Vaisala Ceilometer CL31

USER'S GUIDE

VAISALA

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CHAPTER 1
GENERAL INFORMATION

This chapter provides general notes for the product.

About This Manual

This manual provides information for installing, operating, and maintaining Vaisala Ceilometer CL31.

Contents of This Manual

This manual consists of the following chapters:

- Chapter 1, General Information, provides general notes for the product.
- Chapter 2, Product Overview, introduces the features, advantages, and the product nomenclature.
- Chapter 3, Installation, provides you with information that is intended to help you install this product.
- Chapter 4, Operation, contains information that is needed to operate this product.
- Chapter 5, Functional Description, describes the functionality of the product.
- Chapter 6, Maintenance, provides information that is needed in the basic maintenance of the product.
- Chapter 7, Troubleshooting, describes common problems, their probable causes and remedies, and gives the contact information.
- Chapter 8, Repair, explains how to remove and replace different parts of Vaisala Ceilometer CL31.

- Chapter 9, Technical Data, provides the technical data of the product.
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Related Manuals

Table 1   Related Manuals

Manual Code	Manual Name
M210310EN-A	Termination Box User's Guide

Feedback

Vaisala Customer Documentation Team welcomes your comments and suggestions on the quality and usefulness of this publication. If you find errors or have other suggestions for improvement, please indicate the chapter, section, and page number. You can send comments to us by e-mail: manuals@vaisala.com

Safety

General Safety Considerations

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.

CAUTION	Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

NOTE	Note highlights important information on using the product.

WARNING	Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Vaisala Oyj assumes no liability for the customer's failure to comply with these requirements.

Product Related Safety Precautions

Vaisala Ceilometer CL31 delivered to you has been tested for safety and approved as shipped from the factory. The following safety precautions must be observed during all phases of operation, service, and repair of this instrument:

WARNING	To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor AC power connector. The power cable must either be plugged into an approved three-contact electrical outlet or the instrument must be carefully grounded to a low-resistance safety ground.

WARNING	Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

WARNING	Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

WARNING	Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized Depot for service and repair to ensure that safety features are maintained.

WARNING	Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

WARNING	High voltage will be present when the Laser Transmitter CLT311 or Receiver CLR311 covers are removed and they are connected to a powered unit. High voltage is present in AC Power Unit CLP311, Internal Heater CLH311, Ceilometer Engine Board CLE311, and the Window Blower CLB311 at the top of the Shield.

Laser Transmitter CLT311, Receiver CLR311, and AC Power Unit CLP311 are equipped with the following warning label:

WARNING! HIGH VOLTAGE INSIDE THIS ENCLOSURE

Internal Heater CLH311 can be hot and is equipped with the following warning labels:
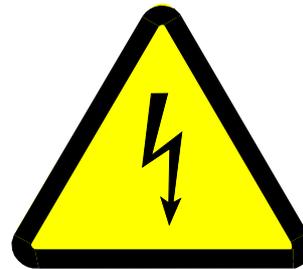
Laser Safety

Vaisala Ceilometer CL31 is classified as a Class 1M laser device in accordance with International Standard IEC/EN 60 825-1. Complies with 21 CFR 1040.10 and 1040.11 except for the deviations pursuant to the Laser Notice No. 50, dated July 26, 2001. This means that when CL31 is installed in a field environment with instrument covers on and pointed vertically or near-vertically, it poses no established biological hazard to humans.

The device is equipped with the following label:

**LASER RADIATION
DO NOT VIEW DIRECTLY
WITH OPTICAL INSTRUMENTS
CLASS 1M LASER PRODUCT**

Ceilometer CL31 is intended for operation in an area restricted from public access, and to be pointed vertically or near-vertically. The following precautions must be followed during the service and maintenance of the instrument:

WARNING	Never look directly into the Ceilometer Transmitter or Ceilometer Optics with magnifying optics (such as glasses, binoculars, and telescopes). Never remove the Ceilometer Transmitter from its normal position without first switching off both the line and the battery power and detaching the trasnmitter ribbon cable from the Ceilometer Engine Board.
	When operating, avoid looking at the ceilometer unit from the beam direction. When tilting the unit, make sure that it is not being viewed from the beam direction with magnifying optics.
	Only trained personnel should perform maintenance functions. Access to the work area by unauthorized persons during service operations must be prevented.

ESD Protection

CAUTION	The equipment contains parts and assemblies sensitive to damage by Electrostatic Discharge (ESD). Use ESD precautionary procedures when touching, removing or inserting.

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage

the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing.

To make sure you are not delivering high static voltages yourself:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord. When neither of the above is possible, touch a conductive part of the equipment chassis with your other hand before touching the boards.
- Always hold the boards by the edges and avoid touching the component contacts.

Recycling

Recycle all applicable material.

Dispose of batteries and the unit according to statutory regulations.

Do not dispose of with regular household refuse.

Warranty

For certain products Vaisala normally gives a limited one-year warranty. Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

CHAPTER 2
PRODUCT OVERVIEW

This chapter introduces the features, advantages, and the product nomenclature.

Introduction to Vaisala Ceilometer CL31

Vaisala Ceilometer CL31 measures cloud height and vertical visibility. The small and lightweight measurement unit suits well for mobile operation.

Ceilometer CL31 employs pulsed diode laser LIDAR technology (LIDAR = Light detection and ranging), where short, powerful laser pulses are sent out in a vertical or near-vertical direction. The reflection of light - backscatter - caused by haze, fog, mist, virga, precipitation, and clouds is measured as the laser pulses traverse the sky. The resulting backscatter profile, that is, the signal strength versus the height, is stored and processed and the cloud bases are detected. Knowing the speed of light, the time delay between the launch of the laser pulse and the detection of the backscatter signal indicates the cloud base height.

Ceilometer CL31 is able to detect three cloud layers simultaneously. If the could base is obscured due to precipitation or ground-based fog, CL31 reports vertical visibility. No adjustments in the field are needed. The embedded software includes several service and maintenance functions and gives continuous status information from internal monitoring. The software is designed to give the full backscatter profile.

To make Ceilometer CL31 easier to use and to ease the transfer from old ceilometer versions to this new one, CL31 includes data messages used in CT12K, CT25K, CT25KAM, and LD40.

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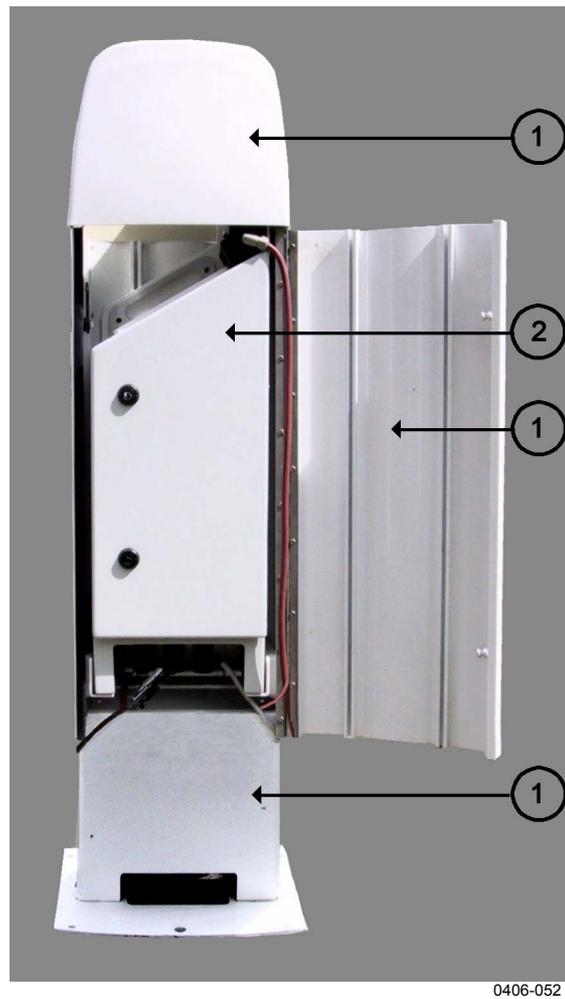
Figure 1   Vaisala Ceilometer CL31

The following numbers refer to Figure 1 above:

1   =   Shield
2   =   Measurement Unit

Product Nomenclature

Table 2   Vaisala Ceilometer CL31 Main Parts

Code	Common Name	Description
CLO311	Optics Unit	
CLW311	Window Assembly	Spare part
CLT311SP	Ceilometer Transmitter	Spare part
CLR311	Ceilometer Receiver	Spare part
CLM311	Laser Monitor Board	Spare part
CLE311SP	Ceilometer Engine Board	Spare part
CLP311	AC Power	Spare part
4592	No-break Battery	Spare part
CLH311-115SP	Inside Heater (100 ... 115 VAC)	Spare part
CLH311-230SP	Inside Heater (220 ... 240 VAC)	Spare part
CLB311-115SP	Window Blower (100 ... 115 VAC)	Spare part
CLB311-230SP	Window Blower (220 ... 240 VAC)	Spare part
CT3839SP	Power cable (230 V)	Spare part
CT35324SP	Power cable (115 V)	Spare part
CT3838	Data cable	Spare part
DRW217429	Coaxial Cable	Spare part

Table 3   Vaisala Ceilometer CL31 Optional Parts

Code	Common Name	Description
DMX501	Modem Module	Spare part
CLRADIOKIT	Radio Modem Installation Kit	Excl. radio modem and antenna
TERMBOX-1200	Termination box, Mains and signal	For extended surge and overvoltage protection
QMZ101	Maintenance cable	
PSION	Maintenance terminal (palmtop computer)	
CLTERMHOOD	Optical Termination Hood	
CT35022	Shock Absorber	For ship installations
HMP50 UAB1A1A	Internal Humidity Transmitter	

The complete delivery also includes mating cables with connectors for power and communication, installation hardware, a key for the measurement unit door, and this CL31 User's Guide.

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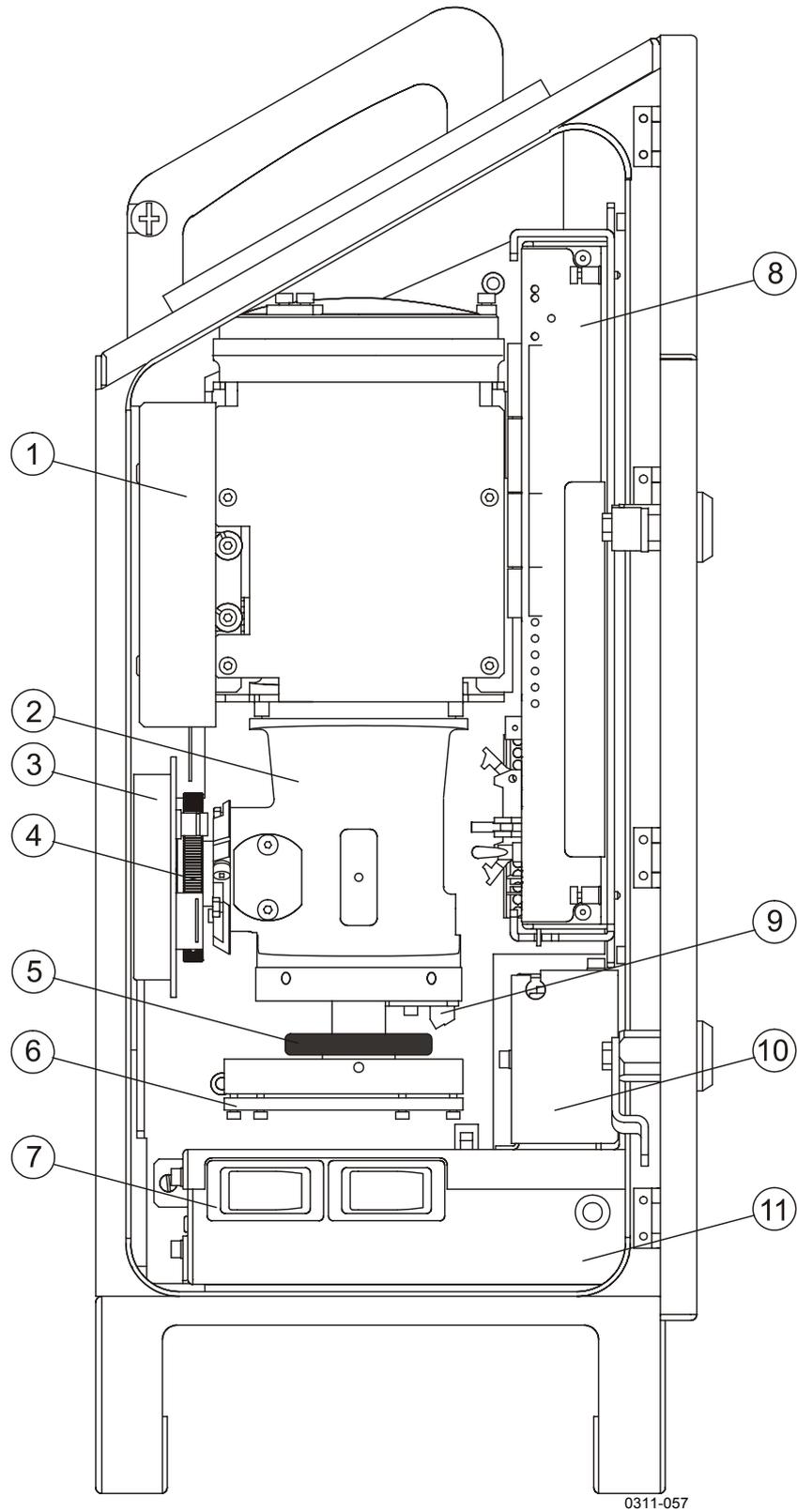
Figure 2   Ceilometer CL31 Main Parts

The following numbers refer to Figure 2 on page 16:

1	=	Internal heater CLH311
2	=	CLO311 Optics unit
3	=	Ceilometer Receiver CLR311
4	=	Receiver ring
5	=	Transmitter ring
6	=	Ceilometer Transmitter CLT311
7	=	F1 Main circuit breaker
		F2 Window blower circuit breaker
8	=	Ceilometer Engine Board CLE311
9	=	Laser Monitor Board CLM311
10	=	Battery 4592
11	=	AC Power CLP311
12	=	Battery switch

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CHAPTER 3
INSTALLATION

This chapter provides you with information that is intended to help you install this product.

Installation Procedure

This section describes the installation procedure of Vaisala Ceilometer CL31.

Unloading and Unpacking Instructions

CL31 is shipped in one container that contains the shield, the measurement unit inside the shield, and all the equipment, accessories, and documentation needed for carrying out the installation. Store the original packaging for possible later transport need.

For opening, the package should be placed on a flat surface with the indicated top side up. You should open the container from the top side and carefully remove the ceilometer and all the other equipment.

- Use proper gloves for protection against sharp edges, etc.
- Avoid touching the window or lens surfaces, unless you plan to clean them properly afterwards.
- Keep the integral protective caps on the unused external connectors (J4 Maintenance line).
- Use the measurement unit handle for lifting and carrying the measurement unit. See Figure 3 on page 20.
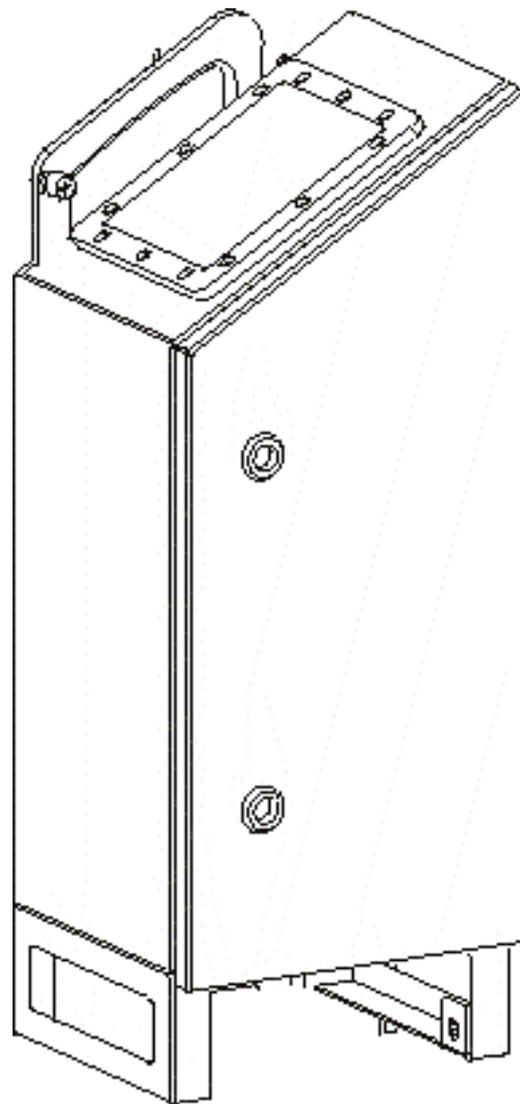
0311-054

Figure 3   Measurement Unit Handle

If mishandling occurs during transit or installation, the instrument should be returned to a Vaisala office or authorized Depot for inspection.

Preparing a Concrete Foundation

The standard foundation for the CL31 ground installation is a concrete foundation. The minimum dimensions suggested are presented in Figure 4 on page 21. Mounting hardware is included with the delivery.

> **NOTE**
>
> In case CL31 is used to replace another ceilometer (CT25K, CT12K, LD40, LD25, or LD12) the existing foundation and foundation screws can be used.
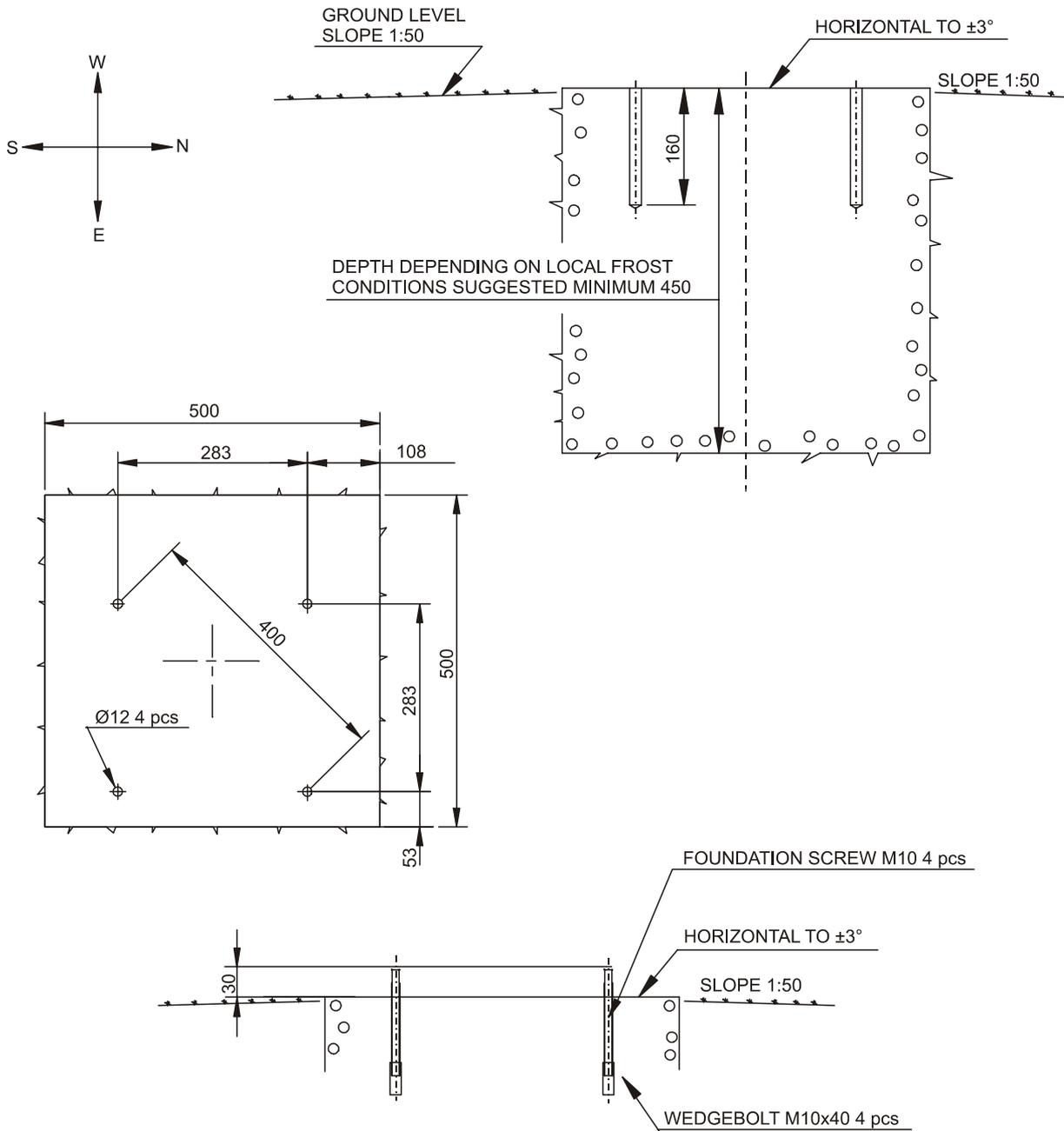
Figure 4   Foundation Construction

There are two alternative ways to create a concrete foundation for Ceilometer CL31. You can either cast a new concrete foundation or use an existing one.

NOTE	If the tilt feature will be used (see section Using the Tilt Feature on page 29), observe this in the layout of the foundation screws and shield placement.

Creating a New Concrete Foundation

1. Fasten the M10 × 40 wedge bolts to the lower ends of the foundation screws (4 each).
2. Fix a drilling template to the upper ends of the foundation screws with nuts.
3. Place the template with the attached foundation screws into the hole in such a way that approximately 30 mm (1.25 inches) of the foundation screw threads stand above the surface.
4. Pour in the concrete and finish the foundation.

Using an Existing Foundation

1. Drill four holes with a diameter of 12 mm and a depth of 165 mm (0.5 × 6.5 inches) into the concrete.
2. Fasten the M10 × 40 wedge bolts to the lower ends of the foundation screws (4 each).
3. Place the wedge bolt and foundation screw combinations into the holes, with the wedge bolts down, and hammer the protruding threads down.
4. Tighten the foundation screws a few turns to attach the wedge bolts to the hole walls.

Mounting the Ceilometer CL31

Ceilometer CL31 is delivered with the measurement unit attached to the shield. If two people are handling the installation, the shield can be mounted with the measurement unit attached. It is, however, recommended that you first remove the measurement unit, mount the shield, and then reattach the measurement unit to the shield.

To mount Ceilometer CL31, proceed as follows:

1. Remove the measurement unit from the shield. To do this, loosen the three attachment screws (marked A in Figure 5 below), disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

2. Place the shield on the foundation in such a way that the door faces North in the Northern hemisphere and South in the Southern hemisphere. Refer to Figure 6 on page 24.

3. Place the flat washers on the foundation screws and fix the nuts. Refer to Figure 6 on page 24.

4. Place the measurement unit inside the shield, connect the blower cable to connector J1, and tighten the three attachment screws (marked A in Figure 5 below).
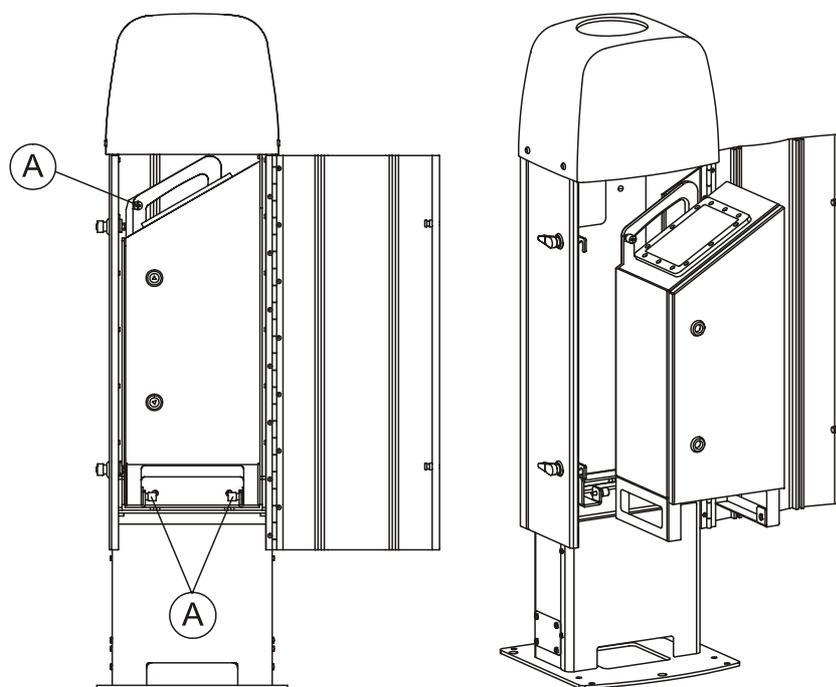
0311-055

Figure 5   Removing and Attaching the Measurement Unit

N   NORTH IN NORTHERN HEMISPHERE

(⟶ S   SOUTH IN SOUTHERN HEMISPHERE)

PEDESTAL

NUT M10 4 pcs

WASHER B10 8 pcs

FOUNDATION SCREW
M10 4 pcs
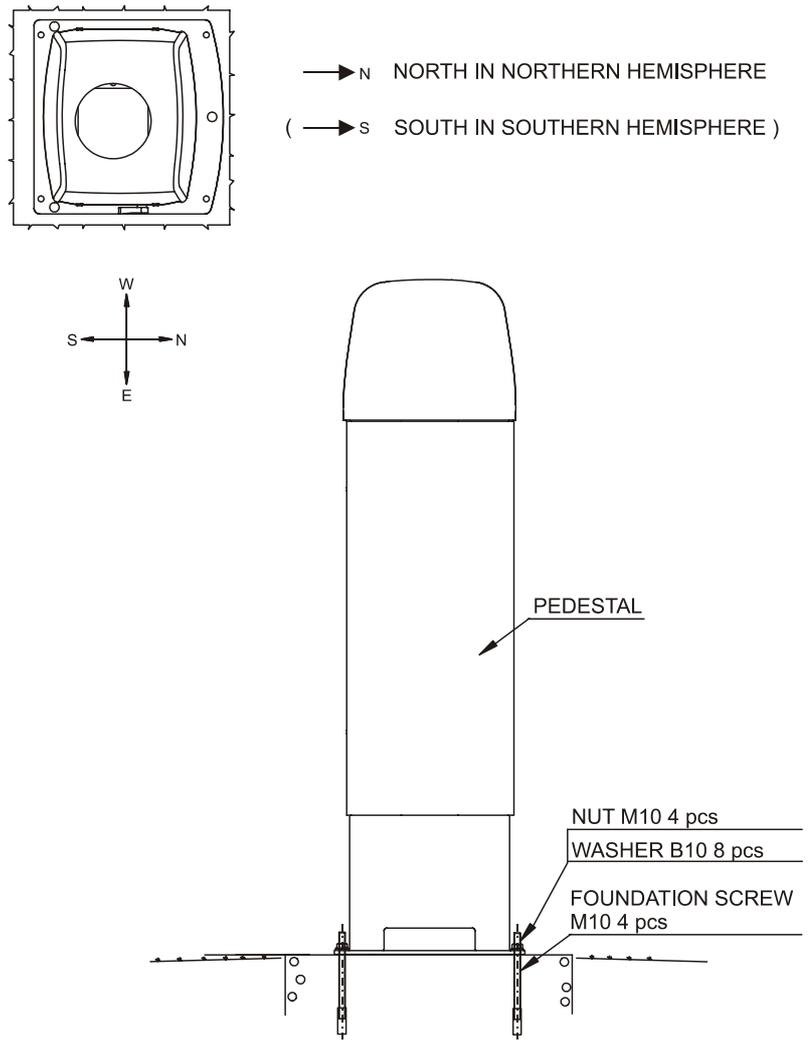
0311-056

Figure 6   Mounting the Shield

Connecting the External Cables

All external connectors to the measurement unit are located at the bottom front edge as seen from the door direction. Figure 7 below shows the external connectors J1, J2, J3, and J4.
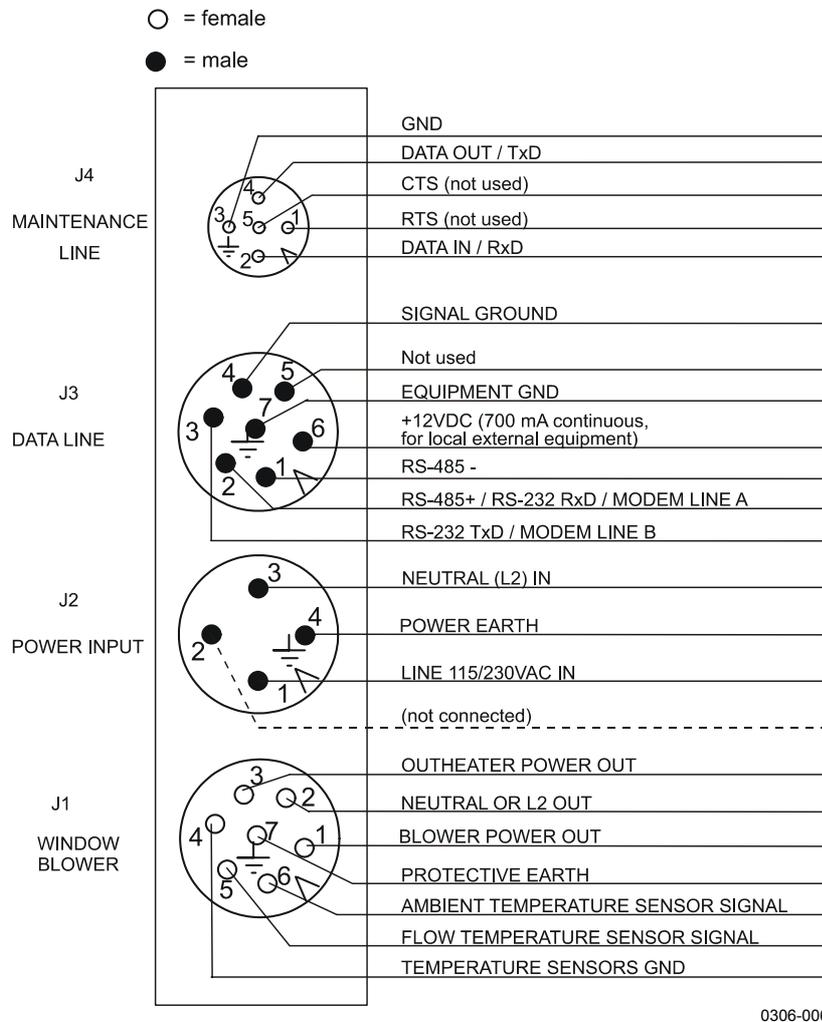
Figure 7   External Connectors (Bottom View)

The window blower mounted into the shield is connected to connector J1. Line power input is connected to connector J2. Remote communication is normally connected to connector J3. A local maintenance terminal, a laptop or a palmtop for example, can be connected to connector J4. A protective cap is included for covering J4 when it is not used.

External mating connectors with 2 m (7 ft) cable are included for J2 and for J3. The power plug of the J2 cable can be cut when the unit is permanently installed at the final site.

The wire connections and cable glands of the optional Termination Box are presented in the Termination Box User's Guide (refer to section Related Manuals on page 8).

NOTE	When the permanent line power installation is made, the maximum size of the fuse protecting the power line is 10 A.

Data Line Connection

Vaisala Ceilometer CL31 offers three possible options for the data line connection. These options are presented in the following figures.
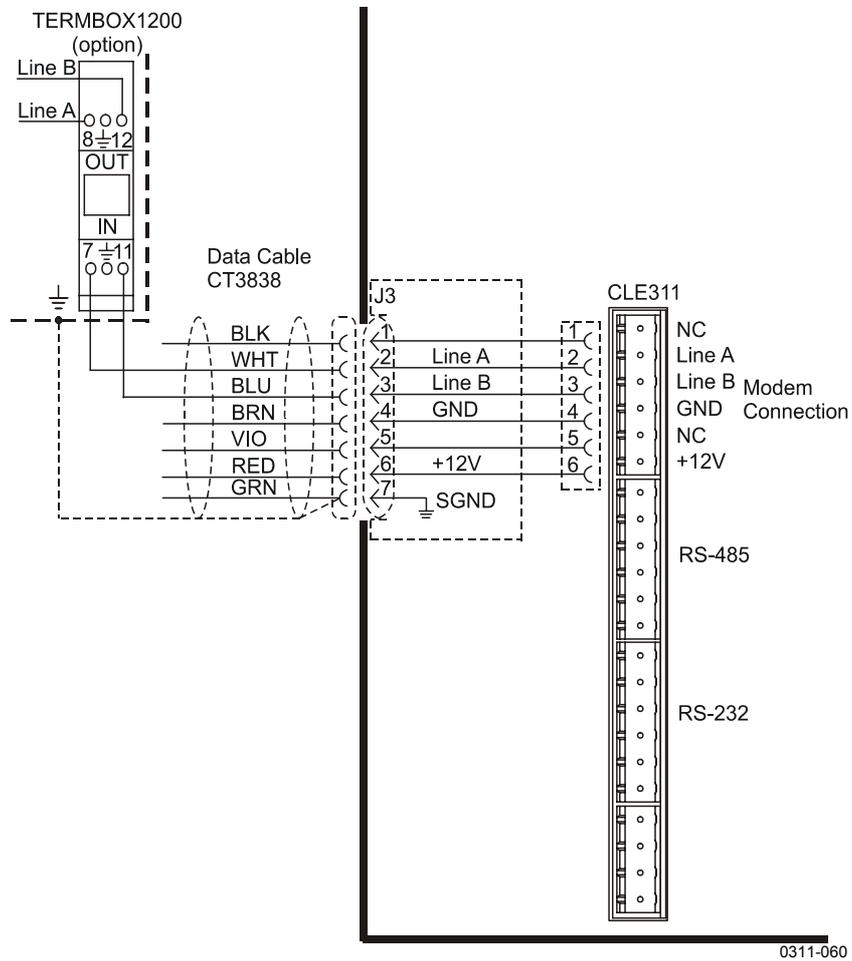
0311-060

Figure 8   Data Line Modem Connection

Default Settings for the Data Line Modem Connection

Modem mode   V.22bis
Bit rate   2400
Data bits   8
Stop bits   1
Parity   None
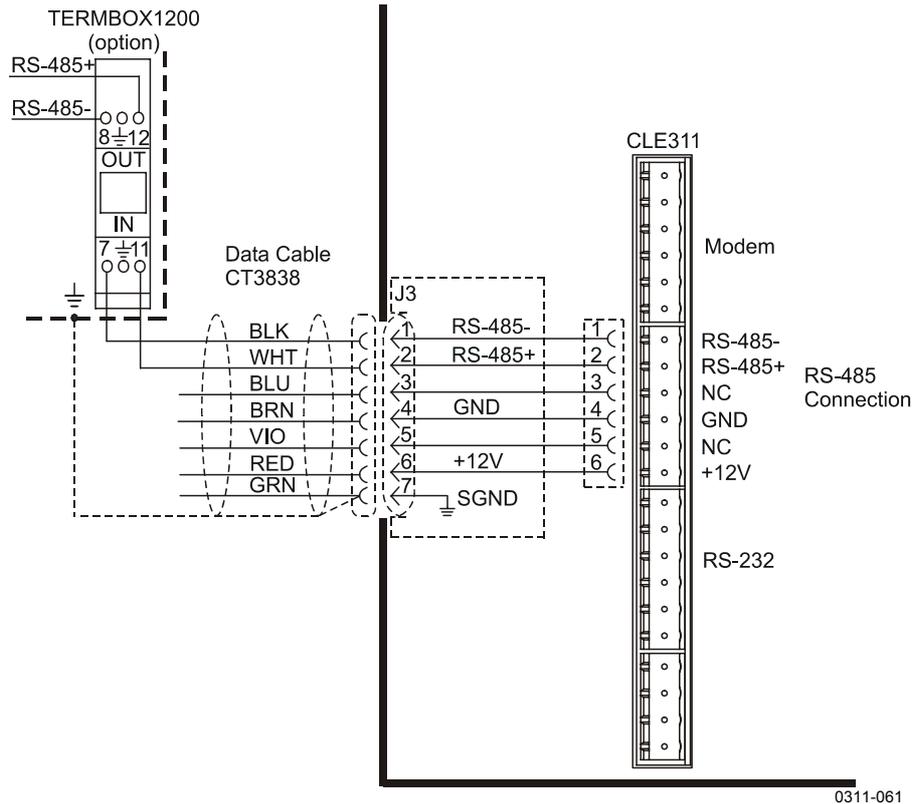
0311-061

Figure 9   Data Line RS-485 Connection

Default Settings for the Data Line RS-485 Connection

Bit rate   19200
Data bits   8
Stop bits   1
Parity   None
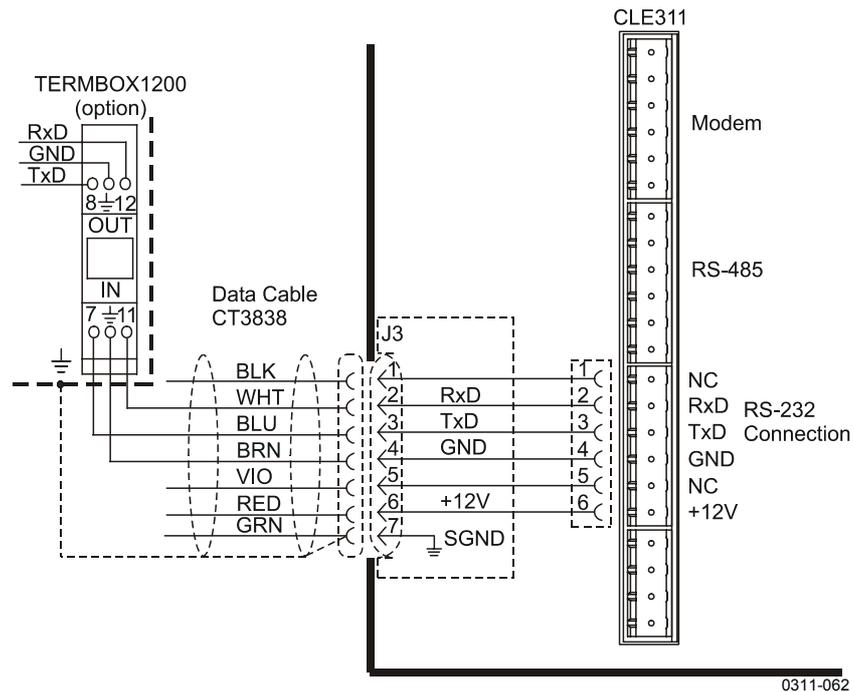
Figure 10   Data Line RS-232 Connection

Default Settings for the Data Line RS-232 Connection

Bit rate	19200
Data bits	8
Stop bits	1
Parity	None
Handshake	None

Grounding

The power supply connector J2 provides a standard protective ground for the instrument chassis.

CL31 is equipped with a separate grounding screw for external grounding at the bottom of the shield.

CAUTION	Connection to a solid earth ground at the installation site is mandatory for adequate lightning and transient protection.

Maintenance Terminal Connection

Any terminal or PC with a serial interface and a terminal emulation program can be used for operation and maintenance of Ceilometer CL31. The maintenance terminal connection is established with the QMZ101 maintenance cable, which connects the RS-232 port of the PC to the maintenance port of the ceilometer.

A standard maintenance terminal option includes a PSION Palmtop Computer and its Technical Manuals.

Setting up Maintenance Terminal Connection

1.   Connect the RS cable to the ceilometer maintenance port (connector J4) and the terminal computer.

2.   Set the following settings for the terminal:

        Bit rate   9600
        Data bits   8
        Stop bits   1
        Parity   None
        Handshake   None

Operation of Maintenance Terminal Connection

To operate the connection, do the following:

1.   Turn the power on in CL31.

2.   Open the CL31 maintenance with the **open** command.

3.   The prompt CEILO > appears. For details, see Chapter 5, Functional Description, on page 73.

Using the Tilt Feature

Ceilometer CL31 is designed to allow operation in a tilted direction. The built-in tilt angle sensor detects the tilt angle, that is, the deviation from vertical. The tilt feature allows three tilt angles: vertical, 12 degrees with the measurement unit door upwards, and 12 degrees with the measurement unit door downwards. The cosine of the tilt angle is used for an automatic correction of the detected cloud base height, which enables accurate cloud base measurements also in a tilted direction.

The tilt feature provides the following advantages:

- Protection in heavy weather conditions:
  Using a tilt angle of 12 degrees protects the measurement unit window from precipitation, thus enhancing the performance in heavy weather conditions.

- Precision in aircraft approach detection:
  The beam can be directed towards a direction that better represents the approach of an aircraft than the straight vertical. This is useful, for example, for helicopter approaches, and sites where the ceilometer cannot be located exactly at the desired spot.

WARNING	When tilting the unit, make sure that nobody is watching it with binoculars or other magnifying optics.

NOTE	To avoid direct sunlight, tilt the unit away from the sun. That is, tilt it north in the northern hemisphere and south in the southern hemisphere. Direct insolation exposure will not damage the unit but will cause alarms and temporarily invalidate the data

As these advantages may be contradictory or cannot be realized simultaneously, the user must decide the direction of the final installation.

Mobile Operation Aspects

The small and lightweight measurement unit of Ceilometer CL31 is also suitable for mobile operation. It has a built-in 12 V battery, which enables operation without external power supply for about an hour in normal room temperature.

NOTE	For switching the CL31 power fully off, also turn off the battery switch in addition to the line power switch. Having the unit on with the battery supply will only drain the battery.

NOTE	Do not attempt to carry a fully assembled unit alone, preferably, lift the measurement unit from the shield. The two main parts, the measurement unit (12 kg) and the shield (18.5 kg), can be lifted and carried separately.

Startup

This section describes the different aspects of Ceilometer CL31 that need to be considered before starting up the device.

Startup Procedure

Open the unit door with the key included in the delivery. Make a visual check of the internal connectors and subassemblies (refer to Figure 11 on page 32 for further information if necessary). Then proceed as follows:

1. Turn the main circuit breaker F1 to the **Off** position (for location, see Figure 12 on page 33).

2. Plug in the line supply cable to connector J2 (for location, see Figure 7 on page 25) after checking the voltage of the power supply cable connector.

3. Turn the Main Circuit Breaker F1, the Window Blower Circuit Breaker F2, and the Battery Switch to the **On** position. After the initialization routines, the **Laser on** LED starts blinking at 2-second intervals. Also the six diagnostic LEDs light up. For location of the LEDs and switches, refer to Figure 12 on page 33 and Figure 13 on page 34.

NOTE	For switching the CL31 power fully off, also turn off the battery switch in addition to the line power switch. Having the unit on with the battery supply will drain the battery.

WARNING	Make sure that nobody is viewing the unit from the beam direction with magnifying optics.
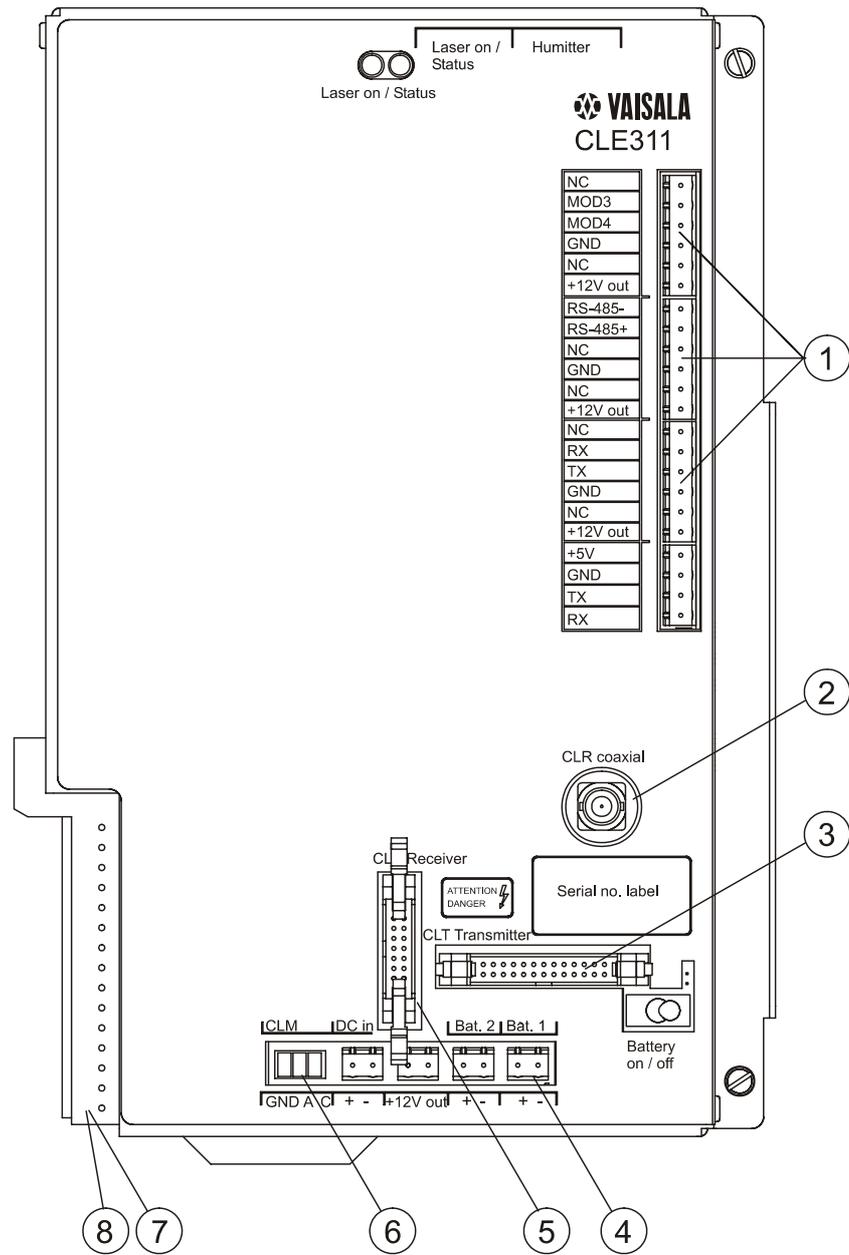
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Figure 11   Subassembly Interconnections

The following numbers refer to Figure 11 on page 32:

1 = Data line connection to AC power CLP311
2 = Coaxial cable connection to Ceilometer Receiver CLR311
3 = Connection to Ceilometer Transmitter CLT311
4 = Connection to Battery 4592
5 = Connection to Ceilometer Receiver CLR311
6 = Connection to Laser monitor board CLM311
7 = Connection to AC power CLP311
8 = Connection to Internal heater CLH311
9 = Battery switch
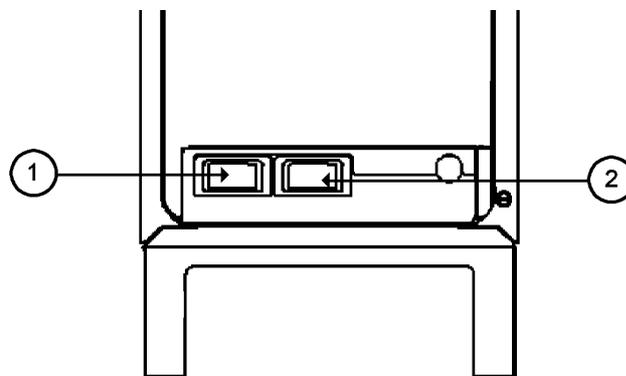
0406-053

Figure 12   CL31 Switches

The following numbers refer to Figure 12 above:

1 = F1 Main circuit breaker
2 = F2 Heater/Blower circuit breaker

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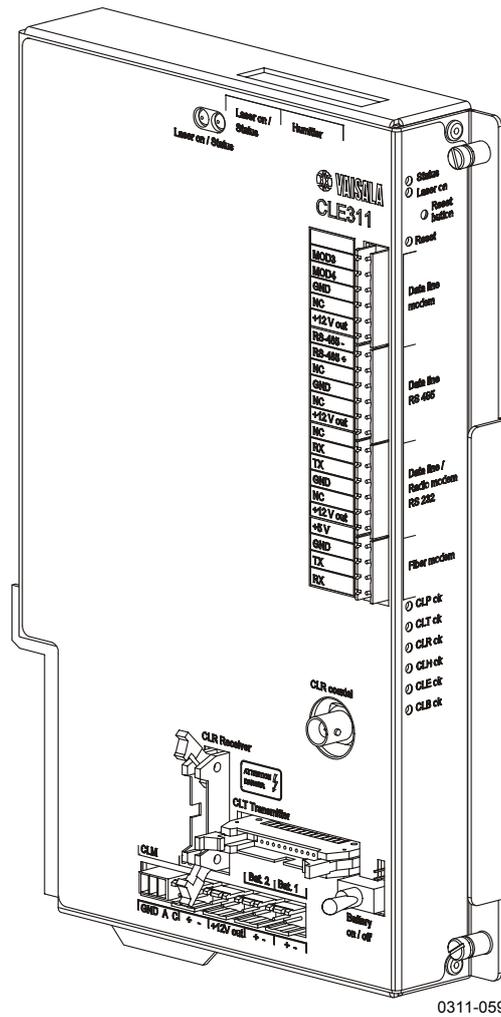
Figure 13   Ceilometer Engine Board CLE311

Settings for Normal Operation

The switch settings for normal operation are as follows:

Main circuit breaker F1	ON
Heater/Blower circuit breaker F2	ON
Battery switch	ON

The data message and interface configuration and the configuration of measuring interval and transmission speed are standard factory settings. When required, the settings can be changed by giving commands with the terminal.

During the factory alignment procedure, the optical adjustments are carefully carried out to fulfill the requirements and specifications of the device. Optical adjustments have been made at the factory or depot, thus there is no need to readjust them in the field.

Factory Settings of User Programmable Parameters

Table 4 below lists the factory defaults of user-programmable parameters. The prevailing parameter settings of Ceilometer CL31 can be seen with the following command:

get params *parameter_group*

The user-programmable parameters can be changed with the following command:

set *parameter_group parameter*

Table 4   Factory Defaults of User-Programmable Parameters

Parameter	Factory Default
Control blower	Auto
Control inheater	Auto
Data_acq power_save	Disabled
Data_port baud	19200
Data_port mode	RS232
Data_port parity	8N1
Maint_port baud	9600
Maint_port parity	8N1
Message angle_corr	On
Message transmission	Periodic
Message transmission delay	100 ms
Message height_offset	0
Message interval	2 s
Message port	Data
Message profile scale	1.0
Message profile noise h2	Off
Message type	msg2_20x385
Message units	Feet
Message vv_limit ceiling	2000 m (6562 ft)
Message vv_limit sky_cond_percent	50
Oper_mode	Normal
Port_timeout	2 min
Unit_id	0 (zero)

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CHAPTER 4
OPERATION

This chapter contains information that is needed to operate this product.

Operation Modes

There are two operation modes, normal and standby. The **set oper_mode normal** and **set oper_mode standby** commands are used to switch between the modes. In the normal mode, continuous measurement and message transmission occurs according to the chosen parameters. The standby mode, which involves turning off the wearing parts, can be used during periods when measurement is not needed.
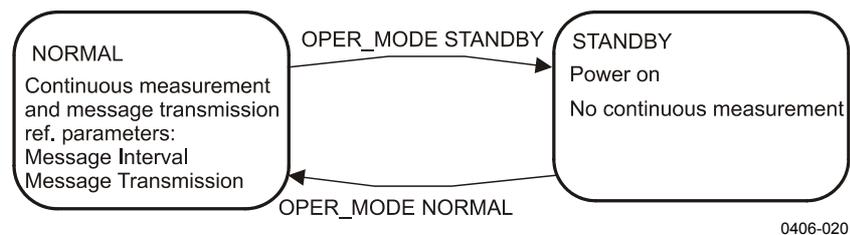
Figure 14   Operation Modes

Serial Lines - Open and Closed Port

The two serial lines provided are called the maintenance line (external connector J4) and the data line (external connector J3). The data line is intended to be used for measurement data communication and can be operated through a modem or baseband. The maintenance line is intended for on-site maintenance access, and is used only as a baseband. However, functionally the operation of the lines is identical,

the same commands, operations, and messages operate through any of the lines, and the following description applies to both of them.

The factory default setting is 8 data bits, No parity, 1 Stop bit, and for baseband lines, 9600 maint, 19200 data. The bit rate can be selected from the user menu.

Both use the 7-bit USASCII character format. Both the UPPER and lower letter cases can be used.

The standard operation of the serial lines requires no handshake signals.

A communication port, in other words the serial line, has the following two internal states (Figure 15 on page 39):

- CLOSED: This is the measurement data message transmitting state. In this state, messages are transmitted as a response to a polling input string or automatically at predetermined intervals, depending on the corresponding settings (message transmission). User commands are not accepted, except for the **open** command, which turns the line into the OPEN state.

- OPEN: This is the user dialog state. In this state, the user commands are responded to and command input is echoed. A command prompt CEILO > is displayed to indicate that CL31 is ready for command input from the user. The commands are executed by pressing ENTER, for example, OPEN 1 <enter>. No automatic transmission of the measurement data message is executed in the open state. The port reverts to the closed state with the **close** command. An automatic, 2-minute time-out after the last character input is applied. A 2 to 30-minute time-out may be set with the **set port_time_out** command.

NOTE	Only one of the ports can be open for commands at a time. Only one of the ports transmits measurement messages at a time. Additionally, in the RS-485 mode, a unit ID must be given with the **open command**.
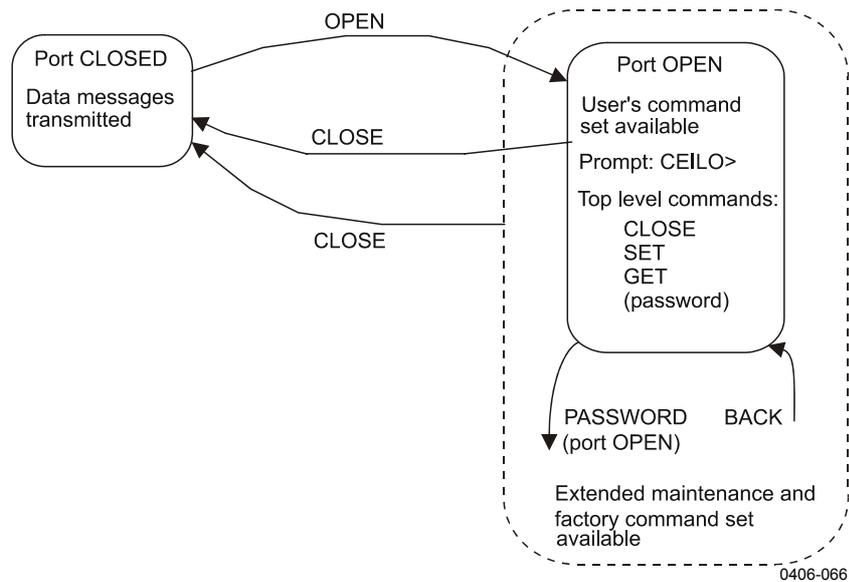
Figure 15   Open and Closed Port

User Commands

User commands are described in Table 5 on page 40. User commands are accessible after opening the line with the **open** command. No password is needed.

The exact format of commands does not have to be remembered, as the command line interpreter provides interactive support. At each menu level, pressing ENTER provides an output of the available menu. Inserting a letter followed by ENTER outputs all commands starting with that letter. Inserting two letters followed by ENTER outputs all commands that start with those two letters, etc., until only the desired command is left. This command is then executed by pressing the ENTER key.

In addition to the user menu and the user level command set, there is a second in-depth maintenance and service level menu and command set, which is intended for more profound system changes and diagnostics. These advanced level commands are presented in a separate table (see Table 6 on page 43). The password for this level is "advanced". The commands on this level should only be used according to the instructions in this manual.

Table 5   User Level Commands

Command	Description
close	Closes a user interface. Releases a port for message transmission.
get diag contamination	Prints diagnostic history of window contamination.
get diag angle	Prints diagnostic history of inclinometer angle.
get diag battery	Prints diagnostic history of battery voltage.
get diag int_temp	Prints diagnostic history of internal temperature.
get diag l_power	Prints diagnostic history of laser power.
get diag l_temp	Prints diagnostic history of laser temperature.
get failure history	Prints history of alarm and warning status.
get failure status	Shows active alarms and warnings.
get params data_acq	Prints data-acquisition related parameters.
get params factory	Prints factory calibration values.
get params message	Prints message related parameters.
get params port	Prints serial port and modem parameters.
get sensors	Prints data-acquisition values, tilt angles, and humidity, if available.
get temperatures	Displays temperatures.
get uptime	Displays uptime clock.
get voltages	Displays voltages.
name	Displays device type, name, and ID.
open	Opens a user interface.
reset	Resets the ceilometer using the watchdog reset.
set control blower on	Sets the window blower on.
set control blower off	Sets the window blower off.
set control blower manual	Sets manual control.
set control blower auto	Sets automatic control.
set control inheater on	Sets inheater on.
set control inheater off	Sets inheater off.
set control inheater manual	Sets manual control.
set control inheater auto	Sets automatic control.
set control outheater on	Sets outheater on.
set control outheater off	Sets outheater off.
set data_port baud 115.2 k	Data serial port speed.
set data_port baud 57.6 k	Data serial port speed.
set data_port baud 38.4 k	Data serial port speed.
set data_port baud 28.8 k	Data serial port speed.
set data_port baud 19.2 k	Data serial port speed.
set data_port baud 14.4 k	Data serial port speed.
set data_port baud 9600	Data serial port speed.
set data_port baud 7200	Data serial port speed.
set data_port baud 4800	Data serial port speed.
set data_port baud 3600	Data serial port speed.
set data_port baud 2400	Data serial port speed.
set data_port baud 1800	Data serial port speed.
set data_port baud 1200	Data serial port speed.
set data_port baud 900	Data serial port speed.
set data_port baud 600	Data serial port speed.
set data_port baud 300	Data serial port speed.
set data_port mode RS-232	Data serial port mode.
set data_port mode RS-485	Data serial port mode.
set data_port parity 7E1	Data serial port settings.

Command	Description
set data_port parity 7O1	Data serial port settings.
set data_port parity 8N1	Data serial port settings.
set defaults	Restores the following default settings:
	Operation mode: normal
	Measurement mode: standard
	Data acquisition autoadjustments: on
	Blower control: auto
	Inheater control: auto
	Diagnostics intervals: 2 min
	Power-save mode: disabled
	Power-save sleep interval: 60 s
	Message angle correction: on
	Message transmission: periodic
	Message transmission delay: 100 ms
	Message height-offset: 0
	Message interval: 2 s
	Manual message: disabled
	Message port: data
	Message profile scale: 1.0
	Message profile noise-h2: off
	Message type: msg2_20x385
	Message units: feet
	Message VV limit ceiling: 6562 ft (2000 m)
	Message VV limit sky-condition percentage: 50 %
	Port timeout: 2 min
	Unit ID: 0
set diag interval angle	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval battery	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval contam	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval int_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_power	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval clear	Clears all diagnostic-data history.
set maint_port baud 115.2 k	Maintenance serial port speed.
set maint_port baud 57.6 k	Maintenance serial port speed.
set maint_port baud 38.4 k	Maintenance serial port speed.
set maint_port baud 28.8 k	Maintenance serial port speed.
set maint_port baud 19.2 k	Maintenance serial port speed.
set maint_port baud 14.4 k	Maintenance serial port speed.
set maint_port baud 9600	Maintenance serial port speed.
set maint_port baud 7200	Maintenance serial port speed.
set maint_port baud 4800	Maintenance serial port speed.
set maint_port baud 3600	Maintenance serial port speed.
set maint_port baud 2400	Maintenance serial port speed.
set maint_port baud 1800	Maintenance serial port speed.
set maint_port baud 1200	Maintenance serial port speed.
set maint_port baud 900	Maintenance serial port speed.
set maint_port baud 600	Maintenance serial port speed.
set maint_port baud 300	Maintenance serial port speed.
set maint_port parity 7E1	Maintenance serial port settings.
set maint_port parity 7O1	Maintenance serial port settings.
set maint_port parity 8N1	Maintenance serial port settings.
set message transmission delay	Sets request-based delivery response delay (ms).

Command	Description
set message transmission periodic	Sets periodic message transmission.
set message transmission request	Sets message request-based delivery.
set message interval 2 ... 120	Sets message delivery interval in seconds.
set message port data	Delivers messages into data port.
set message port maintenance	Delivers messages into maintenance port.
set message type msg1_10x770	Sets Msg1 with 10x770 profile.
set message type msg1_20x385	Sets Msg1 with 20x385 sample profile with 385 samples and 20 m resolution.
set message type msg1_5x1500	Sets Msg1 with 5x1500 profile.
set message type msg1_5x770	Sets Msg1 with 5x770 profile.
set message type msg1_base	Sets Msg1 without a profile.
set message type msg2_10x770	Sets Msg2 with 10x770 profile.
set message type msg2_20x385	Sets Msg2 with 20x385 profile.
set message type msg2_ 5x1500	Sets Msg2 with 5x1500 profile.
set message type msg2_ 5x770	Sets Msg2 with 5x770 profile.
set message type msg2_base	Sets Msg2 without a profile.
set message type status	Sets status message.
set message type ct25k_msg1	Sets CT25K message 1.
set message type ct25k_msg6	Sets CT25K msg6 / CT25KAM msg60.
set message type ct25k_msg61	Sets CT25KAM msg61.
set message type ct12k_dmsg2	Set CT12K message no. 2.
set message type ct12k_dmsg3	Set CT12K message no. 3.
set message type ld40_std_tg	Sets LD40 Standard Telegram.
set modem v21 answer	Sets modem to answer with v21.
set modem v21 originate	Sets modem to call with v21.
set modem v22 answer	Sets modem to answer with v22.
set modem v22 originate	Sets modem to call with v22.
set modem v22bis answer	Sets modem to answer with v22bis.
set modem v22bis originate	Sets modem to call with v22bis.
set modem off	Disables the communication module and uses serial line communication.
set name <string>	Sets the unit name.
set oper_mode standby	Sets standby mode. Profile sampling is inactive.
set oper_mode normal	Sets normal operation.
set port_time_out 0 ... 30	Sets the command line time-out to 0 ... 30 minutes. Zero disables.
set unit_id <character>	Sets the unit ID.
status	Prints the status message.
system	Lists system information: type, ID, SW version, HW modules, serial number.
version	Displays the SW version.

Table 6   Advanced Level Commands

Command	Description
back	Go back one security level. Go back to the user level commands.
get failure diag	Show failure diagnostics data.
get params algorithm	Prints cloud algorithm related parameters.
service replace_instr battery	Prints service instructions for replacing a battery.
service replace_instr cle_engine_board	Prints service instructions for replacing a CLE311 engine board.
service replace_instr clp_ac_power	Prints service instructions for replacing a CLP311 power unit.
service replace_instr clr_receiver	Prints service instructions for replacing a CLR311 receiver.
service replace_instr clt_transmitter	Prints service instructions for replacing a CLT311 transmitter.
service self_check	Runs the self-check.
service spare_part cle_engine mark	Marks CLE spare part status.
service spare_part cle_engine clear	Clears CLE spare part status.
service spare_part clt_transmitter mark	Marks CLT spare part status.
service spare_part clt_transmitter clear	Clears CLT spare part status.
service sw_update	Updates the software.
set data_acq autoadj on	Sets SW-control of data acquisition parameters.
set data_acq autoadj off	Disables SW-control of data acquisition parameters.
set data_acq meas_mode standard	Maximum range 7700 m, 10 m resolution, laser pulse rate 10 kHz.
set data_acq meas_mode high_res	Maximum range 7550 m, 5 m resolution, laser pulse rate 8 kHz.
set data_acq power_save disable	Disables power-save mode.
set data_acq power_save enable	Enables power-save mode.
set data_acq power_save interval 30 ... 30000	Power-save interval in seconds. Default is 60.
set data_acq receiver gain low	Sets receiver to low gain.
set data_acq receiver gain high	Sets receiver to high gain.
set data_acq transmit length_of_p short	Sets transmitter to short pulse.
set data_acq transmit length_of_p long	Sets transmitter to long pulse.
set data_acq transmit inlaser 0 ... 4095	Sets control value for laser pulse.
set factory outlaser 0 .. 2500	Sets target outlaser.
set factory win_clean	Sets window clean status for window cond. calibration.
set message angle_corr on	Heights in messages are corrected for the tilt angle.
set message angle_corr off	Heights in messages are not corrected for the tilt angle.
set message height_offset <value>	Sets height offset in current units. (Range is -304 ... 304 m or -1000 ... 1000 ft.) Positive values are added to and negative values are subtracted from the measured height.
set message manual_msg <string>	Sets a manual message. Empty string disables.
set message profile scale	Scaling factor for range gate data (%).
set message profile noise_h2 on	Range gates data is always range normalized, even noise.

Command	Description
set message profile noise_h2 off	Range gates data is range normalized, if backscatter is contained.
set message units feet	Reported heights unit is feet.
set message units meters	Reported heights unit is meters.
set message vv_limit ceiling 0 ... 7620	Sets vertical visibility ceiling limit (meters/feet). No vertical visibility will be reported above this limit. (Default: 2000 m).
set message vv_limit sky_cond_percent 1 ... 100	Sets vertical visibility reporting limit (%).
set message units vv_limit ceiling	Sets vertical visibility ceiling limit (meters/feet).
set option humitter on	Enables the humitter option.
set option humitter off	Disables the humitter option.
set option sky_cond off	Disables the sky condition option.
set option sky_cond on 0 .. 99999	Enables the sky condition option with an activation code.

Data Messages

To ease the use of Ceilometer CL31 and to ease the transfer from old ceilometer versions to the new one, CL31 includes data messages used in CT12K, CT25K, CT25KAM, and LD40. CL31 provides the following data messages:

- CL31 Data messages 1 and 2

- CL31 Status message

- CT12K data messages No. 2 and No. 3

- CT25K data messages No. 1 and No. 6

- CT25KAM data messages No. 60 and No. 61

- LD40 Standard Telegram

Each port can be set to transmit a specified message automatically. Alternatively, the port can be set to transmit the set message only when polled by a predetermined polling string of characters, or the polling string can contain the message identification.

The messages may provide a different resolution and require a different measurement mode. A change of a message always switches into a correct measurement mode automatically.

However, CL31 Status message and CL31 Data messages 1 and 2 of subclass 5 (without profile data) may be used in both 10 m and 5 m resolutions. A selection of these messages always activates the 10 m

resolution (standard mode). If needed, users can change into the 5 m resolution (high resolution) by typing the following advanced level command: **set data_acq meas_mode high_res**. Thus, the above messages will work in 5 m resolution.

NOTE	All characters are 7-bit USASCII.
	↵ symbolizes Carriage Return + Line Feed (2 characters) throughout this document.
	Start-of-Header, Start-of-Text, End-of-Text, End-of-Transmission, Carriage Return, and Line Feed are non-printing characters in most practical terminal use.

CL31 Data Messages No. 1 and 2

Data message No. 1 contains cloud height/vertical visibility measurement and elementary status information that enables a host system or operator to see that no warnings or alarms are present. This message also includes a range and sensitivity normalized backscatter profile, which makes it suitable, for example, for a graphical data presentation or research purposes.

The data resolution is 5 m/10 m/20 m (16 ft/33 ft/66 ft) with distance, and 20 bits (five hex-ASCII characters) with signal magnitude.

An example of CL31 data message No.1 is presented below:

```
☎CLA10011☺↵                                  1st line    12 char.
30 01230 12340 23450 FEDCBA987654↵           2nd line    35 char.
00100 10 0770 098 +34 099 12 0621 L0112HN15 139↵  3rd line    49 char.
00000111112222233333 ... (5 x 770 bytes)↵    4th line    3852 char.
☻1a3f♦↵                                      5th line    8 char.
                                             Total       3956 char.
```

An example of CL31 data message No. 2 is presented below:

```
☎CLA10021☺↵                                  1st line    12 char.
30 01230 12340 23450 FEDCBA987654↵           2nd line    35 char.
  3 055   5 170   0 ///   0 ///   0 ///↵     3rd line    37 char.
00100 10 0770 098 +34 099 12 0621 L0112HN15 139↵  4th line    49 char.
00000111112222233333 ... (5 x 770 bytes)↵    5th line    3852 char.
☻1a3f♦↵                                      6th line    8 char.
                                             Total       3993 char.
```

For data lines with low bandwidth, there is a short version of each message. In the short version of message No.1, lines 3 and 4 are left out. Correspondingly, in the short version of message No.2, lines 4 and 5 are left out. In the table below, the data message types are summarized with the minimum bit rates and storage capacity. The examples are divided into two measurement resolutions of 10 m and 5 m. They have different minimum reporting intervals, 2 s and 3 s.

Table 7   Messages with 10 m Resolution (Standard Mode)

Message Number and Subclass	Message Name	Length (bytes)	Min bps (2 s)	Data/Month (2 s)	Min bps (12 s)	Data/Month (12 s)
11	msg1_10x770	3956	28.8k	4890 MB	4800	815 MB
12	msg1_20x385	2031	14.4k	2510 MB	2400	418 MB
15	msg1_base	55	300	68 MB	300	11 MB
21	msg2_10x770	3993	28.8k	4940MB	4800	423 MB
22	msg2_20x385	2068	14.4k	2560 MB	2400	425 MB
25	msg2_base	92	600	114 MB	300	19 MB

Table 8   Messages with 5 m Resolution (High Resolution)

Message Number and Subclass	Message Name	Length (bytes)	Min bps (3 s)	Data/Month (3 s)	Min bps (15 s)	Data/Month (15 s)
13	msg1_5x1500	7606	28.8k	6267 MB	9600	1253 MB
14	msg1_5x770	3956	14.4k	3260 MB	4800	625 MB
15	msg1_base	55	300	45 MB	300	9 MB
23	msg2_5x1500	7643	28.8k	6230 MB	9600	1260 MB
24	msg2_5x770	3993	14.4k	3290 MB	4800	660 MB
25	msg2_base	92	600	76 MB	300	15 MB

The interpretation of the message lines is as follows:

1ST LINE

Example: ☎CLA10011☺↵

where

☎   =   Start-of-Heading character
CL =   Ceilometers' identification string; always CL
A   =   Unit identification character 0 ... 9, A ... Z
100 =   Software level ID 100 ... 999
1   =   Message number; message without sky condition data
          is = 1, with sky condition data is = 2

where

1	=	Character for subclasses of message

        1 = 10 m x 770 samples, range 7700 m (*msg1_10x770*)
        2 = 20 m x 385 samples, range 7700 m (*msg1_20x385*)
        3 = 5 m x 1500 samples, range 7500 m (*msg1_5x1500*)
        4 = 5 m x 770 samples, range 3850 m (*msg1_5x770*)
        5 = without a backscatter profile

☺ = Start-of-Text Character
↵ = Carriage Return + Line Feed

2ND LINE

Example: `30 01230 12340 23450 FEDCBA987654`↵

where

3	= First digit of line:	Detection status as follows:
	0	No significant backscatter
	1	One cloud base detected
	2	Two cloud bases detected
	3	Three cloud bases detected
	4	Full obscuration determined but no cloud base detected
	5	Some obscuration detected but determined to be transparent
	/	Raw data input to algorithm missing or suspect

0	= Second digit of line:	Warning and Alarm information as follows:
	0	Self-check OK
	W	At least one Warning active, no Alarms
	A	At least one Alarm active

01230	= If detection status is 1, 2, or 3:	Lowest cloud base height
	If detection status is 4:	Vertical Visibility as calculated
	If detection status is 0 or 5:	/////

12340	= If detection status is 2 or 3:	Second lowest cloud base height
	If detection status is 4:	Highest signal detected
	If detection status is 0, 1, or 5:	/////

23450	= If detection status is 3:	Highest cloud base height
	If detection status is 0, 1, 2, 4, 5:	/////

FEDC = Alarm (A), Warning (W), and internal status (S) information. Each character is
BA98   a hexadecimal representation of four bits, i.e. values between 0 and 9 are
7654   presented with respective numbers and values 10, 11, 12, 13, 14, and 15 are
        presented with letters A, B, C, D, E, and F, respectively. As each of the 12
        characters represent the sum of four individual bits, the total number of bits is
        48 (b00-b47), with the following breakdown and interpretation:

F:	b47	(8000 0000 0000)	Transmitter shut-off (A)
	b46	(4000 0000 0000)	Transmitter failure (A)
	b45	(2000 0000 0000)	Receiver failure (A)
	b44	(1000 0000 0000)	Voltage failure (A)
E:	b43	(0800 0000 0000)	Alignment failure (A)
	b42	(0400 0000 0000)	Memory error (A)
	b41	(0200 0000 0000)	Light path obstruction (A)
	b40	(0100 0000 0000)	Receiver saturation (A)
D:	b39	(0080 0000 0000)	(spare) (A)
	b38	(0040 0000 0000)	(spare) (A)
	b37	(0020 0000 0000)	(spare) (A)
	b36	(0010 0000 0000)	(spare) (A)
C:	b35	(0008 0000 0000)	(spare) (A)
	b34	(0004 0000 0000)	(spare) (A)
	b33	(0002 0000 0000)	Coaxial cable failure (A)
	b32	(0001 0000 0000)	Ceilometer engine board failure (A)
B:	b31	(0000 8000 0000)	Window contamination (W)
	b30	(0000 4000 0000)	Battery voltage low (W)
	b29	(0000 2000 0000)	Transmitter expires (W)
	b28	(0000 1000 0000)	High humidity (W)
A:	b27	(0000 0800 0000)	(spare) (W)
	b26	(0000 0400 0000)	Blower failure (W)
	b25	(0000 0200 0000)	(spare) (W)
	b24	(0000 0100 0000)	Humidity sensor failure (W)
9:	b23	(0000 0080 0000)	Heater fault (W)
	b22	(0000 0040 0000)	High background radiance (W)
	b21	(0000 0020 0000)	Ceilometer engine board failure (W)
	b20	(0000 0010 0000)	Battery failure (W)
8:	b19	(0000 0008 0000)	Laser monitor failure (W)
	b18	(0000 0004 0000)	Receiver warning (W)
	b17	(0000 0002 0000)	Tilt angle > 45 degrees warning (W)
	b16	(0000 0001 0000)	(spare) (W)
7	b15	(0000 0000 8000)	Blower is on (S)
	b14	(0000 0000 4000)	Blower heater is on (S)
	b13	(0000 0000 2000)	Internal heater is on (S)
	b12	(0000 0000 1000)	Working from battery (S)
6	b11	(0000 0000 0800)	Standby mode is on (S)
	b10	(0000 0000 0400)	Self test in progress (S)
	b09	(0000 0000 0200)	Manual data acquisition settings are effective (S)

	b08	(0000 0000 0100)	(spare) (S)
5	b07	(0000 0000 0080)	Units are meters if on, else feet (S)
	b06	(0000 0000 0040)	Manual blower control (S)
	b05	(0000 0000 0020)	Polling mode is on (S)
	b04	(0000 0000 0010)	(spare) (S)
4	b03	(0000 0000 0008)	(spare) (S)
	b02	(0000 0000 0004)	(spare) (S)
	b01	(0000 0000 0002)	(spare) (S)
	b00	(0000 0000 0001)	(spare) (S)

For example, if no clouds are detected, if the window is contaminated, the battery voltage is too low, the internal heater is on and units are meters, a warning is given and the second line appears as follows:

```
0W  ///// ///// /////   0000C0002080
```

ADDITIONAL 3RD LINE IF MESSAGE NO. = 2

Example: __3_055__5_170__0_///__0_///__0_///↵

(space character indicated with '_' for clarity)

where

3	= First digit of line:	Detection status as follows:
	0 ... 8	Cloud amount of the first layer in oktas
	9	Vertical visibility
	-1	Data missing, sky condition option not active or the ceilometer is in standby mode
	99	Not enough data (after start-up)
055	= Second digit of line:	Height of the 1st cloud layer (550 m or 5500 ft depending on the selection)
5	= Third digit of line:	Cloud amount of the 2nd layer in oktas
170	= The fourth number of line:	Height of the 2nd cloud layer (1700 m or 17000 ft depending on the selection)
0	= Fifth digit of line:	Cloud amount of the 3rd layer in oktas
///	= Sixth digit of line:	Height of the 3rd cloud layer
0	= Seventh digit of line:	Cloud amount of the 4th layer in oktas
///	= Eighth digit of line:	Height of the 4th cloud layer
0	= Ninth digit of line:	Cloud amount of the 5th layer in oktas
///	= Tenth number of line:	Height of the 5th cloud layer

The reporting resolution is 10 m or 100 ft depending on the selection. If the cloud amount is zero, the corresponding layer height is ///.

3RD LINE (4TH LINE OF MESSAGE NO. 2)

Example: `00100 10 0770 098 +34 099 12  621 L0112HN15 139↵`

where

00100	=	Parameter SCALE, 100 (%) is normal (0 ... 99999 possible)
10	=	Backscatter profile resolution in meters.
0770	=	Length of the profile in samples 385, 770, 1400, or 1500
098	=	Laser pulse energy, % of nominal factory setting (0 ... 999)
+34	=	Laser temperature degrees C (-50 ... +99)
099	=	Window transmission estimate % (0 ... 100)
12	=	Tilt angle, degrees from vertical (0 ... 90)
0621	=	Background light, millivolts at internal ADC input (0 ... 2500)
L0112HN15	=	Measurement parameters (pulse **L**ong/**S**hort, pulse qty 0112x1024, gain **H**igh/**L**ow, bandwidth **N**arrow/**W**ide, sampling **15**/**30** MHz)
139	=	SUM of detected and normalized backscatter, 0 ... 999. Multiplied by scaling factor times 10^4. At scaling factor 100 the SUM range 0 ... 999 corresponds to integrated backscatter 0 ... 0. $srad^{-1}$.

NOTE   This line is omitted if the message subclass is 5.

4TH LINE (5TH LINE OF MESSAGE NO. 2)

Example: `00000111112222233333........(5 x 770 bytes)↵`

The two-way attenuated backscatter profile with sensitivity normalized units $(100000 \cdot srad \cdot km)^{-1}$ unless otherwise scaled by the *SCALE* parameter. Each sample is coded with a 20-bit HEX ASCII character set; msb nibble and bit first, 2's complement. The length of this line is equal to 5 times the length of the profile + 2. Note that the profile is not corrected for the tilt angle.

Using the *SCALE* parameter a total dynamic range of 29 bits can be achieved for this message.

The line ends with Carriage Return and Line Feed characters.

NOTE	This line is omitted if the message subclass is 5.

5TH LINE (6TH LINE OF MESSAGE NO. 2)

Example: ⊗1a3f♦↵

where

⊗   = End-of-Text character
1a3f   = Checksum, see below for calculation procedure
♦   = End-of-Transmission character
↵   = Carriage Return + Line Feed

CRC16 Checksum

The CRC16 checksum can be calculated using the following
algorithm written in the C programming language:

```c
/* 16-bit type. */
typedef unsigned short Word16;

/* Calculate CRC-16 value as used in CL31. */

Word16 crc16(const unsigned char *buf, int len)
{
    Word16 crc;
    Word16 xmask;
    int    i, j;

    crc = 0xffff;

    for (i = 0; i < len; ++i)
    {
        crc ^= buf[i] << 8;

        for (j = 0; j < 8; ++j)
        {
            xmask = (crc & 0x8000) ? 0x1021 : 0;
            crc <<= 1;
            crc ^= xmask;
        }
    }

    return crc ^ 0xffff;
}
```

The calculation of the checksum starts after the Start-of-Heading character and ends after the End-of-Text character, that is, the first character included is C and the last one included is End-of-Text.

CL31 Status Message

The Status message displays the internal monitoring of the entire unit. It is mainly meant for testing and maintenance purposes. The Status message can be displayed by giving the **status** command.

An example of the status message is presented below:

```
☎CL0100S0☺↵
10 00850 ///// ///// 000000000080↵

Alarms↵
 Tmit Shutoff  OK     Transmitter  OK↵
 Receiver      OK     Voltages     OK↵
 Alignment     OK     Ext Memory   OK↵
 Light Pth Obs OK     Rec Saturat  OK↵
 Coaxial Cable OK     Engine       OK↵

Oper Mode:  normal   Autoadj:   on↵
Meas Mode:  standard Interval:  2.0 s↵
Power Save: disabled Sleep Int: 60 s↵

Transmitter          Receiver↵
 Pulse Len: long      Gain:      high↵
 Inlaser:   1745      Bandwidth: narrow↵
 Pulse Cnt: 16384     Smpl Rate: 15 MHz↵
 Pulse Frq: 10.0 kHz↵

Window Cnd: 100 %    Outlaser:  1064↵
Backg Rad:  2.4                 103 %↵

Tilt Angle: 0.4      Humidity: N/A↵

Temperatures↵
 Internal:  23.7     External:  8.7↵
 DC Power:  22.6     Inclinom:  28.9↵
 Laser:     25.6     Blower:    8.3↵

Heater: off (auto)   Outheater: off↵
Blower: off (auto)↵  Batt use: off

System Status:   OK↵
 Suspect Module: none↵
☹↵
```

Message interpretation:

1ST LINE

The first line of the CL31 status message is structurally identical to the first line of the CL31 data message No. 1 (see the message interpretation in section CL31 Data Messages No. 1 on page 45) except that the second to last character that identifies the message number, is always SØ☺↵.

2ND LINE

The second line of the CL31 status message is structurally identical to the second line of the CL31 data message No. 1 (see the message interpretation in section CL31 Data Messages No. 1 on page 45).

LINES 3 ... 8

Lines three to eight display the alarm status of Ceilometer CL31. Should an alarm be present, CL31 will invalidate the cloud data.

9TH LINE

The ninth line displays the operation mode and autoadjustment settings of CL31. In normal use, the operation mode should be set to **normal** and autoadjustment should be set to **on**.

10TH LINE

The tenth line displays the measurement mode and measurement interval settings of CL31. In normal use, the measurement mode should be set to **standard**. The measurement interval is by default 2.0 s.

11TH LINE

Line 11 displays the power-save mode status and sleep interval settings of CL31. In normal use, the power-save mode is **disabled**. The sleep interval indicates the interval when CL31 does not measure if the power-save mode is on.

LINES 12 ... 16

Lines 12 to 16 display the transmitter and receiver settings of CL31.

`Transmitter`	`Pulse Len`	=	Pulse length, **long** in normal use (100 ns)
	`Inlaser`	=	Controls the peak laser power
	`Pulse Cnt`	=	Pulse count, the number of pulses fired during a single measurement cycle, 16384 by default
	`Pulse Frq`	=	Laser pulsing frequency (10.0 kHz)
`Receiver`	`Gain`	=	**High** by default, may be **low** in fog or heavy snow
	`Bandwidth`	=	**Narrow** by default
	`Smpl Rate`	=	Receiver signal sampling rate, defines the vertical resolution of the measurement. Default is 15 MHz which corresponds to a 10 m resolution.

17TH LINE

Line 17 displays the window contamination status and outlaser settings of CL31. The estimated transparency of 90 % to 100 % means that the window is clean. It is recommended that the window is cleaned whenever there is a window contamination warning, that is, the transparency is estimated as 70 % or lower.

Outlaser is the laser pulse energy measured with CLM311 Laser Monitor Board. The value underneath the outlaser value (on line 17) refers to the percentage of the laser power relative to the factory setting. The embedded software will maintain this value between 95 % and 105 %.

18TH LINE

Line 18 displays the background radiance value of CL31. The background radiance varies according to the background illuminance condition and temperature. The following values, outlaser percentage, is described above.

19TH LINE

Line 19 displays the tilt angle in degrees from vertical. Humidity measurement is visible if the option is activated.

LINES 20 ... 23

Lines 20 and 23 display temperature values in degrees centigrade. These values are used for the automatic control of internal heaters and blower, and for status monitoring.

LINES 24 ... 25

Lines 24 and 25 display the status of the internal heater, blower, blower heater, and battery.

26TH LINE

Line 26 displays a summary of the system status. It should be **OK**. Alternatively, it can display the texts **Warning** or **Alarm/Fail**, if there are warnings or alarms present.

27TH LINE

Line 27 displays the automatic diagnosis in case of a failure. The system suggests a module to be replaced. If there is a secondary option, it will be stated in parentheses.

28TH LINE

Example: ☺↵

where

☺   = End-of-Text character
↵   = Carriage Return + Line Feed

CT12K Messages

Ceilometer CL31 also includes two Ceilometer CT12K messages. These are digital message No.2 and digital message No.3.

CT12K Digital Message No. 2

This message contains detailed range gate data, and internal monitoring data for the most important variables.

An example of digital message No.2 is presented below:

```
☎↵
10 04200 00150 ///// ///// 0000011010 ↵
2 0 0.08 36   0 100 23.9 0.00  0  0   ↵
0DD ...............................DD ↵
-1                                    ↵
-2                                    ↵
-3                                    ↵
-4                                    ↵
-5                                    ↵
-6  (data values;)                    ↵
-7                                    ↵
-8                                    ↵
-9                                    ↵
10                                    ↵
11                                    ↵
12DD..............................DD ↵
☹↵
```

ON/OFF data is l/O accordingly. Other data is decimal or hexadecimal numbers. The total length of the message is 636 characters. The printout is 15 lines, the width is max 44 characters, of which 42 are visible.

Message Interpretation:

1ST LINE

Example: ☎↵

where

☎ =   Start-of-Heading character
↵ =   Carriage Return + Line Feed

2ND LINE

The first line of the message is status line 1. Status line 1 is identical in all CT12K messages.

Example:

```
NSB  H₁H₁H₁H₁H₁  T₁T₁T₁T₁T₁  H₂H₂H₂H₂H₂  T₂T₂T₂T₂T₂  S₁S₂S₃S₄S₅S₆S₇S₈S₉S₁₀↵
```

where

N	=	0	No significant backscatter (clear air)
		1	One layer detected
		2	Two layers detected
		3	Sky is fully obscured but no cloud base can be detected from echo signal received (e.g. fog or precipitation)
		4	Sky is partially obscured and no cloud base is detected

S	=	0	No CL31 alarm is active
		1	Alarm is active

B	=	Space if S = 0
		'bel' character if S = 1. Because 'bel' is a nonprinting character, the alarming line appears one character shorter in a printout than normally.

N	=	0 / 4	$H_1=H_2=T_1=T_2=$ /////
		1 / 2	$H_1H_1H_1H_1H_1$ = The lowest detected cloud height in 5 digits. Leading zeroes not suppressed. $T_1T_1T_1T_1T_1$ = Range of backscatter of first layer, ///// if not defined
		2	$H_2H_2H_2H_2H_2$ = Second cloud height, ///// if not defined $T_2T_2T_2T_2T_2$ = Range of backscatter of second layer, ///// if not defined
		3	$H_1H_1H_1H_1H_1$ = Calculated vertical visibility $T_1T_1T_1T_1T_1$ = Signal range i.e. height of highest detected backscatter

S_1	=		An alarm or a warning is active
S_2	=		Voltage alarm
S_3	=		Transmitter alarm or transmitter expires warning
S_4	=		Transmitter shutoff alarm (Laser temperature too high)
S_5	=		High radiance warning
S_6	=		Blower On
S_7	=		Heater On
S_8	=	0	Unit is feet
		1	Unit is meters
S_9	=	0	Always (Data type in internal table. N/A)
S_{10}	=	0	Always (Fast Heater Off is active. N/A)

3RD LINE

The second line of the message is status line 2.

Example: `G F N.NN SUM IIN LAS TLx OF.FS XX PP↵`

where
G	=	0	Low gain
		2	High gain
F	=	0	Always (Laser pulse frequency. N/A)

N.NN = Background radiance/100. One digit, two decimals.

SUM = Sum of total backscattered power per unit solid angle i.e. range and instrument normalization applied. Three digits, no decimals. Leading zeroes replaced by space characters.

IIN = 0 Always (Algorithm related internal processing information. N/A) 3 digits

LASE = Measured laser power in percentages of current laser power of target laser power (LLAS). 3 digits.

TL.x = Internal variable indicating transmitter temperature. Two digits, one decimal; preceded by minus sign if negative. Degrees Celsius.

OF.FS = 0.00 Always (Offset of zero signal. N/A) Two digits, two decimals.

XX = 0 Always (Algorithm related internal processing information. N/A) Two digits.

PP = 0 Always (A two-digit number representing calculated extinction coefficient values. N/A)

LINES 4 ... 16

Lines 3 to 15 are the data lines of the message.

Example: $HHD_0D_1D_2D_3$ .... D_9↵

where

HH	=	Height of the first value
D	=	Data values

The data is scaled to a hexadecimal number O ... FE (decimal 0 ... 254). Overflow is indicated by FF. A leading zero is replaced by a space character.

Data values are presented for each 50 ft range gate. The height of the first value in the line in thousands of feet. Two digits, a leading zero is replaced by a space. Twenty 50 ft values per line starting with 0 (ft), next line 1000 (ft). 13 lines altogether. Last line (12000 ft) has 10 values.

CT12K Digital Message No. 3

This message contains Status Line 1 identical to Message No. 2 (see section CT12K Digital Message No. 2 on page 55) and one single range gate data line indicating the presence or absence of backscatter in each range gate.

An example of digital message No.3 is presented below:

```
☎↵
10 04200 00150 ///// ///// 0000011010 ↵
0001FFF80000000000007A000......000   ↵
☹↵
```

ON/OFF data is l/O accordingly. Other data is decimal or hexadecimal numbers. The total length of the message is 112 characters. The printout is 2 lines, the maximum width is 66 characters, of which 64 are visible. The time for message transmission at 300 baud is 3.73 s.

Message Interpretation:

1ST LINE

Example: ☎↵

where

☎ = Start-of-Heading character
↵ = Carriage Return + Line Feed

2ND LINE

The first line of the message is status line 1. Status line 1 of digital message No.3 is identical to that of message No. 2 (see the message interpretation in section CT12K Digital Message No. 2 on page 55).

3RD LINE

The second line of the message is a backscatter data line.

Example: $D_1D_2D_3D_4$........................D_{64}↵

where

D = A single, ASCII coded hexadecimal character O ... F, where each bit of the 4-bit nibble of the hex character expressed in a binary form represents one range gate.

D_1 = Represents the four lowest 15 m (approximately 50 ft) range gates, that is, 45 m (appr. 0 ft, 50 ft, l00 ft, 150 ft).

D_2 = Represents the four next ones, that is, 60 m (appr. 200 ft, 250 ft, 300 ft, 350 ft), etc.

0 Indicates no detectable backscatter in four adjacent range gates
F Indicates backscatter in all four range gates
8 Indicates backscatter in the lowest range gate only
1 Indicates backscatter in the highest range gate only

All other characters indicate a gate-by-gate combination of backscatter according to the binary nibble, converted to hexadecimal.

CT25K Data Messages

Ceilometer CL31 also includes two Ceilometer CT25K data messages. These are data message No. 1 and data message No. 6.

CT25K Data Message No. 1

This message is intended for cloud height/vertical visibility measurement when no other measurement information is desired. The message includes the most elementary status information, which enables a host system or operator to see that no warnings or alarms are present. An example of data message No.1 is presented below:

```
☎CTA2010☺↵                        1st line   11 char.
30 01230 12340 23450 FEDCBA98↵    2nd line   31 char.
☹↵                                3rd line    3 char.
                                  ------------------
                                  total 44 characters
```

The transmission time and size is the following:

0.18 s at 2400 bps (10-bit char.)

10.6 Kbytes/h, 253 Kbytes/d, 7.6 Mbytes/mo. at 4 msg./min., uncompressed.

Message interpretation:

1ST LINE

Example: ☎CTA2010☺↵

where

☎ = Start-of-Heading character
CT = Ceilometers' identification string; always CT
A = Unit number 0 ... 9, A ... Z
20 = Software level id 00 ... 99
1 = Message number; this message is always = 1
0 = Spare character for future subclasses of message
☺ = Start-of-Text Character

2ND LINE

Example: 30 01230 12340 23450 FEDCBA98↵

Second line of CT25K data message No. 1 is identical to that of CL31 data message No. 1 (see the message interpretation in section CL31 Data Messages No. 1 on page 45), except for the status bit string, which is 4-byte hex coded. The status bit string is coded as follows:

where

FEDC BA98 = Alarm (A), Warning (W), and internal status information. Each character is a hexadecimal representation of four bits, that is, values between 0 and 9 are presented with respective numbers and values 10, 11, 12, 13, 14, and 15 are presented with letters A, B, C, D, E, and F respectively. As each character represents the sum of four individual bits, the total number of bits is 32 (b00-b31), with the following breakdown and interpretation:

F:	b31	(8000 0000)	Transmitter shut-off (Laser temperature high.) (A)
	b30	(4000 0000)	Transmitter failure (A)
	b29	(2000 0000)	Receiver or coaxial cable failure (A)
	b28	(1000 0000)	Engine, voltage or memory failure (A)
E:	b27	(0800 0000)	(spare) (A)
	b26	(0400 0000)	(spare) (A)
	b25	(0200 0000)	(spare) (A)
	b24	(0100 0000)	(spare) (A)

D:	b23	(0080 0000)	Window contaminated (W)
	b22	(0040 0000)	Battery low (W)
	b21	(0020 0000)	Transmitter expire warning (W)
	b20	(0010 0000)	Heater or humidity sensor failure (W)
C:	b19	(0008 0000)	High radiance warning together with b02 (W)
	b18	(0004 0000)	Engine, receiver, or laser monitor failure warning (W)
	b17	(0002 0000)	Relative Humidity is high > 85 % (option) (W)
	b16	(0001 0000)	Light path obstruction or receiver saturation (also receiver failure active, b29) (A)
B:	b15	(0000 8000)	Blower failure (W)
	b14	(0000 4000)	(spare) (W)
	b13	(0000 2000)	(spare) (W)
	b12	(0000 1000)	(spare) (W)
A:	b11	(0000 0800)	Blower is ON
	b10	(0000 0400)	Blower heater is ON
	b09	(0000 0200)	Internal heater is ON
	b08	(0000 0100)	Units are METERS if ON, else FEET
9:	b07	(0000 0080)	Polling mode is ON
	b06	(0000 0040)	Working from battery
	b05	(0000 0020)	Always 0 (Single sequence mode is. N/A)
	b04	(0000 0010)	Always 0 (Manual settings are effective. N/A)
8:	b03	(0000 0008)	Tilt angle is > 45 degrees (W)
	b02	(0000 0004)	High radiance warning together with b19. (W)
	b01	(0000 0002)	Manual blower control
	b00	(0000 0001)	(spare)

3RD LINE

☹↵ = End-of-Text and Carriage Return + Line Feed

CT25K Data Message No. 6

Message number 6 is similar to message number 1 but extended with a sky condition line (see section Sky Condition Algorithm). For an interpretation, see section CT25K Data Message No. 1 on page 60.

The following is an example of message number 6 format:

```
☎CTA2060☺↵                        1st line   11 char.
30 01230 12340 23450 FEDCBA98↵    2nd line   31 char.
3 055  5 170  0 ///  0 ///↵       3rd line   30 char.
☹↵                                4th line    3 char.
                                  -------------------
                                  total 75 characters
```

The transmission time and size is the following:

total 75 characters

=> 0.31 s at 2400 bps (10 bit char.)

=> 18.0 Kbytes/h, 432 Kbytes/d, 12.7 Mbytes/mo. at 4 msg/min, uncompressed

Message interpretation:

LINES 1 and 2 are identical to that of Message number 1.

LINE 3

Example: `3 055  5 170  0 ///  0 ///`

where

3 = The first number of line: detection status as follows:

0 ... 8	Cloud amount of the first layer in oktas.
9	Vertical visibility.
-1	Data missing or the ceilometer is in standby mode.
99	Not enough data (after start-up).
055	The second number of line: Height of the 1st cloud layer (5500 ft or 550 m depending on feet or meter selection).
5	The third number of line: Cloud amount of the 2nd layer in oktas.
170	The fourth number of line: Height of the 2nd cloud layer (17000 ft or 1700 m depending on feet or meter selection).
0	The fifth number of line: Cloud amount of the 3rd layer in oktas.
///	The sixth number of line: Height of the 3rd cloud layer.
0	The seventh number of line: Cloud amount of the 4th layer in oktas.
///	The eighth number of line: Height of the 4th cloud layer.

The reporting resolution is 100 ft or 10 m depending on feet or meter selection. If the cloud amount is zero, the corresponding layer height is ///.

CT25KAM Data Messages

Ceilometer CL31 also includes two Ceilometer CT25KAM data messages. These are data message No. 60 and data message No. 61.

CT25KAM Data Message No. 60

CT25KAM message number 60 is identical to CT25K message number 6. Refer to section CT25K Data Message No. 6 on page 62.

CT25KAM Data Message No. 61

CT25KAM message number 61 is similar to CT25KAM message No. 60 (and CT25K message No. 6) but extended with a fifth layer in the sky condition line. An example of data message No. 61 is presented below:

```
☎CTA2061☺↵                               1st line    11 char.
30 01230 12340 23450 FEDCBA98↵           2nd line    31 char.
 3 055  5 170  0 ///  0 ///  0 ///↵      3rd line    37 char.
☹↵                                       4rd line     3 char.
                                         -----------------
                                         total 82 characters
```

The transmission time and size is the following:

total 82 characters
=> 0.34 s at 2400 baud (10-bit char.)
=> 20.4 Kbytes/h, 490 Kbytes/d, 14.6 Mbytes/mo. at 4 msg/min, uncompressed

LD40 Standard Telegram

Ceilometer CL31 also includes one Ceilometer LD40 data message. This is the standard telegram 'X1TA'. This message is given in clear text and includes cloud heights and additional meteorological data, date, time, sensor address, and status information of the instrument.

An example of the 'X1TA' telegram and a message interpretation are presented below:

```
☺X1TA_8_015_00.00.00_00:00_00875_11150_NODET_0100_0325_N
ODT_11300_11600_+025_ft_01_00000000_96 ↵ ☹
```

where

☺	=	Start-of-text character
X	=	Sensor type (X LD40)
1	=	Sensor ID number (0 to 9..ABC..MN)
TA	=	Text telegram
8	=	Instrument type, Always 8 = LD40
015	=	Telegram update time or message interval in seconds
00.00.00	=	Always (Date N/A))
00:00	=	Always (Time N/A)
00875	=	First cloud layer
11175	=	Second cloud layer
NODET	=	Third cloud layer (in this case: not detected)
0100	=	Penetration depth of laser beam into first cloud layer
0325	=	Penetration depth of laser beam into second cloud layer
NODT	=	Penetration depth of laser beam into third cloud layer
11300	=	Vertical visibility
11600	=	Maximum range of detection
+025	=	Cloud height offset (in this case the ceilometer is situated 25 ft above the runway level)
f	=	Dimensions of all values between byte 26 and byte 76 (ft or m_)
00	=	Always (Precipitation index. N/A)
00000000	=	System status and messages
96	=	Checksum (This value is only an example; the correct value may be different from this one.)
↵	=	Carriage return + Line feed
◆	=	End-of-transmission character

NOTE	The notation '_' stands for a space character.

Telegram Structure Remarks

a. Spaces (20 hex) always appear with the following bytes: 5, 7, 11, 20, 26, 32, 38, 44, 49, 54, 59, 65, 71, 76, 79, 82, 91.

The only other byte that may contain a <SPACE>, is byte 78, provided that the dimension is in meters.

Numbers are always given with the leading zeros as in bytes 27 to 31 in the example.

b. NODET (and NODT) indicates that the value in question has not been detected because there was only one cloud layer or no cloud layer at all, for example.

Like any measured value, NODET also contains information about the result of the measurement.

NODET may appear instead of cloud layers, minimum vertical extensions of clouds, and vertical visibility.

c. When bytes 83 to 90 signal an CL31 alarm, all cloud detection values within the telegram are replaced by minus signs (-, 2D Hex). For example:
----- is shown instead of bytes 27 to 31.

d. All values given are height above the runway level; Ceilometer CL31 itself might be located above or below the runway level. Therefore, byte 72 must always contain a sign byte, either + or -.

Failure and Warning Messages

Bytes 83 to 89 of the LD40 standard telegram inform about warnings and errors. A '0' signifies that no error of that error group has happened.

An alarm will lead to data telegrams to contain invalid data. A warning status does not cause invalid data.

The following tables describe how CL31 is mapped to the LD40 error groups. Table 9 below shows the definition of the different error groups.

Table 9   Error Group Definition

Error Group	Byte No.	Description
1	83	Engine board and voltages
2	84	Light path, receiver saturation and window condition.
3	85	Receiver and coaxial cable
4	86	Transmitter
5	87	Memory failure and general warnings
6	88	Temperature regulation
7	89	Always 0. Not used.

The following tables describe each single error code of the different error groups.

Table 10   Error Group 1 (Byte 83)

Error Code	Description
0	Status OK
1	Engine or voltage failure (A)
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used

Table 11   Error Group 2 (Byte 84)

Error Code	Description
0	Status OK
1	Light path obstruction (A) or Window contamination warning (W)
2	Receiver saturation (A)

Table 12   Error Group 3 (Byte 85)

Error Code	Description
0	Receiver OK
1	Not used
2	Not used
3	Not used
4	Receiver failure (A) or Coaxial cable failure (A) or Receiver warning (W)
5	Not used
6	Not used

Table 13   Error Group 4 (Byte 86)

Error Code	Description
0	Transmitter OK
1	Transmitter expires (laser power low) (W)
2	Transmitter failure
3	Not used
4	Not used
5	Not used
6	Transmitter shutoff (laser temperature too high) (A)

Table 14   Error Group 5 (Byte 87)

Error Code	Description
0	Status OK
1	Laser monitor failure (W) or Blower failure (W) or High radiation warning (W) or Engine warning (W) or Tilt angle warning (angle is > 45 degrees) (W) or Battery voltage low (W) or Battery failure (W) or Humidity high (option) (W) or Humidity Sensor failure (option) (W)
2	Not used
3	Memory failure (A)
4	Not used

Table 15   Error Group 6 (Byte 88)

Error Code	Description
0	Temperature regulation OK
1	Heater failure (W)

Table 16   Error Group 7 (Byte 89)

Error Code	Description
0	Always 0 (Data transmission. N/A)
1	Not used
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Not used
8	Not used

Checksum Calculation

The checksum of a data or a command telegram is calculated by computing the sum of all signs (alphanumerical signs and control codes such as STX, EOT CR, LF, except the checksum bytes itself), build the two's complement and take the lower byte of this result.

The higher half-byte and the lower half-byte - converted to a visible ASCII character - is the checksum.

See the following example with the **polling** command:

Telegram:

STX H0C!X1P----------83 EOT

1. Compute the sum:

   Sum = STX + 'H' + '0' + 'C' + !" + 'X' + '1' + 'P'
   + 10 x '-' + EOT

   Sum = 0x02 + 0x48 + 0x30 + 0x43 + 0x21 + 0x58
   + 0x31 + 0x50 + 10 x 0x2D + 0x04

   Sum = 0x037D HEX = 893 DEZ

2. Building the two's complement:

   The two's complement is built by inverting the binary representation of the sum and adding 1:

   2Com = ¬ Sum + 1= ¬ 0x037D + 0x01 = 0x0C83 HEX
   = 3203 DEZ .

3. Take lower byte and build ASCII-character:

   The lower byte of 2Com is 0x83 HEX, so the high byte of the checksum is 8 and the low byte is 3:

   Checksum = 83

Manual Message

The ceilometer can be set to transmit user defined cloud heights and status information. The user can set a cloud message in the format of line 2 of any real cloud message (e.g. Message No. 1 or CT25K data message). The message is a string and the maximum length is 33 characters. If the length is less than 33 characters, the remaining length will be padded with spaces. (The CT25K messages use only 29 characters). The end of a string is determined by a new line and the leading spaces are omitted. This message is volatile. The manual message command is behind the password "advanced". Below is an example of a manual message:

```
CEILO >  advanced
Service password accepted.
CEILO >  set message manual_msg "30 00200 01000 05000
000000000000"
OK
```

The **get params message** command displays the current manual message.

To return to the normal messages, give an empty string:

```
CEILO >   set meesage manual_msg

OK
```

The manual message is intended for testing purposes. After reset, the normal message takes effect.

Polling Mode

A port can be set to transmit a message only when polled by a predetermined polling string of characters. The polling string can contain the message identification.

The CL31 unit can be assigned an identification of one-character digit or letter. The factory setting is 0 (zero).

The polling mode is activated with the following command:

```
CEILO >  set message transmission request
```

Returning to the normal autosend mode is done using the following command:

```
CEILO > set message transmission periodic
```

The polling string format is as follows:

<Enq> CL*IdNo* ↵

where

Enq = Character ENQUIRE = ASCII 05H = control-E.
CL = Fixed ceilometer identifier; CL for CL31 messages, CT for CT25K and CT25KAM messages.
Id = Identification character, 7-bit printable ASCII character.
No = Optional message identifier; 1 or 6 for CT messages and 1 or S for CL messages. The CL identifier 1 returns the default option for data message No. 1. To return a particular subclass message, use one of the following identifiers: 11, 12, 13, 14, or 15. Data message No. 2 is requested similarly: 21, 22, 23, 24, or 25.
↵ = ENTER (Carriage Return) + Line Feed.

The following are examples of the polling command:

<Enq> CL112<Enter>   Message 1, subclass 2 from ceilometer No.1
<Enq> CT11<Enter>   CT25K Message 1 from ceilometer No.1

NOTE	If the *id* character in a polling string is replaced with a blank space, all ceilometers on the line will respond. Accordingly, if *No* is a blank space, CL31 sends the default message.

LD40 message is polled by sending a LD40 Command Telegram. Table 17 below describes the command telegram frame of a polling request.

Table 17   Command Telegram Description 'Polling Request'

Byte	Example	Description
0	<STX>	02 HEX (Start of text)
1	H	Command telegram header
2	0	Command telegram header
3	C	Command telegram header
4	!	Command telegram header
5	X	Instrument type --> Ceilometer
6	1	Sensor Id number (0 to 9..ABC..MIN). In

Byte	Example	Description
		this case --> 1
7-17	P----------	Command indicator --> P (polling), byte 8-17 not used and filled with '-'
18-19	83	Checksum (Hex-coded two's complement of the sum of bytes from 0 to 20, excluding bytes 18 and 19.
20	<EOT>	04 Hex (End of transmission)

CHAPTER 5
FUNCTIONAL DESCRIPTION

This chapter describes the functionality of the product.

Theory of Operation

Basic Principle of Operation

The operating principle of Ceilometer CL31 is based on the measurement of the time needed for a short pulse of light to traverse the atmosphere from the transmitter of the ceilometer to a backscattering cloud base and back to the receiver of the ceilometer.

With the speed of light being:

$c = 2.99 \times 10^8$ m/s (= 186 000 miles per second)

A reflection from 25000 ft will be seen by the receiver after

$t = 50.9\ \mu s$

The general expression connecting time delay (t) and backscattering height (h) is

$h = ct/2$

where c is the speed of light.

Practical Measurement Signal

Generally, particles at all heights backscatter light, and so the actual return signal may look like that shown in Figure 16 below.
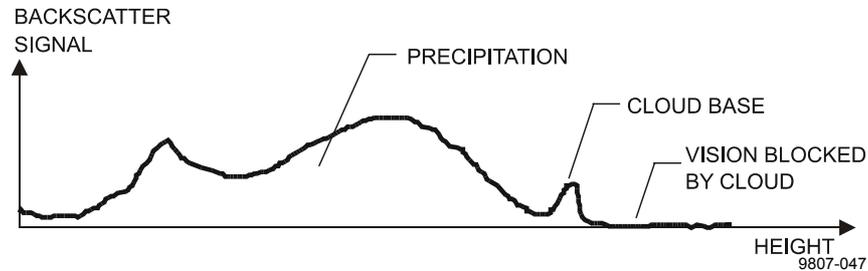

Figure 16   Typical Measurement Signal

The instantaneous magnitude of the return signal will provide information on the backscatter properties of the atmosphere at a certain height. Information about fog and precipitation, as well as clouds, can be derived from the return signal. Since fog and precipitation attenuate the light pulse, the cloud base signal will appear lower in magnitude in the return echo. However, the fog and precipitation information also provides data for estimating this attenuation and computing the necessary compensation, up to a limit.

In its normal full-range operation, Ceilometer CL31 digitally samples the return signal every 33 or 67 ms from 0 to 50 µs, providing a spatial resolution of 5 or 10 m feet from ground to the distance of 25000 feet. This resolution is adequate for measuring the atmosphere, since visibility in the densest clouds is of the same order.

Noise Cancellation

For safety and economic reasons, the laser power used is so low that the noise of the ambient light exceeds the backscattered signal. To overcome this, a large number of laser pulses are used, and the return signals are summed. The desired signal will be multiplied by the number of pulses, whereas the noise, being random, will partially cancel itself. The degree of cancellation for white (Gaussian) noise equals to the square root of the number of samples; thus, the resulting signal-to-noise ratio improvement will be equal to the square root of the number of samples. However, this processing gain cannot be extended endlessly since the environment changes and, for example, clouds move.

Return Signal Strength

The instantaneous return signal strength is in general form (the Lidar equation):

$$P_r(z) = Eo \cdot \frac{c}{2} \cdot \frac{A}{z^2} \cdot \beta(z) \cdot e^{-2\int_0^z \sigma(z')dz'}$$

where

$P_r(z)$	=	The instantaneous power received from distance z [W = Watt]
E_O	=	The effective pulse energy (taking all optics attenuation into account) [J = Joule = Ws = Watt - second]
c	=	The speed of light [m/s = meters per second]
A	=	The receiver aperture [m^2]
z	=	The distance in question [m]
ß(z)	=	The volume backscatter coefficient at distance z [$m^{-1}srad^{-1}$, srad = steradian]
$e^{-2\int_0^z \sigma(z')dz'}$	=	The two-way atmospheric transmittance, accounts for the attenuation of transmitted and backscattered power by extinction at various distances (z') between transceiver and distance in question (z). The expression equals 1 in clear atmosphere (i.e., with no attenuation).

Height Normalization

Assuming a clear atmosphere, it can be seen that the power is inversely proportional to the square of the distance or height, that is, the strength of a signal from 10000 ft is generally one-hundredth of that from 1000 ft.

The height-square dependence is eliminated by multiplying the value measured with the square of the height (height normalization). Noise, however, being height-independent from a measurement point of view, will then be correspondingly accentuated with increasing height.

Backscatter Coefficient

The volume backscatter coefficient, ß(z), of the Lidar Equation represents the portion of light which is reflected back towards the ceilometer from a distance z (for example, by water droplets). It is

obvious that the denser a cloud is, the stronger the reflection will be. The relationship can be expressed as follows:

ß(z) = k·σ(z)

where

k   =   A constant of proportionality.
σ(z) =   The extinction coefficient (the attenuation factor in a
              forward direction).

The extinction coefficient relates to *visibility* in a straightforward manner. If visibility is defined according to a 5 % contrast threshold (World Meteorological Organization definition for Meteorological Optical Range MOR, equals daylight *horizontal* visibility), then

σ = 3 / V

where

σ =   The extinction coefficient
V =   MOR visibility (5 % contrast)

The constant of proportionality, k, also called the Lidar Ratio, has been subjected to a lot of research. Although the Lidar Equation can be solved without knowing its value, it must remain constant with the height if accurate estimates of the extinction (or visibility) profile are to be made.

It has been discovered that in many cases, k can be assumed to equal 0.03, tending to be lower in high humidity (to 0.02), and higher in low humidity (to 0.05). However, in precipitation of various kinds, for example, k will have a wider range of values.

Assuming a value of 0.03 ($srad^{-1}$) for k, visibility in clouds being in the range of 15 to 150 m (50 to 500 ft), gives the following range of value for β:

$\beta = 0.0006 \ldots 0.006 \ m^{-1}srad^{-1} = 0.6 \ldots 6 \ km^{-1}srad^{-1}$

Extinction Normalization and Vertical Visibility

Any fog, precipitation, or similar obstruction to vision between the ground and the cloud base may attenuate the cloud base signal and produce backscatter peaks that far exceed that from the cloud. Virtually any backscatter height profile is possible, up to some physical limits. To distinguish a significant cloud return signal, the attenuation of, for example, fog or precipitation, has to be taken into account by normalizing with regard to extinction. The profile thus obtained is proportional to the extinction coefficient at various heights, and enables the use of a fairly straightforward threshold criteria to determine what is cloud and what is not.

By assuming a linear relationship between backscatter and extinction coefficient according to the previous formula and by assuming that the ratio, k, is constant over the range observed, it is possible to obtain an extinction coefficient profile through a mathematical computation. This is also called inverting the backscatter profile to obtain the extinction coefficient profile, and answers the question of what kind of extinction coefficient profile would produce the backscatter profile measured.

No assumption as to the absolute value of the ratio, k, needs to be made if k is constant with height. The assumptions that have to be made are fairly truthful, and in any case accurate enough for the purpose of cloud detection.

Likewise, the inversion is also independent of several instrumental uncertainties including transmitted power and receiver sensitivity.

An estimate of *Vertical Visibility* can easily be calculated from the extinction coefficient profile because of the straightforward extinction coefficient-to-visibility relationship, provided that a constant contrast threshold is assumed. Visibility will simply be the height where the integral of the extinction coefficient profile, starting from the ground, equals the natural logarithm of the contrast threshold, sign disregarded.

Tests and research have, however, shown that the 5 % contrast threshold widely used for horizontal measurement is unsuitable for vertical measurement if values close to those estimated by a ground-based observer are to be obtained.

Ceilometer CL31 uses a contrast threshold value which, through many tests, has been found to give vertical visibility values closest to those reported by ground-based human observers. A safety margin is obtained with regard to pilots looking down in the same conditions since the contrast objects, especially runway lights, are much more distinct on the ground.

CHAPTER 6
MAINTENANCE

This chapter provides information that is needed in the basic maintenance of the product.

Periodic Maintenance

Periodic maintenance is normally limited to window cleaning. In addition, warnings and alarms should be checked regularly with the maintenance terminal or another terminal or PC with a serial connection (see section CL31 Status Message on page 52). Proper function of the window blower, the only mechanically moving part, automatically checked once an hour. Malfunction is reported in the data and status messages.

Alarms and Warnings

The data message has to be checked for alarms and warnings at regular intervals. The second character of line two contains warning and alarm information indicating the present status of the device as follows:

0	Self-check OK
W	At least one warning active, no alarms
A	At least one alarm active

In case there is an active alarm or warning, more information is given at the end of the second line as a binary code indicating the cause. The status message gives detailed information about the failure. See section Data Message on page 44.

Repair and service must be done according to the instructions in Chapter 7, Troubleshooting, on page 83 and Chapter 8, Repair, on page 91.

Window Cleaning

Data messages include a warning that informs when the window is contaminated. After the system has detected contamination on the window, it will start the blower, which is designed to remove light contaminants and dry off rain drops. If the contamination cannot be removed, CL31 will issue a **Window Contaminated** warning which indicates that the window must be cleaned.

To clean the window, proceed as follows:

1. First flush the window with clean water to remove coarse grains. Remember to keep the enclosure door closed.
2. Then clean the window with a soft, lint-free cloth moistened with a mild detergent. Be careful not to scratch the window surface.

While cleaning the window, you can also check the operation of the window blower. Unless it is already running, the blower should start when you block the laser beam with the cleaning cloth for some 5 seconds or more. This will verify that the blower is functional. If there are no low clouds, precipitation, or fog present, the blower should stop after the window is cleaned. In case of a malfunction, the window blower has to be replaced.

Calibration

After 5 years of operation, calibrate the window contamination measurement.

Also if the CL31 system starts issuing **Window Contamination** warnings frequently without a real reason, this may indicate that the window is worn out or the window contamination measurement has drifted. In that case, the window contamination measurement can be calibrated to ensure proper functioning.

To calibrate, do the following:

1. Make sure that the window is cleaned.

2. Then open the command line and enter the Advanced level by giving the **advanced** command.

3. Give the **set factory win_clean** command.

The calibration is carried out automatically.

NOTE	If the window is visibly worn out, replace it.

Checking the Door Gasket

The door of the measurement unit utilizes an electrically conductive rubber gasket to suppress electromagnetic radiation. When the door is opened, check that the gasket and the opposite contact surface is clean. Use a wet cloth for cleaning if necessary.

Battery Check

Check the battery condition annually. If any signs of aging such as a bulging battery case, white powder or residue near the battery vent, leaking electrolyte, or corroded terminals is observed replace the battery. Lead acid batteries may age in 3 to 5 years time and result in a rupture and loss of electrolyte.

NOTE	When disposing of old batteries, be sure to follow local environmental regulations.

NOTE	In freezing temperatures there is a danger of battery rupture if the battery is completely discharged. Do not store empty batteries in freezing temperatures. Replace the battery if signs of mechanical rupture are observed.

Storage

Have caps on all external connectors if stored unpacked for extended times in an unconditioned area. Keep the measurement unit door closed and also keep a dust cover on the window during long periods of storage.

Save the container for future transport use. When replacing, the equipment must be placed and padded in the same way as when initially received.

CHAPTER 7
TROUBLESHOOTING

This chapter describes common problems, their probable causes and remedies, and gives the contact information.

The goal of troubleshooting is to locate the cause for the potential problem. Failure situations are usually caused by dirt in optics or unclarity of the optical path. Also external conditions or the following replaceable subassemblies may be the source of problems:

- CLE311 Ceilometer Engine Board
- CLT311 Ceilometer Transmitter
- CLR311 Ceilometer Receiver
- CLM311 Laser Monitor Board
- CLP311 AC Power
- CLB311-115/230 Blower
- CLH311-115/230 Heater
- DRW217429 Coaxial cable
- 4592 Battery

If damage is suspected in a subassembly or a board, replace it with a spare part and send the defective part to Vaisala for repair/replacement.

NOTE	Replacements must only be performed by qualified maintenance personnel, and they must be done according to the instructions in Chapter 8, Repair on page 91. As a principle, customer made repairs are restricted to the replacement of subassemblies.

Accessing the Diagnostic Information

During normal operation, CL31 continuously monitors its internal status and regularly checks the blower and the heater. CL31 analyzes the diagnostic test results automatically and reports potential failures with every data message. Refer to section CT25K Data Messages on page 60.

CL31 identifies the potentially faulty subassemblies automatically. If this does not help you to find the origin of the fault and restore the ceilometer back to normal operation, refer to Table 18 on page 86, Table 19 on page 88, and Table 20 on page 89 for probable causes of warnings, alarms, and other typical faults. You can also refer to these tables to rule out any problems related to cable connections or the clarity of the window or optical path.

Equipment

To establish a service connection to the CL31 you need to have a maintenance terminal which can be a palmtop computer with an RS-232 Interface or a PC with serial interface, Maintenance cable QMZ101, and any terminal program. The CT-VIEW software can be used for this purpose. Also, if you perform the operation check indoors, you need to have an Optical Termination Hood (CLTERMHOOD) which absorbs the laser light that would otherwise reflect from the ceiling and possibly saturate the receiver.

If data messages are not needed, for example, if the ceilometer is out of use, the maintenance connection can also be established through the data line. This will, however, cause the data flow to be discontinued for as long as the command line is kept open.

Troubleshooting Instructions

To check the normal operation of CL31, proceed as follows:

1. Clean the window carefully with a soft, lint-free cloth moistened with a mild detergent. Be careful not to scratch the window surface.

2. If you are indoors, put the optical termination hood (the black hat) on the ceilometer window. To the ceilometer this corresponds to a clear, nighttime sky.

3.   Connect the maintenance terminal to the maintenance port at the bottom of CL31. Turn on both CL31 and the maintenance terminal. If you are using the palmtop or the CT-VIEW program for the first time, make the necessary installations according to the manuals of these products.

4.   Verify that the ceilometer starts proper operation. A quick status check can be made by looking at the LEDs on the CLE311 board (refer to Figure 19 on page 99). After the initialization routines, the **Laser on** LED should start blinking at 2-second intervals. If all the key modules are ok, also all the six diagnostic LEDs should light up.

5.   A blower check is also done during the first three minutes, during which the blower is running. The automatic check also verifies the functioning of the blower heater. The result of this check is available three minutes after starting the unit and it is indicated by the **CLB ok** LED. It is also displayed in the status message.

6.   The status message can be obtained by typing the **open** command and pressing ENTER on the maintenance terminal (PC) keyboard.

A CEILO > prompt should appear. Give the **get failure status** command and press ENTER.

An example of the response is as follows:

```
Alarms
 Tmit Shutoff  OK     Transmitter  ALRM
 Receiver      OK     Voltages     OK
 Alignment     OK     Ext Memory   OK
 Light Pth Obs OK     Rec Saturat  OK
 Coaxial Cable OK     Engine       OK

Warnings
 Window Contam OK     Battery Low  OK
 Transm Expire OK     Humid High   OK
 Blower        OK     Humid Sensor OK
 Int Heater    OK     High Rad     OK
 Engine        OK     Battery      OK
 Laser Monitor OK     Receiver     OK
 Tilt Angle    OK

System Status:   FAIL
 Suspect Module: CLT
```

The two last lines in the status message will indicate if there are warnings or alarms present. The **Suspect module** line indicates

the sub unit that is suspected to be faulty. In this example, it is the Ceilometer Transmitter CLT311.

7.   Wait until the 3-minute blower check is over and check the result from the status message. After this, place a piece of white paper on the ceilometer window. The blower should start within one minute. Remove the paper. The blower should stop within one minute.

8.   If there are clouds present, compare the ceilometer measurement with a qualified weather observer's height approximation.

9.   In case there are no clouds present and if the site is suitable, do a hard target test. Turn the measurement unit 90 degrees and aim it on a fixed target (such as a wall or a forest front).

NOTE	The minimum distance to a hard target should be 300 meters (1000 ft). The backscatter signal from a hard target is very strong compared to the signal from a cloud. The receiver may saturate if the distance is too short.

CAUTION	When tilting the unit, make sure that nobody is watching it with binoculars or other magnifying optics.

Disable the automatic angle correction by first giving the OPEN command and then the following commands:

```
CEILO >  SET MESSAGE ANGLE_COR OFF

CEILO >  CLOSE
```

Compare ceilometer's distance reading to a reference measurement.

Warning and Alarm Messages

This section describes different warning and alarm messages.

Table 18   Warnings

Status Message Info	Reason	Instructions
Window contamination warning (appears from time to time and lasts < 5 min).	Usually drizzle drops on the window.	The blower will clean the window. If clouds are detected, the height information is correct. If no clouds are detected, it is possible that high clouds are missed.

Status Message Info	Reason	Instructions
Window contamination warning (continuous).	Bird droppings, leaves, dust etc. have contaminated the window.	Clean the window.
Battery low warning	The unit has been powered too long using the backup battery.	Connect the line voltage or replace the battery.
	Recharging of the battery has failed.	If the battery is old, replace it. If the battery is OK, check the operation of Ceilometer Engine Board CLE311.
Transmitter expires warning.	Laser diode too old.	Replace Transmitter CTL311. The measurements can still be used, but it is possible that some clouds are missed.
High humidity warning (option)	Relative humidity > 85 %. Water has been condensed inside the ceilometer. Leakage in the enclosure or leakage in the door.	Take the ceilometer inside, open the maintenance door and let it dry in a warm air conditioned place. Condensed water on optical surface may disturb the measurement. There is a danger of short circuits.
Blower failure warning.	Blower cable is not connected.	Check that the blower cable is connected.
	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Blower is stuck.	Check if visible obstacles disable blower operation.
	Blower is damaged.	Replace the blower.
Humidity sensor failure warning (option)	Humidity sensor is not connected.	Connect the humidity sensor or disable the option in the software.
	Humidity sensor is damaged.	Replace the humidity sensor.
Heater fault warning	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Heater is damaged.	Replace the heater.
High background radiance warning	Direct sunlight.	In case there are no alarms, the measurements are ok. If there is an alarm, the measurements are invalid.
Ceilometer Engine Board failure warning	Non-critical fault in Ceilometer Engine Board CLE311.	Replace Ceilometer Engine Board CLE311.
Battery failure warning	Battery is dead.	Replace the battery.
Laser monitor failure warning	Laser power monitor board CLM311 has failed.	Replace CLM311.
	Laser power measurement on Ceilometer Engine board CLE311 has failed.	Replace CLE311.
Receiver warning	A non-critical CLR311 Receiver failure.	Replace CLR311.
Tilt angle > 45° warning	The unit is not correctly installed or the tilt angle is larger than 45°.	Check the installation. The height measurement accuracy is lost with tilt angles greater than 45°.

Table 19   Alarms

Problem	Reason	Instructions
Transmitter shut-off alarm (Laser temperature > 85°C)	Direct sunlight has heated the laser.	Wait for the sun to exit the field-of-view. CL31 will return to normal operation.
	Environment temperature too high.	Check if there is a specific reason for the high temperature.
Transmitter failure alarm.	Laser is worn out or damaged.	Replace Laser Transmitter CLT311.
	Laser does not get electrical power.	Check from the status message that the line **Voltages** is marked **OK**.
Receiver failure alarm.	Receiver CLR311 is damaged.	Replace CLR311.
	Loose cable connection.	Check that the cables from Receiver CLR311 and Ceilometer Optics CLO31 are undamaged and correctly connected.
	Receiver test not operating.	Check that the Optics unit CLO31 is not misplaced or damaged.
Voltage failure alarm.	Ceilometer Engine Board CLE311 is damaged.	Replace CLE311.
Alignment failure alarm.	Optics alignment is faulty.	Contact Vaisala Helpdesk and send the measurement unit to Vaisala for repair.
Memory error alarm.	A failure in the CLE311 memory.	Replace CLE311.
Light path obstruction alarm.	Window is badly contaminated or severely scratched.	Clean the window or in case of damage, replace CLW311.
	Something blocks the laser beam.	Check the clarity of the optical path.
Receiver saturation alarm.	Direct sunlight.	Wait for the sun to exit the field-of-view. CL31 will return to normal operation.
	Something is partially blocking the laser beam.	Check the clarity of the optical path.

Table 20   Miscellaneous Problems

Problem	Reason	Instructions
CL31 does not start, no LEDs are lit	Power is not connected.	Check that both the main and the battery switches are in the ON position. Check the presence and correctness of the line voltage. Also check that the battery is OK.
	Loose cable connection.	Check the cable connections.
Laser on LED is not blinking at all but the **Status** LED is lit.	Operation mode is standby.	Connect the maintenance terminal and check if the operation mode is normal.
	CLE311 is damaged.	Replace CLE311.
Data message is missing.	Dialogue is not operating.	Check the cable connections. Open the terminal.
	Wrong communication parameters.	Check the communication parameters (number of bits, parity, etc.).
	Wrong data port.	Open the terminal program and first give **open** command and then the **get params message** command. Check that the PORT is set to DATA.
	Operation mode is standby.	Open the terminal program and first give the **open** command and then the **status** command. Check that the OPERATION MODE is NORMAL.
Cloud detection is missing.	Alarm or warning in the data message.	Open the terminal program and first give the **open** command and then the **get failure status** command. Check that there are no alarms or warnings.
	No alarm or warnings in the data message.	Contact Vaisala.
The capacity to see high clouds is reduced.	Low receiver gain (no fog or snow).	Check the automatic receiver gain setting in the status message. If it is low, check that the window is clean. Check that the optical path is clear. Visually check that the lens is clean.
	Extensive amount of dirt or water droplets on the window and a failure in the diagnostics.	Check the window clarity. Check the blower operation by giving the **service self_check** command and check that the blower works.

Technical Support

For technical questions, contact the Vaisala technical support:

E-mail   helpdesk@vaisala.com

Phone (int.)   +358 9 8949 2789

Fax   +358 9 8949 2790

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CHAPTER 8
REPAIR

This chapter explains how to remove and replace different parts of Vaisala Ceilometer CL31.

Replacing Window Assembly CLW311

NOTE	The Ceilometer Window Assembly CLW311 is recommended to be replaced indoors to prevent water and other contamination from getting into the measurement unit.

To replace Ceilometer Window Assembly CLW311, you will need a 2.5 mm Allen-key and a screwdriver.

Then proceed as follows:

1. Open the measurement unit door with the special key provided with the unit. Then switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2. Close the door and remove the measurement unit. To do this, loosen the three attachment screws (marked A in Figure 5 on page 23) on the back of the measurement unit, disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

3. Loosen the 12 screws on the frame of the window and remove the window by lifting it out with the screws attached. Also remove any pieces of the old gasket.

4. Use some solvent to clean the surface of the measurement unit before attaching the new window. Also check that the gasket on the window is undamaged and in place.

NOTE	Avoid touching the new window with your bare hands as it may be scratched or the lower surface of the window may be contaminated.

5. Place the window on the measurement unit and attach the 12 screws with your fingers to prevent the window from sliding off its place.

6. Then tighten the screws in a crosswise order to allow the window gasket to tighten evenly. For example, you can first tighten the screw on top of the window frame, then the one on the bottom, then the one on the left, and the one on the right. Tighten the remaining eight screws in a clockwise order, in such a way that you first tighten one screw and then the one opposite to this, then the one next to the first screw and so forth. After tightening these eight screws, you should retighten the first four screws.

NOTE	Remember to use a thread-locking compound to the window screws before final tightening of them.

7. After attaching the window you should clean it properly. Refer to section Window Cleaning on page 80.

8. After cleaning the window, reattach the measurement unit to the shield. To do this, placing it inside the shield, reconnect the blower cable to connector J1, and tighten the three attachment screws.

9. Connect the CT3839 power cable.

10. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no failures with the system. If failures exist, separate troubleshooting may be necessary.

Replacing Ceilometer Laser Transmitter CLT311

WARNING	Ceilometer Transmitter CLT311 emits invisible laser radiation, which is harmful to the eye if viewed at a short distance. Never remove the Ceilometer Transmitter from its normal position without first switching off both the line and the battery power and detaching the transmitter ribbon cable from the Ceilometer Engine Board CLE311.

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

The transmitter should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the transmitter has been detected.

To replace Ceilometer Laser Transmitter CLT311, you will need a 2.5 mm Allen-key.

Then proceed as follows:

1. Open the measurement unit door and confirm that there is an active transmitter failure. In case of a transmitter failure, the **CLT ok** LED will be turned off. Refer to Figure 19 on page 99.

2. Switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3. Detach the transmitter ribbon cable from Ceilometer Engine Board CLE311.

4.   To detach the transmitter, loosen the transmitter ring by turning it to the right. If necessary, you can use a 2.5-mm Allen key as a lever. Remove the transmitter from the unit. Refer to numbers 5 and 6 in Figure 18 on page 98.

5.   Place the new transmitter to its place and tighten the transmitter ring in such a way that the labels of the transmitter face the measurement unit door.

6.   Connect the transmitter ribbon cable to the CLE311 board.

7.   Connect the CT3839 power cable.

8.   Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing Ceilometer Receiver CLR311

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

The receiver should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the receiver has been detected.

To replace Ceilometer Receiver CLR311, you will need a 2.5 mm Allen-key.

Then proceed as follows:

1.   Open the measurement unit door and confirm that there is an active receiver failure. In case of a receiver failure, the **CLR ok** LED will be turned off. Refer to Figure 19 on page 99.

2.   Switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3. Detach the coaxial cable from the receiver. Also detach the receiver ribbon cable from Ceilometer Engine Board CLE311.

4. To detach the receiver, loosen the receiver ring by turning it downwards. If necessary, you can use a 2.5-mm Allen key as a lever. Remove the receiver from the unit. Refer to numbers 3 and 4 in Figure 17 on page 96.

5. Place the new receiver to its place and tighten the receiver ring in such a way that the labels of the receiver face the left wall of the enclosure.

6. Connect the receiver ribbon cable to the CLE311 board. Also connect the coaxial cable to the receiver.

7. Connect the CT3839 power cable.

8. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all six diagnostic LEDs light up after the self-test. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

0406-056
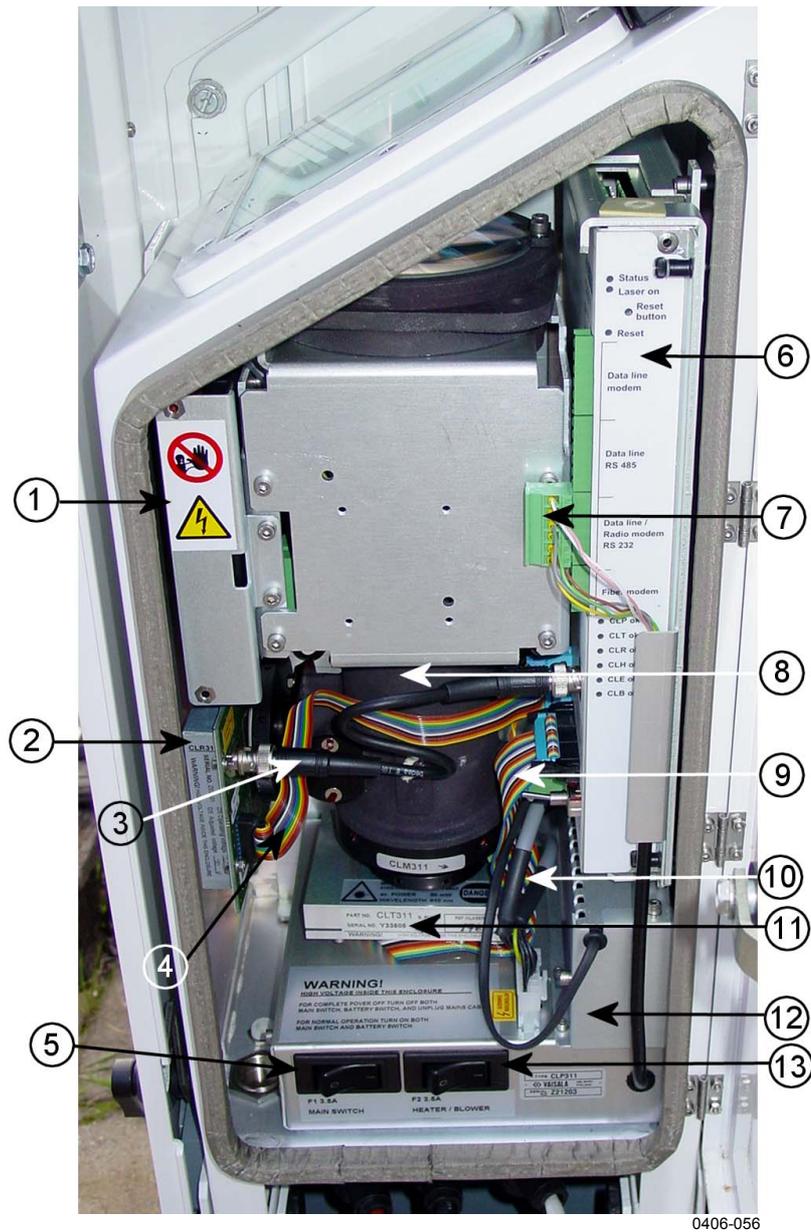
Figure 17   CL31

The following numbers refer to Figure 17 on page 96.

1   =   Internal heater CLH311
2   =   Ceilometer Receiver CLR311
3   =   Coaxial cable
4   =   Receiver ribbon
5   =   Main circuit breaker F1
6   =   Ceilometer engine board (CLE111)
7   =   Data line connector
8   =   Optics unit CLO311
9   =   Transmitter ribbon

The following numbers refer to Figure 17 on page 96.

10 = AC power cables
11 = Ceilometer transmitter CLT311
12 = No-break battery 4592
13 = Window blower circuit breaker

0311-057
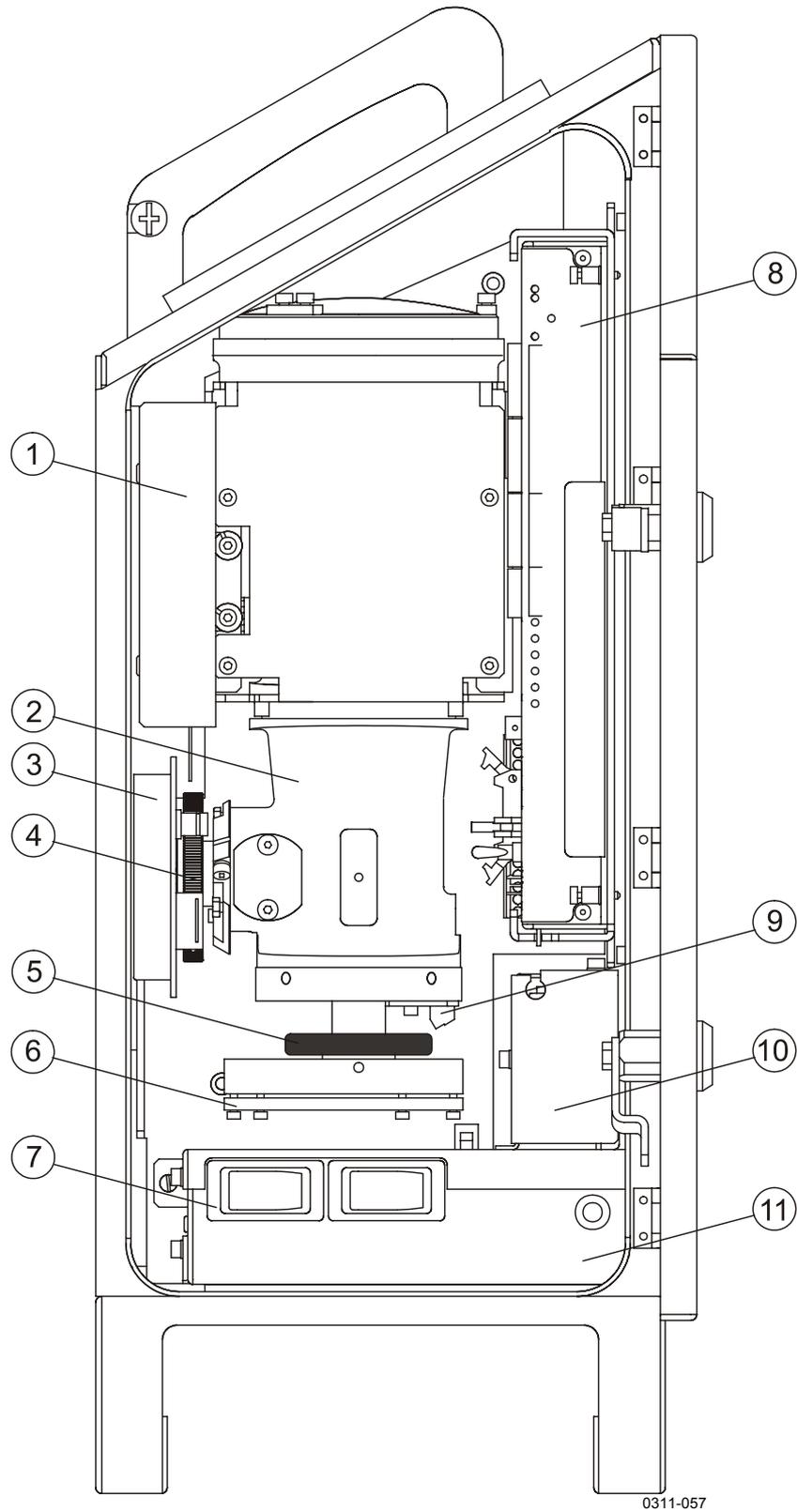
Figure 18   Main Components of Ceilometer CL31

The following numbers refer to Figure 18 on page 98:

1 = Internal heater CLH311
2 = Ceilometer optics CLO311
3 = Ceilometer Receiver CLR311
4 = Receiver ring
5 = Transmitter ring
6 = Ceilometer Transmitter CLT311
7 = F1 Main circuit breaker
    F2 Window blower circuit breaker
8 = Ceilometer engine board CLE311 (see Figure 19 below)
9 = Laser monitor board CLM311
10 = No-break battery 4592
11 = AC power unit CLP311

0311-059
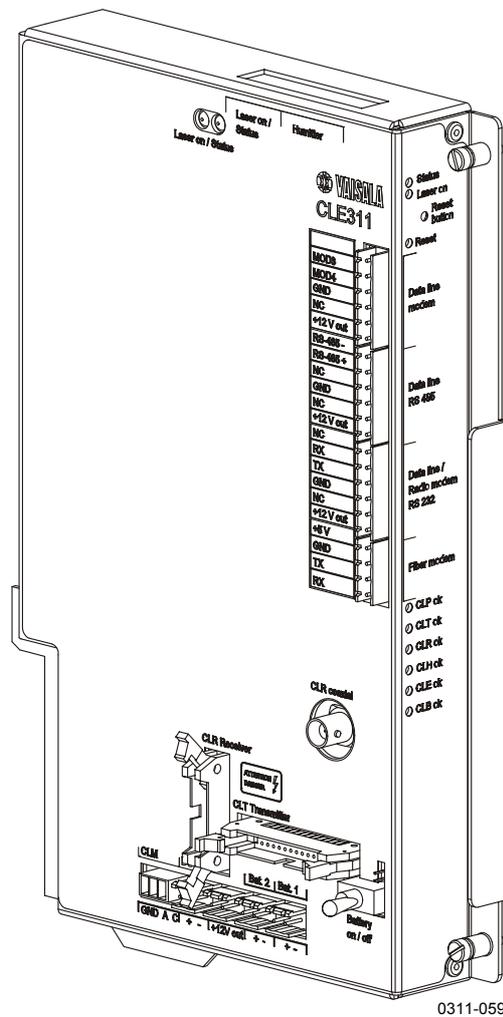
Figure 19   Ceilometer Engine Board CLE311

Replacing Ceilometer Engine Board CLE311

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

Ceilometer Engine Board CLE311 should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the CLE311 board has been detected.

To replace Ceilometer Engine Board CLE311, you will need a screwdriver.

Then proceed as follows:

1.   Open the measurement unit door and confirm that there is an active CLE311 board failure. In case of a CLE311 board failure, the **CLE ok** LED will be turned off. Refer to Figure 19 on page 99.

2.   Switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3.   Detach the transmitter ribbon cable, the receiver ribbon cable, and the coaxial cable from Ceilometer Engine Board CLE311.

4.   Memorize the position of the data line connector (RS-232/ RS-485/Modem) in front of the CLE311 board and detach it. Refer to Figure 19 on page 99.

5.   Loosen the hand screws to release the CLE311 board from the frame. Gently pull the CLE311 board halfway out of the measurement unit and detach the battery cable and the cable connectors of Laser Monitor CLM311. Then remove the entire CLE311 board. Refer to Figure 19 on page 99.

6.   Place the new CLE311 board onto the frame in such a way that you can connect the battery cable and the cable of Laser Monitor CLM311.

7.   Attach the receiver ribbon cable, the transmitter ribbon cable, and the coaxial cable when the board is pushed halfway in.

8.   Push the new CLE311 board in such a way that it connects to the back plane connector. Tighten the hand screws to lock the position of the board.

9.   Connect the data line connector to the same position as it was connected to on the previous board.

10.   Connect the CT3839 power cable.

11.   Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs light up after the set-test. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing No-break Battery 4592

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

The no-break battery should be replaced when it is damaged or can otherwise no longer be recharged.

To replace the no-break battery, you will need a crosshead screwdriver and a 3 mm Allen-key.

Then proceed as follows:

1.   Open the measurement unit door and switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2.   Disconnect the no-break battery cable from the CLE311 board.

3.   Remove the two screws locking the lid of the no-break battery cage. One of the screws is located on top of the battery cage, the other is on the left side near the top of the cage.

4.   Open the lid of the battery cage and slide out the battery. Disconnect the battery cable.

5.   Connect the battery cable to the new battery, connecting the red end to the positive (+) end and the black end to the negative (-) end.

6.   Slide the new battery into the battery cage and close the lid. Tighten the two screws back to their places.

7.   Reconnect the no-break battery cable to the CLE311 board.

8.   Connect the CT3839 power cable.

9.   Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs light up after the self-test. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing AC Power CLP311

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

AC Power CLP311 should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the power unit has been detected.

To replace the AC power, you will need an Allen-key.

Then proceed as follows:

1.   Open the measurement unit door and confirm that there is an active AC power unit failure. In case of an AC power unit failure, the **CLP ok** LED will be turned off. Refer to Figure 19 on page 99.

2.   Switch the power off with all three switches (F1, F2, and battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3. Remove the no-break battery. Refer to steps 3 to 5 in section Replacing No-break Battery on page 101.

4. Remove the entire battery cage by removing the three screws holding it in its place. One of the screws is located underneath the battery cage, the other two are on the left side near the bottom of the cage.

5. Detach the data line connector.

6. Remove the six attachment screws from the bottom of the ceilometer measurement unit. Also disconnect the AC power cable. Lift the AC power unit from the ceilometer measurement unit.

7. Put the new AC power unit in place of the old one and connect the AC power cable. Tighten the six attachment screws back to their places.

8. Attach the data line connector again.

9. Put the no-break battery cage back to its place and tighten the three screws.

10. Replace the no-break battery as you removed it. Refer to steps 6 to 8 in section Replacing No-break Battery on page 101.

11. Connect the CT3839 power cable.

12. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all six diagnostic LEDs light up after the self-test. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing Window Blower CLB311-115 / CLB 311-230

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

The window blower should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the blower has been detected.

To replace Ceilometer Window Blower CLB311, you will need a 5 mm Allen-key.

Then proceed as follows:

1. Open the measurement unit door and confirm that there is an active window blower failure. In case of a window blower failure, the **CLB ok** LED will be turned off. Refer to Figure 19 on page 99.

2. Switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3. As the blower is attached to the shield of the ceilometer, you will first have to remove the measurement unit from the shield to get to the blower. To remove the measurement unit, loosen the three attachment screws (marked A in Figure 5 on page 23) on the back of the measurement unit, disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

4. Use an Allen key to loosen the two screws on the side of the window blower pull out the blower.

5. Use the same Allen screws to attach the new window blower.

6. Reattach the measurement unit by placing it inside the shield, reconnecting the blower cable to connector J1, and tightening the three attachment screws.

7. Connect the CT3839 power cable.

8. Switch the power on with all three switches. Wait for 3 minutes after the start-up until self-check is completed. Ensure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing Ceilometer Optics CLO311

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

NOTE	Ceilometer Optics CLO311 is recommended to be replaced indoors.

To replace Ceilometer Optics CLO311, you will need a 3 mm Allen-key.

Then proceed as follows:

1. Open the measurement unit door and switch the power off with all three switches (F1, F2, and Battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2. Close the door and remove the measurement unit. To do this, loosen the four attachment screws (marked A in Figure 5 on page 23) on the back of the measurement unit, disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

3. Disconnect the battery, transmitter, receiver, laser monitor board, and data cables from the CLE311 board.

4. To remove the Ceilometer Optics assembly, first remove the optics holder by loosening the four Allen screws on its front

cover. Then detach the internal heater connector and holding the cable aside, gently pull out the optics tube with its upper end first.

5.   Slide the new optics tube to its place with the bottom end first. Make sure that no cables get stuck between the optics tube and other ceilometer components.

6.   Snap the internal heater connector to its place.

7.   Place the optics holder to its place setting the internal heater cables to their place on the upper left corner of the optics holder. Tighten the four screws of the optics holder.

8.   Reconnect the battery, transmitter, receiver, laser monitor board, and data cables to the CLE311 board.

9.   Reattach the measurement unit by placing it inside the shield, reconnecting the blower cable to connector J1, and tightening the three attachment screws.

10.   Connect the CT3839 power cable.

11.   Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no failures with the system. If failures exist, separate troubleshooting may be necessary.

Replacing Internal Heater CLH311-115 / CLH311-230

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

NOTE	Internal Heater CLH311 is recommended to be replaced indoors.

The internal heater should be replaced if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the heater has been detected.

To replace Internal Heater CLH311, you will need a 3 mm Allen-key.

Then proceed as follows:

1. Open the measurement unit door and confirm that there is an active internal heater failure. In case of an internal heater failure, the **CLH ok** LED will be turned off. Refer to Figure 19 on page 99.

2. Switch the power off with all three switches (F1, F2, and battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

3. Close the enclosure door and remove the measurement unit. To do this, loosen the three attachment screws (marked A in Figure 5 on page 23) on the back of the measurement unit, disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

4. As a safety precaution and to ease the replacement procedure, disconnect the battery and data cables from the CLE311 board.

5. Remove the metal plate protecting the heater by loosening its two screws.

6. To get to the internal heater, you also need to remove the Ceilometer Optics assembly CLO311. To do this, detach all the cables and remove the optics holder by loosening the four Allen screws on its front cover. Then detach the internal heater connector and holding the cable aside gently pull out the optics tube with its upper end first.

7. To remove the internal heater, use an Allen key or a short screwdriver and loosen the three screws attaching the heater to the left wall of the measurement unit enclosure. Then slide out the internal heater.

8. Slide the new internal heater to its place and hold it there while tightening the three screws.

9. Slide the optics tube to its place with the bottom end first making sure no cables get stuck between the optics tube and other ceilometer components.

10. Snap the internal heater connector to its place.

11. Place the optics holder to its place setting the internal heater cables to their place on the upper left corner of the optics holder. Tighten the three screws of the optics holder.

12. Reattach the metal plate protecting the internal heater by tightening its two screws.

13. Reconnect the battery and data cables to the CLE311 board and attach all the detached cables.

14. Reattach the measurement unit by placing it inside the shield, reconnecting the blower cable to connector J1, and tightening the three attachment screws.

15. Connect the CT3839 power cable.

16. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing Internal Cable Set

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

NOTE	The internal cable set is recommended to be replaced indoors.

To replace the internal cable set, you will need the following tools:

- 2.5 mm Allen-key
- Flat-bladed screwdriver, 3 mm wide tip
- Phillips PH1 screwdriver

Then proceed as follows:

1. Open the measurement unit door and switch the power off with all three switches (F1, F2, and battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2. Close the door and remove the measurement unit. To do this, loosen the three attachment screws (marked A in Figure 5 on page 23) on the back of the measurement unit, disconnect the blower cable from connector J1 (see Figure 7 on page 25), and pull out the unit.

3. The internal cable set is attached to the back wall of the measurement unit enclosure, thus to gain access to it you have to remove the CLE311 board, the optics assembly with the transmitter, and the receiver. Refer to sections Replacing Ceilometer Engine Board CLE311 on page 100, and Replacing Ceilometer Optics CLO311 on page 105. Remove the connector of the cable set from the CLP311 unit.

4. Remove the grounding screw from the back of the optics frame by loosening it and thus disconnecting the two protective grounding terminals attached to it. See Figure 20 on page 110.

0408-020
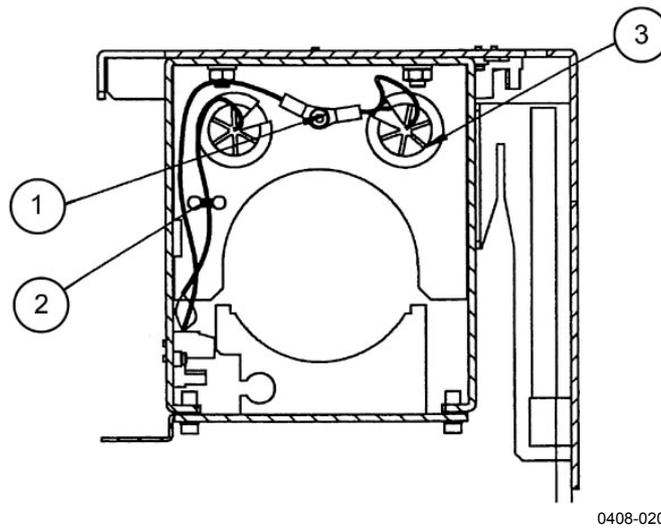
Figure 20   Grounding Wires of the Internal Cable Set (top view)

The following numbers refer to Figure 20 above:

1 = Grounding screw
2 = Grounding tie
3 = Grounding guide

5. Unscrew the two wires from the internal heater connector. See Figure 21 below.
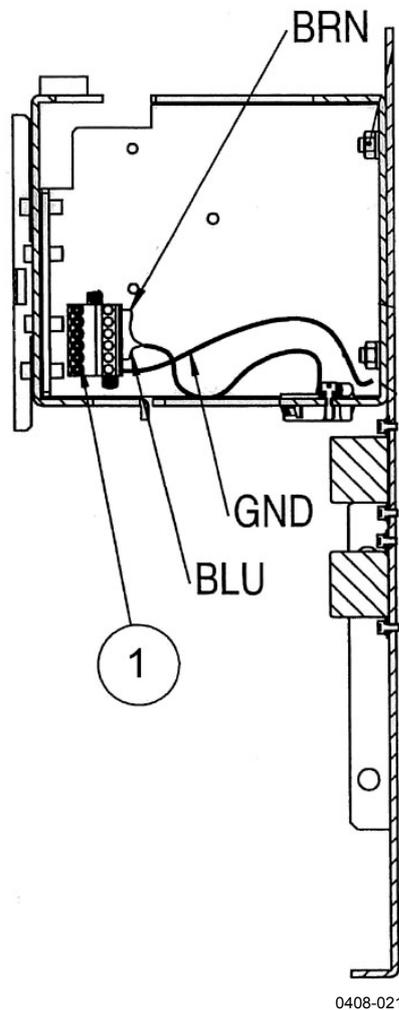
Figure 21   Internal Heater Wiring and Connector at the Left of the Optics Frame

The following numbers refer to Figure 21 above:

1   =   Internal heater connector

6. Disconnect the two mains filters from the optics frame. See number 2 in Figure 22 on page 112.

7. Disconnect the connector terminal from the body of the optics frame. See number 3 in Figure 22 on page 112

8. Take out the cable set with the mains filters from the CL31 enclosure.
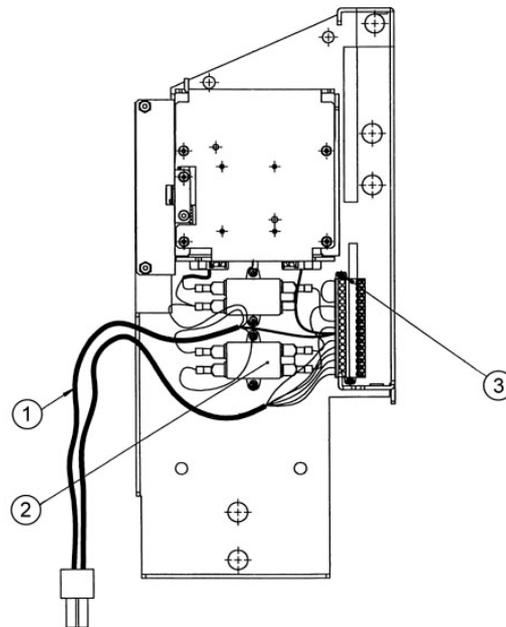
0408-022

Figure 22   Optics Frame with Cable Set

The following numbers refer to Figure 22 above:

1   =   Cable set
2   =   Mains filters
3   =   Cable set connector and attachment screw

9.   Connect the new mains filter to the wiring harness as shown in
     Figure 23 below.
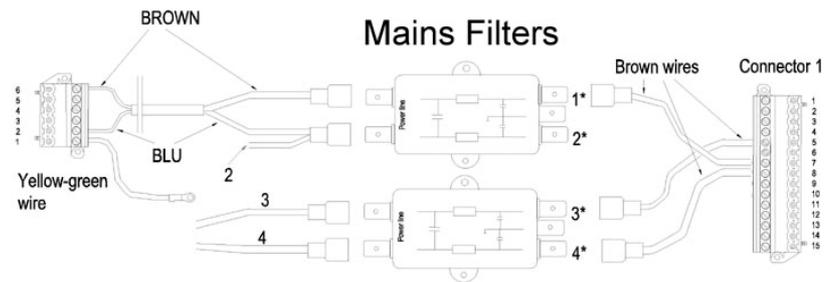
0406-067

Figure 23   Connecting Mains Filters to the Cable Set

The asterisks in Figure 23 above are explained below:

1*   ———————▶   7
2*   ———————▶   No Connect
3*   ———————▶   5
4*   ———————▶   8

10. Connect the mains filters to the optics frame as shown in Figure 23 on page 112.

11. Push the grounding wire and internal heater wires through the plastic supports in the optics frame and connect the grounding wires to the optics frame. See Figure 22 on page 112.

12. Connect the internal heater wires according to Figure 21 on page 111 and Figure 23 on page 112.

13. Install the connector terminal (number 3 in Figure 22 on page 112) to the optics frame.

14. Re-install the optics CLO311 and the Ceilometer Engine Board CLE311.

15. Attach the connector of the electric harness to the CLP311 unit. Replace the enclosure to its place. Reconnect the data and blower cables. Reconnect the CT3839 power cable.

16. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

Replacing Laser Monitor Board CLM311

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.

To replace Laser Monitor Board CLM311, you will need a 2.5 mm Allen-key and a calculator.

Then proceed as follows:

1. Open the front door of the ceilometer enclosure and switch the power off with all three switches (F1, F2, and battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2. Disconnect the CLT311 cable from the CLE311. Detach the transmitter from the optics unit using the 2.5 mm Allen key as a lever.

3. Detach the CLM311 twisted pair cable from the CLE311 board.

4. Detach the Laser Monitor Board CLM311 by loosening the two Allen screws. You can access the screws best through a hole in the transmitter ring (see number 5 in Figure 18 on page 98).

5. Write down the sensitivity value of the old, defective board, for example, 102 % . If no value is written on the CLM311, use the standard value 100 %.

6. Write down the sensitivity value of the new CLM311 board, for example, 98 %. If there is no value on the CLM311, use the standard value 100 %.

7. Replace the new board and tighten the Allen screws.

8. Attach the twisted pair cable to the CLE311 board at the CLM311 connector.

9. Tighten the transmitter CLT311 back to its place and reconnect the cable to CLE311.

10. Connect the CT3839 power cable and the maintenance terminal to CL31.

11. Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all six diagnostic LEDs are lit. Refer to Figure 19 on page 99.

12. Open the command line with the **open** command. The password is **advanced**.

13. Enter the **get params factory** command and write down the **Target Outlaser** value.

14. The new calibration value is calculated as follows:

    ```
    NEW OUTLASER = (OLD OUTLASER x NEW CLM311
    SENSITIVITY VALUE) / (OLD CLM311 SENSITIVITY VALUE)
    ```

    For example:
    880 x 98 % / 102 % = 837 (rounded to the nearest integer value)

15. Then give the following command:

    ```
    SET FACTORY OUTLASER <value>
    ```

    where `<value>` is the new, calculated target outlaser value.

16. Give the **status** command and check from the status message that the measured outlaser is close (±5 %) to the new outlaser value. Also check that the system status is OK and there are no suspect LRUs.

The ceilometer unit should now return to normal operation. Verify that the unit is working properly and that there are no other failures with the system. If other failures exist, separate troubleshooting may be necessary.

Replacing Modem Module DMX501 (Optional)

CAUTION	Servicing the equipment must only be performed by qualified maintenance personnel.
	Always replace the modem module indoors.

To replace Modem Module DMX501, you will need a screwdriver.

Then proceed as follows:

1. Open the front door of the ceilometer enclosure and switch the power off with all three switches (F1, F2, and battery). For the location of the switches, refer to Figure 18 on page 98 and Figure 19 on page 99.

WARNING	Disconnect the CT3839 power cable before continuing!

2. As the DMX501 module is located on the CLE311 board, you will have to remove the CLE311 board to get to the DMX501 module. Remove the CLE311 board by detaching the cables connected to it and loosening the hand screws. For details, refer to steps 3 to 5 in section Replacing Ceilometer Engine Board CLE311 on page 100.

3. Ground yourself before touching the DMX501 module. You can do this, for example, by touching a conductive part of the equipment chassis with your other hand before touching the DMX501 module.

4.   Pull the DMX501 module gently out of its place on the CLE311 board to avoid bending its legs.

0406-057
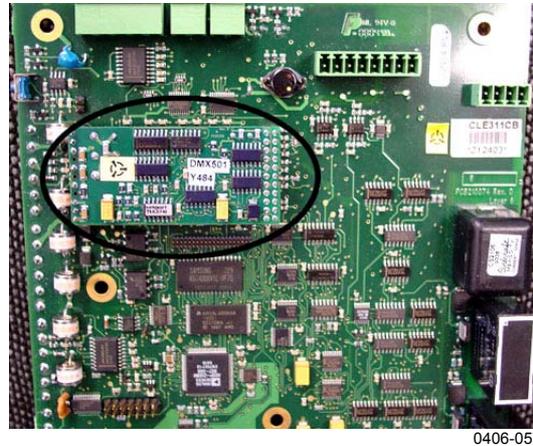
Figure 24 DMX501

5.   Check that the legs of the new DMX501 module are straight before placing it on the CLE311 board. Once the DMX501 module is in its place, push it gently to the CLE111 board.

6.   Put the CLE311 board back the same way as you removed it. For more details, refer to steps 6 to 9 in section Replacing Ceilometer Engine Board CLE311 on page 100.

7.   Connect the CT3839 power cable.

8.   Switch the power on with all three switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all six diagnostic LEDs light up after the self-test. Refer to Figure 19 on page 99.

The ceilometer unit should return to normal operation. Verify that the unit is working properly and that there are no failures with the system. If failures exist, separate troubleshooting may be necessary.

CHAPTER 9
TECHNICAL DATA

This chapter provides the technical data of the product.

Specifications

This section describes the different technical specifications of Vaisala Ceilometer CL31.

Mechanical Specifications

Table 21   Ceilometer CL31 Mechanical Specifications

Property	Description / Value
Dimensions:	
Measurement unit	620 × 235 × 200 mm (24 × 9 1/4 × 8 1/4 in.)
Height with shield	1190 mm (47 1/4 in.)
Weight:	
Measurement unit	12 kg (26.5 lb.)
Shield and blower	18.5 kg (41 lb.)
Plywood transport container:	
Container size	1400 x 490 x 450 mm (55 x 19 1/4 x 17 3/4 in.)
Container weight	52 kg (115 lb.)

External Connector J1 - Window Conditioner

Table 22   Window Conditioner

Property	Description / Value
Connector J1	Type Binder series 693, 09-4228-00-07 (female)
Mating connector type	Type Binder series 693, 99-4225-70-07 7-pin (male) elbow

External Connector J2 - Power Input

Table 23   Power Input

Property	Description / Value
At nominal line voltage	115 V or 230 V
Power consumption (typical):	
Total	310 W
Measurement unit	15 W
Internal heater	100 W
Window conditioner heater	175 W
Window blower	20 W
Frequency	45-65 Hz
Power connector (J2)	Type Binder series 693, 09-4223-00-04
	4-pin (male)
Mating connector type	Type Binder series 693, 99-4222-70-04
	(female) elbow
No-break power supply	12 V Sealed Lead Acid Battery, 2 Ah
Overvoltage protection	Low-press filter , VDR

Output Interface

The data port can operate according to the following serial line standards:

RS-232
RS-485, multidrop, 2-wire

The data port can also be operated through a DMX501 modem module. The maintenance port is an RS-232 serial line.

External Connector J3 - Data Line

The data line is intended to be used for measurement data communication, but it can also be used with a Ceilometer Maintenance Terminal, PC, or other terminals.

Table 24   Data Line

Property	Description / Value
Connector (J3)	Type Binder series 693, 09-4227-00-07 7-pin (male)
Mating connector type	Type Binder series 693, 99-4226-70-07 (female) elbow
Baud rate	9600 bps standard with RS-232
	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 bps available
	300, 1200 or 2400 bps available with modem DMX501
Max. distance to operate	300m (1000 ft) with RS-232, 1.2 km (4000 ft) with RS-485, all at 2400 bps with typical communication cables 16 km (10 mi) with Modem
Standard character frame	1 Start Bit 8 Data Bits No Parity 1 Stop Bit
Standard character code	USASCII
Pin connections	1 RS485 -/RTS# (no SW support) 2 RS485+/RS-232 RxD/ Modem Lead A 3 Modem Lead B /RS-232 TxD 4 Signal Ground 5 CTS# (no SW support) 6 +12 V DC (700 mA continuous, for local external equipment)

Modem circuits are non-polar and symmetrical. All modem circuits are electrically floating to overvoltage protection rating (300 V - 500 V).

Overvoltage protection in each circuit	Primary Noble Gas Surge Arrester Secondary VDRs, Transient Zener Diodes or normal Diodes

NOTE	For information on data line connection options, refer to Figure 8 on page 26, Figure 9 on page 27, and Figure 10 on page 28.

External Connector J4 - Maintenance Line

Maintenance line is intended for on-site maintenance and can be used with a Ceilometer Maintenance Terminal, PC, or other terminal.

Table 25   Maintenance Line

Property	Description / Value
Connector (J4)	Female five (5) pin M12 connector (e.g. Lumberg RKF 5 / 0,5 M)
Mating connector type	Male five (5) pin M12 connector (e.g. Lumberg RST 5-644)
Baud rate	9600 default and standard 300, 2400, 4800, 9600, 19200, 38400, 57600 bps available
Distance to operate	300 m (1000 ft) at 2400 baud with typical communication cables
Standard character frame	1 Start Bit 8 Data Bits No Parity 1 Stop Bit
Standard character code	USASCII
Pin connections	See Figure 25 below (RTS/CTS not used).

1 RTS
2 RxD
3 GND
4 TxD
5 CTS
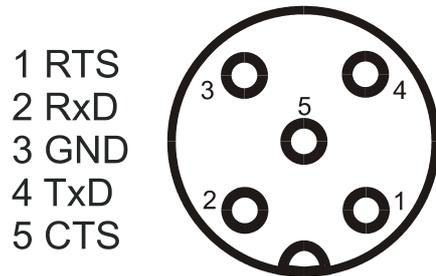
Figure 25   Pin Connections of Connector J4

Overvoltage protection in each circuit	Primary Noble Gas Surge Arrester Secondary VDRs, Transient Zener Diodes or normal Diodes

Modem Module DMX501

Table 26   Modem Module DMX501 Specifications

Property	Value / Description
Data rate	300, 1200, 2400 bps
Modem standards supported	V.21, V.22, V.22bis
Supply voltage	5 V (+4.75 V to 5.5 V)
Current consumption	Reset / power-down 9 mA, operation 26 mA
Modem chip crystal frequency	11.0592 MHz
USART clock frequency	11.0592 MHz / 2 (Modem xtal freq. divided by 2)
Line interface	Matched to 600 Ω

Transmitter Specifications

Table 27   Transmitter Specifications

Property	Description / Value
Laser source	Indium Gallium Arsenide (InGaAs) Diode Laser
Center wavelength	910 ± 10 nm at 25 °C (77 °F)
Operating Mode	Pulsed
Nominal pulse properties at full range measurement:	
Energy	1.2 μWs ± 20% (factory adjustment)
Peak power	11 W typical
Width, 50%	110 ns typical
Repetition rate	10.0 kHz
Average power	12.0 mW
Max Irradiance	760 μW/cm² measured with 7 mm aperture
Laser classification	Classified as Class 1M laser device in accordance with IEC/EN 60 825-1 Complies with 21 CFR 1040.10 and 1040.11 except for the devations pursuant to the Laser Notice No. 50, dated July 26, 2001.
Beam divergence	±0.4 mrad x ±0.7 mrad

Receiver Specifications

Table 28   Receiver Specifications

Property	Description / Value
Detector	Silicon Avalanche Photodiode (APD)
Surface diameter	0.5 mm (0.02 in.)
Receiver bandwidth	3 MHz (-3db)
Interference filter	Center wavelength 915 nm typical
50% pass band	36 nm
Transmissivity at 913 nm	80 % typical
Field-of-view divergence	± 0.83 mrad

Optical System Specifications

Table 29   Optical System Specifications

Property	Description / Value
Optics System Focal Length	300 mm (11.8 in.)
Effective lens diameter	96 mm (3.8 in.)
Lens transmittance	96 % typical
Window transmittance	97 % typical, clean

Performance Specifications

Table 30   Performance Specifications

Property	Description / Value
Measurement range	0 ... 7.5 km (0 ... 25,000 ft.)
Measurement resolution	10 m (33 ft) or 5 m (16 ft), selectable
Reporting resolution	5 m or 10 ft., units selectable
Reporting interval	2 ... 120 s, selectable
Measurement interval	2 s default (3 s in high-resolution mode)

Environmental Conditions Specifications

Table 31   Environmental Conditions Specifications

Property	Description / Value
Ambient temperature	-40 ... +60 °C (-55 ... +60 ° optional)
Humidity	to 100 %RH
Wind	to 100 kt (50 m/s)
Vibration	5 - 13.2 Hz, ± 1.0 mm 13.2 - 100 Hz, ± 0.7 g

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