Model 5030

Instruction Manual

Synchronized Hybrid Ambient Real-time
Particulate Monitor
Part Number 102017-00
8Jan2013

USEPA Automated Equivalent $PM_{2.5}$ Method: EQPM-0609-184

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WEEE Compliance

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:

Thermo Fisher Scientific has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Fisher Scientific's compliance with these Directives, the recyclers in your country, and information on Thermo Fisher Scientific products which may assist the detection of substances subject to the RoHS Directive are available at: www.thermo.com/WEEERoHS.

Preface Section

This manual provides information about operating, maintaining, and servicing the Model 5030 SHARP Monitor. It also contains important alerts to ensure safe operation and prevent equipment damage. The manual is organized into the following chapters and appendices to provide direct access to specific operation and service information:

- Chapter 1 “Introduction” provides an overview of product features, describes the principle of operation, and lists the specifications.
- Chapter 2 “Installation” describes how to unpack, setup, and startup the instrument.
- Chapter 3 “Operation” describes the front panel display, the front panel keypad, and the menu-driven software.
- Chapter 4 “Calibration” provides the procedures for calibrating the instrument and describes the required equipment.
- Chapter 5 “Preventive Maintenance” provides a spare parts list and preventive maintenance procedures to ensure reliable and consistent instrument operation.
- Chapter 6 “Troubleshooting” presents guidelines for diagnosing instrument failures, isolating faults, and includes recommended actions for restoring proper operation. It also includes descriptions of status messages and reports.
- Chapter 7 “Servicing” presents safety alerts for technicians working on the instrument, step-by-step instructions for repairing and replacing components. It also includes contact information for product support and technical information.
- Chapter 8 “Optional Equipment” describes the optional equipment that can be used with this instrument.
- Appendix A “Warranty” provides a copy of the warranty statement.
- Appendix B “RS-232 Commands” provides a description of the RS-232 commands that can be used to remotely control an instrument using a host device such as a PC or a data logger.
- Appendix C “Connector and Board Schematics” provides the connector and board schematics for the Model 5030 main circuit board.

Safety

Review the following safety information carefully before using the analyzer. This manual provides specific information on how to operate the analyzer, however, if the analyzer is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Safety and Equipment Damage Alerts

This manual contains important information to alert you to potential safety hazards and risks of equipment damage. Refer to the following types of alerts you may see in this manual.

Safety and Equipment Damage Alert Descriptions

Alert	Description
DANGER	A hazard is present that could result in death or serious personal injury if the warning is ignored. ▲
WARNING	A hazard or unsafe practice could result in serious personal injury if the warning is ignored. ▲
CAUTION	A hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored. ▲
Equipment Damage	A hazard or unsafe practice could result in property damage if the warning is ignored. ▲

WEEE Symbol

The following symbol and description identify the WEEE marking used on the instrument and in the associated documentation.

Symbol	Description
	Marking of electrical and electronic equipment which applies to waste electrical and electronic equipment falling under the Directive 2002/96/EC (WEEE) and the equipment that has been put on the market after 13 August 2005. ▲

Where to Get Help

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

US NRC Exemption

The Model 5030 SHARP Monitor is an exempt product in accordance with NRC license No. 20-23922-01E and SSD Registration Certificate No. AVR-1234-D-101-E. The user is exempt from any licensing requirements for this device. Laws may vary outside of the United States.

USEPA $PM_{2.5}$ FEM: EQPM-0609-184

Thermo Scientific Model 5030 SHARP Monitor operated for 24-hour average measurements; including a 1-micron inlet; $PM_{2.5}$ VSCC ; inlet connector; sample tube; DHS heater with 35% RH threshold; mass foil kit; GF10 filter tape; nephelometer zeroing kit; 8-hour filter change; and operational calibration and servicing as outlined in Model 5030 SHARP instruction manual.

The following conditions must be followed in order to comply with USEPA Designation EQPM- 0609-184 for ambient monitoring of $PM_{2.5}$:

1. Operated for 23-25 hour average measurements.

2. Flow rate set to 1000 L/h (16.67 L/min).

3. Automatic filter change (8-hour cycle time).

4. Automatic filter change when flow rate < 950 L/h.

5. Automatic filter change when sampled filter spot mass is > 1,500 µg.

6. DHS set to 35% RH.

7. Calibrated with zero and span mass transfer foil kit for 0 to 5,000 $\mu g/m^3$ range.

8. System calibrated for temperature, barometric pressure, and volumetric flow rate.

The USEPA method required the SHARP to be installed with the following Thermo Fisher Scientific hardware:

1. 10-micron omni directional inlet operated at 16.67 Lmin (e.g., Model SA246b or as specified in 40 CFR 50, Appendix L) with $PM_{2.5}$ VSCC™.

2. Inlet to sample tube connector.

3. Standard 1-meter heater.

4. SHARP monitor.

5. Pump kit.

6. Glass fiber filter tape.

7. Vertical stabilization of sample tube, as necessary.

8. Nephelometer zeroing kit

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Chapter 1
Introduction

The Model 5030 Synchronized Hybrid Ambient Real-time Particulate (SHARP) Monitor is a hybrid nephelometric/radiometric particulate mass monitor capable of providing precise, one-minute, real-time measurements with a superior detection limit. The SHARP Monitor measures the mass concentration of ambient PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ aerosol in real-time. The SHARP monitor incorporates a high sensitivity light scattering photometer whose output signal is continuously referenced to the time-averaged measurements of an integral beta attenuation mass sensor. This system achieves heretofore-unattained short-term precision and accuracy. The SHARP monitor incorporates advanced firmware to optimize the continuous mass calibration of the nephelometric signal, ensuring that the measured mass concentration remains independent of changes in the particle population being sampled.

The SHARP monitor incorporates a dynamic heating system (DHS) designed to maintain the relative humidity of the air passing through the filter tape of the radiometric stage well below the point at which the collected particles accrete and retain liquid water. This DHS system minimizes the internal temperature rise ensuring negligible loss of semi-volatiles from the collected sample when the ambient relative humidity is below the threshold to which the heater is controlling. As the ambient RH increases above the threshold, the applied heating is optimized to maintain the RH threshold above the beta attenuation filter tape. The purpose of this heating system is specifically designed to force the continuous mass monitor to agree with the gravimetric reference method and the relative humidity conditions to which the reference filter samples are conditioned. Furthermore, sufficient flexibility is provided within the firmware to configure the heating conditions to satisfy global monitoring protocols.

The Model 5030 has the following features:

- Multi-line alphanumeric display
- Menu-driven firmware
- Field programmable logging averages
- Analog output
- High sensitivity

- Excellent linear response
- Mitigation of aerosol artifacts
- Long-life optics, detectors, and beta source
- Automatic temperature and pressure compensation
- Internal quality assurance and data storage features

Thermo Fisher Scientific is pleased to supply this continuous aerosol mass monitor. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. Thermo service personnel are available for assistance with any questions or problems that may arise in the use of this analyzer.

Principle of Operation

The Model 5030 is based on the principles of aerosol light scattering (nephelometer) and beta attenuation to measure precise and accurate ambient aerosol concentrations. The Model 5030 aerosol sample pathway is shown in Figure 1-1.

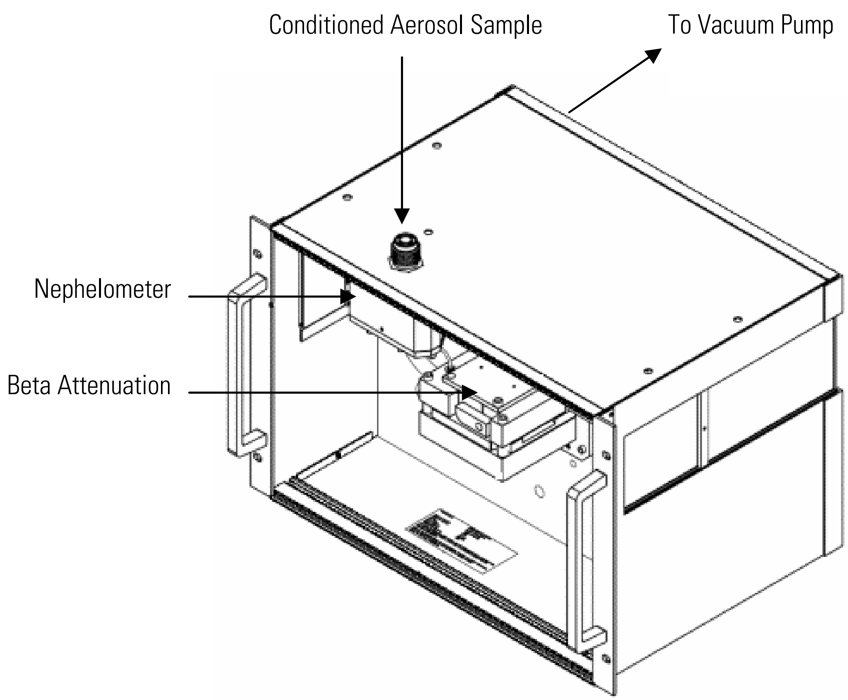


Figure 1–1. SHARP Monitor Sample Path

The SHARP optical assembly senses the light scattered by the aerosol passing through an 880 nm illumination beam. The nephelometry response is linear with aerosol concentration; independent of sample flow rate; and a running one-minute average and dynamic average are continuously calculated. Within the base of the optical assembly, a relative humidity (RH) sensor is located immediately upstream of the sample filter-tape assuring a representative measurement of the aerosol conditioning prior to real-time mass determination.

Thereafter, the aerosol is deposited onto a glass fiber filter tape. The filter tape will accumulate an aerosol sample towards a threshold value, whereupon the filter tape will automatically advance prior to reaching saturation. During the collection of aerosol onto the filter tape the SHARP Monitor uses the radiometric principle of beta attenuation through a known sample area to continuously collect and detect the deposited mass. Additionally, the beta-attenuation chamber measures alpha emissions from the accumulated aerosol and excludes negative mass artifacts due to the presence of daughter nuclides from radon gas decay to achieve a “refined mass” measurement. Simultaneous refined mass measurements of sampled aerosol on the filter tape and sample volume measurement through a calibrated orifice provide a continuous concentration measurement of the ambient mass concentration. The collected sample temperature is measured within the attenuation chamber.

Calculation of Particulate Mass on Filter Tape

The beta detector of the 5030 SHARP delivers a count rate, which is proportional to the intensity of the beta beam. The mass is calculated from this count rate according to the following equation :

$$\sum m_n = F_{cal} * \ln\left(\frac{\beta_0}{\beta_n - F_{\beta_n/\alpha_n} * (\alpha_n - \alpha_0)}\right)$$

where;

Σm_n	=	mass loading in micrograms [μg],
β_0	=	background β count rate with an unloaded filter [1/s],
β_n	=	the gross count rate with a loaded filter [1/s],
F_{cal}	=	mass foil calibration factor in micrograms [μg],
$F\beta_n/\alpha_n$	=	global natural β : α count rate ratio ≈ 3.5
α_n	=	the gross α count rate of natural aerosol radioactivity [1/s], and
α_o	=	background α count rate [1/s]

The theoretical calibration factor (F_{cal}) is given by:

$$F_{cal} = \frac{A}{\mu / \rho} = \frac{2}{0.3} * mg \approx 6{,}600 \mu g$$

where;

A	=	filter spot area (cm^2), and
μ/ρ	=	mass attenuation coefficient for ^{14}C [cm^2/mg]

For continuous beta compensation during changing temperature and pressure, the following equation is applied:

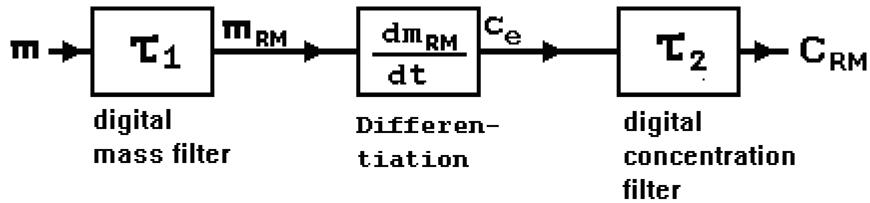
$$\beta_n = \beta_R \times \left(1 - [(k_{T2} * \Delta T_2) - (k_{P2} * \Delta P_2) + (k_{p3} * \Delta P_3)]\right)$$

where;

β_n	=	compensated beta count [1/s],
β_R	=	raw beta count [1/s],
ΔT_2	=	$T_2 - T_{2o}$, change in sample temperature since filter change (°C)
$\Delta P2$	=	$P2 - P_{20}$, change in vacuum under filter tape since filter change (hPa),
$\Delta P3$	=	$P3 - P3_0$, change in barometric pressure since filter change (hPa),
k_{T2}	=	temperature coefficient,
k_{P2}	=	sub-filter pressure coefficient
k_{P3}	=	barometric pressure coefficient

Calculation of the $PM_{2.5}$ Concentration with Digital Filter and Fixed Time Constant

Calculation Mode:



From the accumulated particulate mass (Σm), a discrete mass value (m) is calculated every four (4) seconds. The discrete mass is then passed through a digital filter with the time constant (τ_1) of 20 minutes. The filter smoothes the discrete mass fluctuations, resulting in a smoothed discrete mass value (m_{RM}). The mass differentiation with respect to time in then calculated (dm_{RM}/dt). Thus, dm_{RM}/dt is divided by the average air flow rate (Q) from the last 4-seconds, resulting in a raw concentration (C_e). The storage cycle time is four (4) seconds, thereby recognizing rapid concentration gradients. However, C_e does exhibit an unacceptable noise level through this short period of time and therefore a second digital filter is applied with a second time constant (τ_2) of 20 minutes to offer a final concentration for reporting (C_{RM}).

$$C_e = \frac{\frac{dm_{RM}}{dt}}{Q}; Ce \xrightarrow{\tau 2} C_{RM}$$

The above description provides the basis for the beta attenuation derived mass concentration. Simultaneously, the nephelometer concentration is measured as a 1-minute running average (N_{f_1n}). Thereafter, both N_{f_1n} and C_{RM} are passed through a digital filter with a dynamic time constant (τ_v) ranging from 20-480 minutes, whereby the time constant used is a function of the coefficient of variation of the nephelometer signal:

$$\tau_v \propto f(\nu_{N_{f\_1n}})$$

No matter what the constant, both N_{f_1n} and C_{RM} are passed through τ_v resulting in synchronized long-tern averages $N_{f\_\tau v}$ and $C14_{f\_\tau v}$, respectively.

Activity Concentration of Radon (C_{Rn}) Gas

The fraction of the Radon isotope Rn-222 in ambient air is typically less than 10% and is neglected by most methods. However, the *C14 BETA* measures and corrects for this natural activity due to potentially high interferences with beta attenuation during periods of low ambient particulate concentrations. The activity concentration (C_{Rn})of Rn-222 can be calculated according to the following equation:

$$C_{Rn} = \left(\frac{1}{\varepsilon_{\alpha 2}} \right) * \left(\frac{\alpha_n - \alpha_0}{Q * T_{222}} \right)$$

where;

$\varepsilon_{\alpha 2}$	=	detection efficiency of α particles,
α_n	=	gross count rate [1/s],
α_o	=	background α count rate with an unloaded filter [1/s],
Q	=	air flow rate [m^3/s], and
T222	=	4,550 seconds; an equilibrium constant for Rn-222 daughter nuclides Within the sampled aerosol.

This equation is valid as soon as the radiological equilibrium of the Rn-222 decayed daughter nuclides are reached. This is approximately 90 minutes after a filter change. During this period the C_{Rn} just before the filter change is displayed. It is should also be mentioned that C_{Rn} is smoothed by an algorithm with a 300 second time constant.

Calculation of Concentration Averages

The average concentration is calculated from individual cyclic concentration measurements. All valid cyclic concentration values are summed either as a 30-minute or 60-minute average concentration being calculated, stamped with the time of day and date, and stored within the internal memory. If at least 2/3^{rds} of the cyclic concentration measurements are valid, the average is considered to be valid.

The Model 5030 retains 1 year of 30-minute concentration averages or 2-years of 60-minute averages via the internal 512 kilo-Byte memory. Each record is stored with a respective date, time, instrument status, and classification.

Every 30-minutes the 1 hour and 3 hour average concentration is calculated as a mean value from the latest two (2) and six (6) 30-minute average concentration values, respectively.

After midnight (00:00), the daily average concentration is calculated from the valid 30-minute averages of the previous day.

The 30-minute average, 1 hour average, 3 hour average, and 24 hour average concentrations are displayed on the Model 5030 LCD display by pressing "DISP". These data are also available via the serial interfaces (COM1, COM2) by remote commands and print format command.

The Model 5030 airflow schematic is shown in Figure 1-2. This figure shows the general locations of the ambient, sample, and heater wall temperature sensors; the upstream sample RH sensor, the vacuum, differential orifice, and barometric pressure sensors; and the vacuum pump controlled by variable speed.

Through proper sensor placement a continuous air density correction is applied to the beta attenuation derived concentration. A dynamic average of this concentration is continuously calculated. The ratio of the dynamic beta concentration to the dynamic nephelometer concentration is also continuously calculated. This ratio is then used as a correction factor (CF) for the one-minute average nephelometer reading. Therefore, the following applies:

$$SHARP_n = N_{f\_1}n * (C14_{f\_}\tau v / N_{f\_}\tau v)_n$$

where:

$N_{f\_1}n$ = Nephelometer 1 minute running average (µg/m^3).

$C14_{f\_}\tau v$ = Dynamically filtered Beta-derived concentration (µg/m^3).

Nf_τv = Dynamically filtered Neph-derived concentration (µg/m3).

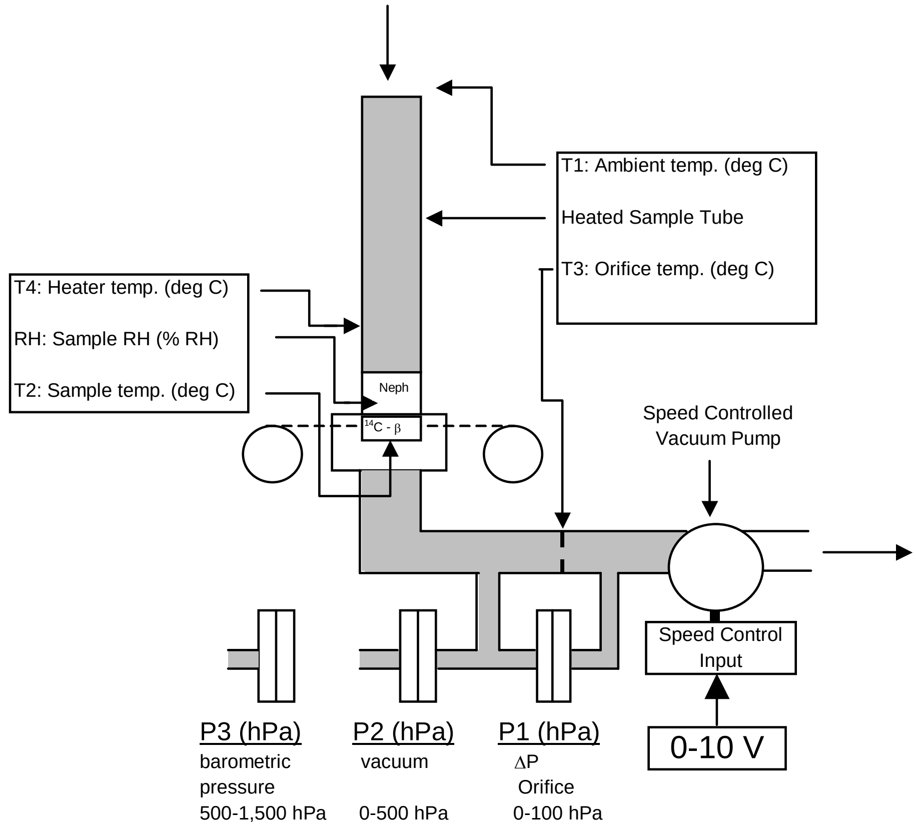


Figure 1–2. Model 5030 SHARP Flow Schematic

The Model 5030 SHARP provides an updated concentration every 4 seconds via the analog output, serial output, and user menu. User selected 30-minute or 60-minute concentrations are date and time stamped with any status/error conditions logged to the internal memory.

Specifications

Table 1–1 lists the instrument's features and specifications.

Table 1–1. Model 5030 Specifications

Feature	Description
Concentration ranges	0 to 1,000 µg/m^3 and 0 to 10,000 µg/m^3 (auto-ranging)
Minimum detectable concentration limit	< 0.5 µg/m^3 @ 2σ (one-hour time resolution) < 0.2 µg/m^3 @ 2σ (24-hour time resolution)
Hourly precision	±2 µg/m^3 < 80 µg/m^3 ; ±5 µg/m3 > 80 µg/m^3
Measurement time resolution	One minute (updated every 4-seconds)
Precision between two monitors	±0.5 µg/m3 (2-σ, 24-hour time resolution)
Span drift	0.002% per day (< 0.7% per year)
Display resolution	0.1 µg/m^3 (internally logged and displayed data)
Accuracy	±5% (compared to 24 hour FRM)
Sources	Optical: IRLED, 6 mW, 880 nm Beta: Carbon-14, < 3.7 MBq (< 100 µCi), 5700-year half-life
Detectors	Optical: silicon/hybrid amplifier Radiometric: proportional counter (α and β)
Air flow rate	1 m^3/h (16.67 lpm) measured across an internal sub-sonic orifice
Output	Two serial interface RS232 (25-pin and 9-pin)
Analog output	4-20mA or 0-10 output of concentration (µg/m^3) (specify upon order)
Operating environment	-22 to 140 °F (-30 to 60 °C)*: Non condensing
Power supply instrument	100-240V, 50/60Hz, 330W max., 15W without pump or heater
Pump	100-110/100-120V, 50/60Hz or 220/240V, 50/60Hz, 100W
Dimensions Instrument	19-inches (W) x 12.25-inches (H) x 13-inches (D) // 483mm(W) x 311mm(H) x 330mm(D)
Pump	8.25-inches (W) x 8.75-inches (H) x 4.25-inches (D) / 210mm(W) x 222mm(H) x 108mm(D)

Chapter 2 Installation

The following installation procedures for the Model 5030 describe packaging, lifting the instrument, unpacking the instrument, performing an acceptance test, installing the monitor, and establishing communications.

For more information about optional equipment (such as, PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ inlet assemblies, heated sample delivery tube, roof flange installation, ambient shelter installation, and standard rack-mount installation), see the "Optional Equipment" chapter.

Packaging and Transport

The Model 5030 instrument, power cord, and operator manual are shipped in an ISTA 2A-certified packaging and all other items/accessories are shipped separately. The Model 5030 ISTA 2A-certified packaging is comprised of the instrument within an inner box which is secured within an outer box using foam end-caps and corner bracing. In this configuration, the packaging is ready for shipping by carrier domestically and internationally.

The inner box that the instrument resides in is an ISTA 1A-certified packaging and is appropriate for transporting the instrument on local paved roads to the monitoring site. Precautions should be taken to secure this package from shifting during local transport.

Using the ISTA-2A packaging is strongly recommended for transporting the instrument over poor roads or on highways.

Lifting

A procedure appropriate to lifting a heavy object should be used when lifting the monitor. This procedure consists of bending at the knees while keeping your back straight and upright. The monitor should be grasped at the bottom, in the front and at the rear of the unit. Do not attempt to lift the monitor by the cover or other external fittings. While one person may lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

Unpacking

If there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection. The carrier, and not Thermo Fisher Scientific, is responsible for any damage incurred during shipment.

Use the following procedure to unpack and inspect the instrument.

1. Remove the instrument from the shipping container(s) and set on a table or bench that allows easy access to both the front and rear of the instrument.

2. Continue with the "Acceptance Testing and Startup Procedures" that follow.

Acceptance Testing and Startup Procedures

The Model 5030 has been bench tested and calibrated at the factory prior to shipping. The mass sensors, RH sensor, internal sample temperature sensor, flowmeter temperature sensor, external ambient/heater temperature sensors, barometric pressure, and volumetric flow rate have been calibrated to traceable standards. Only the ambient and heater temperature sensors integrated within the vertical sample tube may require calibration since these two (2) sensors are specific to each heated sample tube and shipped separately. For a quick start, proceed immediately to the "Startup Procedures" and skip the "Acceptance Testing."

To assure the best quality data, it is recommended that you perform an acceptance test. Frequently, as part of a quality assurance program acceptance testing will be conducted prior to field installation. This is an excellent opportunity to compare the monitor to the primary and transfer standards that are being used within the monitoring program. Furthermore, it is an opportunity to assure that the monitor is operating according to the manufacturer specifications.

After acceptance testing, a completed monitoring installation will require final volumetric flow rate verification.

The following list of figures will help to identify the Model 5030 components and accessories:

Figure 2-1 Model 5030 Front Panel and Component List

Figure 2-2 Model 5030 Rear Panel and Component List

Figure 2-3 Vacuum Pump Assembly and Connectors

Figure 2-4 Heated Sample Tube

Figure 2-5 Roof/Shelter Flange Installation

Figure 2-6 Zero Test Assembly

Figure 2-7 Model 5030 Main Circuit Board

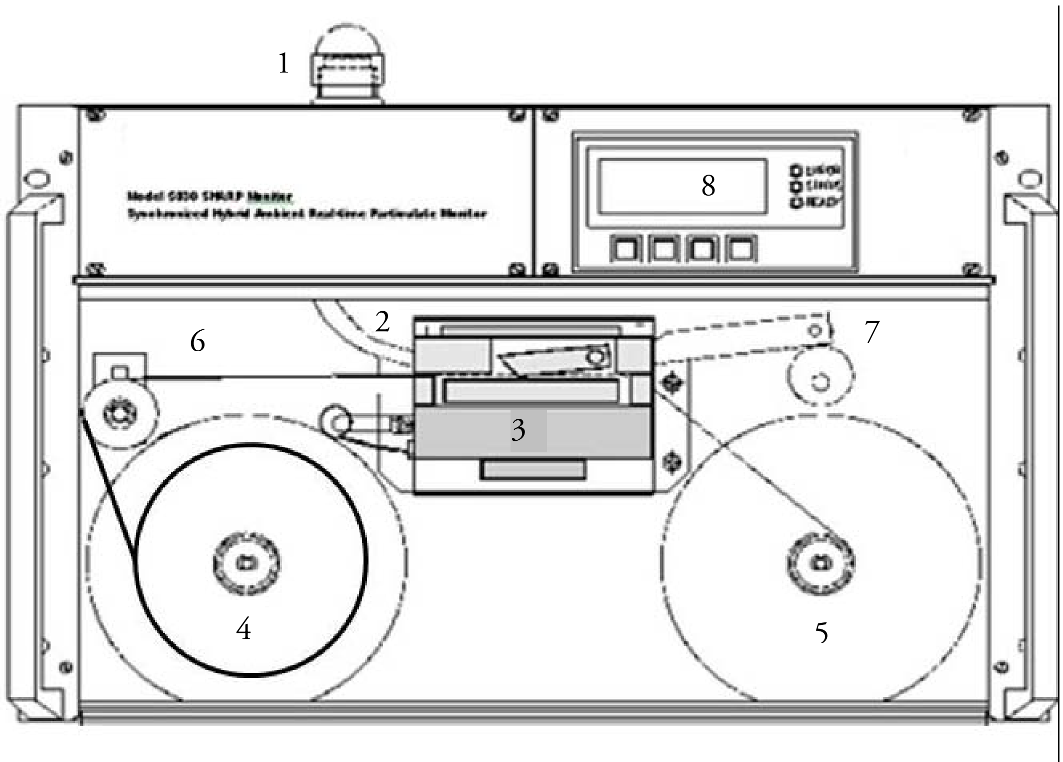


Figure 2-1. Model 5030 Front Panel and Component List

1. Inlet - Nephelometer connector (shown with inlet cap)
2. Nephelometer - Beta detection chamber connection
3. Beta Attenuation chamber
4. Filter tape supply reel
5. Filter tape take-up reel
6. Reversing sintered roller and filter tape transport sensor
7. Filter-tape exchange lever-arm and cam
8. Display

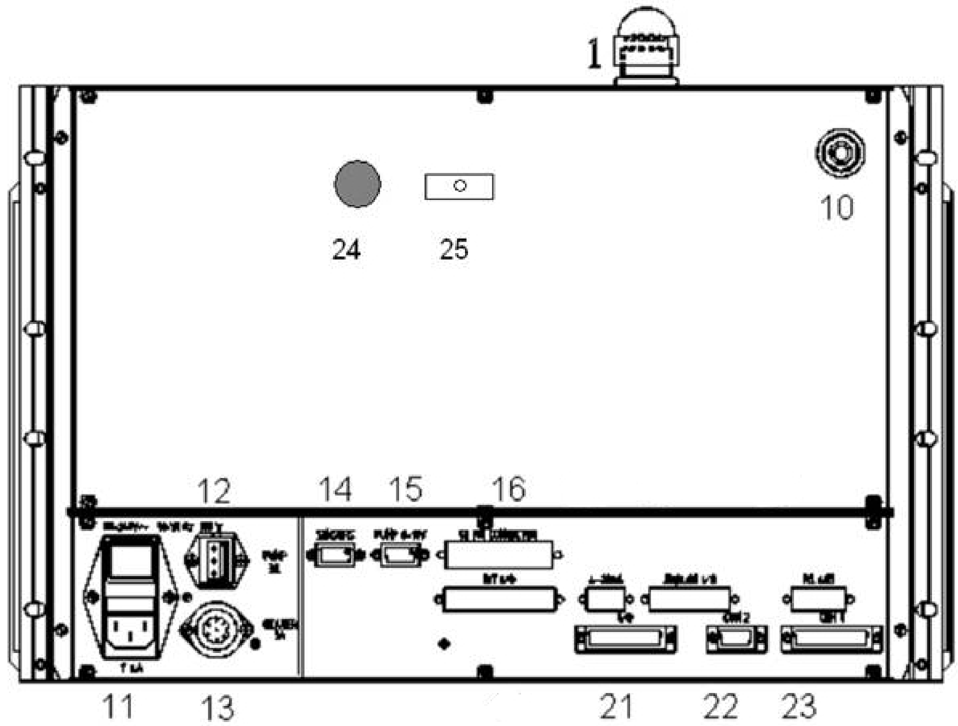


Figure 2-2. Model 5030 Rear Panel and Component List

10. Vacuum pump hose connection
11. Power connection, fuse (2 x 6A), and main switch
12. 3A auxiliary pump connection (used on new Busch/Becker Pumps)
13. Smart Heater connection
14. Ambient/Heater temperature sensor connection
15. 0-10V Pump control connection
16. 50-pin network connection (option)
21. 25-pin I/O connection
22. COM2 serial data interface V.24/RS 232, 9-pin D-sub female connector
23. COM1 serial data interface V.24/RS 232, 25-pin D-sub female connector
24. HV Battery Buffer Supply (three {3} Alkaline C-Cell Batteries)
25. HV Battery Buffer Switch (on/off/test)

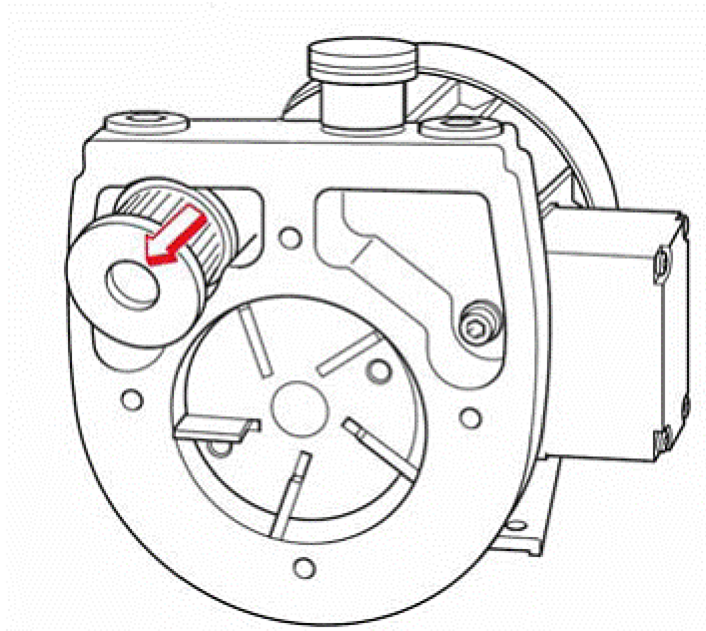


Figure 2-3. Vacuum Pump Assembly and Connectors

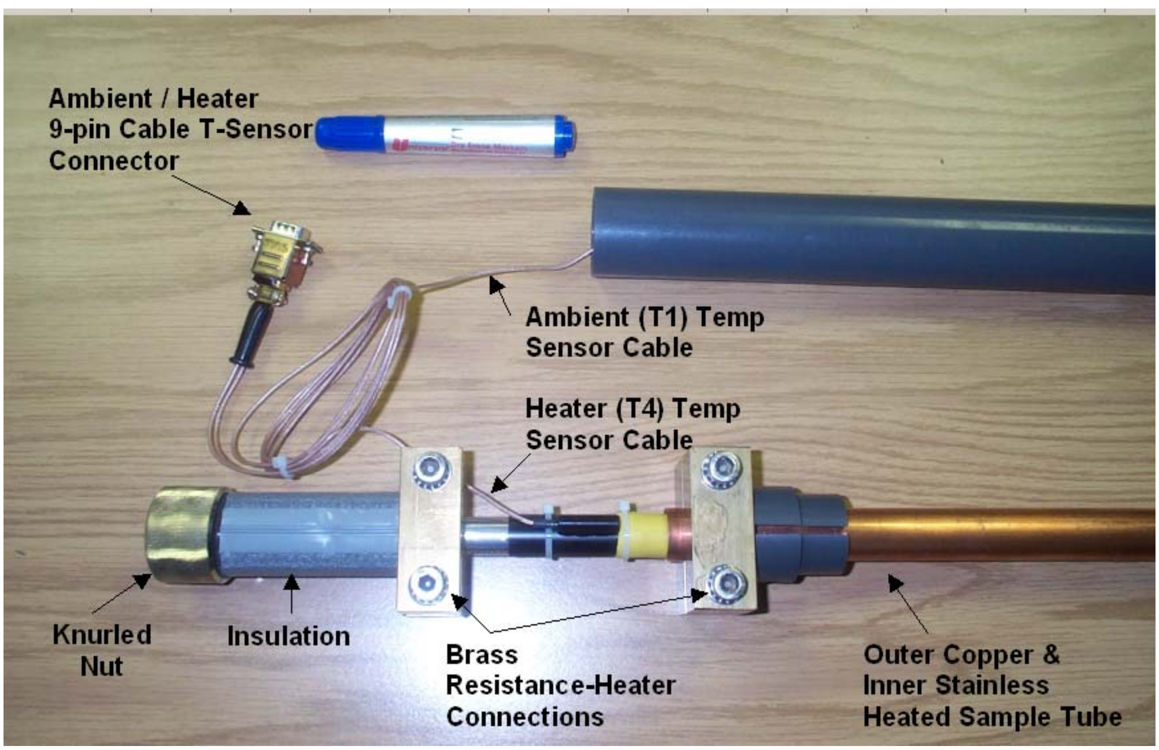


Figure 2-4. 1-Meter Heated Sample Tube

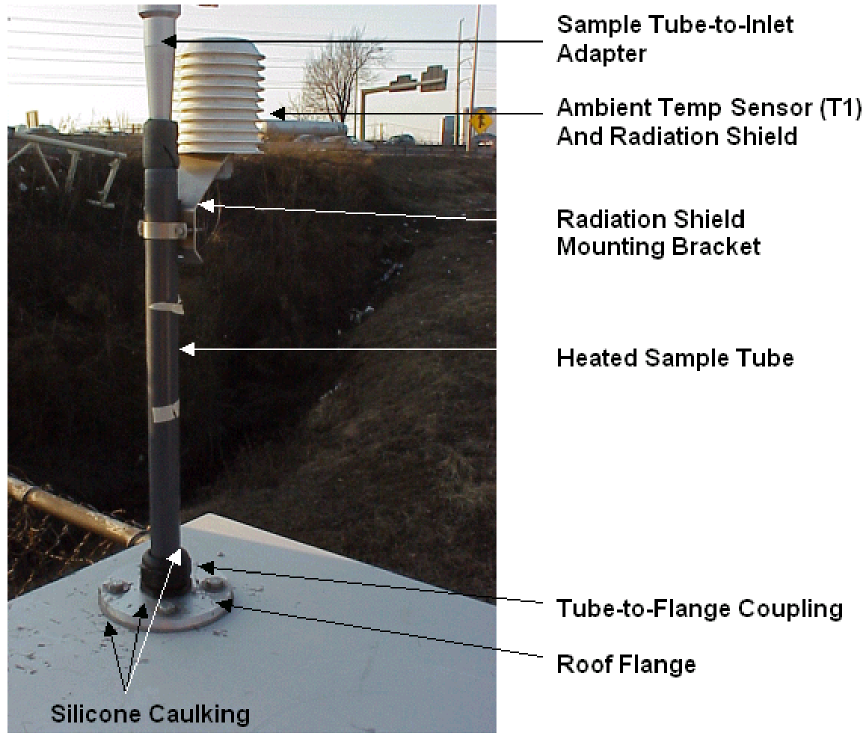


Figure 2-5. Roof/Shelter Flange Installation

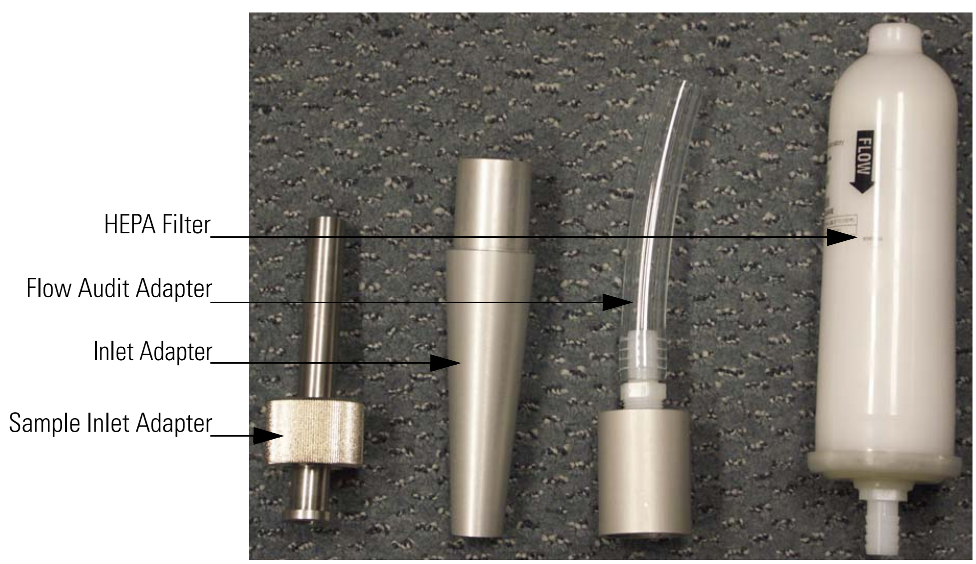


Figure 2-6. Zero Test Assembly

Bench Acceptance Test

Prior to installing the Model 5030, you should perform the acceptance testing procedures. These tests are conducted to evaluate the out-of-box performance of the instrument, perform any necessary calibrations prior to final site installation, and familiarize the user with the menu structure.

Use the following procedure to perform the bench acceptance test.

Equipment Required:

Model 5030 SHARP Monitor,

Model 5030 Power cord

Mini-ambient/heater temperature cable assembly (**DO NOT USE THE HEATED SAMPLE TUBE ASSEMBLY AT THIS POINT**)

Vacuum Pump Assembly

Flow Adapter Assembly

NIST-traceable Thermometer

NIST-traceable Hygrometer

NIST-traceable Barometer

NIST-traceable Volumetric Flow Transfer Standard

1. After unpacking the instrument place the Model 5030 and accessories onto a table or bench located within a stable indoor environment.

   Prior to continuing with acceptance testing, the instrumentation and accessories should have sufficient time to equilibrate to room temperature due to temperature variations during shipping and/or storage.

2. Following a sufficient equilibration period, connect the power cord to the rear of the instrument and to a properly grounded power supply. **If the Model 5030 turns ON at this point, set the power switch to the "OFF" position and then proceed.**

3. Connect the braided vacuum hose to the top brass port on the pump and the other end to the vacuum pump hose connection on the rear of the monitor.

4. Connect the 9-pin vacuum pump control cable to the 0-10V Pump control connector on the rear of the monitor.

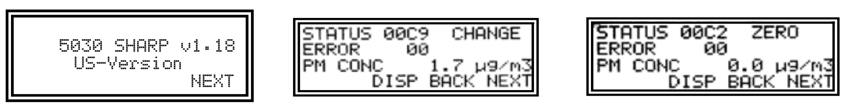
5. Connect the vacuum pump power cord to a properly grounded power supply.

6. Connect the 9-pin ambient/heater temperature assembly to the 9-pin connector labeled “sensors” on the rear of the monitor.

7. Check connections for proper installation.

8. Set monitor power switch to the ON position.

After powering up the Model 5030, the following User Screen sequence (from left to right) will automatically appear:

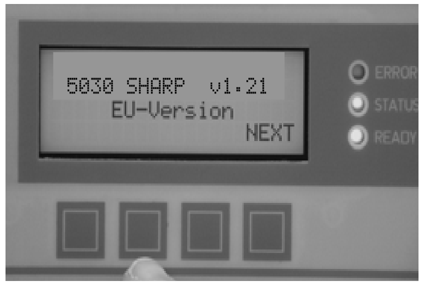


The initial screen information provides the instrument Model, version of Firmware, and the Monitor Protocol (US or EU). The second screen informs the user that the filter tape is changing. The third screen informs the user that the Model 5030 is zeroing the mass of the filter tape and air column, and will begin measuring the accumulated mass on the filter tape. During this third screen, the pump should be operational.

Establishing Monitor Protocol

Two (2) monitoring protocols have been written into the Model 5030 SHARP firmware. These protocols cover the United States and the European Union. The SHARP Monitor protocol can be changed within the first 10 seconds after the monitor is turned on by pressing the second key from the left. The protocol remains in memory if power is interrupted and needs to be chosen only once.

The following screens demonstrate how to change protocols at start up.



Refer to Table 2-1 for a comparison of the EU and US monitoring protocols.

Table 2-1. EU and US Monitoring Protocols

Monitoring Protocol	EU	USEPA
Concentration Factor	110%	100%
Stored Values	30 minutes	one hour
Relative Humidity Threshold	65%	58%
Maximum Allowable Heater Temperature	45° C	60° C
Minimum Heater Power	5%	2%
Software Version (Oct 2012)	1.21	1.21

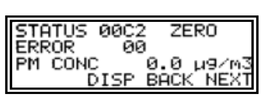
Menu Tutorial

The following brief menu tutorial will help to guide you through the menu structure and to complete acceptance testing.

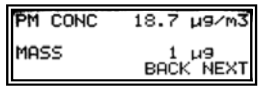
The status codes within the User Screen should appear as above. After the sample stabilizes, the “ZERO” will change to “NORMAL”. However, within the first 12 hours, the status code of 0040 will remain while the instrument stabilizes. Thereafter, an operational status of 0000 will appear.

Should a STATUS code appear within the User Screen that is different from what is shown above, or if a ERROR code appears in the User Screen, supplemental text information and/or detailed error codes can be reviewed and interpreted according to the “Troubleshooting” chapter.

By pressing the DISP key, the user can enter the User Screen sub-menus. Once there, the user can scroll through the sub-menu by pressing NEXT. These are the following screens that should be seen upon startup:

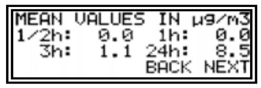


This is the main User Screen showing a combined STATUS Code, combined ERROR Code, and PM Concentration. Press **DISP**.



This screen provides the current aerosol concentration and accumulated mass in micrograms. Press **NEXT**.

This screen shows the measured volumetric flow rate in liters per hour (l/h), the standard flow rate (Nl/h), as well as the pump controller output in percent of the output range (such as, 68.6%). Divide by 60 to obtain liters per minute. Press **NEXT**.



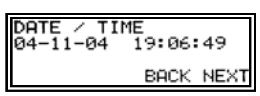
This screen shows the most recent 30–minute, one-hour, three-hour, and 24-hour average concentrations carried over from prior operation. Press **NEXT**.

This screen shows the background radon content measured by the instrument. Press **NEXT**.

This screen shows the individual text codes in relation to the combined status codes that are expected at startup. Press **TEXT** for additional information.

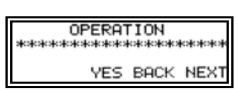
This screen shows the additional "POWER ON" status code after starting the instrument. Press **NEXT**.

This screen shows the detailed error status code. If necessary, this should be interpreted through the "Troubleshooting" chapter. Press **NEXT**.



This is the last screen within the main User Screen, and this shows the current Date (yy-mm-dd) and Time (hh:mm:ss). Refer to the "Operation" chapter for changing these values. Press **NEXT**.

By pressing NEXT, from the last screen within the main User Screen, the following screen will appear:



This is the Operation menu. Press **NEXT**.

This is the Service menu. Press **NEXT**.

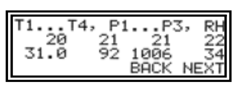
This is the Calibration menu. Press **NEXT**.

You have now returned to the main User Screen. By pressing **NEXT** or **BACK** you may scroll to the Operation, Service, and Calibration menus. By pressing **DISP**, you will scroll through the User Screen sub-menus again.

To continue with the acceptance testing, scroll forward to the Service menu and press **YES** to enter this menu. Once there, press **SET** to unlock the keypad and you should see the following screen:

From here, continue to press **NEXT** until you see the following screen:

Press **YES** to enter this Service sub-menu and continue to press **NEXT** until you see the following screen:



At this screen, the top row is an abbreviated text of the digital measurements being provided. The description of these abbreviations is as follows:

T1: Ambient Temperature (deg C),

T2: Sample Temperature (deg C),

T3: Orifice Temperature (deg C),

T4: Heater External Wall Temperature (deg C),

P1: Orifice Pressure Drop (hPa),

P2: Vacuum under sample filter tape (hPa),

P3: Barometric Pressure (hPa),

RH: Sample Relative Humidity (% RH).

Table 2-2. Barometric Pressure Conversions

hPa = atm X 1,013.2501
hPa = in Hg X 33.8638867
hPa = mm Hg x 1.3332239

The second line of the above screen provides the T1, T2, T3, and T4 measurement. The third line of the above screen provides the P1, P2, P3, and RH measurements.

Assuming adequate time has passed for thermal equilibration and the vacuum pump has been drawing room air into the instrument, compare the ambient temperature (T1), sample temperature (T2), orifice temperature (T3), and heater temperature (T4) to your NIST traceable thermometer.

Note At this point during acceptance testing the mini-ambient/heater temperature assembly is attached to the rear of the instrument. Please be sure that the pump exhaust or any other heat source is not influencing these sensor readings. ▲

One-Point Temperature Verification

As per 40CFR, Part 50, Appendix L, Section 9.3, record the T1, T2, T3, and T4 sensor readings from the Model 5030 and compare to your NIST-traceable thermometer. Each of these measurements should be within ±4 °C tolerance of your NIST-traceable thermometer. Within this tolerance, the temperature sensors have passed the acceptance test.

If the Model 5030 sensors are slightly out of tolerance (±5 °C), the acceptance test should be classified as marginal. If the sensor performance is less than marginal, please contact Thermo Fisher Scientific's Technical Support at (866) 282-0430 or your local sales representative.

Temperature sensor calibration is covered in the "Calibration" chapter.

One-Point RH Sensor Verification

Record the RH sensor reading from the Model 5030 and compare to your NIST-traceable Hygrometer. The Model 5030 RH sensor should compare within ±2% RH tolerance of your NIST-traceable Hygrometer. If the Model 5030 RH sensor performance is within this tolerance, the acceptance test has passed.

Note The temperature verification should be completed prior to performing the RH-sensor verification due to a thermal compensation applied to the RH-sensor. ▲

If the Model 5030 RH sensor is slightly out of tolerance, ±3% RH, the acceptance test should be classified as marginal. If the sensor performance is less than marginal, please contact Thermo Fisher Scientific's Technical Support at (866) 282-0430 or your local sales representative.

RH sensor calibration is covered in the "Calibration" chapter.

It is recommended that the NIST-traceable Hygrometer should also compare well with the RH-measurement used within a gravimetric laboratory that is part of a compliance program.

One-Point Barometric Pressure Verification

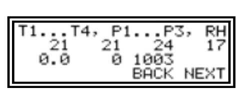
As per 40CFR, Part 50, Appendix L, Section 9.3, record the Model 5030 P3 barometric pressure sensor reading. This value is in units of hectopascal (hPa). If necessary, using the conversion chart (Table 2-2) to convert your NIST-traceable measurement to units of hPa for an appropriate comparison. The Model 5030 P3 sensor should compare within ±13.33 hPa tolerance of your NIST-traceable barometer. If the Model 5030 P3 sensor performance is within this tolerance, the acceptance test has passed.

If the Model 5030 P3 sensor is slightly out of tolerance, ±15 hPa, the acceptance test should be classified as marginal. If the sensor performance is less than marginal, please contact Thermo Fisher Scientific's Technical Support at (866) 282-0430 or your local sales representative.

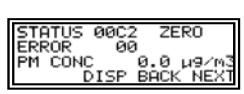
The Model 5030 P3-Barometric Pressure sensor calibration is covered in the "Calibration" chapter.

One-Point Volumetric Flow Rate Verification

As per 40CFR, Part 50, Appendix L, Section 9.2.5, the flow rate of the Model 5030 should be verified during this acceptance test. Prior to this test it is important for the previous temperature and pressure acceptance tests to be completed. Should the T1, T3, or P3 sensors require calibration, this should be done prior to the flow rate verification.



From this screen, repeatedly press **NEXT** until you arrive at the Main User Screen:



From here, press **DISP** then press **NEXT** and the following screen appears:

At this screen the Model 5030 volumetric flow rate in units of liters per hour and is shown on the second line of the display, next to OPERATION. The third line of this screen shows the flow rate in units of standard liters per hour. This standard flow rate is corrected to 1013.25 hPa (1 atm, 29.92 in Hg, or 760 mm Hg) and to the temperature displayed next to NORM. The last line of this screen shows the pump control voltage output in percent (%).

Attach the small sample tube adapter to the Model 5030 inlet. Attach the inlet adapter to the sample tube. Depending upon your NIST-traceable volumetric flow transfer standard (FTS), you may either attach your FTS now or add the flow audit adapter to accommodate any flexible tubing that your FTS may require. Allow 60 seconds to stabilize the flow.

Note Keep this inlet assembly for nephelometer zero. ▲

Record the Model 5030 Volumetric Flow Rate as Qm and the FTS flow rate as Qi, assuring that both are being recorded in units of L/h. Take three (3) readings each from Qm and Qi and average the respective values. Use the following equation to calculate the percent difference:

$$\%D = 100 \times \frac{Qm - Qi}{Qi}$$

If %D is within ±4%, then the Model 5030 volumetric flow rate acceptance test has passed. If the Model 5030 volumetric flow rate is slightly out of tolerance, ±5%, the acceptance test should be classified as marginal. If the volumetric flow rate performance is less than marginal, please contact Thermo Fisher Scientific's Technical Support at (866) 282-0430 or your local sales representative.

The Model 5030 Volumetric flow rate calibration is covered in the "Calibration" chapter.

Perform a leak test. Refer to "Leak Test Procedure" on page 2-10.

Nephelometer Zero

Prior to field installation, the inline nephelometer should be tested and zeroed. There are two approaches that can be used at this point:

- Perform a background zero on the Model 5030 nephelometer (~2 minutes), or

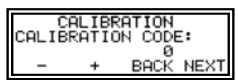
- Perform an overnight zero test to evaluate absolute zero measurement and calculate the instrument detection limit.

Assuming this test is continuing from the previous user screen:

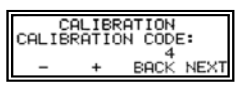
Continue to press **NEXT**, until the following screen appears:

Press **YES**.

If the screen indicates the Calibration is locked, press **SET** to unlock Calibration menu.



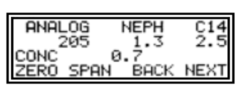
Increment the calibration code to “4” by pressing the **+** key.



Press **NEXT**.

The Calibration Screen can now be fully accessed. Continue to Press **NEXT** until the following screen appears:

At this screen, Press **YES**.



At this screen, there are four (4) parameters of consideration.

In the screen above, the first value (205) is the nephelometer analog signal in units of least significant bits (LSB). The second value (1.3) is the nephelometer one-minute average aerosol concentration in units of micrograms per cubic meter (μg/m^3). The third value (2.5) is the long-term beta attenuation derived aerosol concentration in units of μg/m^3. The fourth value (0.7) is the Model 5030 hybrid real-time aerosol concentration in units of μg/m^3.

Background Zero

From this menu, placing a HEPA Filter at the inlet and Pressing ZERO on the keypad can zero the nephelometer. A HEPA filter is provided with each Model 5030 for this purpose. Furthermore, by introducing a known concentration of aerosol to the Model 5030, a span calibration can be performed on the nephelometer. However, for the purpose of this step only the zero of the nephelometer should be performed.

To perform a zero measurement on the nephelometer, connect the Zero Test Assembly (as done previously during the volumetric flow rate verification).

1. Attach the small sample tube adapter to the Model 5030 inlet.

2. Attach the inlet adapter to the sample tube.

3. Attach the flow audit adapter.

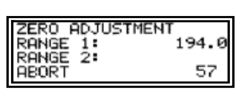
4. Attach the HEPA filter to the flow audit adapter.

5. Allow 5-minutes for the factory-zero to stabilize.

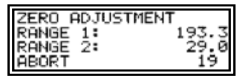
At the end of 5 minutes, the ANALOG and NEPH values should be stable. The NEPH value should read 0.0 µg/m^3, ±2.0 µg/m^3. If the Model 5030 Nephelometer performance is within this tolerance, the acceptance test has passed. These two (2) values can be considered the "as-found" values for the Model 5030 zero measurement. Should the NEPH value be ±4.0 µg/m^3, the nephelometer performance can be considered marginal, and outside of this range the nephelometer requires the background be zeroed.

It is recommended that the ANALOG and NEPH values be recorded and control-charted in an effort to maintain any history of background shift.

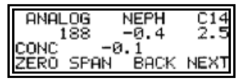
To zero the background, maintain the HEPA filter at the inlet and press **Zero**.



After pressing ZERO, the screen will begin an automatic 60-second average of the nephelometer operating on the 0-1,000 µg/m^3 concentration range. The counter is in the lower right hand of the screen.

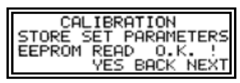


After the first range is zeroed, the 2nd Range (0-10,000 μg/m^3) is independently zeroed over a 20-second period.



Now the Nephelometer background is zeroed for both ranges of measurement. Another 5-minute measurement cycle can be performed and compared to the "as found" values. Press **NEXT** until the following screen appears:

Press **YES**.



The nephelometer zero calibration has now been set. Press **NEXT**

CAUTION If operational parameter changes have been made within the Operations menu, they must be saved via the CALIBRATION menu in order to become new default settings. Otherwise, the original parameter settings will be restored when RELOAD is used within the CALIBRATION menu. ▲

24-Hour Zero and Detection Limit

Perform the following steps to thoroughly evaluate the absolute zero and detection limit of the Model 5030.

1. Keep the instrument in the Calibration Mode (Status = 0070).

2. Maintain the HEPA filter at the inlet.

By conducting this test, the zero measurement should run for approximately 24 hours. After performing this test, the hourly data should be downloaded from the instrument memory. The average of 24 consecutive measurements would be the 24-hour absolute zero of the instrument.

With a sample population of 24, one-hour measurements, an hourly detection limit can be calculated according to:

$$DL_{1-hr} = 2\sigma$$

whereas, σ is calculated from the following non-biased standard deviation equation:

$$\sigma = \sqrt{\frac{n\sum_{i=1}^{n} X^2 - \left(\sum_{i=1}^{n} X\right)^2}{n(n-1)}}$$

and, X*i* is each hourly zero measurement over a 24 hour period.

After completing the nephelometer zero, the acceptance test is now complete. Should any questions or issues be outstanding, please contact Thermo Fisher Scientific's Technical Support at (866) 282-0430 or your local sales representative.

Heated Sample Tube Sensor Calibration

While the instrument and accessories are fully equilibrated to room temperature, it would be beneficial and convenient to locate the heated sampling tube and connect the ambient/heater temperature sensor 9-pin cable assembly to the Model 5030 in place of the temperature sensor assembly that comes standard with each instrument.

After replacing the ambient/heater sensor cable with the ambient/heater cable assembly attached to the heated sample tube, repeat the one-point temperature verification for T1 and T4. If acceptable, the instrument and accessories are ready for installation. Otherwise, refer to the "Calibration" chapter to calibrate the sensors. Please note that although the resistance of the standard temperature cable assembly is closely matched to that of the heated sample tube cable assembly, Thermo Fisher Scientific qualifies and ships the heated sample tubes separately and therefore are not calibrated for any instrument with each shipment.

Setup and Installation

The Model 5030 is designed to be installed within an approved ambient shelter or a climate controlled shelter whose environments are non-condensing and the temperature range is between –22 to 60 °C. Through the use of a flange kit, the Model 5030 may be installed on a flat building or shelter roof surface. Depending upon the inlet height, additional vertical bracing may be required. The Model 5030 can be either rack mounted or tabletop mounted.

Siting

The siting criteria for proper aerosol collection should generally adhere to the following criteria:

- Final inlet height ≥ two (2) meters above roof line and away from direct building ventilation/exhaust
- Final inlet height should be as close as possible to the inlet height of the reference methods being compared against
- 1-2 meter inlet distance between collocated samplers @16.67 L/min
- 2-3 meter inlet distance between collocated 16.67 L/min and hi-vol samplers
- Instrument front panel should be North to Northeast facing in an ambient shelter or avoid direct sunlight if rack mounted in climate controlled shelter.

For more information on siting an aerosol measurement inlet, spatial and temporal aspects of network design and optimum site exposure, refer to 40 CFR Part 58, Appendix D and in the guidance document for network design and optimum site exposure for $PM_{2.5}$ and PM_{10} published by the U.S. EPA Office of Air Quality Planning and Standards.

Heated Sample Tube Lengths

There are two style heaters at 1-meter and 3-meter lengths. The one meter length is normally used in conjunction with the ambient shelter provided by Thermo Fisher Scientific. The three meter length has a two meter heated zone and an additional one meter of excess sample tubing to be cut to the exact height requirements onsite. Please check availability for these heaters.

Rack Mounting

One limiting factor when siting the Model 5030 is placement within a standard 19-inch rack mounting. Future planning should be made to reserve the topmost rack mounting position available due to the vertical positioning of the sample tube directly from the roof into the top of the Model 5030. In addition, modification to the rack cabinet to accommodate the vertical tubing connection also needs to be considered prior to installation.

Review the following installation steps prior to field installation.

1. Mount the Model 5030 to the rack using a set of FH132 sliding rail hardware.

2. Determine the location of the Model 5030 inlet tube on the roof enclosure (ambient shelters are already provided with this location cleared).

3. Drill a 2 ½-inch (64 mm) diameter hole at that location through the roof.

4. Caulk around the 2 ½-inch hole and place the roof flange over the hole (for the ambient shelter a gasket is provided in place of the caulking for this step).

5. Secure the flange in place with four 3/8-inch lag bolts. Caulk around the lag bolts to prevent leaks.

6. Thread the black tube-to-flange coupling into the flange until fully tightened. Caulk around the outside edge of the coupling-flange interface.

7. Remove the upper coupling with rubber ferrule and set aside.

8. Determine the exact length of sample tube needed above the roofline to accommodate the inlet assembly.

   Assuming an inlet height of 2-meters (78 ¾-inch) a $PM_{2.5}$ inlet assembly would require exactly 1,391 mm (54 ¾-inch) of sample tubing above the roofline and a PM_{10} inlet assembly would require 1,521 mm (59 ¾-inch) of sample tubing above the roofline.

   Cut the stainless steel sample tube and debur the inner and outer edge of the sample tube to avoid cutting the O-rings on the inlet adapter and blocking any aerosol entering the sample tube.

9. Remove the two sets of brass resistance-heater connections from the heated sample tube and set aside.

10. Place the inlet tubing through the roof flange and onto the top of the Model 5030.

Note PLEASE PAY EXTRA CARE TO THE INTEGRATED AMBIENT/HEATER TEMPERATURE SENSOR CABLE ASSEMBLY THAT MUST PASS THROUGH WITH THE HEATED TUBE. ▲

11. Place the rubber ferrule and coupling over the heated sample tube and thread the coupling into the lower coupling adapter already secured. APPLY ONLY FINGER TIGHT.

12. At instrument level, properly align and tighten the stainless steel knurled nut onto the top of the Model 5030.

13. Return to the roof level and firmly tighten the roof flange-coupling assembly. Caulk around the coupling-to-sample tube interface to avoid leaks.

14. Attach the ambient temperature radiation shield assembly to the outer gray plastic sample tube and insert the ambient temperature sensor into the radiation shield.

15. Attach the inlet assembly onto the sample tube (for example, inlet adapter, sharp-cut cyclone, PM_{10} Inlet).

16. Attach vertical bracing to the exterior sample tube in at least two lateral directions that are 90 degrees apart or employ the use of a tripod attachment as available.

17. Connect the power cord to the rear of the Model 5030 and to a properly grounded power supply of the appropriate voltage and frequency. Should the Model 5030 turn ON at this point, set the power switch to the OFF position and then proceed.

18. Connect the braided vacuum hose to the top brass port on the pump and the other end to vacuum pump hose connection on the rear of the monitor. Properly tighten both ends of this braided hose.

19. Connect the 9-pin vacuum pump control cable to the 0-10V Pump control connector on the rear of the monitor.

20. Connect the vacuum pump power cord to a properly grounded power supply of the appropriate voltage and frequency.

21. Connect the 9-pin ambient/heater temperature cable assembly from the heated sample tube to the 9-pin connector labeled “sensors” on the rear of the monitor.

22. Place the heater control unit on top of the Model 5030 with the green power switch facing forward.

23. Connect the brass resistance-heater connectors to the upper-most exposed copper tubing and the lower-most exposed stainless sample tube.

24. Connect one (1) blue/gray heater control cable to each brass resistance heater connector. Wrap exposed stainless sample tube with insulation provided.

25. Plug the heater control unit amphenol-connector into the rear of the Model 5030 labeled “heater.”

26. Check connections for proper installation.

27. Set monitor power switch to the ON position.

WARNING The Model 5030 Monitor and pump are supplied with three-wire grounding cords. Under no circumstances should this grounding system be defeated. ▲

Establishing Communications

Unless specified upon order, the Model 5030 comes equipped with a default analog output signal of 0-20 milliamps (mA).

Analog Output Installation

This setting can simply be adjusted to a 4-20 mA setting via the user screen. In order to configure the Model 5030 for an analog output of 0-10 volts (V), jumpers on the main circuit board must be repositioned.

WARNING If the output signal jumpers are to be changed, **TURN THE POWER TO THE INSTRUMENT OFF FIRST AND UNPLUG FROM THE POWER SUPPLY!** ▲

The Model 5030 analog output of measured aerosol concentrations can be accessed from the rear I/O socket on the central unit. Pin numbers 12 and 13 from the I/O socket are used as the (+) 0-20mA/0-10V concentration signal and as the (-) 20mA/ground connectors, respectively.

In order to switch the analog output signal from mA to V, the jumper settings on the circuit board must be changed.

1. Reference Figure 2-7 to make any necessary changes. In this figure, locate the four (4) connectors labeled x10, x11, x24, and x25 towards the right side of the circuit board. These connectors run from top to bottom in Figure 2-7 and are towards the rear of the instrument. Each connector comes from the factory with the jumpers connected to pins 3-4 and 7-8, and this provides an analog output of 0-20 mA.

   For a description of the connector pin layout, see the upper right hand corner of Figure 2-7 labeled: "**Pin No.**"

WARNING Disconnect power before accessing the circuit board. ▲

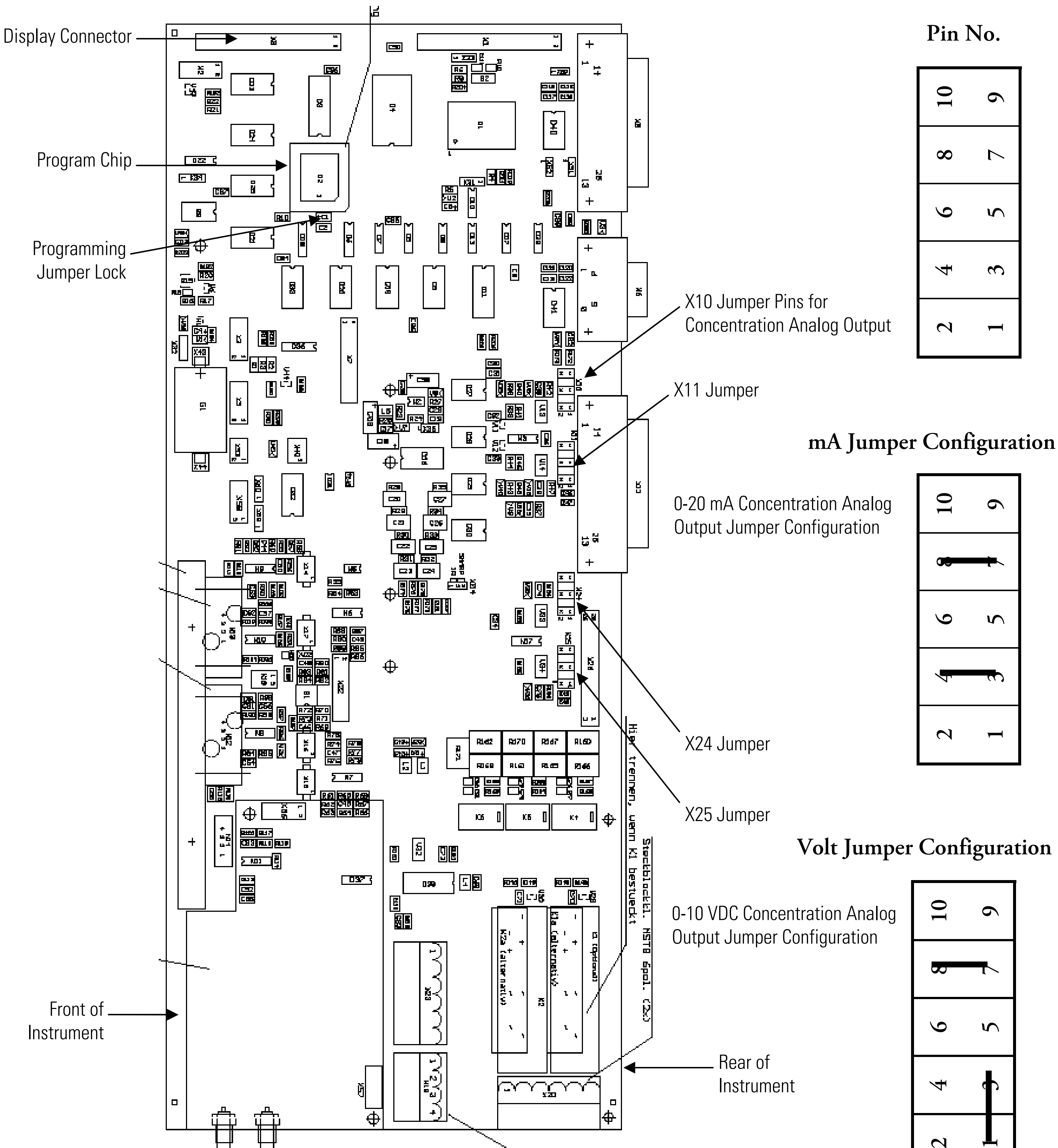


Figure 2–7. Model 5030 Main Circuit Board

2. To complete a change of jumpers, access the circuit board by unscrewing the six (6) small screws on the small access panel on the lower rear of the instrument. **Gently** pull the panel with fixed circuit board outward only two inches (5 cm) to expose the connectors.

3. To configure the analog output for voltage, change the jumper settings on connector x10 and x24 only (as referenced in Figure 2-7) to provide a 1-3 and 7-8 jumper setting per connector. Do not change the jumper settings on connectors x11 and x25.

4. **Gently** insert the circuit board and secure the rear access panel with the six (6) screws.

5. Power on the central unit and check for voltage output readings.

Note Although the jumpers have now been changed for a voltage output signal, the Display menu will still show mA as the analog output. Please apply 0 mA = 0V; 4 mA = 2V and 20 mA = 10V. ▲

To revert back to an analog output in mA, follow the above instructions and place the x10 and x24 connectors into the original jumper settings of 3-4 and 7-8.

Any information regarding Serial Data Output is discussed in Chapter 3 and RS-232 Commands are provided in Appendix B.

Serial Data Communications

There are two RS-232 serial data ports on the Model 5030. Referencing Figure 2-2, these two com-ports are labeled COM1 (No 23) and COM2 (No 22) and are a 25-pin and 9-pin female connectors, respectively. HyperTerminal is the software used to connect to the Model 5030. The communications protocol used for both serial ports is as follows:

Baud rate	300, 600, 1200, 4800, or 9600
Data Bits	7
Parity	Even
Stop Bits	2
Flow Control	Hardware

It is recommended that COM2 be used for remote dial-up connection and COM1 be reserved as either an onsite interface or for scheduled data printouts. One COM1 cable is provided with each Model 5030. A full explanation of serial communication is provided in the "Operation" chapter.

Filter Tape Installation

From the Service menu, press **YES**.

Enable the keypad by pressing **SET**, and then press **NEXT**.

From this screen, press **YES**.

Open the Detector Head by pressing **YES**.

Use the following procedure to install the filter tape (Figure 2-1:).

1. Open the front transparent cover plate on the Model 5030.

2. Loosen the knurled nuts on both the supply reel (4) and the take-up reel (5) and remove any used filter tape and empty the supply spool.

3. Put a full roll of tape on the filter tape supply reel (4), and place the empty take-up spool on the filter tape take-up reel (5).

4. Feed the filter tape from the supply reel clockwise around the reversing roller (6), through the left side of the detection chamber, and fix the filter tape to the filter tape take-up reel (5) using double-sided sticky tape.

5. Hand-tighten the knurled nuts on both the supply reel (4) and the take-up reel (5).

6. Press **YES** to advance the filter tape, and the tape counter should be increasing. Advance the filter tape until it has wrapped around itself twice on the take-up reel (5). Press **NEXT**.

7. At this screen, Press FC+Z. This will perform a filter change and zero and reinitialize aerosol measurement.

8. Replace the front transparent cover plate on the central unit.

In case the inserted filter tape is not correctly tensioned (for example, in case the reversing roller does not turn during the filter change cycle), the pump will be switched on immediately after the filter tape change attempt is complete, but at the same time a corresponding error status will occur. Consequently, the filter tape needs to be checked. After investigation, another filter change cycle has to be initialized by pressing the key “FC+Z” again.

Chapter 3 Operation

Operation and Service Menus

This chapter describes the front panel display, keypad pushbuttons, and menu-driven software for the Operation and Service menus. The Calibration menu is described in the "Calibration" chapter.

Display

The 4 line by 20 character alphanumeric display shows the sample concentration, instrument parameters, instrument controls, and help messages. Some menus contain more items than can be displayed at one time. For these menus, use the BACK and NEXT pushbuttons to move through the menus and submenus.

Keypad

The keypad of the Model 5030 consists of 4 keys to operate the instrument. Together with the display unit, these keys form the interactive user surface. The functions that are covered by the single keys are described in the lowest line of the display.

BACK,NEXT	Moving backwards and forwards within the menu
YES	Entering a sub-menu, carrying out the action(s) being displayed
YES,NO	Switching on/off parameter flags
+, –	Setting numerical values

These keys are only for general information. The additional key functions that are more individual or specific within each menu are described in the corresponding menu descriptions.

During normal operation, the keyboard usually is locked. The majority of the menu points and all displays can be accessed by pressing the BACK, NEXT and YES keys. Changing operational settings and the calibration of sensors are only possible after unlocking the keyboard. With the keyboard unlocked only changes to the operational settings are possible. To calibrate the unit, a code must be entered to further unlock the Calibration menu.

Main User Screen

```
STATUS:0000 NORMAL
ERROR:  00
PM CONC   12.7µg/m3
     DISP BACK NEXT
```

```
STATUS:0009 CHANGE
ERROR:  00
PM CONC   12.7µg/m3
     DISP BACK NEXT
```

```
STATUS:0002 ZERO
ERROR:  00
PM CONC   12.7µg/m3
     DISP BACK NEXT
```

In the Main User Screen the status code, error code, and aerosol concentration are found. The concentration value in micrograms per cubic meter (µg/m^3) will be updated every 4 seconds. By pressing DISP and NEXT other values such as aerosol mass, air flow rate, average concentration values, error status, and time can be displayed. The Main sub-menus are as follows:

```
STATUS 00C2  ZERO
ERROR   00
PM CONC    0.0 µg/m3
      DISP BACK NEXT
```

This is the main User Screen showing a combined STATUS Code, combined ERROR Code, and PM Concentration, press **DISP**.

```
PM CONC   18.7 µg/m3

MASS          1 µg
          BACK NEXT
```

This screen provides the current aerosol concentration and accumulated mass in micrograms, press **NEXT**.

```
AIR FLOW
OPERATION     0 l/h
NORM 25 °C    0 Nl/h
  0.0 %     BACK NEXT
```

This display shows the volumetric flow at the inlet, the flow rate at STP conditions (standard temperature and pressure, 1013 hPa and 25 °C), and the pump power (%). Please note the standard temperature is adjustable in the Calibration menu. Press **NEXT**.

```
MEAN VALUES  IN µg/m3
1/2h:  0.0  1h:  0.0
  3h:  1.1 24h:  8.5
           BACK NEXT
```

This screen shows the most recent 30–minute, one-hour, three-hour, and 24-hour average concentrations carried over from prior operation. Please note that the 24-hour average is the “daily” average. Press **NEXT**.

```
RADON CONTENT
CONCENTR:    0 Bq/m3
NAT.ACT.:    0 Bq
           BACK NEXT
```

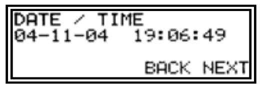
This screen shows the background radon content measured by the instrument and is used for refining the mass measurement. Press **NEXT**.

```
STATUS 00C2
SAMPLE STABILIZING
NEPH CAL STABILIZING
     TEXT  BACK NEXT
```

This screen shows the individual text codes in relation to the combined status codes that are expected at startup, press **TEXT** for additional information.

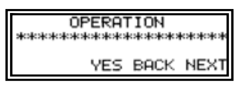
This screen shows the additional "POWER ON" status code after starting the instrument. Press **NEXT**.

Here, the error status is shown. Each character represents four error bits, assuming values in the range of 1 and F (hexadecimal: 16). To interpret the error status, see the "Troubleshooting" chapter. Press **NEXT**.



This is the last screen within the main User Screen, and this shows the current Date (yy-mm-dd) and Time (hh:mm:ss). To change these values the keypad must be unlocked. Press **NEXT**.

By pressing NEXT, from the last screen within the main User Screen, the following screen will appear:



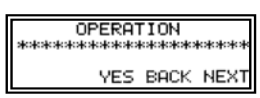
This is the OPERATION menu, press **NEXT**.

This is the SERVICE menu, press **NEXT**.

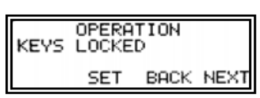
This is the CALIBRATION menu, press **NEXT**.

Operation Menu

This section describes the Operation menu.



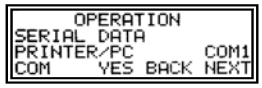
Press YES to enter the Operation menu, press BACK to return to the Main Menu, or press NEXT to enter the Service menu.



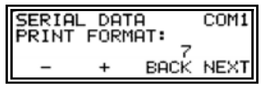
To toggle between the operation via keypad and serial interface, press the SET key. Please remember that the parameters cannot be changed without having enabled the keypad. Press **SET**.

Press **NEXT**.

Serial Communication Parameters



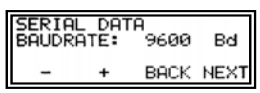
Pressing the COM key toggles between the COM1 and COM2 interface. Choose COM1 or COM2 to change the serial parameters. Press **NEXT**.



The print format indicates which data report will be issued at the serial interface. You can adjust the print format using the +/- keys. Press **NEXT**.

Press **PRINT** to begin the serial output.

After the set time has elapsed, the selected data report will output to the serial interface. If set to 0 minutes, the next menu allows a cycle ranging from 0 to 120 seconds. Printouts will be limited and repeated to this print cycle. Press **NEXT**.



This display window allows setting the baud transmission rate. Choose between 300, 600, 1200, 2400, 4800 and 9600 Baud, using the +/- keys.

This display window allows a device number to be applied to the instrument and is important when multiple monitors are tied into a network on the same communications line.

Print Formats

Print formats are provided by an output spooler. While printing, the normal measurement operation will not be interrupted and the measuring instrument can be operated as usual. Remote Control commands are possible using the second serial interface during printing out the lists via the first serial interface. From the internal memory, sufficient information from the print formats is available. The transmission of all half-hourly mean concentrations over an entire year, including information on date and status, requires approximately 632 Kbytes. At a bit transmission rate of 9600, the transmission process will need approximately 10 minutes. The transmission of hourly values will take less space and time.

The following information provides examples of the Serial Output Print Formats, whereby only Print Formats 1-7 will automatically be output according to the Print Cycle:

1) Date, time, status, and concentration (µg/m^3)

04-10-26 15:39:38 000000 10.3

2) Date, time, status, concentration and mass (µg)

04-10-26 15:39:38 000000 10.3 130.4

3) Date, time, status, concentration, mass, and air flow rate (l/h)

04-10-26 15:39:38 000000 10.3 130.4 1000

5) Date, time, status, concentration, ½ h Conc., 1h Conc., 3h Conc., and Daily Conc.

04-10-26 15:39:38 000082 10.3 10.0 10.7 11.0 10.5

6) Measuring network protocol

MD03 001 3585+01 82 00 324 000000 002 +3630+01 82 00 324 000000 003 -3585-01 82 00 324 000000

or

MD01 000 +3299+01 48 02 323 000000

7) Date, time, status, concentration, mass, flow rate, RH (%), T1 (°C), T2 (°C), T3 (°C), T4 (°C), Heater Cycle (%), P1 (hPa), P2 (hPa), P3 (hPa), BetaConc-short, BetaConc-long, Neph Counts, NephConc, NephConc-long, Neph-CalFactor, and Beta Counts

04-10-26 15:39:38 000082 10.3 130.4 999.8 40.5 21.0 30.0 28.0 45.0 43.8 35.8 103.0 997.9 13.5 9.1 172 21.0 18.5 0.492 14562

8) Parameter list

Print Format 8 provides the Parameter List for the Model 5030 SHARP. The parameter list provides all internally stored parameters for the operation and calibration of the Model 5030 SHARP. It is recommended upon receipt of the Model 5030 SHARP that Print Format 8 (Parameter List) be downloaded and kept as a record of the manufacturer's default settings. Upon each calibration and Parameter Change, a download of the

Parameter List should be performed and kept for record keeping. Should a warning or error status condition occur, download the Parameter List for review.

Table 3-1. Model 5030 SHARP Parameter List

Themo Fisher Scientific SHARP v1.21 SERIAL NUMBER 19 05-03-03	
PRINT FORMAT:	COM2 7
PRINT CYCLE:	1 min
BAUDRATE:	Bd 9600
DEVICE ADDRESS:	1
FILTER CHANGE	
MASS >	µg 1500
CYCLE	h 8
HOUR:	24
AVERAGE STORAGE MODE	1
AIR FLOW	1000
CALIBRATION	
SENSITIVITY:	6946
CONCENTRATION FACTOR	100%
HIGH VOLTAGE	1320 V
REF-THRESHOLD	530 mV
T2-COMP-FACTOR	0.00292
P2-COMP.FACTOR	0.00015
Pabs-COMP.FACTOR	0.00055
OPTICAL CALIBRATION	
T2-COMP-FACTOR NEPH.	0.2500
OPTIC SENSITIVITY	0.53495
OFFSET RANGE 1	177
OFFSET RANGE 2	29
SENSOR CALIBRATION	T1 T2 T3 T4 RH P1 P2 P3
	-37 -58 19 -1 439 71 49 0
AIR FLOW	91.6
FLOW RATE REFERENCE VOLUMETRIC FLOW REF	
STANDARD TEMPERATURE	25 °C
HEATER PARAMETERS	
RH NOMINAL VALUE	58% RH
MAX. HEATING TEMP.	60 °C
MIN. HEATING POWER	2%

Table 3-1. Model 5030 SHARP Parameter List, continued

Themo Fisher Scientific SHARP v1.21 SERIAL NUMBER 19 05-03-03	
ANALOG OUTPUTS	
OUTPUT ZERO	0 mA
CONC	-100 1000
GESYSTEC PROTOCOL	
STATUS VERSION	STANDARD
NUMBER OF VARIABLES	1
CONC	
END	

9) Parameter Change list: 22 entries

Print Format 9 provides a Parameter Change List. With each Operational or Calibration change, a record is kept as a means of tracking the parameter changes. This is an excellent tool for recalling time and dates of operator interaction, qualifying data and instrument security.

Table 3-2. Parameter Change List

List of Changed Parameters No: 76			
03-02-24	13:21	EF-THRESHOLD	300, 300
03-02-24	13:21	HIGH VOLTAGE	1270, 1300
03-02-24	13:19	CALIBRATION CODE	0, 4
03-02-24	12:57	EF-THRESHOLD:	300, 200
03-02-24 HIGH	12:57	VOLTAGE	1300, 1270
03-02-24	12:55	CALIBRATION CODE	0, 4
03-02-10	16:45		94, 94
03-02-10	16:45		1000, 995
03-02-10	16:44		94, 93
03-02-10	16:44		999, 1010
03-02-10	16:43		999, 1040
03-02-10	16:43		93, 90
03-02-10	16:38	BAROMETRIC PRESSURE	820, 960
03-02-10	16:38	TEMP. INLET HEATER	17, 20
03-02-10	16:38	SYSTEM TEMPERATURE	25, 20
03-02-10	16:38	HEAD TEMPERATURE	31, 20
03-02-10	16:37	TEMPERATURE OUTSIDE	27, 20
03-02-10	16:32	CALIBRATION CODE	0, 4

Table 3-2. Parameter Change List, continued

List of Changed Parameters No: 76, continued			
03-02-10	16:19	CALIBRATION CODE	0, 4
57-00-57	00:57		0, 0
57-00-57	00:57		0, 0
57-00-57	00:57		0, 0

11 & 19) Logbook: 20 & 1,632 entries respectively

Print Formats 11 and 19 provide a Logbook of events. When the instrument status changes, the new status (including date, time, detailed status code, general status code, concentration, mass, air flow rate, and most sensor data) are entered into a logbook. Should an event of interest occur, reviewing the Logbook can provide precise information of the instruments operation. If further defining of the detailed error status is necessary, see the "Troubleshooting" chapter.

```
Thermo Fisher Scientific      SHARP v1.21      SERIAL NUMBER  001    04-02-23
---------------------------------------------------------------------
LOG
DATE /TIME          ERROR              STATUS
03-02-25  15:11:06 0000 0000 0000 0000 000082   -36     0  1000    20    22    20    30    97   958
79253     0
03-02-25  15:11:03 0000 0000 0000 0000 000092   -36     0   999    20    22    20    30    97   958
78746     0
03-02-25  15:10:29 0000 0000 0000 0000 000082   -36     0     0    20    22    20     0     0   957
77014 35384
03-02-25  15:09:37 0000 0000 0000 0000 000089   -36     0     0    31    22    20     0     0   958
77880 48250
03-02-24  14:04:46 0000 0000 0000 0000 000089   -36     0     0    19    20    20     0     0   964
79857 49203
03-02-24  13:27:44 0000 0000 0000 8000 020038   -36   -92     0    20    20    20     0     1   965
82449     0
...
showing
Date       time     error              status  Conc. Mass     Q    T1    T2    T4     P1    P2   P3
Rb        Ra
```

30) Half-hour or Hourly Averages (last 60 stored values)

31) Half-hour or Hourly Averages (last 60 stored values) without header

39) Half-hour or Hourly Averages (> 1 year of data w/expanded memory option) without header

In compliance with the measuring interval/cycle set, each measured value that has been calculated and saved in memory can be printed via Print Formats 30, 31 or 39. Print Formats 30 and 39 start without headers, and Print Format 31 is represented below. Print Formats 30 and 39 are usually preferred for later data reduction via spreadsheet applications. Print Format 39 provides data from the expanded memory, over one year of 30-minute average data.

Thermo Fisher Scientific SHARP v1.21 SERIAL NUMBER 323 04-02-24

Averages

Date/Time		**Status**	**Conc**	**C-14-CONC**
04-02-23	12:01	020058	32.9	32.9
04-02-23	11:01	2E01DB	32.9	32.9
04-02-20	17:01	000070	32.3	25.9
04-02-20	16:01	000070	33.5	35.1
04-02-20	15:01	000040	31.8	31.5
04-02-20	14:01	0000FB	31.1	33.2
04-02-20	13:01	0000CB	26.1	25.9
...				
04-02-18	22:01	000040	12.9	14.1
END				

Please note that the above Print Formats 30, 31, and 39 store both the hybrid concentration and the traditional C14-Beta derived concentration.

40 & 41) Daily mean values: up to 380 lines

Print Format 41 has no header lines.

```
Thermo Fisher Scientific   SHARP v1.21  SERIAL NUMBER   001    04-02-24
---------------------------------------------------------------------
DAILY MEAN VALUES
DATE     o.k.%   CONC[µg/m³]
---------------------------------------------------------------------
04-02-23 100  17.9
04-02-22 100  4.3
04-02-21 100  7.6
04-02-20 100  24.7
04-02-19 100  22.4
.
.
```

Filter Change Frequency

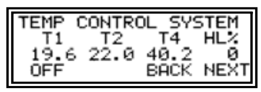
The Model 5030 SHARP comes with a filter change cycle of 0-hours, a filter change hour of 24 (midnight), and a mass limit of 1500 micrograms. The Model 5030 SHARP will automatically perform a filter change when the mass on the filter spot reaches 1500 micrograms, when the filter change cycle has been reached, and when the filter change hour has been reached. To change these settings, please cross-reference Table 3-1 and the RS-232 commands in this manual.

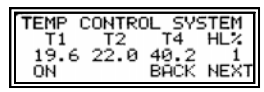
Flow Rate Setpoint

The Model 5030 SHARP has a fixed flow rate of 1000 L/h (16.67 L/min).

Dynamic Heating System

The temperature control system that is used on the Model 5030 SHARP Monitor is the Dynamic Heating System (DHS). A relative humidity sensor is placed downstream of the optical sensing volume and upstream of the beta attenuation sample chamber. The RH-sensor placement offers the ability to measure the RH of the incoming aerosol. At this point in the menu, only the DHS can be turned ON or OFF using the keypad. Press **NEXT**.





Note T1 = ambient temp.,T2 = sample temp., T4 = Heater Wall Temp., and HL = Heater Duty Cycle. ▲

Additional DHS Settings are accessed using write-control commands. See Appendix B.

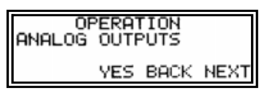
Analog Output Configuration

The Model 5030 SHARP has one analog output channel (no. 1) on the main board.

The analog output can be individually configured by jumpers: as voltage output (0/2 -10V) or as current loop (0/4 - 20mA). The current output can be equipped with a module for potential-free signal separation. For the analog output a live zero signal (4mA or 2V) can be selected.

The assigned quantity for the analog output can be selected by the user. The available quantities and their codes are listed in the table below. The symbol is not shown in the configuration display. The user should assume the units per quantity as listed in the following table.

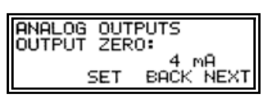
Code	Symbol	Quantity	Unit
1	CONC	Aerosol Concentration	µg/m³
2	MASS	Compensated mass	µg
3	Q-OP	Air flow rate (Volumetric Conditions)	l/h
4	Q-N	Air flow rate (Standard Conditions)	Nl/h
5	T1	Ambient temperature	°C
6	T2	Temperature at filter tape	°C
7	T4	Temperature of external tube heater surface	°C
8	RH	Sample Relative Humidity	%
9	P1	Differential pressure / orifice	hPa
10	P2	Vacuum under filter	hPa
11	P3	Barometric pressure	hPa
12	C-1H	Aerosol Concentration filtered 1 hour	µg/m³
13	M-1H	Compensated mass filtered 1 hour	µg



Here the operator may define the analog output range.

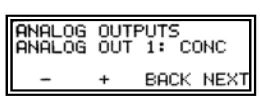
Note Analog output selections on the display will always show units of milliamp (mA). Corresponding voltage (V) outputs are achieved by jumper settings. See the “Installation” chapter. ▲

Press **Yes**.

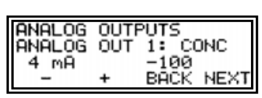


User-selected zero point output of 0 mA/0V or 4 mA/2V.

Here the user has chosen a live zero to be a 4 mA (or 2V) analog output. Press **NEXT**.



Here the user can choose the analog output of the default channel by using the +/- keypad. Press **NEXT.**



User-selected concentration for the zero point of the analog output range. Possible settings: -100 to 1000 µg/m^3. Press **NEXT**.

```
ANALOG OUTPUTS
ANALOG OUT 1: CONC
20 mA        400
  -    +   BACK NEXT
```

User-selected concentration for the span point of the analog output range. Possible settings: 0 to 10,0000 µg/m^3. Press **NEXT**.

Language

By pressing the SET key, you can either select English, Spanish, or German language to be displayed:

```
     OPERATION
LANGUAGE: ENGLISH

      SET  BACK NEXT
```

```
     OPERATION
LANGUAGE: ESPANOL

      SET  BACK NEXT
```

```
     OPERATION
LANGUAGE: DEUTSCH

      SET  BACK NEXT
```

Press **NEXT**.

```
       SERVICE
*********************

       YES BACK NEXT
```

You are now at the Service menu.

Service Menu

```
       SERVICE
*********************

       YES BACK NEXT
```

The Service menu allows the user to carry out hardware and component tests and cable connections. Press **YES**.

```
       SERVICE
KEYS UNLOCKED

      SET  BACK NEXT
```

By pressing the SET key, operation can be switched over between keypad and serial interface. Please note that without enabling the keypad, no parameter changes and no actions can be accomplished. Press **NEXT**.

Mechanical Control

```
       SERVICE
MECHANIC CONTROL

       YES BACK NEXT
```

This sub-menu enables the measuring head to be opened and the filter transport to be initiated manually. Press **Yes**.

```
       SERVICE
OPEN HEAD ?

PUMP   YES BACK NEXT
```

The pump can be switched ON and OFF by pressing **PUMP**. Please make sure not to switch off the pump by pulling off the connecting cable/plug. Otherwise the device assumes that the pump is defective or the tubing was pulled off and consequently sets a corresponding error status.

For the purpose of inserting a new filter tape, it is possible to open the measuring head by pressing **YES**. The pump is then switched off automatically.

In case the measuring head has been opened, as described in the previous menu, the filter tape transport motor can be switched on by pressing the **YES** key. The number displayed symbolizes the counts of the incremental encoder. This way, it is always possible to check the filter tape for correct transport (for example, especially after installing a filter tape printer).

To stop the motor, press the **NEXT** and **BACK** keys. Subsequently, the measuring head should be closed again or a filter change should be performed to continue operation.

To close the measuring head, press **YES**. The user may also press the FC+Z key to initiate a full filter change and zero if sampling is to resume. Press **NEXT**.

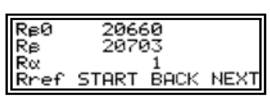
Mass Display

In this screen, the instantaneous mass reading (MASS) smoothed mass (QLF) are made. In this menu, the mass can be set to zero or the entire mass calculation can be reset using the ZERO and RESET keys, respectively. Once the mass is stable, the QLF value will appear with an asterisk (*) next to that value and a confidence value will appear to the right of the QLF. Press **NEXT**.

Hardware and Sensor Diagnosis

In this screen, a diagnosis of the measurements being made are provided. Press **YES**.

Beta Attenuation Detector



Beta-attenuation Detector. In this screen, the user can validate the initial beta count ($R_{\beta ø}$), the real-time beta counts (R_{β}), the alpha counts (R_{α}), and the reference setting (Rref) are all being measured by the proportional detector.

To check the proportionate function of the detector, this is best done immediately after a filter change (see Mechanic Control Above and FC+Z). Press **START** and this will initiate a running average of the R_α and R_β readings and generally, R_α should be < 1.0 after approximately 60 seconds.

During this functional check, the right hand side of the screen will show the counter (increasing to 900 seconds), the running average of R_β and the running average of R_α from top to bottom of the screen, respectively.

After this test, if the R_α average value is >1.0, the automated adjustment procedure should be completed through the Calibration menu (refer to the "Calibration" chapter) otherwise, press **STOP**.

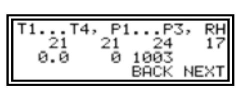
The same test can now be conducted on the reference channel (Rref) of the proportional detector. First, press **Rref**. The "R_α" character should now change to a "Rref". Press **START** to begin the functional check. During this check, Rref will increase to approximately 50% of R_β. After approximately 60 seconds, the Rref average value is NOT within 40-60% of R_β, the automated adjustment procedure should be completed through the Calibration menu (refer to the "Calibration" chapter) otherwise, press **STOP** and then press **NEXT**.

The R_β, R_α, and Rref values should be recorded with each functional check.

Sensor Signals

The following screen will display digital signals of the Model 5030 SHARP sensors.

Note Should one of the values within this screen blink repeatedly this is an indication that a sensor malfunction is occurring. Should this occur, please see the "Troubleshooting" chapter. ▲



In this screen, the sensors are presented with appropriate units of measure. A description of these sensors appears in the following table. Press **NEXT.**

Sensor	Units	Description
T1	°C	Ambient temperature sensor
T2	°C	Sample temperature sensor
T3	°C	Orifice temperature sensor
T4	°C	Heater outer-wall temperature sensor
P1	hPa	Orifice differential pressure
P2	hPa	Differential vacuum under filter tape
P3	hPa	Barometric pressure
RH	%RH	Sample relative humidity

Analog Output Test

In this screen, the user can test the analog signal output being sent to their external data logger. By pressing the respective key, 0/4 mA or 20 mA, an equivalent analog output is provided to the analog channel. This allows for adjusting chart recorders connected to the unit and for testing cable connections. Corresponding voltage output setting will also apply to this test, whereas 4 mA = 2V and 20 mA = 10V. When quitting this menu by pressing either the **BACK** or **NEXT** key, the measured value will be again output to the analog interface.

Chapter 4 Calibration

This chapter describes the procedures for performing the necessary sensor calibrations. This chapter is also a follow-up to the Acceptance Testing outlined in the "Installation" chapter and a continuation of the menu display descriptions in the "Operation" chapter.

Equipment Required

The Model 5030 SHARP comes with a HEPA filter and adapter for zeroing the instrument. Optional mass transfer standards are available from Thermo Fisher Scientific for performing an annual mass calibration. However, additional specialized equipment is needed to calibrate the Model 5030 for temperature, relative humidity, barometric pressure, and volumetric flow measurements. The following equipment should be used:

- A thermistor or thermocouple thermometer capable of measuring ambient temperatures in a range of -30 to +45 °C, readable to the nearest 0.1 °C. This thermometer should be referenced to within an accuracy of ±0.5 °C to NIST-traceable precision thermometers. Multiple thermometers may be used to cover the temperature range as long as each thermometer meets the accuracy and readability specifications described above.

- A barometer capable of measuring barometric pressure over a range of 600 to 800 mm Hg (80 to 106 kilo Pascals [kPa]) and readable to the nearest 1 mm Hg. At least once a year, this barometer should be calibrated to within ±5 mm Hg of a NIST-traceable barometer of known accuracy.

- Flow-rate Transfer Standard (FTS) measurement equipment capable of calibrating, or verifying, the volumetric flow rate measurement with an accuracy of ±2 percent. This flow rate standard must be a separate, stand-alone device. It must have its own certification and be traceable to a NIST primary standard for volume or flow rate. Dry-piston meters and bubble flow meters should only be used under controlled laboratory conditions. Ambient field measurements should use a NIST-traceable low pressure drop orifice/venturi flow meter (such as, BGI Delta-Cal).

- A relative humidity (RH) standard capable of measuring in the range of 35-75% RH, readable to the nearest 0.5% RH and accurate to within 2% RH.

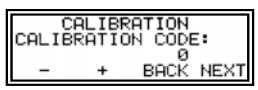
Pre-Calibration

Prior to calibration, be sure the Model 5030 is operating properly. The Model 5030's internal diagnostics makes this a quick and simple process. Turn on the instrument and allow it to stabilize for one hour prior to calibrating. If you are receiving this instrument for the first time, the optional acceptance testing in the "Installation" chapter should also be reviewed. If the internal sample temperature sensor (T2) requires calibration, the IMR heating system should be turned off at least one hour prior to calibrating.

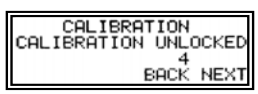
Calibration Menu

Press **YES** to enter the Calibration menu.

Press **SET** to access the calibration code menu.

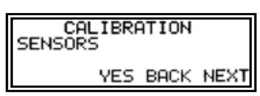


Change the code value to 4, by pressing the +, - keys and press **NEXT**.



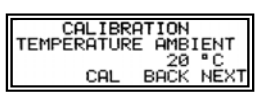
The Calibration menu should now be unlocked. Press **NEXT**.

Temperature, RH and Barometric Sensor Calibration

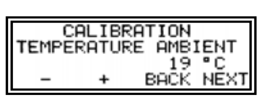


To calibrate any of the Temperature sensors, Relative Humidity Sensor, or Barometric Pressure Sensor, press **YES** to perform a 1-point calibration.

Note Wet bath-type calibrations are not recommended. ▲



The measured ambient temperature (T1) value is displayed. To enter the reference value, press the **CAL** key and then the +,- keys. The value will be accepted by pressing the **NEXT** key.



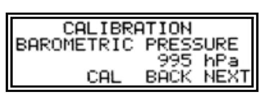
Reference measurements are made by inserting the reference probe into an attached or nearby naturally aspirated radiation shield. After completion, press **NEXT**.

The T1 calibration procedure above is also valid for the T2 HEAD Temperature (also referred to as, sample temperature) and can be referenced to shelter temperature if the Model 5030 has been equilibrated for approximately one hour while sampling room or shelter air. Press **NEXT**.

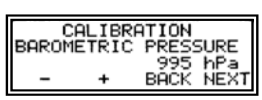
The T1 calibration procedure is also valid for the T3 system temperature located at the orifice for flow measurement. Sufficient time should be given for the T3 sensor to equilibrate to the T2 temperature (approximately 45 minutes with no heating). Press **NEXT**.

The T1 calibration procedure is also valid for the T4 Heater Outer-wall temperature sensor. This sensor can be removed from the heated tube assembly and equilibrated to room or reference temperature conditions within 5-10 minutes. Press **NEXT**.

Similar to the T2 sensor, it is important for the instrument to be equilibrated to the conditions of the incoming air temperature since any air temperature differential from the RH reference device and the RH sensor located within the monitor can influence the accuracy of this calibration. To enter the RH reference value, press the **CAL** key and then the +, - keys to adjust the RH sensor to the reference measurement. The value will be accepted by pressing the **NEXT** key.



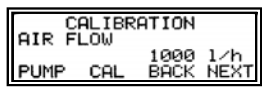
Enter the absolute barometric pressure (P3) on site (make sure not to use a pressure that refers to sea level!). If local airport data is being used, be sure to correct for elevation. To enter the P3 reference value, press the **CAL** key and then the +, - keys to adjust the RH sensor to the reference measurement. The value will be accepted by pressing the **NEXT** key.



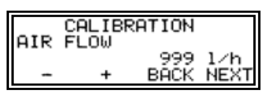
Barometric Pressure Conversions
hPa = atm X 1,013.2501
hPa = in Hg X 33.8638867
hPa = mm Hg X 1.3332239

There are two additional pressure sensors responsible for the differential orifice measurement (P1) and the sample differential vacuum measurement (P2) under the filter tape. Both of these pressure sensors are very stable with the factory calibration and are re-zeroed with every filter change.

Sample Flow Rate Calibration



This is the sub-menu used for the air flow rate calibration. The user may toggle the pump on/off with the PUMP key. Generally it is good practice to turn the pump off prior to attaching and removing the flow transfer standard (FTS).



The volumetric flow rate is initially indicated as measured by the Model 5030. Press CAL to adjust the air flow rate calibration coefficient. Thereafter, adjust the volumetric air flow rate measured by a FTS using the +, - keys and press NEXT. Allow 30 seconds between indicated air flow adjustments. Repeat as necessary until corresponding FTS and Model 5030 flow rate values agree within 2%.

Flow Conversions
L / h = L / min X 60
L / h = m^3 / hr X 1000
L / h = m^3 / min X 60,000

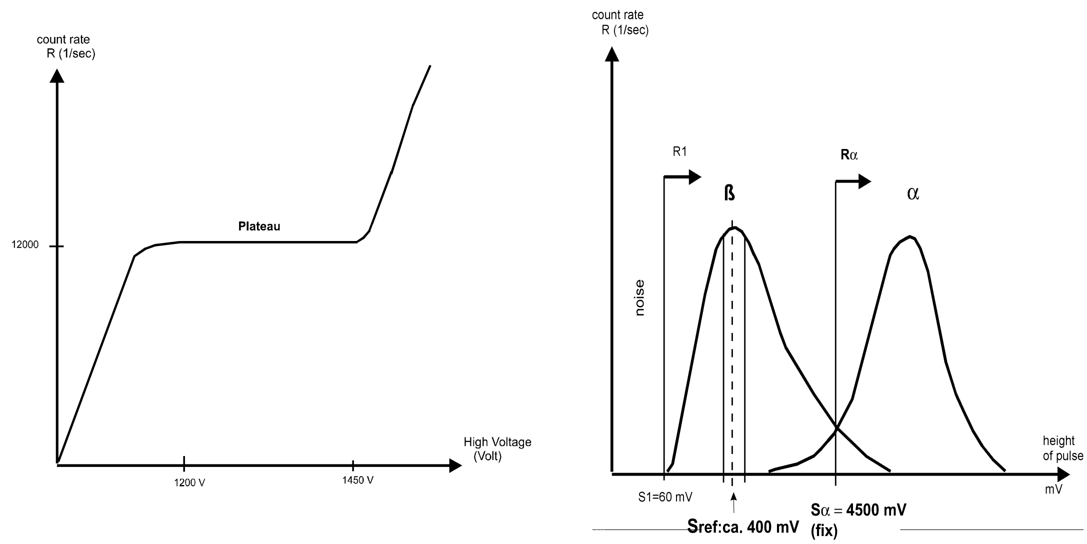
Note The air flow calibration always has to be performed last. Subsequent temperature and pressure sensor calibrations could have an impact on the air flow calibration. ▲

Automated Detector Adjustment

The automated detector adjustment is completed through a series of serial commands and can be found on our Air Quality Instruments Online Library at www.thermoscientific.com/aqilibrary.

Theoretical Adjustment of the High Voltage and the Thresholds

The following images provide some technical information on the operation of the detector, and its theory of operation.



a) Detector - Plateau

b) Height of Pulse

Figure 4-1. Theoretical Adjustment of the High Voltage and the Thresholds

During the factory setup, the High Voltage of the detector, the thresholds and the plateau are determined and documented within the final test protocol. Only in case of a detector error or instrument status condition should this readjustment be done.

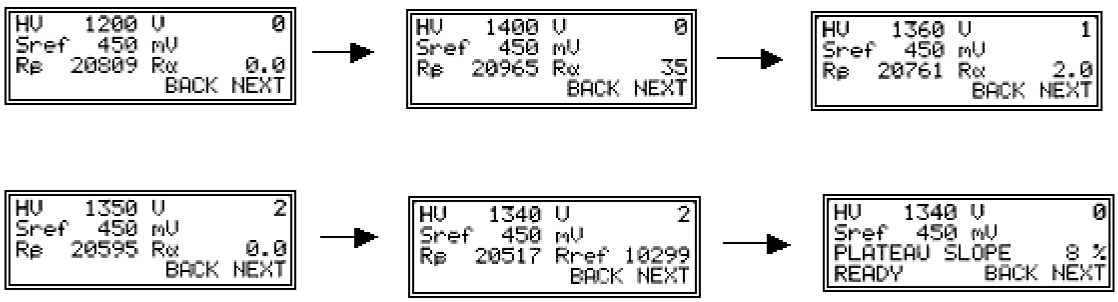
The Model 5030 SHARP - detector is a proportional counter, which depends on the operating High Voltage (HV). Figure 4-1a shows the relation of count rate versus HV. The detector is operational within the range of the plateau and all pulses caused by the ^{14}C betas can be counted.

Figure 4-1b shows the height of pulse as a relation of count rate versus the threshold in mV. This system is designed to be able to separate the beta (β) radiation from natural alpha radioactivity (Radon). The natural alpha particles have higher energies than the ^{14}C betas. Therefore the alpha particles give a higher signal.

If the HV is too low the count rate of the detector is not in the plateau. If the HV is too high the system measures more ^{14}C beta counts as alpha activity.

The instructions to “Insert Filter Tape” are directed at the user to perform a filter change prior to initializing this automatic adjustment procedure. This is described in the “Automated Detector Adjustment” procedure described previously. Press **START**.

The display of the Model 5030 will automatically proceed through the HV and threshold adjustments necessary to bring the detector within operating specifications. During this automatic procedure, the beta counts (R_β), the alpha counts (R_α), and the reference setting (Rref) are being measured and optimized within this routine.

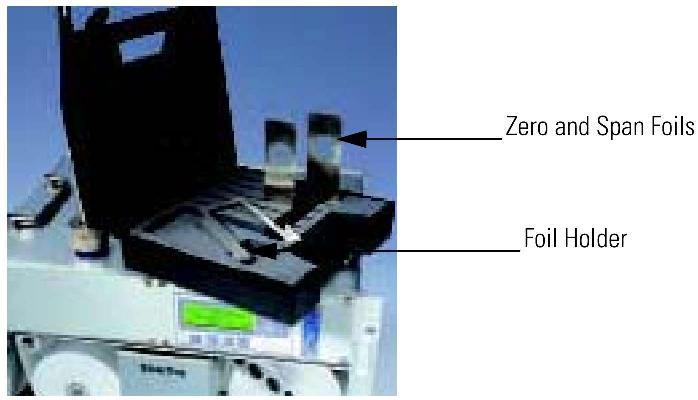


The procedure is now complete. Press **NEXT**.

If the Plateau Slope is >10%, repeat the adjustment.

Mass Foil Calibration

The Model 5030 SHARP is calibrated for mass in the factory using a series of null and span foils. The mass transfer standard foil sets are available from Thermo Fisher Scientific, and should be used as part of a QA Program for performing a QC check on the mass measurements. This mass foil calibration procedure can be used for QC checks, auditing, and calibration.



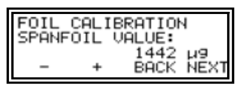
- It is recommended to perform an annual mass calibration on the Model 5030 SHARP Monitor.
- The foil sets must be kept in a clean container.
- The foils must not be wiped, otherwise a loss or gain of mass can occur thereby biasing the mass calibration.
- Foils sets can be returned to Thermo Fisher Scientific for recalibration as necessary.
- Separate foil sets are recommended for periodic QC checks, auditing, and calibration.
- Should the user suspect the foil window(s) has been damaged, scratched, or coated, these foil sets should be returned to Thermo Fisher Scientific for recalibration.

The null foil has the same approximate mass as a clean filter spot and the span foil is a calibrated mass increase above the null foil. Therefore, the foils come in a set and must not be mixed with other sets since a bias in mass calibration will occur.

Since the beta attenuation method is linear with mass increase, the Model 5030 need not be calibrated in the exact range of beta attenuation per filter spot. What is important, is calibrating the corresponding beta count reduction with an increase of calibrated mass.

Note To achieve the most accurate mass calibration, the T2 sample temperature should be as stable as possible and therefore the instrument should have the IMR heating system turned off, and the instrument should be allowed to equilibrate to shelter or ambient temperature. If the Model 5030 SHARP is mounted within an ambient shelter, then the most stable time of day to perform a mass calibration would be either early morning or late afternoon. ▲

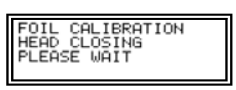
To begin the mass calibration using the reference mass foils, press **YES**.



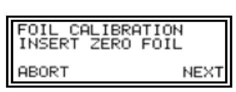
Please enter the SPAN foil value using the +, - keys. Press **NEXT**.

The beta attenuation chamber should now open. During this period, this screen will be displayed for approximately thirty seconds.

Cut/break the filter tape on the left side of the measurement head and pull the remaining filter tape out from the right hand side. Then insert the foil holder from the left into open gap. Maintaining a slight sideward pressure on the filter holder, press **NEXT** to proceed with the foil calibration, or press **ABORT** to stop the foil calibration.



While the beta attenuation closes, this screen will display for approximately thirty seconds.



Insert the zero/null foil. Press **NEXT** to continue or press **ABORT** to stop the foil calibration.

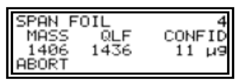
The auto zero procedure of mass will begin and last for approximately 200 seconds.

MASS = Instantaneous Mass

QLF = Quick Lock Filter for the mass

CONFID = Confidential Interval

When the zero is complete, the beta attenuation measurement head will remain closed. Remove the zero/null foil and insert with the span foil (for example, 1442 µg). Press **NEXT** to continue or press **ABORT** to stop the foil calibration.



The span foil calibration procedure is now active. After ~ 200 seconds the calibrations procedure should end.

After the span calibration, the screen will show the OLD and NEW mass calibration factors. Press **NO**, if you DO NOT want to change, or press **YES** to store the new calibration factor.

After selecting YES, the screen will indicate the measurement head is opening. You may now remove the span foil and place it into its protective case. Thereafter, you may remove the foil holder and immediately insert the filter tape from the left. Should the user not have sufficient time to replace the filter tape, the Mechanic Control in the Service menu can be used. Press **NEXT** to proceed.

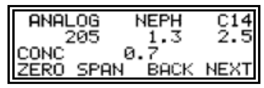
Nephelometer Zero and Calibration

The Model 5030 SHARP has a nephelometer (aerosol light scattering sensor) built-in upstream of the beta attenuation measurement chamber and downstream of the instrument sample delivery tube. This nephelometer is calibrated for zero and span in the factory using a HEPA filter and ISO Fine Test Dust 12103-1, A-2, respectively. Of the two measurements, it is more important to perform periodic checks on the zero performance of the instrument.

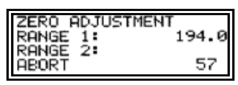
Although field tests have indicated both a stable zero and span measurement, it is more likely that the nephelometric chamber could increase in background over time, thus affecting both zero and span measurements. However, due to the nature of this hybrid method it is only necessary to perform periodic Zero Calibrations on the Model 5030 SHARP, thereby leaving the aerosol response to be calibrated by the long-term beta attenuation measurement.

The Zero/background of the nephelometer is measured by placing the inlet adapter and HEPA filter at the inlet of the instrument. To zero the nephelometer, proceed according to the following displays:

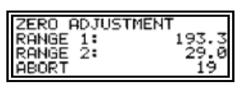
To begin the Nephelometer Zero/Calibration, make sure the HEPA filter is installed at the inlet and press **YES**.



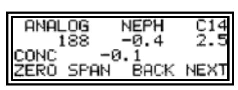
At this next screen, you can record the as-found digitized analog signal value under ANALOG (for example, 205 LSB), and the as-found one minute average zero measurement under NEPH (for example, 1.3 µg/m^3). Generally the user should allow 3-5 minutes for the Nephelometer reading to stabilize after disturbing the inlet connections. The other two values appearing on this screen is the long-term beta concentration under C14 (for example, 2.5 µg/m^3) and the current hybrid concentration to the right of CONC (for example, 0.7 µg/m^3). In order to zero the nephelometer, press **ZERO** on the keypad and the following screen will appear:



After pressing ZERO, the screen will begin an automatic 60-second average of the nephelometer operating on the 0-1,000 µg/m^3 concentration range. The counter is in the lower right hand of the screen.



After the first range is zeroed, the second Range (0-10,000 µg/m^3) is independently zeroed over a 20-second period.



Now the Nephelometer background is zeroed for both ranges of measurement. Another five minute measurement cycle can be performed and compared to the “as found” values.

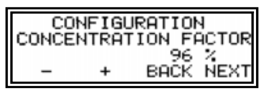
Performing a SPAN Calibration of the Nephelometer is initially done in the factory. During this SPAN Calibration a master nephelometer, gravimetrically calibrated to ISO Fine Test Dust 12103-1, is placed immediately upstream of the Model 5030 SHARP. During calibration the test dust is delivered to the test assembly, and once a stable concentration is achieved the technician will press SPAN on the Model 5030 menu. During this period, the Model 5030 will calculate a one-minute average from the nephelometer while the display counts down from 60-seconds to zero. At the end of the test run, the average concentration from the master Nephelometer is enlisted using the +/- keys. Press **NEXT**.

Configuration Menu

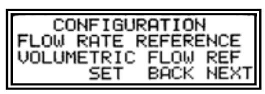
Within the Configuration menu, the user can choose what sample volume conditions to use, to define the standard temperature value, and to establish a communication protocol compatible with previous Thermo Fisher Scientific models.

To enter the Configuration menu, press **YES**.

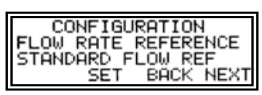
By default, the Model 5030 SHARP comes with a 100% scaling of the beta attenuation derived aerosol concentration. Should any site-specific issues require a change in the response in the accuracy (slope) of the Model 5030 SHARP, compared to a reference measurement, the response can be adjusted in this screen by pressing the +/- keys.



After the response scale has been adjusted, press **NEXT**.



In this menu, the user can choose which conditions the sample flow rate, and thus sample volume and concentrations, are to be reported in. The choices are either Volumetric Conditions or Standard Conditions. The sample volume conditions can be toggled by pressing the SET key.



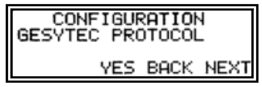
Press **NEXT**.

Volumetric conditions are also known as actual or local conditions (LTP) and reference the volumetric sample flow that has entered the inlet. Standard conditions (STP) adjust the measured sample flow rate and sample volume to 1 atmosphere of barometric pressure and a user-defined standard temperature.

Note The sample flow rate at the inlet is always controlled to a volumetric flow rate due to the particle penetration characteristics required for size cut requirements. ▲

Depending upon the air monitoring program requirements, the standard temperature can be adjusted as needed using the +/- keys. Press **NEXT** to continue.

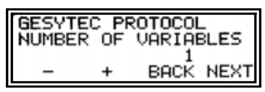
German Networking Protocol



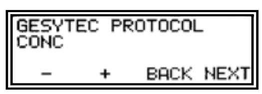
The GESYTEC Protocol references network protocols in Germany and can be set to either I-N Compatible or to a STANDARD version.

Press **SET** to switch between version required by the user.

Press **NEXT** to continue.



In the following two screens the number of variables (1-7) and the value for each variable can be chosen as necessary.   Press **NEXT**.

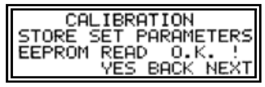


Press **NEXT**.

Storing Calibration Values and Operational Parameters

This Calibration menu asks the user if they would like to set the new parameters (such as, Calibration and Operation) to be stored into the EEPROM. If this is not done, the next time the power is cycled, or a user chooses to Reload Values From EEPROM in the next screen, all Operational and Calibration changes will be lost. To store these settings, press **YES**.

All parameters, dates and calibration data are written into the EEPROM. These data are reloaded, either in case an error is detected in the battery-buffered RAM when switching the main switch or by simply giving the respective command via keyboard entry in the next screen.



The system indicates whether the writing process has been successful or whether a write/read error has occurred. It should also be noted that any Operation menu changes (see the "Operation" chapter) should also be saved to EEPROM. If a power outage should occur, Operation menu changes will revert back to prior settings.

Reloading from EEPROM

Should a program error occur, it is first recommended that the user attempt to reload the operational parameters from the EEPROM.

CAUTION If operational parameter changes have been made within the Operations menu, they must be saved via the CALIBRATION menu in order to become new default settings. Otherwise, the original parameter settings will be restored when RELOAD is used. The RELOAD command is also used if any memory errors are seen. Furthermore, RELOAD from the EEPROM will happen automatically after the power is turned on and if an error in the battery buffered SAVE-RAM has been found. ▲

After all calibrations are completed, the keypad may be disabled, and normal operation should continue. Normally, a filter change and zero (FC+Z) is usually activated after a calibration.

Chapter 5 Preventive Maintenance

The Model 5030 SHARP has been designed to operate unattended for a period of up to one year. However, monitoring program requirements can vary and sometimes depend upon the application and the regulations that the sampling method must meet.

This chapter describes the periodic maintenance procedures that should be performed on the Model 5030 SHARP to ensure proper, uninterrupted operation. Certain components, such as the sample pump and filter tape, have a limited life and should be checked on a regular basis and replaced as necessary. Other procedures, such as annual optics and sample chamber cleaning should be performed by a trained technician, and periodic checks on the calibration of the pressure and temperature sensors should also be performed. In this chapter, the specific checks and/or cleaning procedures for these elements are reviewed.

Refer to the "Servicing" chapter for the component replacement procedures.

Spare Parts

Table 5-1 lists the recommended spare parts.

Table 5-1. Recommended Spare Parts

Part Number	Description
FH111	Filter Tape Roll
FH153C14	Pump Repair Kit for FH180 and FH180-1 Pumps: includes SM169001042 Set of 3 Carbon Vanes and KT144248920 Set of 2 PVC Separators
SM169001042	Set of Three Carbon Vanes for FH180, FH180-1 and 425452061 Pumps
KT144248920	Set of 2 PVC Separators for FH180 an FH180-1 Pumps
FH153-01	Pump Repair Kit for 425452061 Pump; includes SM169001042 Set of 3 Carbon Vanes and KT144248920 Set of 2 PVC Separators
KT144248925	Set of 2 PVC Separators Only for 425452061 Pump
425452065	110-240V, 50/60Hz Vacuum Pump
KT169001023	Pump Repair Kit for 42542065 Pump; includes set of 5 Carbon Vanes
KT169001024	Pump Protection Filter

Maintaining the Sample Vacuum Pump

A rotary vane pump with a dry rotor is used as a source of vacuum. The pump performance is excellent, with minimal heat and noise generation. Only a few maintenance items are required, even when running continuously. The pump can be operated without the need for installing additional filters since the air delivered to the pump is already free from any particulate matter. However, minor amounts of carbon dust may be exhausted from the pump operation and should be filtered or vented if indoor air is being measured.

By default, the air flow rate is set to 1000 l/h (16.67 l/min) with a ±5% tolerance. When measuring aerosol, the pump can be set between 500-1200 L/h (8-20 L/min), but must be set to a corresponding flow rate of any size selective inlets (for example, PM_{10}, $PM_{2.5}$). Nevertheless, if the Model 5030 SHARP cannot reach the desired nominal flow rate, a filter change will be performed automatically under the assumption that the filter spot may have become clogged.

An excellent indicator of pump performance is achieved by reviewing the % Power to the pump in the Main Display sub-menu. If the flow rate of the Model 5030 SHARP is below the nominal set point and the pump power is very high (>95%), then the user should check and tighten all external fittings, and if necessary tighten the internal fittings surrounding the flow path. Otherwise, if all fittings are tight and pump wear is suspected, then the user should replace the vanes (See the "Servicing" chapter).

Maintenance of the rotating pump must be performed in accordance with the special instructions given by the pump manufacturer.

Because the pump usually only operates with pre-filtered air, abrasion of the carbon vanes is only minor. The service life of a set of carbon vanes amounts to more than one year of operation. For this reason, one should either check the carbon vanes at intervals of 2,000 - 3,000 hours, which corresponds to a three-month cycle or change them once a year (See the "Servicing" chapter).

Vane replacement must be performed outdoors. Failure to do so may introduce carbon particles into the air and damage electronic equipment.Before servicing, the vacuum pump must be switched off and secured against accidental power-up. In order to replace the vanes, the silencer housing, the silencer diaphragms, the distance ring, and the cylinder cover must be removed (Figure 5-1). Blow carbon dust from vane cavity with an air hose.

WARNING Avoid inhaling carbon dust. Use an approved particle filter or respirator. ▲

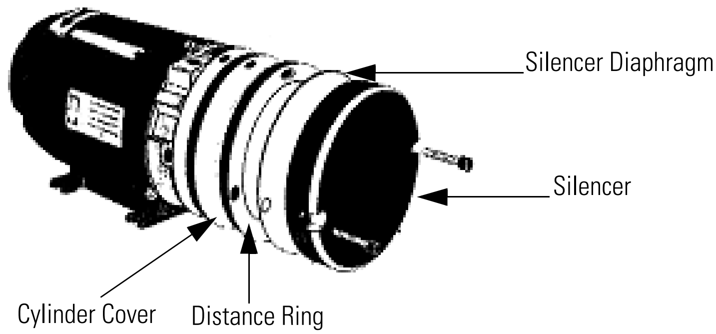


Figure 5-1. Location of Pump Parts

When installing new vanes, be sure that the beveled side points outwards (see circled areas within Figure 5-2). Reassemble the parts in the reverse order.

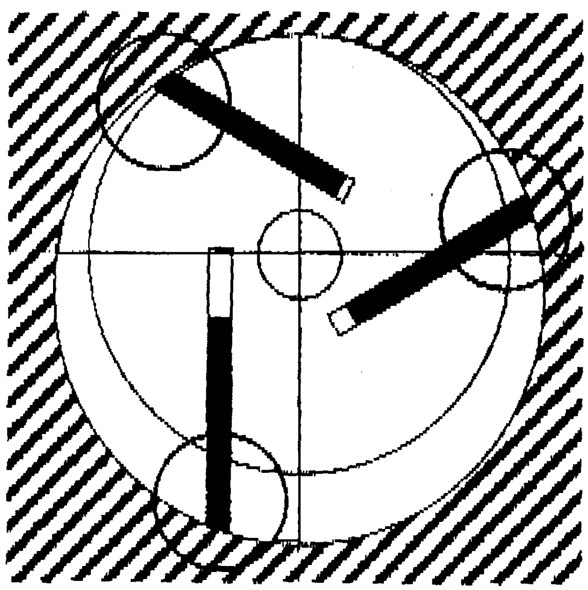


Figure 5-2. Carbon Vane Installation

Checking the Air Flow

To check and calibrate the air flow rate, please see the detailed description given in the "Calibration" chapter. For this purpose, a flow transfer standard (FTS) is needed to determine and calibrate the air flow (preferred flow meters can be supplied by Thermo Fisher Scientific as maintenance accessories).

Typically it is recommended by the USEPA to visit the monitoring site biweekly to perform a flow check for control charting purposes. Flow audits can be done once per quarter. If the flow rate of the Model 5030 SHARP does not deviate by more than ±5% of the auditing standard then no calibration is required except for an annual calibration. A drifting control chart from biweekly flow checks can define for the user what the calibration frequency may be for the instrument and if there is any sensor drift. However, the Model 5030 has been designed to hold a valid calibration for up to one year.

Please be cautious in choosing flow standards in the field. Typically bubble flow meters and dry piston meters should be limited to laboratory use and are not recommended by Thermo Fisher Scientific as an appropriate flow meter for field conditions. Thermo Fisher Scientific recommends the use of a venturi-style flow meter.

Temperature Sensors

Four temperature sensors are included in the Model 5030 SHARP:

- T1 ambient sensor
- T2 sample sensor (located inside the beta attenuation chamber)
- T3 flow sensor (which measures the temperature at the subsonic orifice)
- T4 heater sensor (located on the external heater wall)

The measuring range of these temperature sensors is -22 to 158 °F (-30 to 70 °C), however the Model 5030 SHARP is rated for a temperature range of -22 to 140 °F (-20 to 60 °C). The T4 Heater Sensor is rated for a temperature range of 0-100 °C.

Although the Model 5030 SHARP should hold a valid calibration for up to one year, typically it is recommended by the USEPA to visit the monitoring site biweekly to perform a flow check for control charting. Should an error in the flow check be significant (>7%), the error may be caused by one of the temperature sensors. It would also be beneficial to control chart the temperature sensors with each site visit. Furthermore, temperature sensor audits can be done once per quarter. If any temperature sensor does not agree within ±3.6 °F(±2 °C) of the auditing standard then a calibration is required in addition to an annual calibration. A drifting control chart from biweekly checks can define for the user what the calibration frequency may be for the instrument and if there is any persistent sensor drift. Should a temperature sensor need to be replaced, reference the “Servicing” chapter.

Note The T1 Ambient temperature sensor is readily accessible. However, the T2, T3, and T4 sensors should be allowed to equilibrate to either ambient or room temperature if the IMR Heating system has been active within the past one-hour. ▲

Pressure Sensors

Three pressure sensors are included in the Model 5030 SHARP:

- P1 orifice sensor
- P2 pump vacuum sensor
- P3 barometric pressure sensor

P1 measures the pressure differential across an orifice and is used for the flow calibration. P2 measures the vacuum under the filter tape, relative to barometric pressure. P3 directly measures the barometric pressure.

Although the Model 5030 SHARP should hold a valid calibration for up to one year, typically it is recommended by the USEPA to visit the monitoring site biweekly to perform a flow check for control charting.

Should an error in the flow check be significant (>7%), the error may be caused by one of the pressure sensors (most probably P3 barometric pressure). It would also be beneficial to control chart the P3 sensor with each site visit. Furthermore, P3 sensor audits can be done once per quarter.

If the P3 sensor does not agree within ±10 mm Hg (±13.33 hPa) of the auditing standard, then a calibration is required in addition to an annual calibration. A drifting control chart from biweekly checks can define for the user what the calibration frequency may be for the instrument and if there is any persistent sensor drift. Should a fatal error occur with a pressure sensor, contact the Thermo Fisher Scientific.

Note The P1 and P2 pressure sensors are factory calibrated and re-zeroed with each filter exchange. Calibration for these two sensors can only be done by a factory-trained technician. ▲

The “Installation” and “Calibration” chapters provide the procedures for re-zeroing the nephelometer. Although the nephelometer is designed to provide a consistent optical background measurement, drift may occur should the optics becoming coated over time. Normally an annual cleaning of the optics by a factory-trained technician should be scheduled.

Although the Model 5030 SHARP should hold a valid calibration for up to one year, typically it is recommended by the USEPA to visit the monitoring site biweekly for the QC checks referenced above. However, during these visits it is also a convenient time to check the optical background of the nephelometric stage (as described in the "Installation" and "Calibration" chapters) by performing a zero measurement using the inlet adapter and HEPA filter. After five minutes, both the ANALOG and NEPH values should be control charted as "as found" values. The NEPH value should read 0.0 µg/m^3, ±2.0 µg/m^3. If the NEP reading is outside of this control criteria, the Nephelometer should be re-zeroed, and a post-site-visit ANALOG and NEPH value should be recorded. Unless unusual dust storms have recently occurred and apparently interfered with subsequent measurements, the nephelometric chamber should be cleaned once per year by a Thermo Fisher Scientific certified technician or qualified field personnel.

Inlet Assemblies

The inlet assemblies can include a simple sampling cane, extended downtube, particle size separation devices (cyclone or impactor), and/or ambient 10-micron inlet. Cleaning schedules and routine maintenance of assembly components (such as, O-rings) should be established and maintained by the user.

$PM_{2.5}$ Impactor Cleaning and Inspection

If using a WINS Impactor (Figure 5-3) with the Model 5030 SHARP for $PM_{2.5}$, disassemble and clean the impactor at least every five sampling days.

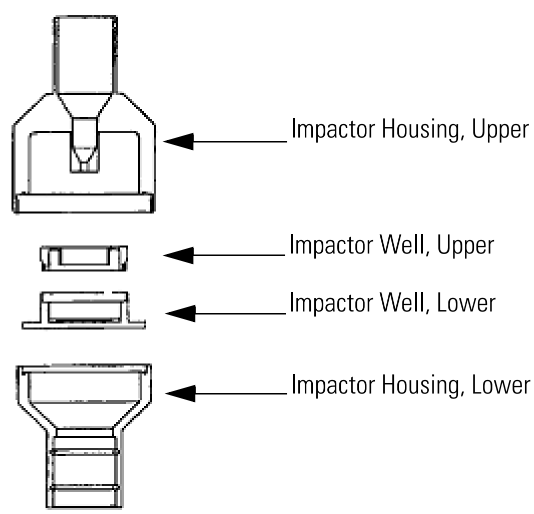


Figure 5-3. Exploded View of $PM_{2.5}$ WINS Impactor

The $PM_{2.5}$ impactor is cleaned by separating the upper and lower housings, wiping the upper and lower impactor well clean with lint-free laboratory tissues or a cloth, putting a new filter in the lower impactor well, and adding 1 ±0.1 ml of impactor oil. The oil should cover the filter uniformly. Reassemble the well and place in the impactor.

Preparation time can be saved by preparing several spare impactor wells and storing them in a clean, particulate-free container until needed.

Once a month, with the impactor assembly open, inspect the interior of the impactor housing, both above and below the impactor well. These areas should be clean and dry. If necessary, clean the areas with a lint-free wipe. On a monthly basis, clean the interior of the impactor nozzle jet using a lint-free pipe cleaner or similar tool. Also monthly, check the O-rings for distortion, cracks, fraying, or other problems and replace as necessary.

Cyclone Maintenance

If a Sharp-Cut Cyclone or a BGI Very Sharp-Cut Cyclone is being used for $PM_{2.5}$ sampling (Figure 5-4), once every 4 weeks the dust pot should be unscrewed, emptied, and cleaned with a lint-free cloth. Once every three months, the entire SCC assembly should be inspected and cleaned, O-rings checked for distortion, cracks, fraying, or other problems. Replace O-rings as necessary.

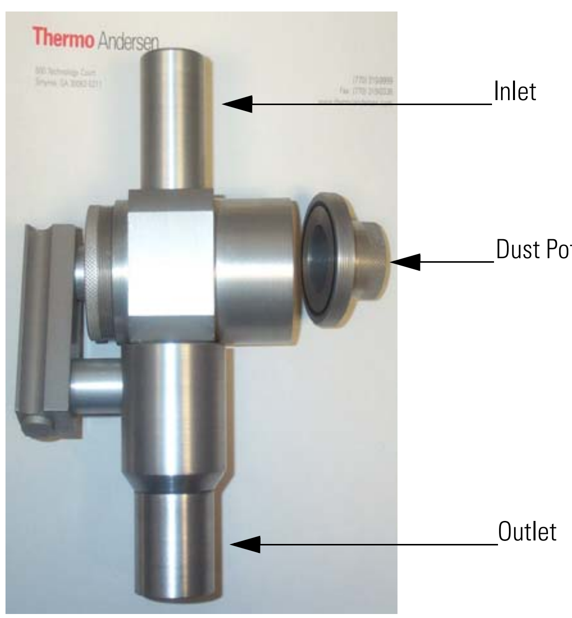


Figure 5-4. $PM_{2.5}$ Sharp-Cut-Cyclone

USEPA PM_{10} Inlet

The water collector bottle located on the PM_{10} inlet should be inspected at least every five sampling days (Figure 5-5). Remove any accumulated water, clean the interior of the bottle, inspect the seals, and replace the bottle in the holder.

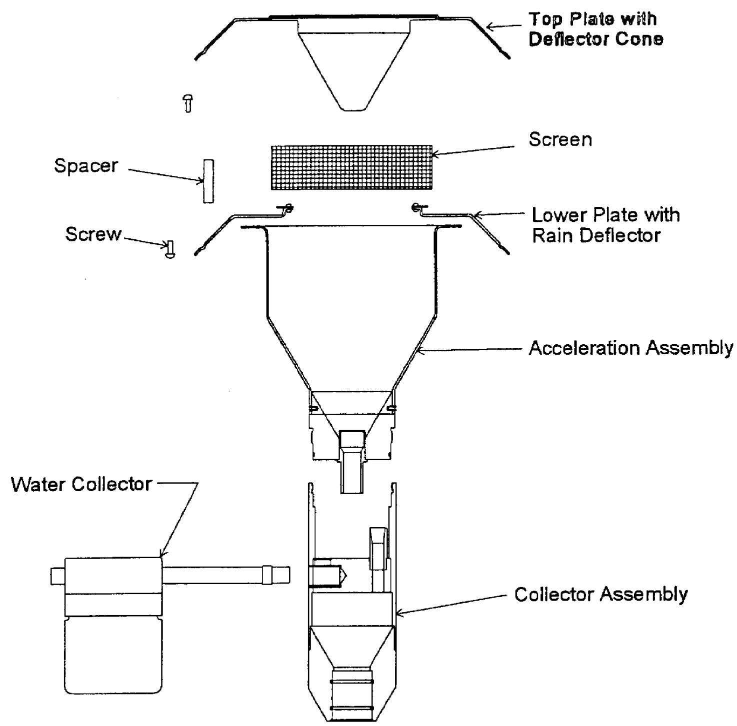


Figure 5-5. USEPA PM_{10} Inlet

Once a month the sampler inlet should be dismantled and cleaned. Mark each assembly point of the sampler inlet with a pen or pencil to provide reference marks during reassembly.

Disassemble the sample inlet unit according to Figure 5-5. If the assembly screws are frozen, apply penetrating oil or commercial lubricant to make removal easier. Clean all interior surfaces and the bug screen with a general purpose cleaner or compressed air, paying particular attention to small openings and cracks. Cotton swabs and/or a small brush are helpful. Completely dry all components.

Also monthly, check the O-rings for distortion, cracks, fraying, or other problems and replace as necessary. Apply small amounts of grease to the rings before assembling the unit.

Reassemble the unit in accordance with the previously scribed match marks. Particular care should be taken to ensure that all O-rings seals are properly seated and that all screws are uniformly tightened.

European PM_{10} Inlet

The same schedule should be used for the European PM_{10} Inlet, at approximately a 1-2 month interval. The components of the inlet should be inspected and cleaned as necessary. Figure 5-6 provided below provides a image and design drawing of the inlet, with references to parts.

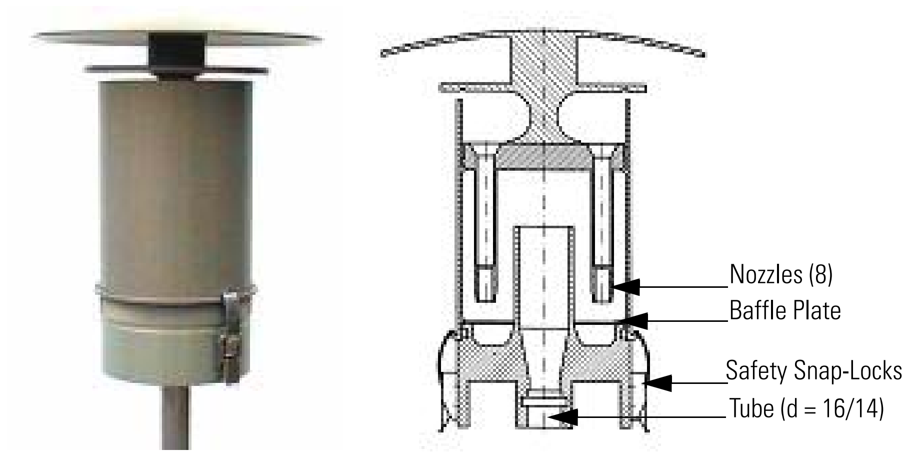


Figure 5-6. European PM_{10} Inlet

PM_{10} size selective inlet (1 m^3/h) for FH 62 Dust Monitors:

- Same construction as the EN reference inlet, but with 1 m^3/h
- With special surface protection using an aluminium EMATAL surface
- With special water separator and easy exchangeable impactor baffle plate
- Standard tube connection: d = 16 mm for connecting a continuous monitor
- Easy converting to $PM_{2.5}$ using the $PM_{2.5}$ nozzle plate (8 nozzles)
- Easy converting to PM_1 using the PM_1 nozzle plate (8 nozzles)

Weather Proofing

The “Installation” chapter covers detailed installation instructions. After proper installation, it is recommended to check the weather-proof installation at all interfaces exposed to ambient conditions. Ensure that the condition of the roof flange and silicone caulking will prevent any precipitation from entering the shelter and possibly damaging the instrument’s electronics.

Leak Check Procedure

The leak check of the 5030 SHARP is conducted by first placing the factory-supplied leak check adapter (Thermo part number 110524-00) on top of the inlet adapter. Afther the leak check adapter (LCA) is installed, attach a flow meter on top of the LCA. The addition of the LCA and the flow meter can cause the instrument to automatically change the filter spot. Allow the flow rate to stabilize and then document the flow meter reading.

The next step is to remove the LCA and reconnect the flow meter onto the inlet adapter. Allow the flow rate to stabilize and document the value from the flow meter. Compare the volumetric flow rate of the flow meter before and after the use of the LCA and calculate the difference.

It is normal for the 5030 to have a lower flow rate approximately 0.8 alpm when the LCA is attached compared to without the LCA. If the difference is less than 0.80 L/min (80 ml/min) the the leack check passes. If it is greater than 0.8 alpm, check for leaks in the system by checking the various fittings upstream of the measurement head. If the source of the leak cannot be found, the instrument requires service by a trained technician.

Chapter 6 Troubleshooting

The Model 5030 SHARP has been designed to achieve a high level of reliability. Only premium components are used, thus complete failure is rare.

In the event of problems or failure, the troubleshooting guidelines presented in this chapter should be helpful in isolating the fault(s).

For additional fault location information refer to the "Preventive Maintenance" chapter in this manual.

The Technical Support Department at Thermo Fisher Scientific can also be consulted in the event of problems. See "Service Locations" at the end of this chapter for contact information. In any correspondence with the factory, please note the serial number of the instrument.

This chapter provides the following troubleshooting information:

CAUTION Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter. ▲

Safety Precautions

Read the safety precautions in the Preface and the "Servicing" chapter before performing any actions listed in this chapter.

Troubleshooting Guides

The troubleshooting guide presented in this chapter are designed to help isolate and identify instrument problems.

Table 6-1. Troubleshooting Guide

Malfunction	Possible Cause	Action
Does not start up	No power	Check that the instrument/pump is plugged into the proper source (100/120V or 220/240V) Check instrument fuse

Table 6-1. Troubleshooting Guide, continued

Malfunction	Possible Cause	Action
	Power supply	Check voltages from power supply
	Digital electronics defective	Check that all boards and connectors are seated properly
		Replace with spare boards to isolate the problem
Cannot change parameters	Keypad is not enabled	Enable keypad through menu
No automatic filter change	Reel nuts not tight	Tighten reel nuts
	No more filter tape	Replace with new filter tape
	Filter not properly adhered	Adhere filter tape to take-up reel and wind over itself once
	Optical Tape Counter defective	Replace optical tape transport sensor
	Filter tape transport drive motor defective	Replace motor
Pressure transducer does not hold calibration or is noisy	Pressure transducer defective	Replace pressure transducer
Run output noisy	Recorder noise	Replace or repair recorder and/or leads.
	Sample concentration varying	Run Model 5030 on a zero filter - if quiet, there is no malfunction
	Foreign material in optical bench	Clean optical bench
	Digital electronics defective	Replace board with a spare board
Analyzer does not calibrate properly	System leak	Find and repair leak
	Pressure or temperature transducer(s) out of calibration	Recalibrate pressure or temperature transducer(s)
	Digital electronics defective	Replace one board at a time with a spare board to isolate the defective board
Analog test ramp	Faulty recorder	Replace recorder
	Zero output on	Turn Zero off

Table 6-1. Troubleshooting Guide, continued

Malfunction	Possible Cause	Action
	Span output on	Turn span off
	Digital electronics defective	Replace board with a spare board
Display is off	Wrong contrast setting	Adjust potentiometer on board
	LCD cable loose	Check connection and cable integrity
	LCD defective	Replace display

Status Messages

The status messages serve to inform and alert the user of the instrument operation. Among these features are the operating status, warning status and error messages.

The status message can be reviewed in the Main Menu and through the internal memory data download. In case there is no status message present, the measuring instrument is in the normal operation mode and the green LED "READY" will be illuminated.

The yellow LED "STATUS" stands for an operating and/or warning status.

The red LED "ERROR" will illuminate in case of an instrument error.

The general status message is abbreviated and represented as a 6-digit hexadecimal number. Each of the 6 characters represents up to 4 independent conditions. The eight global error status bits each represent a group of eight status bits. Consequently, a total number of 64 errors independent of each other can be distinguished allowing the user to pin point a specific error.

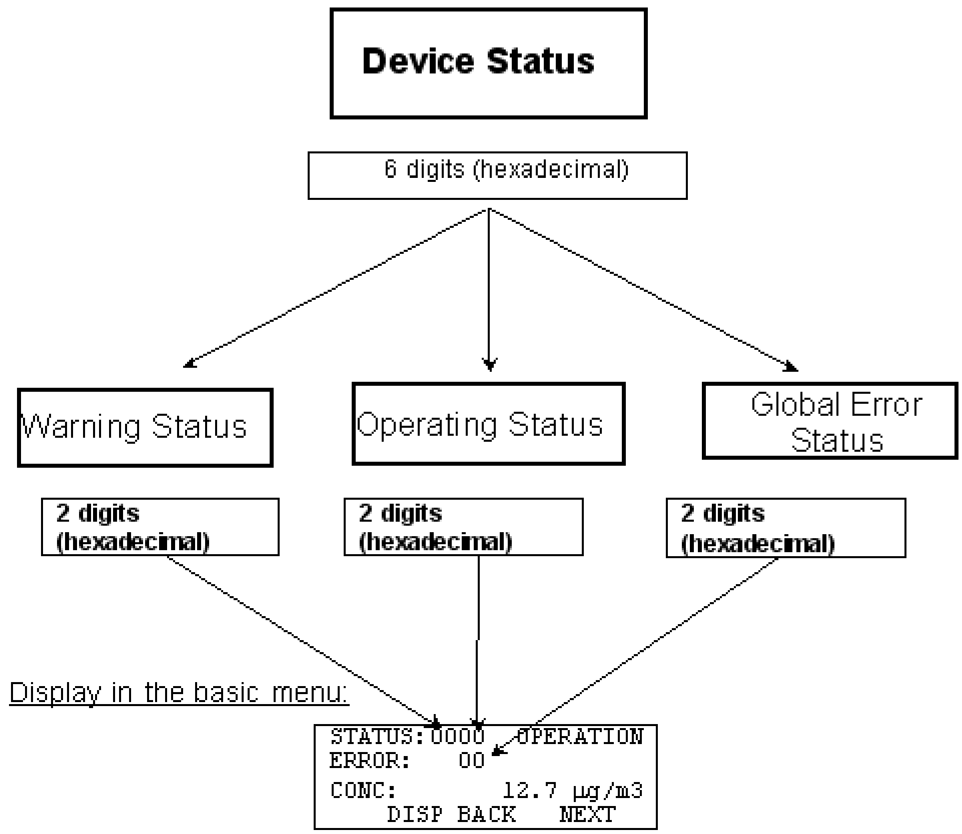
With the measuring instrument being in the normal error-free measurement operation, the status will show the value 000000.

Global status: 6 characters, each one consisting of 4 bits, characters 0 thorough F.

In the following section is a list of the most important status displays. The status, however, can occur also in various other combinations.

Status Concept and Structure

This section interprets the Operational, Warning and Error Status codes that may be indicated by the Model 5030.



Decimal- and hexadecimal system

dec:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hexadec:	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Warning and Operating Detailed Status Reports

Warning Status

Table 6-2. Warning Status Report

Status Code	Definition
01	maximum pump power
02	mass limit is exceeded; filter change will follow
04	Nephelometer Background Offset High (> 700), Neph < -1
08	Relative Humidity > (RH Setpoint + 10%)
10	not used
20	Compensation of the mass signal > ±5%
40	two consecutive plateau checks are wrong during filter change: Rref/R1 < 30% or > 70%
80	Analog Range 2

Operating Status

Table 6-3. Operating Status Report

Status Code	Definition
00	Normal operation, no error
01	Mechanical filter change
02	Plateau check and zero adjustment of the mass (R^0)
04	System Stabilizing (for 12h after switched on)
08	Pump switched off
10	Manual operation (off-line, keyboard enabled)
20	Calibration enabled
40	Nephelometer Calibration Stabilizing
80	Power supply switched on

Structure of the Status Conception

Note The detailed status messages are a result of added status codes and thus form the warning as well as the operating status. ▲

Examples:

Status	Significance	
011	0010	Manual operation
	0001	Mechanical Filter change
0082	0080	Power Supply Switched on
	0002	Zeroing (mass)
00A9	0001	Filter change (mechanical)
	0008	Pump off
	0020	Calibration enabled
	0080	Poewr Supply Switched on

Note Below are the combinations of potential added status codes and their breakdown. In the STATUS example above, recognize that the "A" in 00A9 shows a combination of 20 and 80 for the Operating Status. Do not confuse this with a 02 and 08 for Operating Status. The positioning of the alphabetical character is key to defining which codes the instrument is reporting. Being able to recognize these subtleties will allow the user to easily define and troubleshoot the Model 5030 as necessary. Below is a matrix of alphanumeric combinations. ▲

Status Codes - Alphanumeric Combinations

0	1	2	3 = 2 + 1
4	5 = 4 + 1	6 = 4 + 2	7 = 4 + 2 +1
8	9 = 8 + 1	A = 8 + 2	B = 8 + 2 + 1
C = 8 + 4	D = 8 + 4 + 1	E = 8 + 4 + 2	F = 8 + 4 + 2 +1

Detailed Status Messages

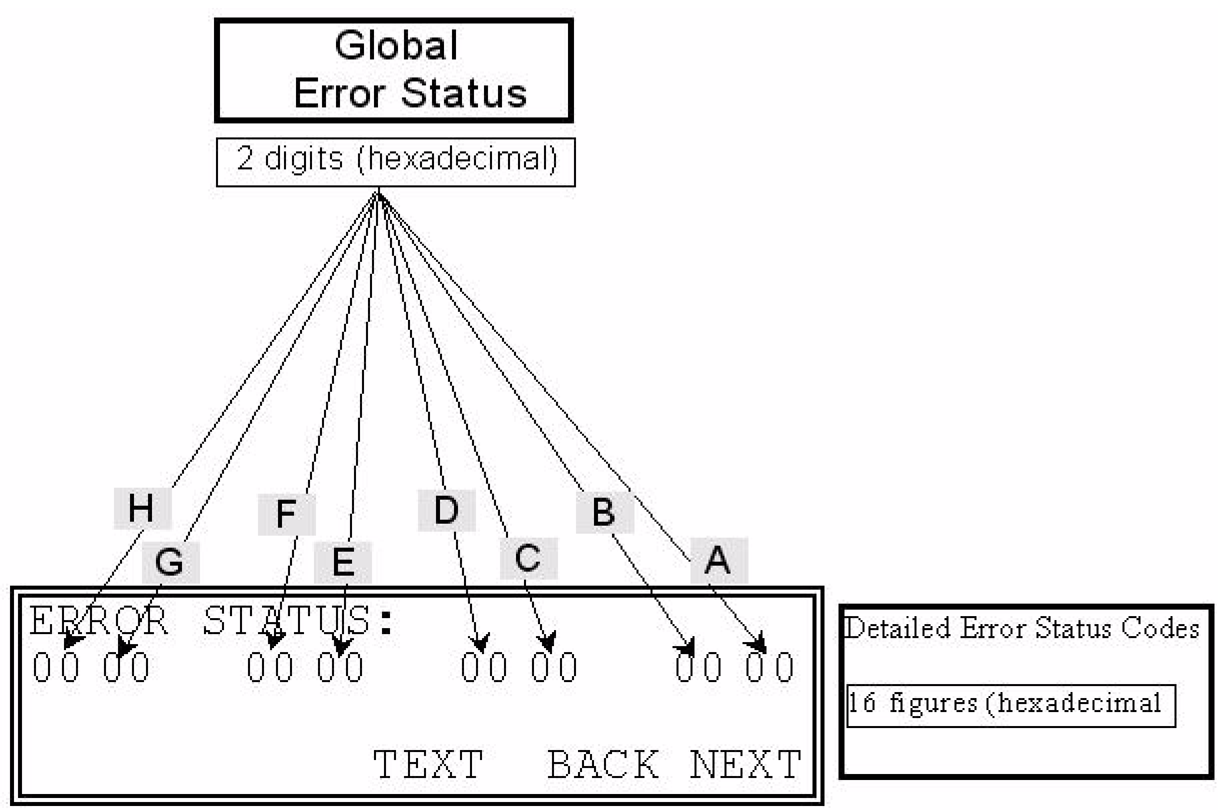
From the Main Menu, a Global Error Status appears as a 2 hexadecimal figure. Table 6-4 indicates the codes and general definitions. Each code should be interpreted by reviewing the detailed error status codes.

Global Error Status

Table 6-4. Global Error Status

Code	Global Error Status Definition	Field
01	Sum status of the data and program memory	A
02	Sum status of sampling and measuring system	B
04	Sum status of pressure sensors	C
08	Sum status of air flow regulation	D
10	Sum status of the sample heater	E
20	Sum status of temperature measurement	F
40	Sum status of the Nephelometer measurement	G
80	Not used	H

The following break down of the Global Error Status Definitions to a Detailed Error Status can be obtained by pressing the **DISP** key once and the **NEXT** key four times from the Main Menu.



Detailed Error Status

```
0000 0000 0000 0000
```

A Sum status of the data and program memory (memory error) (Table 6-5).

Table 6-5. Data and Program Memory

Code	Definition
01	FLASH-EEPROM Error
02	RAM error
04	Save RAM error (backup battery exhausted)
08	EEPROM write/read error
10	free
20	free
40	free
80	free

```
0000 0000 0000
```

B Sum status of the sampling and measuring system (Table 6-6).

Table 6-6. Sampling and Measuring System

Code	Definition
01	detector error < 1000 1/s …> 500000 1/s
02	automatic HV adjustment not possible (<1200V … > 1500V)
04	mass compensation > ±10%
08	pump off protection (do not block the air intake!)
10	lift sensor: “open” position not noticed
20	filter break
40	Plateau Flag (Counter ≥ 10)
80	pump was switched off when nominal air flow could not be reached

0000 0000 00**00** 0000

C Sum status of the pressure sensors (Table 6-7).

Table 6-7. Pressure Sensors

Code	Definition
01	differential pressure sensor P1: over range
02	low pressure sensor P2: over range
04	barometric pressure sensor P3: over range
10	P2 < 10 hPa
20	difference pressure P1 < 1hPa

0000 0000 **00**00 0000

D Sum status of the air flow regulation: (Table 6-8).

Table 6-8. Air Flow Regulation

Code	Definition
01	regulation deviation > 5 %

0000 00**00** 0000 0000

E Sum status of the sample heater (Table 6-9).

Table 6-9. Sample Heater

Code	Definition
01	T4 exceeds max-heater temp > 2 °C
02	RH Sensor Over Range

```
0000 0000 0000 0000
```

F Sum status of the temperature measurement (Table 6-10).

Table 6-10. Temperature Measurement

Code	Definition
01	temperature T1 over range
02	temperature T2 over range
04	temperature T3 over range
08	temperature T4 over range

```
0000 0000 0000 0000
```

G Sum status of nephelometer measurement (Table 6-11).

Table 6-11. Nephelometer Measurement

Code	Definition
01	nephelometer output over range

Overlay of Several Status Messages

The error codes of the detailed error status messages are added and thus form the detailed error status and the global error (failure) status (Table 6-12).

Table 6-12. Detailed Error Status and Global Error Status

Error Status	Description
01: 0000 0000 0000 0004	SaveRAM error (backup battery empty)
02: 0000 0000 0000 3000	Lifting position: opening of the filter tape gap has not been recognized
	Filter tape fissure: no filter tape transport has been recognized
04: 0000 0000 0001 0000	Differential pressure sensor

Status Output by Potential Free Relay Contacts

If the respective status code is not set, the relay circuit will be closed.

If the respective status code is set, the relay circuit will be open.

Each relay has one potential free change contact.

The self-surveillance routine of the Model 5030 SHARP is executed every second and the relays are set or reset according to the actual status.

Status Reports of the standard relays on the main board include:

Relay 0: signals the "Operation Status"

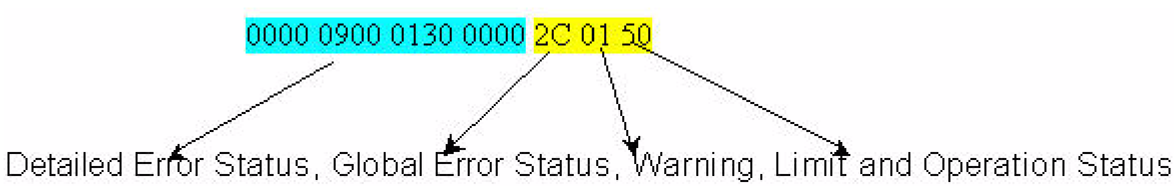
Relay 1: Nephelometer Auto Ranging

Relay 2: signals the "Error (Break-Down) Status"

Output by Serial Interfaces (COM1 and COM2)

Remote Control Commands

After receiving the read command (for example, # <CR>) the device returns:



Data Protocol with Network Connection

Command: <STX> DA address <ETX> <BCC1> <BCC2>

Device returns: <STX> MD 01 address meas.value **status** SFKT <ETX> <BCC1> <BCC2>

Refer to "Appendix B" for a detailed description of the code words alone.

“status” has 4 figures:

2 figures “Operation Status”

2 figures “Global Error (Break-Down) Status”

(“Warning and Limit Status” is not included!)

By Gesytec Protocol Status Version “compatible to FH62I-N”:

Operation Status: data bit D1:

“off-line, keyboard enabled”

data bit D2: “filter change”

Global Error (Break-Down) Status:

data bit D0: “air flow rate error”

data bit D1: “filter tape break or filter tape end”

data bit D2: “offset > ± 100%”

data bit D3: “mass buffer is not filled”

Print Formats

In some print formats (for example, no. 1, , no. 30) the instrument status is provided in addition to the measured value. For example: the device status in the format “**02 00 CA**” is given out.

The first two figures represent the “Global Error Status,” the two in the middle represent the “Warning and Limit Statesman the last two represent the “Operation-Status.”

Example: Print format 3:

03-11-16   14:48:18   0200CA 10.3   129.7   1000.7

Status Concepts for Quality-Assured Measurement

Status Changes and Entries into the Logbook

When the device status changes, the new device status is copied into the logbook together with date, time, concentration, mass, air flow rate, temperatures (T1, T2, T4), RH pressures (P2, P3), and Count Rates (R_β, R_α,).

The logbook contains the 20 latest entries (standard). With the option "512 Kbyte RAM-expansion" it has 1632 entries.

Example: (print format no. 11 or no. 19)

Thermo Fisher Scientific Model 5030 SHARP no.: 2 04-11-02

LOGBOOK

DATE	TIME	ERRORSTATUS	CONC	MASS	Q_PM10	T1	T2	T3	T4	P1	P2	P3
04-11-02	12:08	0000000000000000000000	25	-7	1001	26	26	26	30	2416	63	976
04-11-02	12:03	0000000000000000000004	25	32	998	26	26	26	30	2366	62	976
04-11-02	12:00	0000000000000000000002	25	65	422	26	26	26	30	65	5	976
04-11-02	12:00	0000000000000000000011	25	118	0	26	26	26	30	-65	-2	976
04-11-02	06:08	0000000000000000000000	3	-4	1000	24	25	25	29	2421	63	976

Detailed Error Status Global Error Status Warning + Limit and Operation Status

Status Definition of the Half-Hour Mean Values of the Concentration

The code[Number]s of all status, occurring during the half-hour, are added and thus form the status of the half-hour mean values.

This procedure prevents the loss of status information, even when a special status vanishes again during the half-hour. Multiple occurrence of the same status in a half hour is not recorded.

Example:

TIME	STATUS	COMMENTARY
13.45	00 00 00	normal operation
14.05	00 08 00	relative humidity elevated
14:13	00 00 00	normal operation
14:35	00 00 40	Nephelometer calibration stabilizing
14:49	00 00 00	normal operation
14:55	00 00 10	keypad enabled
15:10	00 00 00	normal operation

Status of the half-hour mean value

14.00 - 14.30 : 00 08 00
14.30 - 15.00 : 00 00 50

File of Mean Values of the Dust Concentration

The mean value file contains a user-selectable 1/2-hour or one-hour concentration:

> date, time, status, 1/2h-mean concentration value, and 1/2h mean C14 concentration

It contains the 60 latest values (standard). With the option "512 Kbyte RAM-expansion" it is extended to 18560 entries (more than one year). The entry happens at every finished half hour.

Chapter 7 Servicing

This chapter describes how to update the software and replace the Model 5030 SHARP filter tape and carbon vanes of the vacuum pump.

For fault location refer to the “Preventive Maintenance” and “Troubleshooting” chapters. For additional service assistance, see “Service Locations” at the end of this chapter.

Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

WARNING The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

The Thermo Scientific Model 5030 SHARP contains a small ^{14}C (Carbon 14) beta radiation emitting source. Source activity is <100 µCi (micro curries) which is below the exempt concentration limit defined in 10 CFR, Section 30.70 - Schedule A. The person with responsibility for the Model 5030 SHARP can return the device to Thermo Fisher Scientific for recycling the ^{14}C source.

Neither the ^{14}C source nor the detector are field serviceable. The Model 5030 SHARP must be returned to the factory for servicing or it can be serviced by an authorized Thermo Fisher Scientific field service technician. ▲

CAUTION Carefully observe the instructions in each procedure. ▲

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components. When the instrument is unplugged, the chassis is not at earth ground. ▲

Handle all printed circuit boards by the edges. ▲

Filter Tape Replacement

As soon as the filter tape on the filter roll is empty, a replacement of the roll is necessary.

The filter tape is usually replaced every year, but this can also depend on the non-standard operational parameters chosen by the user or the loading per filter spot. In high concentration areas, more frequent filter changes can occur due to higher loading. As a basis for an estimation of this time, the reference can serve that ~40 m of tape per roll is sufficient for approximately 800-900 single measurements. Due to the uncertainty of filter tape life in higher concentration areas, checking the filter tape every 6-9 months may be warranted.

To change the filter tape, follow the instructions in the "Installation" chapter.

Carbon Vane Replacement

Vane replacement must be done outdoors. Failure to do so may introduce carbon particles into the air and damage electronic equipment. Before servicing, the vacuum pump must be switched off and secured from any accidental start-up.

In order to replace the vanes, the silencer housing, the silencer diaphragm, the distance ring, and the cylinder cover must be removed (see Figure 7-1).

Nephelometer and Beta Attenuation Servicing

Servicing of the Nephelometer and Beta Attenuation Chambers should be performed by a trained technician. A technical bulletin is available via the internet at http://www.thermo.com/air.

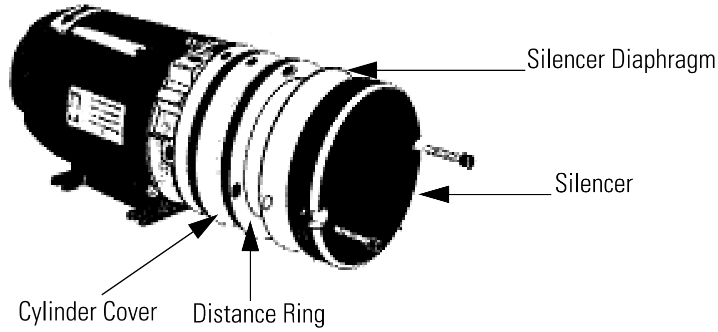


Figure 7-1. Pump Parts Location

Use an air hose to blow carbon particulate from the vane cavity.

WARNING Avoid inhaling carbon particulate. Use an approved particle filter or respirator.

When installing new vanes, be sure the beveled side points outwards (see Figure 7-2). Reassemble the parts in the reverse order.

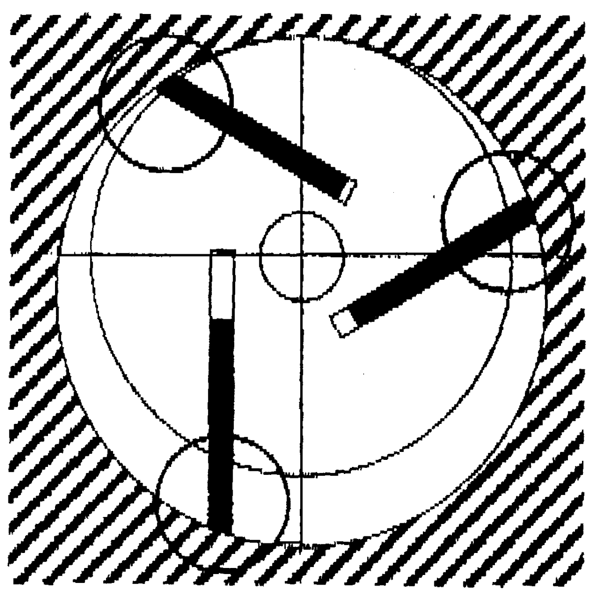


Figure 7-2. Carbon Vane Installation

Firmware Update

Firmware for the Model 5030 SHARP can be updated by exchanging its FLASH-EEPROM. However, it is more easily accomplished through the transmission of a new program code via the COM1 serial interface. During transmission the program is saved in RAM. After the transmission has been completed without corruption, the program code is written into the Flash - EEPROM.

A download of the Parameter List (Print Format 8) should be done prior to any firmware updates. Refer to "Print Formats" in the "Operation" chapter.

Use the following requirements and steps to update to a new firmware version.

Requirements:

- PC with Windows 98 or higher with COM1 serial interface (9 pin)
- Model 5030 SHARP with jumpered X30/Pin 1-2 (insert: longest distance from the Flash - EEPROM)
- Communications Cable with the configuration shown in Figure 7-3. This cable connects the PC 9-pin COM1 port to the Model 5030 SHARP 25-pin COM1 port.

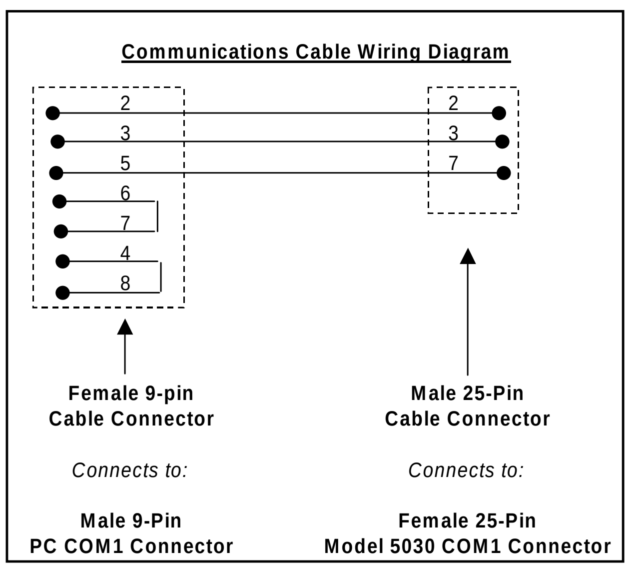


Figure 7-3. Communications Cable Wiring Diagram and Serial Connection

Software Requirements

- Software "winupdate.exe" for the PC (supplied by Thermo Fisher Scientific)

- Firmware file vx-xxx.hex or MASTER.hex for the instrument

Firmware Update Procedure

Use the following procedure to update the Model 5030 SHARP firmware.

1. Connect COM1 of the PC to COM1 of Model 5030 and switch on both instruments.

2. Unlock the keypad in the Operations menu and configure the Model 5030 to:

   - Print cycle: 0 min 0 sec

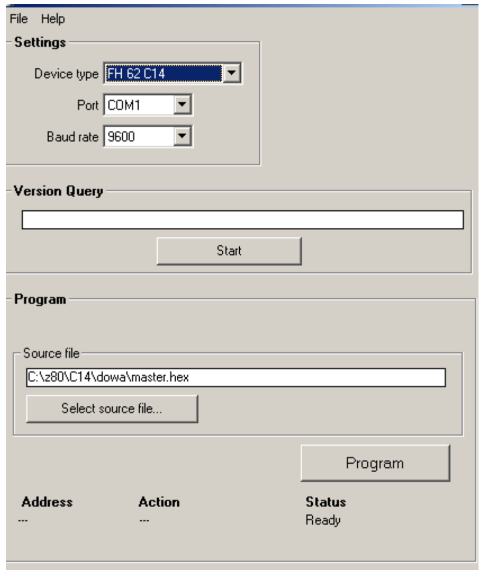
   - Baud rate: 9600 baud

3. Lock the keypad, returning to the remote control mode.

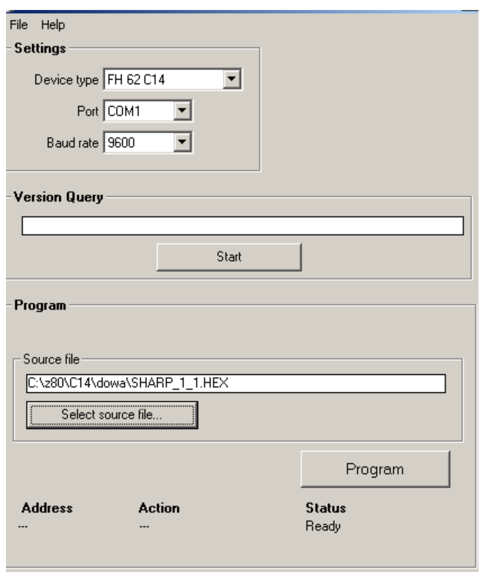
4. Start "winupdate" on the PC.

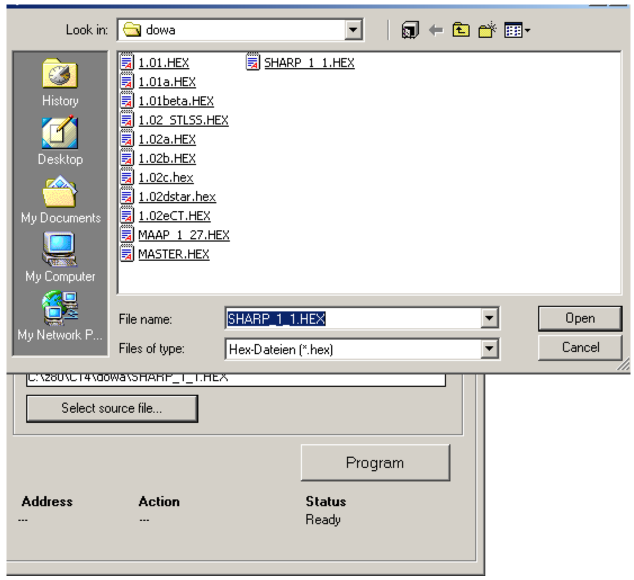
Note You can check and validate the SHARP firmware version before and after upload by clicking on the Start button in the Version Query section. ▲

5. Select Device type for **5030 SHARP**.

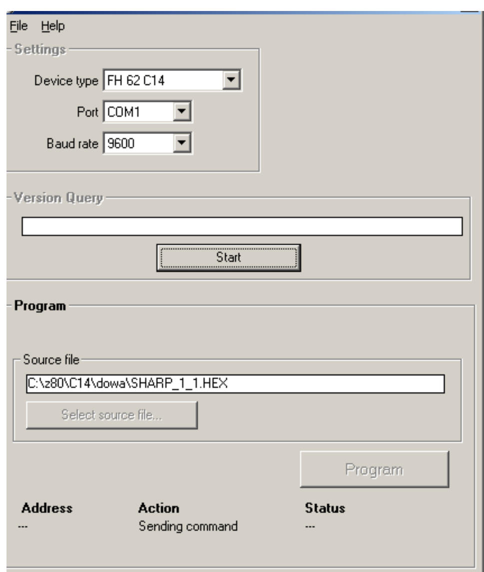


6. Click on the **Select source file** button to choose the software file you want to load into the dust monitor.





7. Click on the **Program** button.



The first screen that appears on the SHARP instrument indicates the address of the data bytes being received. This screen is shown below. The transfer takes approximately three to five minutes.

```
RECEIVING FLASH DATA
-------------------------------------
2C80
```

Data Byte Address Screen

After a successful firmware upload the Flash - EEPROM is programmed. The following screen is displayed.

```
PROGRAMMING FLASHMEM
-------------------------------------
FFC0
```

Programming Flash Memory Screen

After successfully uploading the new firmware to the Model 5030 SHARP, the instrument will automatically restart with the new firmware version. You can now close the WinUpdate program.

The initial screen shown at startup appears for approximately 30 seconds. This screen contains the firmware version. The version (for example, v 1.02) should be checked to make sure that it corresponds to the new version. (This can also be done with "winupdate" by clicking on the **Version Query** START button.)

If the firmware upload was faulty or the programming of the Flash - EEPROM did not work correctly, the instrument starts with the old firmware version.

Note The parameters of the Model 5030 SHARP are not changed when the firmware is updated. As a precaution, however, the parameters should be compared with the values that existed before the update was made. This can be done by using Print Format 8 before and after the update. ▲

Service Locations

For additional assistance, service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 8 Optional Equipment

This chapter describes the Model 5030 optional equipment. Refer to Table 8-1 for a list of the optional equipment part numbers.

The Model 5030 SHARP comes as a standalone unit with an external vacuum pump and it can store a year's worth of data.

Inlet Assemblies

The Model 5030 can be used for different applications. Using different inlet configurations (PM_{10}, $PM_{2.5}$, PM_1 Inlets) or enrichment techniques ($PM_{10\text{-}2.5}$), several particle size fractions can be monitored. The main application is the measurement of PM_{10} and $PM_{2.5}$ for ambient air quality monitoring and health effect studies.

Sampling Tube Extensions

Often the most compatible way to install the Model 5030 at air quality monitoring sites is to collocate the inlet at the same height as other similar-use inlets. The "Installation" chapter discusses specific siting criteria. In addition to using the above referenced inlets, extending the sample downtube length is necessary using a rigid sample tube.

Note Extended lengths of flexible tubing can lead to particle loss and are **strongly** discouraged. ▲

Weather Enclosure

If a climate-controlled shelter is not available for siting the Model 5030, a weather-proof enclosure is available. Please inquire with your Thermo Fisher Scientific representative.

Rack Mounting Accessories

Use Thermo Fisher Scientific part number FH132 Sliding Rail Hardware for mounting the Model 5030 within a standard 19-inch rack.

Table 8-1. Optional Equipment Parts List

Option	Part No.	Description
Inlet Assembly	57-000596	10-Micron Inlet (U.S. EPA PM_{10} Inlet as per 40 CFR at 16.67 l/min)
	57-005896	2.5-Micron Sharp-Cut Cyclone (SCC) at 16.67 l/min)

Table 8-1. Optional Equipment Parts List, continued

Option	Part No.	Description
	57-008740	2.5-Micron Very Sharp-Cut Cyclone (VSCC) at 16.67 l/min)
	10-007742	1.0-Micron Sharp-Cut Cyclone at 16.67 l/min)
Sampling Tube Extensions	4254521-3m	9.75-foot (3 m) Heated Sampling Tube
	4254521-1m	1 meter Heated Sampling Tube
	FH107	Roof Mounting Flange for Sampling Tube (For 40mm tubes, DDF40)
Weather Enclosure	SM149248350	Protective Housing for Ambient Temperature Sensor
Rack Mounting Accessories	425451065	Telescope Plate
	KT149140871	Telescope Mount Bars, 1 pair, for 19-inch Rack Mounting
Analog Extension	425451029	Printed Circuit Board(s) Potential-Free Separation
	425451026	Bit I/O Expansion Board

Appendix A
Warranty

Seller warrants that the Products will operate or perform substantially in conformance with Seller's published specifications and be free from defects in material and workmanship, when subjected to normal, proper and intended usage by properly trained personnel, for the period of time set forth in the product documentation, published specifications or package inserts. If a period of time is not specified in Seller's product documentation, published specifications or package inserts, the warranty period shall be one (1) year from the date of shipment to Buyer for equipment and ninety (90) days for all other products (the "Warranty Period"). Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said published specifications; provided that (a) Buyer shall promptly notify Seller in writing upon the discovery of any defect, which notice shall include the product model and serial number (if applicable) and details of the warranty claim; (b) after Seller's review, Seller will provide Buyer with service data and/or a Return Material Authorization ("RMA"), which may include biohazard decontamination procedures and other product-specific handling instructions; and (c) then, if applicable, Buyer may return the defective Products to Seller with all costs prepaid by Buyer. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the Delivery provisions of the Seller's Terms and Conditions of Sale. Consumables, including but not limited to lamps, fuses, batteries, bulbs and other such expendable items, are expressly excluded from the warranty under this warranty.

Notwithstanding the foregoing, Products supplied by Seller that are obtained by Seller from an original manufacturer or third party supplier are not warranted by Seller, but Seller agrees to assign to Buyer any warranty rights in such Product that Seller may have from the original manufacturer or third party supplier, to the extent such assignment is allowed by such original manufacturer or third party supplier.

In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage and handling of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this warranty, Buyer shall pay Seller therefor at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

THE OBLIGATIONS CREATED BY THIS WARRANTY STATEMENT TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, SELLER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

Appendix B RS-232 Commands

The RS-232 interface enables the Model 5030 to be remotely controlled by a host RS-232 device such as a PC, PLC, and data logger.

Connections

The two female connectors labeled "COM1" and "COM2" on the rear panel are 25-pin and 9-pin, respectively. Either connector can be connected to the remote device. The remaining connector can be used to connect a second serial output.

Remote Control

The transmission of all data takes place via the following settings:

Bits per Second	9600, 4800, 2400, 1200, 600 or 300
Data Bits	7
Parity	Even
Stop Bits	2
Flow Control	

As a rule, a remote command always consists of a character or special character and, if necessary, is followed by numbers. A stop code forms the end of a command.

The stop code is either <CR> (carriage return) or <LF> (line feed). However, it is also permitted to send several stop codes. Besides the characters <CR> and <LF> also the character 7Fhex, or respectively FFhex can be used as stop code.

The Model 5030 is provided with a receive buffer of 256 characters. Consequently, several commands can be received immediately one after the other. For example; a complete set of parameters (approximately 20 commands) can be sent to the Model 5030 as one contiguous string of commands.

The entire systems structure allows for operating several measuring instruments being connected to a common bus line (RS485). This way, all commands can be received from all devices. In the event a command is to be executed by one precisely defined device, then the respective device address has to precede the command character when sending.

A device address is a number followed by a colon. Consequently, a command usually looks like the following:

[Address][:]Command code number stop code

The information in brackets is optional.

As far as the execution of the command is concerned, it makes no difference whether a command is entered via the keyboard or via the serial interface.

In case the system detects unreasonable parameters when receiving a command (such as, parameters that are no longer within the admissible range), the respective command will not be executed and the error counter will increment by 1.

The MODEL 5030 monitor incorporates two serial interfaces which can be operated simultaneously:

- COM1
- COM2

COM1 is connected to a 25-pin D-sub plug connector.

Note COM1 is the only interface used for software updates. ▲

COM2 is wired to a 9-pin D-sub plug connector and can be connected to the interface of a computer using a 1:1 cable.

The command codes are split into 3 groups: READ-, WRITE- and CONTROL-commands and are listed in alphabetical order. The word "number" found in a command always stands for the entry as a maximum 7-digit integer number, unsigned. Leading space characters are permitted.

Data sent by the monitoring device MODEL 5030 always end with <CR><LF>. The guaranteed response time to a remote control command amounts to one second.

Unless stated otherwise, numbers usually consist of 6 characters, representing a maximum 5-digit integer number, ranging from -9999 to 99999 having at least one leading space character.

Remote Control Commands

Remote control commands include read commands, write commands, and control commands.

Read Commands

C	Output of the dust mass concentration in µg/m³ (actual mode)
C1	Output of the β-concentration
C2	Output of the optic concentration
H	Output of the last half hour average in µg/m³
HH	Output of the 1h filtered concentration
H1	1 h average concentration [µg/m³]
H3	3 h average concentration [µg/m³]
HT	24 h (daily) average concentration [µg/m³]
JB	T1, temperature sampling head
JC	T2, temperature dust sampling chamber
JD	T3, temperature inside of the flow meter orifice
JE	T4, temperature external heated sampling tube (at tube surface) all temperature in °C
JF	P1, differential pressure of the air flow measuring module in Pa
JG	P2, low pressure suction chamber
JH	P3, Barometer in hPa
JI	air flow sampling head (operating flow)
JJ	norm air flow (273K, 1013hPa)
JO	air flow rate regulation 0...100%
JQ	power of external heating 0...100%
JR	relative humidity value (%RH)
m1	non filtered mass in µg
m2	mass on LCD with RC-filter (µg)
m3	mass, filtered with Quick-Lock filter

m4 mass filtered with RC-filter for 1 hour (µg)

m7 density compensation factor

N read error transmission counter

If at the receiving of data an error has appeared,

- parity error

- invalid parameters

an error counter is incremented.

Through the reading the counter is set on zero.

t Output of the board type

UA beta count rate R_β [1/s]

UB zero count rate $R_{\beta\o}$ [1/s]

UC alpha count rate R_α [1/s]

UD zero count rate $R_{\alpha\o}$ [1/s]

UP natural alpha activity on the filter [Bq]

UQ Radon –EEC activity concentration [Bq/m³]

US adjustment-factor for the optic

UT low pass filtered β-concentration

UU low pass filtered optics-concentration

v Instrument model and software version[Number] are given out.

Z read date/time of day

answer: jj-mm-tt hh:mm:ss

ZZ read date/time

Answer: jjmmddhhmmss

? read device address

output device status

The complete error -, warning -, and operating status is given out as a string of 22 characters. Each character represents 4 status bits with hexadecimal display. The first 16 characters show the detailed error status, the last 6 characters the global error -, warning -/alarm – and operating status.

Write Commands

dA[number]	set serial[Number]	0..999
d1	print format COM 1	0...255
d2	print cycle in minutes	0...30000
d3	print cycle in seconds	0...120
d4	Baud rate COM 1 and COM 2	
d7	device adress	0...255
d8	print format COM 2	0...255
D[number]	set print format e.g., D8 print format no. 8,	
K4[number]	concentration factor	50...200 %
KB[number]	filter change dust load in µg	0...9999
KD[number]	filter change cycle in hours	0, 3...100
KE[number]	filter change time of day (full hours)	0...24
		0: no filter change
KG[number]	external heating on: 1	
	external heating off: 0	
KH[number]	set point air flow regulation in l/h	0...3500
KK[number]	mass calibration factor	0...50000
KL[number]	Beta temperature compensation factor	(factory)
KM[number]	choosing which averages are saved	
	½ hour averages: 0	
	1 hour averages: 1	
KN[number]	concentration according	
	operating volume: 0	
	norm volume: 1	
KQ[number]	Establishes the Range 1 Optical Offset	
KR[number]	Establishes the Range 2 Optical Offset	
KS[number]	Establishes the Range 1 Optical Calibration	
KT[number]	Nephelometer temperature compensation factor	(factory)
KU[number]	Establishes the RH Target Value	

KV[number]	Establishes the maximum heater setting	
KW[number]	Establishes the minimum heater power (0-20%)	
KY[number]	channel for the analog output	(0 .. 12)
K%	Norm – Temperature	0…99 °C
K?	Flag for language selection	
	(0=German, 1=English, 2=French, Italian, or spanish)	
K+	Sample vacuum compensation factor	(factory)
K*	Barometric Pressure compensation factor	(factory)
K#	Calibration factor of the air flow rate	
Y$	write parameters to EEPROM	
Z[YYMMDDhhmmss]	set date and time	

Control Commands

A	pump off
E	pump on
F	filter change
P	Data output according to the selected print format is triggered.
R	Reset., This command has the same effect reconnecting the supply voltage.
Y	load parameter set from EEPROM
y<	load PARAMETER file (print format 47)
y>	write PARAMETER file (print format 47)
o0	offline
o1	online

Output commands for file output:

/A	Auto stop ON; single line output
/O	Auto stop OFF
/S	Stop
/C	Continue
/T	Terminate

u0	reference count rate on
u1	alpha count rate on
ua[Number]	high voltage range: 0....1600V
ud[Number]	reference threshold range range: 0....5000 mV
b [Number]	Setting the number of days backwards from the current date for terminating the file output. Range: 0...1000 days; 0 will produce the complete file.

Data Protocols with Measuring Network Connection

Once the character <STX> (usually: Ctrl-B) has been received, the monitoring instrument MODEL 5030 starts processing the data received at the serial line according to the protocol that has been agreed upon for devices operating in a measuring network.

To prevent the measuring instrument from executing data outputs on its own, we strongly recommend setting the print format to 0.

This is the basic structure of a data protocol:

<STX>[Text]<ETX><BCC1><BCC2>

Instead of <ETX><BCC1><BCC2> it is also possible to send <CR>. In doing so, the block check will be disabled.

The response of the measuring device will be terminated by <CR><LF>, if the control or inquiry command had an <CR> at the end. If the command is terminated with <ETX> (usually: Ctrl-C) and block check, the response of the measuring instrument will be also terminated with <ETX> and <BCC1><BCC2>.

Data Sampling

Upon request, the measuring instrument sends a measuring data protocol. Transmission of the measuring data is released by the following sequence of characters:

<STX>DA[Address]<ETX><BCC1><BCC2>

where Address: Device address, 3 characters, leading zeros can be replaced by <SP>. It is also possible that the address can be completely dropped. The address at the measuring instrument is set by using the keyboard. (Menu OPERATION: Device address).

Sampling is valid and response will be given, if:

- the <STX> is followed by the characters DA,
- the address is correct or not existing,
- the <ETX> is followed by two correct BCC-characters
- or <ETX><BCC1><BCC2> is replaced by <CR>.

The following is an example for a valid inquiry at the device having the address 5:

<STX>DA<CR>

<STX>DA005<CR>

<STX>DA<SP><SP>5<ETX><BCC1><BCC2>

<STX>DA<ETX>04

Data Transmission

The data inquiry may comprise up to seven variables. As a consequence, the response then contains the respective number of blocks, each block beginning with the address and ending with [SFKT]. With each block, the address will be incremented by 1.

The transmission of measured data is effected as response to the data inquiry/data sampling (1). The format will be as follows (here in this case with 2 variables):

<STX>MD0[n]<SP>

[Address]<SP>[measured value 1]<SP>[Status]<SP>[Serial no.]<SP>[SFKT]<SP>

[Address+1]<SP>[Measured value 2]<SP>[Status]<SP>[Serial no.]<SP>[SFKT]<SP>

<ETX><BCC1><BCC2>

[n]:	Number of variables
[Address]:	Device address set, 3 characters, leading zeros are transmitted
<SP>:	Space character

[Measured value]:	Indicated in μg/m^3, exponential representation with 4 characters mantissa and 2 characters exponent, each one with sign. Mantissa: sign followed by 4 numerical characters. The decimal point is located after the first two decimal characters and is not transmitted. Exponent: sign followed by 2 numerical characters, leading zeros are included in the transmission.
[Status]:	4 characters, operational and error status byte, each one being represented by two characters, formed like the BCC: operating status <SP> error status
[Serial no.]:	Number of manufacture to guarantee unique device identification
[SFKT]:	Special function, not used, six times the numerical character 0.

Note In the previous example, the indication is only in μg/m^3 if the transmitted variable is the Concentration. The user may select other variables for transmission through the Geystec Protocol menu. The variables which can be selected are:

Conc, Mass, Q-OP, Q-N, T1, T2, T4, RH, P1, P2, and P3

Significance of the operating status bits:

1. Standard: Operating and error status as described in the "Troubleshooting" chapter.

2. Compatible with FH 62 I-N:

    02 : Keyboard active

    04 : Filter change

Significance of the error status bits:

01 : Air flow disturbed

02 : Breach or end of the filter tape

04 : Detector error

08: Heater error

10: Any error occurred

<ETX>[BCC1][BCC2] is replaced by <CR><LF>, if the data inquiry has been terminated by <CR>.

Example: GEI (Bavaria/Hessia) protocol including the transmission of the number of black carbon and the concentration of black carbon:

Inquiry: <STX>DA<CR>

Response: <STX>MD03 001 +2578 +03 00 00 023 000000<SP>

↑ Address ↑ Conc ↑ Serial Number

002 +5681+00 00 00 023 000000<SP>

003 +1001+03 00 00 023 000000<CR>

Remote Control

The measuring instrument is controlled by the following protocol:

<STX>ST[Address]<SP>[Command]<ETX>[BCC1][BCC2]

Address: Device address, 3 characters, leading zeros may be replaced by <SP>.

The address may be also dropped. In this case, the first command character directly must follow the characters ST.

Command: All commands listed in this appendix are admissible commands to be applied. The response coming from the device, however, is sent without protocol. For this reason, no read commands should be used.

In case that the control command is accepted by the measuring instrument (the characters ST follow the <STX>, correct address, correct block check), then the command will be executed.

It is allowed to replace <ETX>[BCC1][BCC2] by <CR>.

How to form the block check character (BCC1, BCC2):

The BCCs are formed by simply building the exclusive OR operation byte-by-byte over all characters transmitted (incl. <STX>, <ETX>) (based on 00hex). The bit that results is sent as hexadecimal number with two ASCII characters.

Example:

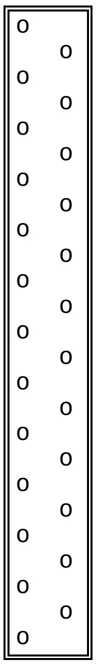
BCC binary: 01011010

Is transmitted by the ASCII characters: 5A

APPENDIX C

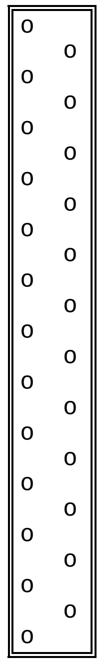
CONNECTOR AND BOARD SCHEMATICS

Female connector COM1



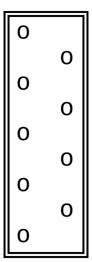
```
1   Shielding
14
2   TD
15
3   RD
16
4   RTS
17
5   CTS
18
6
19
7   GND
20
8
21
9
22
10
23
11
24
12
25
13
```

Female connector standard I/O



```
1   Relay 0 Make contact
14  Relay 0 Break contact
2   Relay 0 Center contact
15  Relay 1 Make contact
3   Relay 1 Break contact
16  Relay 1 Center contact
4   Relay 2 Make contact
17  Relay 2 Break contact
5   Relay 2 Center contact
18
6
19
7
20
8   Input for Telemeter OK (Japan Vers.)
21  GND for Telemeter OK   (Japan Vers.)
9  Input for Telemeter reset (Japan Ver.)
22 GND for Telemeter reset (Japan Ver.)
10
23
11
24
12  +20 mA Concentration
25
13  -20 mA Concentration
```

Female connector COM2



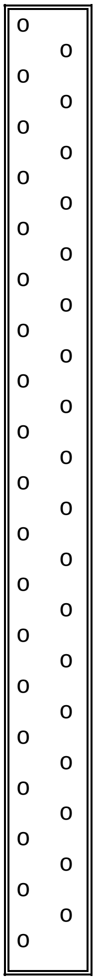
```
1
6  -12V
2   TD
7   CTS
3   RD
8  -12V
4
9
5   GND
```

Relay 0: Operating status
Relay 1: Limit value
Relay 2: Failure
Loading capacity of the contacts:
max 60V/ 0.5A
Rest: Relay picked-up

Analog outputs 0..10V:
Internal resistance : < 1 Ω
Maximum output current: 5 mA

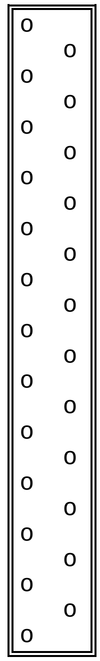
Analog outputs 0..20mA:
Maximum load: 500 Ω

Female connector standard I/O extension



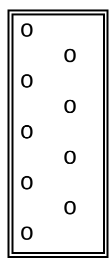
1 Relay 0 Make contact
20 Relay 0 Break contact
2 Relay 0 Center contact
21 Relay 1 Make contact
3 Relay 1 Break contact
22 Relay 1 Center contact
4 Relay 2 Make contact
23 Relay 2 Break contact
5 Relay 2 Center contact
24 Relay 3 Make contact
6 Relay 3 Break contact
25 Relay 3 Center contact
7 Relay 4 Make contact
26 Relay 4 Break contact
8 Relay 4 Center contact
27 Relay 5 Make contact
9 Relay 5 Break contact
28 Relay 5 Center contact
10
29 +IN 1
11 -IN 1
30 GND
12 +IN 2
31 -IN 2
13 GND
32 +IN 3
14 -IN 3
33 GND
15 +IN 4
34 -IN 4
16 GND
35
17
36 +20mA Mass
18 +20mA Concentration
37 -20mA Mass
19 -20mA Concentration

Female connector analog I/O



1 +15V
14 AIN1
2 -15V
15 EEPROM DO
3 AIN5
16 AIN6
4 AIN7
17 AIN8
5 EEPROM CS
18 GND
6 AIN2
19 GND
7 0..10V OUT C
20 AIN 3
8 SHIFT CLOCK (SK)
21 0..10V OUT A
9 AIN4
22 SER. OUT (DI)
10 0..10V OUT B
23 TRIM DAC LD
11 GND
24 0..10V OUT D
12 GND
25
13 GND

Female connector 4-20 mA



1 +20mA A (Air flow rate)
6 -20mA A (Air flow rate)
2 +20mA B (Temp. PM10-head)
7 -20mA B (Temp. PM10-head)
3 +20mA C (Channel 5)
8 -20mA C (Channel 5)
4 +20mA D (Channel 6)
9 -20mA D (Channel 6)
5

Female connector PUMP

```
o        1  GND
   o     6  +0..10V, Pump regulation
o        2
   o     7
o        3
   o     8
o        4
   o     9
o        5
```

Female connector SENSORS

```
o        1
   o     6
o        2
   o     7
o        3
   o     8  Sensor T1, Outside temp.
o        4  Sensor T1, Outside temp.
   o     9  Sensor T4, Heater temp.
o        5  Sensor T4, Heater temp.
```

Plug PUMP

Switched voltage output maximum 3 A

Pin No.	Designation
	protective conductor
3	switched voltage Pump
1	neutral conductor

Plug HEATER

Switched voltage output maximum 3 A

Pin No.	Designation
	protective conductor
2	switched voltage Heating
1	neutral conductor

MAIN BOARD

ANALOG OUTPUTS

Jumper	Connection	Standard Setting	Function
X10	Pin 3-4, 7-8 Pin 1-3, 7-8	X	Concentration (rear side) Current loop 0/4-20mA Voltage output: 0/2-10V

Flash-EEPROM programmable via serial interface COM 1 (Software Update)

Jumper	Connection	Standard Setting	Function
X30	Pin 1-2	X	Programming enabled
	Pin 2-4		Programming disabled

CPU active / disabled

Jumper	Connection	Standard Setting	Function
X31	Pin 1-2	X	CPU active
	Pin 2-4		CPU disabled
X33	Pin 1-3		CPU disabled
	Pin 2-4	X	CPU active

Battery for Save RAM Area

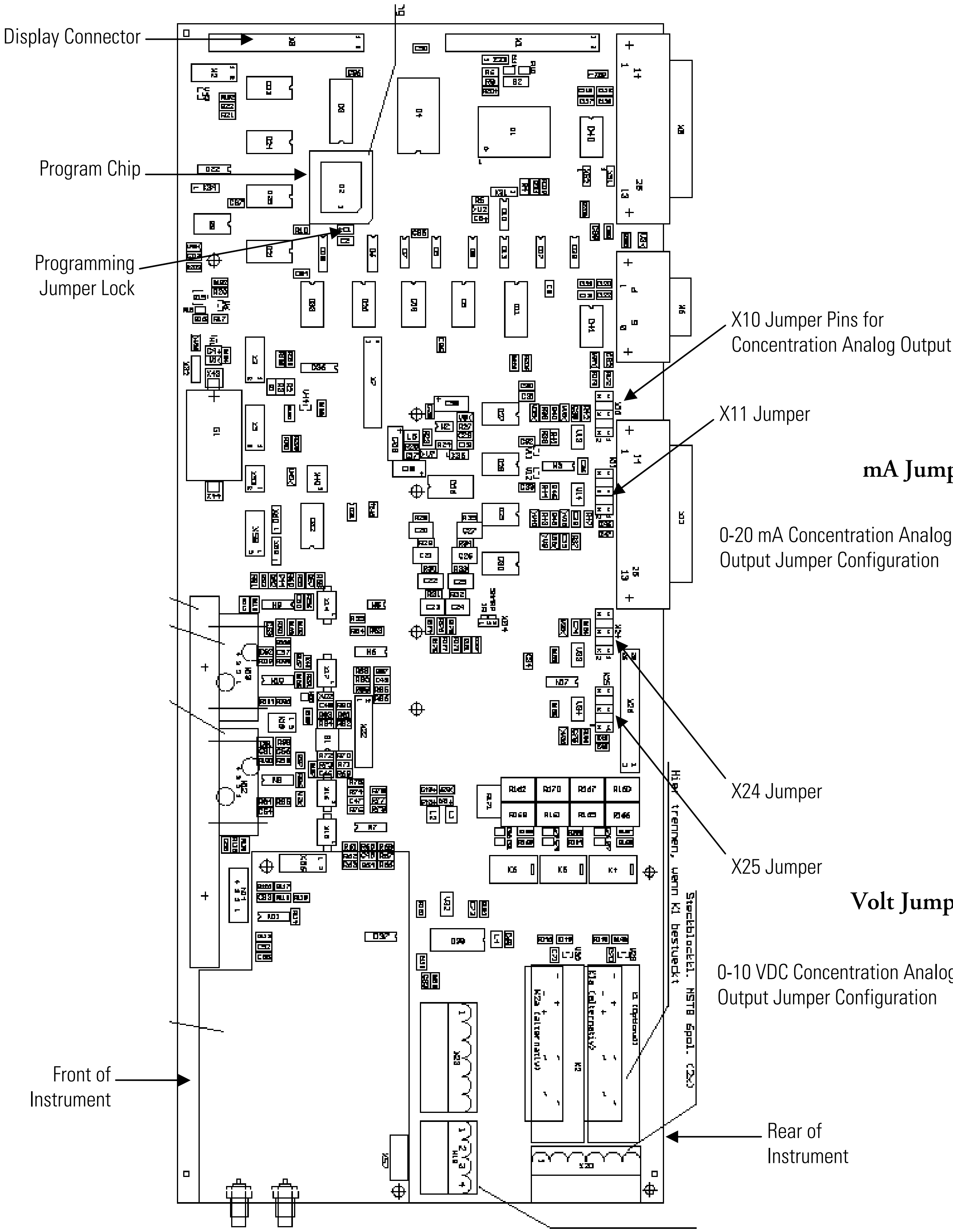
Jumper	Connection	Standard Setting	Function
X32	Pin 1-2Pin 2-3	X	Battery on
	Pin 1-2Pin 2-4		Battery off

Others

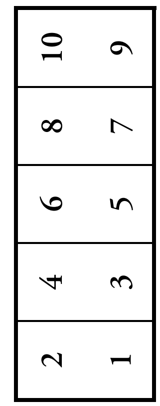
Jumper	Connection	Standard Setting	Function
X34	Pin 1-2	X	GND on I/O-Bus Bit 7
	Pin 2-4		+5V on I/O-Bus Bit 8
X35	-		test pin for ADC reference voltage

Switch		Standard etting	Sensor Type
S1/1 on	S1/2 off		T2: KTY 10
S1/1 off	S1/2 on	X	T2: PT 100
S1/3 on	S1/4 off	FH 62-1	T3: KTY 10
S1/3 off	S1/4 on	FH 62 I-R	T3: PT 100

Model 5030 Main Circuit Board

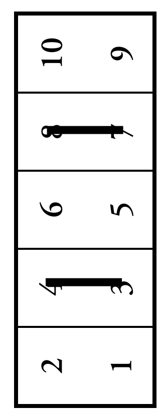


Pin No.



mA Jumper Configuration

0-20 mA Concentration Analog Output Jumper Configuration



Volt Jumper Configuration

0-10 VDC Concentration Analog Output Jumper Configuration