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1 Preface

1.1 Product Introduction

The XC-500 Series Source Sampler from Apex Instruments is designed for manual, isokinetic sampling of gaseous pollutants from stationary sources, e.g. stacks, flues, vents or pipes. The console is most commonly used for EPA Methods 5, 17 and 23.

The Source Sampler is easily adapted to test for a wide range of pollutants from stationary sources, such as particulate matter including PM 2.5 and PM10 fractions, metals, polychlorinated biphenyls (PCBs), dioxins/furans, polycyclic aromatic hydrocarbons (PAHs) and many more pollutants with adaptations of the basic isokinetic test method.

1.2 Purpose of this manual

The purpose of this manual is to provide a basic understanding of the Apex Instruments XC-500 Series Source Sampling Console. The XC-522, XC-523, and XC-572 are applicable for use with a variety of US EPA sampling methods.

Additionally, this manual provides the users with a reasonable amount of reference information on system configuration, calibration procedures, maintenance and troubleshooting as it applies to the specific product and the US EPA Regulations.

1.2.1 Relevant US EPA method descriptions

Method 5 - Determination of Particulate Matter Emissions From Stationary Sources

Method 17 - Determination of Particulate Matter Emissions From Stationary Sources

Method 23 - Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans From Stationary Sources

Detailed information on method sampling may be found through the US EPA website - please visit https://www.epa.gov/emc/emc-promulgated-test-methods for complete method descriptions

1.3 Safety Instructions

1.3.1 Safety information related to the intended use

Source sampling is intended to be performed by technicians who have been trained in source sampling methods. Personnel conducting source sampling are expected to understand basic gas laws and chemistry.

In addition, all technicians should have adequate general safety training to identify, abate and prevent job-related hazards including site-specific training.

Please visit the following link for more information on Stack Sampling Safety Procedures and Protocols: *http://www.sesnews.org/*

1.3.2 Explanation of safety warnings

“DANGER” indicates a hazard with high level of risk which, if not avoided, will result in death or serious injury.

“WARNING” indicates a hazard with medium level of risk which, if not avoided, could result in death or serious injury.

“CAUTION” indicates a hazard with low level of risk which, if not avoided, could result in minor or moderate injury.

“NOTICE” Indicates information considered important, but not hazard-related.

1.3.3 Electrical shock

Use and maintenance of the source sampling console presents potential electrical hazards.

Ensure that the console is protected from wet conditions such as rain or process emissions. If the console is wet, do not continue to operate the console until it has been adequately dried.

Do not perform maintenance on this console when it is still plugged into a power source and the main power switch is turned on.

Do not continue to use the console if wires are exposed or loose from their connectors.

1.3 Safety Instructions cont.

1.3.4 Weight

CAUTION

Although the unit is can conveniently be transported by an individual, the unit itself can present risks due to its weight. When carrying the unit, make sure to use proper form to lift using your legs. Lift and carry the unit using the provided handles or by holding the entire unit close to the body. If a user is not comfortable carrying the unit, a partner may provide the necessary assistance in moving the unit around.

1.3.5 Elevated surfaces

DANGER

Use of the unit on elevated surfaces also poses risks that range from minor to fatal. Be sure to operate the unit on a level, stationary surface. If necessary, secure the unit using straps or braces to ensure that vibration or accidental contact does not knock the unit off of its surface.

1.4 What To Do When the Unit Arrives

1.4.1 Unpack and inspect

Unpack the unit from its shipping container. Inspect the exterior of the unit for visible damage or missing components. Remove the lid by using the four butterfly latches and visually inspect the front of the unit.

NOTICE

Do not tamper with the internal components unless otherwise recommended.

Check the packing list to ensure that everything has arrived. The console comes with a pre-test calibration certificate for the dry gas meter and temperature sensors. A power cord will also be included for any units that use 120V supplied power.

1.4.2 Become familiar with console operations

Perform mock sample runs to ensure operation of console follows proposed test plan and EPA Method procedures.

1.4.3 Leak checks

Perform the console leak checks as explained in *Section 3.2.5 Console Leak Check Procedure* on page 20 of this manual.

1.4.4 Calibration audits

The unit is sold with a factory dry gas meter calibration at flow rates appropriate for the unit. Apex Instruments suggests performing audits of the dry gas meter before and after each testing period and performing a full calibration on the dry gas meter, sensors and thermocouples annually. Ensure that you verify calibration standards with your local administrator.

Perform the unit calibration audits as explained in *Section 4.1 Pre-Test Calibrations* on page 25 of this manual.

1.4.5 Test plan and methods

Begin the sampling operation procedures as directed by the applicable EPA Method and local compliance regulations.

1.5 How To Transport and Store the Unit

1.5.1 Dimensions

Case: Shallow 10U
Height: 23” (58 cm)
Width: 21” (53 cm)
Depth: 12” (30.5 cm)
Weight: 40 lbs (18 kg) base model

1.5.2 Lifting and handling

CAUTION

Avoid dropping the unit and other forms of collision during transport. When lifting, make sure to use the handles on the sides to lift. Do not try to lift the unit by anything other than the handles or the carrying strap.

1.5.3 Storage

Store upright, if possible, in a controlled environment on a shelf off of the ground. The unit should be stored in the case with the lid attached and disconnected from power.

1.5.4 Shipping

While the unit features a rugged design, the components and integrity of the build are delicate; the unit should be treated as a lab instrument when considering transport. Sudden jarring movements or drops could damage the internal components or cause faults within the electrical subsystem and various sensors.

The unit should not be shipped independently. Ensure proper shipment of the unit by packing it in a foam-lined box or an appropriate shipping container that provides adequate protection.

2.0 Description of the Product

2.1 Intended Use and Reasonably Foreseeable Misuse

2.1.1 Source sampling

The sampling console is the operator's control station. The XC-522, XC-523, and XC-572 sampling consoles include a precision dry gas meter fitted with a high-resolution rotary encoder, a vacuum gauge, flow control valves, and a venturi-style orifice tube for monitoring the gas flow rate. Two advanced, self-tuning 1/32 DIN temperature controllers with individual solid-state relays are used for controlling heaters for the probe and oven (filter).

The XC-522 features a DGM-110 dry gas meter with an analog index with cubic feet units, °F for the temperature controllers and temperature display, and a manometer with inches of water units. The XC-522 was obsoleted and replaced by the XC-523 at the beginning of 2022 due to a shortage of DGM-110 dry gas meters.

The XC-523 features a DGM-SK25EX-100 dry gas meter fitted with a quadrature encoder set for cubic feet units and displayed on a Red Lion totalizer, °F for the temperature controllers and temperature display, and a manometer with inches of water units.

The XC-572 features a DGM-SK25EX dry gas meter with an analog index with cubic meter and liter units, °C for the temperature controllers and temperature display, and a manometer with millimeters of water units.

The are also a timer that displays the elapsed time, a manometer that shows the dry gas meter pressure differential (ΔH) and pitot tube differential pressure (ΔP), and a display that shows the temperature of the selected thermocouple channel. For the models with the digital volume option, the Red Lion totalizer displays the current volume for the sample run.

A rotary switch is used for monitoring up to five different temperatures. Coarse and fine valves are used to control the sample flow rate and for adjusting the vacuum during leak checks. A female sample inlet, pitot tube quick connects, and sample pump quick connects provide convenient connections for the sample vacuum and pitot lines.

2.1.2 Versatile use

The XC-522, XC-523, and XC-572 consoles can be easily adapted to various gaseous sampling train systems. Using different configurations of sampling trains, the XC-500 series consoles can be used to test for PM2.5 and PM10 fractions, metals, polychlorinated biphenyls (PCBs), dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and many more pollutants with adaptations of the standard particulate, isokinetic test method.

2.2 Product Compliance

This product complies with all relevant US EPA sampling regulations and was designed based on the schematics and sampling practices established by the EPA in the Code of Federal Regulations.

2.3 System Overview

NOTICE This manual covers the sampling console part of the train. The rest of the sampling train is sold separately.

The first step to effective sampling is to become familiarized with the standard equipment. To illustrate the necessary components of source sampling, we've included an overview of the six main components of the Apex Instruments Source Sampling Train. The main components of a Source Sampling system are: probe assembly, heated filter, glassware case, umbilical cable, the console, and an external sampling pump.

2.3.1 Sampling Console (XC-522, XC-523, and XC-572)

The sampling console houses the dry gas meter, temperature controllers, vacuum gauge, flow adjustment valves, differential pressure manometer, and the thermocouple measurement system.

Some sampling trains have a console with an internal orsat pump assembly to independently extract a gaseous sample for US EPA Method 3 quantifications of O_2 and CO_2.

Sample gas enters the console from the umbilical and then through the pump and dry gas meter.

The console is housed in a strong and durable polyethylene case with a carrying strap on top.

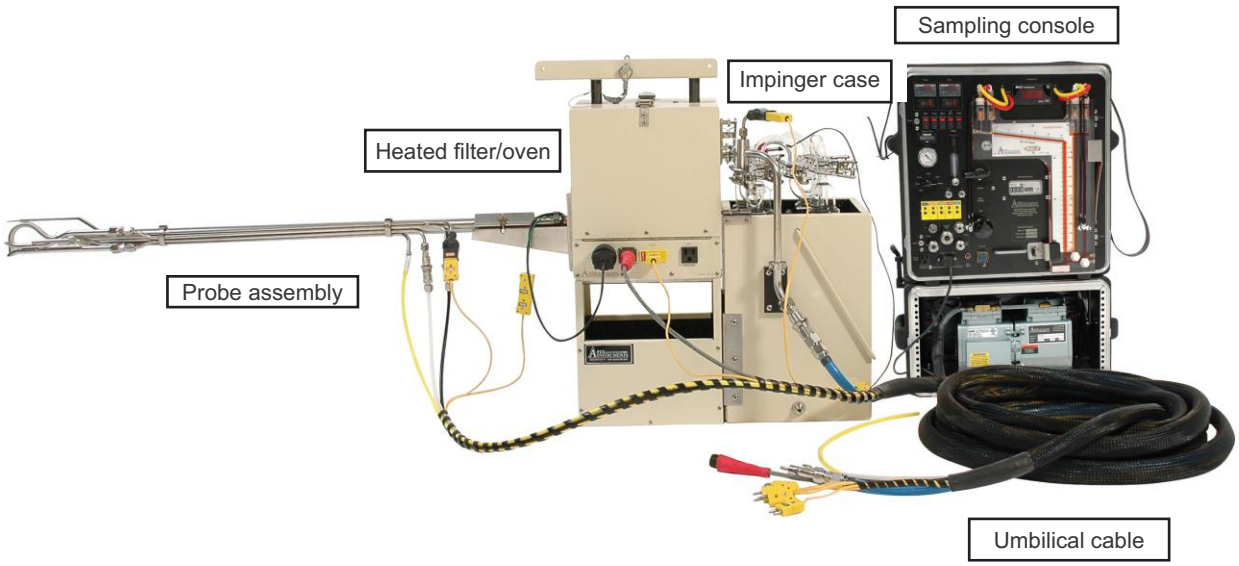

Fig. 1 *Example Sampling System: Ancillary components of the sampling system are sold separately.*

2.4 Technical Specifications

Dry Gas Meter
Model SK25EX-100 multi-chamber positive displacement meter (optionally fitted with a quadrature encoder), Qmax for air 41 LPM at 150 Pa, Qmin 0.26 LPM, Resolution 0.2 Liter, cyclic volume 0.7 Liter,
Type K thermocouple for meter exit temperature (optional Type K thermocouple for meter inlet temperature)

Manometer
Dual-inclined/vertical manometer for determining stack velocity ΔP and sample flow rate ΔH, inclined range of 0-26 mm H_2O (0-1 in. H_2O) with a resolution of 0.2 mm (0.1 in.).

Temperature Display
Panel-mount digital thermometer, bright red LED display, range -105 to 1372 °C (-157 to 2502 °F), separate 6-channel selector switch, °C is standard for export

Temperature Controllers
Probe and Oven. Fuji PXR3 compact, 1/32 DIN self-tuning PID temperature controller with 3 button keypad, SSR driver for 25A solid state relay, Type K thermocouple jack for input

Vacuum Measurement
Bourdon tube, dual-scale, 0 to -30” Hg (0 to -100 kPa)

Umbilical Connection
Electrical multi-conductor circular connector, instrumental grade stainless steel quick connects
Sample inlet - 1/2”, pitot connections - 1/4”, pump connections - 3/8” male and female, Type K thermocouple plugs - AUX, STACK, PROBE, OVEN, EXIT

Power
Supply 120VAC/60Hz 15 amps max. or 240VAC/50Hz 10 amps max., IEC C-14 Inlet

Dimensions and Weight:
H23” x W21” x D12” (58 cm x 53 cm x 30.5 cm), 40 lbs (18 kg) base configuration

2.5 Faceplate Components

Reference the image below for an introduction to the essential components of the XC-500 Series Source Sampling console.

For specific part numbers and a detailed look at the internal components, go to *Sections 6.3 and 6.4* on pages 35 and 36 of this manual.

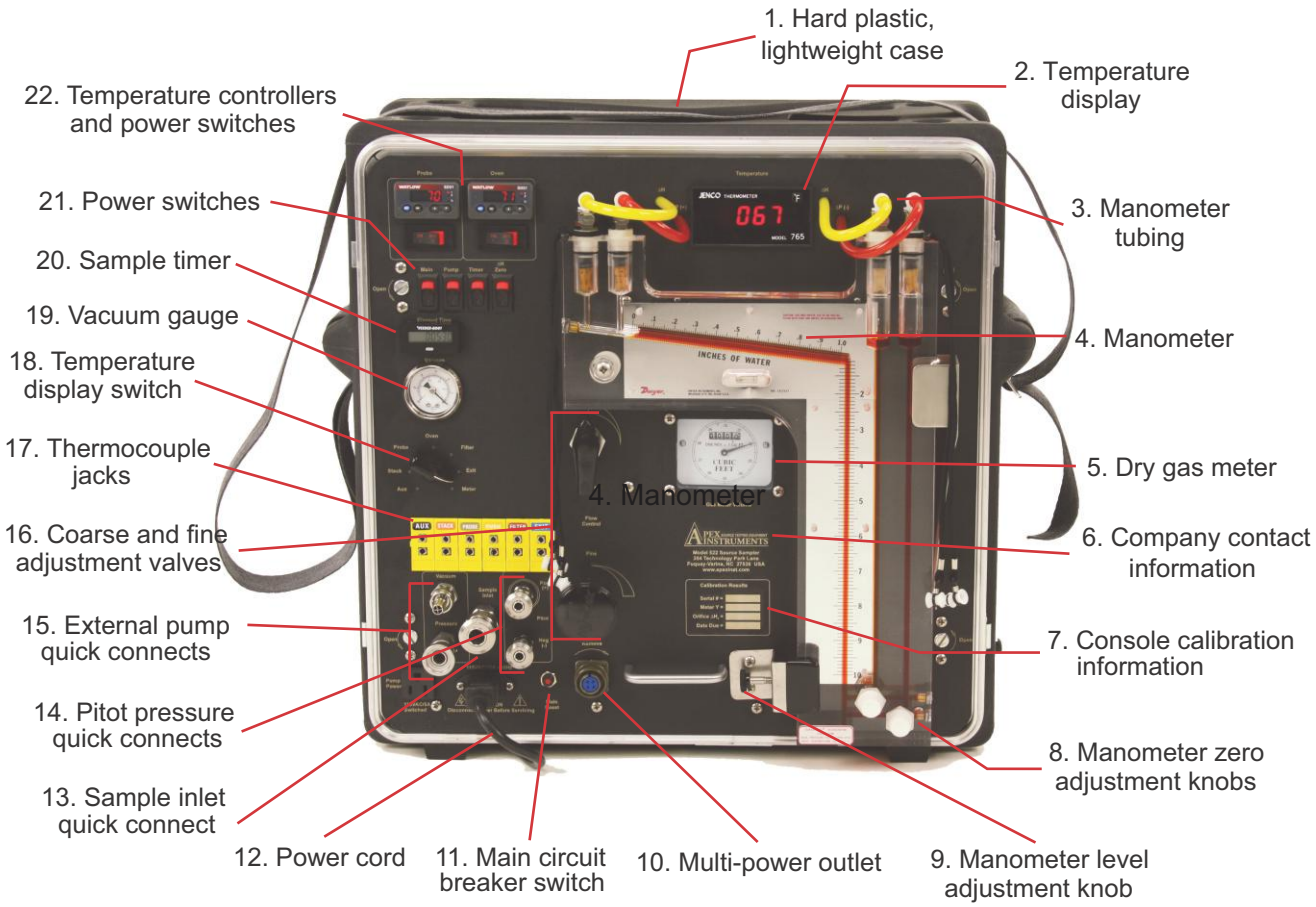

Fig. 2 Front Panel Overview: *Standard version shown, depiction of options may differ.*

3.0 Console Operation

3.1 User Control Overview

3.1.1 General overview

The components on the XC-522, XC-523, and XC-572 consoles allow the operator to control and monitor the sample parameters.

Power Switches: Individual power switches used to turn on the console, turn on the external sample pump, turn on the timer, turn on the solenoid valves used to zero the manometer pressure during a sample run, and turn on the AUX power utilized by the AUX power out on the front of the console.

Timer: Run time displayed in HH:MM:SS format and can be started and stopped using the Timer switch, as well as reset using the button on the timer bezel.

Manometer: The current differential pressure for both the pitot tube on the probe and the orifice tube at the dry gas meter exit. Used to record the ΔP used to calculate stack velocity and determine the isokinetic sample rate along with the K-Factor to calculate the ΔH. The ΔH is correlated to a calibrated flow rate for each sample point.

DGM Volume: The index showing the DGM volume. On digital model consoles, this value is displayed on the Red Lion totalizer and can be reset by pressing the Rst button on the totalizer bezel.

Temperature: The current temperature of the selected TC channel which is controlled by the TC switch on the console.

Flow Control: A set of coarse and fine valves to control the sample flow rate (ΔH).

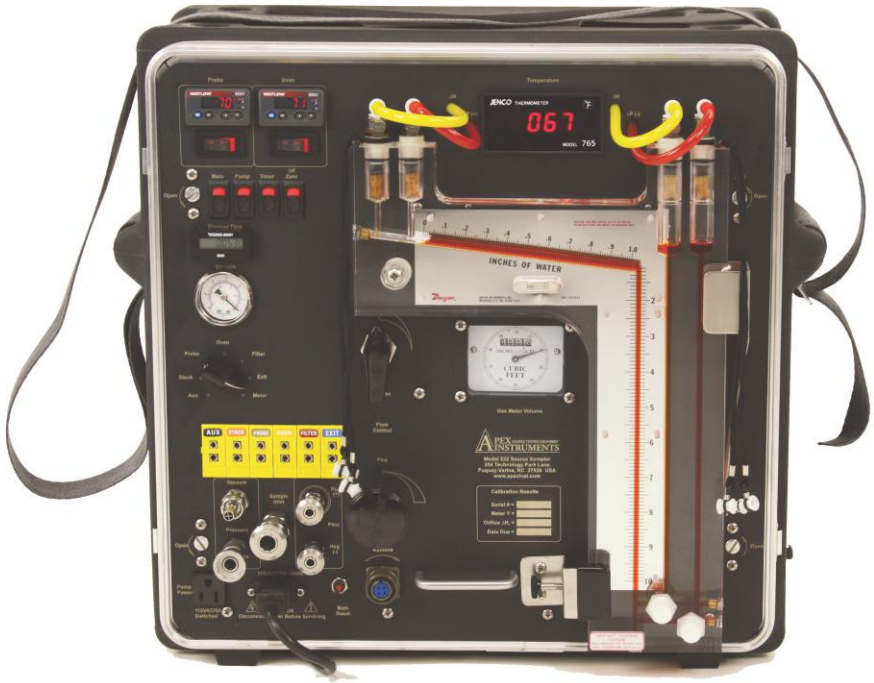

Fig. 3 User Controls

3.2 Pre-Field Test Operations

3.2.1 Console configuration

Ensure that the console has been inspected and is suitable to perform a test run series. The dry gas meter, thermocouple system, and vacuum gauge should all be audited against the most recent calibration.

The temperature controllers should be tested using an applicable probe and filter oven to ensure that the controllers will adequately controller the heaters for the probe and filter oven during the test series.

Perform leak checks on the console, including the “front-half” leak check, “back-half” leak check, and the pitot tube system leak check.

3.2.2 Moisture determination (if applicable)

At the sampling location, prior to testing, determine the percent moisture of the stack gas using the wet and dry bulb temperatures or, if appropriate, a relative humidity meter. Another option is a moisture approximation through procedures outline in EPA Method 4.

3.2.3 Preparation of impinger train

Follow procedures outlined in an applicable EPA Method to prepare the impinger train.

3.2.4 Preparation of sampling train

Assemble the sampling train as shown in the applicable EPA Method. Adjust the probe and oven/filter heaters to a temperature warm enough to prevent water condensation or as dictated in the sampling method using the respective temperature controller on the left side of the console faceplate; keep in mind the previously determined moisture content of the gas stream. Place crushed ice and water around the impingers in the sample case.

Refer to *Section 3.5 Setting the Temperature Controller* on page 24 of this manual for instructions on how to operate the temperature controllers.

3.2.5 Console leak check procedure (front side):

1. Position the valves
    a. Close the coarse valve by turning the handle clockwise to the horizontal position (”3:00”).
    b. Decrease the fine tune knob fully by turning all the way to the left (counter-clockwise).

2. Block airflow of sample inlet
    a. Insert a capped quick connect into the 1/2” sample inlet.

3. Initiate flow
    a. Turn on the pump and open the coarse valve all the way counterclockwise to the vertical position (“12:00”).

4. Adjust vacuum (if necessary)
    a. If the vacuum value displayed by the gauge is below 10 inches Hg (250 mm Hg), slowly turn the fine tune knob clockwise until the vacuum is at least 10 inches Hg.

5. Monitor the console leak rate
    a. Start the timer using the Timer switch and monitor the DGM Volume value and leak check wheel on the analog index (or Red Lion totalizer on digital model consoles) for one minute. If the flow through the DGM exceeds 2% of the average sample rate (e.g. 0.4 L/min for a 20.00 L/min target sample rate), the leak must be found and corrected.

6. Complete the console leak check procedure
    a. Remove the plug from the sample inlet. Be sure to return the valves to a lower flow starting position. Reset the timer by pressing the reset button located on the bezel of the timer. For digital models, the DGM Volume reading can remain at the current value or can be zeroed by pressing the Rst button on the Red Lion totalizer.

Fig. 4 Front-Side Leak Check

3.2.6 Sample train leak check procedure

A leak check before the sampling run is recommended, but not required.

1. Close the coarse valve by rotating the handle 1/4 turn right (clockwise) until it is horizontal or the arrow is pointing to “3:00.” Decrease the fine tune knob by rotating all the way to the left (counterclockwise).

2. Plug the probe/nozzle inlet using a clean cap.

3. Turn the pump on using the switch in the upper-left corner of the console and open the coarse valve fully by turning to the left (counter-clockwise) until it is pointing straight up.

4. Adjust the fine valve by rotating it clockwise to pull a vacuum of at least 10 inches Hg (250 mm Hg), which can be observed by the vacuum gauge on the console.
   a. If this vacuum level is overshot, either complete the leak check at this value or slowly release the cap from the probe or nozzle and close the coarse valve.
   b. Adjust the fine valve by rotating it counter-clockwise and then repeat the leak check process.

5. Observe the leak rate as indicated by the DGM Volume and leak check wheel on the analog index (or Red Lion totalizer on digital model consoles) for one minute and ensure that the volume is not increasing during this time. A leakage rate in excess of 4% of the target average sample rate is not acceptable (e.g. 0.80 L/min for a 20.00 L/min target sample rate).

The operator can use the timer to track and quantify leak rates. The timer can be started or stopped by using the applicable switch. If the timer needs to be reset, the reset button on the timer bezel can be pressed once.

6. Remove the plug from the probe/nozzle inlet and turn off the pump. Be sure to return the valves to a lower flow starting position. Reset the timer by pressing the reset button on the timer bezel. On digital model consoles, the DGM Volume reading can remain at the current value or can be zeroed by pressing the Rst button on the Red Lion totalizer bezel.

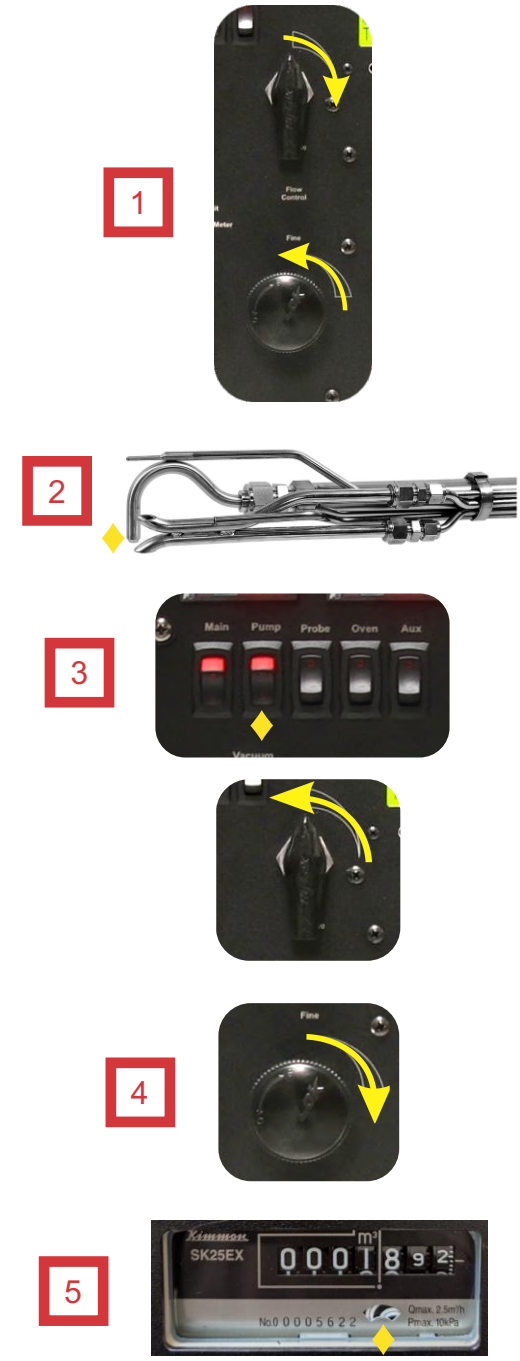

Fig. 5 System Leak Check

NOTICE Slowly release the probe/nozzle inlet cap before closing the coarse valve.

3.3 Field Test Operations

3.3.1 Performing a Method 5 sampling test

This operation guide is written based on US EPA Method 5 sampling. Ensure that you follow the appropriate procedures outlined in the applicable isokinetic method to be performed. EPA Methods 1, 2, and 4 should already be performed and an approximation of Method 3 should be made or measured. Use pre-test conditions to calculate a K Factor that will be used to determine the operational ΔH for each traverse point. The K Factor should not change unless source conditions change drastically from pre-test conditions when the initial calculation was made.

The sample impingers should be charged and the volume or weight should be measured before use. Record these values on the field data sheet or laboratory recovery log. Set up the impinger train in the sample case and add ice and water. Connect all of the equipment, including the nozzle, probe, filter, impinger train, umbilical, console, and any other applicable sample lines or connections.

Ensure probe and heated oven or filter, as applicable, have reached the set point. If either has not reached the suggested temperature, turn the heaters on using the appropriate switch in the upper-left corner of the console and/or allow time to reach the set point.

Ensure that the timer is at 0:00. If it is not, press the reset button on the timer bezel once. Zero the ΔH and ΔP manometer legs using the white adjustment knobs on the bottom-right side of the manometer. Ensure that no pressure is being applied to the manometer and conditions are ambient. With the coarse valve closed, start the pump using the switch in the upper-left corner of the console.

Record all applicable site data such as plant name, location, date, personnel, etc. Record the initial DGM reading displayed on the DGM index (or Red Lion totalizer for digital model consoles) and barometric pressure using a local airport reading or NIST-traceable barometer adjusted for elevation on the field data sheet. For digital console models, the DGM reading can begin at the current value or can be zeroed before the run by pressing the Rst button on the totalizer bezel.

To begin sampling, position the tip of the probe and nozzle at the first traverse point. Note the clock time and then open the coarse valve and turn on the timer.

Adjust the sample flow as closely to the target ΔH as possible. Maintain this flow rate for the duration of the first traverse point.

Take readings (clock time, DGM volume, ΔH flow rate, ΔP reading, vacuum, all applicable equipment temperatures) at least every 5 minutes or at the change of a traverse point. Recalculate the target ΔH, at each traverse point; adjust the flow rate appropriately using the fine valve. Add more ice or a fresh ice pack to the impinger train during the run to keep the temperature of the gases leaving the last impinger between 0°C (32°F) and 20°C (68°F).

At the conclusion of each run, close the coarse valve and record the final readings (clock time and final DGM volume). Now the pump can be turned off and the probe can be removed from the stack. Once the probe has cooled down, conduct a leak check as described in *Section 3.2.6 Sample train leak check procedure* on page 21of this manual or Section 8.4.4 of EPA Method 5 (this check is mandatory). If a leak is detected, void the test run or use procedures acceptable by the administrator to adjust the sample volume for the leakage.

Drain the ice bath. The nozzle, sample probe and front half of the filter holder (if applicable) should be rinsed into an appropriate container using the applicable solvents. The filter media should be stored safely inside of its own container. The sample impingers may need to be recovered, but the weights or volumes should be measured first. Follow the applicable EPA method for the remaining post-run sample recovery procedures.

3.4 Post-Field Test Operations

3.4.1 Post-test calibration check

After each field test series, conduct a calibration check using the procedures outlined in EPA Method 5, Section 10.3.2 (or Section 16.3), noting that three calibration runs at a single, intermediate orifice setting (based on the previous field test) with the vacuum set at the maximum value reached during the test series should be performed.

The console should be confirmed to be leak-free prior to performing this calibration. Calculate the average value of the DGM calibration factor (EPA Method 5, Section 10.3.2). If the value has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings as detailed in EPA Method 5, Section 10.3.1

If the post-test calibration indicates that the metering system is unacceptable for use, either void the test run or use methods, subject to the approval of the Administrator, to determine an acceptable value for the collected sample volume. (EPA Method 5, Section 10.3.3)

3.5 Setting the Temperature Controller

3.5.1 Set value setting

1. The current temperature of the equipment is shown on the Fuji controller. To change the set value (SV) press SEL once.

2. Current value is displayed and SV is lit. Press the ^ v to increase or decrease the displayed value (set value).

3. After the new setting is entered, press SEL to lock in the value and return to the C1 (control 1) display.

Repeat procedure to check value if necessary.

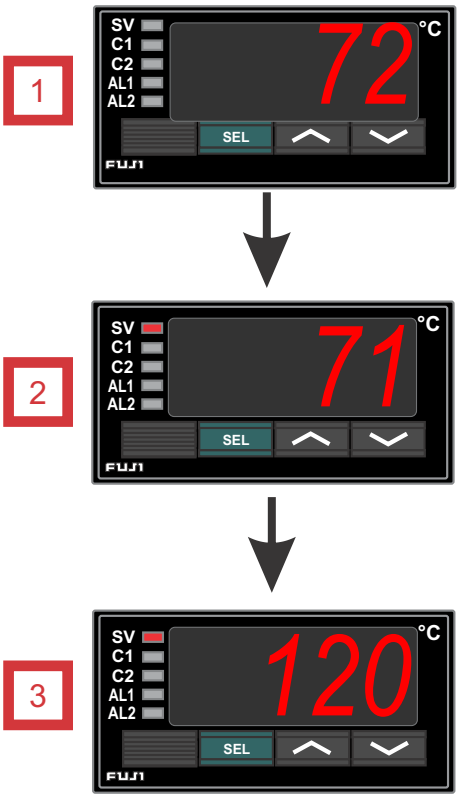

Fig. 6 Temperature Controller Configuration

3.6 Operation using software (reserved)

The XC-522, XC-523, and XC-572 sampling consoles do not currently use software for operation, all functions are controlled directly on the consoles.

4.0 Maintenance

4.1 Pre-Test Calibrations

4.1.1 Factory meter calibration

Apex Instruments performs an initial 5-point calibration following the procedures outlined in EPA Method 5. The result of the calibration is an average calibration factor Y_i (V_w / V_m, adjusted to the same reference temperature and pressure) that is used as the calibration factor for subsequent test runs. Calibration flow rates are performed at 5 points using the calibration part number below:

XC-522 and XC-523: DGMC-5A-HF
XC-572: DGMC-5A-HFM

4.1.2 Initial end user audits

Apex Instruments suggests that the end user perform audits on the dry gas meter, thermocouples, vacuum gauge and pressure sensors before performing a field test (post-test calibrations fulfill this suggestion). Perform an audit using a critical orifice set (rated for the intended sampling flow rates) plugged in to the sample inlet on the console. Run the audit at 1-2 in. Hg (25-50 mm Hg) above the calculated critical vacuum. Calculate the Y (Gamma) using the standardized orifice's flow rate and compare this value to the standardized flow rate metered by the dry gas meter after a minimum of 10 minutes using this formula: ($Q_{cr(std)}$ / $Q_{m(std)}$) * 100.

If these values differ by more than 5%, check the integrity of the console before beginning sampling.

To audit the thermocouples, use a calibrated temperature simulator (NIST-traceable preferred) to simulate a known temperature and compare the value on the simulator to the console's displayed value by plugging in directly to one of the thermocouple jacks on the front of the console. If the displayed value on the console does not match the simulator, use the console's menu to offset the displayed value to match the simulator's value.

Another quick check is done by taking the TC out of the dry gas meter outlet and dipping it in an ice bath that also has a calibrated thermometer dipped inside. Ensure the dry gas meter thermocouple channel reading matches the calibrated thermometer at or near freezing, 32 °F (0 °C). If it is not, adjust the console reading to match the ice bath's thermometer.

4.2 Post-Test Calibrations

4.2.1 Dry gas meter

Apex Instruments and the EPA recommends that the user perform post-test audits following a field test series using the procedures outlined in EPA Method 5, Section 10.3.2 Calibration After Use. This procedure closely mirrors the pre-test calibration, except only three runs need to be made that are at or near the sample rate metered and at or higher than the vacuum observed during the test.

The average of the post-test audit factors, Y, is not allowed to deviate more than 5% from the pre-test calibration factor Y_i. If this deviation is greater than 5%, a post-test calibration factor needs to be redetermined using the Pre-Test Calibration procedure. This new post-test calibration factor is then compared to the post-test audit factor and whichever is smaller is accepted as the DGM calibration factor.

Conduct a post-test audit using the audit procedure outlined in *Section 3.4 Post-Field Test Operations* on page 23 of this manual. If the $Q_{m(std)}$ obtained before and after the test differ by more than 5%, void the test run; if not, calculate the volume of the gas measured with the critical orifice.

If recalibration indicates that the metering system is unacceptable for use, void the test results or use approved methods by the administrator to determine an acceptable value for the collected sample.

4.2.2 Temperature sensors

Audit against mercury-in-glass thermometers. An alternative thermometer may be used if the thermometer is, at a minimum, equivalent in terms of performance or suitably effective for the specific temperature measurement application (EPA Method 5, Section 10.5).

The user can also audit the temperature sensors following the procedure outlined in *Section 4.1.2 Initial end user audits* on page 25 of this manual.

4.3 Post-Test Maintenance

4.3.1 Purging

At the conclusion of a test series, it is highly recommended to “purge” the console plumbing by drawing in clean, ambient air for 10 minutes or greater. This process will extend the life of the internal tubing, fittings and dry gas meter. The purge can be conducted by turning the sample pump (internal or external for certain options) on and opening the valves to draw air through the inlet of the sample port on the front of the console when it is not connected to other equipment or a sample train.

4.3.2 Cleaning

Maintaining the cleanliness of the console will also extend the life of its components. The outside of the case and console can be cleaned with a non-abrasive, weak degreaser or soapy water. Ensure that exposed electrical components are not sprayed during this process.

Never clean the console while it is connected to power or powered on.

4.3.3 Inspections

Periodically inspect components of the console to ensure everything is in working order and nothing is exhibiting a sign of future issues. Check for things such as exposed or frayed wires, melted or damaged electrical components, discolored or cloudy tubing, and any sign of oil or moisture. The console can be safely vacuumed out while disconnected from power in a dry location. Vacuuming the internals of the console will remove any dust or particulate buildup that could cause issues in the long term. Any signs of damage to the internal or external components of the console should be replaced immediately.

4.4 Semi-Annual Maintenance

All components of the console should be audited and evaluated on a semi-annual schedule (once a quarter or every six months). This comprehensive procedure should include audits of the dry gas meter, thermocouples, and electrical components. Post-test calibrations and audits satisfy this suggestion.

4.5 Annual Maintenance

Apex Instruments highly recommends that the console be returned to Apex Instruments on an annual basis. The Technical Services Group will perform an evaluation of all components of the system including functionality and build-integrity checks. All sensors and the dry gas meter can also be calibrated at this time.

4.6 Manufacturer Support for the Product

4.6.1 Technical services

Our knowledgeable service staff includes skilled industry professionals, stack testers and technicians ready to help with specific service needs. From basic troubleshooting to full equipment overhauls and repairs, our technical service team can help.

Phone: (919) 346-5754, Toll Free (877) 726-3919
Email: support@apexinst.com

4.6.2 Calibration services

Apex Instruments offers dedicated, climate-controlled precision calibration services for a variety of measuring instruments to help keep all equipment up to date and within US EPA calibration requirements. Calibration services are available for consoles, reference meters, critical orifice, orifice sets, pitot tubes (geometric and wind tunnel) and thermocouple simulators.

Please contact the service department or a sales representative for more details on our calibration services. Certification of calibration available upon request. The part number for the annual calibration is as follows:

XC-522 and XC-523: DGMC-5A-HF
XC-572: DGMC-5A-HFM

4.6.3 Obtaining documentation and information

Internet

Detailed product information, firmware and/or software, stack sampling guides and EPA regulation references are available on our website: https://www.apexinst.com

Support and service

Any requests for field data sheets, calibration spreadsheets, diagrams or component supporting documentation, please reach out to our Technical Services Group for assistance.

5.0 Troubleshooting

5.1 Screens and Displays

5.1.1 No power to Jenco temperature display screen

⚠ CAUTION

1. Connector or wires in the bottom-right corner of the rear of the temperature display unit are not secure
   Resolution - Ensure that all wires are firmly clamped inside of the connector and that the connector is plugged into the unit

2. Console main power switch is not turned on
   Resolution - Turn on the main power switch

3. Console is not plugged in to a working power outlet
   Resolution - Find an appropriate power source with the correct voltage output and plug the power cord in to the outlet

4. Main circuit breaker on the front of the console is extended out showing red shank
   Resolution - Push in the main circuit breaker. If this is happening repeatedly, turn the console off immediately, disconnect power and remove from service until the console is inspected and repaired.

5.1.2 No power to Red Lion totalizer display screen (if applicable)

1. Connector or wires in the bottom-right corner of the rear of the totalizer unit are not secure
   Resolution - Ensure that all wires are firmly clamped inside of the connector and that the connector is plugged into the unit

2. Console main power switch is not turned on
   Resolution - Turn on the main power switch

3. Console is not plugged in to a working power outlet
   Resolution - Find an appropriate power source with the correct voltage output and plug the power cord in to the outlet

4. Main circuit breaker on the front of the console is extended out showing red shank
   Resolution - Push in the main circuit breaker. If this is happening repeatedly, turn the console off immediately, disconnect power and remove from service until the console is inspected and repaired.

5.2 Pressures

5.2.1 Vacuum gauge non-zero

CAUTION

1. Vacuum gauge reads a non-zero value with no flow going through the system
   Resolution - Replace the vacuum gauge
   Resolution - Check the tubing connections between the inlet to the console and the vacuum gauge

5.2.2 ΔP reading is changing quickly and is difficult to read

1. ΔP reading is too sporadic
   Resolution - Confirm that test location is Method 1-compliant
   Resolution - Read the average of the bounce or the middle of the high and low points for a traverse point

5.2.3 Pump motor running abnormally

1. Console is not plugged into a working outlet of the correct voltage
   Resolution - Ensure the console is powered off and then plug into a working outlet of the correct voltage

5.2.4 DGM volume not increasing or index is not spinning

1. Console is not being operated upright
   Resolution - Reposition the console to be standing upright

CAUTION

2. Console has a leak
   Resolution - Check all fittings and tubing inside of the console for a leak, repair if necessary

3. Console scaling factor is not correct or is set at 0.0000 (digital model consoles only)
   Resolution - Find the scaling factor on the most recent full calibration and input this value into the settings through the console menu option

5.3 Temperatures

5.3.1 TC displayed values are changing too quickly to read

1. TC values are too sporadic
   Resolution - Check that wires are not loose anywhere between the TC jacks, temperature selector rotary switch, temperature controller, and temperature display.
   Resolution - Check that no TC wires are broken or pinched

5.3.2 TCs reading inaccurately (or not reading at all)

1. TC channels reading inaccurately
   Resolution - Adjust TC offset with Jenco offset screws using calibrated temperature simulator

⚠ CAUTION

2. TC channels not reading
   Resolution - Ensure all TC wires are connected at the rear of the TC jacks inside of the console
   Resolution - Ensure all TC wires are in good condition and are in their plugs on the umbilical and other sampling equipment

5.3.3 Probe, oven or AUX not heating or receiving power

1. Temperature controller or power switch for appropriate equipment is not turned on
   Resolution - Turn on the switch for the appropriate temperature controller

2. Power output is not connected or secure on the console and the umbilical power adapter
   Resolution - Make sure the power output is connected securely on the console faceplate and the umbilical cable

3. Temperature controller is not setup properly
   Resolution - Verify that the Fuji controller settings are correct and adjusted to the correct set point

5.4 Additional Common Console Problems

⚠ CAUTION

Issue	Resolution
Maximum vacuum or flow rate decreases	- Filters are dirty and need to be replaced - Obstruction in sample flow path - Blockage or kinks in plumbing - Leak in console plumbing or sample train
Pump motor fails to start or hums	- Check for correct current (5 to 6 Amperes) - Check to see if fuse is blown - Unit has frozen due to ambient temperature, move pump to a warmer environment to “heat” it up and then return to the sampling location - Unit has overheated - Console is connected to incorrect voltage power source (240V console powered by 120V power source, for example)
Probe doesn’t heat or heats slowly	- Verify that the correct thermocouple is plugged in - Verify that the Fuji controller settings are correct and adjusted to the correct set point - Auto-tune the temperature controller - Check all connections for probe power (output on console end, output on oven end, power plug from probe to oven, and TCs)
Oven doesn’t heat or heats slowly	- Verify that the correct thermocouple is plugged in - Verify that the Fuji temperature controller settings are correct and adjusted to the correct set point - Check all connections for the oven power (output on console end, output on sample case end, and TCs)
Jenco display doesn’t power on	- Check connections on the board for proper power input - Ensure console is being used in operational range -13 to 158 °F (-25 to 70 °C)
Console doesn’t power on	- Check the position of the circuit breaker switch, if pop-out switch is popped out and red is showing, push it back in - Check to make sure the console is plugged in to a working power source

6.0 Diagrams and Schematics

6.1 Electrical Diagram (XC-522 120V Shown)

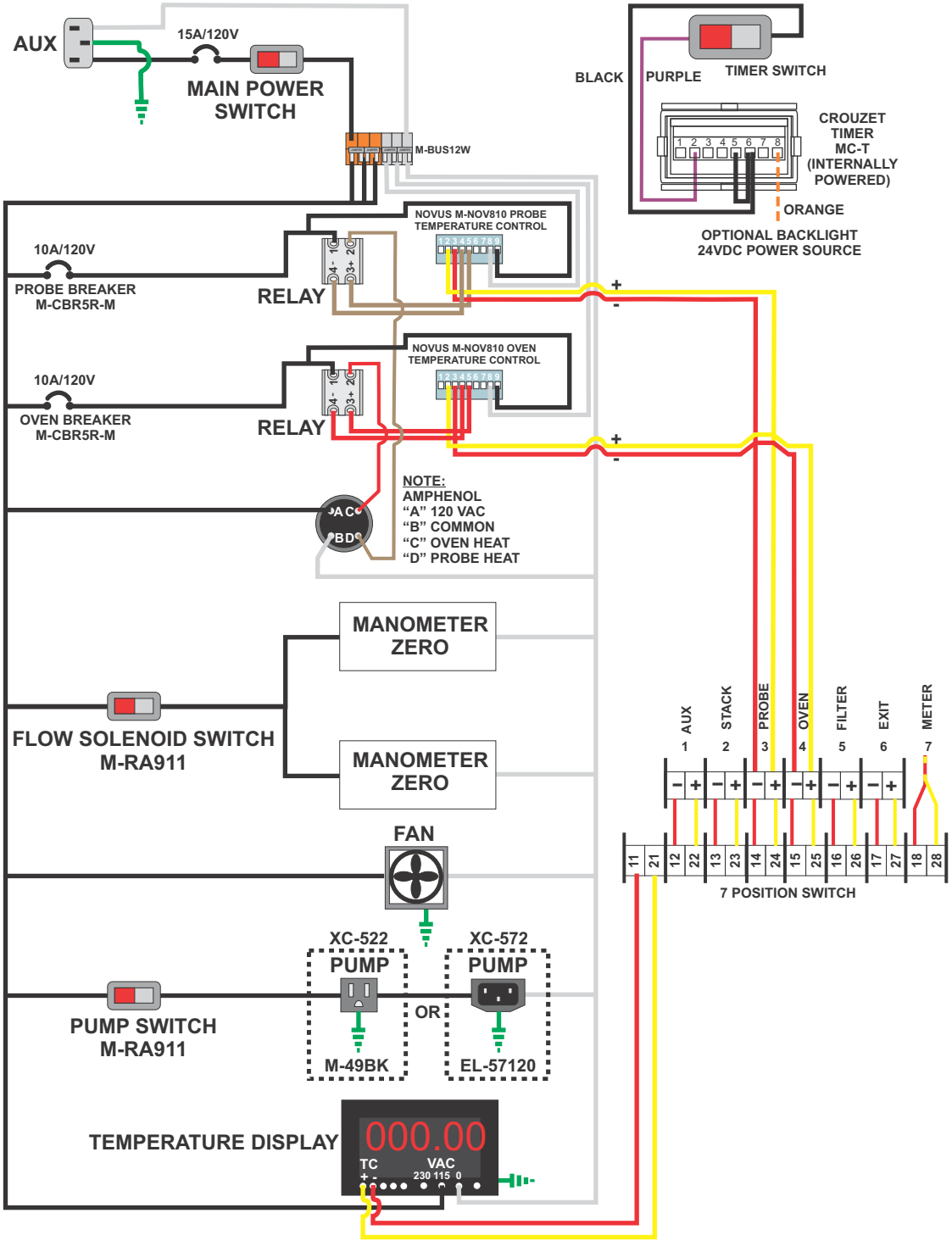

Fig. 7 Electrical Diagram

6.2 Plumbing Diagram

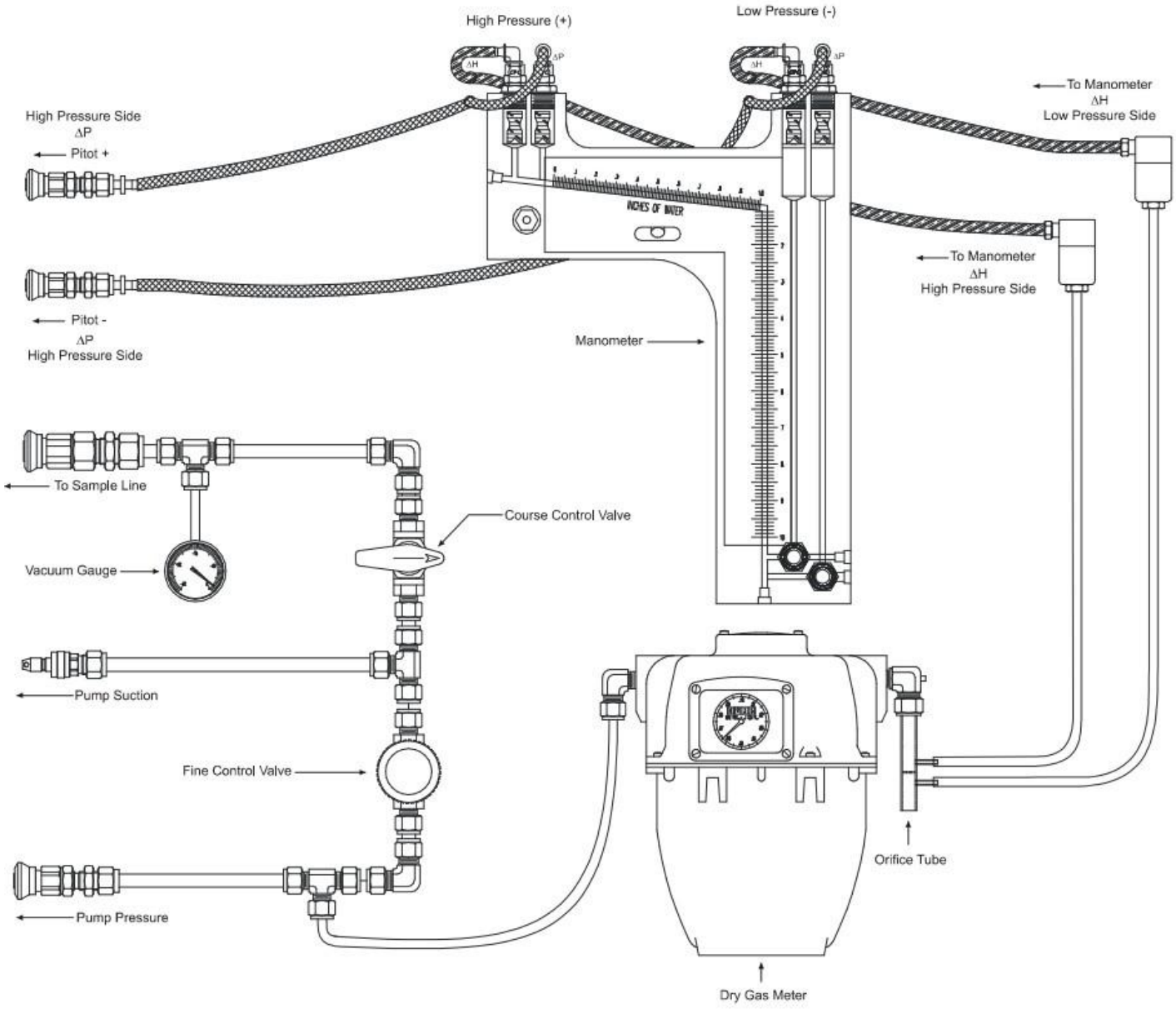

Fig. 8 Plumbing Diagram

6.3 Parts List - Front Panel (XC-522 120V Shown)

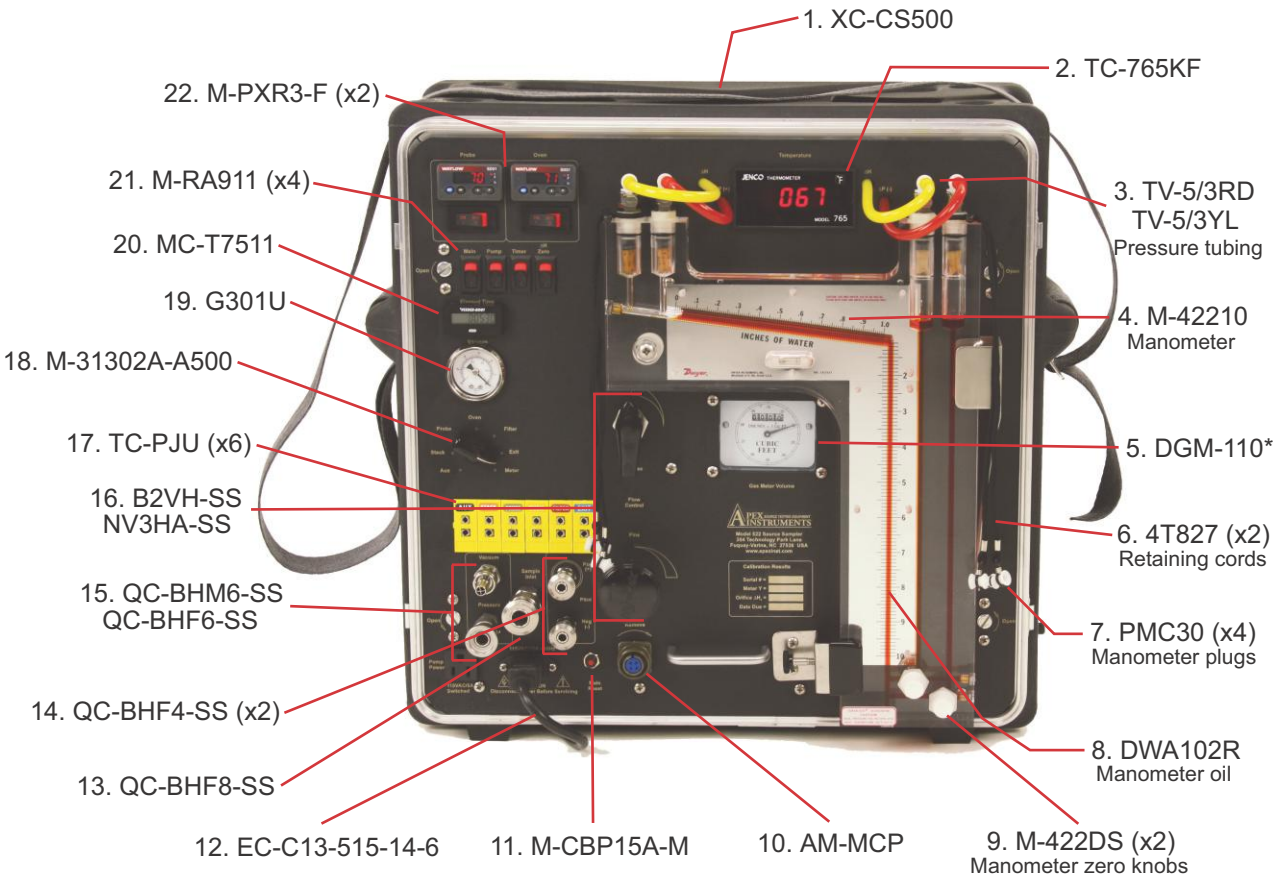

Fig. 9 Parts List - Front Panel: *Standard version shown, depiction of options may differ*

*Dry Gas Meter Options

(XC-522) DGM-110
(XC-523) DGM-SK25EX-100
(XC-572) DGM-SK25EX

6.4 Parts List - Interior (XC-522 120V Shown)

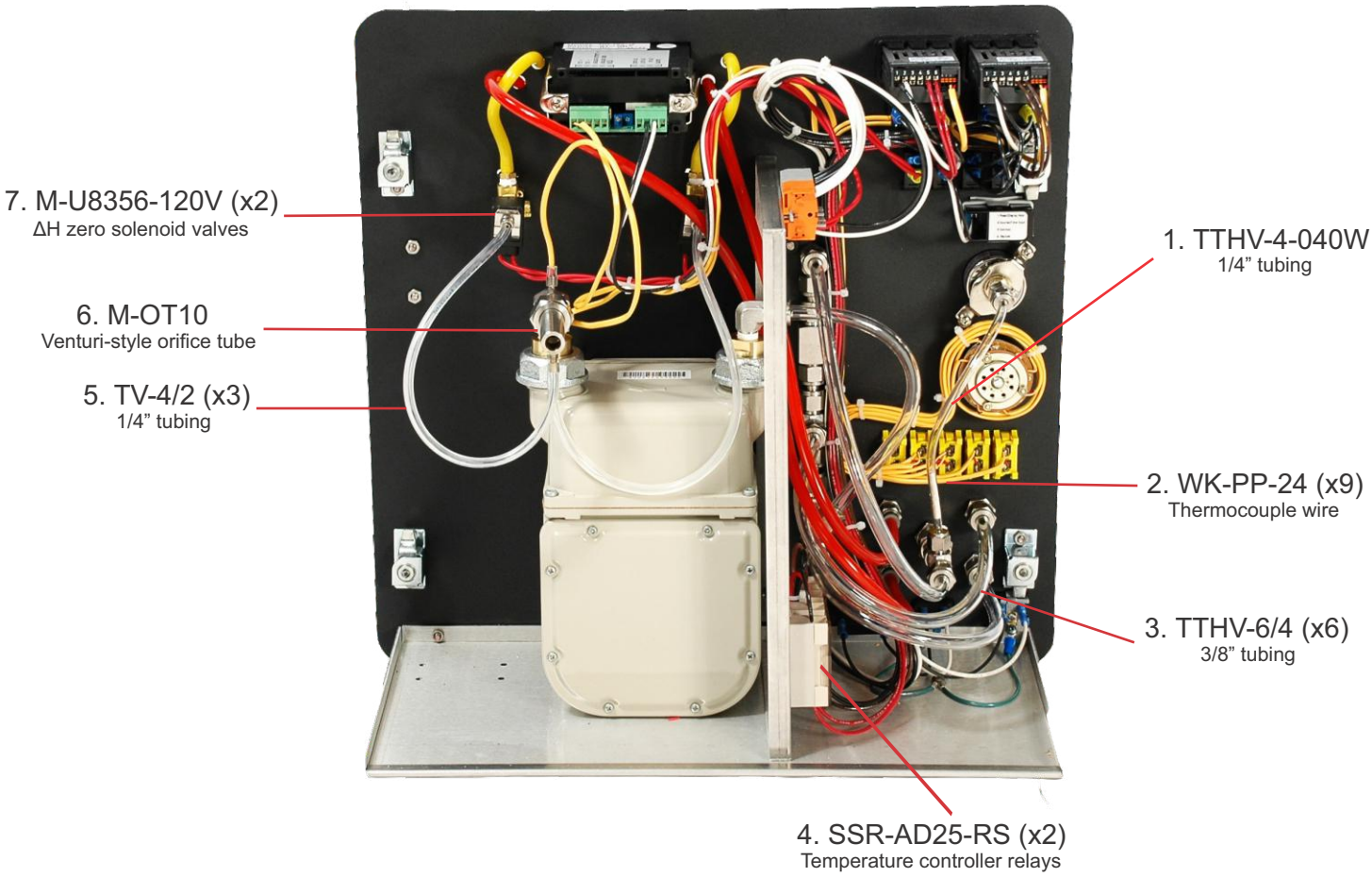

Fig. 10 Parts List - Interior: *Standard version shown, depiction of options may differ*

7.0 References and Related Documentation

7.1 References

7.1.1 EPA and CFR

EPA EMC Promulgated Test Methods
- Method 1
- Method 2
- Method 3
- Method 4
- Method 5
- Method 17
- Method 23
- Method 26A
- Method 29
- Method 201A
- Method 202

Code of Federal Regulations (CFR) 40 Part 60

7.2 Related Documentation

7.2.1 Apex Instruments documentation

Apex Instruments Isokinetic Sampling Handbook

ISOKINETIC SAMPLING DATA

Plant Name		Date	
Sampling Location		Project #	
Operator		Run #	
# of Points Across		# of Ports Used	

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Tube Coefficient	(C_p)		
Avg Stack Temp	(t_s)		°C
Avg Gas Meter Temp	(t_m)		°C
DH @ 0.75 SCFM	($\Delta H@$)		mm H_2O
Avg Pitot Tube Diff. Pressure	(Δp_{avg})		mm H_2O
Stack Moisture Content	(B_{ws})		%
Stack Dry Molecular Weight	(M_{ds})		g/g-mole
Estimated Orifice Flow Rate	(Q_m)		acmm
DP to DH Isokinetic Factor	(K)		

Sampling Equipment			
Meter #			
Meterbox Cal. Factor	(Y)		
Nozzle #			
Actual Nozzle Diameter	(D_{na})		mm
Req. Nozzle Diameter	(D_{ni})		mm
Probe # / Length			m
Liner Material			
Sample Case / Oven #			
Impinger Case #			

Pressures			
Barometric Pressure	(P_b)		mm Hg
Stack Static Pressure	(P_{static})		mm H_2O
Absolute Stack Pressure	(P_s)		mm Hg
Absolute Meter Pressure	(P_m)		mm Hg

ΔV_m	Leak Checks				
Pre		m^3/min	@		mm Hg
Mid		m^3/min	@		mm Hg
Post		m^3/min	@		mm Hg
ΔV_m <		m^3/min	☐	Leak Check OK?	
Pitot OK?	☐		Orsat OK?	☐	

Traverse Point #	Sampling Time (Θ)	Clock Time	Dry Gas Meter Reading (V_m)	Velocity Head (Δp)	Desired Orifice ΔH (ΔH)	Actual Orifice ΔH (ΔH)	Stack Temp (t_s)	Probe Temp (t_{ml})	Meter Outlet Temp (t_{mo})	Filter Temp	Impinger Exit Temp	Pump Vacuum
	min	hh:mm:ss	m^3	mm H_2O	mm H_2O	mm H_2O	°C	°C	°C	°C	°C	mm Hg
Last Pt									Maximum Vacuum			
Average Values												

APEX INSTRUMENTS SOURCE TESTING EQUIPMENT

Updated: 2020/06/11

Console Calibration

Pre-Test - 5-Point Metric Units (Critical Orifice)

Meter Console Information		Calibration Conditions		Factors/Conversions		Orifice Information	
Model #:		Bar. Press. (mm Hg):		Std. Temperature (°K):	293.15	Orifice Set ID:	
Serial #:		Relative Humidity (%):		Std. Pressure (mm Hg):	760.0	Cal. Due Date:	
DGM Model #:		Ambient Temp. (ºC):		K_1 (°K/mm Hg):	0.3857	Theoretical Critical Pressure (in. Hg)[1]:	
DGM Serial #:							

Calibration Data

Console Test Meter (DGM)							Critical Orifice				
Run Time[5]	Meter Pressure[6]	Volume			Outlet Temperature		Serial Number	Coefficient[2]	Actual Vacuum[1]	Ambient Temperature	
		Initial	Final	Total	Initial	Final				Initial	Final
Θ (minutes)	P_m (mm H_2O)	V_{mi} (m^3)	V_{mf} (m^3)	V_m (m^3)	t_{mi} (ºC)	t_{mf} (ºC)	# (ID)	K' (Metric)	P_w (mm Hg)	t_{ai} (ºC)	t_{af} (ºC)

Calibration Results

Standardized Data							Calculated Results		
Dry Gas Meter		Critical Orifice			Gamma		Flowrate	$\Delta H_@$	
Std. Volume	Std. Flow Rate	Std. Volume	Std. Flow Rate	Raw Volume	Value	Variation[3]	Std & Corr	@ 0.0212 SCMM	Variation[4]
Vm_{std} (m^3)	Qm_{std} (m^3/min)	Vcr_{std} (m^3)	Qcr_{std} (m^3/min)	V_{cr}(m^3)	Y	ΔY	$Qm_{std/corr}$ (m^3/min)	$\Delta H_@$ (mm H_2O)	$\Delta\Delta H_@$ (mm H2O)
						Y Avg.			$\Delta H_@$ Avg.

	Initial Scaling Factor
	New Scaling Factor[7]

Notes

[1] For valid test results, the Actual Vacuum during calibration should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in Metric units, [(m3)(°K)1/2)]/[(mm. Hg)(min)].

[3] For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is ±0.02.

[4] For $\Delta H_@$, orifice pressure differential that equates to 0.75cfm (0.0212m^3/min) at standard temperature and pressure, acceptable tolerance of individual values from the average is ±0.2in (5.1mm) H_2O.

[5] Recommended minimum run time per orifice is 10 minutes.

[6] Theoretical meter pressure (gauge) ΔH: 09 orifice - ~0, 40 orifice - ~7, 48 orifice - ~13.5, 55 orifice - ~27, 63 orifice - ~43, 73 orifice - ~76 (mm H2O).

[7] For a digital console calibration, enter the initial scaling factor for the console to get an updated scaling factor after the completed calibration. With the new scaling factor, the Y (Gamma) is now 1.0000.

Technician: _____ Signature: _____ Date: _____

I certify that the above Dry Gas Meter was calibrated in accordance with US EPA Methods, CFR 40 Part 60.

7.3 Equations and Nomenclature

7.3.1 Equations

- $B_{ws} = \dfrac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$
- $V_{m(std)} = \dfrac{K_1 V_m \left[P_{bar} + \left(\dfrac{\Delta H}{13.6}\right)\right]}{T_m}$
- $I = \dfrac{100 T_s \left[K_4 V_{1c} + \dfrac{(V_m Y)}{T_m}\left(P_{bar} + \dfrac{\Delta H}{13.6}\right)\right]}{60\theta v_s P_s A_n}$
- $Y = \dfrac{V_{cr(std)}}{V_{m(std)}}$
- $I = \dfrac{T_s V_{m(std)} P_{std} 100}{T_{std} v_s \theta A_n P_s 60(1 - B_{ws})}$

  $= K_5 \dfrac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$
- $V_{w(std)} = V_{1c} \dfrac{\rho_w R T_{std}}{M_w P_{std}}$

  $= K_2 V_{1c}$
- $K' = \dfrac{K_1 V_m Y \left(P_{bar} + \dfrac{\Delta H}{13.6}\right) T_{amb}{}^{1/2}}{P_{bar} T_m \theta}$
- $Y_c = \dfrac{10}{V_m}\left[\dfrac{0.0319 T_m}{P_{\boldsymbol{bar}}}\right]^{1/2}$
- $Q = K_1 \dfrac{P_{bar} V_w}{(T_w + T_{std})\theta}$
- $Y_{ds} = \dfrac{V_w (T_{ds} + T_{std}) P_{bar}}{V_{ds}(T_w + T_{std})\left(P_{bar} + \dfrac{\Delta p}{13.6}\right)}$
- $V_{cr(std)} = K' \dfrac{P_{bar}\theta}{\sqrt{T_{amb}}}$
- $Y_{qa} = \dfrac{\theta}{V_m}\sqrt{\dfrac{0.0319 T_m}{\Delta H_{@}\left(P_{bar} + \dfrac{\Delta H_{avg}}{13.6}\right)}\left(\dfrac{29}{M_d}\right)}\left(\sqrt{\Delta H}\right)_{avg}$
- $V_{m(std)} = V_m Y \dfrac{T_{std}\left(P_{bar} + \dfrac{\Delta H}{13.6}\right)}{T_m P_{std}}$

  $= K_1 V_m Y \dfrac{P_{bar} + \left(\dfrac{\Delta H}{13.6}\right)}{T_m}$
- $\Delta H_{@} = 0.0319 \Delta H \dfrac{T_m \theta^2}{(P_{bar} Y^2 V_m{}^2)}$

7.3.2 Nomenclature

acf = actual cubic feet
acfm = actual cubic feet per minute
A = effective area of flue in square feet
acm = actual cubic meters
acmm = actual cubic meters minute
A_n = inside area of sampling nozzle in square feet
B_{ws} = water vapor in gas stream, proportion by volume
%C = percent carbon by weight, dry basis
%CO = percent carbon monoxide by volume, dry basis
$\%CO_2$ = percent carbon dioxide by volume, dry basis
C_p = pitot tube coefficient
D_l = dust loading per heat input in pounds (grams) per million Btu (calories) per Fr constant
D_l^3 = dust loading per heat input in pounds (grams) per million Btu (calories) per Fr calculated
dscf = dry standard cubic feet
dscfh = dry standard cubic feet per hour
dscm = dry standard cubic meters
dscmh = dry standard cubic meters per hour
fps = feet per second
F_r = ratio factor of dry flue gas volume to heat value of combusted fuel in dry standard cubic feet (meters) per million Btu (calories)
gms = grams
gm-mole = gram-mole
grs = grains
ΔH = orifice pressure drop in inches water, average
%H = percent hydrogen by weight, dry basis
H_c = heat of combustion in Btu per pound, dry basis
hr = hour
%I = percent isokinetic
in. Hg = inches mercury
lbs = pounds
lbs-mole = pound-mole
%M = percent moisture by volume
mmBtu = million Btu
mmcal = million calories
mm Hg = millimeters mercury
mps = meters per second
M_s = molecular weight in pound (gram) per pound (gram) mole (wet basis)
%N = percent nitrogen by weight, dry basis
$\%N_2$ = percent nitrogen by difference, dry basis
%O = percent oxygen by difference, dry basis
$\%O_2$ = percent oxygen by volume, dry basis
P_b = barometric pressure in inches mercury
P_{std} = standard absolute pressure (29.92 in Hg)
P_s = absolute pressure in flue in inches (millimeters) mercury
P_f = static pressure in flue in inches water, average
$\sqrt{\Delta P}$ = square root of velocity head in inches water, average
%S = percent sulfur by weight, dry basis
scf = standard cubic feet
scm = standard cubic meters
T_{std} = absolute temperature of air in degrees Rankine at standard conditions (528 degrees)
T_s = absolute temperature of flue gas in degrees Rankine, average
T_m = absolute temperature at meter in degrees Rankine, average
V_s = velocity of flue gas in feet (meters) per second
V_l = volume of condensate through the impingers in millimeters
V_{lc} = volume of liquid collected in condenser in millimeters plus weight of liquid absorbed in silica gel in grams indicated as milliliters
V_m = volume of metered gas corrected to dry standard conditions in cubic feet (meters)
V_{ms} = volume of metered gas measured at meter conditions in cubic feet
V_o = volume of flue gas at actual conditions in cubic feet (meters) per minute
Q_{sd} = volume of flue gas corrected to dry standard conditions in cubic feet (meters) per hour
V_t = total volume of flue gas sampled at actual conditions in cubic feet (meters)
V_w = volume of water vapor in metered gas corrected to standard conditions in cubic feet (meters)
V_{wc} = volume of water condensed in impingers corrected to standard conditions
V_{wsg} = volume of water collected in silica gel corrected to standard conditions
W_a = total weight of dust collected per unit volume in grains (grams) per actual cubic feet (meters)
W_d = total weight of dust collected per unit volume in pounds (grams) per dry standard cubic feet (meters)
W_g = total weight of dust collected in grams
W_h = total weight of dust collected per unit volume in pounds (grams) per hour, dry basis
W_p = total weight of dust collected in pounds
W_s = total weight of dust collected per unit volume in grains (grams) per dry standard cubic feet (meters)
W_{sg} = impinger silica gel weight gain in grams
Y = metered gas volume correction factor
θ = total elapsed sampling time in minutes

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