

E-FRM-DC REFERENCE METHOD PARTICULATE SAMPLER OPERATION MANUAL

E-FRM-DC-9800, REV C



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1 INTRODUCTION

1.1 About This Manual

This document is organized with the most important information toward the front of the manual. All users should read and understand the sections on setup, operation, and field audits. Toward the back are sections that provide in-depth information on subjects such as diagnostics and accessories. These sections should be consulted as needed.

This manual is periodically revised for maximum accuracy and to incorporate new features or updates. User feedback is welcome. Electronic versions of this manual are available upon request.

1.2 Technical Service

Should you require support, please consult your printed documentation or our website www.metone.com to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours;

7:00 a.m. to 4:00 p.m. Pacific Time, Monday through Friday.

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In addition, technical information and service bulletins are often posted on our website. Please contact us and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows us to track and schedule service work and to expedite customer service. Please have the instrument serial number available when contacting the manufacturer. On most models manufactured by Met One Instruments, it will be located on a silver product label on the unit, and printed on the calibration certificate. The serial number will begin with a letter and be followed by a unique five digit number such as U15915.

1.3 E-FRM-DC: Environmental Federal Reference Method Sampler



Figure 1-1 E-FRM-DC Air Sampler

The Met One Instruments, Inc. Model E-FRM-DC is a programmable single-event filter sampler designed to meet federal specifications as a reference method for the determination of daily PM_{2.5} or PM₁₀ particulate concentrations in ambient air.

It employs a single pre-weighed 47 mm sample filter disc in an EPA-standardized cassette which must be manually exchanged by the operator prior to each sample period. The instrument runs a sample period based on an operator programmed start time and sample duration.

A vacuum pump, controlled to 16.67 liters-per-minute, draws ambient air through a series of standardized inlets that provide the PM_{2.5} or PM₁₀ cut points. The sample then passes through the filter, where the airborne particulate matter is deposited.

The dirty filter is collected after the sample period and sent to a lab to be equilibrated and reweighed per the standardized EPA gravimetric procedures. The resulting clean and dirty mass values for the filter are then correlated to the volume of air sampled to determine the concentration of particulate in micrograms-per-cubic-meter ($\mu\text{g}/\text{m}^3$)

The E-FRM-DC can easily be configured for reference method PM_{2.5} sampling using the standardized BGI VSCC™ very-sharp-cut cyclone or the classic WINS Impactor.

Alternatively, other sharp-cut cyclones can be installed for non-designated or indicative PM_{2.5} or PM₁ sampling.

If PM₁₀ monitoring is desired, the PM_{2.5} cyclones can be omitted entirely, and a pass-through adapter can be installed in its place.

1.3.1 E-FRM-DC U.S. EPA Configurations

The E-FRM-DC is US-EPA designated under the following designation numbers:

- RFPS-0315-221: PM_{2.5} designation
- RFPS-0216-231: PM₁₀ designation
- RFPS-0316-232: PM_{10-2.5} designation

US-EPA designated methods using the E-FRM-DC are modified occasionally to reflect hardware or software improvements. These modifications do not impact previously designated configurations of the E-FRM-DC but may provide the end user with a product upgrade path that will allow the monitor to continue to be operated as a US-EPA designated method. For further details, please contact our service department. Details concerning USEPA designated configurations of the E-FRM-DC may be found on the US-EPA website.

1.4 Model E-FRM-DC Specifications

PARAMETER	SPECIFICATION
Measurement Principle:	Programmable-event filter sampler for determination of particulate matter concentrations
Resulting Data Units:	Micrograms per actual or standard cubic meter $\mu\text{g}/\text{m}^3$. Calculated from lab filter weights and actual or standard sampled volumes.
Design Specifications:	Title 40 CFR, Part 50 Appendix L
U.S. EPA Designations:	RFPS-0315-221, RFPS-0216-231, RFPS-0316-232
Main Inlet Type:	EPA-pattern PM_{10} size-selective louvered inlet standard (MOI part no. BX-802)
$\text{PM}_{2.5}$ Separator Type:	Options: BX-808 Very Sharp Cut Cyclone or BX-804 WINS Impactor
PM_{10} Sampling Config:	Pass-through tube (used in place of cyclone) included for PM_{10} sampling.
Other Configurations:	Compatible with $\text{PM}_{2.5}$ or PM_1 SCC cyclones. TSP inlet available.
Filter Type:	47mm PTFE disc filters standard. Other filter material types available.
Filter Holder:	Accommodates standard EPA-pattern white Delrin filter cassettes.
Filter Temp Control:	Filter Temp within 5°C of ambient during sampling and standby. Logged in data.
Operating Temperature:	-30 to $+50^\circ\text{C}$ Ambient
Operating Pressure:	400 to 800 mmHg, Ambient
Sample Events:	24 hour samples standard. Programmable start date/time and duration.
Flow Rate:	16.67 L/min ($1 \text{ m}^3/\text{hr.}$). With flow sensor and real-time actual flow control.
Flow Accuracy:	$\pm 2\%$ ($\pm 0.33 \text{ L/min}$)
Flow Records:	Flow rate, temperature, pressure logged in 5 minute intervals.
Vacuum Pump:	Single-head diaphragm 12 VDC pump
Upper Concentration Limit:	At least $200 \mu\text{g}/\text{m}^3$ estimated for daily average.*
Data Collection:	RS-232 port (9-pin). USB data port. USB flash drive port. Software supplied.
Memory Capacity:	24 sample events
Compatible Software:	FSCommaAQ
User Interface:	4.3" graphical touch screen
Enclosure Type:	Active fan ventilation
Deployed Dimensions:	2.0 meters (78.75") high, 65.5 cm (25.75") wide, 64.1 cm (25.25") deep
Footprint Dimensions	65.5 cm (25.75") wide, 64.1 cm (25.25") deep
Weight:	Sampler 33 lb (except PM_{10} inlet head); Stand 10.5 lb
External Power Supply:	Input: 100-240VAC, 50/60Hz, 1.4A; Output: 12VDC, 8.5A (102W) Maximum
E-FRM-DC Power:	12VDC @ 2.75A (33W) Maximum

* The approximate upper concentration limit is based on the sampler's ability to maintain 16.67 L/min sample flow over the entire 24 hour period, despite PTFE filter loading with typical urban $\text{PM}_{2.5}$ particulate. Actual concentration limits will vary depending on ambient conditions, altitude, and particulate type.

Specifications may be subject to change without notice.

2 SITE SELECTION and POSITIONING CRITERIA

Selection of a proper site for the sampler is critical for accurate measurements. These items must be correctly addressed in order for the collected data to be acceptable for regulatory requirements, such as US-EPA PM₁₀ or PM_{2.5} data reporting.

Specifications for site selection and inlet positioning for samplers operated as US-EPA designated reference methods for PM_{2.5} or PM₁₀ can be found in United States regulation **40 CFR, Part 58, Appendix D and E**. There are also a variety of EPA guidance documents and quality assurance documents which describe site criteria in detail. In any case, the Code of Federal Regulations takes precedence. The operator is encouraged to contact local environmental authorities for information concerning local regulations if the E-FRM-DC is to be operated outside of the United States.

Note: The sampler location may consist of an elevated site such as a flat rooftop, the top of a walk-in lab shelter, or an elevated platform. The location may also be at or near ground level on a concrete pad or a simple wooden platform. In any case, the location must be level and easily accessible for routine service and filter replacement. Locating the sampler stand directly on the soil is not usually recommended, due to possible intrusion of dirt, insects, and vegetative growth.

Inlet Height Criteria:

- The sampler total inlet height must be located in the “breathing zone”, between 2 and 15 meters above ground level for neighborhood scale sites. Middle scale or microscale sites require a total inlet height of between 2 and 7 meters.
- If the unit is to be installed on ground level, then the inlet height must be at least two meters above the ground. The sampler stand and enclosure are designed to locate the inlet two meters above whatever surface the unit is placed on.
- If the unit is located on the roof of a building, the inlet height must be no less than two meters above roof surface of the building. The total height must be no more than 15 meters above ground level.
- If the sampler is to be collocated with other particulate instruments, such as BAM units or other samplers or monitors, then the air inlets must all be the same height within one meter vertically. Met One Instruments recommends a tighter tolerance of within 30cm (1 foot).
- If the sampler inlet is the highest metallic point on a building, then a lightning rod must be installed to prevent destruction of the sampler during electrical storms.

Inlet Spacing and Clearance Criteria:

- If the sampler is to be collocated with another instrument, such as a BAM-1020 or other sampler or monitor, then the inlets must be spaced between one and four meters apart.
- If installed near a PM₁₀ high-volume sampler, then the distance between the inlet of the sampler and the Hi-Vol should be no less than three meters.
- The sampler inlet must be unobstructed for two meters in all directions from any object that may influence airflow characteristics, such as walls, parapets, or structures on a rooftop.
- If located beside a major obstruction (such as a building), then the distance between the inlet and the building should be equal to twice the height of the building.

- There must be at least a 180 degree arc of completely unrestricted airflow around the sampler inlet. The predominant wind direction during the highest concentration season must be included in the 180 degree arc.
- The sampler inlet must be at least 10 meters from the drip line of any trees.

Artificial Particulate Sources:

To avoid possible errors in the concentration measurements, the inlet must be located as far as possible from any artificial sources of particulate, such as blowers or vents on a rooftop. Even sources of filtered air must not blow across the sampler inlet.

Spacing from Roadways:

Except for microscale studies or purposeful near-road studies, the sampler should usually not be located directly next to a major highway or arterial roadway, as vehicle exhaust will dominate the concentration measurement. Criteria for roadway spacing of particulate monitors can be complicated. See 40 CFR Part 58 - Appendix E, section 6.3 (July 2009).

- For general neighborhood scale monitoring, the sampler should be at least 10 meters away from a road with a daily traffic volume of less than 1,000 vehicles, at least 30 meters from a road with a volume of 20,000 vehicles, at least 100 meters from a road with a volume of 70,000 vehicles, and at least 250 meters from a road with a volume of greater than 110,000 vehicles.
- The unit should be located as far as possible from unpaved roadways, as these also cause artificial measurements from temporarily suspended fugitive dust.
- The unit should usually not be installed in unpaved areas unless year-round vegetative ground cover is present, to avoid the effects of re-entrained fugitive dust.

3 SETUP

Use the following information to correctly assemble, configure, and deploy the E-FRM-DC sampler. Installation of the sampler should ideally be performed by personnel familiar with environmental monitoring equipment. There are no special precautions or handling concerns except for the normal level of care required for handling scientific equipment. Refer to the instructions and diagrams on the following pages.

3.1 Unpacking

Unpack the mass monitor and accessories and compare them to the packing list to make sure all items are present.

Any damage incurred to the equipment during shipping are the responsibility of the carrier. If any damage to the shipment is noticed before unpacking, **a claim must be filed with the commercial carrier immediately**. Follow any special unpacking instructions provided by the carrier as all items are carefully removed from the containers and each component inspected. It is recommended to document and photograph all damaged packages and items before, during, and after unpacking them. Contact Met One Instruments (see section 1.2 of this manual) to arrange for any replacement items needed.

The normal PM₁₀ configuration of the instrument is supplied with the following standard accessories:

- One (1) E-FRM-DC Stand (82537-2)
- One (1) PM₁₀ Inlet (BX-802)
- One (1) 12VDC Power Supply Assembly (83249)
- One (1) Ground Cable (9035)
- One (1) Sample Inlet Down Tube (83178)
- One (1) Ambient Temperature Sensor (80866-1) With Solar Shield (820471)
- One (1) PM₁₀ Measurement Pass-Through Adapter Tube (81210)
- One (1) RS-232 Serial Communication Cable (82459)
- One (1) USB Extension Cable, Type A-B Male (500784)
- One (1) 47 mm Filter Cassette (460128)
- One (1) 47 mm PM_{2.5} PTFE Filter (460122)
- One (1) Set of Leak Test Cassettes (External 82607-1, Internal 82607)
- One (1) Flow Audit Adapter with Leak Test Valve (BX-305)
- One (1) FSCommAQ Data Acquisition Software (82530)
- One (1) Operating Manual

Note that the PM₁₀ pass-through adapter tube (81210) is installed inside the E-FRM-DC Sampler when purchased in the PM₁₀ configuration.

The following optional accessories may be purchased separately:

- BX-808 Very Sharp Cut PM_{2.5} cyclone.
- BX-804 WINS Impactor
- Non-reference cyclones for PM_{2.5} or PM₁ cut-points.
- BX-803 TSP (Total Suspended Particulate) Sampling Inlet
- Additional 47 mm filter cassettes or filters.

All special shipping items (box, foam packing material, etc.) used to ship the E-FRM-DC should be retained. They should be re-used if the sampler is to be transported (changing site locations, returning to the factory, etc.). Contact Met One Instruments (see section 1.2 of this manual) for replacement packing materials if necessary.

3.2 Electrical Service

The E-FRM-DC sampler uses a 12 VDC power supply which can be supplied with 115-230 VAC input power. The sampler is rated at 33 Watt max. continuous with the pump running.

The sample site needs to be equipped with AC power and a standard weatherproof outdoor electrical outlet. An earth-ground point near the unit is recommended.

An 8A replaceable power fuse is contained within the electronics enclosure.

For critical applications where possible sample invalidations due to power failures are unacceptable, the sampler should be equipped with a backup uninterruptible power supply (UPS). The supply must be rated for the electrical load and must be appropriately configured for an outdoor application. Consult a qualified electrical contractor.

3.3 Instrument Assembly and Deployment

The E-FRM-DC sampler is designed for easy setup and deployment. This allows it to be used for either permanent long-term sampling at a fixed site or for portable audit sampling for temporary applications.



Figure 3-1 E-FRM-DC Front View with Door Closed and Opened

Once the desired sample location is determined, the following steps should be performed to properly configure the E-FRM-DC.

3.3.1 Assemble the E-FRM-DC Stand

The E-FRM-DC stand consists of nine primary components and the associated fasteners. There is one top plate, four legs, and two each long and short support bars. It has an overall height of 29 inches when assembled. This is the same approximate height of a typical table or desk.

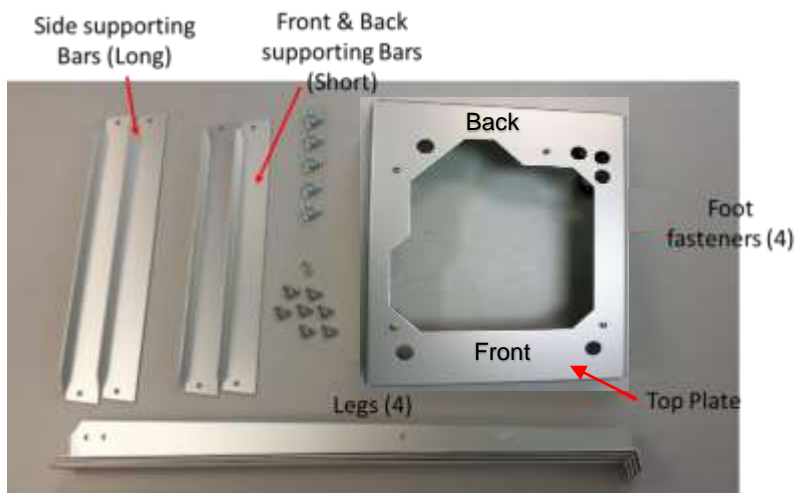


Figure 3-2 E-FRM-DC Sampler Stand Components

Assemble the stand as follows:

1. Place the top plate upside down (flat side down) on a flat surface.
2. Place one leg on the outside of each corner (see Figure 3-3) and loosely secure with the provided fasteners.
3. Place the short front and back support bars in position and fasten to the legs. Note the sampler mounting holes are offset toward the front of the stand.
4. Place the long side support bars in position and fasten to the legs.
5. Tighten all fasteners.
6. Turn the stand over to the upright position. Verify all fasteners are fully secured and tight. Confirm all four of the captive foot fasteners are present (see Figure 3-2).



Figure 3-3 E-FRM-DC Sampler Stand Final Assembly

3.3.2 Install E-FRM-DC sampler on top of Stand

Place the E-FRM-DC sampler onto the stand. The feet on the bottom of the sampler should line up with the holes in the top of the stand. Use the four captive foot fasteners to secure the sampler to the stand by screwing them in to the sampler feet as shown in Figure 3-4.

Fasten Down the Stand: For long-term deployments, the E-FRM sampler stand must be fastened down to the mounting surface in order to prevent wind-toppling, theft, or unauthorized repositioning. This is especially critical if the sampler is located on a platform, rooftop, or another elevated surface. The holes in the base may be utilized to accommodate lag bolts or anchor bolts.



Figure 3-4 Securing the E-FRM-DC Sampler to the Stand

3.3.3 Installing the Ambient Temperature Sensor

On the exterior rear wall of the sampler enclosure, remove the two sets screws and washers in the upper right hand corner. Align the ambient temperature (AT) sensor mounting holes with the mounting holes in the enclosure (see Figure 3-5) and reinstall the screws and washers to secure the probe in place. See section 3.3.7 for cable connection details.



Figure 3-5 Ambient Temperature Sensor Assembly Mounting

3.3.4 Installing Inlet Down Tube and BX-802 PM₁₀ Inlet Head

Loosen the black watertight fitting on the inlet tube receiver located on top of the E-FRM-DC sampler. Slide the sample inlet down tube through the fitting and down into the inlet tube receiver. Press down firmly and be certain the tube snaps into the O-ring socket securely, then tighten the black plastic fitting.

Place the BX-802 PM₁₀ inlet on top of the inlet down tube. Press or pull down on the BX-802 and ensure it is fully seated on the tube.



Figure 3-6 Installation of the PM₁₀ Inlet

Note: The PM₁₀ inlet is used most configurations of the E-FRM-DC sampler. It serves as a pre-separator for subsequent PM_{2.5} stages when using either one of the PM_{2.5} cyclone separators or the WINS impactor. It is not used when the E-FRM-DC is configured for TSP sampling.

3.3.5 Configure the Internal Size Selection Hardware

Sampled air enters the E-FRM-DC Sampler through the PM₁₀ inlet head (see section 3.3.4) unless the sampler is being used to sample TSP. In order to monitor PM_{2.5} particulate (or other non-designated or indicative PM_{2.5} or PM₁ sampling), the sample air must pass through an additional separator.

3.3.5.1 Configuration for PM_{2.5} Particulate

To configure sampler for PM₁₀ particulate collection, see section 3.3.5.2.

When using the sampler to monitor PM_{2.5}, the PM_{2.5} cyclone is mounted inside the enclosure. The BX-808 cyclonic separator can be purchased separately for this purpose. Initially, the cyclone will need to be installed as shown in Figure 3-7 by performing the following steps:



Figure 3-7 Installation of the PM_{2.5} Cyclonic Separator

1. Insert the BX-808 into the socket in the roof of the sampler as shown in Figure 3-7 on the far left. Press up firmly to fully seat the cyclone.
2. Pull the filter release handle all the way forward to provide as much space between the lower filter holder and the BX-808 as possible. Install the upper filter holder by inserting it into the bottom of the BX-808. See the center image in Figure 3-7.
3. Press firmly upward on the upper filter holder to fully seat the holder into the BX-808. When properly installed, the BX-808 and the upper filter holder should appear as shown in the far right image of Figure 3-7.



Caution: Do **NOT** try to push the handle back and use the lower filter holder to push the upper filter holder into position. This can damage both holders, their sealing gaskets, and possibly the handle operating mechanism.

Note: The WINS Impactor may be exchanged for a PM_{2.5} cyclone when configuring the sampler for PM_{2.5} sampling. It is installed in the same manner as the BX-808.

3.3.5.2 Configuration for PM₁₀ Sampling

To configure sampler for PM_{2.5} particulate collection, see section 3.3.5.1.

When sampling PM₁₀, the PM₁₀ pass-through adapter is mounted on the sampling station receiver inside the enclosure. The pass-through adapter can be installed by performing the following steps:



Figure 3-8 Installation of the PM₁₀ Pass-Through Adapter


1. If installed, remove the PM_{2.5} accessories by reversing the installation steps found in section 3.3.5.1.
2. Insert the pass-through adapter into the socket in the roof of the sampler as shown in Figure 3-8 on the far left. Press up firmly to fully seat the adapter.
3. Pull the filter release handle all the way forward to provide as much space between the lower filter holder and the pass-through adapter as possible. Install the upper filter holder by inserting it into the bottom of the pass-through adapter. See the center image in Figure 3-8.
4. Press firmly upward on the upper filter holder to fully seat the holder into the pass-through adapter. When properly installed, the adapter and the upper filter holder should appear as shown in the far right image of Figure 3-8.



Caution: Do **NOT** try to push the handle back and use the lower filter holder to push the upper filter holder into position. This can damage both holders, their sealing gaskets, and possibly the handle operating mechanism.

3.3.6 Power Supply Installation

The E-FRM-DC sampler is powered by a 12 VDC power supply mounted on the back of the enclosure.

 **Caution:** *Cabling should be inspected before deployment to verify the cable integrity. Replace the power supply or the AC power cable if the cable is damaged. Failure to do so is unsafe and may result in electric shock and equipment damage!*

On the external rear wall of the enclosure, position the power supply assembly over the three mounting holes (two at top, one at bottom-right) as shown in Figure 3-9. Mount the power supply using the hardware provided. See section 3.3.7 for cable connection details.



Figure 3-9 Securing the Power Supply Case

3.3.7 Power, Sensor, and Communication Connections

The 12 VDC power and ambient temperature sensor cables (in addition to all communication cables) connect to the E-FRM-DC sampler inside the enclosure as shown in Figure 3-11.

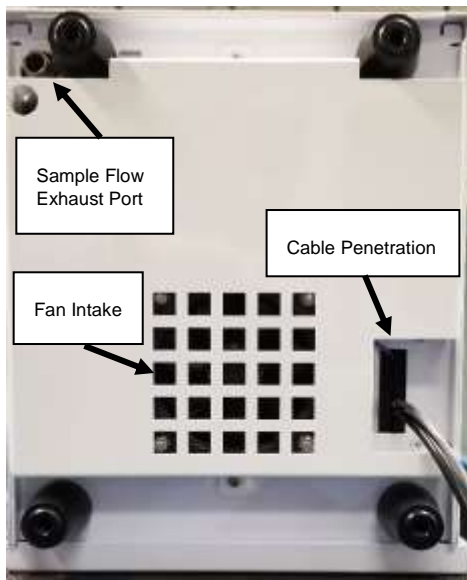


Figure 3-10 Bottom of E-FRM-DC Enclosure

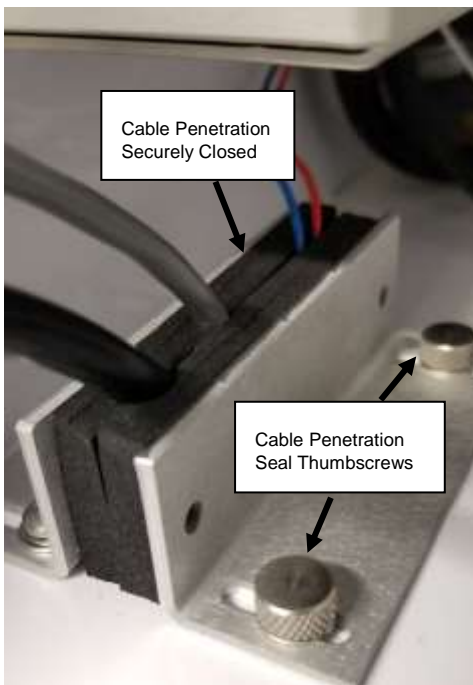



Figure 3-12 Cable Penetration Seal



Figure 3-11 Cable Connections

Attach the cables by performing the following steps:

 **Caution:** Connect the 12 VDC Power Connector before connecting the AC power cable to a live electrical source!

1. Locate the cable penetration seal on the inside floor of the enclosure. See Figure 3-12.
2. Loosen and remove the two thumbscrews closest to the fan intake (see Figure 3-12) and remove the associated seal half.

3. From beneath the enclosure, insert the power and sensor cables up through the seal and into the enclosure.
4. Inside the enclosure, connect the 12 VDC power cable connector as shown in Figure 3-11.
5. Connect the ambient temperature (AT) sensor cable connector, also as shown in Figure 3-11.
6. If the USB or optional RS-232 serial cables are to be permanently installed, route the cables through the seal and connect them to the appropriate connector (see Figure 3-11).
7. To ensure that the filter release handle motion will not be obstructed by the cabling, route all cables through the penetration with minimal excess cable inside the enclosure.
8. Inside the enclosure, reinstall the cable penetration seal half and loosely install the thumbscrews to hold it in place. Slide the seal half securely against the other seal half and tighten the thumbscrews (see Figure 3-12).
9. Verify all connectors are secure and all exhaust vents are clear of obstructions.
10. If it is desired to reduce noise from the pump, insert a 1m length of flexible 3/8" O.D. tubing into the sample flow exhaust port (see Figure 3-10 for port location)

The sampler is now ready to be connected to a reliable AC power source using the provided AC power connector of the Power Supply Assembly.



Warning! Electrical service must be properly configured for outdoor use with the correct voltage and frequency in accordance with local electrical codes. Consult a qualified electrician if unsure.

3.3.8 Dust Filter Removal and Installation

The E-FRM-DC Sampler enclosure is cooled by drawing ambient air up through the bottom of the enclosure. This cool air passes over the internal components and is then exhausted out of the rear wall near the top of the enclosure. A cooling fan draws cool air up into the enclosure and forces the warm air out of the rear wall exhaust vent. Note: The cooling fan is activated when the Filter Temperature (FT) sensor inside the enclosure measures greater than 2°C above the external Ambient Temperature (AT) sensor measurement.

To keep the housing interior as clean as possible, the incoming air passes through a filter located above the fan. The filter can be cleaned with water and reused a maximum of five times. Ensure the filter is completely dry before reinstalling it in the sampler.



Figure 3-13 Dust Filter Installation

To remove and install a new or cleaned dust filter, refer to Figure 3-13 and follow these steps:

1. The filter holder is held in place on top of the fan by a small catch on each of the four sides. Lifting from one corner of the filter holder will allow for removal of the filter holder.
2. Remove the dirty dust filter from the filter holder and wipe off any residual dust.
3. Using canned air, blow off any dust on the fan housing and blades by blowing down through the fan from inside the enclosure. This will prevent dust from being forced inside the sampler.
4. Place a clean dust filter into the filter holder.
5. Position the filter holder back in place over the fan and gently engage the four catches.

3.4 Configurations for PM_{2.5} or Other Particulate Cut-Points

It is critical for the user to understand and keep track of the exact inlet hardware configuration, in order to ensure that the resulting concentration data is identified for the correct PM classification! The sampler cannot automatically identify the inlet cut-point configuration. The inlet configuration type should be selected to match the physical setup hardware by the operator through the user interface. This setting will appear in the data files for quality assurance purposes. See section 5.

All standard configurations of the sampler use a standard louvered PM₁₀ size-selective inlet (Met One Instruments part number BX-802) as the main air inlet for the system. This inlet separates out and traps water, debris, and particles larger than 10 microns in size, while allowing smaller particles through to the sampler. For PM_{2.5} sampling, the PM₁₀ inlet serves as a particulate pre-separator for the secondary cyclone or impactor stage inside the sampler. For PM₁₀ sampling, a pass-through adapter (Met One Instruments part number 81210) is installed in place of a PM_{2.5} separator to allow the particulate directly through to the filter.

The sampler is configured for PM_{2.5} sampling by using an internal VSCC™ (Very-Sharp-Cut Cyclone, Met One Instruments part number BX-808) to further separate out and trap particles larger than 2.5 microns in size, while allowing smaller particles through to the sample filter. The particle performance of these cyclones closely matches that of the classic WINS Impactor, but with simpler maintenance requirements. The VSCC™ cyclone is manufactured by BGI, Inc. as a condition of the EPA designated status of the cyclones. See www.bgiusa.com for details.

The classic WINS Impactor, built to 40 CFR Part 50L specifications, is the predecessor to the BGI cyclones for designated PM_{2.5} sampling, and is available from Met One Instruments (part number BX-804) upon request. It fits into the same position as the BX-808 inside the sampler.

The cyclone position can accommodate an older style SCC (Sharp-Cut-Cyclone, Met One Instruments part number BX-807) for less common PM_{2.5} sampling applications where a lower cost system is needed, and EPA designation is not required for the resulting data. The SCC cyclone is very similar to the VSCC™ cyclone but is not designated as a Federal Reference Method for PM_{2.5}.

The cyclone position can also accommodate a version of the SCC Sharp-Cut-Cyclone for PM₁ sampling (Met One Instruments part number BX-811). This separates out particles larger than 1 micron in size. This configuration is not very common because PM₁ sampling is not currently regulated or designated by the EPA.

4 USER INTERFACE and MENU SYSTEM

This section describes the E-FRM-DC user interface system, and describes the functions of the main menu options, including how to view data and errors.

E-FRM-DC		2019-11-01 15:00:44
Filter ID	MOI INDOOR	
Status	Sampling	
Remaining	08:59:16	
Sample Duration	00:00:28	
Sample Start	2019-11-01 15:00:15	
Sample Stop	2019-11-02 00:00:00	
⏪ ⏩ ⏴		

Figure 4-1 The E-FRM-DC Main Operating Screen

4.1 The User Interface – Touchscreen Display Functions

The E-FRM-DC user interface is a touchscreen display used to control almost all the features and functionality of the sampler. It is mounted inside the enclosure and is only accessible when the front door of the E-FRM-DC is open.

4.2 Main Operating Screens

The main operating screen is designed to provide the current status of the sampler and any programmed events. Additionally, if there is no event programmed, a shortcut to the Event Manager will be presented. The left hand image shown in Figure 4-2 will normally be displayed at startup while the right hand image shows a typical main screen while waiting for a programmed event to begin. Note that it provides indication of the ID of the filter being used for the sample, the start and stop times of that sample, and the current status.

E-FRM-DC		2017-10-07 03:11:34
> Event Manager		
Status	Stopped	

E-FRM-DC		2017-10-07 03:17:43
Filter ID	8675309	
Status	Waiting	
Sample Start	2017-10-08 00:00:00	
Sample Stop	2017-10-09 00:00:00	

Figure 4-2 The E-FRM-DC Main Screen

Note that once an event is pending or in progress the Event Manager shortcut is no longer available on this screen. To access the event manager when the shortcut is not present, go to the Operate Menu (see section 4.4).

Table 4-1 describes the real-time fields displayed on the main operating screen:

Parameter	Description
Filter ID	Designated ID of the filter cassette for the sample event
Status	Current operation such as sampling, waiting, stopped, etc.
Sample Start	The start time of the sample in the following format: YYYY-MM-DD HH:MM:SS
Sample Stop	The stop time of the sample in the following format: YYYY-MM-DD HH:MM:SS

Table 4-1 Main Display Parameter Descriptions

See section 5 for more details about programming sample events.

4.3 Menu Hierarchy and Navigation

The E-FRM-DC menu structure is outlined in the following table.

Main Menu	Sub Menu Options	Overview
Operate See section 4.4	Pause/Stop Sample Event Manager Transfer Data USB Import About	Cancel the current sampling event (not always visible) Configure upcoming sample events Download stored data to a USB memory stick Upload preconfigured events from USB memory stick Displays the serial number, current firmware type and version number
Test See section 4.5	Temp Calibrate Pres Calibrate Flow Calibrate Leak Test Parameters Box Fan	Calibrate temperature sensors or restore default settings Calibrate pressure sensors or restore default settings Calibrate flow rate or restore default settings Perform the leak check View current real-time sensor values Manually start and stop the cooling fan
Setup See section 4.6	Event Defaults Standard Temp Sound Volume Touch Calibrate Clear Memory Set Clock Unit ID Password Serial Port	Set the default values for the Event Manager Set the standard temperature value Adjust the volume of the touchscreen sounds Calibrate the touch screen Clear all stored data and alarm logs Set the date and time Set or change the numerical ID of the sampler Change or disable the master password Set the baud rates for serial communications
Alarms See section 4.7	No sub menu	View alarms

Table 4-2 E-FRM-DC Menu Hierarchy

Menu selections and instructions are detailed in the following sections of this operating manual as assigned in the Main Menu column of Table 4-2 above.

To access the various main menus, press the three horizontal lines in the top left corner. A drop down menu will appear (Figure 4-3) to allow selection of any of the four main menus. This option is available on all main menu screens (such as the Setup Menu shown in Figure 4-4) and on the main operating screen.



Figure 4-3 Main Menu Drop Down Selections

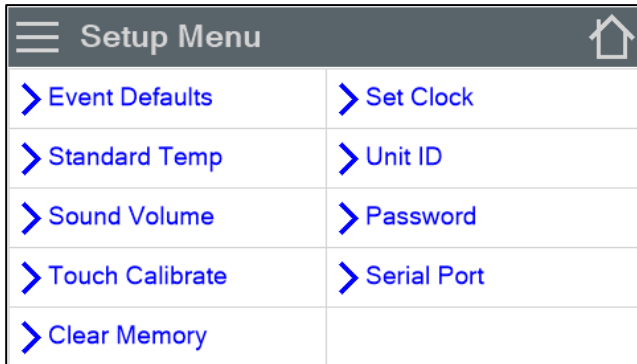


Figure 4-4 Setup Menu

To return to the main operating screen (see section 4.2), press the Home icon located in the upper right corner of all main menu screens. This icon can be seen in the Setup Menu image shown here in Figure 4-4.

To cancel an action and return to the previous menu screen, press the X icon located in the upper right corner of all sub menu screens. This icon can be seen in the Clock Setup screen image shown in Figure 4-5.



Figure 4-5 Clock Setup Screen

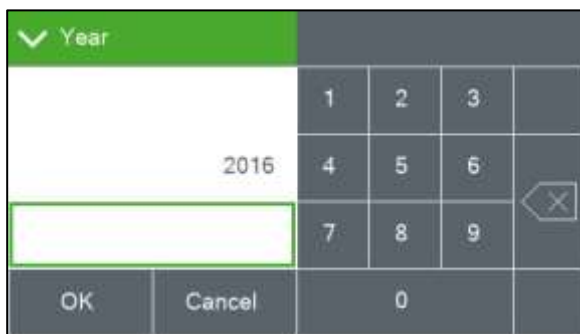


Figure 4-6 Visual Keypad for Numeric Entry

Some parameters, such as the Date and Time settings (Figure 4-5) or a Unit ID value, require numeric entry. When a button to edit such a field is pressed, a visual keypad (Figure 4-6) will be displayed allowing users to input the value. Press the OK key to accept the changes or the Cancel key to return to the previous screen. The X key on the far right performs a backspace operation.

Other parameters, such as the filter cassette ID value, may require alphabetical entry along with numerical values. When a button to edit such a field is pressed, a visual alphanumeric keypad (Figure 4-7) will be displayed allowing users to input the value. Press the OK key to accept the changes or the Cancel key to return to the previous screen. The X key in the lower right performs a backspace operation.



Figure 4-7 Keypad for Alphanumeric Entry

The ABC key, in the lower right hand corner, performs the function of a SHIFT key. It toggles between upper and lower case letters and allows the numbers across the top to switch to special characters such as the dollar sign, asterisk, or ampersand.

4.4 Operate Menu

The Operate Menu is the doorway to the most commonly used areas for normal operation of the E-FRM-DC. Note that the appearance of the menu changes slightly when a sample event is in progress, as shown in the right hand image of Figure 4-8.

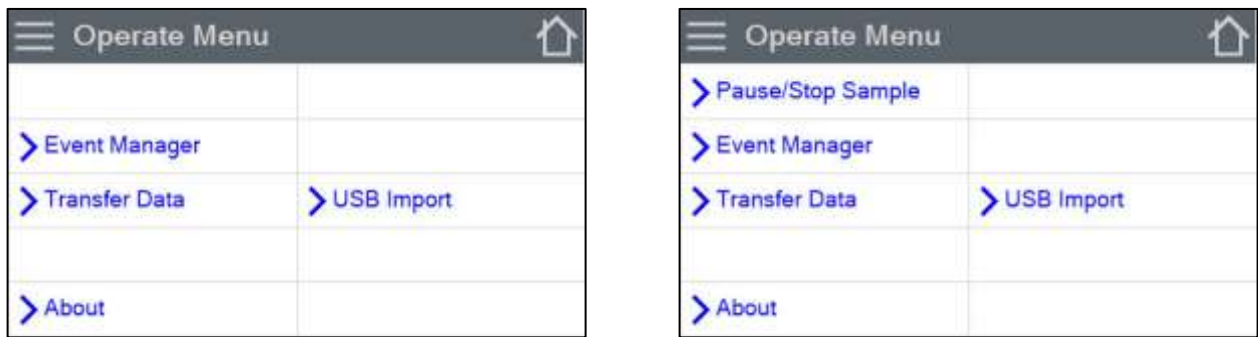


Figure 4-8 The Operate Menu

4.4.1 Pause/Stop Sample

If it is necessary to interrupt or halt sampling, the Pause/Stop Sample button should be used. Press the key and the selection screen shown on the far left of Figure 4-9 will appear. Use the grey PAUSE button to temporarily suspend the current sample but be able to resume normal operations when maintenance or testing is complete. Use the grey STOP button if it is necessary to completely cease operations and delete all subsequent events.



Figure 4-9 Pause Sample Sequence

Once either PAUSE or STOP is chosen, the current sample will immediately cease. If necessary, the current filter cassette may be removed and stored in a container during maintenance until ready to resume sampling. See Figure 4-9 for an example of the full sequence.

If an event is paused, all programmed sampling events, including the one that was interrupted, may be resumed if there is still time remaining in the interrupted event itself. The filter cassette must be reinstalled before sampling is resumed.

To resume operations, return to the Operate Menu and press the Resume Sample option as shown in Figure 4-10. Verify the filter cassette is in place and press the grey RESUME button. The sample event schedule will now proceed as programmed.

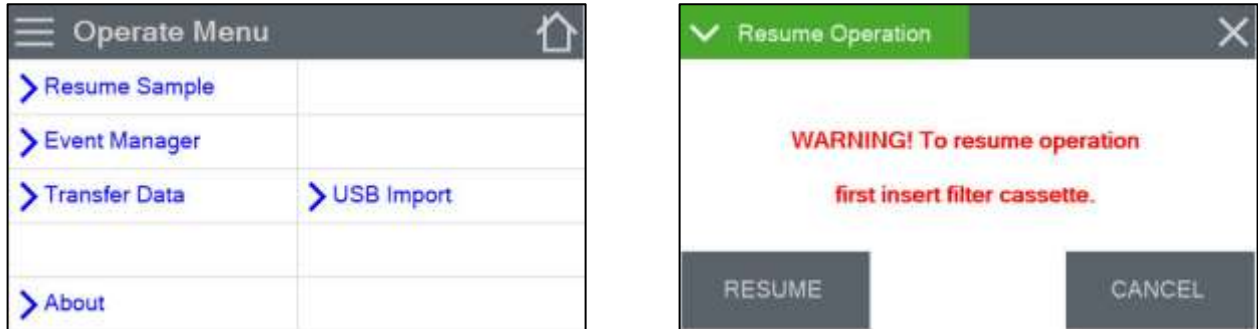


Figure 4-10 Resume Sample Sequence

If the STOP option is used, any remaining scheduled sample events will be erased. In this case, a completely new schedule will need to be created or loaded from a USB flash drive (see section 4.4.4) before sampling can resume.

4.4.2 Event Manager

This screen provides the options needed to manage the sampling event schedule. It displays the currently programmed samples and allows for adding more, up to a maximum of two scheduled events. It also has options for removing or modifying existing events. See section 5 for detailed instructions on creating and managing the sampling event schedule.

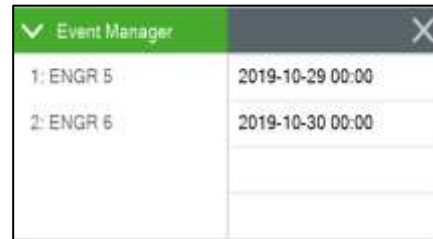


Figure 4-11 The Event Manager Screen

4.4.3 Transfer Data

Copying data to a USB memory stick is performed from this screen. See section 8.1.1 for detailed instructions.

4.4.4 USB Import

Importing event schedules from a USB memory stick is performed from this screen. See section 0 for detailed instructions.

4.4.5 About

This screen displays the monitor's serial number and installed firmware types and version numbers.



Figure 4-12 The About Screen

4.5 Test Menu

The Test Menu provides a means of testing and calibrating individual sensor inputs and calculations. Because these settings directly impact flow rates, most of these tests are password protected.

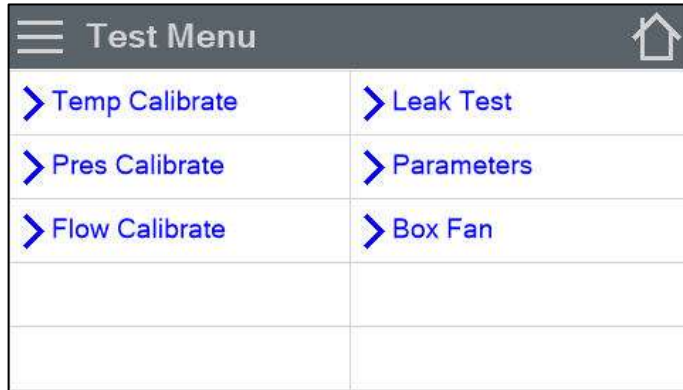


Figure 4-13 The Test Menu

4.5.1 Temp Calibrate

This screen provides the options and indications needed to default, verify, and calibrate the temperature sensors. This can be done as an independent verification or as part of the flow calibration procedure. See sections 6.4 and 6.5 for detailed instructions.



Figure 4-14 The Temp Calibrate Screen

4.5.2 Pres Calibrate

This screen provides the options and indications needed to default, verify, and calibrate the pressure sensors. This can be done as an independent verification or as part of the flow calibration procedure. See sections 6.4 and 6.5 for detailed instructions.



Figure 4-15 The Pres Calibrate Screen

4.5.3 Flow Calibrate

This screen provides the options and indications needed to default, verify, and calibrate the flow sensor as part of the flow audit and calibration procedures. See sections 6.2 and 6.5 for detailed instructions.



Figure 4-16 The Flow Calibrate Screen

4.5.4 Leak Test

The main external and follow-up internal leak tests use this screen. See section 6.2 for detailed instructions on performing these tests.



Figure 4-17 The Leak Test Screen

4.5.5 Parameters

This screen provides the ability to view the real time value of a wide variety of parameters. Results are updated every second. No changes can be made; they are for viewing purposes only.

A screenshot of a software window titled "Parameters". The window has a green header bar with a dropdown arrow and a close button. The main content area displays a table of parameters and their values.

AT	23.2 C
FT	23.8 C
FP	732.0 mmHg
BP	731.9 mmHg
Flow	0.00 LPM

Figure 4-18 The Test Menu Parameters Screens

4.5.6 Fan Test

This screen provides a means of verifying that the enclosure cooling fan is functioning correctly. The fan is located on the bottom of the enclosure. The fan is toggled on and off using the grey button located in the lower left corner of this screen.



Figure 4-19 The Fans Screen

Pressing the button for the fan causes it to change state from either OFF to ON or from ON to OFF. The current state of the fan is listed to the right of the fan name as shown in Figure 4-19. In this example, the fan is currently off. When the fan is turned on, operators should be able to both hear the fan spin and feel air in motion around it. Cool air is pulled up into the enclosure from the bottom. It then flows across the internal components and cools them. The warm air is and then exhausted out of the enclosure vent on the rear wall.

Note: During normal operation, the cooling fan is activated when the Filter Temperature (FT) sensor inside the enclosure measures greater than 2°C above the external Ambient Temperature (AT) sensor measurement.

4.6 Setup Menu

The E-FRM-DC uses a comprehensive system of setup menus which contain all the settings and parameters needed for operation of the sampler. Most of these settings are set at factory default values. Some settings may be altered by the operator. This section describes the SETUP menu in detail and should be reviewed when the instrument is first put into service. Once set, most of the values in the SETUP menus will not need to be changed. The SETUP values will not be lost if the E-FRM-DC is unplugged or powered down.

WARNING: Entering the SETUP menu system requires stopping the sample cycle.

Press the SETUP key on the main menu drop down selection (see Figure 4-3) to enter the menu as shown in Figure 4-20 below. The setup menu provides a choice of operations. Press the desired field to enter that screen.

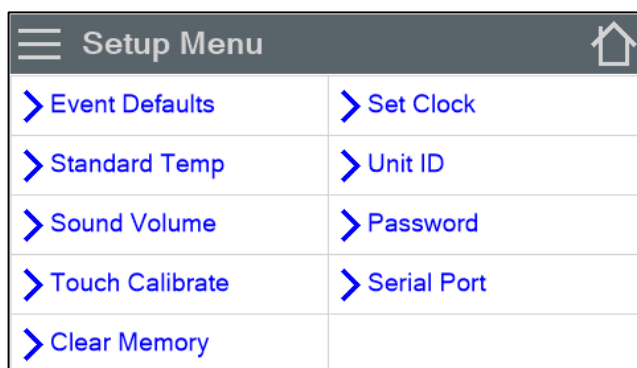


Figure 4-20 The Setup Menu Screen

4.6.1 Event Defaults

This is where the default values for creating new sample events are set. These fields should be set to the most common values that are expected to be used when deploying the sampler. This will greatly reduce the required setup time when programming a sequence of sample events. Press the green box of the field that needs to be modified.

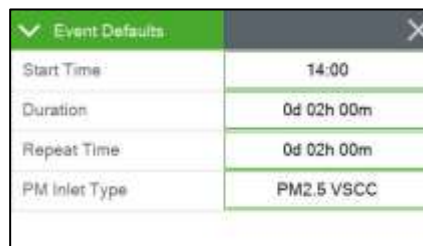


Figure 4-21 The Event Defaults Screen



Figure 4-22 The Event Defaults Setting Screens

The associated setting screen (see Figure 4-22) will be displayed. On the time and duration screens, select the specific parameter to modify and press the selection box. The numerical entry keypad (Figure 4-6) will be displayed and the value for that parameter may be entered. Once all

fields have been set on a given screen, press the grey OK button in the lower left corner to save them.

For the PM Inlet Type, simply select the type of sampling to be performed and press OK to save the setting. Note that not all available options for this field are able to be displayed on the same screen. Use the up and down arrows in the lower right corner to see all of the available options.

See section 5.1 for detailed instructions on programming sample events and explanations of the various fields shown here.

4.6.2 Standard Temp

This is the value of standard air temperature, used for the standard calculations when the sampler is configured for PM₁₀ operation. It is typically set to 25°C in the United States and this is the default value. However, local regulations may require different values. It can be set to 0, 20, or 25°C. Press the green bordered field and select from the list of available temperatures.



Figure 4-23 The Standard Temp Screen

4.6.3 Clear Memory

The Clear Memory screen provides a means of clearing all the currently logged data and alarms. The logs may be cleared individually or simultaneously. Press the green selection box to select from the list of available memory files. Once the choice is set, press the grey CLEAR button in the lower left corner of the screen.



Figure 4-24 The Clear Memory Screen

A confirmation screen appears prior to clearing the log(s) to avoid accidental erasure. It will ask to clear DATA LOGS, ALARM LOGS, or ALL LOGS, depending on the selection made. Press the grey CLEAR button in the lower right corner of the confirmation screen to erase the selected memory file(s).



Figure 4-25 The Clear Memory Confirmation Screen

The sampler will return to the Setup menu when the operation is complete.

To cancel the procedure at any time during this sequence, press the grey X button located in the upper right corner to exit back to the Setup menu without clearing anything.

4.6.4 Set Clock

This is where the date and time are set. Time is a 24-hour clock only. Press the green box of the field that needs to be modified. The numerical entry keypad (Figure 4-6) will be displayed allowing users to enter the value for that parameter. Once all fields have been entered, press the grey Set button in the lower left corner to set them.



Figure 4-26 The Set Clock Screen

The lithium battery backup keeps the clock running during power-down. Met One Instruments recommends a monthly check of the clock.

4.6.5 Unit ID

Users may enter a Unit ID number up to three digits long for the E-FRM-DC. Press the green bordered value box and the numerical entry keypad (Figure 4-6) will be displayed. Enter the new Unit ID value.

This ID number will be included in the data reports.



Figure 4-27 The Unit ID Screen

4.6.6 Password

Certain menus and options of the E-FRM-DC are password protected. Any four-digit password may be used. Press the green bordered value box and the numerical entry keypad (Figure 4-6) will be displayed. Enter the new password.



Figure 4-28 The Password Screen

Setting the password to 0000 means no password is used.

4.6.7 Serial Port

The baud rate for the serial communication ports is set here. Note that the USB and the RS-232 connection share this setting.

Press the green bordered value box and a list of the available baud rate settings will be displayed.



Figure 4-29 The Serial Port Screen

Tap the required baud rate setting and it will be applied. The baud rate options are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115,200. Section 8.1 has more details about serial communications.

In some cases, remote access over modems may require flow control to compensate for slow or noisy connections. In these situations, the RS-232 serial connection can be configured to use XON/XOFF flow control. Flow control is set to NONE by default but can be changed using the Handshake selection box.

4.6.8 Sound Volume

The touchscreen will beep every time a selection is made, and that volume may be adjusted in this screen. Press the green bordered value box and the numerical entry keypad (Figure 4-6) will be displayed. Enter a value from 0 – 100 with 100 being very loud and 0 being no beep at all. Any changes made here will not be active until exiting this screen.



Figure 4-30 The Sound Volume Screen

4.6.9 Touch Calibrate

This screen allows for calibration of the touchscreen. Press the grey Calibrate button to begin and then simply follow the instructions on the screen to calibrate it. If each step is not completed within five seconds, the test will cancel itself and return to page two of the Setup menu.



Figure 4-31 The Touch Calibrate Screen

There is a countdown clock for this feature displayed on each step of the calibration process.

4.7 Alarms Menu

This screen is used to view time-stamped alarm events with the most recent alarm will be displayed first. If there are more errors than can be displayed on the screen at one time, use the up and down arrow keys that will appear at the bottom of the screen to scroll through the alarm log.



Figure 4-32 The Alarms Menu

5 SCHEDULING SAMPLER EVENTS and SAMPLER OPERATION

The E-FRM-DC sampler is capable of performing two consecutive sample events. This section explains in detail how to use the event manager to create, modify, and delete sample events. It also explains how to view the historical data. Note: *If users do not swap the filter cassette between the samples, the second sample will be collected on the same filter.*

5.1 Configuring New Sample Events Using the Event Manager

From either the Main Operating Screen or the Operate Menu, select the Event Manager to enter the Event Manager interface (see section 4.4.2). Any programmed events will be listed on this screen. If there are currently no events programmed, the display will be empty.

Press the grey Add button in the lower left corner to bring up the Event Add interface shown in Figure 5-1.

Enter the ID number or name of the filter cassette in the Filter ID field.



Event Add	
Filter ID	NCC1701
Start Time	2016-07-31 00:00
Duration	3d 00h 00m
PM Inlet Type	PM10
Cancel	Save

Figure 5-1 The Event Add Screen

Next, set the start time. Initially, the start time will be set to the next occurrence of the value configured in the Event Defaults screen (see section 4.6.1). Change this field to indicate the desired start date and time, if needed.

Once the start time is correct, verify the duration setting. The duration is the length of time the sampler will run the pump and collect particulate on the filter media.

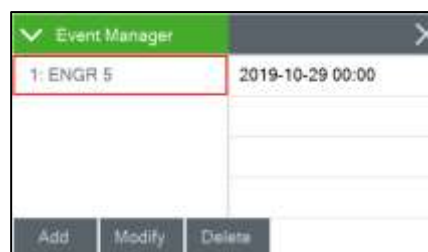
Finally, verify the PM Inlet Type configuration. The E-FRM-DC is not able to sense the installed configuration accessories, so it is important that the operator properly set this field to mark the data set with the correct type of collected particulate. To change this field, press the green bordered value box and choose the correct option from the list of choices. If using the BX-808 cyclone separators, select PM2.5 VSCC. If using the BX-804 WINS Impactor, select PM2.5 WINS. For any other PM_{2.5} accessory, select PM2.5 SCC. If using only the BX-802 inlet head for PM₁₀ monitoring, select PM10. Select PM1 SCC or TSP if the sampler is configured for monitoring PM₁ or TSP sampling, respectively.

Once all the fields are set as desired, press the grey Save button in the lower right corner to save the settings and return to the Event Manager screen.

5.2 Modifying Sample Events Using the Event Manager

From either the Main Operating Screen or the Operate Menu, select the Event Manager to enter the Event Manager interface (see section 4.4.2). Any programmed events will be listed on this screen.

To review the settings for a particular cassette, select the filter cassette ID of interest and press the Modify button.



Event Manager	
1: ENGR 5	2019-10-29 00:00
Add	Modify
Delete	

Figure 5-2 The Event Manager Screen

The event details will be displayed just as they were when adding it in the first place. Simply modify whichever parameter needs to be updated and then press the grey Save button to set the changes.

5.3 Deleting Sample Events Using the Event Manager

From either the Main Operating Screen or the Operate Menu, select the Event Manager to enter the Event Manager interface (see section 4.4.2). Any programmed events will be listed on this screen.

To remove a particular event, select the filter cassette ID of interest and press the grey Delete button in the lower left corner (see Figure 5-2). The Event Delete screen shown in Figure 5-3 will be displayed. If this is the desired event to delete, press the grey Delete button in the lower right corner to erase it. To cancel the delete action, use the grey Cancel button or press the grey X button in the upper right corner of the screen.

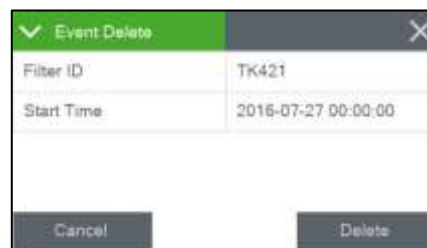


Figure 5-3 The Event Delete Screen

5.4 Viewing Current and Previous Sample Events

The current sample details, including both instantaneous and five minute averages, can be seen using the up and down arrow keys in the lower right corner of the main operating screen.

Historical data can be viewed using the left arrow key. When viewing past data, the header at the top of the screen will display the word HISTORY in bold red letters.



Figure 5-4 The Event Viewer History Screen

Viewing current or historical data does not interrupt the current sampler state and may be done at any time. The displayed parameter screens are summarized in Table 5-1.

View Screen	Parameters Shown
Main Status	Event schedule, elapsed time, remaining time, sample start and stop times
Current	Current ambient temperature, barometric pressure, filter temperature, and flow
5 Min Values	Current 5 minute average of ambient temperature, barometric pressure, filter temperature, and flow
Volume Summary	Current total sampled air volume in both actual and standard conditions, standard temperature, and PM inlet type
CV Summary	The flow coefficient of variability (CV), mean, and standard deviation for the current sample period
Min/Max Summary	The min and max values for ambient temperature, barometric pressure, and filter temperature during the current sample, with time stamps

<p>Warnings</p>	<p>Filter delta temperature warning when Filter Temp exceeds Ambient Temp by 5°C for more than 30 consecutive minutes. The time-stamped max delta temperature (dT) between the ambient temperature and the filter temperature during the sample. Flow warning when the flow rate exceeds the flow set point by +/- 5% for more than 5 minutes. Note: Sampling terminated when the flow rate exceeds the flow set point by +/- 10% for more than 1 minute. Elapsed warning when the elapsed sample time was less than 23 hours or greater than 25 hours.</p>
<p>Power Interruptions</p>	<p>Time stamp of power interruptions greater than 60 seconds during the sample.</p>

Table 5-1 E-FRM Current Status Screen Descriptions

5.5 Importing New Sample Events from a USB Flash Drive

The FSCommaQ software package can be used to create a full event schedule on a computer. This schedule can then be saved to a USB flash drive and loaded into the E-FRM-DC sampler instead of manually configuring each event through the front panel display of the sampler. Note that the event schedule must be configured to match the serial number of the sampler. See the FSCommaQ software manual for instructions on creating the event schedule and saving it to the USB flash drive.

From the Operate Menu, select the USB Import option to enter the USB Import interface (see section 4.4.4). A warning will be displayed indicating that any events added in this manner will not replace currently scheduled events but will be added to the end of the list (see Figure 5-5).

Note: The maximum number of events able to be scheduled is two. This means that if there are already two events scheduled, no events can be imported. If there is one event scheduled, only one event can be imported.

Press the grey APPEND button to acknowledge the notice and proceed to the import screen. The Status and Error fields will be blank, and the grey IMPORT button will be located in the lower left corner. If it is not already installed, insert the USB flash drive containing the event schedule into the slot below the E-FRM-DC display.

Press the grey IMPORT button and the sampler will locate the pre-configured schedule and import it, appending the events to the end of any remaining samples already in the sample queue.

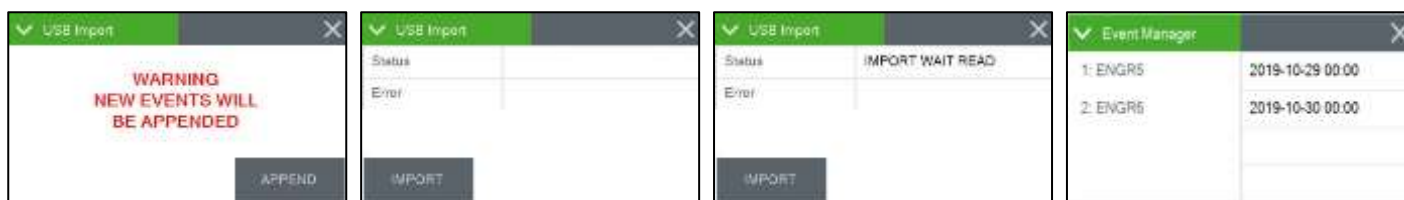


Figure 5-5 The USB Import Sequence

To manually add additional samples, press the grey ADD button and follow the procedure listed in section 5.1. See sections 5.2 and 5.3 to make any necessary modifications or deletions.

Once the event schedule has been configured satisfactorily and the new filter is loaded in the filter holder, press the grey X button in the upper right corner to return to the Operate Menu.

6 FLOW SYSTEM and FLOW CALIBRATIONS

6.1 Flow System Diagram

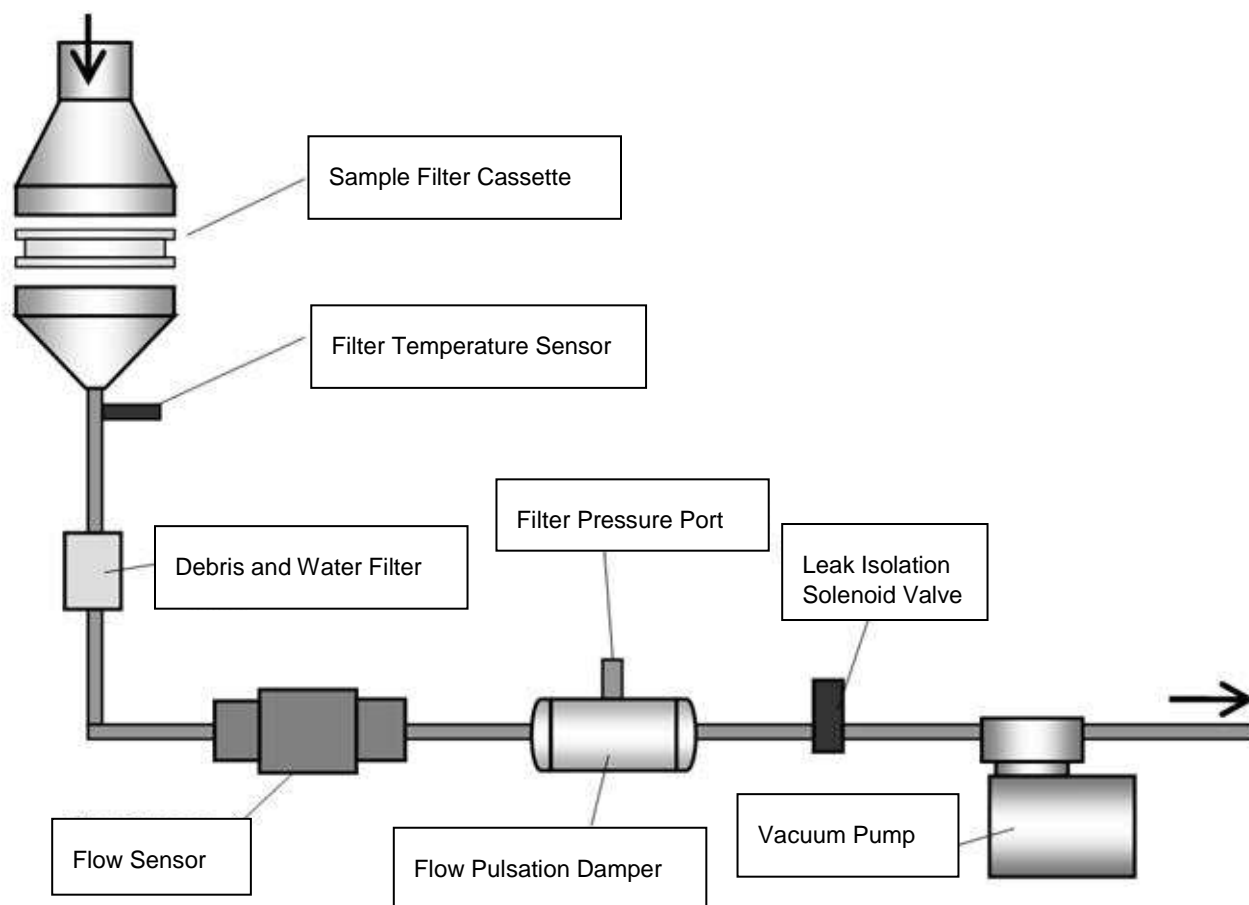


Figure 6-1 E-FRM-DC Flow System Diagram

6.2 Leak Tests and Flow Audits

The critical aspects of filter sampler flow system maintenance include routine leak tests (also commonly referred to as leak checks) and temperature, pressure, and flow audits. Agencies that routinely verify these aspects almost always obtain high-quality concentration data from the instrument. In general, the sampler flow rate accuracy should be audited periodically, and the flow bias assessed at least quarterly and annually. These activities are usually separated into two levels.

“Audits” usually consist of checking the leak, temperature, pressure, and flow values from the sampler at a single point (usually at ambient conditions) comparing these values to a traceable standard device, and simply recording the results with no adjustments. Because these audits are fairly quick, they are usually performed on a regular basis, such as monthly. See section 6.3 for the leak check procedure and section 6.4 for AT, BP, and Flow audits.

“Calibrations” usually consist of comparing the sampler values to the traceable standard device at one or multiple points and making calibration adjustments to the sampler as needed. Calibration may be required as the result of a problem found during an audit or may simply occur at a fixed interval as a matter of standard operating procedures, such as quarterly. Calibrations must always be documented. See section 6.5 for detailed AT, BP, and Flow calibration procedures.

See section 7.1 for the recommended intervals of these verifications.

6.3 Leak Tests

To perform the leak test, the following accessories will be needed:

- BX-305 Isolation valve
- 82607 Internal Leak Test Cassette (solid cassette)
- 82607-1 External Leak Test Cassette (cassette with small hole in the center)

The leak test consists of two stages, the external leak test and the internal leak test. The external leak test is a total system leak test including all internal and external fittings. If that test passes, there is no need to perform the internal leak test. If the external leak check fails, then the internal leak test is used to narrow down the leak location.

6.3.1 The External Leak Test

1. Remove the PM₁₀ inlet head but leave the inlet tube installed.
2. Install the BX-305 inlet adapter and place the valve on it in the closed position.
3. Go to the Test > Leak Test > EXTERNAL screen (see section 4.5.4). The Insert Cassette screen shown on the far right of Figure 6-2 should appear:



Figure 6-2 External Leak Test Cassette Insertion Screen

4. Pull the filter release handle forward to open the filter cassette holder. If installed, remove the current sample cassette.
5. Install the External Leak Test Cassette in the filter holder. Note that this is the test cassette with the hole in the center.
6. Push the filter release handle back to lock the cassette in place.
7. Once the test cassette is installed, press the grey CONTINUE button on the Insert Cassette screen (Figure 6-2).
8. The sampler should display the Leak Test External screen shown in Figure 6-3.
9. Press the grey START button. The pump will turn on briefly to draw a vacuum on the system. It will then turn the pump off and measure the leak over time. The leak rate must not exceed the factory set reference leak rate. The sequence should look as shown in Figure 6-3.



Figure 6-3 External Leak Test Sequence

Figure 6-3 shows the absolute internal pressure (the Current field), the vacuum rate and how it compares to the reference vacuum decline rate (the Vacuum field), whether the test is passing or failing (the Leak field), and how much time has elapsed since the start of the test (the Elapsed field). The current stage of the test procedure is shown in the Status field.

10. Check the results of the leak test.
 - a. If the test fails, go to section 6.3.2 and perform the internal test.
 - b. If the test passes, proceed to step 11.
11. Slowly open the valve on the inlet adapter to relieve the vacuum inside the sampler.
12. Remove the BX-305 adapter and reinstall the PM₁₀ inlet head.
13. Press the grey X button in upper right corner to exit the test. A notice to remove the test cassette will be displayed as shown in see Figure 6-4.



Figure 6-4 Leak Test Cassette Removal Screen

14. Pull the filter release handle forward to open the filter cassette holder and remove the test cassette.
15. Press the grey EXIT button (see Figure 6-4) to exit the test and return to the Test Menu.

6.3.2 Internal Leak Test

If the external leak test passes, there is no need to perform the internal leak test. The full sampler flow system is in good condition.

If External Leak Test failed, the internal leak test must be performed. The internal test uses the solid test cassette to isolate the internal flow system from the external inlet components. If the internal leak test fails, the leak is downstream of the filter cassette location; if it passes, the leak is before the filter cassette location (see Figure 6-1).

To conduct the internal leak test, perform the following procedure. Note that this procedure assumes the External Leak Test (section 6.3.1) has just been completed.

1. Go to the Test > Leak Test > INTERNAL screen. The Insert Cassette screen shown on the far right of Figure 6-5 should appear:



Figure 6-5 Internal Leak Test Cassette Insertion Screen

2. Install the Internal Leak Test Cassette in the filter holder and then push the filter release handle back to lock the cassette in place. Note that this test cassette is solid. *There is no hole in the center.*
3. Once the test cassette is installed, press the grey CONTINUE button on the Insert Cassette screen (Figure 6-5).
4. The sampler should display the Leak Test Internal screen.
5. Press the grey START button. The pump will turn on briefly to draw a vacuum on the system. It will then turn the pump off and measure the leak over time. The leak rate must not exceed the factory set reference leak rate. The sequence should look as shown in Figure 6-6.

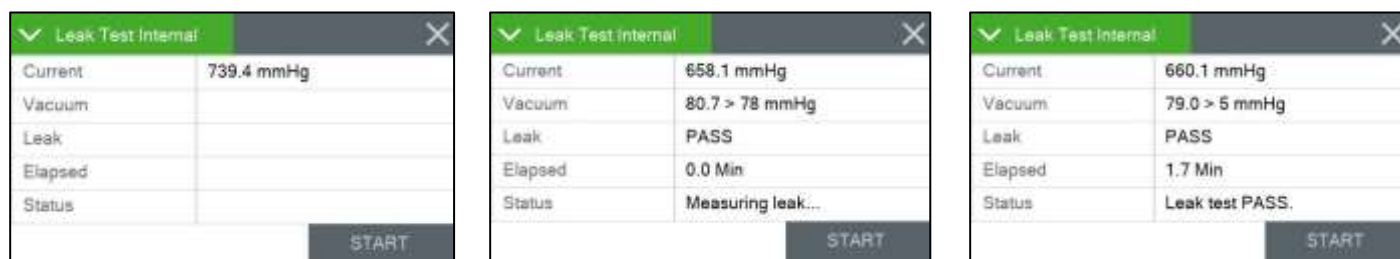


Figure 6-6 Internal Leak Test Sequence

Figure 6-6 shows the absolute internal pressure (the Current field), the vacuum rate and how it compares to the reference vacuum decline rate (the Vacuum field), whether the test is passing or failing (the Leak field), and how much time has elapsed since the start of the test (the Elapsed field). The current stage of the test procedure is shown in the Status field.

6. Check the results of the leak test.
 - a. If the test passes, there is a leak above the cassette. Complete the rest of this procedure and then go to section 7.6.1.
 - b. If the test fails, there is a leak below the cassette. Complete the rest of this procedure and then go to section 7.6.2.
7. *Slowly* open the valve on the inlet adapter to relieve the vacuum inside the sampler.
8. Press the grey X button in upper right corner to exit the test. The Remove Cassette screen should appear.
9. Pull the filter release handle forward to open the filter cassette holder and remove the test cassette.
10. Press the grey EXIT button to exit the test and return to the Test Menu.
11. Follow the corrective actions in section 7.6 as determined in step 6 of this procedure.

6.4 Temperature, Pressure, and Flow Audits

The audits in this section are performed using the Parameters screens. These screens are explained in more detail in section 4.5.5. It is recommended these audits be performed between sample cycles so sample runs will not be interrupted and internal components, such as the BX-808 or the PM₁₀ pass through adapter may be removed.

To perform the following audits, reference temperature, barometric pressure, and flow standards with sufficient accuracy will be needed. For example, a calibrated Met One Instruments BX-307 will provide reference temperature, pressure, and flow values.

6.4.1 Auditing the Ambient Air Temperature Sensor

Use the following procedure to verify the ambient temperature measured by the Sampler:

1. Place the reference temperature sensor near the ambient temperature sensor mounted on the external rear wall of the sampler. The sensors should be placed as close together as is practical, such as is shown in Figure 6-7.



Figure 6-7 Ambient Temperature Audit with BX-307

2. Allow the sensors enough time to fully equilibrate.
3. Read the current Ambient Temperature (AT) on the Parameters screen and compare it to the reference temperature. The reference and AT readings should be within $\pm 2^{\circ}\text{C}$ of each other. If they are not, perform the temperature calibration procedure located in section 7.2.

6.4.2 Auditing the Filter Temperature Sensor

The filter temperature sensor is located below filter cassette sample location as shown in Figure 6-8.

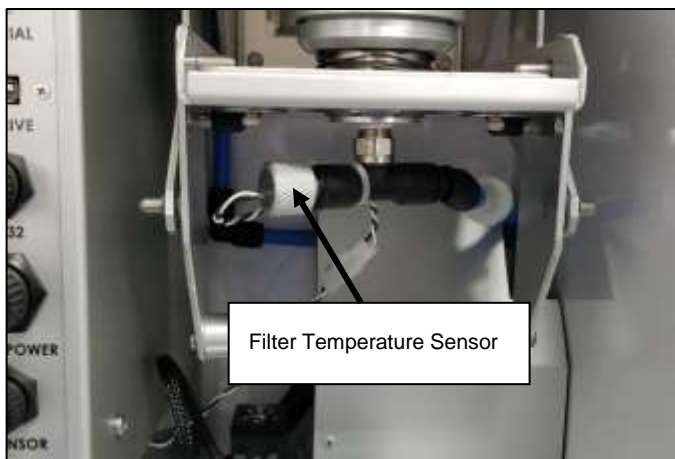


Figure 6-8 Filter Temperature Sensor Location



Figure 6-9 Filter Temperature Sensor Removed

1. Grip the knurled end of the filter temperature sensor and pull gently to remove it from the air flow path.
2. Position the filter temperature sensor side-by-side with reference temperature sensor. Note the sensor is on the tip of the probe (see Figure 6-9).
3. Allow the sensors enough time to fully equilibrate.
4. Read the current filter temperature (FT) on the Parameters screen and compare it to the reference temperature. The reference and FT readings should be within $\pm 2^{\circ}\text{C}$ of each other. If they are not, perform the temperature calibration procedure located in section 7.2.
5. Re-install the filter temperature sensor ensuring no interference issues exist with the operation of the filter holder operating mechanism.

6.4.3 Auditing the Filter and Box Pressure Sensors

The filter pressure sensor is located downstream of the sample filter (see Figure 6-1) and the box pressure sensor is located completely outside of the flow path. This allows the filter pressure to measure the lower pressure inside the flow path while the box pressure indicates actual ambient conditions. This means the filter and box pressure values should both indicate actual ambient pressure when the pump is not running, and the sample flow path is vented. Because of this, these two sensors may be audited simultaneously using the following procedure.

1. Verify the pump is off and there is no sample filter cassette holder installed in the sample position.
2. Read the current Filter Pressure (FP) and Box Pressure (BP) on the Parameters screen and compare them to the reference pressure. Each sampler pressure sensor should be within ± 10 mm Hg of the reference value. If it is not, perform the pressure calibration procedure located in section 7.3. for whichever pressure sensor does not meet the specification.

6.4.4 Auditing the Sampler Flow Rate

An accurate flow rate is critical to the proper operation of the PM_{10} inlet head and any additional $\text{PM}_{2.5}$ or PM_1 particle size selectors. The system must pass the external leak test (see section 6.3.1) as the first step. An excessive leak in the system will result in too much air bypassing the cyclonic separators and the particulate sizes will not be accurate.

Also, the Ambient Temperature and Box Pressure sensors are used in the calculation of the flow rate. As such, the AT and BP sensor audits in sections 6.4.1 and 6.4.3 must also pass prior to beginning this procedure.

The following accessories will be needed to perform this audit:

- Reference flow standard (such as the BX-307)
- Spare 47 mm filter cassette with a 47 mm $\text{PM}_{2.5}$ PTFE (460122) or equivalent filter installed

This audit should be performed while the system is as close to normal operating conditions as possible. This means having either the internal separator or PM_{10} pass through device installed. It also means loading a clean sample filter. This filter will only be used for this audit and should not be used as a collection sample when finished. It should be discarded whenever it becomes damaged or is deemed to be excessively dirty by local standards.

Note that the internal size selector and loaded filter should be of the same type that is currently being used for sample collection. For example, when the E-FRM-DC is being used to sample for

PM₁₀ particulate on Teflon filters, then the PM₁₀ pass through device should be installed and a Teflon filter should be loaded.

1. Remove the PM₁₀ inlet head but leave the inlet tube installed.
2. Install the flow standard on the top of the inlet tube.
3. Go to the Test > Flow Calibrate screen (see section 4.5.3). The Insert Cassette screen shown on the right of Figure 6-10 should appear:



Figure 6-10 Flow Calibrate Cassette Insertion Screen

4. Insert the test cassette (loaded with sampler filter) and close the filter holder.
5. Once the test cassette is in position, press the grey CONTINUE button on the Insert Cassette screen (Figure 6-10). The sampler should display the Flow Calibrate screen (shown in Figure 6-11). The pump will start automatically and adjust flow to the 16.7 lpm test point.



Figure 6-11 Flow Calibration Flow Rate Selection Screen

6. Compare the E-FRM-DC flow rate to the flow standard. If the flow rate is within $\pm 2\%$ of the transfer standard, skip to step 8.
7. If the difference exceeds $\pm 2\%$ of the transfer standard, the flow rate needs to be calibrated. Go to section 6.5 and perform the Multi-Point Flow Calibration.
8. Press the grey X button in upper right corner to exit the test. The screen shown below in Figure 6-12 should appear:



Figure 6-12 Flow Calibration Cassette Removal Screen

9. Remove the cassette.

10. Press the grey EXIT button (see Figure 6-12) to exit the test and return to the Test Menu.
11. Remove the flow standard from the inlet tube and install the BX-802 sample head.
12. Resume normal operation of the sampler.

6.5 Multi-Point Flow Calibrations

The section details the steps required to calibrate the flow system of the E-FRM-DC. All the prerequisites and accessories needed for the flow audit (see section 6.4.4) are the same for performing this flow calibration.

1. Remove the PM₁₀ inlet head but leave the inlet tube installed.
2. Install the flow standard on the top of the inlet tube.
3. Go to the Test > Flow Calibrate screen (see section 4.5.3). The Insert Cassette screen shown on the right of Figure 6-13 should appear:



Figure 6-13 Flow Calibrate Cassette Insertion Screen

4. Insert the test cassette (loaded with sampler filter) and close the filter cassette holder.
5. Once the test cassette is in position, press the grey CONTINUE button on the Insert Cassette screen (Figure 6-13). The sampler should display the Flow Calibrate screen shown on the left side of Figure 6-14. The pump will start automatically and adjust flow to the 16.7 lpm set point.
6. Press the green bordered Set Point field and the Set Point flow rate selection screen shown on the right hand side of Figure 6-14 will appear.

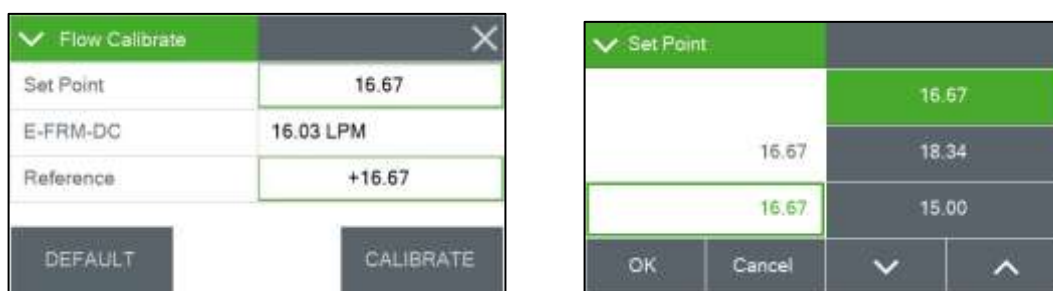


Figure 6-14 Flow Calibration Flow Rate Selection Screen

7. Select 15.00 from the list of flow rate set points and then press the grey OK button in the lower left corner. The display will return to the Flow Calibrate screen and adjust the flow to the new set point.
8. Allow the unit to regulate the flow until the flow reading stabilizes at the target flow rate. Enter the flow value from your flow standard into the REFERENCE field and press SET.
 Note: The E-FRM-DC flow reading will not change to match the REFERENCE field until after you have entered all three flow calibration points, since it is calculated by a slope function.

9. Press the Set Point field and select the second flow point rate of 18.34 lpm. Allow the flow to stabilize, then enter the value from your flow standard and press SET.

Note: If the E-FRM-DC is unable to achieve flow regulation at the 18.34 lpm point, this could be an early indication that the vacuum pump needs to be serviced.

10. Press the Set Point field and select the third flow point rate of 16.67 lpm. Allow the flow to stabilize, then enter the value from your flow standard and press CALIBRATE.

After this third flow point is calibrated, the E-FRM-DC flow reading will change to show the corrected flow, then the E-FRM will re-regulate the flow to 16.67 lpm based on the new calibration. The E-FRM flow reading should now match your flow standard device at 16.67 lpm \pm 2%.

11. If difficulty is encountered, press the "Default" button to clear out all previous calibrations and restore factory calibration values, then retry the calibration starting at step 6.

12. Press the grey X button in upper right corner to exit the test.

13. Remove the cassette.

14. Press the grey EXIT button to exit the test and return to the Test Menu.

15. Remove the flow standard from the inlet tube and install the BX-802 sample head.

16. Resume normal operation of the sampler.

7 MAINTENANCE AND TROUBLESHOOTING

This section provides information about routine maintenance, identifying errors and alarms, and performing diagnostic tests if a problem is encountered on the E-FRM-DC. The TEST menu functions are also described in this section.

7.1 Recommended Periodic Maintenance Table

Table 7-1 shows the recommended interval for the regular maintenance, field checks, and service tasks.

Maintenance Item	Period
Leak Check	Prior to Filter Change
Flow system check/audit.	Prior to Filter Change
Clean PM ₁₀ inlet particle trap.	Monthly
Clean PM _{2.5} cyclonic separator particle trap. (if used)	Monthly
Clean PM _{2.5} WINS Impactor well, replace filter and oil. (If used)	Monthly
Clean PM ₁ cyclonic separator particle trap. (if used)	Monthly
Check or set real-time clock.	Monthly
Verify proper pump and box fan operation.	Monthly
Complete flow system calibration.	Quarterly
Completely disassemble and clean PM ₁₀ inlet and PM _{2.5} cyclone.	Quarterly
Rebuild vacuum pump (use rebuild kit)	12 Months
Clean internal debris filter.	6 Months
Clean vertical inlet tube	12 Months

Table 7-1 Recommended maintenance Schedule for the E-FRM-DC Sampler

7.2 Ambient and Filter Temperature Calibrations

A reference temperature standard will be needed to perform the following calibration procedures. For example, a calibrated Met One Instruments BX-307 will provide the required reference temperature reading.

1. Navigate to the Test> Temp Calibrate menu.
2. The display will show the ambient temperature sensor test interface first.
3. Place the reference temperature sensor near the ambient temperature sensor mounted on the exterior of the sampler. The sensors should be placed as close together as is practical, such as is shown in Figure 6-7.
4. Allow the sensors enough time to fully equilibrate.
5. Read the current Ambient Temperature (AT) in the E-FRM-DC field and compare it to the reference temperature. The reference and AT readings should be within $\pm 2^{\circ}\text{C}$ of each other.
 - a. If the sensors do not match within specification, press the green bordered Standard value field. The numeric entry keypad (Figure 4-6) will be displayed.
 - b. Enter the value reported by the reference standard and press the grey OK button to return to the Temp Calibrate screen.
 - c. Press the grey CALIBRATE button to set the new calibration.

6. Tap the green bordered Temp Sensor field and select FT for the filter temperature sensor.
6. Remove the filter temperature sensor (see Figure 6-9).
7. Place the Filter Temperature sensor side-by-side with the reference temperature sensor.
8. Allow the sensors enough time to fully equilibrate.
9. Read the current Filter Temperature (FT) in the E-FRM-DC field and compare it to the reference temperature. The reference and FT readings should be within $\pm 2^{\circ}\text{C}$ of each other.
 - a. If the sensors do not match within specification, press the green bordered Standard value field. The numeric entry keypad (Figure 4-6) will be displayed.
 - b. Enter the value reported by the reference standard and press the grey OK button to return to the Temp Calibrate screen.
 - c. Press the grey CALIBRATE button to set the new calibration.
10. Re-install the filter temperature sensor.

7.3 Filter and Box Barometric Pressure Sensor Calibrations

A reference pressure standard will be needed to perform the following calibration procedures. For example, a calibrated Met One Instruments BX-307 will provide the required reference pressure reading.

1. Navigate to the Test> Pres Calibrate menu.
2. The screen will display the Box Pressure sensor (BP) first.
3. Place the reference pressure sensor near sampler. The exact location isn't critical as the pressure will not vary enough around the sampler to make a noticeable impact.
4. Allow the sensors enough time to fully equilibrate.
5. Verify the pump is off and there is no sample filter cassette holder installed in the sample position.
6. Read the current box pressure (BP) in the E-FRM-DC field and compare it to the reference pressure. The reference value should be within ± 10 mm Hg.
 - a. If the sensors do not match within specification, press the green bordered Standard value field. The numeric entry keypad (Figure 4-6) will be displayed.
 - b. Enter the value reported by the standard and press the grey OK button to return to the Temp Calibrate screen.
 - c. Press the grey CALIBRATE button to set the new calibration.
7. Tap the green bordered Pres Sensor field and select FP for the filter pressure sensor.
8. Read the current filter pressure (FP) in the E-FRM-DC field and compare it to the reference pressure. The reference value should be within ± 10 mm Hg.
 - a. If the sensors do not match within specification, press the green bordered Standard value field. The numeric entry keypad (Figure 4-6) will be displayed.
 - b. Enter the value reported by the standard and press the grey OK button to return to the Temp Calibrate screen.
 - c. Press the grey CALIBRATE button to set the new calibration.

7.4 Error and Alarm Descriptions

Errors and alarms may occur in the sampler as a result of operational conditions outside of the specified ranges, machine malfunctions, or data flags. The alarms may be shown on the sampler display or in the sample event data log files.

The E-FRM-DC error codes are detailed in Table 7-2.

Code	Description	Cause																								
1	Power Outage	The event occurs for a power cycle or whenever the micro-processor is reset.																								
2	Flow failure	The event occurs when the sample flow is +/-10% out of regulation for 1 minute. The event occurs when the sample flow is +/-5% out of regulation for 5 minutes.																								
4	Temp Delta	Occurs when the filter temperature is greater than ambient temperature by 5°C or more for 30 minutes.																								
8	Elapsed Time	This error is logged when a sample event runs for either less than 23 hours or greater than 25 hours.																								
16	Not Used																									
32	Sensor Range	Occurs when a sensor is outside of the following limits: <table border="1" data-bbox="625 913 1425 1192"> <thead> <tr> <th>Sensor</th> <th>Minimum</th> <th>Maximum</th> <th>Stop Operation</th> </tr> </thead> <tbody> <tr> <td>AT</td> <td>-40</td> <td>70</td> <td>Yes</td> </tr> <tr> <td>FT</td> <td>-40</td> <td>70</td> <td>Yes</td> </tr> <tr> <td>FP</td> <td>228</td> <td>818</td> <td>No</td> </tr> <tr> <td>BP</td> <td>228</td> <td>818</td> <td>Yes</td> </tr> <tr> <td>Flow</td> <td>0</td> <td>20</td> <td>Yes</td> </tr> </tbody> </table> <p>Sensors that do not stop operations will be flagged and logged but the sample cycle will continue.</p>	Sensor	Minimum	Maximum	Stop Operation	AT	-40	70	Yes	FT	-40	70	Yes	FP	228	818	No	BP	228	818	Yes	Flow	0	20	Yes
Sensor	Minimum	Maximum	Stop Operation																							
AT	-40	70	Yes																							
FT	-40	70	Yes																							
FP	228	818	No																							
BP	228	818	Yes																							
Flow	0	20	Yes																							
64	Flow Link Down	This error occurs if the link to the flow sensor is interrupted for more than 10 seconds. This will keep the unit from running if stopped or, if running, will halt the current sample.																								
128	Maintenance	The event occurs when the user stops normal operation.																								

Table 7-2 The E-FRM-DC Alarm Conditions

An alarm is indicated and logged at the time it occurs. The resolution time is not recorded. See section 4.7 for an explanation of viewing alarms through the front panel display.

Note: If multiple errors or alarms occur in the same data period, then the logged alarm code will be the sum of the two individual code numbers. This is a rare occurrence.

7.5 Basic Problem and Cause/Solution Table

The following table contains information on some of the more common problems that may be encountered, and some steps to identify and remedy the problems. Met One Instruments welcomes customer suggestions for new items to include in this section of future manual revisions. If the solution cannot be found in the following table, then contact one of our expert service technicians for help in resolving the problem.

Problem:	The airflow won't regulate at the correct rate of 16.7 lpm.
Cause/Solution:	<ul style="list-style-type: none"> • This may indicate a missing or damaged filter cassette/filter. Proper flow control requires a correctly installed filter cassette/filter. • This usually indicates that the air pump is losing vacuum capacity due to wear. • Check for leaks. Leaks will often cause the inlet flow to be low even though the flow sensor is measuring the correct flow rate. This is because the flow sensor is downstream of the filter cassette. Correct any leaks found. • Perform a flow calibration. If the flow regulates at the lower calibration point, but not the higher point, the pump is probably worn out or a leak is present. • Check the inlet and PM heads for obstructions.

Problem:	The sampler has flow leaks, even after cleaning.
Cause/Solution:	<ul style="list-style-type: none"> • Check the O-rings on the very sharp-cut cyclone (if used). These frequently leak. • Check for bad O-rings on all other components. • Check all of the push-in air fittings throughout the air flow system.

Problem:	The clock settings are lost when the mass monitor is powered down.
Cause/Solution:	<ul style="list-style-type: none"> • There is a lithium coin cell battery inside the mass monitor that maintains the clock when the mass monitor is powered off. The battery may need to be replaced if the clock resets when the mass monitor is powered off.

Problem:	The Sampler won't start a measurement cycle.
Cause/Solution:	<ul style="list-style-type: none"> • The unit is programmed not to start a sample cycle until the beginning of a scheduled sample event. Make sure the sampler clock is set correctly. Check the event schedules in the Setup and Event menus. • The unit will usually display an error if it cannot start a new sample cycle.

7.6 Leak Correction

The PM₁₀ inlet head and any subsequent cyclonic or impact separators require an accurate flow rate for proper performance. If there are leaks downstream of these separators, a portion of the air flow will bypass the separators which can result in too low of a flow rate. This results in improper performance and will invalidate the sample.

If leaks are detected during the periodic leak tests (see section 6.3) they must be corrected immediately. Clean, inspect and lubricate all O-rings to ensure proper sealing. Replace damaged O-rings.

7.6.1 Correcting an External Leak

Leaks determined by the isolation procedure (see section 6.3.2) to be located in the external section of the sampler are usually caused by one or more components not being fully seated. If all of the inlet components are confirmed to be properly installed, the leak is likely a failed O-ring seal.

7.6.2 Correcting an Internal Leak

Leaks determined by the isolation procedure (see section 6.3.2) to be located in the internal section of the sampler are usually caused by a failed O-ring or one of the push-in fittings not being properly seated.

8 DATA RETRIEVAL

8.1 Using the RS-232 or USB Cable Connections

The E-FRM-DC is able to communicate via serial commands using RS-232 or USB Serial. The sampler only allows one of these connections at a time. These connections allow users to both download data and operate the instrument

The default RS-232 settings are as follows:

Baud Rate: 115,200

Data Bits: 8

Parity: None

Stop Bits: 1

Flow Control:None

8.1.1 User Communication

In the User Communication (or Terminal) mode, commands are issued by entering a letter or number command and then pressing the Enter, <cr>, key. The <Esc> key is not used when sending commands in this mode.

Press the Enter key three times to enter User Communication mode. An asterisk character appears confirming the mode is active and that the instrument is ready for a new command. Commands will be echoed back from the instrument and an asterisk will appear after a command has completed.

\$ – User level password protected commands

COMMAND	DESCRIPTION
1	Request settings report
2	Request All data report
3	Request New data report
4	Request Last data report
7	Request Alarm log report
C	Clear data log files – \$
D	Get/Set date part of the real time clock – \$
H	Help menu
T	Get/Set time part of the real time clock – \$
CA	Clear the Alarm log file – \$
DS	Report data log channel descriptors
DT	Get/Set the date and time of the real time clock – \$
HS	Get/Set Handshake type – 0-NONE, 1-XON/XOFF
ID	Get/Set location ID or address – \$
OI	Get/Set output interval – \$
OP	Get/Set operation state
PM	Get/Set PM inlet type – \$
PR	Print report – 0-Settings, 1-Data, 2-Alarm, 3-Factory

COMMAND	DESCRIPTION
PW	Unlock protected commands: Unlock user commands (User setting) – \$
QH	Report Data log record header
RQ	Report current data log readings
RV	Report Model/Part/Revision
SB	Get/Set baud rate – \$
SS	Get Met One Instruments serial number
ST	Get Data log period – \$
UN	Get/Set data record descriptor channel units
DDT	Get/Set default event duration time – \$
DRT	Get/Set default event repeat time – \$
DST	Get/Set default event start time – \$
GTC	Start a touch screen calibration – \$
RPW	Report password encrypted
SPW	Get/Set user password – \$
XRD	Get record descriptor report
XRF	XMODEM read file
STDT	Get/Set standard temperature – \$
DSCRC	Get data log channel descriptor CRC
EVENT	Get the requested event report
XRDCRC	Get file descriptor CRC

Table 8-1 Common Serial Command Set

To issue one of the commands listed in Table 8-1, type the command listed and press the Enter key. The command will run and display the requested information or current setting, as appropriate.

For example, to view the current date setting type the letter D followed by the Enter key. The current date will be reported. The sequence would appear like this:

```
D<cr>
D 2013-01-18<cr><lf>
```

To change a setting, the typical sequence is to type the command, press the space bar one time, enter the new value in the same format that is displayed when checking the setting, and then pressing the Enter key.

Continuing the example above, to change the date setting type the letter D, space, and then the current date in YYYY-MM-DD format followed by the Enter key. A confirmation of the new date will be reported. The sequence would appear like this:

```
D 2016-02-28<cr>
D 2016-02-28<cr><lf>
```

Pressing <Esc> or Q<cr> will exit terminal mode.

For a detailed listing of all commands and their formats, consult the E-FRM-DC 7500 document available upon request from the Met One Instruments service department. See section 1.2.

8.1.2 Computer Communication

In the Computer Communication mode, character echo is suppressed. This means if commands are issued in this mode using a keyboard, there will be nothing displayed on the screen. The command format includes a checksum to verify data integrity.

The mode is entered whenever an <Esc> character is sent to the instrument. Commands are issued using the following format:

```
<Esc>Cmd p1 p2*cs<cr>
```

Computer commands are prefaced with an <Esc> character followed directly by a command (Cmd). After the command there can be zero or more parameter field (p1 and p2) where each field is separated by a space. The end of the message is signaled by the Checksum Delimiter character (*) followed by the checksum itself (cs). Finally, the command is terminated with a carriage return (<cr>).

A computer command example requesting the Model/Part/Revision numbers would look like this:

```
<Esc>RV*1234<cr>
```

All command responses are terminated with a checksum. The above command response would have this format:

```
E-FRM-DC, 82901, R1.0.1<cr><lf>  
FPGA, 82464, R1.0.0<cr><lf>  
Display, 82451, R1.1<cr><lf>
```

For a listing of all commands and their formats along with additional in depth Computer Communication details, consult the E-FRM-DC 7500 document available upon request from the Met One Instruments service department. See section 1.2.

8.2 Using a USB Flash Drive

The E-FRM-DC can copy data files directly to a user-supplied USB flash drive. This drive must be installed in the USB Drive port located inside the monitor. This USB Drive port is not used for any other purpose.

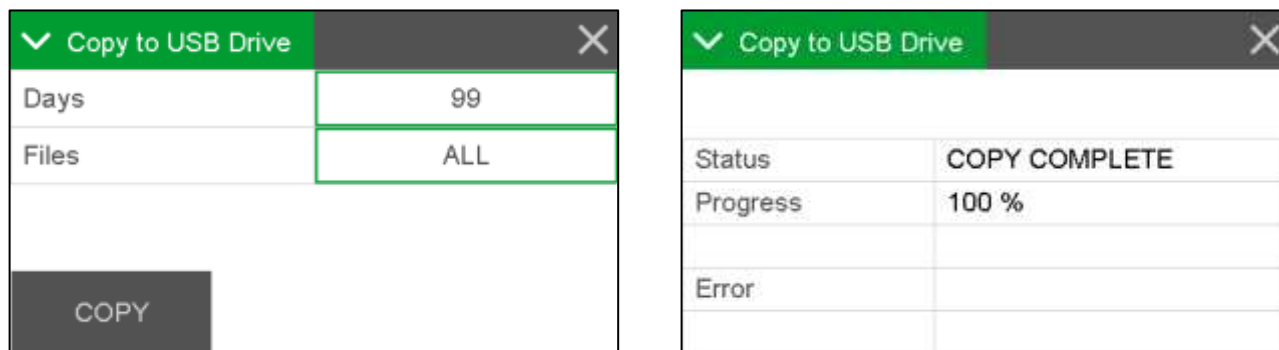


Figure 8-1 Data Transfer Interface Screens

1. Enter the Operate > Transfer Data menu (see Figure 8-1).
 - a. The Days field determines how many records will be downloaded. If it is necessary to change the number of days being copied, press the green bordered value box and the numerical entry keypad (Figure 4-6) will be displayed. Enter the number of days between 0 and 999 where 0 = All Days.
 - b. The FILES field determines whether all of the stored record types will be downloaded or only the user selected records. The USER files are ones which are used for all routine data collection purposes. The ALL option includes additional factory diagnostics files which are only used if data is being sent to Met One Instruments for factory support. The default setting is USER. If this field needs to be changed, press the green bordered value box and a list of the options available will be displayed. Tap the one required, and it will be applied.
2. Locate the USB Drive slot and insert a USB memory stick into it.
3. Press the grey COPY button to copy the selected data to the USB memory stick.

When the COPY COMPLETE message is displayed (see Figure 8-1), remove the USB memory stick and close the front door of the sampler.

8.3 Using FSCommAQ Software

Data can easily be retrieved from the E-FRM-DC directly to a PC using the included FSCommAQ software package. Simply establish a communication link between the sampler and the computer as described in section 8.1 and then follow the procedure outlined in the FSCommAQ manual. The software and manual are provided on a CD-ROM with the sampler. They are also available to download for free; contact the Met One Instruments, Inc. service department (see section 1.2) for more information.

9 SPARE PARTS and ACCESSORIES





9.1 Consumables, Replacement Parts, and Accessories

The following parts are available from Met One Instruments for maintenance, replacement, service, and upgrades. If unsure about a part, please contact the Service department and provide the serial number of the E-FRM-DC. Some of these parts require technical skills or special considerations before use or installation.



Consumables

Description	Part Number
Filter, 47MM, PM2.5 PTFE, FRM	460122
Filter Cassette, FRM, 47 MM	460128
Silicone O-Ring Grease, Mini Packet	995712
Fan Filter, Replacement, 5 Pack	560001




Temperature and Pressure Sensors

Description	Part Number	Graphic
Ambient Temp Sensor Assembly -30 to +50°C	80866-1	
Ambient Sensor Solar Shield	820471	
Pressure Sensor Circuit Board	80940-1	
Filter Temperature Sensor	82673-1	





Flow System Components

Description	Part Number	Graphic
Flow Sensor Assembly	970575	
Solenoid Valve	580191	
Inline Filter Assembly	580299	
Pump Assembly	83167	
Pump Diaphragm Rebuild Kit	82493	
Pump Head Rebuild Kit	82494	



Electrical & Electronic Parts

Description	Part Number	Graphic
Board Stack Assembly	82526-1	
Power Supply	82522	
Fuse, 8A	590854	


Inlet Components

Description	Part Number	Graphic
PM ₁₀ Size-Selective Inlet Head, EPA Specified	BX-802	
TSP Sampling Inlet, with insect screen	BX-803	
PM _{2.5} Sharp Cut Cyclone	BX-807	
PM _{2.5} Very Sharp Cut Cyclone (required for PM _{2.5} FEM monitoring)	BX-808	
PM _{2.5} WINS Impactor	BX-804	
O-Rings, BX-807 SCC Cyclone (set of 6)	720097	
O-Rings, BX-808 VSCC Cyclone (set of 8)	720105	
O-Ring kit for BX-802 PM ₁₀ Inlet Head (set of 3)	8965	
O-Ring, Inlet Tube Receiver, 2 required	720069	
O-Ring, PM ₁₀ Pass Through Adapter, 2 required	720084	



Calibration & Service Tools

Description	Part Number	Graphic
Flow Inlet Adapter Kit (Leak Test Valve) Includes short inlet tube adapter.	BX-305	
Volumetric Flow Calibration Kit (includes Flow, Temp, and Pressure Reference Standards)	BX-307	

Communications Options & Accessories

Description	Part Number	Graphic
FSCommAQ Software CD	82530	
USB Communication Cable, Type A-B Male	500784	
RS-232 Communication Cable	82459	

General Accessories

Description	Part Number	Graphic
Replacement Door Assembly	83164	
Fan, Circulation	590072	

Audit Sheet

Model:		Serial Number:	
Audit Date:		Audited By:	

Flow Audits			
Flow Reference Standard Used:	Model:	Serial No:	Calibration Date:
Temperature Standard Used:	Model:	Serial No:	Calibration Date:
Barometric Pressure Standard Used:	Model:	Serial No:	Calibration Date:

Leak Check Value: as found: lpm as left: lpm

Ambient Temperature:	as found:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">E-FRM-DC</th> <th style="width: 50%;">Ref. Std.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> </tbody> </table>	E-FRM-DC	Ref. Std.	C	C	as left:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">E-FRM-DC</th> <th style="width: 50%;">Ref. Std.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> </tbody> </table>	E-FRM-DC	Ref. Std.	C	C	N/A	<input style="width: 20px;" type="text"/>
E-FRM-DC	Ref. Std.													
C	C													
E-FRM-DC	Ref. Std.													
C	C													
Filter Temperature:	as found:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">E-FRM-DC</th> <th style="width: 50%;">Ref. Std.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> </tbody> </table>	E-FRM-DC	Ref. Std.	C	C	as left:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">E-FRM-DC</th> <th style="width: 50%;">Ref. Std.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> </tbody> </table>	E-FRM-DC	Ref. Std.	C	C	N/A	<input style="width: 20px;" type="text"/>
E-FRM-DC	Ref. Std.													
C	C													
E-FRM-DC	Ref. Std.													
C	C													
Barometric Pressure:	as found:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">mmHg</th> <th style="width: 50%;">mmHg</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">mmHg</td> <td style="text-align: center;">mmHg</td> </tr> </tbody> </table>	mmHg	mmHg	mmHg	mmHg	as left:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">mmHg</th> <th style="width: 50%;">mmHg</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">mmHg</td> <td style="text-align: center;">mmHg</td> </tr> </tbody> </table>	mmHg	mmHg	mmHg	mmHg	N/A	<input style="width: 20px;" type="text"/>
mmHg	mmHg													
mmHg	mmHg													
mmHg	mmHg													
mmHg	mmHg													
Flow Rate (Actual Volumetric):	as found:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">lpm</th> <th style="width: 50%;">lpm</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">lpm</td> <td style="text-align: center;">lpm</td> </tr> </tbody> </table>	lpm	lpm	lpm	lpm	as left:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">lpm</th> <th style="width: 50%;">lpm</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">lpm</td> <td style="text-align: center;">lpm</td> </tr> </tbody> </table>	lpm	lpm	lpm	lpm	N/A	<input style="width: 20px;" type="text"/>
lpm	lpm													
lpm	lpm													
lpm	lpm													
lpm	lpm													

Mechanical Audits

Fan filter clean:	as found	<input style="width: 20px;" type="text"/>	as left	<input style="width: 20px;" type="text"/>
PM ₁₀ particle trap clean:	as found	<input style="width: 20px;" type="text"/>	as left	<input style="width: 20px;" type="text"/>
PM ₁₀ drip jar empty:	as found	<input style="width: 20px;" type="text"/>	as left	<input style="width: 20px;" type="text"/>
PM ₁₀ bug screen clear:	as found	<input style="width: 20px;" type="text"/>	as left	<input style="width: 20px;" type="text"/>
PM _{2.5} particle trap clean:	as found	<input style="width: 20px;" type="text"/>	as left	<input style="width: 20px;" type="text"/>

Error Log					
Error	Date	Time	Error	Date	Time
1			4		
2			5		
3			6		

Audit Notes:
