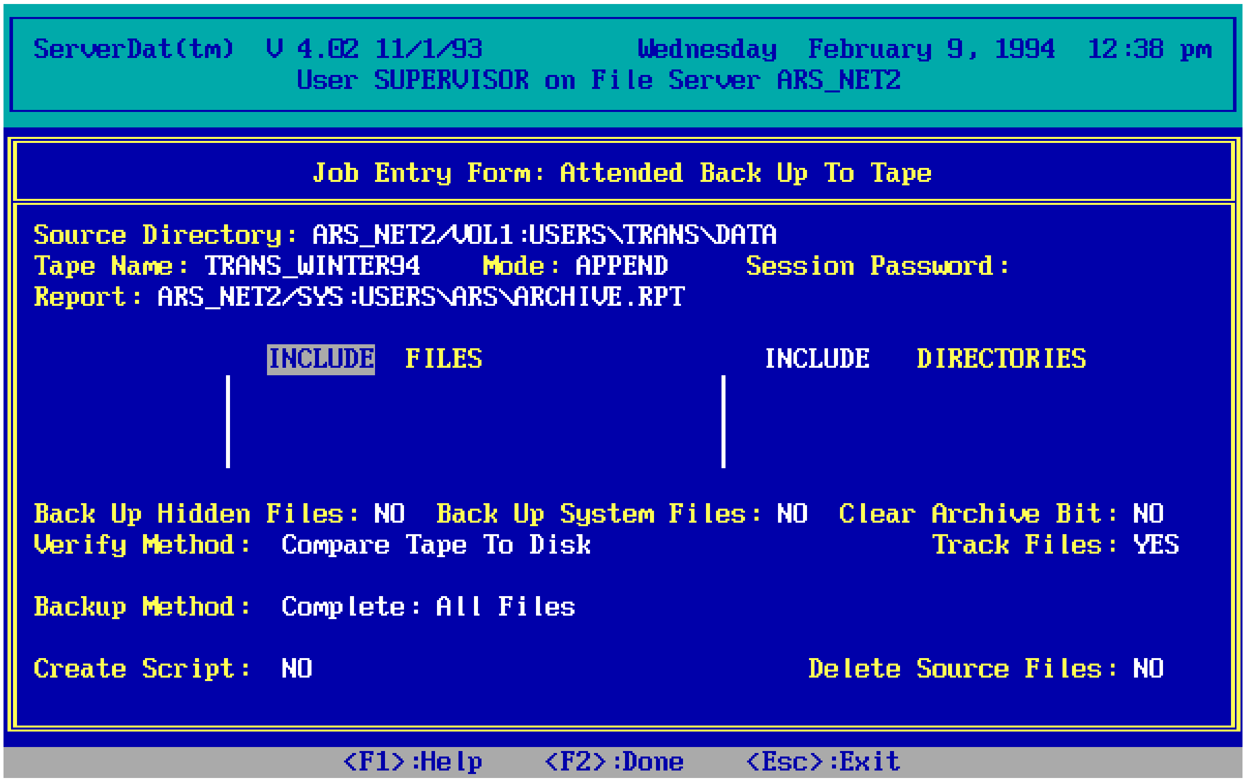
6) Select **SPEED ENTRY** from the "Selection Method Menu."

7) Select the volume that contains the source files (SYS is drive F:, VOL1 is drive G:).

8) Mark the directories/files to archive by highlighting the directory/file name and pressing **F5**. Press **F2** when all directories/files to archive have been marked.

9) Fill in the "Attended Back Up To Tape Job Entry Form" on the computer screen display (see Figure 4-2) with the following information:

    - Tape name following the tape naming convention as described in this TI.
    - Mode (append or overwrite).
    - The report directory and name (the report lists the archived files and any error messages generated during the job). This file will be used later for hard copy documentation of the archive.



ServerDat(tm) V 4.02 11/1/93 Wednesday February 9, 1994 12:38 pm
User SUPERVISOR on File Server ARS_NET2

Job Entry Form: Attended Back Up To Tape

Source Directory: ARS_NET2/VOL1:USERS\TRANS\DATA
Tape Name: TRANS_WINTER94 Mode: APPEND Session Password:
Report: ARS_NET2/SYS:USERS\ARS\ARCHIVE.RPT

INCLUDE FILES INCLUDE DIRECTORIES

Back Up Hidden Files: NO Back Up System Files: NO Clear Archive Bit: NO
Verify Method: Compare Tape To Disk Track Files: YES

Backup Method: Complete: All Files

Create Script: NO Delete Source Files: NO

<F1>:Help <F2>:Done <Esc>:Exit

Figure 4-2. Attended Backup to Tape Job Entry Form (Screen Display).

4.3.2.2 The Data Archive Report

The Data Archive Report is the file named in Step 9 in Section 4.3.2.1. The report can be printed by running ARCHRPT.BAT, a DOS batch file that loads WordPerfect and runs a WordPerfect macro to reformat and print the report. To run the batch file:

- Type at the network DOS prompt **ARCHRPT**, then press the "Enter" key.

- When prompted, enter the report file name as entered in Step 9 in Section 4.3.2.1.

The report will be sent to the HP Laserjet 4 printer. Photocopy the report and stone one copy with each archive tape. Store an additional copy in the Data Archive Log notebook.

4.3.2.3 Disposition of Tapes and Data Archive Records

Archive tapes and records are distributed as follows:

- One copy of each archive tape is stored at ARS in the archive storage cabinet in the computer room. The tape is placed in a plastic protector pouch with a copy of the archive report and Data Archive Request Form, then into a storage box with other archive tapes. The storage box will reside in the archive storage cabinet at ARS for no less than five years.

- One copy of the monthly archive tape is returned to the data coordinator with a copy of the archive report and a copy of the completed Data Archive Request Form for storage in the Data Collection Center (DCC).

- One copy of the periodic archive tape is returned to the project manager with a copy of the archive report and a copy of the completed Data Archive Request Form for off-site storage.

- One copy of the archive report and one copy of the completed Data Archive Request Form will be placed in the Data Archive Log notebook. The Data Archive Log notebook resides in the archive storage cabinet in the computer room.

- Any additional copies of the tape will be distributed as indicate don the Data Archive Request Form.

4.3.2.4 Reported Transmissometer Data Archive Tape Labeling Convention

Each reported transmissometer data archive tape will be labeled using the following convention:

- The first eight characters will be "TRANSRPT_."

- Characters 9 through 13 will denote the month and year the report was issued using a three-letter abbreviation for the month (JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC) and two digits for the year (94, 95, 96, etc.).

- Character number 14 will be an underscore (_).

The remaining fields on the "Job Entry Form" should hold the following values:

- Include Files - This can be used to selectively archive certain files by standard DOS "wild card" criteria. If all files in the directories marked in Step 8 are to be archived, leave this field blank.
- Back Up Hidden Files = **NO**
- Back Up System Files = **NO**
- Clear Archive Bit = **NO**
- Verify Method = **COMPARE TAPE TO DISK**
- Back Up Method = **COMPLETE: ALL FILES**
- Track Files = **YES**
- Create Script = **NO**
- Back Up System Files = **NO**
- Clear Archive Bit = **NO**
- Verify Method = **COMPARE TAPE TO DISK**
- Back Up Method = **COMPLETE: ALL FILES**
- Track Files = **YES**
- Create Script = **NO**
- Delete Source Files = **YES** or **NO**. Select **YES** only if the files are no longer needed on the network drive. Use caution with this option.

10) Press **F2** to begin the job once the "Job Entry Form" is complete. The program displays the archiving activity on the screen in real-time, giving the total number of files, bytes and blocks, and the specific file and its size as the job is processed.

11) If the "Delete Source Files" field in the "Job Entry Form" was set to "Yes," the program will ask whether or not to delete the source files. The deletion can be confirmed if the files are no longer needed on the network. The source files should not be deleted if additional archives are required.

12) Press any key when the job is done to return to the "Attended Operations Menu."

13) Press the **EJECT** button on the tape drive to remove the tape cartridge.

14) Label both the tape cartridge and the cartridge case with the tape name (refer to Step 9).

15) Repeat all steps to create duplicate tapes.

- Characters 15 through 21 will denote the reporting period; two digits for the beginning season year (i.e., 93, 94, 95) followed by a single digit to indicate the season (1=winter, 2=spring, 3=summer, 4=fall). Next will be a dash (-) followed by two digits for the ending season year and one digit for the ending season.

- The final two characters are an underscore (_) and a number representing the tape copy number.

For example, copy one of the reported transmissometer archive tape for a report issued in September of 1994 covering the period of Summer 1993 through Spring 1994 would be named: TRANRPT_SEP94_933-942_1.

4.4 SUPPORTING HARD COPY DOCUMENTATION ARCHIVING

Supporting hard copy documentation is archived continually. The documentation is located in the DCC in labeled three-ring notebooks and in labeled file cabinets.

4.4.1 Site-Based Transmissometer Supporting Hard Copy Documentation Archives

Site-based transmissometer monitoring support documentation includes:

- Site specifications (refer to TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

- Monitoring timelines (refer to TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*)

- Data coordinator/site operator correspondence (refer to TI 4110-3130, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*)

- Site operator log sheets (refer to TI 4110-3100, *Routine Operator Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*)

- ARS trip reports from yearly site visits (refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*)

- Bi-monthly plots (refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*)

- Seasonal summary plots (refer to TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)*)

- Annual summary plots (refer to TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)*)

4.4.2 Instrument-Based Transmissometer Supporting Hard Copy Documentation Archives

Instrument-based transmissometer monitoring support documentation includes:

- Instrument calibration (refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*)
- Instrument maintenance logs (refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*)
- Field audit reports (refer to SOP 4710, *Transmissometer Field Audit Procedures*)

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTEC LPV-2 TRANSMISSOMETER FIELD AUDIT PROCEDURES**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4710**
DATE	**FEBRUARY 1994**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
ORIGINATOR	David Beichley	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Reduce number of lamps used during audits	March 1995	
0.2	Change originator/responsibilities	December 1997	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the procedures for performing a field audit of an Optec LPV-2 transmissometer operated according to IMPROVE Protocol. The primary purpose of the field audit is to assure quality data capture by:

- Ensuring accurate on-site transmissometer readings by comparing to audit reference transmissometer readings.
- Ensuring accurate replacement transmissometer readings by comparing to audit reference transmissometer readings.
- Verifying the transmittance of the on-site transmissometer receiver and transmitter windows.

This SOP serves as a guideline for the following:

- Duties of the ARS project manager, ARS field specialist, and the field audit assistant
- Necessary equipment, instrumentation, and materials
- Pre-audit preparation (ARS and on-site)
- Audit methods, procedures, documentation, and evaluation

2.0 RESPONSIBILITIES

Field audits are typically performed as part of annual routine servicing visits. Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

2.1 PROJECT MANAGER

The project manager shall:

- Provide the ARS field specialist with calibration numbers for on-site, replacement, and reference transmissometers.
- Review all audit data to confirm correct system operation prior to the field specialist leaving the site.
- Direct appropriate corrective action if indicated by the audit results.
- Review and approve any changes to audit procedures.

2.2 FIELD SPECIALIST

The field specialist shall:

- Schedule and coordinate the field audit and verify that the site operator will be available to assist with the audit, or if the operator cannot assist with the audit, arrange for other assistance.

- Ensure that all instrumentation (and associated calibrations), equipment, materials, and tools are properly prepared and fully functional.

- Ensure that the audit assistant fully understands his/her tasks and is capable of adequately performing them.

- Perform all on-site procedures outlined in this SOP.

- Document audit results on the appropriate form(s).

- Forward the audit results to the project manager.

2.3 SITE OPERATOR OR AUDIT ASSISTANT

The site operator or audit assistant shall:

- Be available for training with the field specialist during the audit.

- Assist the field specialist during the field audit by performing all required tasks at the transmitter station.

3.0 REQUIRED INSTRUMENTATION, TOOLS, EQUIPMENT, AND MATERIALS

Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)* for general instrumentation, tools, equipment, and materials required when performing servicing/testing tasks at transmissometer sites. Specific instrumentation, tools, equipment, and materials required for field audits are detailed in the following subsections.

3.1 INSTRUMENTATION

- Replacement transmissometer with calibrated lamps. Typically, 9 of the 10 lamps calibrated with an instrument accompany the instrument to the field site. Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*, for information related to the designation of ARS and on-site reference lamps.

- Audit transmissometer (without receiver computer) with calibrated lamps. The replacement transmissometer computer is used with the audit transmissometer. Five calibrated lamps (one traveling reference lamp, two audit lamps, and two spare lamps) accompany the audit transmissometer. Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*, for information regarding designation of the audit lamps.

- Campbell 21X datalogger programmed to log transmissometer receiver computer outputs, with associated cable and connector. Refer to Figure 3-1, Campbell 21X datalogger program (transmissometer computer outputs).
- Handheld Rotronics air temperature/relative humidity sensor.
- Digital multimeter (DVM). The audit assistant uses the field specialist's calibrated DVM for lamp voltage measurements at the transmitter station.

3.2 TOOLS

On-site station/operator toolboxes should exist in both the transmissometer transmitter and receiver shelters. These toolboxes and on-site operational supplies should include all of the tools necessary to perform an audit. Specifically, the receiver station requires a 5/64” Allen hex wrench or hex screwdriver for attachment and removal of the transmissometer detector head from the receiver telescope. The transmitter station requires a small, flat-head screwdriver for removal of transmitter control box cover plate.

3.3 EQUIPMENT

- Calculator
- Two 2-way radios with spare batteries and charger
- Documentation camera, preferably a 35 mm SLR with 35-135 zoom lens and color print or slide film

3.4 MATERIALS

The following documentation forms and information sheets are needed for the audit:

- On-Site Transmissometer Audit Form (Transmitter Station)
- On-Site Transmissometer Audit Form - Documentation Sheet (Receiver Station)
- On-Site Transmissometer Audit Form - Data Sheet (Receiver Station)
- Operational calibration memos for on-site and replacement transmissometers
- Audit calibration memo for the reference transmissometer

Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*, for information regarding the calibration memos.

CAMPBELL 21X DATALOGGER PROGRAM
(TRANSMISSOMETER COMPUTER OUTPUT)

Program Description: Standard On-Site Operation

Author:______________________ Date:______________________

Instruct. Location	Program No.	Entry	Description
*4	01	1	Printer enable
	02	0	300 baud
*5			
	05	91	Year
	05		Julian Day
	05		Time
*1			
	01	1	
	01	P2	Diff voltage
	01	3	Reps
	02	5	Range
	03	1	in chan
	04	1	Location
	05	2.0	Multiplier
	06	000	Offset
	02	P92	If time
	01	0	Min into
	02	1	Min interval
	03	10	Set output flag
	03	P77	Real time
	01	110	Day/hr/min
	04	P78	Resolution
	01	1	High res
	05	P70	Sample to output
	01	5	Reps
	02	1	Start in *6 location 1
	06	P10	Battery voltage
	01	4	Location 4
	07	P17	Panel temp
	01	5	Location 5

Figure 3-1. Campbell 21X Datalogger Program (Transmissometer Computer Output).

4.0 METHODS

The transmissometer field audit is typically performed as part of the annual transmissometer servicing site visit. Refer to TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, for tasks and procedures that are performed prior to the audit.

The primary tasks for the transmissometer field audit are:

- Pre-audit instrument preparation and set-up (transmitter and receiver stations)

- Pre-audit tasks and documentation

- Audit procedures and documentation (transmitter and receiver stations)

This section includes five (5) major subsections:

4.1 Pre- On-Site Audit Preparation
4.2 Audit Assistance
4.3 Audit Procedures
4.4 Audit Evaluation
4.5 Audit Record Archival

4.1 PRE- ON-SITE AUDIT PREPARATION

Prior to travel to the site, the following preparations need to be made (for individual responsibilities refer to Sections 2.1 - 2.3):

- Schedule and coordinate with site personnel for assistance with the audit. Approximately 4-6 hours should be allotted. It is advisable to also schedule an alternate period on the following day for the audit, in the event of adverse weather or visibility conditions.

- Verify transmissometer calibration numbers and the lamp testing order.

- Ensure preparedness of all instruments, equipment, tools, and materials.

4.2 AUDIT ASSISTANCE

The person who will assist with the audit should be contacted upon arrival at the site. The prearranged schedule for performing the audit should be confirmed at this time. Weather conditions and forecast should be considered to see if any change in scheduling is warranted.

It is assumed that the audit assistant (typically the site operator) has been trained in the operation of the transmissometer system. Specific tasks the audit assistant performs during the audit are outlined in Section 4.3.3, Transmitter Station Audit Procedures and Documentation.

4.3 AUDIT PROCEDURES

4.3.1 General Procedures

The transmissometer field audit is designed to verify accurate on-site and replacement transmissometer measurements by comparing to measurements made with the audit reference transmissometer. The reference transmissometer is calibrated at the ARS test facility before and after each field audit to ensure that the accuracy of the measurements has not been affected by instrument handling and/or transport.

To reduce the amount of equipment shipped to and from a transmissometer site, the audit transmissometer system is operated with the replacement transmissometer computer during the audit. Gain measurements are made on all instruments during instrument servicing at ARS. (Refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*). These gain measurements are then incorporated into the calculation of calibration numbers generated for the audit transmissometer. (Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*).

To ensure a quality audit, it is important that the audit is performed during a period of good weather and stable conditions. If the weather and/or conditions are not suitable, the audit should be rescheduled. The audit is comprised of a series of 10-minute readings with various lamps calibrated with the on-site, audit, and replacement transmissometer units. The sequence of instruments and lamps is configured to provide the best possible intercomparison between individual lamps calibrated with a transmissometer system and also between respective transmissometer systems.

The transmissometer field audit also includes the window transmittance test, which verifies the combined transmittance of the transmitter and receiver station windows. This test is typically incorporated into the end of the audit, but can be performed separately if necessary. The window transmittance test is comprised of three 10-minute reading segments, typically using the first operational lamp of the installation transmissometer. The first and last segments should be performed with the receiver and transmitter windows installed. The middle segment is performed with both windows removed. This allows determination of the window transmittance and also provides an indication of stability of ambient conditions.

A complete audit (including window transmittance test) consists of 14 test segments, performed in the order shown in Table 4-1, Standard Audit Order for On-Site and Replacement Transmissometers. This table specifies the transmissometer and lamp to be used for each test segment; to summarize, the audit order is to use:

- The on-site instrument with two lamps, beginning with the last operational lamp, followed by the on-site reference lamp.

- The reference instrument with two lamps. If possible, use lamps that have been used in previous audits. This simplifies comparisons with other audits.

Table 4-1

Standard Audit Order for On-Site and Replacement Transmissometers

	Segment #	Transmissometer	Lamp	Comments
On-site	#1	On-site	Last Operational	
Transmissometer	#2	On-site	On-site Reference	
Audit	#3	Audit	Audit #1	
	#4	Audit	Audit #2	
	#5	Replacement	First Operational	
	#6	Replacement	On-site Reference	
Replacement	#7	Replacement	Last Operational	
Transmissometer	#8	Audit	Audit #2	
Audit	#9	Audit	Audit #1	
	#10	Replacement	Last Operational	
	#11	Replacement	On-site Reference	
Window	#12	Replacement	First Operational	Windows in Place
Transmittance	#13	Replacement	First Operational	Windows Removed
Test	#14	Replacement	First Operational	Windows in Place

Note: Receiver and transmitter windows are in place for the on-site and replacement transmissometer portions of the audit.

- The replacement instrument with three lamps, beginning with the lamp that will be the first operational one in the series. The second lamp is the on-site reference and the third is the last operational lamp in the series.

- The reference instrument with the same two lamps used earlier, but in reverse order.

- The installation instrument with the same three lamps used earlier, but in reverse order with the last audited lamp remaining as the first operational lamp.

The window transmittance test portion of the audit can include the last 10-minute reading of the intercomparison portion of the audit as the first segment of the transmittance test.

It is important that neither receiver nor transmitter telescope alignment is changed or adjusted during the transmittance test. Both alignments should be checked at the end of the test to confirm that there was no change in alignment from the initial reading segment of the test.

Having used the last intercomparison reading as the first segment of the window transmittance test, the remaining two segments are:

- A 10-minute reading with both receiver and transmitter windows removed.

- A 10-minute reading with both receiver and transmitter windows reinstalled.

Refer to Sections 4.3.3, Transmitter Station Audit Procedures and Documentation and 4.3.4, Receiver Station Audit Procedures and Documentation, for specific tasks and related documentation at the transmitter and receiver stations during the audit.

4.3.2 Pre-Audit Instrument Preparation and Set-Up

Prior to the audit, the following preparatory tasks are performed at the transmitter station:

- Inspect and clean the on-site, replacement, and audit transmitter telescope objective lenses and the shelter window with alcohol and Kimwipes. If the on-site transmitter telescope has a condition that could have affected instrument readings for an extended period of time (e.g. lens smear, cobweb in the telescope tube, etc.) audit the unit without correction of the condition. Instrument operation, prior to and after correction of the condition, will be determined during the post-field calibration of the instrument at the ARS test facility. Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers*.

- Set-up the reference and replacement transmissometer transmitter units. The telescopes, control cables, and control boxes should be connected so that the assistant need only change the power connections between control boxes and DVM connections between lamp voltage measurement pigtails when switching between transmitter systems.

- Inspect, and if necessary, clean the on-site, replacement, and reference transmitter lamps. The lamp filaments should also be inspected to verify that they are intact.

- Switch the on-site, replacement, and reference transmitter units to the continuous run mode. This is done by setting the integration timing switch to the 64-minute position while the cycle timing switch remains in the 60-minute position.

- Verify operation for the on-site, replacement, and reference transmitter systems, and the voltmeter.

Prior to the audit, the following preparatory tasks are performed at the receiver station:

- Inspect and clean the on-site, replacement, and audit receiver telescope lenses and the shelter window. If the on-site receiver telescope has a condition that could have affected data for an extended period of time (e.g. lens smear, cobweb in the telescope tube, etc.) audit the unit without correction of the condition. Instrument operation, prior to and after correction of the condition, will be determined during the post-field calibration of the instrument at the ARS test facility. Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers*.

- Assemble the replacement and reference receiver detector heads and telescopes.

- Set-up the replacement (reference) computer with established settings. Refer to Computer Settings, Section 4.3.4, Receiver Station Audit Procedures and Documentation.

- Connect the Campbell 21X datalogger to the output connector of the on-site receiver computer. During the audit the datalogger is connected to the computer in use.

- Verify that all instrumentation is fully operational.

4.3.3 <u>Transmitter Station Audit Procedures and Documentation</u>

The audit assistant at the transmitter station performs the following tasks during the audit:

- Operates the transmissometer transmitter units

- Cleans, inspects, and changes lamps

- Aligns the transmitter telescope

- Switches transmitter units

- Measures lamp voltages

- Inspects, and if necessary, cleans the shelter window and transmitter projection lens

- Troubleshoots transmitter malfunctions
- Operates the 2-way radio
- Documents lamp voltages and lamp and instrument changes, in addition to any miscellaneous events or conditions that might affect instrument operation and/or audit results

The assistant changes lamps and switches instruments upon request of the field specialist at the receiver station. Upon completion of the request, the assistant verifies transmitter operation and alignment and informs the field specialist at the receiver of the status.

Documentation of the assistant's actions are recorded on the On-Site Transmissometer Audit Form (Transmitter Station) (Figure 4-1). Tasks and documentation at the transmitter station are completed as follows:

ARS FIELD SPECIALIST	Record the name of the ARS field specialist or person performing the audit.
AUDIT ASSISTANT	Record the name(s) of the audit assistant(s) at the transmitter station.
SITE	Record the location name of the transmissometer installation.
DATE	Record the current date (month, day, year).
TIME (ON/OFF)	Record the times when a lamp is turned on and off.
LPV #	Record the transmitter unit number the lamp is operated in.
LAMP	Record the lamp number.
LAMP VOLTAGE	Record the lamp voltage from the voltmeter. This should be done just prior to turning the instrument off when switching to another lamp or instrument.
WINDOWS (IN/OUT)	Record whether the transmitter window was in or out for that testing segment. Typically the window is only removed during the window transmittance test.
COMMENTS	Record any comments regarding weather conditions, instrument malfunctions, etc. that might influence instrument operation and/or readings during the audit.

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ON-SITE TRANSMISSOMETER AUDIT FORM
(TRANSMITTER STATION)

ARS FIELD SPECIALIST ______________________ SITE __________

AUDIT ASSISTANT ______________________ DATE __________

TIME ON	TIME OFF	LPV #	LAMP #	LAMP VOLTAGE	WINDOWS IN/OUT

COMMENTS (Weather/Visibility/Equipment/etc.): ______________________

xtraudt_xmtr.doc (12/97)

Figure 4-1. On-Site Transmissometer Audit Form (Transmitter Station).

4.3.4 Receiver Station Audit Procedures and Documentation

The field specialist at the receiver station performs the following tasks during the audit:

- Operates and switches the transmissometer receiver units
- Operates the Campbell 21X datalogger
- Inspects and if necessary, cleans the shelter window and the receiver telescope objective lens
- Aligns the receiver telescope
- Operates the 2-way radio and communicates with the audit assistant regarding lamp and instrument changes
- Documents receiver settings, AT/RH measurements, b_{ext} estimates, documentation photographs, ambient conditions (weather and visibility), and miscellaneous comments related to the audit on the On-Site Transmissometer Audit Form - Documentation Sheet (Receiver Station) (Figure 4-2)
- Documents instrument and lamp changes, lamp voltages, calibration numbers, transmissometer test data, and miscellaneous events or conditions that could affect the audit data on the On-Site Transmissometer Audit Form - Data Sheet (Receiver Station) (Figure 4-3)

Documentation of the field specialist's actions are recorded on the On-Site Transmissometer Audit Form - Documentation Sheet (Receiver Station) (refer to Figure 4-2). Tasks and documentation at the receiver station are competed as follows:

ARS FIELD SPECIALIST	Record the name of the ARS field specialist or person performing the audit.
AUDIT ASSISTANT	Record the name(s) of the person(s) assisting with the audit at the transmitter station.
SITE	Record the location name of the transmissometer installation.
DATE	Record the current date (month, day, year).
COMPUTER SETTINGS	Record the following transmissometer computer-related information for the on-site, replacement, and reference computers. Refer to the on-site, replacement, and reference instrument calibration memos for the path, gain, and lamp-specific calibration number settings.

Air Resource Specialists, Inc.

ON-SITE TRANSMISSOMETER AUDIT FORM
DOCUMENTATION SHEET - (RECEIVER STATION)

ARS FIELD SPECIALIST ____________________ SITE ____________________
AUDIT ASSISTANT____________________ DATE ____________________

Computer Settings	LPV #	Gain	Path	Integration	Cycle
On-Site Computer					
Replacement Computer					
Reference Computer					

AT/RH Measurements	Time	AT	RH
Audit Begin	:		
Mid-Audit	:		
Audit End	:		

AT/RH Handheld Sensor MFR/Model/SN____________________

b_{ext} Estimate	Time	B_{ext}	Comments
Audit Begin	:		
Audit End	:		

Photo Documentation	Time	Direction(s)	Lens Size (mm)
Audit Begin	:		
	:		
Audit End	:		
	:		

Weather and Visibility Conditions ____________________

Miscellaneous Comments ____________________

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Figure 4-2. On-Site Transmissometer Audit Form - Documentation Sheet (Receiver Station).

Air Resource Specialists, Inc.

ON-SITE TRANSMISSOMETER AUDIT FORM - DATA SHEET
(RECEIVER STATION)

ARS FIELD SPECIALIST ____________________ SITE ____________________

AUDIT ASSISTANT ____________________ DATE ____________________

UPDATE	LPV	LAMP	LAMP	CAL	LPV DISPLAY		CAMPBELL DISPLAY			WINDOWS
TIME	#	#	VOLTAGE	#	Raw Rdg	b_{ext}	Raw Rdg	b_{ext}	Std Dev	IN/OUT
:										
:										
:										
:										
:										
:										
:										
:										
:										
:										
:										
:										

Comments (Weather/Visibility/Equipment/Etc.): ____________________

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Figure 4-3. On-Site Transmissometer Audit Form – Data Sheet (Receiver Station).

LPV #	Record the number of the computer. The replacement computer is typically used as the reference instrument computer.
GAIN	Record the gain setting. Note that since the replacement computer is used with the reference instrument, the gain used might vary from one instrument system to the next.
PATH	Record the path length dialed in the computer.
INTEGRATION	Record the time to which the computer integration switch is set; 10-minute integrations are standard during audits.
CYCLE	Record the cycle-switch setting. The standard audit setting is "C" (continuous).

CALIBRATION (CAL) NUMBER

Note: The calibration number is recorded on the On-Site Transmissometer Audit Form - Data Sheet (Receiver Station). Refer to Figure 4-3. The calibration number is instrument- and transmitter lamp-specific and will be changed for each audit segment.

AT/RH MEASUREMENTS

Record the time of measurement, and the air temperature (AT) and relative humidity (RH) measurements made with the handheld AT/RH sensor. These measurements are made at the beginning, middle, and end of the audit. Also record the manufacturer (MFR), model, and serial number (SN) of the handheld AT/RH sensor.

b_{ext} ESTIMATE

Record the b_{ext} estimate and time it was made at the beginning and end of the audit. Also comment on any conditions or factors that pertain to this estimate.

PHOTO DOCUMENTATION

Record the time, direction(s), and lens used (e.g., 50mm, 135mm) for the photographs taken to document visibility conditions. These photographs are taken at the beginning and end of the audit and should be of the longest vistas possible, with at least one including all or a portion of the site path.

WEATHER AND VISIBILITY CONDITIONS

Describe the weather and visibility conditions and any changes that occur during the audit.

MISCELLANEOUS COMMENTS

Record any miscellaneous information that is relevant to the audit.

Performance of tasks and documentation of data and audit segment information during the audit is done using the On-Site Transmissometer Audit Form - Data Sheet (Receiver Station). Refer to Figure 4-3. Information is documented on the form as follows:

ARS FIELD SPECIALIST	Record the name of the ARS field specialist or person performing the audit.
AUDIT ASSISTANT	Record the name(s) of the person(s) assisting with the audit at the transmitter station.
SITE	Record the location name of the transmissometer installation.
DATE	Record the current date (month, day, year).

For each 10-minute audit segment, document the following information:

UPDATE TIME	Record the local time when the receiver computer updates with the 10-minute averaged reading.
LPV #	Record the number of the transmissometer system used during the audit segment.
LAMP #	Record the number of the transmitter lamp used.
LAMP VOLTAGE	Record the transmitter lamp voltage reported by the audit assistant.
CAL #	Record the calibration number used for the audit segment.
LPV DISPLAY	Record the instrument raw reading and the calculated b_{ext} from the computer display. (A1 switch set to C and B, respectively).
CAMPBELL DISPLAY	Record the instrument raw reading, the calculated b_{ext}, and the standard deviation from the Campbell 21X datalogger. The raw reading or b_{ext} value (dependent on A1 switch setting) is displayed on the Campbell datalogger in the *6-mode, Input Storage Location 1. The standard deviation (SD) is displayed in the *6-mode, Input Storage Location 2.
WINDOWS IN/OUT	Record whether the receiver window was in or out for the testing segment. Typically the window is only removed during the window transmittance test, when the transmitter window is also removed.
COMMENTS	Record any comments regarding events, conditions, instrument operation, etc. that could affect the audit.

Refer to Figures 4-4, 4-5, and 4-6 for examples of completed transmitter and receiver station audit forms.

Air Resource Specialists, Inc.

ON-SITE TRANSMISSOMETER AUDIT FORM
(TRANSMITTER STATION)

ARS FIELD SPECIALIST Ivar Rennat SITE GRBA

AUDIT ASSISTANT Kurt Pfaff DATE 11/18/93

TIME ON	TIME OFF	LPV #	LAMP #	LAMP VOLTAGE	WINDOWS IN/OUT
09:52	10:04	005	714	5.985	In
10:06	:17	↓	668	6.084	↓
:28	:41	006	838	5.869	↓
:44	:58	↓	839	6.001	↓
11:06	11:20	020	1007	5.657	↓
:24	:37	↓	1011	5.750	↓
:39	:53	↓	1015	5.682	↓
:59	12:18	006	839	5.998	↓
12:20	:32	↓	838	5.851	↓
:38	:52	020	1015	5.681	↓
:54	13:06	↓	1011	5.742	↓
13:09	:21	↓	1007	5.655	↓
:21	:36	↓	↓	↓	Out
:36		↓	↓	↓	In

COMMENTS (Weather/Visibility/Equipment/etc.):

11:30 Estimated visual range is ~ 100 mi.

13:20 No apparent change in visual range.

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Figure 4-4. Completed Example of On-Site Transmissometer Audit Form (Transmitter Station).

Air Resource Specialists, Inc.

ON-SITE TRANSMISSOMETER AUDIT FORM
DOCUMENTATION SHEET - (RECEIVER STATION)

ARS FIELD SPECIALIST Ivar Rennat SITE GRBA

AUDIT ASSISTANT Kurt Pfaff DATE 11-18-93

Computer Settings	**LPV #**	**Gain**	**Path**	**Integration**	**Cycle**
On-Site Computer	005	500	3.91	10 min.	C
Replacement Computer	020	700	3.91	10 min.	C
Reference Computer	020	700	3.91	10 min.	C

AT/RH Measurements	**Time**	**AT**	**RH**
Audit Begin	09:20	4.1°C	47.7%
Mid-Audit	11:00	6.4°C	39.2%
Audit End	14:15	5.1°C	28.8%

AT/RH Handheld Sensor MFR/Model/SN Rotronic/Hygroskop GT/#27034

b_{ext} Estimate	**Time**	**B_{ext}**	**Comments**
Audit Begin	09:20	0.025	Correlates well w/Trans. reading
Audit End	14:15	0.020	

Photo Documentation	**Time**	**Direction(s)**	**Lens Size (mm)**
Audit Begin	09:30	Notch Peak (~E)	135
	" : "	~N	"
Audit End	14:20	Notch Peak (~E)	"
	" : "	~N	"

Weather and Visibility Conditions Winds gusty from SW (5-20 mph). Partly cloudy. Bluish haze in distance. 11:30 Estimate visual range 100 miles.

Miscellaneous Comments
Appeared to have little change in visibility conditions during audit.

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Figure 4-5. Completed Example of On-Site Transmissometer Audit Form - Documentation Sheet (Receiver Station).

Air Resource Specialists, Inc.

ON-SITE TRANSMISSOMETER AUDIT FORM - DATA SHEET (RECEIVER STATION)

ARS FIELD SPECIALIST Ivar Rennat
AUDIT ASSISTANT Kurt Pfaff

SITE GRBA
DATE 11-18-93

UPDATE	LPV	LAMP	LAMP	CAL	LPV DISPLAY		CAMPBELL DISPLAY			WINDOWS
TIME	#	#	VOLTAGE	#	Raw Rdg	b_{ext}	Raw Rdg	b_{ext}	Std Dev	IN/OUT
10:02	005	714	5.985	713	635	0.029	6365.2	289.58	25.892	In
:16	↓	668	6.084	737	679	0.020	6813.0	199.64	51.784	↓
:39	006	838	5.869	918	846	0.021	8457.1	209.15	82.425	↓
:55	↓	839	6.001	923	840	0.024	8396.4	238.40	45.636	↓
11:18	020	1007	5.657	837	789	0.015	7887.2	148.20	59.832	↓
:35	↓	1011	5.750	852	807	0.014	8066.0	138.20	45.621	↓
:50	↓	1015	5.682	843	786	0.018	7850.8	179.75	60.370	↓
12:16	006	839	5.998	923	846	0.022	8458.7	218.85	38.624	↓
:31	↓	838	5.851	918	845	0.021	8443.8	209.39	50.144	↓
:50	020	1015	5.681	843	778	0.021	7772.8	208.85	35.938	↓
13:04	↓	1011	5.742	852	794	0.018	7938.9	179.84	42.755	↓
:19	↓	1007	5.655	837	781	0.018	7805.1	179.29	45.493	↓
:33	↓	↓	↓	↓	966	–	9656.8	–	40.078	Out
:46	↓	↓	↓	↓	777	0.019	7760.9	189.59	26.499	In
14:13	↓	↓	↓	↓	774	0.020	7731.5	199.86	31.271	↓

Comments (Weather/Visibility/Equipment/Etc.):

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Figure 4-6. Completed Example of On-Site Transmissometer Audit Form - Data Sheet (Receiver Station).

If the standard deviation (SD) for an audit segment is 10 or more, that segment should be repeated. If the second segment also has a high standard deviation, another lamp from the series should be used instead. Continued high standard deviations indicate an instrument malfunction or unacceptable testing conditions. If the malfunction cannot be quickly resolved or conditions do not stabilize, the audit should be terminated and rescheduled.

4.4 AUDIT EVALUATION

Upon completion of the field audit, the following forms are faxed to the project manager for review:

- On-site Transmissometer Audit Form (Transmitter Station)
- On-site Transmissometer Audit Form - Documentation Sheet (Receiver Station)
- On-site Transmissometer Audit Form - Data Sheet (Receiver Station)

Evaluation of the field audit results includes:

- Reviewing the receiver station documentation sheet.
- Reviewing the transmitter station audit form.
- Entering specific audit data from receiver station data sheet into the Audit Evaluation Worksheet.
- Entering accumulated operational hours for lamps audited with the on-site transmissometer into the Audit Evaluation Worksheet.
- Analyzing instrument and lamp comparison data and statistics from the Audit Evaluation Worksheet.
- Informing the field specialist of the audit results including the need to repeat all or part of the field audit.

Subsections 4.4.1 through 4.4.4 provide detailed descriptions of the procedures for evaluating field audit results.

4.4.1 Review of Receiver Station Documentation Sheet

Project manager review of the receiver station documentation sheet is to ensure that the documentation is complete and provides a thorough assessment of on-site conditions during the audit.

4.4.2 Review of Transmitter Station Audit Form

Review of the transmitter station audit form includes:

- Verifying that the instrument number and lamp number recorded for each audit segment matches the corresponding instrument and lamp numbers recorded on the receiver station data sheet.

- Comparing the lamp voltages measured during the individual audit segments with corresponding lamp voltages measured during instrument servicing and calibration. Lamp voltages recorded during the audit are added to the Transmissometer Lamp Voltage Measurements Log (Refer to TI 4110-3400, *Annual Laboratory Maintenance Procedures for LPV-2 Transmissometers (IMPROVE Protocol)*).

Lamp voltage measurements for individual lamps used with the audit instrument and replacement instrument may vary (minimum to maximum) over a range of fifty (50) millivolts. Due to lamp brightening (Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers*), lamp voltages for operational lamps used by the on-site instrument will exhibit much larger (300-500 millivolt) variations from the instrument servicing and calibration measurements.

4.4.3 Data Entry of Audit Evaluation Worksheet

The computer-based Audit Evaluation Worksheet (Figure 4-7) is used by the project manager to calculate statistical parameters that indicate the quality of the audit and identify instrument or lamp inconsistencies.

For each audit segment, the lamp number (LAMP#), calibration number (CAL#), receiver raw reading (RAW RDG), and standard deviation (STD DEV) are entered into the worksheet from the receiver station data sheet. LAMP# and CAL# are entered directly as recorded on the receiver station data sheet. RAW RDG and STD DEV are taken from the Campbell datalogger display data and must be divided by 10 and rounded off to one decimal place (e.g., a raw reading of 6365.2 is entered on the worksheet as 636.5). The on-site instrument section of the worksheet includes an entry for lamp hours. Since the operational lamps for this instrument will have accumulated approximately 400 "on" hours (typical operational period of two months), the raw readings must be corrected for lamp brightening (Refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*). For operational lamps, the value to be entered for LAMP HOURS is obtained from the lamp change records maintained by the ARS Data Collection Center (Refer to TI 4300-4023, *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*). When the on-site reference lamp is being audited, the LAMP HOURS entry should be zero (0).

After the required data are entered into the worksheet, the parameters used to evaluate the audit are automatically calculated for each audit segment by the worksheet. These parameters are defined as follows:

AUDIT EVALUATION WORKSHEET
LPV-2 TRANSMISSOMETER
GRBA - 11/18/93

AUDIT BLOCK #1 ON SITE TRANSMISSOMETER LPV# 005

LAMP#	CAL#	LAMP HOURS	MEAN RAW RDG	STD DEV	T(meas)	T(corr)	SD/MEAN
668	737	544	681.3	5.2	0.924	0.886	0.76%
713	724	537	658.1	7.6	0.909	0.871	1.15%
						0.878	0.96%

AUDIT BLOCK #2 AUDIT TRANSMISSOMETER LPV# 006

LAMP#	CAL#	MEAN RAW RDG	STD DEV	T(meas)	SD/MEAN
838	918	845.7	8.2	0.921	0.97%
713	724	839.6	4.6	0.910	0.55%
				0.915	0.76%

AUDIT BLOCK #3 REPLACEMENT TRANSMISSOMETER LPV# 020

LAMP#	CAL#	MEAN RAW RDG	STD DEV	T(meas)	SD/MEAN
1011	852	806.6	4.5	0.947	0.56%
1007	837	788.7	6.0	0.942	0.76%
1015	843	785.1	6.0	0.931	0.76%
				0.940	0.69%

AUDIT BLOCK #4 AUDIT TRANSMISSOMETER LPV# 006

LAMP#	CAL#	MEAN RAW RDG	STD DEV	T(meas)	SD/MEAN
839	923	845.9	3.9	0.916	0.46%
838	918	844.4	5.0	0.920	0.59%
				0.918	0.53%

AUDIT BLOCK #5 REPLACEMENT TRANSMISSOMETER LPV# 020

LAMP#	CAL#	MEAN RAW RDG	STD DEV	T(meas)	SD/MEAN
1015	843	777.3	3.6	0.922	0.46%
1011	852	793.9	4.3	0.932	0.54%
1007	837	780.5	4.5	0.932	0.58%
				0.929	0.53%

AUDIT BLOCK COMPARISONS

MEAN T (meas) COMPARISON	MEAN OFFSET
Block #3 - Block #2	2.62%
Block #3 - Block #4	2.34%
Block #5 - Block #4	1.15%

Figure 4-7. Example Audit Evaluation Worksheet.

- T(meas) - The atmospheric transmittance over the sight path. This is the ratio of the ten-minute mean raw reading (RAW RDG) to the calibration number (CAL#).

- T(corr) - This is T(meas) for on-site instrument lamps adjusted for lamp brightening (Refer to TI 4400-5000).

- SD/MEAN - This parameter is the ratio (expressed as a percent) of the standard deviation (STD DEV) to the mean raw reading (RAW RDG) and indicates the stability of sight path transmittance during the 10-minute audit segment.

A mean T(meas) value is calculated for each audit block. Replacement transmissometer audit blocks are compared to adjacent Audit transmissometer audit blocks to determine a mean offset in T(meas).

4.4.4 Evaluation of Audit Results

Procedures for evaluating transmissometer field audit results are currently being developed. Over the past two years, over 30 field audits of LPV-2 transmissometers have been conducted. Data from these audits are being entered into an Audit Results Database. Audit results statistics will be used to define error limits for comparison of path transmittance measurements obtained with an instrument being audited to path transmittance measurements obtained with an audit instrument.

Lamps used operationally with transmissometers being removed from the field (on-site instruments) typically have accumulated 400 to 600 hours of "on" time. This accumulated operating time results in a shift in lamp brightness as described in TI 4400-5000. Audit data for lamps used in the field are corrected for lamp brightening following the procedures outlined in the previously referenced TI. Three sets of audit results statistics will be created as follows:

- One set of audit result statistics is generated for audit instrument and on-site instrument comparisons applying the standard lamp brightening correction factor. This data set is used only as an early indication of the quality of the data collected during the operational period for the on-site transmissometer.

- Operational instruments are post-calibrated after removal from a field site (Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometer*). On-site instrument audit data will be corrected using post-calibration lamp brightening factors. The second set of audit result statistics is generated using these data. This data set is incorporated into ongoing analyses of lamp brightening effects on data quality.

- The third set of audit results statistics is based on measurement comparisons between the replacement transmissometer and the audit transmissometer. Because replacement instrument lamps are calibrated prior to installing the instrument at a field site (see TI 4200-2100), the lamps have not accumulated any "on" time prior to the audit and lamp brightening is not a factor. These statistics will be used to define error limits for acceptance of replacement instrument audits.

As additional field audits are conducted, the audit results will be added to the database, allowing a more accurate description of the error limits.

4.5 AUDIT RECORD ARCHIVAL

Upon completion of the audit review, the project manager transfers all field audit records and documentation to site-specific operations notebooks located in the ARS Data Collection Center. Specific field audit documentation archived includes:

- On-site Transmissometer Audit Form (Transmitter Station)
- On-site Transmissometer Audit Form - Documentation Sheet (Receiver Station)
- On-site Transmissometer Audit Form - Data Sheet (Receiver Station)
- Audit Evaluation Worksheet