San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

AIR MONITORING PROGRAM

STANDARD OPERATING PROCEDURES
FOR
Teledyne Advanced Pollution Instruments (API)
Model 602 Beta^{PLUS}
Particulate Measurement System

First Edition
September 2016

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

APPROVAL OF STANDARD OPERATING PROCEDURES (SOP)

Title:	Teledyne Advanced Pollution Instruments Model 602 Beta^{PLUS} Particulate Measurement System
SOP:	First Edition – September 2016
Section:	Air Monitoring Program
Department:	Strategies and Incentives Department
Workgroup:	Strategies and Finance Workgroup
Prepared by:	Mike Fard, Air Quality Instrument Specialist Joshua Fine, Air Quality Instrument Technician Nathan Trevino, Supervising Air Quality Instrument Technician
Approval:	This SOP has been reviewed and approved by:

Jon Klassen
Program Manager
Air Monitoring Program

9/23/16
Date

TABLE OF CONTENTS

1 BACKGROUND: 1
1.1 INTRODUCTION: 1
1.2 PRINCIPLE OF OPERATION: 1
1.3 SAFETY PRECAUTIONS: 1
1.4 INTERFERENCES/LIMITATIONS: 2
1.5 EQUIPMENT AND SUPPLIES: 3
2 INSTALLATION: 3
2.1 TOOLS AND SUPPLIES: 4
2.2 PHYSICAL INSPECTION: 4
2.3 INSTRUMENT LOCATION: 5
2.4 CENTRAL UNIT: 6
2.5 MASS MEASUREMENT SYSTEM SAFETY LOCK: 7
2.6 DRILLING INLET/TEMPERATURE TUBE HOLES: 8
2.7 INLET/TEMPERATURE SUPPORT HARDWARE: 8
2.8 SAMPLE INLET TUBES: 8
2.9 FILTER CASSETTE LOADING: 9
2.10 FILTER CASSETTE UNLOADING: 11
2.11 REFERENCE FILTERS: 12
2.12 SPY FILTERS: 13
2.13 VACUUM PUMPS: 14
2.14 CONDENSATE COLLECTOR: 15
2.15 SMART HEATERS: 16
2.16 SAMPLE INLETS: 16

2.17 SAMPLE NOZZLES: 16
2.17.1 CHANGING INLET NOZZLE PROCEDURE: 17
2.18 AMBIENT TEMPERATURE SENSOR: 18
2.19 AIR COMPRESSOR: 18
2.20 DATA LOGGER: 19
2.21 BATTERY: 19
3 CONFIGURATION: 19
3.1 DATE AND TIME: 19
3.2 OPERATING MODE: 20
3.3 SAMPLING AND MEASUREMENT PARAMETERS: 21
4 CALIBRATION: 21
4.1 INTRODUCTION: 21
4.2 OVERVIEW: 21
4.3 TOOLS: 21
4.4 PROCEDURES: 22
4.4.1 SPAN TEST (FLOW CHECK) 22
4.4.2 MASS MEASUREMENT SYSTEM (BETA SPAN TEST) 27
4.4.3 BAROMETRIC PRESSURE 36
4.4.4 AMBIENT TEMPERATURE 38
4.4.5 ZERO TEST 38
5 VERIFICATION: 39
5.1 FLOW RATE: 39
5.2 AMBIENT TEMPERATURE: 40
5.2.1 FRONT PANEL: 40
5.2.2 602BETAPLUSMANAGER.NET: 40

5.3 BAROMETRIC PRESSURE VERIFICATION: 41
5.3.1 FRONT PANEL: 41
5.3.2 602BETAPLUSMANAGER.NET: 41
5.4 FILTER TEMPERATURE SENSOR VERIFICATION: 41
5.5 FILTER %RH SENSOR VERIFICATION 43
5.6 FILTER PRESSURE SENSOR VERIFICATION 44
5.7 LEAK: 45
5.7.1 LEAK TEST (MANUAL): 45
5.7.2 LEAK TEST (AUTOMATIC): 46
5.8 BETA SPAN TEST (AUTOMATIC) (STATUS: READY): 47
5.9 TIME AND DATE: 48
6 SAMPLING: 48
6.1 START SAMPLING: 48
7 ROUTINE SERVICE CHECKS: 49
7.1 STATUS: 49
7.2 CONDENSATE COLLECTORS: 49
7.3 LOADER MAGAZINE STATUS: 50
7.4 LOAD NEW FILTERS: 50
7.5 USED SAMPLE FILTER SPOTS: 51
7.6 SERVICE AIR PRESSURE: 51
7.7 SHELTER TEMPERATURE: 51
7.8 WARNINGS & ALARMS: 52
7.9 FILTER PRESSURE DROP: 52
7.10 COLLECT TEMPERATURE: 52
7.11 BATTERY TEST: 52

8 MAINTENANCE: 53
8.1 PARTICULATE SIZE SELECTIVE INLET DISMANTLING & Cleaning: 53
8.1.1 US EPA PM10 INLET: 54
8.1.2 PM10 PRE-IMPACTOR ON PM2.5 LINE B: 54
8.1.3 BGI PM2.5 VSCC™: 55
8.2 ROTARY VANE VACUUM PUMP REBUILD (1st GENERATION PUMP) 55
8.3 CLEANING INLET NOZZLES: 57
9 TROUBLESHOOTING: 59
10 REFERENCES 59
11 APPENDIX 60

1 BACKGROUND:

1.1 INTRODUCTION:

The purpose of this Standard Operating Procedure (SOP) is to document the procedures used by the San Joaquin Valley Air Pollution Control District (District) to operate the Teledyne Advanced Pollution Instruments Model 602 Beta^{Plus} Particulate Measurement System (TAPI 602). The goal of this SOP is to provide a consistent reference to which site operators can refer for the operation, maintenance, and calibration of the TAPI 602 instruments in the District's air monitoring network. Maintaining consistency of these activities across the network will ensure the validity and comparability of the data collected from the instruments operating in the District's region. This SOP will be amended on an as needed basis as the procedures for the operation, maintenance, and calibration of these instruments change over time.

1.2 PRINCIPLE OF OPERATION:

The TAPI 602 is a system used for sampling and mass measurement of suspended particulate matter on the reference filters. Mass measurement is carried out using an internal low-activity ß radiation source. The instrument consists of three basic components: the analyzer unit, the sampling filters and the pneumatic components. Each component is self-contained and may be easily disconnected for servicing and replacement.

The TAPI 602 uses beta ray attenuation to calculate collected particulate mass concentrations in units of $\mu g/m^3$. Carbon-14 (^{14}C) emits low energy levels of beta radiation and as this radiation passes through matter, it will cause the intensity to diminish or become attenuated. Using two independent sampling paths the TAPI 602 will collect suspended particulate matter from the ambient air on two glass fiber filters. In a standard setup, the TAPI 602 is configured with one channel collecting particulate matter ≤ 10 µm and the other ≤ 2.5 µm.

1.3 SAFETY PRECAUTIONS:

Only properly trained personnel should perform TAPI 602 instrument testing, installation, operation, maintenance and calibration procedures. The District's qualifications for personnel hired to work on the air monitoring network include experience in principles and techniques of electronics, experience in working with analytical instruments, and general understanding of physics and chemistry. Personnel interacting with the TAPI 602 should be familiar with the key components required for the operation of the sampler, the menu options within the interface, and proper filter handling. Personnel are expected to receive

approximately 1-2 months of training under an experienced technician before operating the TAPI 602 sampler independently.

As with all monitoring equipment, precautions should be taken when working around electricity, power tools and above ground elevations. Avoid the use of chemical agents which might cause damage to components. To avoid electrical shock, prior to cleaning or performing any maintenance on the TAPI 602 instrument, place the Main power switch to OFF and unplug the 115 volt AC power cord.

The ^{14}C radioactive beta source should never be dismantled, removed or tampered with. It will never be necessary for any of the District's staff to adjust, replace, or touch the ^{14}C source. All ^{14}C issues will be handled by the manufacturer either under warranty or at the District's cost. The beta radiation source does not pose a danger to the technician when installed by Teledyne API. The radiation source is installed and tested by Teledyne API under NRC and state of California licensing requirements. The source is not user serviceable and can only be accessed through use of a specialized tool only available to Teledyne API personnel trained in its use.

1.4 INTERFERENCES/LIMITATIONS:

Moisture: The TAPI 602 is a mass analyzer, and therefore any component that is suspended in the 47mm glass fiber filters and attenuates beta rays will subsequently affect the average mass value for that hour. Moisture in the ambient air can affect both instrument performance and hourly average mass values. Moisture is removed by the condensate first and then by the smart heater on each sample line.

Condensate Collector: The condensate collector resembles a small silver aluminum can mounted in line on each sample inlet line. See Installation - Condensate Collector for more details.

Smart Heater: The Smart Heater resembles a small black aluminum can mounted on each sample inlet line with the temperature controls being set in the TAPI 602 settings. See Installation – Smart Heater for more details.

Spy Filters: The spy filters are used as filter blanks and should only be changed if the lot number changes on the filters being used. By using the "spy filters" technique, the TAPI 602, allows one to collect good quality mass concentration

data, provided that filters with a high structural homogeneity are chosen (e.g. "Whatman Schleicher & Schuell QF20 Ø 47mm" filters) See Installation – Spy Filters for more details.

Reference Filters: The reference filters are supplied with the instrument and look like aluminum foil sandwiched inside a disk with a medium center hole and two small holes at the edge opposite each other. See Installation – Reference Filters for more details.

47mm Glass Fiber Filters: The glass fiber filters are very delicate and can be easily torn or gouged. Handle carefully by the edges. Damaged filters should be discarded, but the TAPI 602 has built if reference checks that will discard the filter by advancing it through the instrument if it does not meet quality checks. See Installation – Filter Cassette Loading and Unloading for more details.

Power Supply: The TAPI 602 requires a 115 volt 10.0 amp power supply to handle both pumps and smart heater operating at maximum capacity.

Parts Replacement: The District will use factory specified replacement parts or factory equivalent.

1.5 EQUIPMENT AND SUPPLIES:

The following items listed are required for the operation and maintenance of the TAPI 602 instrument: silicone spray grease, shop towels, certified flow meter, 47mm glass fiber filters, tweezers, protective gloves, non-abrasive cleaner, tap water, soft brush, cotton swabs, and for remote connectivity capability, serial cable, PC with Windows OS and serial port, and 602 Beta^{PLUS} Manager.Net software.

2 INSTALLATION:

The TAPI 602 installation procedures have been separated into the following areas.

- List of Tools/Supplies
- Physical Inspection
- Siting
- Installation of Central Unit
- Drilling Inlet/Temp Tube Holes
- Attaching Inlet/Temp Support Hardware

- Filter Cassette Loading
- Pump(s) Connections
- Outside Temperature Connection
- Compressor Connection
- Data Logger Connection

2.1 TOOLS AND SUPPLIES:

- Hole Saw/bits
- Weatherproof silicone or roof sealant
- Ethernet cable
- Serial Cable
- Tape (i.e. transparent adhesive or masking)
- Lag screws (4) adequate for roof penetration mounting
- Shelf, fixed or siding with 79 lbs capacity minimum
- Plumb bob
- Drill cordless
- Screwdriver
- Socket set
- Flow standard with current certification for 16.7 LPM
- Temperature Standard with current certification

2.2 PHYSICAL INSPECTION:

Upon receipt of TAPI 602, inspect instrument and all associated components for damage. If any damage is found, document it with digital pictures and report it immediately to the Air Monitoring Program Supervisor or his/her designee if he/she is not present.

NOTE: The TAPI 602 should never be moved unless the Mass Measurement System Safety Lock is enabled. Potential damage can occur if the Mass Measurement System Safety Lock is not enabled. See section 2.5 MASS MEASUREMENT SYSTEM SAFETY LOCK.

List of TAPI 602 Components:

1) TAPI 602 Central Unit
2) (2) Vacuum Pumps
3) Air Compressor
4) Filter Cassette Loader Magazine
5) Filter Cassette Unloader Magazine
6) (100) Filter Cassettes: 50 black-white and 50 white-white

7) (200) Glass Fiber Filters
8) (2) Multi-time Inlet Nozzles (not shown)
9) (2) HEPA filters
10) (2) Condensation Collectors
11) Inlet Tubing
12) PM10 FRM inlet
13) PM10 FRM inlet (European)
14) PM2.5 Very Sharp Cut Inlet
15) (2) Smart Heaters
16) Inlet Support Brackets
17) Vacuum Pump Tubing
18) Ambient Temperature Sensor
19) Ambient Temperature Cable (5m)
20) Ambient Temperature Solar Radiation Shield
21) Power Cords
22) Small Accessories Bag
23) Operating Manual
24) Quick Start Guide

2.3 INSTRUMENT LOCATION:

The TAPI 602 instrument has specific physical requirements that should be considered prior to installation. In addition, all of the District's TAPI 602 instruments should be deployed in accordance with 40 CFR Part 58 Appendix E PM2.5 requirements to ensure data continuity. The TAPI 602 central unit is neither waterproof, nor water-resistant and must be protected from moisture. The TAPI 602 was designed to operate in a temperature-controlled environment (between 0℃ and 50 ℃), with relative humidity not condensing. All TAPI 602 will be deployed inside a weather proof and temperature controlled structure. The effort to maintain a consistent temperature for the TAPI 602 throughout each day is to ensure a baseline quality database by limiting the number of unknown variables that may exist within California's Ambient Monitoring Network.

In general, when choosing the location for TAPI 602, it may help to consider the following items:

1) Inlet radius clearance: The TAPI 602 sample inlet must have a one (1) meter radius free of any objects that may influence airflow characteristics, including the airflow of other instruments. For example, if a TAPI 602 is to be installed at a station with a PM2.5 FRM or FEM filter instrument, the inlets of each instrument must be no less than one (1) meter apart from each other. If

installing near a PM10 SSI HiVol instrument, then the distance between the inlets of the TAPI 602 and the HiVol must be no less than two (2) meters.

2) Inlet height: The height of the inlet should be equal to the height of the inlet for all (FRM) particle instruments or the large round PM10 impactor on the SSI HiVol.

3) Overhead Clearance: A minimum of 40” clear from the ceiling to the shelf on which the TAPI 602 is to be placed is required. This distance is to accommodate the removal and installation of the filter cassette magazines that connect on the top of the TAPI 602 instrument.

4) Inlet: The straight, vertical inlet tubing limits the placement of the TAPI 602 central unit. The inlet tubing is 1” OD, rigid aluminum tube. The lower end of the inlet tube should be connected via coupler to the condensate collector then another coupler to the inlet adaptor with the smart heater on it. The other end of the inlet tube points vertically through the ceiling of the containing structure. The selected particle size inlets are mounted on the upper end of the inlet tube. The FRM PM10 head should be installed 2 meters (approx. 6’) above the roofline. Provisions must be made during installation to allow for future removal, maintenance, and re-installation of all equipment.

NOTE: Total inlet tube length should not exceed more than 16’.

2.4 CENTRAL UNIT:

The TAPI 602 central unit can be placed on any flat level surface with a minimum capacity of 79lbs. As with all instrumentation installations, racks, tables, or fixtures must be secure and the overall installation must protect both the instrument and personnel. Because the TAPI 602 connector fitting for the inlet tubes is located on top of the central unit, installation of the TAPI 602 does not allow for instruments to be mounted above it. Wherever the TAPI 602 is installed, space for vertical position of inlet tubes, inlet hardware, filter cassette magazines, and smart heaters must be taken into account.

FIGURE 1: CENTRAL UNIT

2.5 MASS MEASUREMENT SYSTEM SAFETY LOCK:

The Mass Measurement System Safety Lock is enabled when shipped from the factory. Before powering on the instrument, it is necessary to disabled the Mass Measurement System Safety Lock. Each time the TAPI 602 is transported the Mass Measurement System Safety Lock *must* be enabled..

To disable the Mass Measurement System Safety Lock:

1) Open the front panel of the instrument
2) Unplug the female connector from the lock board
3) Plug the female connector into the male connector labeled “Geiger” on the MOTEV board
4) Close the front panel of the instrument

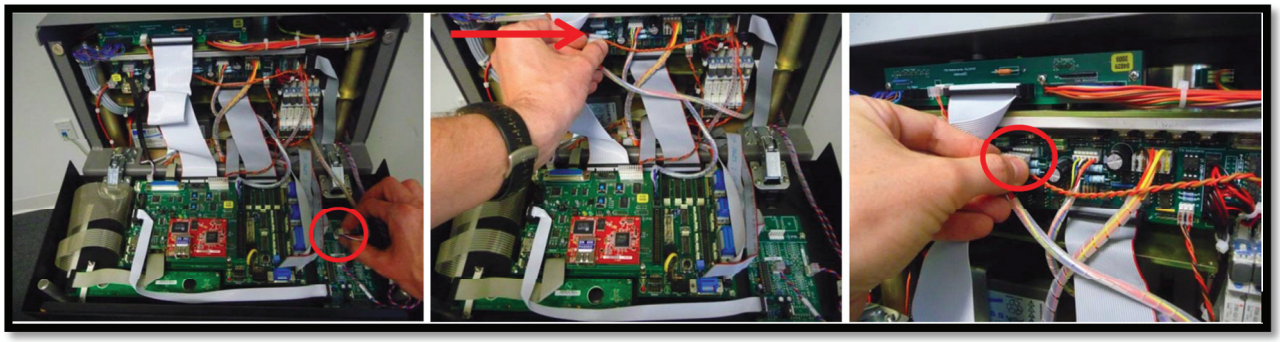


FIGURE 2: MASS MEASUREMENT SYSTEM SAFETY LOCK

2.6 DRILLING INLET/TEMPERATURE TUBE HOLES:

Applications may vary due to structural and material makeup. Forethought may help alleviate problems and frustration. After locating a suitable place for the TAPI 602 central unit, the holes for the TAPI 602 inlet tubes and ambient temperature tube can be drilled. Protect instrument from falling debris. The inlet support hardware includes a rooftop mounting plates for stations with a flat roof.

Inside ceiling hole: The hole on the inside of the enclosure should be 2.5” diameter to accommodate the inlet tubes. Use an appropriate size hole saw. A plumb bob is used to help locate the ceiling hole location. If the roof has a hollow portion then use an extra-long pilot bit to drill through both the ceiling and the roof. Use the hole saw to drill from each side into the hollow portion of the enclosure.

Outside roof hole: The hole on the outside of the enclosure should be the same size as the interior hole. Using the pilot hole drilled from the inside center the hole saw and drill.

2.7 INLET/TEMPERATURE SUPPORT HARDWARE:

Assemble the inlet mounting plate and then attach the four down leg supports. Use 4 lag screws to secure the legs to the enclosures roof while applying adequate amount of sealant to weatherproof. Attach the roof inlet coupler to roof with 4 screws per roof inlet coupler with adequate amounts of sealant for weather proofing.

Assemble quadrapod using supplied hardware, legs, and cross plate. Locate the quadrapod directly above the sample tube holes, and up against the sample tubes. Attach the three tubes to the cross bar of the quadrapod using the supplied hardware. Be sure the Sample Inlet Tubes are directly upright. Secure the quadrapod to the roof using a combination of 2” deck screws and roof sealant. Be sure to completely cover the screws with roof sealant. Allow the roof sealant to dry for several hours (follow the roof sealant instructions).

2.8 SAMPLE INLET TUBES:

The instrument sample tubes inside the shelter to the main unit should always be kept insulated and away from the direct exhaust of HVAC (blowing hot or cold air) in order to avoid possible damage to the equipment’s Sample Line Heater Control because the instrument contains a sample line heater on each flow channel.

There are a total of two sample tubes that are used for Line A and B with one additional line for the ambient temperature sensor communications cable. The PM10 sampling on Line A is approximately 15” taller than the inlet for PM2.5 sampling on Line B. All three tubes are supported by the cross bar attached to the quadrapod.

2.9 FILTER CASSETTE LOADING:

Filter cassettes must be loaded in order to perform most operational tests.

1) Separate the filter cassettes with the TAPI Filter Cartridge Separator Tool or by hand.

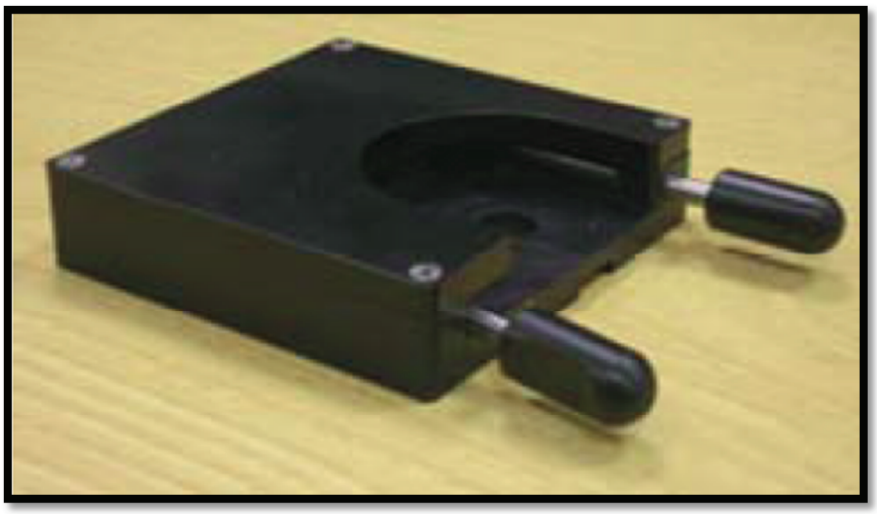


FIGURE 3: FILTER CARTRIDGE SEPERATOR TOOL

2) To use the filter cartridge separator tool, insert the filter cassette into the slot within the tool with the small hole side of the filter cassette down.
3) Squeeze the handle together and the filter cassette will separate.
4) Remove both parts of the separated filter cassette. If a glass fiber filter is present then use either clean hands, powder-free latex gloved hands, nitrile gloved hands, or tweezers to remove the glass fiber filter.

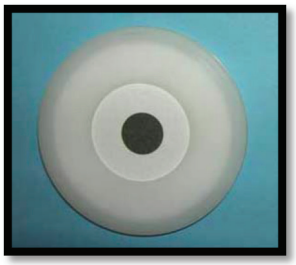


FIGURE 4: FILTER CASSETTE WITH USED GLASS FIBER FILTER

5) Place the filter cassette with small portion flat side down and the large hole portion flat side down on a clean surface.

FIGURE 5: FILTER CASSETTES SEPERATED & EMPTY

6) Place a new glass fiber filter rough side down towards the small hole of the filter cassette with tweezers or by a clean hand or a powder-free latex or nitrile gloved hand as long as the glass fiber filter is handled by the edges.

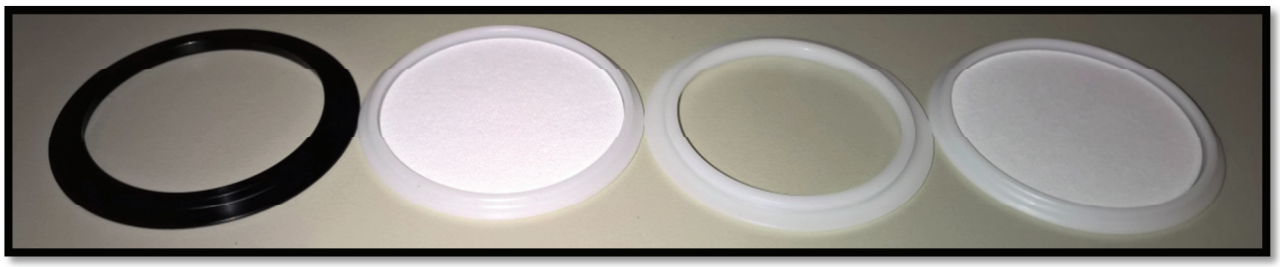


FIGURE 6: *FILTER CASSETTES SEPERATED & GLASS FIBER FILTER LOADED*

7) Place the large hole portion of the filter cassette flat side up over the glass fiber filter.
8) Push down on the filter cassette around the edge until the cassette snaps closed. Continue doing this for all filter cassettes to be loaded.

FIGURE 7: FILTER CASSETTES CLOSED

9) Flip the filter cassettes over so the small hole face-up. Stack the filter cassettes on the appropriate filter loading accessory alternating between black-white and white-white filter cassettes.

FIGURE 8: FILTER CASSETTES STACKED

10) Remove the filter cassette loader magazine from the main control unit by turning counter-clockwise until it stops then lift it out of the main control unit.
11) Slide the filter cassette loader magazine over the stacked filters.

Note: Filters can be added to the loader magazine at any time including during sampling without stopping sampling.

Note: Minimum 8 filters needed in loader filter magazine to begin operating.

12) Insert the cassette filter loader magazine into the main control unit lining up the notches and grooves. The cassette filter loader magazine should drop into main control then turn it clockwise till it locks and the “Locked” “LOADER” light is illuminated green.

NOTE: The instrument will consume 6 filters per day in hourly mode when both channels are in operation.

NOTE: The Model TAPI 602 BETA*PLUS* currently only carries US EPA FEM designation when using glass fiber filters. The EPA approved Model TAPI 602 BETA*PLUS* Particle Measurement System is used for hourly mass concentration measurement (monitoring networks, etc.) at 1 m^3/h operating flow rate only.

2.10 FILTER CASSETTE UNLOADING:

After each filter has completed either 8 sequential runs (a.k.a. Accumulation steps) or a filter pressure drop of 50 kilopascals (kPa), the instrument will move the filter to the filter cassette unloader magazine. At maximum, every 16 days the unloader magazine will need the filter cassettes removed.

1) Turn the unloader filter cassette magazine counter-clockwise and lift out of main control unit.
2) Remove cap off of filter unloader cassette magazine.

3) Quickly turn over the Unloader cassette magazine.
4) Keep the Unloader magazine in a vertical & upside-down position and place it on a flat surface.
5) Carefully lift the unloader filter cassette magazine upward trying to keep the filters in one stack. Place the unloader filter cassette tube right tide up on the flat surface next to the stack.
6) Remove filters from the plunger at the bottom of the stack.
7) Place plunger back in unloader filter cassette magazine and replace cap.
8) Insert the unloader filter cassette magazine into the main control unit lining up the notches and grooves.
9) Turn unloader filter cassette magazine clockwise till it stops.
10) Verify “Locked” green LED is illuminated under “UNLOADER”.

NOTE: If the Unloader is out of its slot for more than 10 seconds, the instrument assumes that all of the filters have been removed from the Unloader.

2.11 REFERENCE FILTERS:

Reference filters are supplied with the instrument and look like aluminum foil sandwiched inside a disk with a medium center hole and two small holes at the edge opposite each other. Each reference filter has a specific value, which needs to be entered into the instrument.

1) With the instrument in Status Ready Press and Hold “ESC” for more than 5 seconds.
2) Use select Arrow keys to enter 920, press “ENTER”.
3) Remove Unloader magazine to gain access to the filter housing plate.
4) Use Yes/No arrows to select “R1”, press Enter. The plate will automatically rotate. If the housing does not align correctly with this slot, it is possible to adjust the position of the plate by using the SELECT keys which rotate the plate clockwise or counter-clockwise in step increments [the Center indicator can have values between “<5” *(5 steps left max)* and “5>” *(5 steps right max)*].
5) Use the insertion tweezer accessory tool to place the correct reference filter down into the filter housing plate.
6) Repeat steps 4 & 5 for “R2”.
7) Press “ESC” will take you to the main menu.

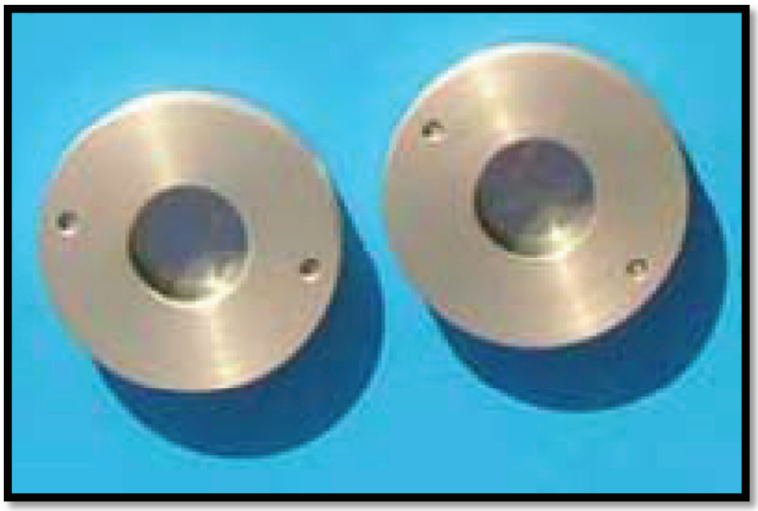


FIGURE 9: REFERENCE FILTERS

2.12 SPY FILTERS:

The Spy Filters will need to be created using filters from the same lot number as those being used for monitor sampling. In hourly sample mode, the TAPI 602 must use glass fiber filters only.

The spy filters are installed during initial setup and should be replaced if the instrument is relocated, and/or turned off for an extended time period.

To assemble the spy filters, uses the accessory kit provided by API and follow this procedure.

1) Place a glass filter on the rest and press it using the spy filter punch.
2) Extract with tweezers the obtained glass fiber filter with reduced diameter and insert it into the aluminum filter cassette.
3) Screw the filter cassette holder together with the clamp key
4) With the instrument in Status Ready Press and Hold “ESC” for more than 5 seconds.
5) Use select Arrows to enter 920 press “ENTER”
6) Remove Unloader to gain access to the filter housing plate.
7) Use Yes/No arrows to select “S12” press Enter. The plate will automatically rotate. If the housing does not align correctly with this slot, it is possible to adjust the position of the former by using the SELECT keys which rotate the plate clockwise or anticlockwise in step increments (the Center indicator can have values between “<5” *(5 steps left max)* and “5>” *(5 steps right max)*). Info was direct from manual

8) Use the insertion tweezer accessory tool to place the correct spy filter down into the filter housing plate.

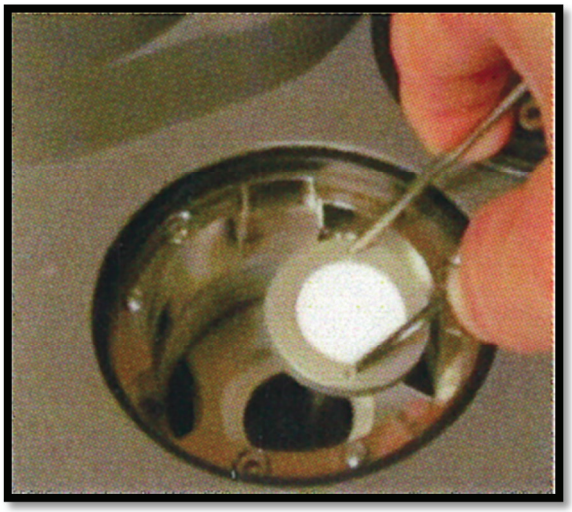


FIGURE 10: SPY FILTER INSERTION

9) Repeat steps 7 & 8 for “S34” and “S56”.
10) Press “ESC” will take you to the main menu.

2.13 VACUUM PUMPS:

Two vacuum sample pumps, for channel A and B, which can be placed below the control unit draws ambient air through the selective size sample inlets, sample tube, sample condensate collectors, smart heaters, and through glass fiber filter and then out the pump exhaust port. Both pumps are carbon vane type with silencers on the exhaust outlet to reduce noise. The flow rate through the two sampling lines is regulated automatically and independently per channel.

FIGURE 11: VACUMM PUMP

On the rear of the main control unit, connect the two blue fritter filters into the threaded connections on the back of the instrument pneumatic tray. If you press hard on the rear of the pneumatic tray, it will slide forward, as it is held in place by magnet connectors on the front of the instrument chassis. If this happens, gently slide the tray back into position under the instrument and check all hose connections.

It is recommended to position the vacuum pumps in an isolated area to reduce the heat accumulation and noise. Connect the vacuum pumps power cord to the rear of the instrument and connect the vacuum pump suction lines to the rear of the pneumatic tray. The connections are labeled and be sure to use Pump A with Line A and Pump B with Line B. Connect the exhaust tube with filters to each of the two pumps. The pump exhaust is hot and can be vented away from the instrument, and preferably outside using an extension tube.

NOTE: Confirm pumps are wired for 115V application.

2.14 CONDENSATE COLLECTOR:

There is a condensate collector located just above the sample line heater.
This is designed to capture water droplets that form on the inside of the sample tube as the result of water condensing out of the sample stream.
Monthly this condensate collector should be checked for water, especially after rain or high humidity.

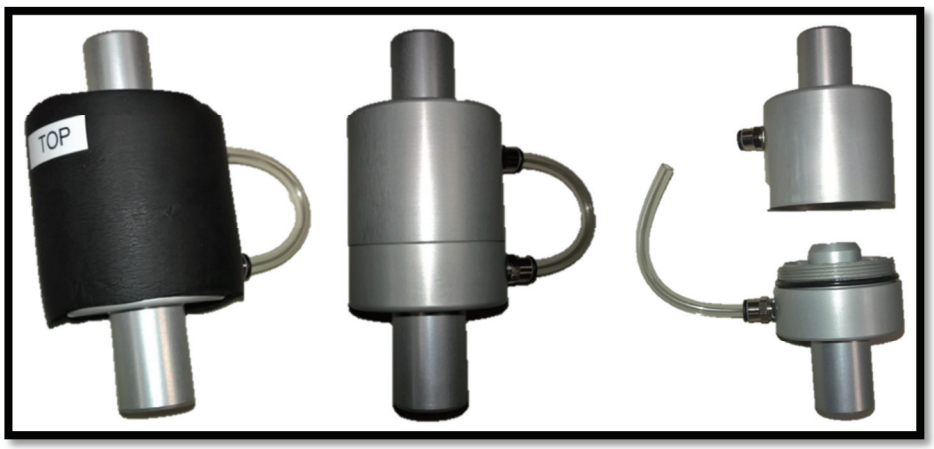


FIGURE 12: CONDENSATE COLLECTOR

NOTE: Make sure orientation is correct as shown above in Figure 12.

2.15 SMART HEATERS:

The smart heaters resemble small aluminum cans. There should be a 2” clearance from any object near the TAPI 602. The smart heater should be about 0.5”-1.0” away from where the inlet tube enters the TAPI 602 central unit. A minimum distance between the top surface of the TAPI 602 and the ceiling is 10”. The instrument is a US EPA candidate method for PM10, PM2.5, and PM10-2.5. For the purposes of using this system as a FEM method, the sample line heater should be set at factory to activate at 40% relative Humidity and deactivate at 30% relative humidity.

FIGURE 13: SMART HEATER

2.16 SAMPLE INLETS:

For US EPA Federal Equivalent Method (FEM) PM_{10} NAAQS compliance use, it is required to sample through the PM10 FEM approved selective size inlet.
For US EPA Federal Equivalent Method (FEM) PM2.5 NAAQS compliance use, it is required to sample through the PM10/PM2.5 combination inlet to obtain a valid PM2.5 measurement.

2.17 SAMPLE NOZZLES:

The instrument is supplied with two different sampling line inlet nozzles. The nozzles differ only in the shape and dimensions of the lower portion. In Hourly Mode, use tool model DU0000044 (installed by default in the instrument). In Multi-Time Mode, tool model DU0000045 must be used. If running the instrument for monitoring purposes as an EPA approved FEM the procedure below may be ignored as the correct (Hourly Mode) nozzle comes installed in the instrument.

5-2a

TAPI p/n DU0000044

5-2b

TAPI p/n DU0000045

FIGURE 14: SAMPLE NOZZLES 5-2A(HOURLY) & 5-2B(MULTI-TIME)

2.17.1 CHANGING INLET NOZZLE PROCEDURE:

1) Unlock the loader and the unloader.
2) Remove the black discs around the sample inlet lines.
3) Remove the black plastic ring around the loader.
4) Remove 6 screws holding the instrument cover.
5) Remove upper cover.
6) Remove the Rubber Gasket / Moisture Barrier.
7) Unscrew the three allen set screws on the sides of the nozzle.
8) Place the inlet nozzle on a flat surface and unscrew the three security dowels from the plastic flanges.
9) Separate the nozzle from the black flange and remove the spring and white cylindrical shim.
10) Place the white shim and the spring back onto the new nozzle.
11) Replace the black flange and while pressing it down on the flat surface (compressed spring), screw in the three security dowels.
12) Make sure that the O-ring on the bottom is inserted and positioned correctly.
13) Position the component back on the instrument and screw in the three check pins.
14) Replace the rubber gasket which acts as a moisture barrier.
15) Replace the instrument's upper cover and fasten the 6 screws.
16) Replace the black protection discs.
17) Reload the Loader and Unloader and lock them.

WARNING: the lower part of the Hourly nozzle must be handled very carefully to avoid impacts that could damage it. Damage to the nozzle could affect the pneumatic seal of the inlet system.

2.18 AMBIENT TEMPERATURE SENSOR:

Connect the ambient temperature sensor cable to the rear of the instrument. The connector on the rear of the instrument is labeled Ext Temp.

2.19 AIR COMPRESSOR:

Set up the Service Air Compressor near the instrument and connect the (red) supply air tube to the rear of the instrument. The service air connection is located on the rear right hand side of the instrument if viewing from the front. Simply press the connector into place and it will automatically latch. Tugging on the line will confirm the air line in attached properly.

FIGURE 15: AIR COMPRESSOR

Connect the Service Air Compressor power cord into a suitable power supply outlet. Once connected to AC power, the compressor will activate and increase the pressure to the level set at the regulator. Adjust the regulator to 30 psi initially. The compressor will turn off once this level is achieved. Adjust the regulator until the instrument reading of the service pressure is between 240-260 kPa (34.9 - 37.7 PSI) as shown on the front panel display or using the 602betaplusmanager.net software. The compressor will turn on occasionally during instrument operation in order to maintain the pre-set pressure level.

2.20 DATA LOGGER:

From the PC or External Data logger, you can display the Data Buffer content and download data to a file. The Data File which is accessible in this way comes from a secondary buffer inside the instrument which is limited to a total of 3000 records. Each record will consist of the total cycle data from a single sampling and measurement line; therefore, 3000 records will yield 1500 records of dual-channel hourly data.

2.21 BATTERY:

The TAPI 602 instrument is equipped with an on board battery to allow the instrument to continue the analysis of the collected sample(s) if the line power is lost to the instrument. During installation the instrument the top cover should be removed and the battery written on with a permanent marker the date of installation to allow the operator to be aware when two years of operation has concluded on the battery, at which time, as preventative maintenance, the battery is replaced with a new battery and the procedure is repeated.

3 CONFIGURATION:

As with any instrument, it is always important to exit out to the main menu screen and return back to the setting changed to confirm the settings did get saved.

3.1 DATE AND TIME:

Before starting the sampling and measurement cycles, it may be necessary to update the date and time setting. Follow the procedure below to set the date and time:

1) With the instrument in READY Status, press *ENTER* to access the main menu.
2) Using the *Select* keys, select the “Instrument Settings” menu and press *ENTER*.
3) Using the *Select* keys, select the “Date & Time” menu and press *ENTER*.

NOTE: date format is dd/mm/yy

4) Using the *Select* keys, move the cursor to the number to be modified (to modify use the *YES / NO* keys to increase or decrease number).
5) Once the date and time are correct, press *ENTER*.
6) Press *ENTER* again to confirm the date and time update and wait until the display goes back to the main menu.

7) The instrument will have to restart in order for the new Date/Time to be applied. A confirmation for the system to reboot will come up once the Date/Time change has been confirmed by the user.

3.2 OPERATING MODE:

The instrument has two operating modes that can be selected by the operator, Monitor Mode and Reference Mode. In Monitor Mode, Multi Time (8, 12, or 24 hour sampling times) and Hourly (1 hour sampling time) sampling modes can be used. In Reference Mode, only the Multi-Time Mode (sampling time ≥ 8 hours increments) can be used.

Note: For US EPA Class III FEM approved use, only Monitor Mode with Hourly timing must be used. 47mm glass fiber filters are also required for regulatory compliance monitoring of PM10, PM2.5, and PM10-2.5.

1) Monitor Mode:

Monitor Mode permits particulate matter sampling and mass measurement per inlet. Operating in this mode allows two PM samples (replicated or representative of two different particle size fractions) to be drawn simultaneously and the relative mass concentration value to be measured using the instrument as two “co-located instruments”. This makes it possible, for example, to determine simultaneously the PM10 and PM2.5 (PM2.5 and PM1, etc.) mass concentrations. Moreover, this configuration allows the user to perform particularly interesting metrological evaluations, for example:

- Evaluation of volatile material losses using the capability of the system to heat or cool the two sampling lines (note: the accessory heating or cooling systems for the lines are not supplied as standard with the system, and must be ordered separately).
- Evaluation of the performance of two different sampling inlets.

In addition, the instrument allows the use of only a single line (A or B) for sampling particulate matter.

NOTE: In *Monitor Mode* we recommend using the same type of filtering medium on both lines.

2) Reference Mode:

In Reference Mode the instrument can be used as a high-quality single-channel reference monitor. In this mode, one sampling line is used for the PM sample collection and mass measurement, while the other line is equipped with an

absolute filter for particulate matter (accessory supply) in order to have a glass fiber filter that will serve as a “field blank” (metrological significance in gravimetric mass determination and in chemical speciation). Therefore, during the mass measurement phase, the data relative to the field blank are also available in addition to the data relative to the “spy filter”. Using these data for the sample mass calculation procedure further improves the quality of the measurements.

The operator can choose the line to be used for sample accumulation and, consequently, the line to be equipped with the absolute filter.

When using the TAPI 602 Beta^{PLUS} Particle Measurement System in Reference Mode, three different configurations can be selected:
Reference Mode Normal
Reference Mode Split “Constant Flow Rate”
Reference Mode Split “Constant Stokes Number”

3.3 SAMPLING AND MEASUREMENT PARAMETERS:
FEM certification requires the sampling mode to be set to Hourly and the filter media to be glass fiber.

4 CALIBRATION:

4.1 INTRODUCTION:
The purpose of this section is to outline the TAPI 602 verification and calibration procedures used by the District. The TAPI 602 operation manual is an important resource of information for TAPI 602 calibrations, and therefore the District highly recommends reviewing the TAPI 602 Operation Manual.

4.2 OVERVIEW:
The TAPI 602 requires calibration of the ambient temperature sensor, the internal pressure sensor, and the volumetric flow controllers.

4.3 TOOLS:
- National Institute of Standards and Technology (NIST)-traceable temperature standard with resolution of +/- 0.1℃ and +/- 0.5℃ accuracy and certified within a year of the date of the calibration being performed on the TAPI 602.
- NIST-traceable pressure standard with resolution of +/- 1 mmHg (0.13 kPa) and +/- 5 mmHg (0.67kPa) accuracy and certified within a year of the date of the calibration being performed on the TAPI 602.

- NIST-traceable flow standard with range of 5-20 lpm (0.3-1.2 m^3/hr) and +/- 2% of reading accuracy and certified within a year of the date of the calibration being performed on the TAPI 602.

4.4 PROCEDURES:

The TAPI 602 flow test is called Span Test.

4.4.1 SPAN TEST (FLOW CHECK)

The instrument can perform either an automatic procedure (Auto Span Test) or a manual procedure (Manual Span Test) to estimate the error in the operating flow rate measurement. The flow rate is to be calibrated on bi-annual basis with the response being ±2% of desired value when compared to NIST-traceable flow standard.

4.4.1.1 SPAN TEST (AUTO) (WHILE SAMPLING)

1) Hold ESC key for more than 5 seconds.
2) Use Select Keys to enter Menu code: 953, Press ENTER.
3) Press Yes key “Hourly Test activation: ON”, Press ENTER.
4) The pneumatic test will be performed at the beginning of the very next sampling cycle. The results will be stored in the Data Buffer and will be available on the display.
5) Test will repeat until Hourly Test activation is changed to OFF.

NOTE 1: In Hourly Mode the Data Buffer fields pertaining to the Pneumatic Tests are updated only when a new test is performed.

NOTE 2: Performing the Pneumatic Tests reduces the sampling time by up to 10 minutes.

To cancel the request for the pneumatic tests, repeat the procedure here above and select “Hourly Test activation: OFF”

4.4.1.2 SPAN TEST (AUTOMATIC)

This test is to be performed only as a troubleshooting aid on as needed basis.

1) Confirm instrument Status “READY”, Press ENTER.
2) Use Select Arrows to “Instrument Tools 5/5”, Press ENTER.
3) Use Select Arrows to “Test 1/4”, Press ENTER.
4) Use Select Arrows to “Line A pneumatic test 1/4”, Press ENTER.
5) Use Select Arrows to “Line A Auto Span Test 3/4”, Press ENTER.
6) Test takes approximately 2 minutes.

7) Results displayed:
   a. Qref: Qtst: ERR

   Q_{ref} = Reference Flow rate at the programmed temperature and pressure.
   Q_{tst} = Flow rate values obtained from test
   ERR = is the percentage deviation
8) Record values on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).
9) Repeat steps for “Line B Auto Span Test 3/4”.

Note 1: If the percentage deviation from the starting calibration value is greater than ±4%, a Warning message is displayed, and if value is greater than ±10%, an Alarm message is displayed.

Note 2: In Multi Time Mode this test is automatically carried out by the instrument at the beginning of every sampling cycle. In Hourly Mode the test is performed in DELAY status and is repeated only on demand by the operator during the sampling and measurement cycles. The results are stored in the Data Buffer and are available in the Instrument Info menu.

4.4.1.3 SPAN TEST (MANUAL)

This test is to be performed only as a troubleshooting aid on as needed basis.

1) Confirm instrument Status “READY” Press ENTER.
2) Use Select Arrows to “Instrument Tools 5/5” Press ENTER.
3) Use Select Arrows to “Test 1/4” Press ENTER.
4) Use Select Arrows to “Line A Pneumatic Test 1/4” Press ENTER.
5) Use Select Arrows to “Line A Manual Span Test 4/4” Press ENTER.
6) Load a filter cassette with new filter, Press ENTER.
7) Display will show:
   a. Tc or Te: P: V: St: Qs: Qi:

   Tc = Critical nozzle temperature expressed in degrees Kelvin.
   Te = External temperature as measured by the temperature probe expressed in degrees Kelvin.
   P = Pressure measured in KPa.
   V = number of steps from lowest MFC value possible.
   St = sets the step size (regulation intervals)
   Qs = The flow rate value measured by the instrument under standard conditions.
   Qi = The inlet volumetric flow rate value that is calculated from the temperature value measured inside the installation room.

8) Remove PM10 inlet and install certified flow meter on sample inlet.
9) Press and hold enter to start pump.
10) Use Select and Yes / No Keys to adjust flow valve opening until Qi ref equals 1.00 m3/h (16.67 L/min).
    a. Select Keys changes the step:
        - H=400steps
        - M=40steps
        - L=4steps
    b. Yes / No Keys increase or decrease the step increment selected.
    c. Wait until "*" on V goes away for 1 minute once Qi ref equals 1.00 m3/h (16.67 L/min).
11) Press ESC to stop test.
12) Wait for test to end.
13) Repeat steps for "Line B Manual Span Test 4/4" (flow meter to be installed above VSCC on Line B).

Note: when installing flow meter outside of the enclosure that the main control unit is located. Q_i will be referencing the enclosure's temperature, so using standard flow Q_s is recommended when comparing readings.

4.4.1.4 SINGLE POINT FLOW CALIBRATION:
The single point flow calibration is to be performed on an annual basis or as needed. The flow calibration can be done while the instrument is in the normal running mode. The data collected during this hour should be invalidated.

TOOLS:
- NIST-traceable flow meter (4-20 lpm flow rate range) capable of measuring in actual, local volumetric conditions.
- 1 or 1 ¼" sample tube to hose barb adapter (if necessary).
- PC with 602betaplusmanager.net software application.

PROCEDURE:
Step 1: Flow Verification
1) Remove the inlet from the sample tube.
2) Place the NIST-traceable flow meter on the sample tube end.
3) Allow the instrument flow rate to stabilize (60 seconds).
4) Record measured flow at the flow meter in actual conditions.

5) If the measured flow is > +/- 4% (<16.0 OR > 17.34 lpm) different that the instrument flow measurement, proceed to Step 2.
6) Repeat procedure for second sampling line, if applicable.

Step 2: Connect using 602betaplusmanager.net Software

1) Identify the current Flow Calibration Settings.
2) Connect PC to instrument using serial connector.
3) Open 602betaplusmanager.net application software, establish connection to the instrument.
4) Go to Service Menu → Instrument Settings Tab → Flow Rate Control System Calibration Parameters.
5) Note the current flow calibration constant parameters (Line X flow rate b – see below).

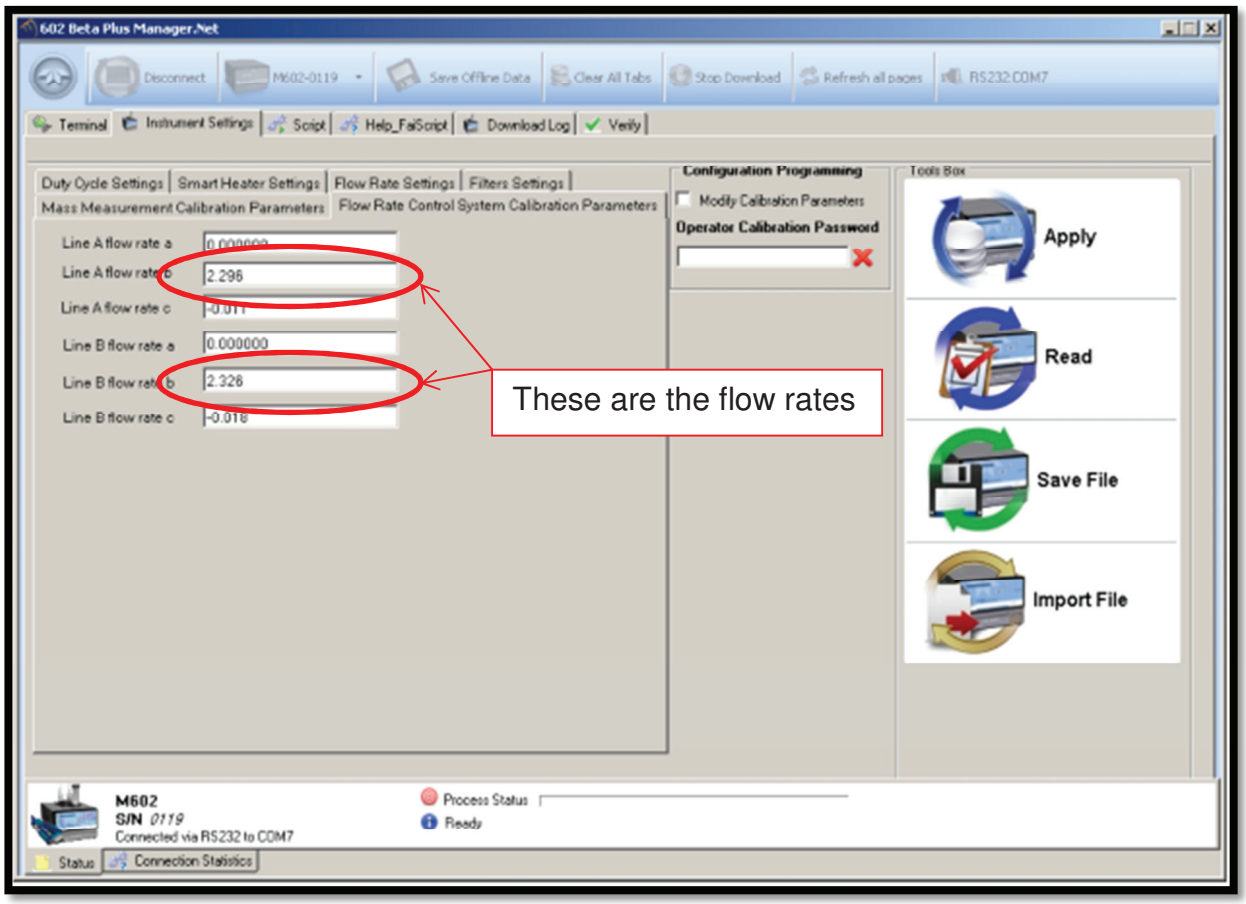


FIGURE 16: 602 BETA PLUS MANAGER.NET SINGLE POINT FLOW CALIBRATION

Step 3: Derive the new flow constant using the formula below:

$$New\ Flow\ Constant =$$

$$Old\ Flow\ Constant - \left[Old\ Flow\ Constant * \left(\frac{(Flow\ Measured\ by\ Instrument - Flow\ Measured\ by\ Flow\ Meter)}{Flow\ Measured\ by\ Instrument}\right)\right]$$

<u>Example 1:</u>

$$New\ Flow\ Constant\ (X) = 2.429 - \left[2.429 * \left(\frac{(16.67 - 16.34)}{16.67}\right)\right]$$

$$X = 2.381$$

<u>Example 2:</u>

$$New\ Flow\ Constant\ (X) = 2.429 - \left[2.429 * \left(\frac{(16.67 - 17.2)}{16.67}\right)\right]$$

$$X = 2.506$$

Step 4: Input New Flow Constant

1) Connect PC to instrument using serial connector.
2) Open 602Beta^{PLUS}Manager.net application software, establish connection to the instrument.
3) Go to Service Menu → Instrument Settings Tab → Flow Rate Control System Calibration Parameters.
4) Insert New Flow Constant into Flow Rate b on the applicable Line (A or B).
5) Insert New Flow Constant into Flow Rate b on the second line (A or B).
6) Check the box to the right which says Modify Calibration Parameters.
7) Input Operator Calibration Password (instrument alphabetical serial number)
    a. A = 0, B = 1, C = 2, D = 3, E = 4, etc.
    b. Example: instrument serial number 0119 = ‘ABBJ’ password.
8) When green checkbox appears, click Apply.
9) Once you press Apply, you will hear the valve adjust to control at the new flow rate.

Step 5: Finish up

1) Recheck the flow at the inlet(s) using the NIST-traceable flow transfer standard OR using the Auto Span Test (see Section 2).
2) Once satisfied, replace the inlet onto the sample tube.

4.4.2 MASS MEASUREMENT SYSTEM (BETA SPAN TEST)

NOTE: Periodic calibration of the instrument is not required, but instrument failure or measurement errors may indicate that one or more components (the Geiger-Müller detector and/or associated electronics) need to be replaced.

The calibration function determined during the final acceptance test will always remain valid over the Geiger-Müller detector's lifetime.

The instrument can automatically perform a ß calibration check (Beta span test) by measuring alternately the ß flux in air and the ß flux passing through the reference filters. The calculated mass thickness values of the two reference filters, are compared with their associated nominal values. The test gives the calculated mass thickness values and the percentage deviations from the respective nominal values.

NOTE: The test takes 25 minutes in Multi-Time mode and 10 minutes in Hourly Mode. The time will be deducted from the following programmed sample time.

NOTE: In hourly Mode the test is performed only if a blank session is not expected during the cycle.

4.4.2.1 BETA SPAN TEST (AUTOMATIC) (STATUS: SAMPLING)

This test is to be performed only as a troubleshooting aid on as needed basis.

1) Hold ESC key for more than 5 seconds.
2) Use Select Keys to enter Menu code: 951, Press ENTER.
3) Press Yes Key "Beta Test activation: ON", Press ENTER.
4) Beta Span Test will beginning after the current sample cycle completes.

4.4.2.2 BETA SPAN TEST (AUTOMATIC) (STATUS: READY)

This test is to be performed only as a troubleshooting aid on as needed basis.

1) Press ENTER key.
2) Use Select Keys to select “Instrument Tools 5/5”, Press ENTER.
3) Use Select Keys to select “Test”, Press ENTER.
4) Use Select Keys to select “Beta Span Test”, Press ENTER.
5) Use Yes / No Keys to select appropriate Operating Mode:
   a. “Hourly”
   b. Press ENTER
6) The test will check Background radioactivity (D), Air (A), reference filter (R1) and reference filter (R2). The effective value of the counts measured by the Geiger Müller (GM) is displayed during the test. At the end of the test, the correct counts for the GM dead time are stored and displayed. The value of the used dead time is the one given by the GM manufacturer (because the calibration function is empirical, effective values of dead time different from the one given by the producer do not affect the mass measurement quality).
7) Use Yes / No Keys to change view from the following
   a. R1 Ref: Test: Err:
   b. R2 Ref: Test: Err:
   c. D: A: R1: R2:

At the end of the test, the following parameters will be displayed for both of the reference filters:

Ref: *Nominal value of the reference filter’s mass surface density (mg/cm²)*
Test: *Measured value of the filters mass surface density (mg/cm²)*
Err*: Percentage error*

NOTE 1: If the percentage deviation (Err) between the nominal surface mass density and the measured value of one or both of the reference filters is greater than 5%, a Warning message is automatically activated (Warning 14, see Appendix 3 of TAPI 602 manual).

NOTE 2: The Hourly and Multi-Time Modes use two different calibration functions and test procedures, because in Hourly Mode the source moving piston is UP while in Multi-Time Mode it is in the DOWN position.

4.4.2.3 **MASS MEASUREMENT SYSTEM CALIBRATION**

NOTE: Due to the high level of stability of the mass measurement system, there is no need for any periodical calibration, unless in case of measurement system failures that would require the replacement of one or more components (GM detector and associated electronics). In the unlikely event that there is a shift in the mass measurement system calibration, the following procedure should be used as a guide for recalibrating the mass measurement system.

The goal of the calibration procedure is to determination the function *g(z)* (see Sections 2.5 & 2.6 of the instrument manual), using a *multipoint* calibration approach.

The calibration procedure used during the final acceptance test allows making quantitatively negligible all the uncertainties associated with the beta measurement reproducibility (Poisson statistics of the beta emission, reproducibility of the mechanical repositioning, detector efficiency fluctuations, density variations of the air interposed between source and detector).
In order to correctly determine the calibration function, during the final acceptance test the Geiger Muller counter response stability is evaluated.

To calibrate the mass measurement system, use the six aluminum reference filters (TAPI P/N DU0000015) with known surface mass density "x_i". The mass thickness values usually used are in the range 0 – 10 mg/cm² and they are shown below.

Reference membrane	Reference mass thickness (mg/cm²)
F11	2.963
F12	3.405
F13	5.926
F14	6.810
F15	8.889
F16	9.773

The TAPI 602 instrument performs five measurement cycles on the reference filters. Each cycle is preceded by the background noise measurement "DRK" and by the natural radioactivity measurement "NAT" and it is structured as follows where "F" are the reference filters and "A" are the "air" counts associated with the single filters.

$$\begin{array}{l} DRK \quad NAT \\ \left.\begin{array}{lllll} A_{11} & F_{11} & A_{1X} & F_{12} & A_{12} \\ A_{13} & F_{13} & A_{1Y} & F_{14} & A_{14} \\ A_{15} & F_{15} & A_{1Z} & F_{16} & A_{16} \end{array}\right\} 1\ cycle \end{array}$$

The total duration of a measurement cycle is about of 97 minutes (the following table shows the duration of each single flux measurement).

Measure	Duration [mm.ss]
DRK	02.30
NAT	02.30
A	03.30
F	10.00

Each of the 17 beta flux measurements (constituting a cycle) are compared with the ancillary measures of temperature, pressure and humidity relative to the measurement area, and the Geiger Muller high voltage value.

Therefore, at the end of the calibration procedure it will be possible to associate to each "x_i" nominal value with the corresponding z_i value and to determine the best fit function by a third-order homogeneous polynomial "*g(z)*" whose coefficients will be the calibration parameters, see par. 7.5.5.

$$z_i = \ln\left(\frac{\Phi_0}{\Phi(x_i)}\right)$$

In the considered interval, the derivative "*k(z)*" of the function "*g(z)*" must be decreasing monotonically.

To perform the mass measurement system calibration follow the procedure below:
1. Make sure that the instrument is installed in a conditioned room so that the temperature range is not higher than 3 K.
2. With the instrument in READY status, follow the "Filters Unloading" procedure (see User Manual par. 5.11).
3. Remove the spy filters in case they are still inside the instrument (see User Manual par. 5.7 & 5.8).
4. Download all data stored in the "Buffer Data" (see User Manual Appendix B), since during the calibration process the "Buffer Data" will be automatically deleted.
5. With the instrument in READY status, press and hold for at least 5 seconds the ESC button to have access to the menus for the support "tools" management.
6. Using the SELECT, YES and NO buttons, select the "*menu code*" 911 and press ENTER to confirm.
7. Press ENTER again to have access to the calibration menu.
8. Unlock the virgin filters "Loader" and insert inside it the 6 reference filters (optional accessory for the instrument), see par. 4.5.

NOTE 1: During the calibration process the real time value of the counts measured by the Geiger Muller will be displayed (for the data download see par. 7.5.3)

NOTE 2: If one or more reference filters are incorrectly loaded, the message “Filter not loaded, Test aborted” will be displayed. In this case press ESC to go back to the main menu and perform the “Filters Unloading” procedure (see User Manual par. 5.10). This will move all of the calibration reference filters to the Unloader. The calibration procedure must be repeated from step 5 on.

NOTE 3: If you want to stop the calibration procedure before it ends, press the ESC button.

NOTE 4: At the end of the calibration procedure the instrument will set to READY status and the reference filters will be automatically moved to the “Unloader”.

4.4.2.3.1 INSERTING THE REFERENCE FILTERS

Before inserting the reference filters in the *Loader*, make sure that it is empty. If filters are present inside the Loader, remove them using the procedure described in Sections 4.8 & 5.11 of the TAPI 601 instrument manual. To insert the reference filters in the *Loader*, unlock it rotating it anticlockwise and make sure that each filter cartridge enter in it with the hollow part turned downwards (see TAPI 602 Manual Section 4.7). The filters insertion sequence must be the one shown in the illustration to the right. It’s important to load the filters in this order, since they will be loaded into the instrument following their order inside the *Loader*.

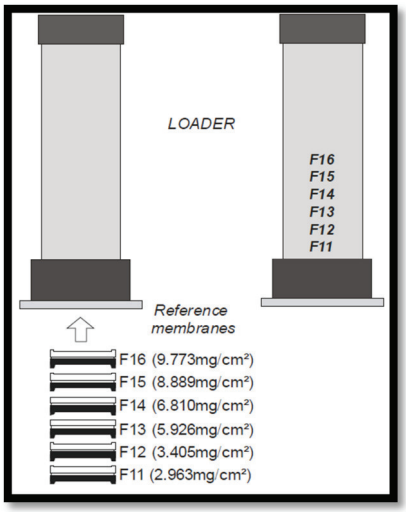


FIGURE 17: INSERTING THE REFERENCE FILTERS

4.4.2.3.2 CALIBRATION DATA DOWNLOAD

The calibration data must be downloaded before performing the other operations on the instrument, otherwise they will be deleted. To download the data connect the instrument to a PC

and send the command 44 (each line of the response is made up of 8 fields separated by commas). This can also be done using the Dr. FAI instrument software.

Command	Response	Response fields	Format
44	1406/07 11.11,1,DRK,300.4,100.7,625.4,50,27 1406/07 11.14,1,NAT,300.4,100.7,625.2,50,21 1406/07 11.17,1,A11,300.4,100.7,625.2,49,1562139 1406/07 11.27,1,F11,300.5,100.6,625.3,49,848937 1406/07 11.29,1,A1X,300.6,100.6,625.2,49,1564526 1406/07 11.39,1,F12,300.6,100.6,625.3,48,780896 1406/07 11.42,1,A12,300.6,100.7,625.2,48,1563670 1406/07 11.45,1,A13,300.6,100.7,625.3,48,1566319 1406/07 11.55,1,F13,300.7,100.7,625.3,48,404001 1406/07 11.57,1,A1Y,300.7,100.6,625.2,47,1565320 1406/07 12.07,1,F14,300.8,100.6,625.3,47,315841 1406/07 12.10,1,A14,300.8,100.6,625.2,47,1565510 1406/07 12.13,1,A15,300.8,100.6,625.2,47,1566012 1406/07 12.23,1,F15,300.8,100.6,625.3,47,156669 1406/07 12.25,1,A1Z,300.8,100.6,625.2,47,1566158 1406/07 12.35,1,F16,300.8,100.6,625.3,46,114971 1406/07 12.38,1,A16,300.8,100.6,625.3,46,1564537 1406/07 12.39,2,DRK,300.8,100.6,625.3,46,19 1406/07 12.42,2,NAT,300.8,100.6,625.2,46,23 1406/07 12.45,2,A11,300.8,100.6,625.2,46,1566836 1406/07 12.55,2,F11,300.8,100.6,625.3,46,849688 1406/07 12.57,2,A1X,300.8,100.6,625.3,46,1565628 1406/07 13.07,2,F12,300.9,100.6,625.3,46,781543 1406/07 13.10,2,A12,300.9,100.6,625.3,46,1567422 1406/07 13.13,2,A13,300.9,100.6,625.3,46,1566733 1406/07 13.23,2,F13,300.9,100.6,625.2,46,404250 1406/07 13.25,2,A1Y,301,100.6,625.2,46,1567796 1406/07 13.35,2,F14,301,100.6,625.3,45,315914 1406/07 13.38,2,A14,301.1,100.6,625.2,45,1567645 1406/07 13.41,2,A15,301,100.6,625.2,45,1567144 1406/07 13.51,2,F15,301,100.5,625.3,45,157133 1406/07 13.53,2,A1Z,301.1,100.6,625.2,45,1565642 1406/07 14.03,2,F16,301.1,100.6,625.2,45,115268 1406/07 14.06,2,A16,301.1,100.6,625.3,45,1566931 1406/07 14.07,3,DRK,301.1,100.6,625.2,45,17 1406/07 14.10,3,NAT,301.2,100.6,625.2,45,22 1406/07 14.13,3,A11,301.1,100.6,625.3,45,1568870 1406/07 14.23,3,F11,301.2,100.6,625.2,45,850998 1406/07 14.25,3,A1X,301.2,100.6,625.3,45,1568016 1406/07 14.35,3,F12,301.2,100.5,625.2,45,782035 1406/07 14.38,3,A12,301.3,100.5,625.3,45,1566755 1406/07 14.41,3,A13,301.3,100.5,625.3,45,1567122 1406/07 14.51,3,F13,301.3,100.5,625.2,45,404902 1406/07 14.53,3,A1Y,301.3,100.5,625.4,45,1567510 1406/07 15.03,3,F14,301.4,100.5,625.2,45,315996 1406/07 15.06,3,A14,301.5,100.5,625.3,45,1567756 1406/07 15.09,3,A15,301.5,100.5,625.2,45,1567631 1406/07 15.19,3,F15,301.5,100.5,625.2,45,157034 1406/07 15.21,3,A1Z,301.6,100.5,625.2,45,1567096 1406/07 15.31,3,F16,301.7,100.6,625.2,45,115378 1406/07 15.34,3,A16,301.7,100.6,625.4,45,1568269 1406/07 15.35,4,DRK,301.7,100.6,625.3,45,21 1406/07 15.38,4,NAT,301.6,100.6,625.3,45,19 1406/07 15.41,4,A11,301.7,100.6,625.2,45,1569175 1406/07 15.51,4,F11,301.7,100.6,625.2,45,850583 1406/07 15.53,4,A1X,301.8,100.6,625.2,45,1567023 1406/07 16.03,4,F12,301.7,100.6,625.2,45,782240 1406/07 16.06,4,A12,301.8,100.6,625.1,45,1567832 1406/07 16.09,4,A13,301.8,100.6,625.2,45,1566488 1406/07 16.19,4,F13,301.8,100.6,625.3,45,405102 1406/07 16.21,4,A1Y,301.7,100.6,625.1,45,1567437 1406/07 16.31,4,F14,301.7,100.6,625.2,44,316351 1406/07 16.34,4,A14,301.7,100.6,625.2,44,1566832 1406/07 16.37,4,A15,301.7,100.6,625.2,44,1568896 1406/07 16.47,4,F15,301.8,100.6,625.3,44,157410 1406/07 16.49,4,A1Z,301.7,100.6,625.3,44,1568005 1406/07 16.59,4,F16,301.7,100.6,625.3,44,115333 1406/07 17.02,4,A16,301.7,100.6,625.2,44,1567367 1406/07 17.03,5,DRK,301.7,100.6,625.3,44,21 1406/07 17.06,5,NAT,301.7,100.6,625.3,44,23 1406/07 17.09,5,A11,301.8,100.6,625.3,44,1568276 1406/07 17.19,5,F11,301.7,100.6,625.3,44,850599 1406/07 17.21,5,A1X,301.8,100.6,625.2,44,1567386 1406/07 17.32,5,F12,301.8,100.6,625.2,44,782066 1406/07 17.34,5,A12,301.8,100.6,625.1,44,1567499 1406/07 17.37,5,A13,301.8,100.6,625.2,44,1568672 1406/07 17.47,5,F13,301.7,100.6,625.2,44,405318 1406/07 17.49,5,A1Y,301.8,100.6,625.2,44,1568445 1406/07 18.00,5,F14,301.7,100.6,625.2,44,316672 1406/07 18.02,5,A14,301.8,100.6,625.2,44,1567880 1406/07 18.05,5,A15,301.8,100.6,625.2,44,1568368 1406/07 18.15,5,F15,301.8,100.6,625.1,44,157620 1406/07 18.17,5,A1Z,301.7,100.6,625.2,44,1568430 1406/07 18.27,5,F16,301.7,100.6,625.2,44,115309 1406/07 18.30,5,A16,301.7,100.6,625.2,44,1566173.	Date and Time	dd/mm/yy hh:mm:ss
		Measurement cycle number	###
		Performed measurement *DRK*= background noise *NAT*= natural radioactivity *A11*= "air" flux *F11*= membrane1 (2.963 mg/cm²) *A1X*= "air" flux *F12*= membrane2 (3.405 mg/cm²) *A12*= "air" flux *A13*= "air" flux *F13*= membrane 3 (5.926 mg/cm²) *A1Y*= "air" flux *F14*= membrane 4 (6.810 mg/cm²) *A14*= "air" flux *A15*= "air" flux" *F15*= membrane 5 (8.889 mg/cm²) *A1Z*= "air" flux *F16*= membrane 6 (9.773 mg/cm²) *A16*= "air" flux	XXX
		Average temperature during the measurement [K]	###.#
		Average pressure during the measurement [kPa]	###.#
		Geiger Muller high voltage[V]	###.#
		Relative Humidity mean value during the measurement [%]	###
		Measured counts [counts/min]	########

FIGURE 18: CALIBRATION DATA DOWNLOAD

4.4.2.3.3 CALIBRATION DATA ANALYSIS

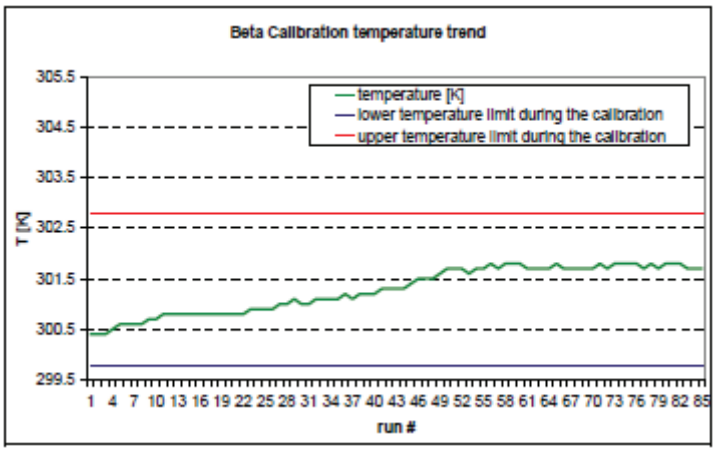
After the data download and before determining the coefficients of the calibration curve of the mass measurement system, it is possible to perform some fundamental quality controls on the calibration procedure:

- ***Background noise***

If during the calibration procedure the background noise exceeds the limit of 150cmp, the procedure must be repeated. If the failure persists, contact Teledyne-API Customer Service.

- ***Temperature*** Ideally, the maximum difference between the temperature values is not higher than 3 K during the calibration process. For example, see the Temperature table and graph below.

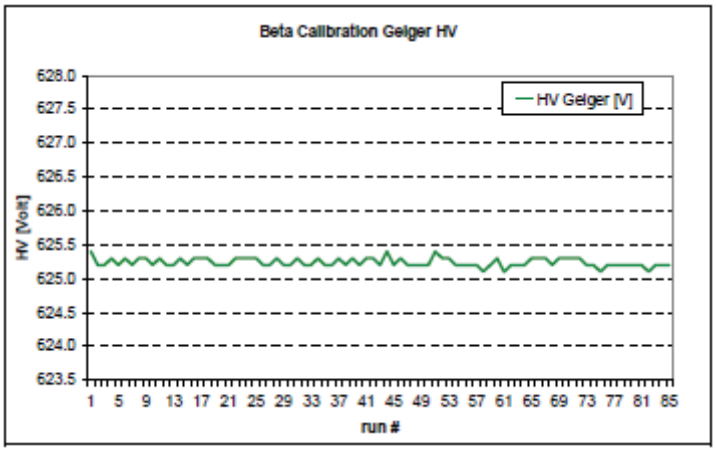
Temperature [K]	
avg.	301.3
max	301.8
min	300.4
max diff.	1.4
# run	85
s.d.	0.452



Geiger Muller High Voltage

The quality of the Geiger detector response is strictly connected with the stability of its high voltage value. The high voltage power supply is able to supply a stabilized voltage within 1% of the mean value. If the standard deviation of the Geiger high voltage value is higher than 2% the calibration procedure must be repeated. For an example see the HV Geiger table and graph below.

Geiger Muller H.V.[Volt]	
avg.	625.2
max	625.4
min	625.1
# run	85
s.d. %	0.010



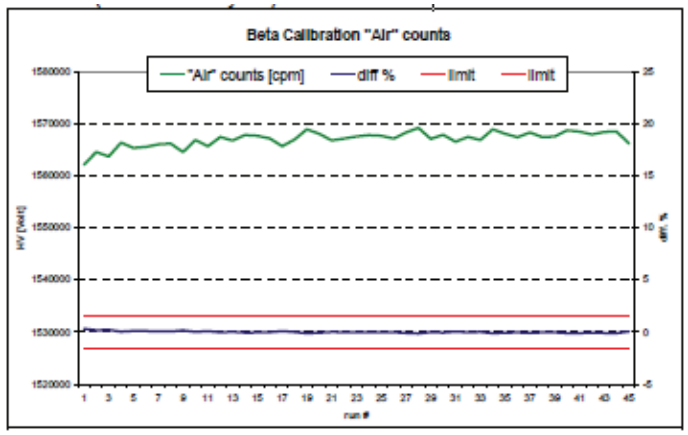
Geiger Muller Stability

The Geiger detector response stability can be calculated, using the flux of the "air counts" and checking that the percentage difference between the mean value of the air count flux and the single values measured is not higher than the 1.5%.

$$-1.5\% < \left[\left(\frac{A_{measured} - \overline{A}}{A_{measured}}\right) \cdot 100\right] < +1.5\%$$

Where: $A_{measured}$ is the single measure of "air" counts and $\overline{A}$ is the mean value of the 45 measures (9 for each cycle) of "air" counts.

"Air" counts [cpm]	
avg.	1567003
max	1569175
min	1562139
# run	45
s.d.	1427
diff. % max	0.31



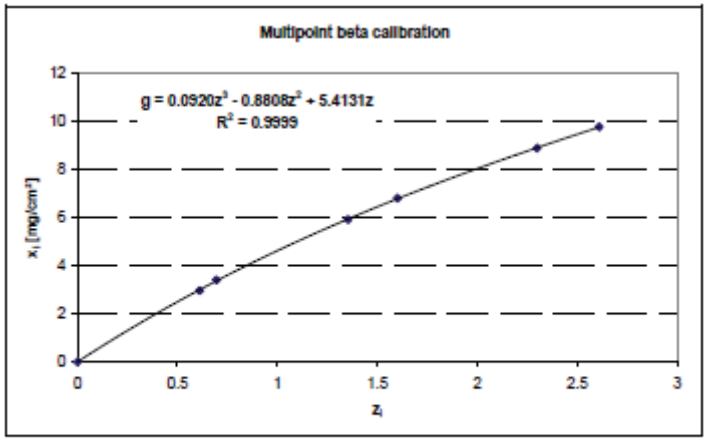
4.4.2.3.4 DETERMINATION OF THE CALIBRATION CURVE COEFFICIENTS

To determine the calibration curve coefficients, it is necessary to associate to each nominal value "x_i" (Reference mass thickness) the correspondent "z_i" value with $z_i = \ln\left(\frac{\Phi_0}{\Phi(x_i)}\right)$, where "$\Phi_0$" corresponds to A (mean value of the 45 measures of "air flux") and "$\Phi(x_i)$" is the mean value of the fluxes associated with each single filter "F".

For example:

measure	counts avg. [cpm]	z_i	x_i [mg/cm²]
air	1567004	0	0
F11	850221	0.611424	2.963
F12	781756	0.695378	3.405
F13	404733	1.353694	5.926
F14	316155	1.600689	6.810
F15	157173	2.299572	8.889
F16	115252	2.609801	9.773

Associating to each nominal value "$\boldsymbol{x}_i$" the correspondent value $z_i = \ln\left(\frac{\Phi_0}{\Phi(x_i)}\right)$, the *best fit* function is determined by a third-order homogeneous polynomial "*g(z)*" (passing through the origin) whose coefficients represent the calibration parameters.



$$g(z) = az^3 + bz^2 + cz$$

The coefficients "*a*", "*b*" and "*c*" represent the calibration parameters of the mass measurement system to be programmed in the instrument.

4.4.2.3.5 SETTING OF THE CALIBRATION CURVE COEFFICIENTS

To set the coefficients of the calibration curve that were experimentally determined, connect the instrument to a PC equipped with RS232 serial interface. The commands needed for setting the coefficients on each instrument are as follows:

Instrument serial number	Coefficient	Command	Confirmation response
0127	*a*	04SHABCH020#.######	!
	b	04SHABCH021#.######	!
	c	04SHABCH022#.######	!
0131	*a*	04SHABDB020#.######	!
	b	04SHABDB021#.######	!
	c	04SHABDB022#.######	!

With #.###### = coefficient value

For example, if we want to set *b* = -0.8808 on Model 602 Beta^{PLUS} sn0127, we have to send the command: 04SHABCH021-0.8808. To check that the calibration coefficients have been correctly programmed, send the command 050, the fields 21, 22 and 23 of the response correspond respectively to the coefficients "*a*", "*b*" and "*c*".

For example Command: 050
Response: 16/03/07,16/03/07,001,0127,101.5,4.213,2.320,-0.005,0.1624,2.623,-0.051,0.1605,0,2000, -0.032200,2.320,-0.005,-0.173000,2.623,-0.051,**0.0920**, **-**

0.8808,**5.4131**,0.005539,
0.007007,160000,1600,1.007,1.007,1.000,1.000,0.000,5,2.8,0.100,0.28,10,10
Coefficients:
a =0.0920
b =-0.8808
c =5.4131

4.4.3 BAROMETRIC PRESSURE

The barometric pressure sensor calibration is to be performed when the instrument is installed and on a bi-annual basis to retain a nominal accuracy of ± 10 mm Hg of the observed value. Obtain the barometric pressure reading from the Model 602 instrument front panel, or through the 602betaplusmanager.net software interface (refer to the manual).

4.4.3.1 CALIBRATION PROCEDURE:

1) Record a reading from NIST-traceable reference barometric pressure device in close proximity to instrument.
2) Repeat 5 readings at and interval of 30 seconds.
3) Connect to 602 Instrument via 602betaplusmanager.net software or hyperterminal.
    a. In command type 201
    b. Read the 5th field entry in the returned string
4) Verify stability is Max-Min < 0.01V.
5) Calculate average value VPA.
6) Verify Instrument Status: READY.
7) Press ENTER key.
8) Use Select Keys to select “Instrument Tools 5/5”, Press ENTER.
9) Use Select Keys to select “Signals Direct Control 3/4”, Press ENTER.
10) Use Select Keys to select “ADC Converter”, Press ENTER.
11) Use Yes/No Keys to select “Channel 5”, Press.
12) Channel 5 menu and read in the same way the voltage values associated with the atmospheric pressure transducer.
13) Use the following commands to insert the barometric pressure and VPA found values:
    a. 04SHXXXX004yyy.y
    b. 04SHXXXX005z.zzz
    Where XXXX = Serial number of the instrument in letters as shown in the table
    yyy.y = barometric pressure value
    z.zzz = voltage displayed

A	0
B	1
C	2
D	3
E	4
F	5
G	6
H	7
I	8
J	9

Below is an example of an instrument with serial number 95, barometric pressure reading =101.5 and VPA=4.233:

Using the command 050 acquire the current set point value from the Terminal prompt from within the service window of 602betaplusmanager.net software or through hyperterminal:

050
=CAL:00/00/00,00/00/00,000,0100,**101.3,4.256**,2.000,
0.000,0.0000,2.000, 0.000,0.0000,6400,6400,0.000000,2.000,
0.000,0.000000,2.000,
0.000,0.000000,0.000000,3.000000,0.000000,0.000000, 160000,
1600,1.007,1.007, 1.000, 1.000, 0.000, 5, 2.8,0.100, 0.28, 10, 10

Type in the following command prompt to update the instrument with the new values:
04SHAAJF004101.5
=!
04SHAAJF0054.233
=!
NOTE: Letters must be written in capitals.

NOTE: Responses different from =! show that the value have not been set properly:
Such as =? Or #

Using the command 050 verify the correct values have been set (in the fields 5 and 6).

050
=CAL:00/00/00,00/00/00,000,0100,**101.5,4.233**,2.000,
0.000,0.0000,2.000, 0.000,0.0000,6400,6400,0.000000,2.000,
0.000,0.000000,2.000,
0.000,0.000000,0.000000,3.000000,0.000000,0.000000, 160000,
1600,1.007,1.007, 1.000, 1.000, 0.000, 5, 2.8,0.100, 0.28, 10, 10

WARNING: do not perform the sensor calibration if there are any doubts about the possible presence of problems on other components. Contact TAPI's Technical Support should you see large deviations in the observed and reference values.

4.4.4 AMBIENT TEMPERATURE

Calibration of the ambient temperature sensor is not possible per the manufacturer of the TAPI 602 instrument. On a bi-annual basis the sensor will be checked and if a sensor is found outside the tolerance limits, the ambient temperature sensor is to be replaced with one that matches the NIST-traceable reference standard ± 2℃.

4.4.5 ZERO TEST

The zero test is performed when there are considerable negative responses on samples to verify stability of the beta source readings. Particulate filters are installed at the sample inlet to eliminate any particulates from entering the sample system. After a sequence of runs, the data is collected and the standard deviation is calculated. If the standard deviation exceeds 4 then you will need to contact Teledyne technical support for further assistance.

PROCEDURE:

Step 1: Confirm instrument Status "READY"
Step 2: Assemble Teledyne Absolute Filters Kit
Step 3: Remove US PM10 inlet from Line A
Step 4: Remove condensate collectors and install Absolute filters
Step 6: Confirm instrument display says "Start", Press ENTER
Step 7: Select sampling Mode "hourly" :
Step 8: Select start date and time, Press ENTER

- Choose top of next available hour: This will synchronize data output with external data logger.

Step 9: When prompted, hold down the Enter button for 3 seconds to initiate sampling.

- The instrument will first go through a series of tests and blank filter measurements. This process will take approximately 75 minutes. No sampling can begin until this initialization process is completed.

Step 10: Let the instrument run for 72 hours
Step 11: Download the instrument concentration values with betaplumanager.net or from data logger collected over the 72 hour period.
Step 12: Calculate average and standard deviation of the 72 values for each Line separately.

NOTE: The calculated average response per line should be near zero with the standard deviation around 4. If the calculated values for either line are outside these values it is recommended to contact the manufacture's technical support.

5 VERIFICATION:

5.1 FLOW RATE:

The TAPI 602 instrument flow rate on Line A and B should be checked once per month using a NIST-traceable reference standard. The flow rate verification should be performed by placing the flow verification meter on the inlet tube. Remove the PM10 selective size inlet head, but retain the VSCC between the inlet tube and the flow meter if sampling in that configuration. Flow verification is done while the instrument is sampling and the hour in which the flow check is done is to be invalidated.
TOOLS:

- NIST-traceable flow meter (4-20 lpm flow rate range) capable of measuring in actual, local volumetric conditions.
- 1 or 1 ¼" sample tube to hose barb adapter (if necessary).

PROCEDURE:

Step 1: Confirm instrument Status "Sampling".
Step 2: Confirm more than 15 minutes are left for sampling within the hour.
Step 3: Remove US EPA PM10 inlet from Line A adaptor.
Step 4: Install flow meter for flow on Line A adaptor.
Step 5: Wait 5 minutes for flow meter flow to stabilize.
Step 6: Record actual flow reading for Line A from flow meter on the TAPI 602 monthly quality control maintenance check sheet (Appendix A) .
Step 7: Re-install US EPA PM10 inlet onto Line A adaptor.
Step 8: Remove PM10 Pre-Impactor on Line B from BGI PM2.5 VSCC™.
Step 9: Install flow meter for flow on Line B BGI PM2.5 VSCC™.
Step 10: Wait 5 minutes for flow meter flow to stabilize.
Step 11: Record actual flow reading for Line B from flow meter on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).
Step 12: Re-install PM10 Pre-Impactor on Line B onto BGI PM2.5 VSCC™.

Step 13: Confirm flow check was completed within the same hour started and before the start of the next hour.

Step 14: Edit hourly data in the data logger for the site by invalidating the hour in which the flow verification was performed.

Note: Volumetric flow measured on the flow meter must be ± 4% of 1m^3/H (16.67 L/Min). If a value is found outside these criteria further investigation is needed along with a flow calibration.

Note: when installing flow meter outside of the shelter that the main control unit is located, Q_i will be referencing the shelter's temperature, so using standard flow Q_s is recommended.

5.2 AMBIENT TEMPERATURE:

The TAPI 602 instrument ambient temperature sensor should be checked once per month using a NIST-traceable reference standard from the instrument front panel or the 602betaplusmanager.net software.

5.2.1 FRONT PANEL:

1) Confirm instrument Status "Sampling" Press ENTER.
2) Use Select Keys to select "Instrument Info 3/5", Press ENTER.
3) Use Select Keys to select "Sample Info 1/8", Press ENTER.
4) Use Select Keys to select "Sample Info A 1/9", Press ENTER.
5) Use Select Arrows to "Sampling – Temperature – Line A 9/9"
    a. External: °K
    b. Record value and convert from Kelvin to match NIST-traceable reference standard
6) Record value from temperature NIST-traceable reference standard.
7) Record temperature readings on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).

5.2.2 602BETAPLUSMANAGER.NET:

1) Confirm instrument Status "Sampling" Press ENTER
2) Go to Current Status Screen

NOTE: Instrument values must be ± 2°C of NIST-traceable reference standard. If the results are outside of ± 2°C of NIST-traceable reference standard, the sensor needs to be replaced.

5.3 BAROMETRIC PRESSURE VERIFICATION:

The TAPI 602 instrument barometric pressure sensor should be checked once per month using a NIST-traceable reference standard from the instrument front panel or the 602betaplusmanager.net software.

5.3.1 FRONT PANEL:

1) Record a barometric pressure reading from NIST-traceable reference barometric pressure device in close proximity to instrument.
2) Confirm instrument Status “Sampling” Press ENTER.
3) Use Select Keys to select “Instrument Info 3/5”, Press ENTER.
4) Use Select Keys to select “Sample Info 1/8”, Press ENTER.
5) Use Select Keys to select “Sample Info A 1/9”, Press ENTER .
6) Use Select Yes/No Arrows to “Sampling – Pressure – Line A 7/9”
    a. Absolute: KPa
    b. Record value and convert from KPa to match NIST-traceable reference standard
7) Record value from barometric pressure NIST-traceable reference standard
8) Record barometric pressure readings on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).

5.3.2 602BETAPLUSMANAGER.NET:

1) Confirm instrument Status “Sampling” Press ENTER
2) Go to Current Status Screen

NOTE: The results from the instrument sensor must be within ±10 mmHg of the reading on the pressure reference standard. If the results are outside of the allowable limits, the sensor must be calibrated.

5.4 FILTER TEMPERATURE SENSOR VERIFICATION:

First, the instrument cover must be removed to check the filter temperature/%RH sensor. Slide the Condensation Collector to Sample Tube coupler up the sampling down tube on both Line A and Line B. Once the couplers have been moved up the sample tubes, the instrument can be slid to one side, and clear of the sampling down tubes. Remove the condensation collectors and sample line heater assembles from both sides as well as the loader and unloader magazines. You can now remove the three screws on either side of the instrument and pull off the cover.

The filter temperature sensor measurement is used as a reference only, and in some cases, to control the temperature of the sample heater (if enabled). The sensor is mounted into the side of the filter presser mounting, below the top metal plate.

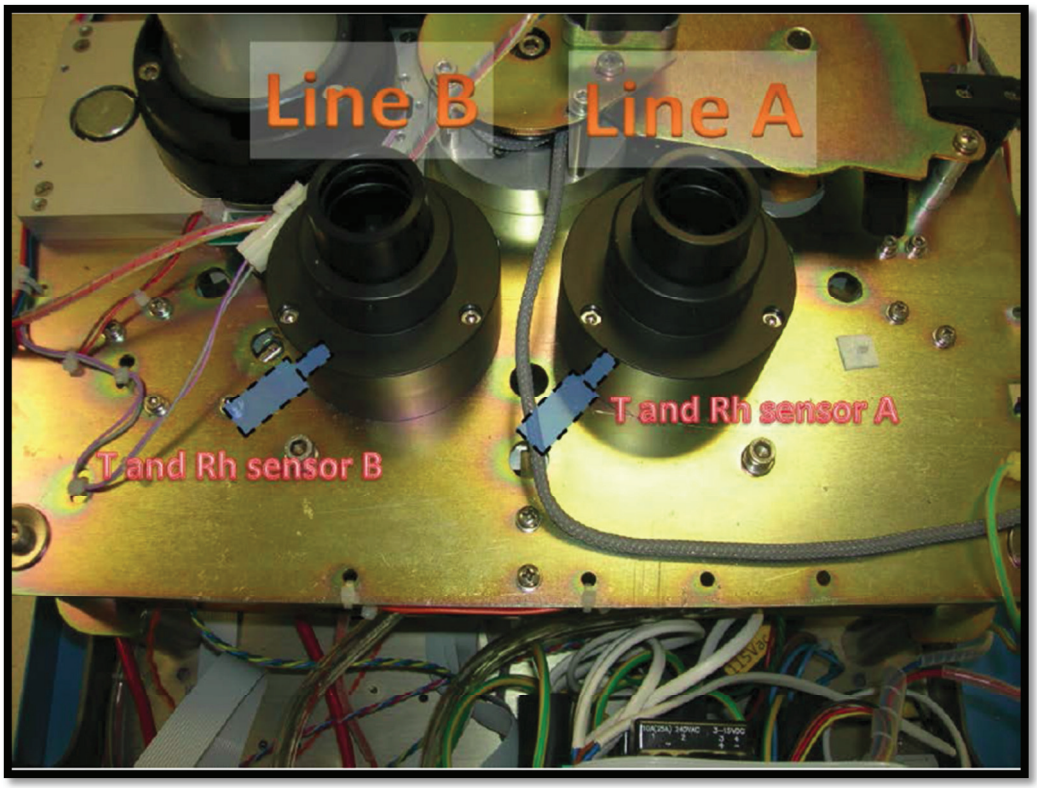


FIGURE 19: TEMPERATURE AND RH SENSOR LOCATION

Once the sensor is located, remove the cable connection. Then grasp and rotate the sensor, then pull it out of the housing. Reconnect the cable connection.

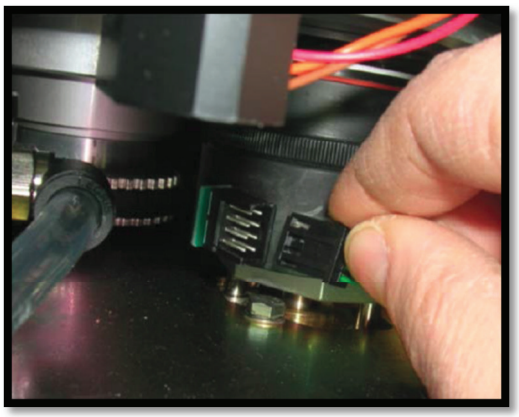


FIGURE 20: TEMPERATURE AND RH SENSOR UNPLUGGING

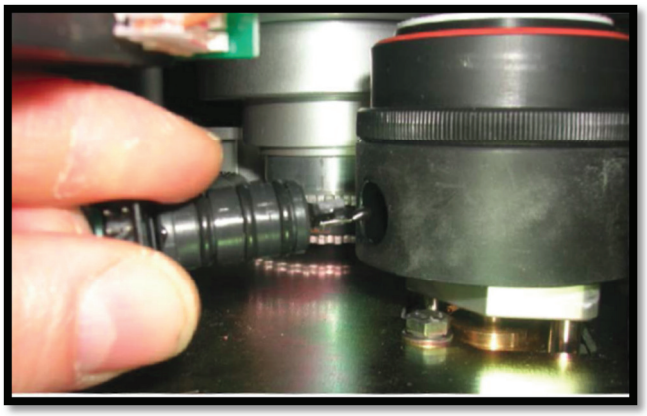


FIGURE 21: TEMPERATURE AND RH SENSOR REMOVAL

Using a certified NIST-traceable temperature sensor transfer standard, position the probes in close proximity and compare the readings. The reading from the 602 filter temperature sensor can be found in multiple locations: the front panel display, 602betaplusmanager.net software, or by sending a command string to the analyzer. If the value on the instrument sensor is found to be outside of the desired range when compared with the reference standard, the thermistor should be replaced.

To access the value from the front panel display, from the Main Screen press ENTER
To access the value from the 602betaplusmanager.net software, from the front panel display, go to the Sampling Info Tab. Line A and Line B Filter Temperatures are displayed in Kelvin.

To access the value using a command string from an external communication program (i.e. hyperterminal) or datalogger, type the following value 14 followed by ENTER (or carriage return, [CR]) for Line A filter conditions and type the value 19 for Line B filter conditions.

The instrument will respond with the following values in order (all in kPa units):
Temp Filter, Flow Rate Temp, Filter Pressure, Filter Pressure Drop, Flow Rate Pressure, Pump Pressure.

Example of response string:
14=100.22,293.28,293.50,260.1,265.00, 23.5,4.8035,293.01
Repeat this step for the other sampling line.

5.5 FILTER %RH SENSOR VERIFICATION

The filter %RH measurement comes from the same sensor as the filter temperature. Following the procedure above, you can also compare the %RH reading from the

sensor to a reliable external %RH measurement device. The filter %RH sensor is used to control the sample heater to within the user defined set point.

The measurements between the instrument and reference sensors should be within +/- 4%. If the value is outside of the desired range, the instrument temperature / %RH sensor should be replaced.

14=100.22,293.28,293.50,260.1,265.00, 23.5,4.8035,293.01
Repeat the steps for the other sampling line.

5.6 FILTER PRESSURE SENSOR VERIFICATION

The filter pressure sensor measurement is used as a reference only, and is most important for ensuring the pneumatic integrity of the sampling system, including the filter cassette seal. Verify the filter pressure sensor reading is within the desired range using a certified NIST-traceable temperature sensor transfer standard. The reading from the 602 filter pressure sensor can be found in multiple locations: the front panel display, 602betaplusmanager.net software, or by sending a command string to the analyzer. If the value on the instrument sensor is found to be outside of the desired range when compared with the reference standard, the thermistor should be replaced.

To access the value from the front panel display, from the Main Screen press ENTER Instrument Info, System Info, Filter A/B Temp (value is displayed in Kelvin).

To access the value from the 602betaplusmanager.net software, from the front panel display, go to the Sampling Info Tab. Line A and Line B Filter Temperatures are displayed in Kelvin.

To access the value using a command string from an external communication program (i.e. hyperterminal) or datalogger, type the following value 14followed by ENTER (or carriage return, [CR]) for Line A filter conditions and type the value 19 for Line B filter conditions.

The instrument will respond with the following values in order:
Temp Filter (K), Flow Rate Temp (K), Filter Pressure (kPa), Filter Pressure Drop (kPa), Flow Rate Pressure (kPa), Pump Pressure (kPa)

Example of response string:
14=293.77,293.18,100.23, 0.00,0.0088,100.24

5.7 LEAK:

The TAPI 602 requires a leak check after installation and on a bi-weekly basis to ensure proper orientation and data quality. The installation leak check should be performed prior to temperature, pressure, and flow calibration. Two different types of pneumatic circuit seal tests are available: the Auto Leak Test and the Manual Leak Test. The Auto Leak Test checks the pneumatic circuit seal downstream from the accumulation section (a solenoid valve closes the pneumatic circuit to perform the Leak Test). The manual Leak Test checks the pneumatic circuits down stream of where the technician interrupts the sampling flow. The Manual test is to be performed on a bi-weekly basis and the automatic test is to be performed on an as needed basis for troubleshooting purposes.

The Manual Leak Test checks the sealing of the entire pneumatic circuit (including the sampling line) or parts of it (using the accessory tools for instrument tests). Manual Leak check information should be recorded on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).

5.7.1 LEAK TEST (MANUAL):

The instrument must be stopped to perform a manual sampling system leak test. There are several locations in the sample system where a leak check can be performed. The two most common are:

- Below PM10 inlet (Bi-Weekly).
- Sample cassette location downward.

Below the first procedure is for below PM10 selective size inlet and the second procedure is for sample cassette and below of the pneumatic sample system.

Below PM10 inlet (above VSCC on PM2.5 line if present):

1) Confirm instrument Status – Ready.
2) Perform Filter Unloading Procedure
   (see Section 5.11 in the TAPI-602 Operating Manual).
3) Use Select Keys to select “Instrument Tools 5/5”, Press ENTER.
4) Use Select Keys to select “Test 1/4”, Press ENTER.
5) Use Select Keys to select “Line A Pneumatic Test 1/4”, Press ENTER.
6) Use Select Keys to select “Line A Manual Leak Test 1/4”, Press ENTER.
7) Remove PM10 inlet hat and place leak check cap on tube.
8) Load standard filter cassette with filter into loader tube, Press ENTER
   a. Manual Leak Test A in progress
   b. Wait 2 minutes after pump stops
   c. Press Enter.
9) Results displayed:

   a. Pr: Qleak:
10) Record values on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).
11) Press ESC key to end "Wait for test to end…"
12) Repeat all steps with "Line B Manual Leak Test 1/4", but install leak check cap on top of VSCC if present.

Sample cassette and below:

1) Confirm instrument Status: Ready.
2) Perform Filter Unloading Procedure
   (see Section 5.11 in the TAPI-602 Operating Manual).
3) Use Select Keys to select "Instrument Tools 5/5", Press ENTER.
4) Use Select Keys to select "Test 1/4", Press ENTER.
5) Use Select Keys to select "Line A Pneumatic Test 1/4", Press ENTER.
6) Use Select Keys to select "Line A Manual Leak Test 1/4", Press ENTER.
7) Load the air tight disk with flat side up into loader tube, Press ENTER.
   a. Manual Leak Test A in progress…
   b. Wait 2 minutes after pump stops
   c. Press Enter.
8) Results displayed:
   a. Pr: Qleak:
9) Record values on the TAPI 602 monthly quality control maintenance check sheet (Appendix A)
10) Press ESC key "wait for test to end…"
11) Repeat all steps with "Line B Manual Leak Test 1/4".

NOTE: If the value is higher than 2.0 ml/(min*kPa), there is a correctable leak in the system. Check the fittings from the pump up to the pneumatic tray, and from the pneumatic tray to the rear panel of the analyzer. Most leaks are found here with these push to connect fittings.

NOTE: Warning message higher than 15 mL/(min*kPa).
Alarm message higher than 30 mL/(min*kPa). Following an alarm, the instrument will not operate until power is cycled.

5.7.2 LEAK TEST (AUTOMATIC):

1) Confirm instrument Status – Ready.
2) Use Select Keys to select "Instrument Tools 5/5", Press ENTER.
3) Use Select Keys to select "Test 1/4", Press ENTER.
4) Use Select Keys to select "Line A Pneumatic Test 1/4", Press ENTER.

5) Use Select Keys to select “Line A Auto Leak Test 1/4”Press ENTER .
6) Results displayed:
    a. Pr: Qleak:
7) Record values on the TAPI 602 monthly quality control maintenance check sheet (Appendix A).
8) Press ESC key “wait for test to end…”
9) Repeat all steps with “Line B Auto Leak Test 2/4”.

Note: The leak test value Q_{leak} will be expressed in mL/min*kPa and the limit is 2.0 ml/(min*kPa).

5.8 <u>BETA SPAN TEST (AUTOMATIC) (STATUS: READY):</u>

1) Confirm instrument Status: Ready.
2) Press ENTER key.
3) Use Select Keys to select “Instrument Tools 5/5”, Press ENTER.
4) Use Select Keys to select “Test”, Press ENTER.
5) Use Select Keys to select “Beta Span Test”, Press ENTER.
6) Use Yes / No Keys to select appropriate Operating Mode:
    a. “Hourly” or “Multi-time”
    b. Press ENTER
    The test will check Background radioactivity (D), Air (A), reference filter (R1) and reference filter (R2). The effective value of the counts measured by the Geiger Müller (GM) is displayed during the test. At the end of the test, the correct counts for the GM dead time are stored and displayed. The value of the used dead time is the one given by the GM manufacturer (because the calibration function is empirical, effective values of dead time different from the one given by the producer do not affect the mass measurement quality).
7) Use Yes / No Keys to change view from the following
    c. R1 Ref: Test: Err:
    d. R2 Ref: Test: Err:
    e. D: A: R1: R2:

At the end of the test, the following parameters will be displayed for both of the reference filters:

Ref: *Nominal value of the reference filter’s mass surface density (mg/cm²)*
Test: *Measured value of the filters’s mass surface density (mg/cm²)*
Err*: Percentage error*

NOTE 1: If the percentage deviation (Err) between the nominal surface mass density and the measured value of one or both of the reference filters is greater

than 5%, a Warning message is automatically activated (Warning 14, see Appendix 3).

NOTE 2: The Hourly and Multi-Time Modes use two different calibration functions and test procedures, because in Hourly Mode the source moving piston is UP while in Multi-Time Mode it is in the DOWN position.

5.9 TIME AND DATE:

The time and date should be verified on a bi-weekly basis or whenever the power is interrupted to the instrument. The Time and Date should match to the station data logger within 30 seconds, but if no data logger is present then look up the Pacific Standard Time at time.gov. If the Time and Date are not matching then they are to be adjusted. If the TAPI 602 drifts significantly then this is an indicator a problem may exist.

NOTE: Time and Date on all instruments are set to Pacific Standard Time (PST).

6 SAMPLING:

Anytime the instrument has sampling aborted the instrument has to be programmed to start sampling again.

6.1 START SAMPLING:

At least 8 filter cassettes containing fresh filter media need to be present in the loader magazine. Confirm they are properly oriented (smaller hole facing up). It is highly recommended to fill loader magazine (e.g. 96 filter cassettes fit into the loader magazine) before starting the instrument.

Following successful completion of the verification procedures:

- FLOW RATE (MANUAL)
- AMBIENT TEMPERATURE
- BAROMETRIC PRESSURE
- LEAK CHECK
- BETA SPAN TEST (AUTOMATIC)
- TIME AND DATE

1) Confirm instrument Status: Ready.
2) Confirm instrument display says “Start”, Press ENTER.
3) Select sampling Mode “hourly” :
    - Hourly mode (used for US EPA compliance monitoring), select Hourly,
4) Select start date and time, Press ENTER .

- Choose top of next available hour: This will synchronize data output with external data logger.

5) When prompted, hold down the Enter button for 3 seconds to initiate sampling.
    - The instrument will first go through a series of tests and blank filter measurements. This process will take approximately 75 minutes. No sampling can begin until this initialization process is completed.

7 ROUTINE SERVICE CHECKS:

7.1 STATUS:

The instrument display screen shows the status of the instrument. Check to be sure the status LEDs are green, and the STATUS displayed is 'SAMPLING' during normal operation.

- READY: The instrument is ready to start a sampling and measurement cycle.
- DELAY: The instrument has been programmed (START) and will start the sampling and measurement process at the programmed date and time.
- SAMPLING: The instrument is sampling and measuring.
- ENDING: The filters in the loader magazine and in the reserve have been used up.
- ALARM: The instrument functionality has been compromised by an anomaly that caused the interruption of the sampling and measurement cycles. After fixing the cause of the interruption, reset by holding "ESC" & "NO" until status returns to READY. A listing of Alarms is located in Appendix 2 of the Operating Manual.
- TEST: The instrument is performing automatic functionality tests on the servomechanisms/sensors/pneumatic circuit/mass measurement system.

7.2 CONDENSATE COLLECTORS:

There are clear tubes protruding from the condensate collectors. Observe if any water is visible in the clear tubes and drain if necessary by removing the upper tubing connection and turning the tubing downward to drain the water from the collection cup inside the trap (it is recommended to have a cup ready to capture the draining water). If the condensate collector contains the self-draining vessel (option), check to see if the separate vessel needs to be emptied. Be sure to secure the fittings removed during this process. It is recommended to perform a manual complete sampling system leak check after emptying a condensate collector.

If any water drops are visible in the condensate collector, adjustments need to be made to the environmental conditions of the shelter. First, be sure the sampling lines are

insulated, with no exposed aluminum inside the shelter (either tubes or couplers). Second, be sure that the HVAC exhaust is not blowing directly on the sample tubes. Lastly, try to maintain the shelter temperature thermostat set point at or above the highest expected ambient dew point temperature. It may also be a good idea to check the sample inlets for any condensation.

7.3 LOADER MAGAZINE STATUS:

The instrument will continue to run autonomously for many months at a time as long as the filter loader magazine does not become empty. Check the Loader magazine to be sure there are enough filters installed until the next scheduled visit. The instrument will typically use a minimum of six (6) filters per day, but there are some exceptions. If either the minimum or maximum pressure drop setting is active and any filter experiences a pressure drop outside of the allowable range, that sample filter will be rejected and a new one will be installed with very little downtime. This will, however, result in higher filter consumption. If the sample filter loader magazine becomes empty, the instrument will enter the ENDING cycle mode and will need to be restarted once new filter cassettes are loaded.

7.4 LOAD NEW FILTERS:

The filter cassette assemblies include three pieces, the top cassette half, the filter media, and the bottom cassette half. The cassettes are color coded to easily decipher between the two channels in case chemical speciation analysis will be performed. One filter cassette assembly has a black bottom and the other has a white bottom. Other than the color, the filter cassettes are identical and can be used on either sample line.

Once the filter cassettes are assembled, stack them onto columns (about 15-20 per stack). The first column should be stacked on top of the filter loading tool. Stacking them in black/white/black/white/etc. order is not necessary. This is only helpful for determining which filter cassette is associated with Line A vs Line B, if post chemical speciation analysis is going to be performed. The instrument measurement results and data storage is unaffected by the color of the filter cassette.

Be sure the filter plunger is inside of the loader magazine in the correct orientation. It can be simply loaded into the magazine by pushing the magazine over the top of the filter plunger. Then, press the first column of filter cassettes into the magazine. Repeat this step with the next two columns.

Once the Loader magazine is full, it can be inserted into the top of the instrument. Turn it clockwise a quarter turn to lock it into position.

New filter cassettes can be loaded at any time, without stopping the instrument. With the instrument sampling, simply unlock and remove the Loader magazine, and load fresh stacks of filters as described above. Any quantity of filters can be loaded at any given time. As long as the Loader magazine does not become empty, the instrument will continue to operate without any interruption.

7.5 USED SAMPLE FILTER SPOTS:

The used sample filters should be observed when disassembling the filter cassettes. The used sample filters should exhibit a round and uniform sample spot after sampling with a single and clear sharp edge. If irregular sample spots are observed, it is likely a moisture problem (condensation in the sample line) or a filter cassette leak. If a filter cassette is suspected to be leaking, a mark could be made on the cassette to track and observe the sample spots. If irregular sample spots are consistently observed with the same cassette, it should be removed and replaced with a new one. An irregular spot can also be created by a dirty nozzle, which should be removed and cleaned per the maintenance section.

7.6 SERVICE AIR PRESSURE:

The Service Air Pressure is indicated on the front panel of the instrument and can be changed using the regulator on the front of the compressor. The pressure should be set to 240-260 kPa (34.9 - 37.7 PSI) and confirmed by viewing the pressure shown on the instrument front panel (under the Instrument Info → System Info menu). The compressor will turn on intermittently, as necessary, to pressurize the reserve canister to the level set on the regulator at the output of the compressor. The pressure must be manually adjusted at this regulator and cannot be adjusted on the instrument.

7.7 SHELTER TEMPERATURE:

The shelter temperature is a driving factor for the sample filter temperature, and good environmental control should be maintained. The general range of acceptable operating temperature inside the shelter or enclosure for the TAPI 602 is 20-30℃. Cooler temperatures are usually better, however, it is important to avoid condensation inside the shelter and the instrument, therefore maintaining the shelter temperature at just above the highest expected ambient dew point temperature is a good general guide. Because the instrument will typically be about 2℃ warmer than the temperature inside the shelter, it would be ideal to keep the shelter temperature no higher than 28℃ for best results. Of course, if the ambient dew point temperatures above 28℃ are expected, than the temperature inside the shelter should be kept at just above the maximum expected ambient dew point temperature.

7.8 WARNINGS & ALARMS:

These are displayed in hexadecimal form and details are contained in the operating manual for deciphering the warning and troubleshooting. A warning indicates a fixable problem with the instrument, but the instrument will continue to operate. A warning is indicated by a yellow light on the front panel and the warning can be identified from the instrument display screen. Press ENTER → Instrument Info → Warnings Info.

The hexadecimal warnings can also be translated using the 602betaplusmanager.net software. Launch the 602betaplusmanager.net application and click on the Teledyne ICON in the upper left hand corner, select Warning Translator. In the warning translator screen, select SWAMDCH and type in the eight digit code (all eight digits must be filled in which may require leading zeros).

7.9 FILTER PRESSURE DROP:

The initial, average, and maximum pressure drop measurements are recorded for each filter. Under normal conditions, the filter pressure drop will change based on the type of filter media being used and the amount of PM collected on the filter, and this will also vary based on the quality of the pump vacuum and barometric pressure. Given these considerations, an acceptable filter pressure drop range is 15-40 kPa. Results outside of the acceptable range can indicate a problem such as a filter cassette leak, improperly assembled filter cassette, or very high atmospheric PM loadings.

7.10 COLLECT TEMPERATURE:

The temperature of the filter compartment during sample analysis is measured and recorded, and is heavily influenced by the instrument shelter or enclosure temperature. The filter compartment (measured as Collect Temperature) itself cannot be controlled, and will typically be about 2℃ warmer than the shelter or enclosure temperature. Therefore, in order to maintain the Collect Temperature below 303K (or 30℃), the shelter temperature should be kept at or below 301K (or 28℃) – see Shelter Temperature above.

7.11 BATTERY TEST:

The battery test allows the operator to check monthly if the instrument will be able to complete the beta count testing if line power to the instrument is interrupted. The batteries do not support the operation of the pumps in the event of a line power loss. Below are the steps to perform the battery test.

1) Confirm instrument Status “Ready” Press ENTER
2) Use Select Keys to select “Instrument Tools 5/5”, Press ENTER
3) Use Select Keys to select “Test 1/4”, Press ENTER
4) Use Select Keys to select “Battery Test 4/6”, Press ENTER

5) Battery test in progresss…
6) Automatic Battery Test DONE
7) Vps =__,_ V I=_% Vbl=__,_V Vb0=__,_V
   - Vps: Interna Operating Voltage
   - I: Battery Charging Current
   - Vbl: “Load” battery voltage
   - Vb0: “No-load” battery voltage

NOTE: If the instrument fails the test (battery charge is insufficient to keep it in operation), the red “*Battery Level Low”* LED and the yellow “*Warning*” LED on the front control panel will turn on.

NOTE: The instrument is also able to automatically perform the battery voltage test during the sampling and measurement cycles. If the battery voltage is too low and unable to keep the instrument in operation, a Warning message will be displayed and stored in the Data Buffer.

8 MAINTENANCE:

8.1 PARTICULATE SIZE SELECTIVE INLET DISMANTLING & CLEANING:

As per US EPA and manufacturer’s guidance, the US EPA PM10 inlet, PM10 pre-impactor, and PM2.5 VSCC-A cyclone inlet should be disassembled and cleaned once every 30 days.

In addition the sampling lines should be checked and cleaned out if necessary. As noted below, whenever inlets or couplers are removed from the sampling lines, the o-rings should be inspected for wear and fresh greased applied as needed.

REQUIRED TOOLS AND ACCESSORIES:

- Philips head screw driver
- Vacuum grease
- Lint free cloth / wipes
- Q-tips.

Preparing the TAPI 602 instrument for inlet cleaning
The sampling inlets can be cleaned when the instrument is in Ready, Sampling or Ending Status. If the instrument is in Sampling or Ending Status the vacuum pumps must be switched off before removing the sampling inlet from the sampling line.

STOPPING PUMPS PROCEDURE:

1) From the main screen press and hold the ESC key for at least 5 seconds to access the Menu code (access to support tools).
2) Enter code 952 using the Select keys and press ENTER to access the pump control function.
3) Choose the pump to be switched off using the Select keys.
4) Press NO to select OFF.
5) Press ENTER to confirm.

After switching the pump off, follow the next procedure to continue with the removal and cleaning of the sampling inlets.

8.1.1 US EPA PM10 INLET:

1) Mark each assembly point of the sampler inlet with a pen or pencil to provide “match marks” during reassembly. Critical assembly points are already “keyed.”
2) Disassemble the sample inlet unit, taking care to retain all the parts. Note: If the assembly screws appear frozen, the application of penetrating oil or commercial lubricant will make removal easier.
3) Using a soft brush, cloth, and cotton swabs, lightly scrub all interior surfaces and the bug screen with distilled water and/or the general-purpose cleaner. Pay particular attention to small openings and crevices. Cotton swabs and/or a small soft brush are most helpful in these areas. Using laboratory tissue and cotton swabs moistened with distilled water, wipe all surfaces to remove any remaining deposits. Completely dry all components.
4) Check all the O-rings for distortion, cracks, fraying, lack of lubricating grease, or other problems. Apply a thin coating of vacuum grease or replace the O-rings as necessary.
5) Reassemble the unit in accordance with the previously scribed match marks. Take particular care to ensure that all O-ring seals are properly sealed and that all screws are uniformly tightened.

8.1.2 PM10 PRE-IMPACTOR ON PM2.5 LINE B:

1) Remove the sampling inlet from the sampling line.
2) Disassemble the sampling inlet.
3) Carefully and thoroughly remove any dust deposits from the impactor disc and any condensation accumulated in the chamber below.
4) Clean all the components using water and a mild detergent.
5) Dry all components with a clean cloth and blow compressed air through nozzles.
6) Apply a thin coat of vacuum grease on the impactor disc.
7) Remove any insects or other debris from the filtering net.
8) Check and, if needed, replace the two o-rings and grease them.

9) Re-assemble the sampling inlet.
10) Should be repeated monthly.

8.1.3 BGI PM2.5 VSCC™:

1) Remove the VSCC from its installed position in the instrument.
2) Pull off the side transfer tube. If it is too tight to remove by hand, pry it off with a rigid plastic lever. Care should be taken to not damage the two “O” ring seals.
3) Remove the top cap and grit pot by unscrewing.
4) Wet a lint free wipe with water and remove all visible deposits. These are most likely to be found at the bottom of the cone and inside the grit pot.
5) Inspect all “O” rings for shape and integrity. If at all suspect, replace. Lubricate all “O” rings with light grease. It is important to well lubricate the transfer tube to avoid difficult disassembly.
6) It is not necessary to remove the two hex head screws (pn 10001), but make sure they are tightly positioned.
7) Assemble in reverse order and reinstall.
8) Perform a leak check according to manufacturer’s operating manual specifications.
9) After re-assembling the sampling inlets, use the pump control function to turn the pumps back on.
    a. Select the pump you wish to switch on using the Select keys.
    b. Press YES to select ON.
    c. Press ENTER to confirm.

NOTE: At the beginning of every sampling and measurement cycle and after unloading the sampled filters (at the end of the mass measurement collection session), the suction pumps are automatically activated.

8.2 ROTARY VANE VACUUM PUMP REBUILD (1ST GENERATION PUMP)

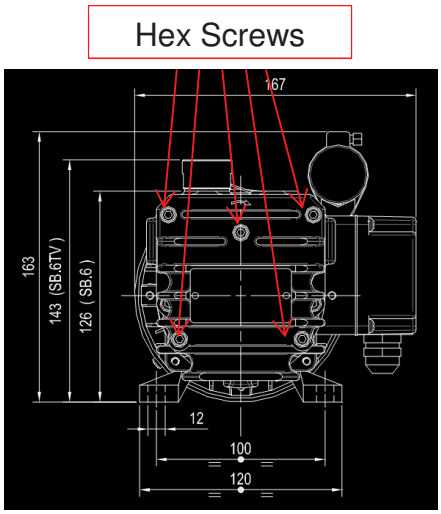
Identify the type of vacuum pump(s) you have. The 1st generation pumps have a rebuild frequency of 6-8 months. The 2nd generation pumps have a rebuild frequency of 3 years. The procedure below refers to the 1st generation pumps only.

The 1st generation pumps are shown below. Some will have an exhaust tube attached with a muffler, and others will have a check valve on the exhaust. The rebuild procedure for the 1st generation pumps is identical for both configurations.

FIGURE 22 VACUUM PUMPS 1ST GENERATION

Unplug the pump and disconnect the tubing from the intake. If the pump has been recently running, allow it to cool down prior to disassembly. The vanes are located on the front side of the pump where the intake and exhaust vents are located.

FRONT SIDE OF THE VACUUM PUMP

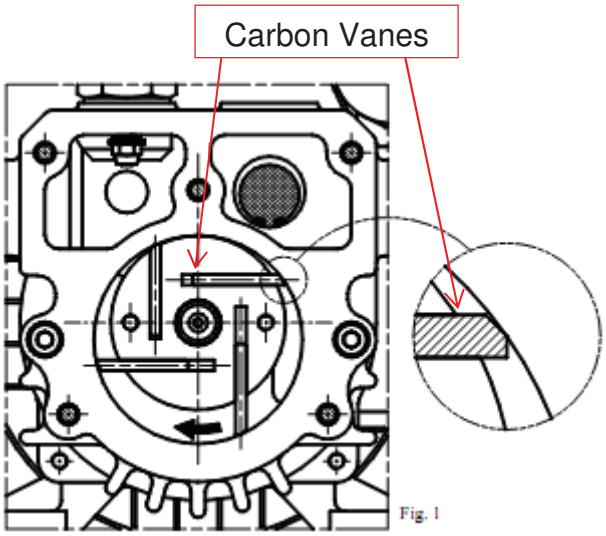


Remove the five screws using the appropriate sized hex screw driver.

Remove the cover and take out the worn vanes. Insert the new vanes provided in the pump rebuild maintenance kit in the rotor grooves placing the beveled edge outside, in contact with the surface of the operating chamber.

Turn the rotor by hand and check that the vanes can move freely.

FRONT VIEW OF PUMP WITH COVER REMOVED



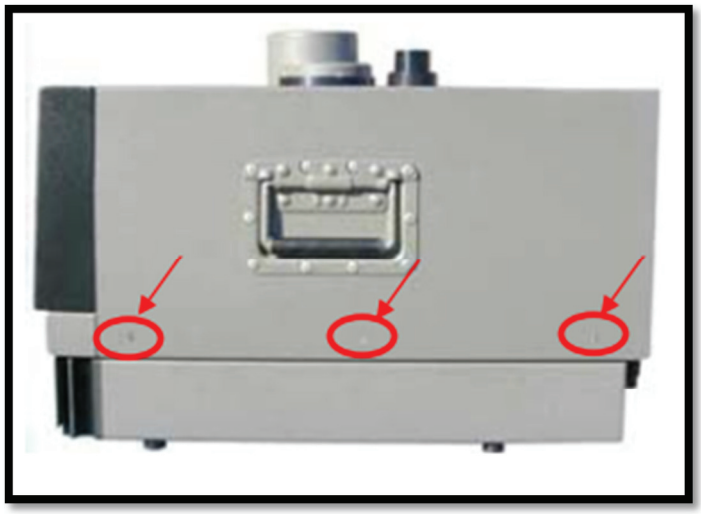
Replace the pump cover and tighten the screws.

8.3 CLEANING INLET NOZZLES:

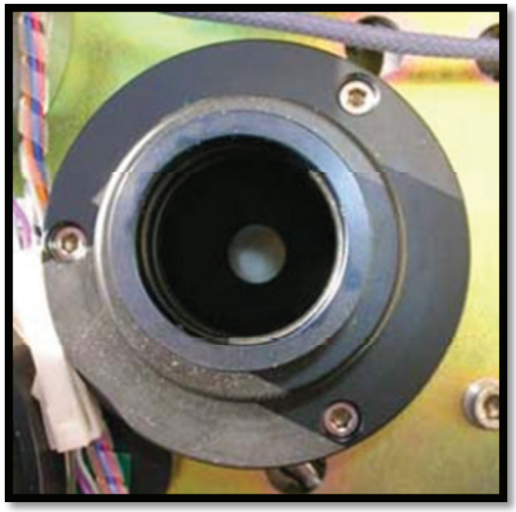
Cleaning of inlet nozzles should be on annual basis or more frequently if conditions warrant more frequent cleaning.

First, be sure the instrument is in the Ready mode. Remove the loader and unloader magazines, and power down the instrument. Remove the retaining ring over the loader position, and slide the cover rings from over the two sampling lines.

Remove the six Philips head screws holding the cover on the instrument (located on either side of the instrument), and remove the cover.



Remove the rubber gasket moisture barrier from the two sampling lines, exposing the hex head screws holding the cover in place.



There are two types of inlet nozzles supplied with the Model 602, hourly (left) and multi-time (right). Using a kim wipe and/or dry canned air, remove any debris from the entire surface including the o-ring. IMPORTANT: DO NOT APPLY ANY GREASE TO THESE O-RINGS.

5-2a

TAPI p/n DU0000044

5-2b

TAPI p/n DU0000045

Replace the inlet nozzles using the reverse procedure described above.

NOTE: When the nozzle is removed for cleaning a foam filter support can be seen below filter plate. This foam filter can get dirty and has been stated by the manufacture that this is ok. If you attempt to replace this foam element because it has been determined it is causing significant flow restriction the replacement could change the compression distance on the nozzle resulting in bad readings. Underneath the foam element is a height adjustable support spider that has thread locker applied to it. If this support spider is loose then the instrument should be shipped back to the manufacturer for servicing.

9 TROUBLESHOOTING:

Contact Teledyne API Technical Support (858-657-9800) should you experience a suspected problem with the TAPI 602 instrument.

10 REFERENCES

- Teledyne Advanced Pollution Instruments (API) Model 602 Beta^{PLUS} Particulate Measurement System http://www.teledyne-api.com/manuals/07318B_602.pdf

- District Class Specifications for Air Quality Instrument Technician I/II Position http://agency.governmentjobs.com/valleyair/default.cfm?action=viewclassspec&classSpecID=819820&agency=2071&viewOnly=yes

- 40 CFR Part 58 Appendix E (January 15, 2013)

- EPA QA Handbook Volume II (December 2008)

- ARB Air Monitoring Quality Assurance Manual Volume V Appendix D (August 2012)

11 APPENDIX

A. TAPI 602 Monthly Quality Control Maintenance Check Sheet

San Joaquin Valley Air Pollution Control District

TAPI 602 PM10 & PM2.5 instrument

Quality Assurance Bi-Monthly Maintenance Check Sheet

Revision: 1 Date: 04/11/2016 By: JF

Site Name / AIRS Number: SITE / AIRS Number Site Technician: TECHNICIAN

Asset Number: _ Last Cal: _ Month: MONTH3 Year: YEAR

Serial Number: _ Cal Exp: #VALUE!

Date	Initials	Delta Cal Asset #	Delta Cal Cert Date	Leak Check (Manual)		Flow (while samoline)						Ambient Temp			Barometric Pressure			Time Check	Loaded New Filters	Water In Trap	Air Comp. Regulator Pressure	Air Comp. Water Purge
				Line A	Line B	Line A (Inlet flow meter)	converted	Delta Cal	Line B (Inlet flow meter)	converted	Delta Cal	602	converted	Delta Cal	602	converted	Delta Cal					
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
_	_	_	_	_	_	_	no data	_	_	no data	_	_	no data	_	_	no data	_	_	_	_	_	_
00/00/0000	XX	0XXXX	Date	<2ml/(min*kPa)		m^3/h	16.00-17.34 LPM		m^3/h	16.00-17.34 LPM		Kelvin	± 2 °C of each other		kPa	± 10mm Hg		0:00	Y / N	Y/N	34.9-37.7 psi	Y/N

Monthly	Month 1	Month 2
Line A Clean PM10 Inlet Head	_	_
Line B Clean PM10 Inlet Head	_	_
Battery Test	_	_

6 Month (Bi-Annual)	
Inspect Pump Lines	_
Inspect Compressor Lines	_
Service Pump Filters	_

3 Month	
Beta Span Check	_

Annually	Line A	Line B
Nozzle Cleaned	_	_
	#1	#2
Spy Filters	_	_
Clean Ambient Temp Housing		

Date	Initials	Comments

Technician: _____ Date: _____

Reviewed by: _____ Date: _____

[redacted]

B. Quality Assurance Bi-Annual Calibration Sheet

SAN JOAQUIN VALLEY AIR POLLUTION CONTROL DISTRICT

602 Bi-Annual Calibration Sheet

Station Name :		Station AIRS # :		Date :	
Serial Number :		Instrument ID :		Last Calib. Date:	
Software Version :		Last Zero Test :			

Calibration Reference Standard

Flow Reference Standard Used :		Model:		Serial Number :		Cert. Date:	
Temperature Standard Used :		Model:		Serial Number :		Cert. Date:	
Barometric Pressure St. Used :		Model:		Serial Number :		Cert. Date:	

As - Is Flow Range

	Flow Set pt.		602 Flow	Ref. Std.	LPM Diff	% Diff from Target		Leak Check Value:			LPM	
	16.7	LPM			#VALUE!	#VALUE!		602	Ref. Std.	Units	% Diff	
	16.7	LPM			#VALUE!	#VALUE!				°C	#VALUE!	Ambient Temp.
	16.7	LPM			#VALUE!	#VALUE!				mmHg	#VALUE!	Barometric Pressure

Mechanical QC Maintenance

	Okay		Okay			Okay		Okay	
Sample Nozzle Clean (Line A):	As - Is:		Final:		PM Head Assembly Clean (Line A):	As - Is:		Final:	
Sample Nozzle Clean (Line B):					PM Head Assembly Clean (Line B):	As - Is:		Final:	
Pump Muffler Unclogged:	As - Is:		Final:		PM 2.5 VSCC Clean (LineB):	As - Is:		Final:	
Sample Inlet Tube Clean:					Inlet O-Rings and Seal Condition:	As - Is:		Final:	

Setup and Calibration Values

Parameter	Expected	Final				Parameter	Expected	Final
Clock Time:						Flow Rate	16.7	
Date:						BKGD:		
						RH Control:	YES	
						RH Setpoint:	35%	
						Delta-T Control:	NO	
						Delta-T Setpoint:	99 C	

Final Flow Range

	Flow Set pt.		BAM Flow	Ref. Std.	LPM Diff	% Diff from Target		Leak Check Value:			LPM	
	16.7	LPM			#VALUE!	#VALUE!		BAM	Ref. Std.	Units	% Diff	
	16.7	LPM			#VALUE!	#VALUE!				°C	#VALUE!	Ambient Temp.
	16.7	LPM			#VALUE!	#VALUE!				mmHg	#VALUE!	Barometric Pressure

[redacted]

Comments:	

Rev. Date: 04/11/2016 JF	Calibrated by:	Reviewed by:
	Submitted Date:	Date:

[redacted]

C. Figure Reference Table

Figure 1: CENTRAL UNIT 7
Figure 23: MASS MEASUREMENT SYSTEM SAFETY LOCK 7
Figure 24: FILTER CARTRIDGE SEPERATOR TOOL 9
Figure 25: FILTER CASSETTE WITH USED GLASS FIBER FILTER 9
Figure 26: FILTER CASSETTES SEPERATED & EMPTY 10
Figure 27: FILTER CASSETTES SEPERATED & GLASS FIBER FILTER LOADED 10
Figure 28: FILTER CASSETTES CLOSED 10
Figure 29: FILTER CASSETTES STACKED 11
Figure 30: REFERENCE FILTERS 13
Figure 31: SPY FILTER INSERTION 14
Figure 32: VACUUM PUMP 14
Figure 33: CONDENSATE COLLECTOR 15
Figure 34: SMART HEATER 16
Figure 35: SAMPLE NOZZLES 5-2A(HOURLY) & 5-2b(MULTI-TIME) 17
Figure 36: AIR COMPRESSOR 18
Figure 37: 602 BETA PLUS MANAGER.NET SINGLE POINT FLOW CALIBRATION 25
Figure 38: INSERTING THE REFERENCE FILTERS 31
Figure 39: CALIBRATION DATA DOWNLOAD 32
Figure 40: TEMPERATURE AND RH SENSOR LOCATION 42
Figure 41: TEMPERATURE AND RH SENSOR UNPLUGGING 42
Figure 42: TEMPERATURE AND RH SENSOR REMOVAL 43
Figure 43 VACUUM PUMPS 1ST GENERATION 56