



ARA LFR-6 Sampler

Operation Manual

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1 INTRODUCTION

ARA Instruments Mission

Our mission at ARA Instruments is to help environmental professionals make important air quality decisions by providing them with cost effective, accurate, and reliable instrumentation. Our air samplers and calibration instruments are used in outdoor ambient air quality applications as well as indoor and industrial uses.

Overview

In response to the need for a low cost alternative to traditional site-based particulate monitors, ARA Instruments has introduced the Low-Flow Research 6 LPM Sampler (LFR-6). It integrates with many additional components for unmatched versatility. The compact sampler collects 24-hour TSP, PM10, or PM2.5 filter samples and can simultaneously measure local meteorological parameters. It can also be equipped with a Real-Time Particulate (RTP) Profiler to log temporal particulate variations. For added versatility, the LFR-6 Sampler can be operated in directional wind sampling mode or meteorological mode.

The LFR-6 Sampler maintains accuracy, while costing a fraction of traditional site-based air samplers. Its compact size and battery-powered function, gives the LFR-6 Sampler many advantages over traditional air samplers. Deployment and relocation is quick and easy, and allows monitoring in locations that are inaccessible with traditional air samplers. Flexible mounting options allow for stand-alone support or the use of existing poles and structures. The ability of the LFR-6 to operate on rechargeable batteries also significantly reduces the cost of establishing a monitoring site.

The LFR-6 Sampler is designed for easy operation and maintenance. The intuitive user interface makes programming and calibrating the sampler simple. PM10 and PM2.5 inlets are field serviceable and require only monthly cleanings. Filter holders accept standard 47mm FRM cassettes for easy handling of various filter media. Batteries can be recharged in approximately 1-hour. Data log files with 5-min averages for all sensors can easily be downloaded to a USB Flash drive.

Cities and governments are deploying networks of LFR-6 Samplers to survey unmonitored areas and validate permanent Reference Method equipment. Researchers and consultants use the LFR-6 Sampler in air quality studies and environmental impact assessments. They are also utilized in industrial pollution applications, such as mines and quarries, and in large construction projects for fence line and roadside monitoring. The small and quiet LFR-6 Sampler is also a great tool for indoor and industrial workplace sampling that requires high accuracy.

The LFR-6 Sampler was designed to be the most versatile and cost-effective solution for air pollution research applications. Traditional filter based sampling methods provide an accurate measurement of particulate matter at a fixed location over a 24-hour period, and are used to determine compliance with national air quality standards. However, adding real-time meteorological and PM data gives air quality professionals a higher understanding of the data, which is crucial to designing effective control strategies. The LFR-6 Sampler has the capability of directional air sampling for fence line, roadside, or single source impact air quality investigations. Additionally, the LFR-6 can be used to “saturate” a study area with multiple samplers to obtain an accurate picture of spatial particulate distribution.

1.1 Principles of Operation

The LFR-6 Sampler is empirically designed to be a more compact version of EPA specifications for PM10 and PM2.5 air sampling at 6 LPM. The LFR-6 Sampler is a microprocessor-controlled portable air sampler, which can be operated manually or programmed to collect scheduled samples. As specified by the EPA, all critical air sampling parameters are continuously monitored and logged as time indexed 5-min averages to validate the sample. These parameters include: flow rate, temperature, barometric pressure, and accumulated volume. Other sampler related performance parameters are also logged. If the LFR-6 Sampler is equipped with the Real-Time Particulate (RTP) Profiler and meteorological sensors, then PM10, PM2.5, wind speed, and wind direction are also included in the data record.

The LFR-6 Sampler can be easily deployed. It can be mounted on a variety of structures using our universal mounting bracket that can be screwed, clamped, or attached to utility poles, trees, fence posts, etc. Another option is to use a freestanding tripod.

The LFR-6 Sampler is equipped to operate from either AC or DC power sources. In the DC mode, the sampler operates from an internal battery pack. A charged battery pack is capable of operating the sampler for about 30-40 hours. This robust capacity allows the sampler to be used in cold weather and high altitude applications. A charger is supplied so the batteries can be re-charged in approximately one hour.

1.2 Particulate Matter Sampling

The LFR-6 Sampler can be set up for TSP, PM10, or PM2.5 particulate sampling by configuring the sampling inlet components prior to the filter medium. To measure TSP, the omnidirectional Louvered Inlet is all that is required. For PM10 sampling, an FRM style inertial separator (PM10 Impactor) is added. To collect PM2.5, the sharp-cut ARA VIS-A Cyclone is attached, which physically selects particles 2.5 microns and below. Common LFR-6 inlet configurations are shown in FIG. 1.

The LFR-6 inertial separators (PM10 Impactor) are designed to operate at a nominal sampling rate of 6 LPM. The LFR-6 Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters.

To allow for unattended operation, the LFR-6 Sampler is easily programmed to initiate and stop sampling. For each sampling event, the LFR-6 Sampler generates a summary of important sampling parameters such as start and stop times, total sampling volume, and average ambient temperature and pressure as well as 5-min averages of all ambient and sampler operational parameters. The logged data file can be easily downloaded to a USB flash drive by the operator. The “csv” (comma separated value) file can easily be imported into a spreadsheet.

2 Hardware Description

2.1 PM10 Inlet

The ARA omnidirectional PM10 Inlet is a compact version of the EPA prescribed Reference Method Inlet, designed for 6 LPM. It features a screened inlet, wind deflector, and precision PM10 inertial separator (impactor) with moisture trap. The PM10 Inlet is designed to operate at 6 LPM. The inlet can be used alone for PM10 sampling or in combination with the ARA VIS-A sharp-cut vortex inversion separator for PM2.5.



2.2 PM2.5 Cyclone

The ARA VIS-A (Vortex Inversion Separator) is a precision engineered and compact sharp-cut cyclone fitted to the LFR-6 inlet that physically selects particles 2.5 microns and below. This ensures precise measurement of only the PM2.5 size fraction. The PM2.5 separator is designed to operate at 6 LPM and requires the ARA PM10 omnidirectional inlet to collect accurate PM2.5 samples.



2.3 Filter Holder

The aluminum filter holder is precisely manufactured for a tight seal and no contamination of the filter media. The filter holder is designed to use common EPA specified 47mm cassettes for PM2.5 sampling.



2.4 Flow Control System

The LFR-6 Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters. Under normal conditions the active flow control will maintain the sampling well within +/- 2%. If the sampling rate cannot be maintained within +/- 5% a flow error is generated and logged, and if the error continues for 5-minutes the sampler will shut down.

3 Initial Setup

3.1. Basic Assembly

When the LFR-6 Sampler arrives, please check to ensure all parts are accounted for and that no items were damaged during shipping. Please contact ARA Instruments immediately to report any damaged or missing parts.

Assemble the inlet for the desired sampling particle size. The configurations for TSP, PM10, and PM2.5 are shown in Figure 1.

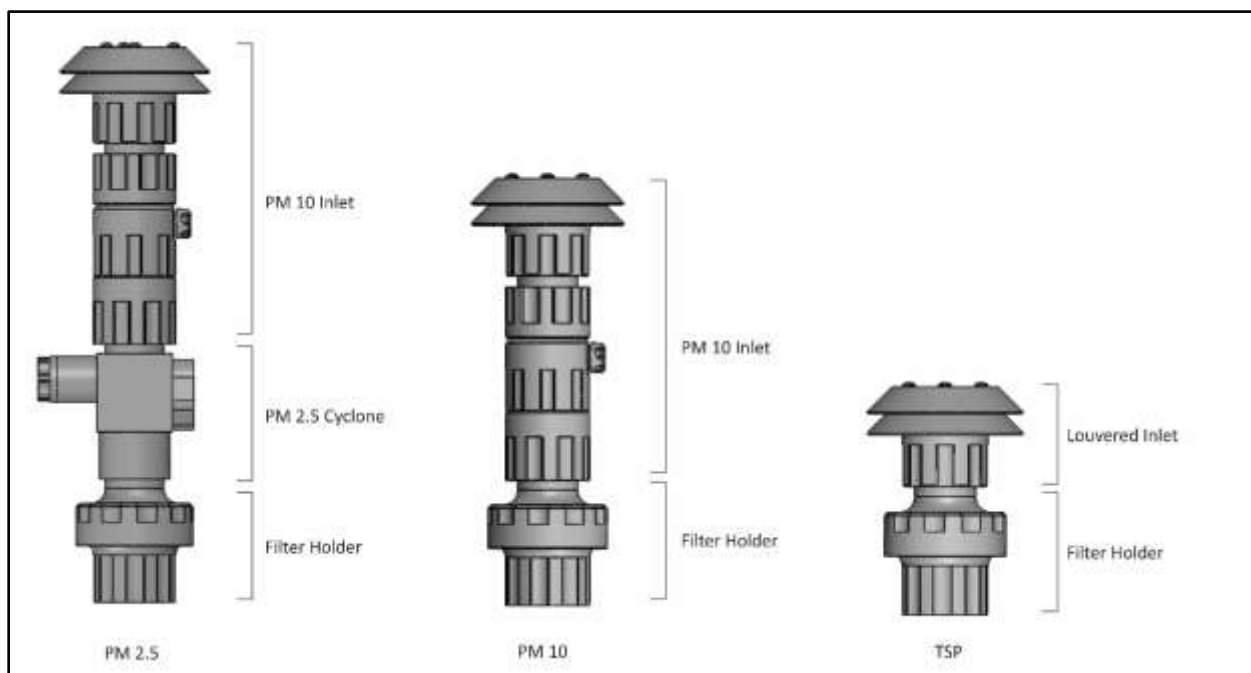


Figure 1. PM 2.5, PM 10, and TSP Configurations

3.2 Deployment

The LFR-6 Sampler is designed for easy deployment. Most air sampling siting guidelines recommend samples be taken in the normal breathing zone 3-5 meters above ground. To meet these requirements, the LFR-6 Sampler can be mounted on a Tripod or affixed to a stationary object like a fence post or utility pole using the Universal Mount Bracket. Both accessories are available from ARA. The Universal Mount (Figure 2) and Tripod (Figure 3) are shown to the right.



Figure 2



Figure 3

The LFR-6 is designed for secure mounting on any vertical round tubing support of 1.25 – 1.375 inches in diameter (30-35mm). A clamp screw located inside the sampler secures the LFR-6 to the support. Using the 3/16" Hex L-Wrench located on the battery holder, tighten the clamp screw to secure.

3.3 Power Source

3.3.1 Batteries

Each LFR-6 Sampler is equipped with two 18V/5Ah DeWalt lithium-ion batteries.

Check Battery Charge

Each battery has a Charge Gauge on the front, consisting of three green LED lights and a button. Press and hold the Charge Gauge button. The LED lights will illuminate designating the level of charge left. See Figure 4 to determine if your batteries need to be charged.

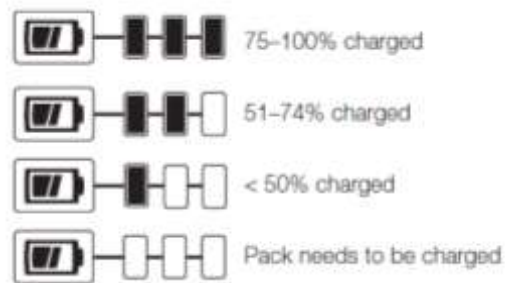


Figure 4. Battery Charge Levels

Charge Batteries

Plug the charger into an appropriate AC outlet. The charger provided by ARA Instruments is rated for 220VAC. If you prefer a 110VAC charger, we recommended DeWalt DCB105.

Insert the battery into the charger as shown in Figure 5. The red charging light will blink continuously, indicating the charging process has started. Batteries should be fully charged within 1 hour. Completion of the charging cycle is indicated by the red light remaining ON continuously. The battery is fully charged and may be used at this time or left in the charger.

The charger is designed to detect certain problems that can arise. Problems are indicated by the red charging light flashing at a fast rate. Try a different battery to determine if the charger is working properly. If the new battery charges correctly, then the original battery is defective and cannot be used.



Figure 5. Battery Charger

Please read all of the DeWalt instructions for the batteries and charger included with your sampler for more details about charging and storing batteries.

Install Batteries

Insert one charged battery into the LFR-6 Battery Holder. Make sure the batteries are fully seated and latched to the Battery Holder.

Insert the Battery Holder into the LFR-6 Sampler.

3.3.2 AC Power Supply

Each LFR-6 Sampler is also equipped with a 120/240V AC Power Supply to be used when an outlet is available.

3.3.3 Using Batteries and AC Power Supply



The AC Power Supply **does not** charge the batteries. The batteries can only be charged with the included Dewalt Battery Charger.

When both the AC Power Supply and Batteries are connected, the LFR-6 Sampler will run off the AC Power Supply. If the AC Power Supply is interrupted, the Batteries will take over until AC Power Supply is restored.

3.3.4 Solar Panel System

The LFR-6 Sampler utilizes a Zamp 24V Solar Panel System.

3.4 Powering LFR-6 Sampler On/Off

Place the Power ON/OFF Rocker switch at the lower right of the front panel of the air sampler in the **ON** position. The Sampler will boot up into the Home Screen. The default operational mode is **MODE:OFF**.

3.5 Navigation

Navigate through the menus by rotating the selector knob to highlight a desired selection. Press the knob to select. The menu system is intuitive, especially to those with air sampling experience. To exit any menu, rotate the selector knob to highlight the top item of all menus and select **EXIT. MODE: OFF** takes you back to the Home Screen.

3.6 Sleep Mode



The LFR-6 Sampler enters power saving “sleep mode” after a few minutes of no input from the selector knob. In this mode, the LCD screen is blank. To wake up the LFR-6 Sampler, press and hold the selector knob for 3-seconds.

3.7 Setting Time and Date

On the Home Screen, confirm that the date and time are accurate. If necessary, follow these steps to set the correct Time and Date:

- Select **SETUP** from the Home Screen
- Scroll down, highlight **SYSTEM SETUP** and select
- Scroll down, highlight **DATE/TIME** and select
- Scroll down until the Day is highlighted and select
- Rotate the selector knob until the correct date is highlighted and select
- Repeat for Month, Year, Hour, Minute, and Second
- Select **DATE/TIME:EXIT**
- Select **YES** to save Date/Time
- Select **SYSTEM:EXIT** and then **SETUP:EXIT** to return to Home Screen

3.8 Installing a Filter



Note: This procedure should take place in a laboratory or clean area. Contact and handling of all filter media should be limited to the non-exposed outer edge with smooth tipped forceps (non-serrated) or plastic tipped forceps. Filter media should never be handled with fingers.

- Unscrew the Filter Holder Top from the Filter Holder Bottom
- Remove Filter Cassette
- Use ARA Cassette Separator to open the cassette. The top and bottom of the Filter Cassette are machined for a press fit. The Filter Cassette Top has a large beveled interior edge. See Figure 7 for appropriate use of Cassette Separator.



Warning: Manually prying the cassette apart with fingers can result in the cassette violently opening, causing damage to filter media or support screen.



Figure 7. Open 47mm Cassette

- With forceps, place a pre-weighed, clean filter media onto the Support Screen in the Filter Cassette Bottom. Install the Filter Cassette Top, firmly and evenly pressing down to complete the assembly.
- Place the Filter Cassette into the Filter Holder and reassemble by firmly screwing together the Filter Holder Top and Filter Holder Bottom.

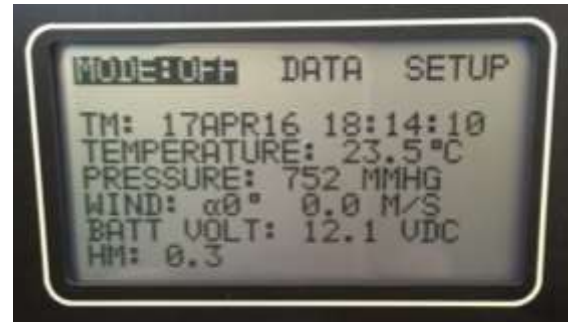
Note: Cassettes can be handled with fingers. Make sure not to touch filter media.

4 Operational Overview

4.1 Home Screen

Once the LFR-6 Sampler is powered ON, the Home Screen appears. The Home Screen displays the Time, Temperature, Barometric Pressure, Wind Speed, Battery Voltage, and Hour Meter (Total Pump Operating Hours).

There are three menu selections across the top of the Home Screen: OFF, DATA, SETUP. These are the Administrative Modes.



4.2 Operational Modes

4.2.1 Mode: OFF

When the LFR-6 Sampler is powered on, Mode: OFF is the default setting.

Select this administrative mode to move between the Operational Modes: OFF, ON, MET, PROGRAM, SECTOR and REMOTE.

4.2.2 Mode: ON

Select to manually turn the LFR-6 pump ON.

4.2.3 Mode: MET

Select to view and log current meteorological parameters and particle sensor data if the Wind Sensor and RTP Profiler are installed. In this mode, data logging begins after 5 minutes. The pump will not run in **MET MODE**.

4.2.4 Mode: PROGRAM

Select to set the sampler to run at user-defined parameters: time, date, duration, interval, and flow rate. This mode logs all standard parameters, in addition to real-time particle data and meteorological data (if installed).

4.2.5 Mode: SECTOR

Select to set the pump to run only when the wind direction is from a user-defined sector. **Mode: SECTOR** is only applicable when the Wind Sensor is installed.

4.2.6 Mode: REMOTE

Select this mode to set the sampler to run only when remote jumper connections are shorted.

4.3 Data

The **DATA** administrative mode allows the user to view or erase summaries of the last few sampling events.

VIEW SUMMARIES – In this selection, the last 10 sampling events are stored and organized by Start Time. The summary data for each event is viewed by scrolling down the LCD screen. To change and view other events, scroll and select **ST** (start time and date). Each press of the selector knob changes the event data to view.

EXPORT LOG – Scrolling to the bottom of the **VIEW SUMMARIES** screen and selecting **EXPORT LOG** allows the user to export a summary, including 5-minute averages of sensor data and sampling parameters of the selected event to a USB flash drive.

ERASE ALL SUMMARIES – Selecting this option allows the user to erase all sampling event data. Note: It is not necessary to erase summaries. The newest sampling event will overwrite the oldest summary data once the maximum has been reached.

4.4 Setup

The **SETUP** administrative mode has various options relating to the sampler program and system setup.

SET PROGRAM: Allows the user to set the program for the next sampler run. Instructions that are more specific can be found in Section 5.1.1.

CLEAR ALL DATA: Will delete all sampler runtime data.

EXPORT SETUP: Using USB drive, the user can download sampler settings.

IMPORT PROGRAM: A program may be imported from the USB drive.

SYSTEM INFO: Lists sampler information, including the Serial Number and latest Firmware version.

UPDATE FIRMWARE: With the correct file on a USB drive the user can update the firmware of the sampler. The latest firmware is available on the ARA Instruments website – www.arainstruments.com

SYSTEM SETUP: This menu allows the user to set the date and time and other sampler parameters.



DATE/TIME: User can set the current date and time. **Note: When the sampler battery is removed, the sampler will hold the current date and time for approximately two weeks.**

FLOW RATE: User can turn the pump on and off and set the flow rate. This mode is useful for flow audits and calibration. There is a user adjustable SLOPE and INT (Intercept) if flow calibration is needed.

AMBIENT TEMPERATURE: This mode allows the user to turn ON or OFF the ambient temperature sensor if desired. If turned OFF the sampler defaults to a user adjustable, standard temperature of 25° C. The user can also enter an offset for calibration purposes.

BAROMETRIC PRESSURE: This mode allows the user to turn ON or OFF the ambient pressure sensor. If turned OFF the sampler defaults to a user adjustable, standard pressure of 760 mmHg. The user can also enter an offset for calibration purposes.

STANDARD TEMP PRESS: This mode allows the user to adjust the standard temperature and pressure used to calculate “standard” flow and volume, and also the default conditions if the temperature and/or ambient pressure sensors are turned off.

LCD BRIGHTNESS: Allows adjustment of the LCD backlight.

RESTORE DEFAULTS: Will set sampler back to factory defaults (***be cautious in using this option since it will erase all calibration data***).

BLUETOOTH CONTROL: For future use.

PARTICLE COUNTER: The LFR-6 Sampler comes with default mass values for PM2.5 and PM10 particulates. Users can adjust these values proportionally to match their local aerosol characteristics.

BOOT HISTORY: This mode is for troubleshooting firmware issues.

REBOOT: Will reboot the sampler.

5 Operating the LFR-6 Sampler

5.1 User-Defined Programming

5.1.1 Creating a Program to Operate at a Specific Time Interval

There are two methods to view the **SET PROGRAM** screen.

Method 1: On the Home Screen, highlight **SETUP** and select by pushing the selector knob. Scroll down to **SET PROGRAM** and select.

Method 2: On the Home Screen, highlight **MODE: OFF** and select. Rotate the knob until **MODE: PROGRAM** is highlighted and select. Scroll down to **ST** (start date and time) and select to open the **SET PROGRAM** page.

You can now select the fields you desire to edit as you setup the sampler to run:

CLEAR PROGRAM: Select this option if you want to clear the current program. This is not necessary but can be helpful if you plan to change most of the parameters.

SAMPLE ID: A unique 4-digit ID can be entered but is not necessary. Sometimes used to identify site or filter media.

START: Select this option to enter the Start Date and Time. Scroll to the field that you would like to edit and push to edit. Turn the selector knob to choose the desired date or time variable, then select and continue to scroll through the fields until the START Date and Time are set as desired.

DURATION: Select this option to enter the duration of the sample event. Enter hours and minutes by turning the selector knob and pushing to edit the desired field.

INTERVAL: This option is used to setup a repeating sample event. Enter the hours and minutes from the end of the programmed run that you would like the event to repeat. An entry of 72:00 would repeat the sample every 72 hours. For a single non-repeating event set the INTERVAL to 00:00.

SET FLOW: Use this field to set the desired flow for the programmed event. The nominal flow rate for ARA PM10 and PM2.5 inertial separators is 6 LPM.

SECTOR: This field can be set to have the sample event turn off and on when the wind direction is in a desired sector.

5.1.2 Running a Program

To activate the sampler at the programmed time and interval the sampler must be set to the Program Operational Mode.

On the Home Screen, select **MODE: OFF**. Rotate the knob until **MODE: PROGRAM** is highlighted and select.



The LCD screen displays **TM** (current date and time) and **ST** (start date and time) of the programmed event. Confirm that these parameters are correct and leave the sampler in Program Mode.

5.1.3 Ending a Program

After a programmed sampling event, the sampler remains in **MODE: PROGRAM** unless manually changed.

Highlight **MODE: PROGRAM** at the top of the LCD screen and select. Rotate the selector knob until **MODE: OFF** is highlighted and select. The Home Screen will appear.

5.2 Meteorological Functions

If the Wind Sensor is installed, the LFR-6 Sampler will log 5-minute averages of wind speed and wind direction throughout any run in any Operational Mode (MODE:ON, MODE:MET, MODE:PROGRAM, MODE:SECTOR, and MODE:REMOTE).

Note: In order for wind speed and wind direction to be recorded in the data file, the wind speed must be greater than 0.5 m/s.

If the user only wants sampling to occur at defined wind directions, **MODE: SECTOR** must be used:

5.2.1 Sector Mode (Directional Sampling)

From the Home Screen, select **SETUP**. Scroll down and select **SET PROGRAM**. Enter desired start time, duration, and flow rate as explained in Section 5.1.1. At the bottom of the menu, the user can set the **SECTOR** of wind direction at which the sampler will turn on and log data.

The alpha (α) value is the centerline azimuth direction, and the theta (θ) value is the size of the central angle. For example, if the sector azimuth (α) was set to 90 degrees, and the central angle (θ) was set to 40 degrees the sampler would turn on only when the wind direction was between 70 and 110 degrees.

5.2.2 Start a Sector Run

From the Home Screen, select **MODE: OFF**. Turn the selector knob and select **MODE: SECTOR**.

The LFR-6 Sampler will begin testing at the date and time defined in the **SET PROGRAM** menu. In this mode, sampling will only occur when the wind is within the prescribed sector for 5 minutes, at a wind speed above 0.5 m/s.

5.3 Real-Time Particulate (RTP) Profiler

If the Real-Time Particulate Profiler is installed, the LFR-6 Sampler will log real-time particulate data throughout any run using any Operational Mode (MODE:ON, MODE:MET, MODE:PROGRAM, MODE:SECTOR, and MODE:REMOTE).

5.3.1 Accuracy

The RTP Profiler uses a Plantower low-cost light scattering sensor. It is intended to be used as a profiler to show trends during the sample run. Because it is an inexpensive optical sensor, it does have sensitivity and response limitations.

On the 5-min data output file, P1 and P2 correlates to PM2.5 and PM10 raw output data (counts/0.01 cubic feet). A zero (0) value indicates a count below the sensor's limit of sensitivity. The sensor is most accurate when PM2.5 concentrations are greater than 10 $\mu\text{g}/\text{m}^3$ and accuracy can be improved by calibrating the sensor for local aerosol conditions.

5.3.2 Calibrating the RTP Profiler

The LFR-6 Sampler comes with default mass values for PM2.5 and PM10 particulates. Users can adjust these values proportionally to match their local aerosol characteristics, which can greatly improve accuracy.

Adjustments can be made by calculating a new default mass value for PM2.5 or PM10:

1. Perform a standard PM2.5 (or PM10) 24-hour sample run, while simultaneously running the RTP Profiler.
2. On the data output file, determine the PM2.5 Average by calculating the average of all 5-minute data in the PM2.5 column.
3. Determine the correction factor:

$$\text{Correction Factor} = \frac{\text{Filter Method Concentration } (\mu\text{g}/\text{m}^3)}{\text{Sensor PM2.5 Average } (\mu\text{g}/\text{m}^3)}$$

4. On the sampler, select **SETUP** from the Home Screen. Select **SYSTEM SETUP**, scroll down, and select **PARTICLE COUNTER**. The default mass values can be adjusted under **PM2.5M** and **PM10M**. (Note: The default nominal mass value is 4 for **PM2.5M** and 64 for **PM10M**)
5. Determine the new PM2.5M Conversion Value:

$$\text{PM2.5M Conversion Value} = \text{Correction Factor} * \text{Current PM2.5M Conversion Value}$$

6. Highlight and select **PM2.5M** on the Sampler and enter the new PM2.5M Conversion Value.

To improve accuracy:

- Use a data set with PM2.5 concentrations greater than 10 $\mu\text{g}/\text{m}^3$.
- Avoid using data below the sensor's limit of sensitivity (P1=0).
- Repeat this process using multiple sample runs.

5.4 View Summaries

A summary of the programmed event can be viewed and downloaded by selecting **DATA** from the Home Screen. Scroll down until **VIEW SUMMARIES** is highlighted and select. The LCD screen shows the **ST** (start date and time) of the last programmed event and the important sample parameters. *Note: Repeated selecting of **ST** will scroll through the last three sample events.*

- Sample Duration, hrs:min
- Sample Volume, cubic meters (at sampling conditions)
- Average Sample Flow Rate, LPM
- Average Ambient Temperature, °C
- Average Barometric Pressure, mm-Hg
- Error Codes, if any
- Sample Volume, cubic meters (at standard conditions for PM10 sampling)
- Starting Battery Voltage
- Ending Battery Voltage

5.5 Export Data

In the **VIEW SUMMARIES** menu, select **EXPORT LOG**. Follow the prompts and insert a USB Flash Drive.



Warning: The USB port has low power capabilities. Plugging in devices other than USB Flash Drives, such as cell phone chargers and portable hard drives, can damage the port. The best option for data removal is using a USB 2.0 Flash Drive.

The LOG file is a CSV (Comma Separated Value) file suitable for import into a Spreadsheet Program for viewing, printing, and analyzing. In addition to the summary of key sampling parameters at the top, the file contains time delimited 5-minute averages of all sensors for analysis and sample validation. See Figure 8 for an LFR-6 Sampler CSV file imported into Excel.

DATE	TIME	SECONDS	LPM_SET	LPM_ACT	VOL_M3	VOL_STD	TEMP_AIR(AVG)	WIND_AZ	WIND_SP(VOLTS)	AWP5	TEMP_PRT(P)	P2	PMS1	PMS2	FLUID				
20-Jul-18	13:25	300	16.7	16.75	0.084	0.082	27.7	754	0	0	17.8	0.101	95.1	0	0	0	0	NONE	
20-Jul-18	13:30	300	16.7	16.7	0.107	0.105	27.3	754	0	0	17.8	0.107	91	0	0	0	0	0	NONE
20-Jul-18	13:35	300	16.7	16.7	0.211	0.206	26.4	754	0	0	17.8	0.105	91.4	0	0	0	0	0	NONE
20-Jul-18	13:40	300	16.7	16.7	0.316	0.310	26.6	754	0	0	17.8	0.109	91.8	0	0	0	0	0	NONE
20-Jul-18	13:45	300	16.7	16.7	0.420	0.413	25.9	754	0	0	17.8	0.105	91.4	0	0	0	0	0	NONE
20-Jul-18	13:50	300	16.7	16.7	0.525	0.492	26.1	754	0	0	17.8	0.102	91.7	0	0	0	0	0	NONE
20-Jul-18	13:55	300	16.7	16.7	0.630	0.571	26.9	754	0	0	17.8	0.102	91.8	0	0	0	0	0	NONE
20-Jul-18	14:00	300	16.7	16.7	0.735	0.652	29.7	754	0	0	17.8	0.11	91.1	0	0	0	0	0	NONE
20-Jul-18	14:05	300	16.7	16.72	0.752	0.734	29.8	754	0	0	17.8	0.11	91.3	0	0	0	0	0	NONE
20-Jul-18	14:10	300	16.7	16.72	0.855	0.818	29.6	754	0	0	17.8	0.11	91.3	0	0	0	0	0	NONE
20-Jul-18	14:15	300	16.7	16.7	0.959	0.896	30.1	754	0	0	17.8	0.175	91.8	0	0	0	0	0	NONE
20-Jul-18	14:20	300	16.7	16.71	1.062	0.879	29.8	754	0	0	17.8	0.175	91.9	0	0	0	0	0	NONE

Figure 8. CSV file imported into Excel

The LOG file name is an 8-digit number designated as 'NNNNJJJH'.

NNNN = Last 4 digits of Sampler serial number

JJJ = Start day of sampling event , Julian (Ordinal) Day Number (Example: February 5th = 36)

H = Start hour of sampling event, Letter (Example: 2 a.m. = B)

The following is a description of the sampling parameters found in the exported LOG file:

PARAMETER	DESCRIPTION
DATE	Sample Date (Day-Month-Year)
TIME	Sample Time Interval (5 minute averages)
SECONDS	Interval Time (seconds)
LPM_SET	Set Flow Rate (actual liters per minute)
LPM_ACT	Actual Flow Rate (actual liters per minute)
VOL_M3	Actual Volume (cubic meters, accumulated)
VOL_STD	Volume Using Standard Conditions (cubic meters, accumulated)
TEMP_EXT	External Temperature (degrees Celsius)
MMHG	Barometric Pressure (mmHg)
WIND_AZ	Wind Azimuth (degrees)
WIND_MPS	Wind Speed (meters per second)
VOLTS	Battery Voltage
AMPS	Battery Amps
TEMP_INT	Internal Temperature (degrees Celsius)
P1	Raw Sensor Output (counts/.01 cubic feet)
P2	Raw Sensor Output (counts/.01 cubic feet)
PM2.5	Estimated Concentration (micrograms per cubic meter)
PM10	Estimated Concentration (micrograms per cubic meter)
FLAGS	NONE – No errors during sampling B – Battery failed, not enough voltage F – Flow rate could not be maintained W – Wind direction is in programmed sector A – Amps are too high. Possible pump failure.

6 Maintenance

6.1 Servicing Schedule

Frequency	Maintenance
Weekly:	Service Water Trap
Monthly:	Clean PM10 Inlet, PM2.5 Cyclone, Filter Holder, and RTP Profiler Inspect O-Rings Perform Leak Check Perform flow, temperature, pressure, and clock verification
Annually:	Replace PM10 Inlet, PM2.5 Cyclone, and Filter Holder O-Rings Pump Rebuild Perform flow, temperature, and pressure calibrations

6.2 Service Water Trap

Water Trap should be serviced weekly during regular sampling use. Unscrew the Water Trap Plug from the Impactor and remove any moisture that has been collected.



6.3 Clean PM10 Inlet, PM2.5 Cyclone, and Filter Holder

Supplies needed:

- 7/64" hex driver
- Phillips screwdriver
- Lint-free wipes
- Silicone lubricant or Armor-All
- Mild soap and warm water

6.3.1 Cleaning PM2.5 Cyclone

1. Using a 7/64" Hex Driver, remove the Cyclone Bypass



2. Carefully unscrew the Collection Cup and Cone



3. Remove all O-rings (take note of which O-rings fit to each part)
4. Soak the Cyclone Body, Bypass, Cone, and Cup in warm water with mild soap
5. Remove any visible deposits with a lint-free wipe
6. Rinse all parts with residue-free water or distilled water
7. Set out parts to air dry (a rinse with acetone or ethanol will speed the drying process)
8. Inspect O-rings for wear and replace as needed
9. Lubricate all O-rings with silicone lubricant
10. Reassemble cyclone parts in reverse order

Note: Do **NOT** use any abrasive cleaning pads. Cyclones are precision manufactured parts and their performance may be altered by very minor scratches.

6.3.2 Cleaning PM10 Inlet

1. Unscrew Inlet Adaptor, Impactor Bottom, Impactor Top, PM 10 Jet, Water Trap Plug, and Louvered Inlet



2. Using a Phillips screwdriver, remove the three (3) screws securing the upper louvered disc and cone
3. Remove the louvered upper disc, cone, and screen (it is not necessary to remove standoffs)
4. Remove all O-rings (take note of which O-rings fit to each part)
5. Soak all parts in warm water with mild soap
6. Remove any visible deposits with a lint-free wipe
7. Rinse with residue-free water or distilled water
8. Set out parts to air dry
9. Inspect O-rings for wear and replace as needed
10. Lubricate all O-rings with silicone lubricant
11. Reassemble cyclone parts in reverse order
12. Note: Do **NOT** use any abrasive cleaning pads. All parts are precision manufactured and their performance may be altered by very minor scratches.

6.3.3 Cleaning Filter Holder

1. Unscrew Filter Holder Top from Filter Holder Bottom



2. Remove 47mm Cassette
3. Using an ARA Cassette Separator, carefully separate the 47mm Cassette into two pieces and remove the filter screen



4. Soak Filter Holder Top, Filter Holder Bottom, Cassette Top, Cassette Bottom, and filter screen in warm water with mild soap
5. Remove any visible deposits with a lint-free wipe
6. Rinse with residue-free water or distilled water
7. Set out parts to air dry
8. Inspect O-rings for wear and replace as needed
9. Only lubricate the bottom two (2) O-rings which secure the Filter Holder to the sampler with silicone lubricant
10. Do **NOT** lubricate the two (2) O-rings securing the 47mm Cassette, as it may contaminate the sample



11. Reassemble filter holder parts in reverse order

Note: Do **NOT** use any abrasive cleaning pads. All parts are precision manufactured and their performance may be altered by very minor scratches.

6.4 Clean RTP Profiler Filter

1. Remove the two screws on the RTP Enclosure and remove the lower half.



2. Use a squeeze bulb duster to remove any dust on the sensor, similar to the one shown below.



3. From the Home screen select **MODE: OFF** and turn the selector knob until **MODE: MET** is highlighted. Press the selector to knob to turn on MET Mode which will run the RTP sensor.
4. Aim the squeeze bulb at the 4 small inlet holes and also the 4 slots for the outlet fan. Note: RTP Enclosure does not need to be removed from the sampler case.



5. Once completed, turn the sampler into **MODE: OFF** and secure the lower half of the RTP enclosure.

6.5 Replace O-Rings

PM10 Inlet, PM2.5 Cyclone, and Filter Holder O-rings should be replaced yearly. Be sure to lubricate any O-rings with a silicone lubricant before assembling. The only exception are the Filter Holder O-rings securing the 47mm cassette. These should **NOT** be lubricated as the grease may contaminate the sample. They are manufactured from fluoropolymer materials that do not require lubrication. Contact ARA Instruments for information on replacement O-ring kits.

6.6 Pump Rebuild

Pumps should be rebuilt after one (1) year of sampling or approximately 3000 hours of sampling. Diaphragms, valves, and bearing should be replaced. Contact ARA Instruments about purchasing a pump rebuild kit with detailed instructions. Pumps may also be rebuilt and assessed at our facility.

6.7 Leak Checks

Dynamic Leak Check:

From the Home Screen, select **SETUP**. Scroll down and select **SYSTEM SETUP**. Scroll down and select **LEAK CHECK**. The sampler will automatically zero the flow sensor for maximum accuracy. To run the check: and scroll down to **PUMP: OFF** and press the selector knob to turn on the pump. Then block off the inlet to the sampler with a calibration adapter, stopper, etc.. The display shows the leak rate in LPM and the pressure drop across the flow sensor. The leak rate should stabilize in a few seconds. ARA recommends a maximum allowable leak rate of 1% (0.06 LPM). To end the test press the selector knob to turn off the pump.

Static Leak Check:

If using an ARA Calibration Adapter or a vacuum gauge attached to the sampler inlet, you can perform a static leak check. This check is normally used to troubleshoot leaks, but is also a way to check on the nominal performance of the pump. To run the static check follow the same steps as for the dynamic leak check above, and when you shut off the pump, observe the vacuum gauge. A healthy pump should draw over 8 in.Hg vacuum. Observe the vacuum gauge for 20 seconds, and if the vacuum reading drops less than 3 in.Hg /20sec. the leak rate is acceptable and indicates a healthy pump. A pump that fails the leak check or does not generate at least 8 in.Hg indicates a system leak, or mechanical problem with the pump, such as dirty valves, etc. Note: This check is mainly used for troubleshooting and maintenance, it is not a required sampling or QC check.

Note: Both leak checks generate about 10 times the vacuum of normal sampling. Rapidly releasing the vacuum can damage filter media. To avoid sample loss, ARA recommends using filter media that will not be used for sampling for conducting leak checks.

7 Calibration

In conformance with US-EPA guidance, we recommend LFR-6 Samplers be calibrated yearly. Please contact ARA Instruments for more information on calibration services.

Calibration Using an ARA FTS Flow Calibrator can be found in **Appendix A**.

8 Troubleshooting

Problem	Solution
In MODE: PROGRAM, the LFR-6 Sampler will not start at the defined time and date.	<p>The LFR-6 Sampler time and date may be incorrect. On the Home Screen, verify that the Date and Time are correct.</p> <p>These parameters are only stored in the LFR-6 Sampler for a few weeks so they may need to be defined again.</p> <p>To make changes, select SETUP → SYSTEM SETUP → DATE/TIME.</p>
The Actual Flow Rate is much lower than the Set Flow Rate.	<p>There may be a leak. Contact ARA Instruments on how to do a leak check.</p> <p>The pump diaphragms and valves may also be dirty. See Section 6 to determine proper cleaning techniques.</p>
The screen is blank but the power switch is still ON.	<p>The Sampler will go into Sleep Mode after a period of inactivity to conserve battery power.</p> <p>Push down on the selector knob for a few seconds and the screen will become active.</p>
When a programmed run begins, the sampler doesn't turn on or consistently stalls.	<p>On the SET PROGRAM screen, ensure that a value has been given to the Duration.</p>

9 Warranty Policy

At ARA Instruments we pride ourselves on high quality workmanship and materials. All equipment manufactured by ARA Instruments is under warranty for one year, from the date of shipment, for parts and labor. Equipment not manufactured by ARA Instruments is covered by the warranty of its manufacturer, which includes Lithium-Ion Batteries and Chargers.

At our discretion, ARA Instruments will either repair or replace defective equipment at no charge during the warranty period for equipment proven defective at our facility. Acknowledgement and approval must be received from ARA Instruments prior to shipping equipment (prepaid) to our facility.

If the purchaser, its employees, or other users do not handle, operate, and install the equipment according to our instruction, the purchaser will assume all liability for its consequences and the warranty will be void. ARA Instruments is not liable for loss, damage, or injury to property or persons for the installation, operation, use, misuse, nonuse, repair, or replacement of equipment.

Upon use of this equipment, the purchaser agrees to all terms issued in this warranty. No other express warranty is given by ARA Instruments.

If equipment becomes damaged or defective, please consider the following:

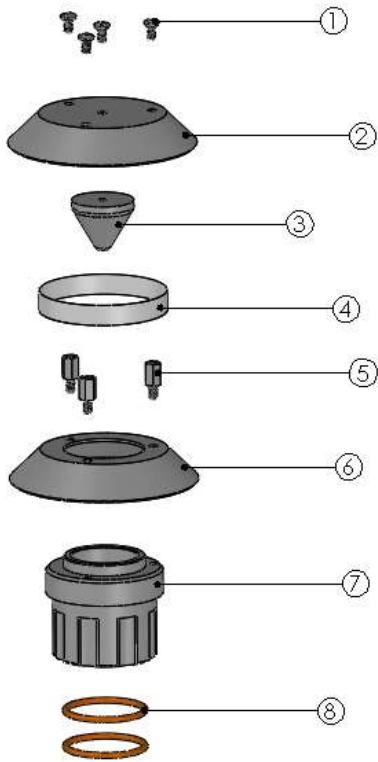
- Call ARA Instruments about the problem
- Obtain approval from an ARA Instruments technician to return damaged equipment
- Package equipment very carefully with sturdy packaging
- Include a packing slip with all items clearly marked
- Include Name, Address, and Phone Number

Ship To:

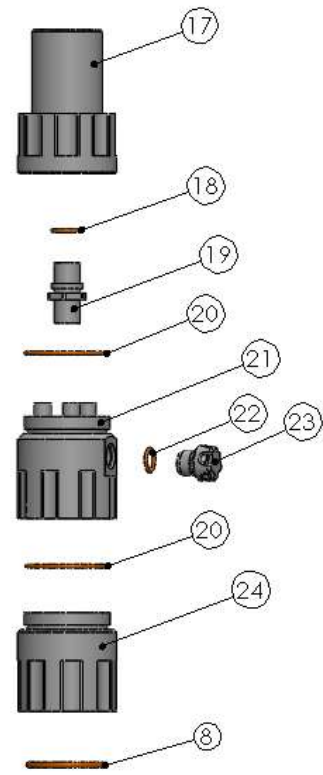
ARA Instruments
90 Hillview 1 – Bldg 2
Eugene, OR 97408, USA
541.844.1686
sales@arainstruments.com

10 Parts List

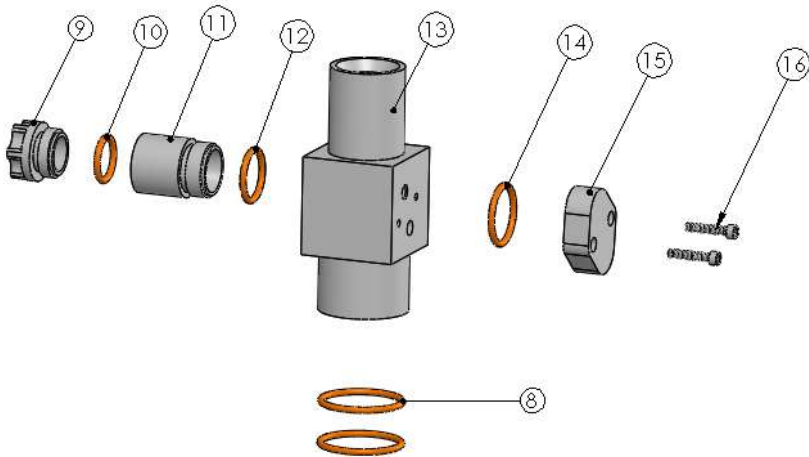
PM 10 Louvered Inlet Assembly



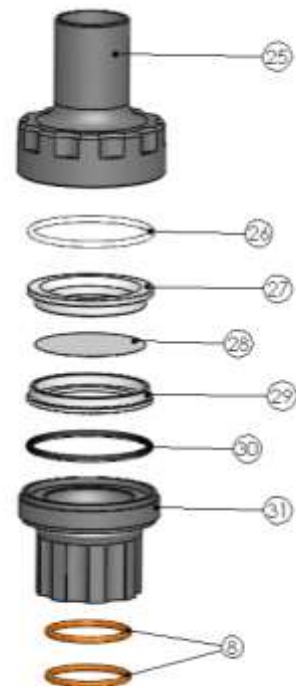
PM 10 Impactor Assembly



PM 2.5 Cyclone Assembly

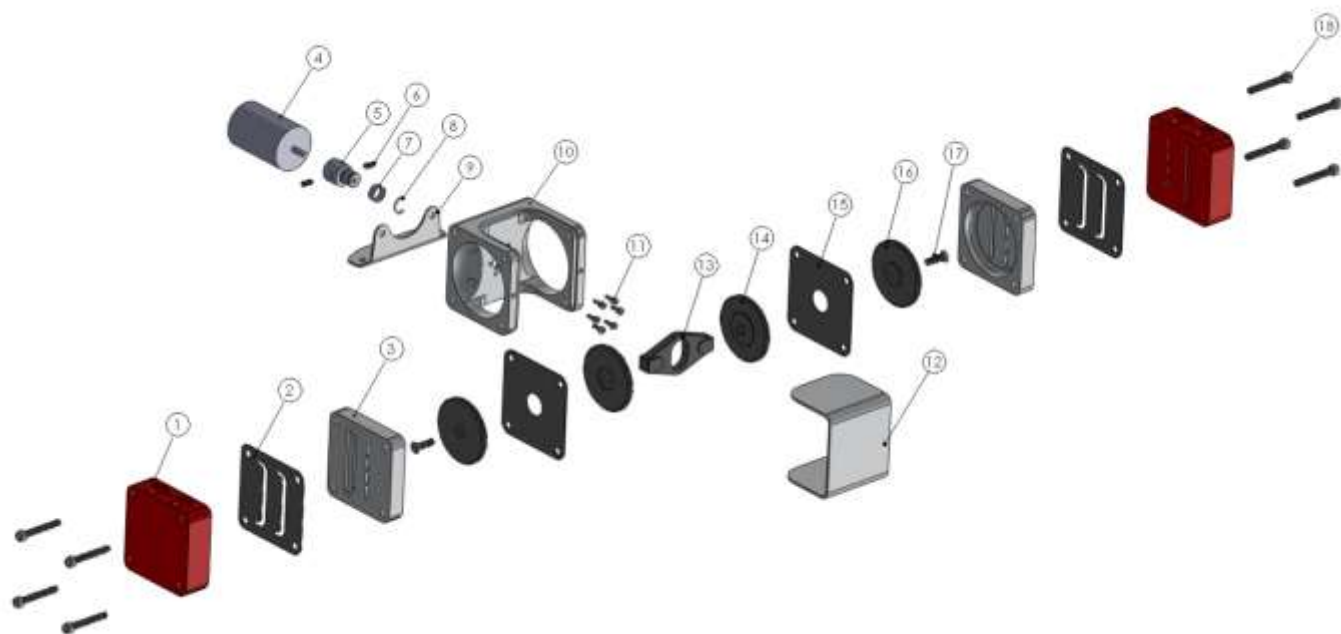


Filter Holder Assembly



NO.	PART
1	6-32 x ¼" Pan Head Phillips Screw
2	Louvered Inlet Disc - Upper
3	Louvered Inlet Deflector Cone
4	Bug Sreen
5	6-32 x 3/8 " M/F Round Standoff
6	Louvered Inlet Disc - Lower
7	Louvered Inlet Body
8	O-Ring, S70, 124
9	6 LPM Cyclone Cup
10	O-Ring, S70, 114
11	6 LPM Cyclone Cone
12	O-Ring, S70, 116
13	6 LPM Cyclone Body
14	O-Ring, S70, 118
15	6 LPM Cyclone Bypass
16	6-32 x 3/8" Socket Cap Screw
17	Jet Body
18	O-Ring, S70, 013
19	6 LPM PM10 Jet
20	O-Ring, S70, 028
21	Impactor Body
22	O-Ring, Buna, 1.5 x 8.5
23	Water Trap Plug
24	Impactor Adaptor
25	Filter Holder Top
26	O-Ring, Teflon, 135
27	47mm Filter Cassette Top
28	Cassette Support Screen
29	47mm Filter Cassette Bottom
30	O-Ring, Viton, 135
31	Filter Holder Bottom

148 Pump Assembly



NO.	PART
1	Pump Head (Right and Left)
2	Pump Valve
3	Pump Cylinder
4	Motor
5	.05 Cam
6	4-40 x 3/16" Set Screw
7	Bearing
8	5/16" C-Clip
9	Pump Mount Bracket
10	Pump Body
11	3mm x 8mm Socket Cap Screw
12	Pump Cover
13	Yoke
14	Piston Bottom
15	Pump Diaphragm
16	Piston Top
17	6-32 x 1/2" Flat Head Phillips Screw
18	6-32 x 1 1/4" Socket Cap Screw

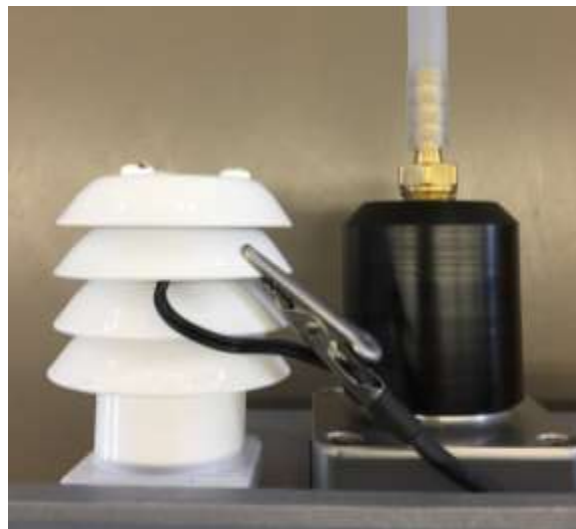
Appendix A: Calibration Using an ARA FTS Flow Calibrator

Use the *Quality Control Form* located on the last page to record data easily in the field.

Calibrate Temperature

On the LFR-6 Sampler Home Screen select **SETUP** and then select **SYSTEM SETUP**. Scroll down and select **AMBIENT TEMPERATURE** and then select **OFFSET**. Change the value to **0.000** and select **YES** to save changes.

Place the tip of the FTS Temperature Sensor into the louvers and attach the clip onto the LFR-6 Sampler temperature radiation shield. Allow the sensors enough time to equilibrate before recording the Indicated Temperature (sampler) and Actual Temperature (FTS). Determine the difference between the Indicated Temperature and Actual Temperature to be used as the offset value.



$$\text{OFFSET} = (\text{FTS Temp}) - (\text{LFR-6 Temp})$$

On the LFR-6 Sampler Home Screen select **SETUP** and then select **SYSTEM SETUP**. Scroll down and select **AMBIENT TEMPERATURE** and then select **OFFSET**. Change the value to the desired offset, calculated above and select **YES** to save changes.

Calibrate Barometric Pressure

On the LFR-6 Sampler Home Screen select **SETUP** and then select **SYSTEM SETUP**. Scroll down and select **BAROMETRIC PRESSURE** and then select **OFFSET**. Change the value to **0.000** and select **YES** to save changes.

Record the Indicated Barometric Pressure (LFR-6) and the Actual Barometric Pressure (FTS). Determine the difference between the Indicated Barometric Pressure and the Actual Barometric Pressure to be used as the offset value.

$$\text{OFFSET} = (\text{FTS Barometric Pressure}) - (\text{LFR-6 Barometric Pressure})$$

On the LFR-6 Sampler Home Screen select **SETUP** and then select **SYSTEM SETUP**. Scroll down and select **BAROMETRIC PRESSURE** and then select **OFFSET**. Change the value to the desired offset, calculated above and select **YES** to save changes.

Calibrate Flow Rate

To calibrate an LFR-6 Sampler, a multi-point calibration must be performed in order to determine the calibration factors. These values can then be entered manually into the LFR-6 Sampler.

FTS Calibrator:

- Select **MODE:HOME** and rotate the selector knob to select **MODE:FLOW**
- With no flow running through the VFD, select **ZERO** to zero the sensors
- After using the **ZERO** function, AMB FLOW, and STD FLOW should be 0.00 LPM. If not, select **ZERO** again to re-initialize the sensors.
- Connect the FRM adapter to the sampler inlet. The other end of the hose should be connected to the VFD outlet (right side).

LFR-6 Sampler:

- From the Home Screen select **SETUP**
- Scroll down, select **SYSTEM SETUP**, and then select **FLOW RATE**
- Select **SLOPE**, turn knob to set slope to **1.000**, and select **YES** to save changes
- Select **INTERCEPT**, turn knob to set intercept to **0.000** and select **YES** to save changes
- Select **SET FLOW** and adjust to **5.0** and select **YES** to save changes
- Select **PUMP:OFF** to turn the pump **ON**
- Allow the pump to run for a few minutes until the FTS Gas Temperature stabilizes
- Record the **IND. FLOW** from the LFR-6 Sampler and the **AMB. FLOW** from the FTS Flow Calibrator
- Repeat the above steps, adjusting the **SET FLOW** to 5.5, 6.0, 6.5, and 7.0.

Calculations:

For easy calculations, our *Calibration Worksheet* Excel file is available for download on the Support page on our website, www.arainstruments.com/support, or you can create your own.

Input the Indicated Flow Rate and Actual Flow Rate values into the spreadsheet. Determine the Slope and Intercept.

	A	B	C	D	E	F
21	Calibration Information					
	Set Flow Rate	Indicated Flow (Sampler)	Actual Flow (Reference)	Percent Difference	Adjusted Flow	Percent Error
22						
23	5.0	4.99	5.11	-2.35	5.12	-0.24
24	5.5	5.5	5.64	-2.48	5.64	0.09
25	6.0	5.98	6.12	-2.29	6.12	0.03
26	6.5	6.49	6.66	-2.55	6.63	0.44
27	7.0	7.01	7.13	-1.68	7.15	-0.33
28	Post Cal 6.0	5.98	6	-0.33		
29						
30	Slope	1.006				
31	Intercept	0.103				
32	Enter These Calibration Constants Into Sampler @					
33	SETUP>SYSTEM SETUP>FLOW RATE					
34						

Figure 9. Determine Slope and Intercept in Excel.

Change the Slope and Intercept on the LFR-6 Sampler:

- From the Home Screen select **SETUP**
- Scroll down, select **SYSTEM SETUP**, and then select **FLOW RATE**
- Select **SLOPE** and turn knob to desired value
- Select **YES** to save changes
- Select **INTERCEPT** and turn knob to desired value
- Select **YES** to save changes

QUALITY CONTROL FORM

SITE INFORMATION

Location: _____ Sampler: _____ Serial No: _____
 Tech: _____ Flow Rate Standard: _____ Serial No: _____
 Date: _____ Temperature Standard: _____ Serial No: _____
 Time: _____ Pressure Standard: _____ Serial No: _____

MAINTENANCE SCHEDULE

Weekly:	Service Water Trap
Monthly:	Clean PM10 Inlet, PM2.5 Cyclone, Filter Holder, and RTP Profiler Filter Inspect O-Rings Perform Leak Check Perform flow, temperature, pressure, and clock verification
Annually:	Replace PM10 Inlet, PM2.5 Cyclone, and Filter Holder O-Rings Rebuild Pump Perform flow, temperature, and pressure calibrations

AUDIT RESULTS

ACTION	INDICATED (Sampler)	ACTUAL (FTS)	% DIFFERENCE	CONTROL LIMITS
Flow Rate (LPM)				4%
Ambient Temp. (°C)				± 2°C
Barometric Pressure (mmHg)				±10 mmHg
Clock Time				±2 min/mo
Leak Check				0.00 LPM

Comments: _____

MULTI-POINT CALIBRATION

SET FLOW (LPM)	INDICATED FLOW (Sampler)	ACTUAL FLOW (FTS)
5.0		
5.5		
6.0		
6.5		
7.0		

	INITIAL	FINAL
SLOPE:		
INTERCEPT:		