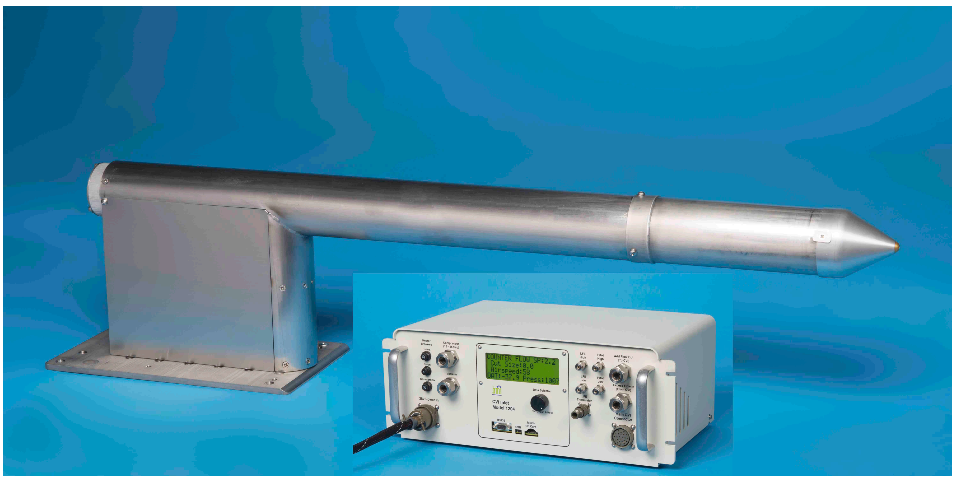
BRECHTEL

Product Manual Ver. 3.2

CVI Inlet 1204

For firmware version 2.0.



BMI PN: 83-00030-01 3.2

May 7, 2023

Contents

1 Cautions

Read this entire manual before mounting and operating your BRECHTEL CVI inlet. The following warnings and disclaimers must be adhered to in order to properly operate the Model 1204 CVI Sampling Inlet.

1.1 Mounting

It is the customer's responsibility to determine the suitability of the inlet mounting location on the aircraft or other moving platform with respect to upstream flow obstructions, turbulence induced by the platform itself, boundary layer thickness, and any other parameters that might influence inlet performance.

It is the customer's responsibility to properly engineer the inlet mounting to the aircraft or other platform following all applicable rules and regulations. It is the customer's responsibility to obtain any FAA or other agency certification required for their particular aircraft according to applicable regulations. It is the customer's responsibility to properly physically mount the inlet to their aircraft or other platform. **BRECHTEL accepts no responsibility for damages, injury, or loss of life due to improper operation or due to inadequate mounting of the inlet to an aircraft or other moving platforms.**

1.2 Sampling Conditions

The Model 1204 CVI Sampling Inlet is designed to sample in cloud. The large droplets ($>$90 micron diameter, 100 m/sec airspeed) sometimes present in clouds may strike the surfaces of the inlet and shatter. The shattering process generates small droplets that produce high concentrations of sub-micron artifact particles upon drying. BE AWARE OF THIS POTENTIAL SAMPLING ARTIFACT WHEN SAMPLING IN CLOUDS WITH DROPLETS LARGER THAN ABOUT 90 MICRONS DIAMETER.

1.3 Storage and Handling

The Model 1204 CVI Sampling Inlet should be removed and properly stored in its original packaging when the aircraft or other vehicle upon which it is mounted will be ferried or otherwise transported over long distances with the sampling inlet not in use. Under these circumstances, install a blanking plate over the inlet mounting location. BRECH-

TEL accepts no responsibility for injury or damage that may occur due to improper operation of the sampling inlet.

Take special care not to strike the tip of the inlet against a solid surface, the tip will be deformed and no longer function properly.

1.4 De-Icing

The De-Icing system of the Model 1204 CVI Sampling Inlet is designed for short exposures to icing conditions, primarily to prevent clogging of the tip of the inlet by ice. The CVI is not designed to sample in clouds under high ice accumulation conditions. The De-Icing is NOT designed to keep all of the inlet external surfaces free of ice under all icing conditions. **BRECHTEL accepts no responsibility for injury or damage that may occur due to exposure of the sampling inlet to icing conditions.**

1.5 Burn Hazard

Short sections of the add flow heater mounted inside the CVI probe are exposed within the pylon. Temperatures near 200 degrees Celsius can be reached on the add flow heater surfaces. If the pylon side covers are removed while the heater is powered on, you can be burned if you touch the bare heating element.

1.6 Compressed Air Hazard

The Model HT-DAIR115 or HT-DAIR230 Dry Air Supply system provided with the CVI operates at pressures up to 65 psig (4.5 bar) internally with regulated output controlled at 28 psig (2 bar). An overpressure relief valve automatically vents to ambient when internal pressures exceed 65 psig. A 6 liter storage tank is maintained at 28 psig for the flow control system. Be sure to properly vent any component held at high pressure before disconnecting tubing, loosening fittings, or performing other work.

2 Changes

Change Description	Page	Date	Author
Ver 2.1: Update firmware descr.	All	March 2014	FJB
Ver 3.0: General update; eliminate pitot	All	Nov 2021	FJB
Ver 3.1: Lower add and sample flow rates; new serial output format	10,16,17	March 2023	FJB
Ver 3.2: Update Table 5	33, 36, 38	May 2023	FJB

3 Contact BRECHTEL

3.1 Getting Help

Contact BRECHTEL for any questions or assistance with this product.

Include the model *and* serial *numbers when contacting Brechtel.*

1789 Addison Way
Hayward, California 94544 U.S.A.

Telephone: (510) 732-9723
Fax: (510) 732-9153
Email: sales@brechtel.com

4 Unboxing

Each BRECHTEL CVI Inlet is inspected and tested in-house at BRECHTEL to ensure out of the box operation upon delivery. Prior to opening, inspect the packaging container and ShockWatch impact indicators.

Carefully open the package and inspect the instrument and any accessories for broken parts, scratches, dents or other signs of damage incurred during shipping. Inspect the shock indicator (Fig 1) to determine if it has activated or if any other visible damage is evident.

Notify BMI within 2 days of receiving package if the shock indicator has activated and/or if any other visible damage is evident.

Retain all shipping packaging, foam inserts and cushions to ensure a safe delivery should the instrument need to be returned.

Verify the contents of the shipment with the packing lists at the end of this manual. The product manual and other supporting documentation are shipped on a USB drive with the product.

Take special care not to strike the tip of the inlet against a solid surface, the tip will be deformed and no longer function properly.

Figure 1: The black lines in the bottom shock-watch indicate the package experienced an impact.

5 CVI Inlet Overview

5.1 Description

The BRECHTEL 1204 CVI Sampling Inlet (hereafter 'sampling inlet' or 'inlet') is intended for deployment on aircraft and other moving platforms for sampling of ambient cloud droplets. A wind-tunnel add-on kit is available to also allow cloud sampling with the CVI at ground-based sites. The inlet is designed to sample cloud droplets larger than a certain "cut-size" and evaporate the droplets so only the dry residual particles that originally nucleated the droplets remain. Droplets and particles smaller than the cut-size are prevented from entering the inlet. The inlet accomplishes this by blowing warm, filtered air out the forward-facing tip to resist the oncoming flow of droplets and smaller aerosol. This so-called "counter flow" is the key to separating larger from smaller aerosols. Once droplets enter the tip they are embedded within warm, dry air, and they evaporate. The CVI delivers between 6 and 15 lpm of sample flow with dried residual particles to aerosol sizing, counting, and chemical composition instruments that sample from the inlet.

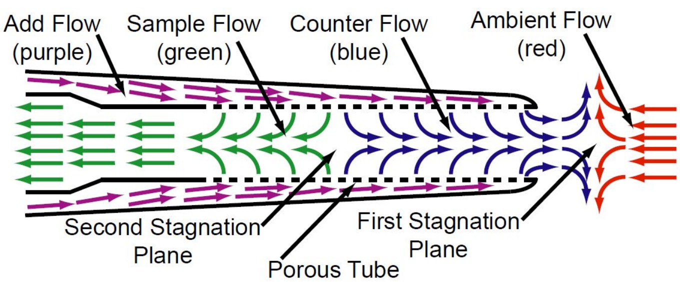


Figure 2: Schematic of CVI inlet tip flows.

Sample droplets must have a minimum Stokes number or inertia to pass through the counter flow and into the sample air flow. The droplet Stokes number is generally controlled by the velocity of the droplets and their diameter. The diameter corresponding to the minimum Stokes number for sampled droplets is referred to as the 'cut size' diameter of the inlet. It is defined as the size at which 50% of the ambient droplets penetrate the counter flow and enter the sample flow. Droplets smaller than the cut size are rejected (blown away from the tip) by the counter flow, while droplets larger than the cut size penetrate the counter flow and enter the sample flow. A schematic of the flows around the tip of the CVI is shown in fig. 2. For a given counter flow, droplet velocity, temperature, and pressure, the cut size of droplet that penetrates into the inlet is fixed. Results from studies of the variation of droplet stopping distance with these parameters have been summarized in an equation used in the control software to report the estimated cut size as the various parameters change.

The CVI operates with counter flow rates between 0 and 10 lpm and a range of 0 to 15 lpm of sample flow to instruments for air speeds between about 50 and 150 m/s. Starting with firmware version 2.0 (March 2023), the sample flow rate can be adjusted to values between 6 and 15 lpm and the counter flow rate can be adjusted to values between 0 and 10 lpm. **It is important to recognize that the size-dependent droplet losses reported for the CVI were obtained from studies with a sample flow rate of 15 lpm. Therefore the results are technically only valid for a 15 lpm sample flow rate.** The droplet diameter cut size of the CVI is user-adjustable between roughly 7 and 15 microns. The software maintains the desired counter flow rate in response to changes in air speed, temperature, and pressure.

Note: The add flow rate is equal to the counter flow rate plus the sample flow rate. For a specific sample flow rate, setting the add flow rate effectively sets a constant counter flow rate.

During aircraft or other moving platform deployment, the velocity of the cloud droplets is the relative velocity of the platform compared to the ambient wind speed. As the air speed, sample pressure and temperature conditions change during flight, proper air flow rates and minimum Stokes number are maintained through micro processor-controlled adjustment of mass flow controllers integrated into the electronics chassis. For ground-based operation using the Ground CVI inlet add on kit, the upstream wind tunnel accelerates the cloud droplets so that they reach the desired velocity at the tip of the CVI inlet.

The dried, residual particles from the evaporated droplets are typically considered to be CCN, as they originally likely participated in the activation of cloud droplets within cloud. However, it is possible that the size and composition of the dried residual particles could be modified by the coalescence of cloud droplets with un-activated particles. The residue particles are drawn into the inlet sampling manifold where various instruments can be used to measure their size, concentration, chemical composition and other properties. The calculated transmission efficiencies through the external probe body for residue particles between 0.01 and 6 microns in diameter are greater than 95% (15 lpm flow rate). The CVI Inlet is especially well suited for studies of cloud droplet microphysics and chemistry since it allows detailed measurements to be made on the particles that originally formed the droplets (CCN) as well as gas-to-particle conversion and other processes within cloud that may modify CCN properties.

For sampling of un-activated, out-of-cloud, interstitial particles up to 6 micrometers in diameter from moving platforms, BRECHTEL offers the Model 1200 Isokinetic Aerosol Sampling Inlet. For sampling un-activated aerosol with the Ground CVI option, a feature may be added to allow an automated three-way valve to select a standard and/or interstitial inlet so instrumentation dedicated to sampling behind the CVI inlet can also be used to sample under non-cloud conditions or to sample un-activated aerosol while in cloud.

5.2 How the CVI inlet Works

The CVI includes four separate major components.

Component 1 CVI external probe,

Component 2 Electronics control chassis with built-in firmware control,

Component 3 Vacuum pump and compressed dry-air supply,

Component 4 Tubing and electrical cable interconnects.

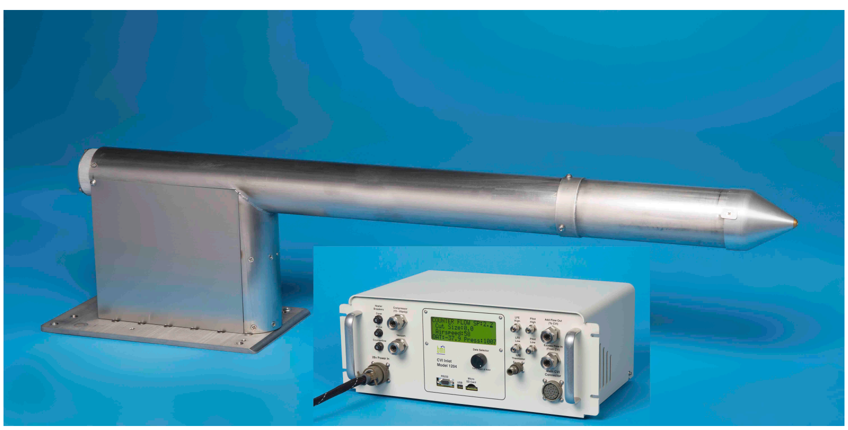


Figure 3: Major components of the CVI inlet. Vacuum pump, dry-air supply, tubing and electrical cables not shown.

The flow schematic of the complete inlet system is shown in Figure 4. Here, add flow (dashed red line) is generated by a compressor with integrated drying (4) and runs through a filter to remove particles. An over-pressure relief valve set to 60-70 psig automatically vents to ambient if the dry air compressor becomes over pressurized. The add flow is adjusted using a mass flow controller located in the chassis (2) and filtered again before entering (solid red line with arrow, 8) the CVI probe (1). Within the probe (1), the add flow passes between two concentric tubes where the add flow heater is located. The heater heats the add flow to the counter flow temperature set point. The counter flow temperature is measured by a thermistor located near the tip of the CVI inlet. A vacuum pump (5) pulls flow through a mass flow controller in the chassis (2) and subsequently through the sample laminar flow element (LFE, 3) and probe sample outlet (7). The main interconnect cable (6) provides power to the deicing heaters, and sends temperature readings to the firmware. 28 volt DC power is supplied to the chassis (2) via the provided power cable (9).

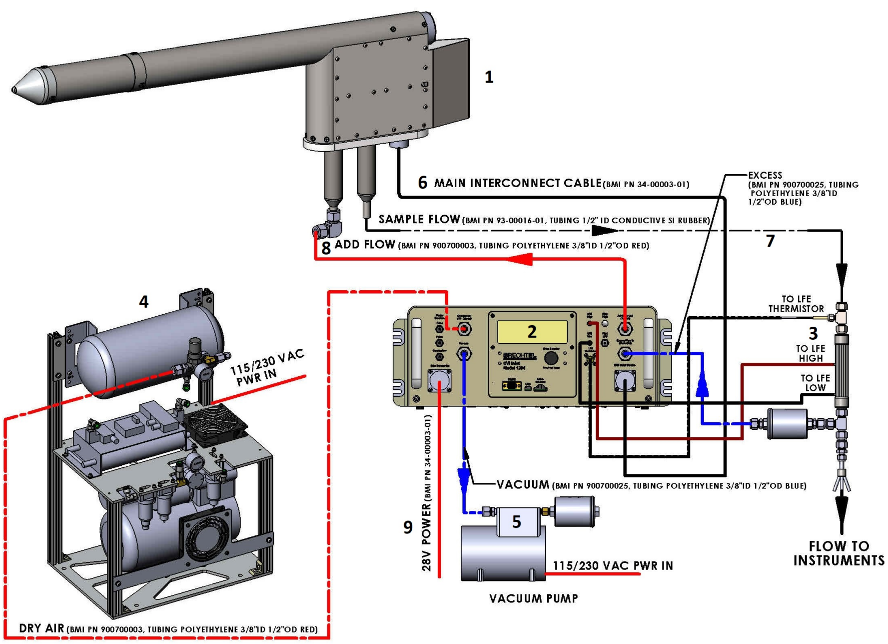


Figure 4: CVI schematic.

At the tip of the inlet the add flow passes through the walls of a porous tube and is divided into the counter flow and the sample flow. For example, if the add flow was 20 lpm and the sample flow was 15 lpm, the counter flow leaving the tip would be 5 lpm. The counter flow can be set to values between 0 and 10 lpm. The division of flows at the tip is shown in greater detail in Figure 2. Droplets larger than the cut size can travel through the counter flow and into the sample flow. The dry, heated sample flow evaporates the water from the droplets. This particle-laden sample flow (green lines with arrows in Fig. 2) is then measured by a laminar flow element (LFE) to maintain the constant sample flow setpoint (user set value between 6 and 15 lpm). An orifice is placed at the exit of the LFE to induce mixing and ensure that particles are evenly distributed throughout the flow before the sample flow is divided in the tee fitting. This mixed flow is then delivered to the 4-way splitter instrument manifold with any excess flow metered and pulled away through a second mass flow controller inside the chassis attached to the CVI vacuum pump. For example, if the the instruments sampling from the CVI draw 8 lpm of total sample flow and the total sample flow is set to 15 lpm, then the flow controller will draw 7 lpm of sample excess flow to maintain the 15 lpm of total sample flow through the LFE. The flow controller will automatically adjust its flow setting as the instrument flow changes.

5.3 Cut Size Performance and Losses

Tests of the CVI inlet cut size performance and penetration efficiency have been performed using the vertical wind tunnel at BRECHTEL . Studies characterized particle losses of various tip components and of the entire forward-facing portion of the probe using hollow glass spheres with diameters between 1-20 micrometer and for wind tunnel air speeds between 50 and 100 m/sec. All studies were performed with a 15 lpm sample flow rate. Computational Fluid Dynamics (CFD) modeling has also been performed to confirm sufficient heating power was available to maintain de-iced surfaces above freezing temperatures. The cut size performance was measured using the same wind tunnel setup and glass beads used in the penetration efficiency tests. The particle transmission efficiency as a function of size of the CVI sample LFE has also been measured.

Transmission Efficiency of Probe

Loss studies were performed by injecting hollow glass spheres along the centerline of the wind tunnel and measuring the size distribution through the probe body with all tip components removed. Each individual tip component (tip assembly and expansion cone downstream of tip assembly) was then replaced and the study repeated. Results in fig. 5 indicate significant losses between 7 and 10 microns in the tip assembly (referred to as tubing prior to expansion in figure). All studies were performed with a 15 lpm sample flow rate, so the results only apply to that flow rate. Transmission efficiencies in the expansion cone drop below 90% for diameters larger than 10 microns. The cumulative losses are shown as the solid black circles and indicate 50% of 10 micron drops pass through the CVI probe while only 30% of 20 micron drops pass through the CVI probe.

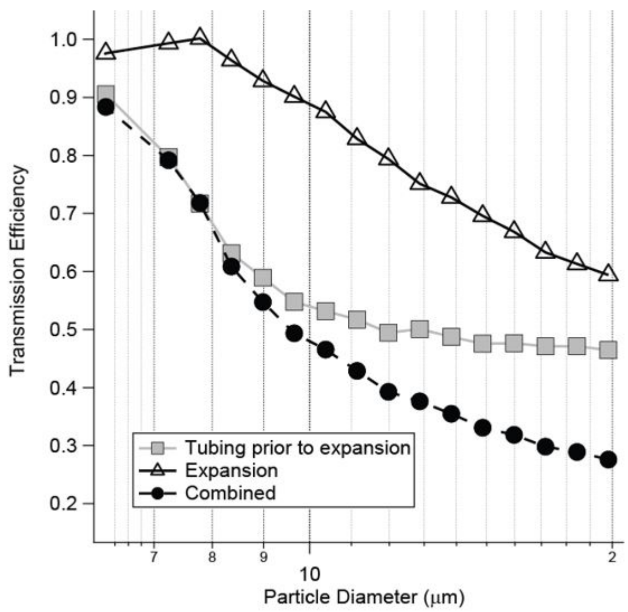


Figure 5: Penetration efficiency of the CVI for 15 lpm sample flow rate.

Cut Size Performance of Probe

The cut size performance of the CVI was measured using the same approach described above for the loss studies, except that the CVI was operated fully assembled with variable counter flow rates to establish how the cut size varied with counter flow rate. Results shown in fig. 6 are for 100 m/sec (top plot) and 50 m/sec (bottom plot), respectively. Add flow rates of 16, 19, and 23 lpm were studied corresponding to counter flow rates of 1, 4, and 8 lpm. All studies were performed at a sample flow rate of 15 lpm. The cut size corresponds to a transmission efficiency of 50%, designated by the horizontal dashed line in the figure. As can be seen, higher counter flow rates correspond to increasing cut size, with cut sizes between 9 and 11 microns observed at 100 m/sec and between 11 and 13 microns observed at 50 m/sec.

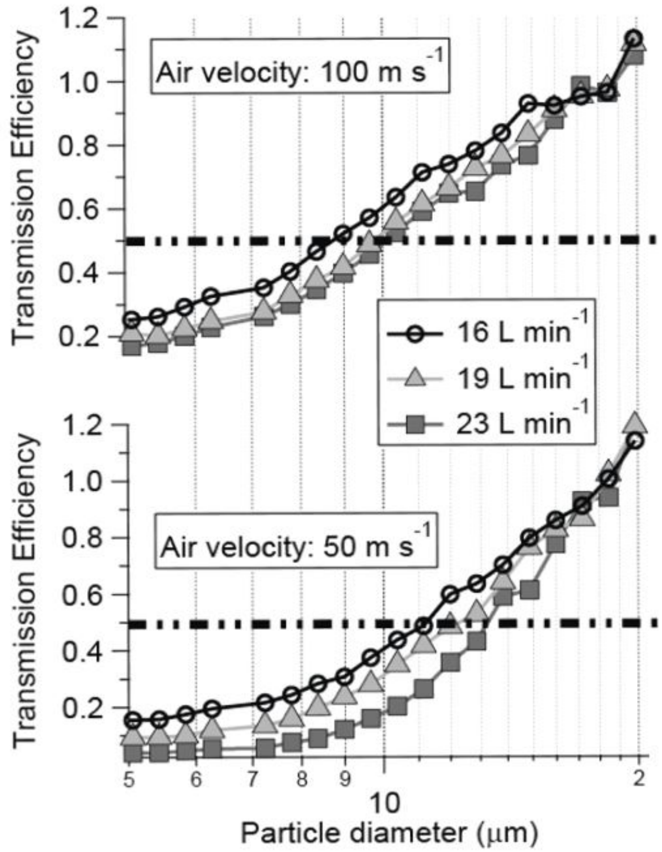


Figure 6: Cut size performance the CVI.

Penetration Efficiency of Sample LFE

The particle size-dependent penetration efficiency of the LFE was measured in the laboratory using monodisperse, DMA-selected diameters between 10 and 1000 nm. The LFE was operated at 15 lpm with one MCPC measuring upstream concentrations and a second MCPC measuring downstream concentrations simultaneously. Note that operating the

LFE at a different sample flow rate will result in different penetration efficiencies. Overall, transmission efficiencies were greater than 89% for all particles over the size range examined. For particles in the 30 to 500 nm diameter range the efficiency was between 92 and 97%. This range generally represents particle sizes dominating the active CCN number concentration.

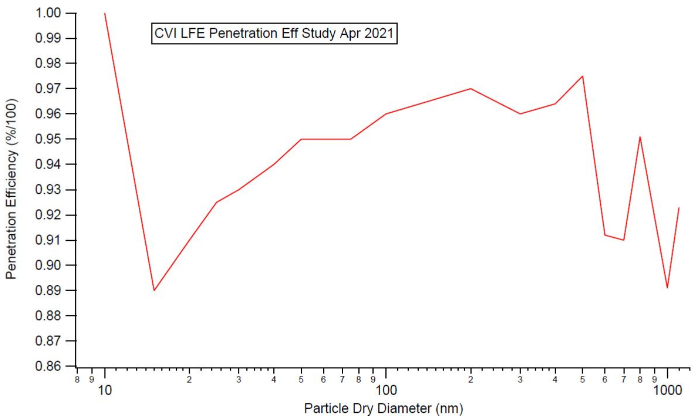


Figure 7: Penetration efficiency of the CVI sample LFE (15 lpm flow only).

5.4 CVI Inlet Options

Internal Options

There are no internal optional features offered with the CVI inlet.

External Add-Ons

There are several optional features external to the inlet that can be added at any time depending on your changing measurement needs. There are also external items like a new tip assembly, mass flow controller, vacuum pump, and dry air system available to replace existing components for service and maintenance needs.

Table 1: CVI Inlet External Options

PN	Option	Description
CVI-Tip	Tip Assembly for 1204 CVI	Spare tip assembly for quick replacement during cleaning.
CVI-GND-115V	Ground-based Operation kit for 1204 CVI, 115VAC	Sample clouds at ground.
CVI-GND-230V	Ground-based Operation kit for 1204 CVI, 230VAC	Sample clouds at ground.
CVI-Kit	Maintenance Kit for 1204 CVI	Replacement and consumable items to maintain inlet.
CVIVP-Mkit	Maintenance Kit, CVI Vacuum Pump	Items to maintain vacuum pump.
CVI-MFCp	Mass flow controller for CVI, pressure downstream of valve	Replacement MFC
CVI-MFCv	Mass flow controller for CVI, vacuum downstream of valve	Replacement MFC

5.5 CVI Inlet Specifications

Table 2: CVI Inlet Specifications

Description	Value
Tip Inside Diameter	0.180 in (4.57 mm)
Tip Porous tube length	0.40 in (10.2 mm)
Droplet Diameter Cut Size (50-100 m/sec)	7 to 15 um
Range of Add Flow Rates	6 to 25 lpm
Range of Counter Flow Rates	0 to 10 lpm
Total Sample Air Flow Rate	6-15 lpm
Sample Flow Rate to Instruments	0 to 15 lpm
Range of attack angle corresponding to less	
than 5% reduction in droplet sampling efficiency	0 to 1.5^{o}
Residual (dried) particle diameter range sampled	
with efficiency >95%	0.01 to 6.0 um
Data Output (also stored locally)	RS232
Data Output Frequency	2 Hz
Data Input	RS232
Data Input Frequency	1 Hz (min)
Physical Specifications	
Size (probe cover outside aircraft)	2.5" OD tube x 30" lg
Size of Electronics Rack Mount Chassis	17" x 7" x 12"
Total System Weight	111 lbs (50.5 kg)
Total Chassis Only Weight	20 lbs (9 kg)
Total Pump System only Weight	70 lbs (32 kg)
Total Probe Only Weight	21 lbs (9.5 kg)
Operating Temperature Range (with heaters)	-40-45 C
Operating Pressure Range	0.2 to 1 atm
Electrical Specifications	
Supply Voltage	28 VDC / 115 VAC / 230 VAC
Power @ 28 VDC (chassis only)	56 watts
Power @ 28 VDC (de-icing heaters only)	917 watts
Power @ 115/230 VAC (pumps)	650 watts

6 System Setup

6.1 Packing List

The CVI inlet will arrive in one sturdy box holding the CVI probe, chassis, sample LFE and 4-way splitter, and interconnect cables and tubing. The dry air system and vacuum pump will each be in their own shipping box. Normally, the boxes are attached to a wooden pallet and a forklift is required to move the pallet.

See the Appendix for a complete list of all the parts that come with the inlet ship kit and maintenance kit. Table 3 shows the parts needed to prepare the inlet for installation.

6.2 Assembly & Installation

The CVI inlet will arrive with the probe assembly, chassis, sample LFE assembly, vacuum pump, and dry air system already assembled. The installation involves mounting each item and completing the tubing and cable interconnects. When complete, examine the inlet installation and tie wrap all cables and tubes so they do not interfere with other instrument installations and will not inadvertently be pulled or otherwise interfered with during flight operations. Follow the schematic and table to connect the various pieces.

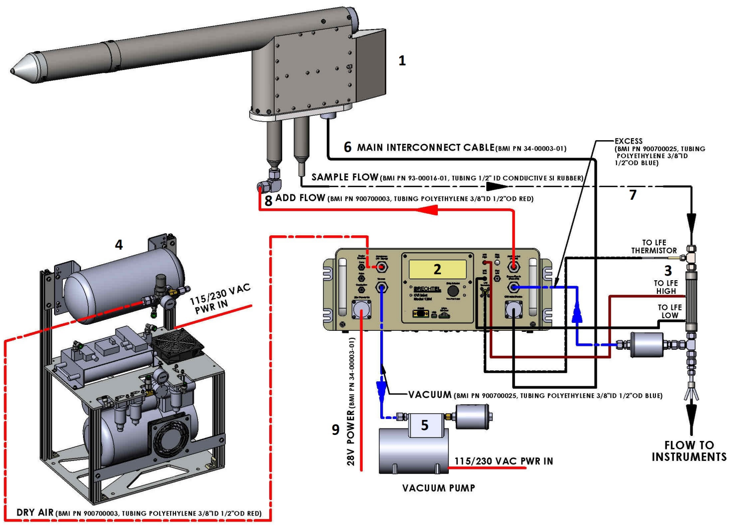


Figure 8: Schematic view of CVI assembly.

Table 3: CVI Inlet Assembly Parts

#	Description	QTY
1	Probe Assembly	1
2	Electronics Chassis	1
3	Sample LFE Assembly	1
4	Dry Air Supply	1
5	Vacuum Pump	1
6	Main Interconnect Cable	1
7	Sample Tube	10 ft
8	Add Flow Tube	10 ft
9	28VDC Power Cable	1

6.3 CVI Probe Mounting to Aircraft

It is the user's responsibility to properly design a mounting scheme to attach the CVI probe to the fuselage. A Designated Engineering Representative (DER), certified by the appropriate government aviation authority (e.g. Federal Aviation Administration, FAA in US), should be consulted to ensure an acceptable design is implemented.

The customer should verify that the inlet position on the platform is not influenced by any upstream components (including propeller wash or engine exhaust). Free stream turbulence intensity measurements just upstream of the proposed tip location during sampling should be used before deciding on a final mounting location to determine if propeller wash or some other factor influences the air sampled by the inlet.

Once the aircraft modifications are completed, attach the CVI probe to the outside skin following all details of the mounting scheme and seam-seal around mounting plates and probe covers to prevent water from entering the probe. An example of a mounting scheme is provided in the figure below.

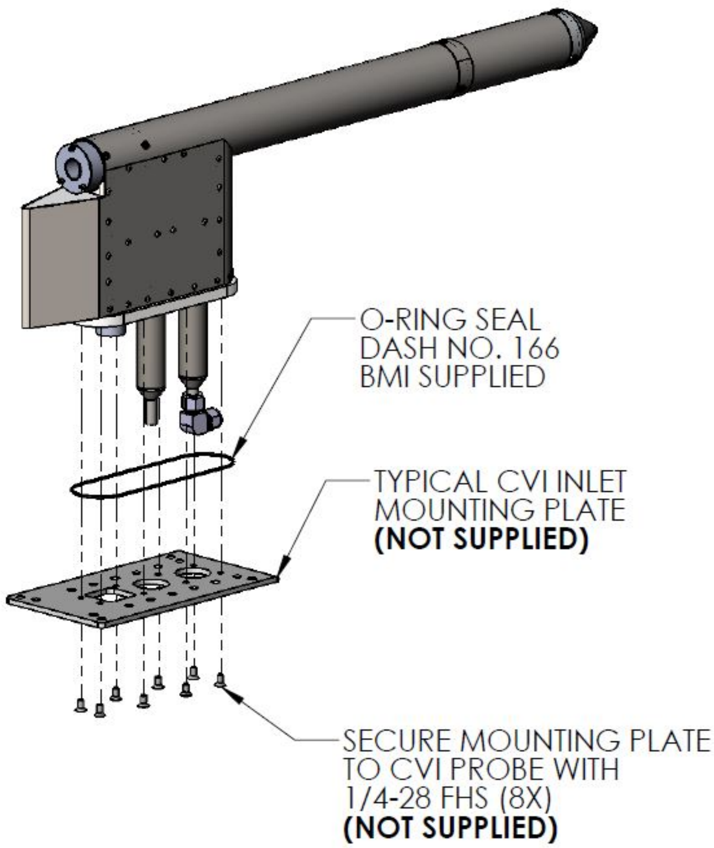


Figure 9: Example mounting of CVI assembly. Note mounting plate is not supplied with inlet.

When mounting the inlet to the aircraft, pay attention to the following details:

1. It may be necessary to connect the 'Main Interconnect Cable' to the mating connector on the CVI mount plate before final attachment of the mount plate to the aircraft if access to the mating connector will be limited from inside the cabin after installation. This can happen in situations with thick cabin walls.

2. Clean the surfaces of all metal components with methanol and clean wipes before final assembly. Do not use acetone. Take care when handling the CVI probe

assembly, undue stress on the tip in particular can result in misalignment and poor operation.

3. Finger wipe all O-rings and O-ring sealing surfaces prior to assembly. A very small amount of vacuum grease should be used just on the O-rings, but any excess should be wiped off before assembly.

4. Inspect the mounting flange mating surface, O-ring grooves and holes for dirt or other defects and clean or repair if needed.

5. Ensure that all required O-rings are installed in the bottom of the CVI mounting plate.

6. While guiding the CVI probe assembly through the fuselage, take care not to scratch the tubing protruding through the CVI mounting plate.

7. Note that BOTH sets of side cover bolts must be removed if removal of the shroud assembly side covers is necessary to access internal wiring. This is because it is a welded assembly.

8. Set the proper pitch angle of the CVI probe assembly before final mounting to account for the typical angle of attack of the aircraft during flight.

6.4 Electronics Chassis

The chassis should be mounted with a minimum of four 10-32 bolts to a standard 19" instrument rack. The chassis comes with angle brackets that should be mounted to the sides of the chassis before the chassis is mounted to the rack. The chassis does not require a support strut in the rear, however, install one if available.

The CVI electronics are grounded electrically to the chassis, and the chassis is grounded to the rack via the mounting bolts, therefore, the rack must be grounded to provide proper electrical grounding for the system.

Mount the chassis within 10 feet of the CVI probe or the tubing and cables provided will not be long enough to connect them to each other.

Figure 10: Front view of electronics chassis of CVI inlet.

The large red button on the rear panel of the CVI is only used for re-programming the firmware. Push the button IN while updating the firmware and be sure the button is in the OUT position during normal inlet operation.

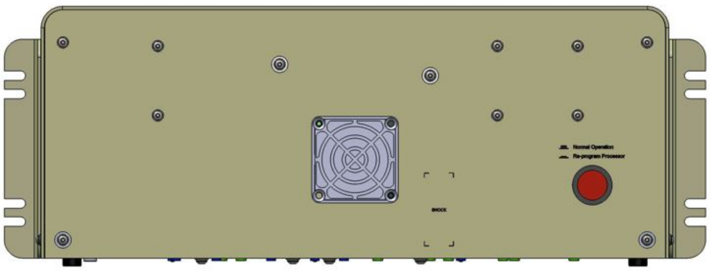


Figure 11: Rear view of electronics chassis of CVI inlet.

Do not block the ventilation holes in the sides of the chassis or components inside may overheat. Leave at least 3 inches of space on either side of the CVI chassis for proper ventilation.

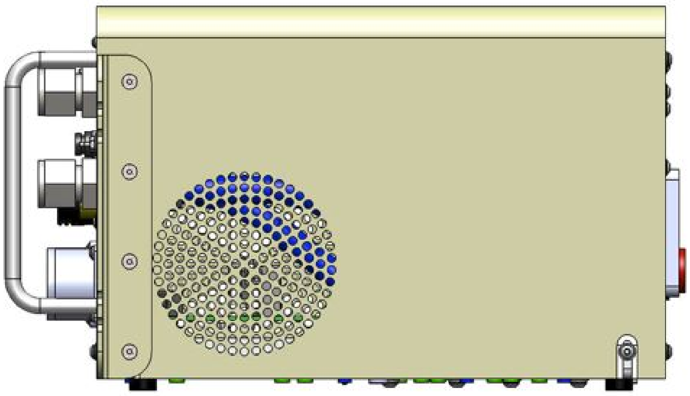


Figure 12: Side view of electronics chassis of CVI inlet.

6.5 Sample Connections

Inside the cabin, mount the sample LFE assembly so the conductive silicone sample tube provided with the inlet will connect the sample outlet tube on the probe to the inlet tube of the LFE assembly. The sample outlet tube on the probe is the tube closest to the electrical connector on the mounting plate. The inlet tube of the LFE assembly is located on the tee fitting with the thermistor. Be sure the LFE assembly is mounted close enough to the chassis so the LFE thermistor cable can be connected to the front panel and so the various tubes also reach the front panel.

Attach the 1/2" diameter tubing from the filter in the LFE assembly to the Sample XS compression fitting port on the front panel of the chassis. Attach the high pressure red silicone tubing from the LFE to the LFE HIGH barb on the chassis front panel. Attach the low pressure black silicone tubing from the LFE to the LFE LOW barb on the chassis front panel.

Attach instrument sample flow tubing to any of the four outlet tubes of the 4-way splitter connected downstream of the LFE. Minimize tubing lengths to reduce particle diffusion losses inside the tubing. Try to keep the distribution of flow rates drawn through the different tubes as even as possible. If one or more of the splitter outlet tubes will not be used, be sure to plug the end of the unused tube with a robust seal like silicone tubing and a hose barb plug fitting. If compression fittings are to be used to attach to the splitter, be sure not to over tighten the fittings or the outlet tubes will be warped and likely leak.

Temporarily plug any open ports or tubes in the LFE assembly if it is to be left disconnected for more than a few hours. This will prevent debris from entering the LFE.

6.6 Dry Air System Mounting

The dry air system is comprised of a compressor mounted to an aluminum base plate. The compressor supplies 65 psig input air to a twin-tube, self-regenerating desiccant dryer to produce extremely dry air (-40 C dew point). An over-pressure relief valve installed just upstream of the dryer begins to vent to atmosphere once internal pressures exceed 65 psig. The dryer cycles between the two drying canisters every 60 seconds, resulting in a venting of the just used canister and the sound of air escaping the system (normal). The dry air from the dryer passes into a 6 liter storage tank with an outlet regulator set to 25 psig.

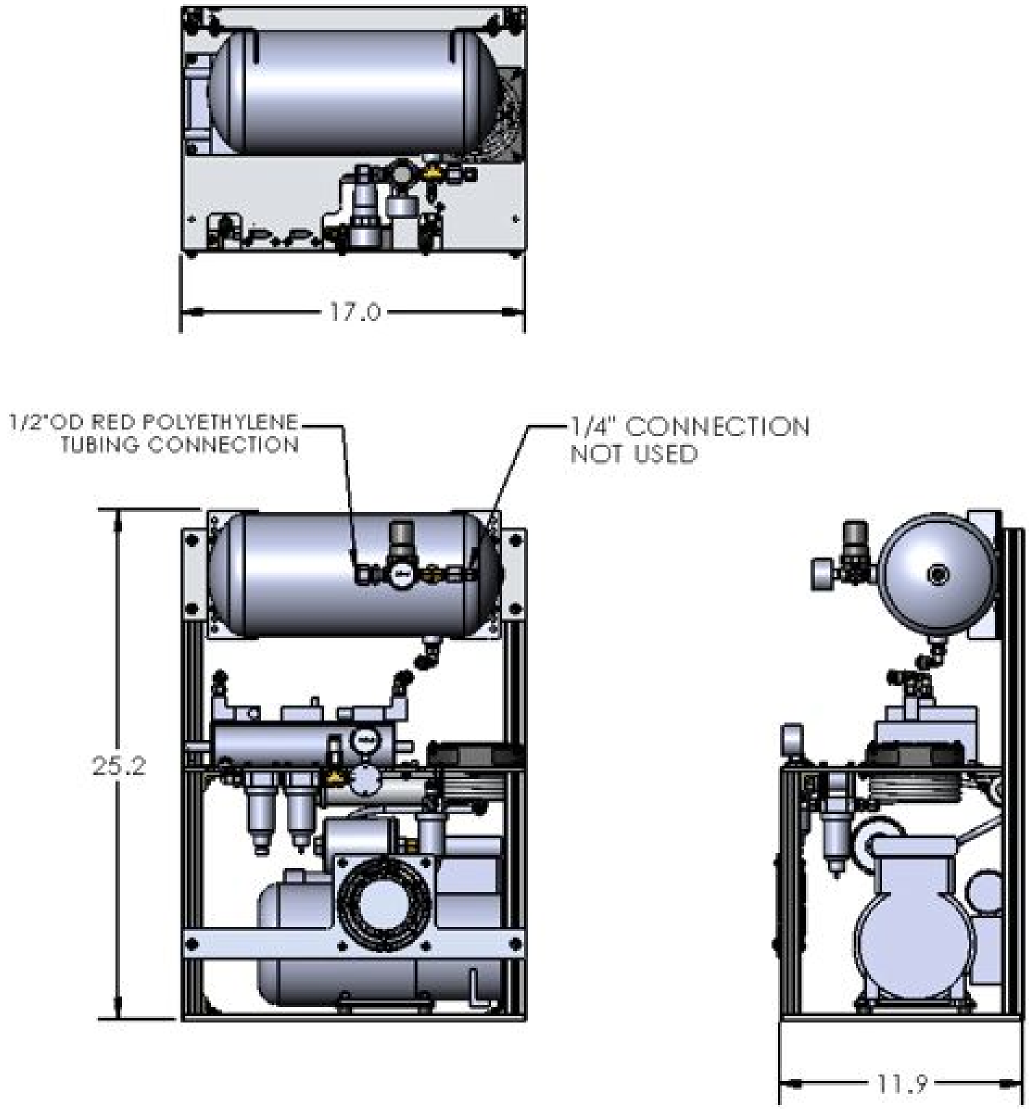


Figure 13: Detailed view of dry air system.

The dry air system weighs 55 lbs and uses 660 watts of single phase, 50-60 Hz AC power with peak power usage up to 990 watts. A single AC connector for the country of use is supplied to provide power to the system. Provision is made to mount the system using several 3/8” diameter bolts through the base plate. It is the user’s responsibility to properly mount the system and adhere to any rules regarding handling of compressed air systems.

Condensate (water) will collect in the water trap just downstream of the copper tubing coil installed on the compressor outlet. The water trap automatically drains every 60 seconds when the pressure drops in the system due to the dryer cartridge switching. Be sure to attach a catch basin or route the water that will drain from the trap to a safe place.

6.7 Vacuum Pump Mounting

The vacuum pump weighs 11 lbs and uses 190 watts of single phase, 50-60 Hz AC power with peak power usage up to 340 watts. A single AC connector for the country of use is supplied to provide power to the system. Provision is made to mount the pump using four 6-32 threaded bolts through the feet of the pump. A filter is installed on the inlet to the pump to protect it from ambient particulate matter. Sporadically, pumps may require a few minutes to reach full pumping capacity, potentially resulting in flow control errors in the CVI during start up. This normally corrects itself once the pump warms up. The pump will not operate correctly if it is started while under vacuum, which can happen if the flow control is turned off in the CVI firmware before the pump is turned off. It is the user’s responsibility to properly mount the pump and adhere to any rules regarding handling of vacuum systems.

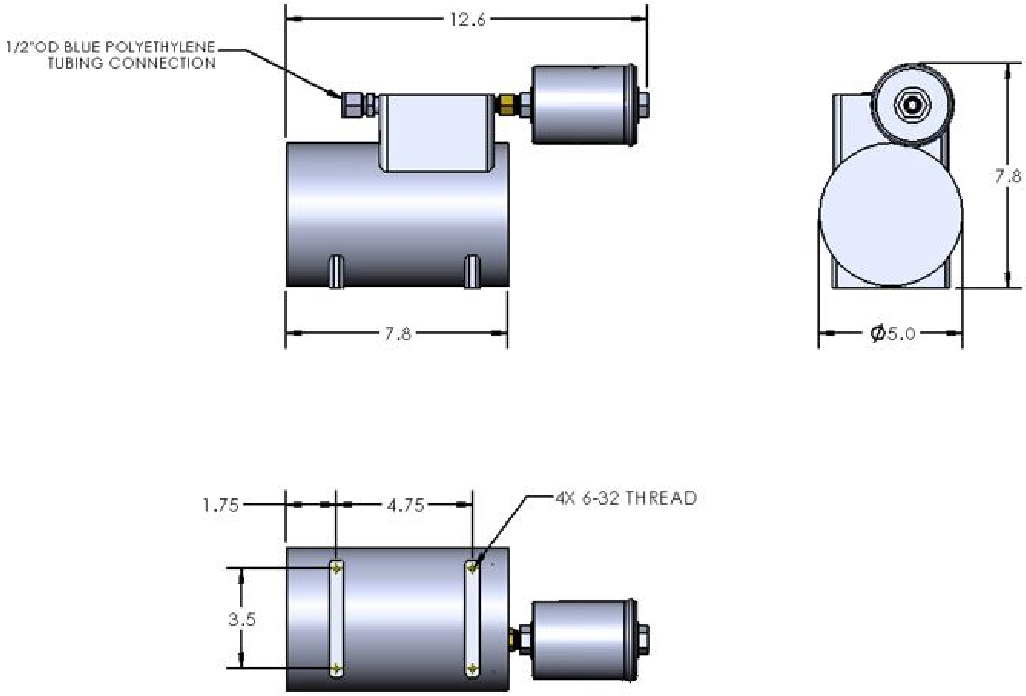


Figure 14: Detailed view of vacuum pump.

6.8 Tubing Connections

Connect the dry air system 1/2" compression fitting output to the Compressed air input fitting on the chassis front panel using the 1/2" red tubing provided. Make sure the tubing connections are tight.

Connect the vacuum pump 1/2" compression fitting output to the Vacuum fitting on the chassis front panel using the 1/2" blue tubing provided. Make sure the tubing connections are tight.

Note that the built-in pitot-static probe option for the CVI inlet is no longer available. The platform air speed must be sent serially via RS232 communications to the CVI firmware from a user-supplied source. However, the Pitot High and Pitot Low tubing connections on the chassis front panel may be used by a user-supplied pitot-static probe if platform air speed is not easily available. The differential pressure sensor used for the pitot-static measurement is calibrated at the factory to a maximum differential pressure of 50 inches of water. Connect the pitot-static probe to the high and low pressure ports on the chassis front panel using semi-rigid tubing (e.g. polyethylene) to avoid pinching. It is the user's responsibility to ensure the air speed reading is representative of the true platform air speed.

6.9 Power & Electrical Connections

The CVI inlet probe and chassis operate on 28 VDC, while the dry air system and vacuum pump may operate on either 115 VAC or 230 VAC, depending on which model is purchased. A pre-assembled, six foot long, 28 VDC chassis power cable is provided with the CVI and has five labeled twisted pairs of wires that should be connected to the appropriate power source on the aircraft with the required power capacity and the ability to be turned on and off. Table 4 provides the cable details. A ten foot long main interconnect cable with 24 pin end connectors is supplied to connect the chassis to the probe. The main interconnect cable allows the firmware to read temperature sensors in the probe and to control power to each of the deicing heaters and add flow heater independently.

Table 4: CVI 28 VDC Power Cable Pinout.

Pin	Description	PWR (Watts)
L	Cone +28V	392
E	Cone GND	-
A	Add Flow +28V	230
K	Add Flow GND	-
G	Pylon +28V	295
F	Pylon GND	-
B	Board +28V	28
C	Board GND	-
H	Not Used	-
J	Not Used	-

The cone and pylon power circuits supply power to deicing heaters for each respective component. Independent circuit breakers are installed in the chassis for each heating circuit and are accessible on the chassis front panel. Keep the circuit breakers disengaged (open) by pulling them away from the front panel of the chassis when deicing is not required. Each deicing heater also has a built-in, re-settable, thermostatic switch that shuts off power to the heater if the temperature exceeds 65 C. One separate 28 VDC supply line is required for the chassis control circuitry power.

The connector on the 28 VDC power cable is an aviation-grade, bayonet-style connector that must be carefully aligned with the mating connector before it can be fully inserted. Align the detents on the inner barrel of the connector with the mating connector to begin engagement. The outer collar also has detents that must be aligned before the collar can be rotated clockwise to fully insert the connector. Turning the collar ”pulls” the connector pair together and a ”snap” at the end verifies the connectors are properly engaged.

The 24-pin main interconnect cable uses the same style connector on each end as found on the power cable but has more pins. Connect one end (with male pins) to the mating connector on the chassis front panel and other end (with female sockets) to the mating connector on the CVI probe mounting plate. Take care to properly align the connectors as described above before fully engaging them. The detailed pinout of the cable is shown in Table 5. Run the cable along the wall of the platform so the connector ends can be attached to the mating panel mount female connectors on the front panel of the chassis and on the inlet mounting flange. Tie wrap the cable to hold it in position during operation.

Table 5: CVI Main Interconnect Cable Pinout. Note that the pinout of both end connectors is identical and pins 7, 8, 15, 17, 19, 21, and 23 are unused. OAT=Outside Air Temperature. SW=Switch. Therm=Thermistor. Pins 7 and 8 were used for the pylon heater temperature interlock switch on early units.

Pin	Description	PWR (Watts)
22	Cone Htr, +28V	392
24	Cone DC GND	-
11	Cone Interlock SW +	-
12	Cone Interlock SW -	-
9	Cone Therm, Vsignal	-
10	Cone Therm, Vref	-
14	Add Flow Htr, +28V	230
16	Add Flow DC GND	-
3	Add Flow Interlock SW +	-
4	Add Flow Interlock SW -	-
1	Add Flow Therm, Vsignal	-
2	Add Flow Therm, Vref	-
18	Pylon Htr, +28V	295
20	Pylon Htr DC GND	-
5	Pylon Therm, Vsignal	-
6	Pylon Therm, Vref	-
13	OAT Therm, Vsignal	-
25	OAT Therm, Vref	-

6.10 Data & Communication Connections

There are several data and communication connections on the front panel of the chassis.

The RS232 serial port connector is bidirectional, it is used both to transmit data TO the inlet AND receive data from the inlet. See the chapter on operating the inlet for details on sending air speed and other data to the inlet firmware as well as on receiving data from the inlet.

The USB mini connector is only used when the firmware is updated. The update procedure is provided in an appendix. BRECHTEL will notify you if this is necessary.

The micro SD card connector accepts FAT32 formatted SD cards so data may be stored locally on the card during inlet operation. See the chapter on operating the inlet for details on using the SD card.

7 Operating the CVI Inlet

Always keep the CVI probe tip and probe body covered with a closed weather-proof cover when the unit is not in use. This will help prevent rain and foreign objects from getting inside the inlet system.

7.1 Setting Firmware Defaults

There are several inlet default operating parameters that must be set by the user prior to operating the inlet. Setting the default values defines the operating state of the inlet when power is first applied. These include the de-icing system ON/OFF state and de-icing heater set-point temperatures, the flow control ON/OFF state, the counter flow heater ON/OFF state and set-point temperature, the counter flow rate, the SD card save ON/OFF state, and the air speed and outside air temperature source (external or internal).

7.2 Startup

Before each flight, verify that all protective covers have been removed from the inlet and and any other outside inlet components.

Note that the counter flow heater requires up to 1 hour to reach its setpoint temperature.

Manually or serially synchronize the inlet clock with the aircraft or other data system.

Power on the inlet electronics by applying 28 VDC power to the chassis, this will automatically run the control software and operate the inlet. Be sure the external airspeed source is communicating the airspeed via RS232. Confirm the Heater Circuit breakers on the chassis front panel are set properly. Apply AC power to the dry air system and vacuum pump after FLOW CONTROL is set to ON in the firmware.

Note that power will not be delivered to the counter flow heater if the add flow is too low (below 6 lpm).

The firmware will begin controlling flow rates and heater temperatures automatically when power is applied to the chassis depending on the default system setting. If it doesn't, check the default settings, especially that Flow Control is set to ON.

The front panel will display the true air speed provided to the program via serial communications. The various operating parameters will be displayed on the front panel as described below.

Data (1 Hz) will automatically be saved to the SD Card if the save feature is ON.

7.3 In-Flight Operation

During flight, periodically check proper operation of the inlet system by verifying that the COM port supplied velocity agrees with and tracks the true air speed of the aircraft. Verify that the counter flow and sample flow rates being set by the program compare favorably to desired set point values. Periodically check the counter flow pressure measured by the inlet flow controllers against the aircraft static port pressure.

The inlet power does not need to be shut down until after touchdown. The SD Card save data feature can be turned off to properly close the file so the card can be removed and data transferred to another storage system. Turn De-icing off.

If the system must be stopped immediately, disconnect the 28 VDC power at the source or remove the the power connector at the front panel.

7.4 Shutting Down

It is best to keep the inlet running through landing and taxi, this will help keep pollution gasses, dust, and other materials from entering the tip of the CVI and contaminating the inlet. Turn off AC power to the dry air system and vacuum pump. DO NOT KEEP THE DRY AIR SYSTEM AND VACUUM PUMP ON WHEN FLOW CONTROL IS OFF.

Once the aircraft is parked, but before power transfer, confirm AC power to the dry air system and vacuum pump is off before turning off 28 VDC power to the chassis. Turn off flow control AFTER AC power to pumps has been removed. This will help ensure vacuum is not left on the line between the vacuum pump and mass flow controller. Turn SD save to OFF and remove the SD card to access the flight data file if necessary. Turn off 28 VDC power to the chassis. Cover the inlet with the weather proof cover. Empty any catch basin used to collect water from the dry air system.

7.5 Cleaning the CVI Tip Assembly

Over time, particles and gasses may coat the porous tube inside the tip assembly and degrade the flow performance by blocking the pores.

Note: It is extremely important that the tip be kept clean to ensure good cut size performance of the inlet.

The tip assembly should be cleaned before each field campaign and after exposure to high particulate matter loading. Degraded tip performance can be indicated by higher particle break through at counter flow rates less than 2 lpm when sampling in clear air. It is useful to have a spare CVI tip assembly so the spare can be installed while the second assembly is being cleaned. Follow the procedure in the maintenance section of this manual to clean the tip assembly.

7.6 Shipping the CVI Inlet

The inlet system has several components that are sensitive to intense shock and vibration; therefore it should only be shipped in its original shipping containers and via Air-Ride Truck or Air Freight. All open swagelock fittings, tubes, and other items should be plugged or covered with parafilm or some other material. It is recommended that the CVI-tip assembly be removed and the Tip shipping blank be installed in its place before shipping. Before closing the box, cover the Inlet system with a large plastic bag or other protection in case the box is exposed to wet conditions. Take care to protect any disconnected electrical connectors by wrapping them in bubble wrap or parafilm. Take special care to properly package the probe assembly in the custom-cut original foam packaging. It is highly recommended that the box be strapped to a wooden pallet to ensure proper handling during shipping.

8 Firmware System Menus & Parameters

The control system for operating, configuring and calibrating the inlet is described in this section. The user interface front panel menus are divided into two major categories: operational menus and default settings menus.

The operational menus are:

1. De-icing
2. SD Card
3. Flow Control
4. Counter Flow
5. Counter Flow Heater
6. Flow Controllers
7. Laminar Flow Element
8. Time & Date

The default settings menus are:

1. De-icing Defaults
2. Flow Defaults
3. Counter Flow Heater Defaults
4. Misc Defaults
5. COM Defaults
6. Sensor Heater
7. Calibration
8. Manual Mass Flow Controller (MFC) Control
9. Heater Parameters

All menus are accessible from the front panel using the data knob. Moving between the two menu types is accomplished by pushing and holding in the data knob. When the cursor on the front panel is in the top left corner, turning the data knob allows you to scroll through the menus. A short push of the data knob will move the cursor to any editable item within the menu. Once the cursor is located at an editable item that needs to be updated, turn the data knob to change the value. To return to the top left corner of the menu, apply as many short pushes of the data knob as are required. Note that after power up, the starting menu is the Flow Control menu (not the De-icing menu). Turn the data knob counter-clockwise to access the SD Card and De-icing menus. All of the operational menus, except for Time & Date, have only one editable item to make it easier to control the system.

Detailed descriptions are provided of each of the menus below.

8.1 DE-ICING

The DE-ICING menu contains all parameters relevant to de-icing tasks and allows you to turn De-icing on and off. See figure 15 for a photo of the De-icing menu. In the operational De-icing menu the only editable parameter is whether the de-icing is on or off. The temperature setpoints for the De-icing system must be changed in the De-icing Defaults menu. The operational De-icing menu will display whether the de-icing is on or off as well as the measured and setpoint temperatures of the Cone and Pylon. The far-right column of numbers on the display denote the percentage level of currently applied power to each of the de-icing zone heaters (0-100%, where 100% is denoted by a value of 200).

Figure 15: Photo of the DE-ICING menu.

For de-icing zone temperature setpoints between 0 and 5 C, the system will operate at 100% heater power. For temperature setpoints of 6 C or higher, the software automatically limits the heater power to 30% of full power to avoid heater damage. We

recommend setting the temperature setpoints no more than 10 C above ambient temperature during de-icing heater tests.

Don't forget that the De-icing system Heater Breakers on the front panel of the electronics chassis must be pushed in (no white showing on breaker) in order to allow current to flow to the heaters. 28 volt DC power must also be applied in order to test the de-icing heaters.

8.2 SD CARD

The SD CARD menu displays the status of the SD Card and allows you to turn data saving on and off. See figure 16 for a photo of the SD Card Menu. When you insert an SD Card, a new file is automatically created with the following naming convention. The name will contain the two digit year, two digit month, two digit day followed by a letter (A-Z) and then a number (0-9). The files are saved as text with extension '.txt'. On a given day, as the SD card is installed and removed, first the number in the filename increments (for example: A0, A1, ..., A9), and then the letter increments (for example: B0, B1,..., B9). Do not use SD cards with capacity greater than 32GB and note that all SD cards must be formatted with FAT32. If no SD Card is installed most of the menu items will be blank.

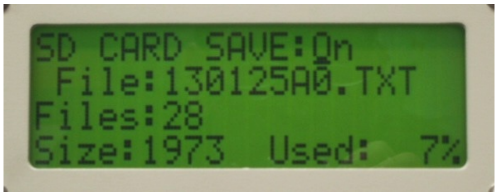


Figure 16: Photo of the SD CARD menu.

It is strongly recommended that you turn off the SD Card SAVE function before removing the SD card to prevent corrupting the SD card.

Other parameters shown in the SD Card menu include the current number of files on the card, the size of the card in MB, and the percent usage of the card.

8.3 FLOW CONTROL

The FLOW CONTROL menu displays most parameters related to flow and allows you to turn flow control on or off. See figure 17 for a photo of the Flow Control Menu. All reported flow rates are volumetric at pressure and temperature conditions at the CVI tip.

The counter flow thermistor near the CVI tip is used for temperature while a value of pressure interpolated between the pressures measured at the add flow and sample mass flow controllers is used to establish the pressure of the CVI tip. A single push of the data knob will move the cursor under the ON/OFF control on the top line. Rotating the knob will toggle flow control ON and OFF.

Shown on the display are the counter flow rate (lpm) and the target flow rate (lpm) separated by a slash, the total sample flow rate (lpm) and the target sample flow rate (lpm) again separated by a slash, and the current instrument (Inst) total flow rate (lpm) being drawn from the CVI inlet sample line. The instrument flow is calculated as the difference between the LFE measured flow and the sample excess MFC measured flow. Remember that the add flow volume flow rate is the sum of the counter flow rate and the total sample flow rate. The outside air temperature is used to correct the tip volume flow to local temperature conditions.

Figure 17: Photo of the FLOW CONTROL menu.

Use the Counter Flow Menu to change the value of the counter flow rate.

8.4 COUNTER FLOW

The COUNTER FLOW menu allows you to change the counter flow set point and subsequently the droplet cut size diameter of the inlet. The theoretical cut size (microns) is displayed on the second line. **Please note: the theoretical cut size calculated by the CVI firmware is an approximate value and should be re-calculated during data post-processing.**

Displayed on the third and fourth lines are the current airspeed (m/s), the Outside Air Temperature (OAT, deg C) and the calculated tip pressure (millibars). A single knob push will move the cursor under the counter flow setpoint on the first line. Once there rotating the knob will change the counter flow setpoint.

The allowable range of the counter flow rate is between 0 and 10 lpm.

Figure 18: Photo of the COUNTER FLOW menu.

8.5 COUNTER FLOW HEATER

The counter flow heater menu displays the status of the counter flow heater (also known as the add flow heater). This menu also allows the user to turn on and off the counter flow heater. A single knob push will move the cursor under the on/off control on the top line. Rotating the knob will toggle the on/off the heater control (Note the counter flow heater circuit breaker has to be pushed in and the 28 volt power on as well for the counter flow heater to function). The three readings displayed are the current measured temperature (degrees C), the temperature set point (degrees C) and the current heater power level (0-200).

Note: the counter flow heater depends on the having a reasonable add flow (larger than 6 lpm). If for some reason the add flow is too low (if flow control is off or the compressor is off) the message "ADD FLOW TOO LOW" will appear. This message will appear and the heater will be shutdown until the add flow is reasonable.

Figure 19: Photo of the COUNTER FLOW HEATER menu.

8.6 FLOW CONTROLLERS

The FLOW CONTROLLERS menu allows the user to view the readings of the two mass flow controllers (MFC) inside the electronics chassis that control the Add Flow and Excess (XS) sample flows. Readings displayed for each controller are: current flow rate (volume flow in lpm), flow rate setpoint (volume flow in lpm) and temperature (deg C).

Note: in normal operation the user cannot control the MFC flow setpoints, this is done automatically by the software (see "Manual MFC Control Menu" to manually control

the MFCs).

Figure 20: Photo of the FLOW CONTROLLERS menu with temperature shown.

The user can view the MFC pressure readings instead of the temperature readings. To do this, a single knob push will move the cursor under the word Temp at which point turning the knob will toggle between temp and Pres (Pressure in millibars).

Figure 21: Photo of the FLOW CONTROLLERS menu with pressure shown.

8.7 LAMINAR FLOW ELEMENT

The LAMINAR FLOW ELEMENT menu allows the user to view the readings of related to the sample laminar flow element: volumetric flow (lpm), temperature (deg C) and pressure (mbar). **Note: the pressure displayed here is the same as the counter flow pressure**. There are no settable parameters on this menu.

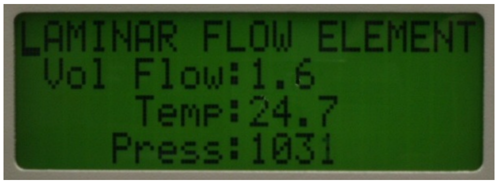


Figure 22: Photo of the LAMINAR FLOW ELEMENT menu.

8.8 TIME & DATE

The TIME & DATE menu displays and allows you to change the time and date. See figure 23 for a photo of the menu. Time must be entered in 24-hour format. Once in the menu, pushing the data knob will allow you to edit the seconds value of the time. Clicking again takes you to the minutes value, once editing of the minutes is completed clicking once more takes you to the hours value. Click the data knob again after editing the time and the day of month can be change. Clicking again allows the month to be changed and one more click takes you to the year, which can then be edited. Clicking once after finishing the edits takes you back to the top left corner of the menu.

This is the last operational menu, the data knob must be turned counter-clockwise to scroll back through the menus previously described. Push in and hold the data knob to enter the default settings menus described below.

Figure 23: Photo of the TIME & DATE menu.

8.9 DE-ICING DEFAULTS

Enter the defaults menus by pressing and holding the data knob. Once inside a given menu, a single push of the knob will move the cursor between items that may be edited.

The DE-ICING DEFAULTS menu allows you to set the default state of the de-icing control (on or off) and the de-icing temperature set points (Deg C). This is the only menu allowing the de-icing temperature set points to be changed. See figure 24 for a photo of the menu. The temperature setpoints may be set for the front cone (Cone) and Pylon (Pylon).

Figure 24: Photo of the DE-ICING DEFAULTS menu.

For de-icing zone temperature set points between 0 and 5 deg C, the system will operate at 100% heater power. With insufficient airflow, for example on the ground, the

de-icing system can be damaged if operated with temperature set points between 0 and 5 C. For temperature set points of 6 C or higher, the software automatically limits the heater power to 30% of full power to avoid damage. We recommend setting the temperature set points no more than 10 C over ambient during de-icing heater tests.

Don't forget that the De-icing system Heater Breakers on the front panel of the electronics chassis must be pushed in (no white showing on breaker) in order to allow current to flow to the heaters. 28 volt DC power must also be applied in order to test the de-icing heaters.

8.10 FLOW DEFAULTS

The FLOW DEFAULTS menu is shown in figure 25. This menu allows users to set the default state of flow control (on/off) and the set points for the counter flow and total sample flows (lpm). Single knob pushes move the cursor between the items that can be edited.

Figure 25: Photo of the FLOW DEFAULTS menu.

The cut size and transmission efficiency studies of the CVI inlet have all been performed with a total sample flow of 15 lpm. We recommend always operating the system with a total sample flow of 15 lpm. The allowable range of sample flow rates is 6-15 lpm.

8.11 COUNTER FLOW HEATER DEFAULTS

The COUNTER FLOW HEATER DEFAULTS menu allows users to set the default state of the counter flow heater control ("Htr Control" on/off) and the counter flow heater temperature set point ("Cntr Htr SP", Deg C). Single knob pushes move the cursor between the items that can be edited.

A final parameter, "Cntr Press Cal", at the bottom of the menu is used to interpolate between the pressures measured by the mass flow controllers on the add flow and sample flow to best determine the pressure at the CVI tip. A value of 50 would indicate that a simple arithmetic average of the two pressure values produced the appropriate value for the tip pressure. Obtaining the correct tip pressure is important for accurate calculation of the volume flow at tip conditions. See the calibration section for details on how to properly set this value.

Figure 26: Photo of the COUNTER FLOW HEATER DEFAULTS menu.

The counter flow heater temperature set point should be kept below 50 deg C.

8.12 MISCELLANEOUS DEFAULTS

This menu is used to set the default SD Card Save setting and the sources for both the airspeed and Outside Air Temperature (OAT). If you require data to be saved to the SD Card, then the SD Card Save parameter should be set to 'ON', otherwise, set it to 'OFF'. The source choices for airspeed and OAT are "Int" (for internal or inlet) and "Ext" for externally supplied values via a serial communication connection. Use the data knob to select either "Int" or "Ext". The current airspeed and OAT values are also reported in the menu. The details of communicating airspeed and OAT values to the inlet are described elsewhere in this manual.

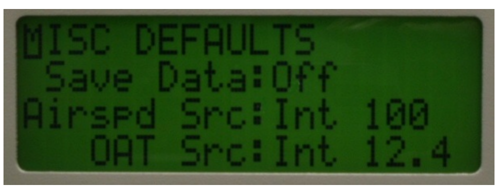


Figure 27: Photo of the MISCELLANEOUS DEFAULTS menu.

8.13 COM DEFAULTS

The COM DEFAULTS menu is used to set the serial communications parameters. The first line 'AutoR' is for Auto Report which can be set ON or OFF. Auto Report 'ON' produces a continuous 2 Hz 'read' report with all inlet readings over the serial port without sending any external commands. See tables below for details of the information reported when a ‘read’ command is sent to the inlet. ‘Labels’ ON is for Report Labels. Report Labels determines if the respective label for each parameter will be sent with the numeric value of the parameter (e.g. ‘add_flow=25.0’ , instead of just ‘25.0’). Report Labels OFF configures the data output so only numeric values are sent via the serial port. Refer to the tables below for a description of the various labels and parameters sent by the inlet software. Delimiter is the character sent between reported parameters. The Delimiter can be ”<CR>” for carriage return, ”TAB” to use the tab character and ”SPACE” to use a space character. If ”TAB” or ”SPACE” is selected as delimiter then all parameters from a ’read’ command will be reported in one row with a carriage return at the end. Note that it is the responsibility of the calling program to append the date and time to data obtained from the CVI serially.

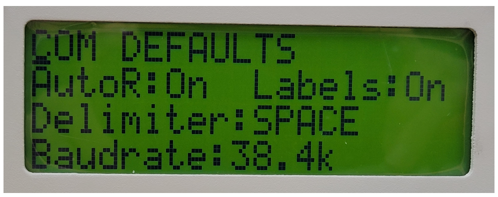


Figure 28: Photo of the COM DEFAULTS menu.

The Baud Rate for serial communications is also set in this menu. Acceptable values are 38.4K, 57.6K and 115.2K. The USB port is only used when the CVI inlet is deployed as part of a GCVI and for CVI firmware updates.

8.14 SENSOR HEATER DEFAULTS

The sensor heater menu is where users can view the readings of the on-board temperature controlled pressure sensors. The Heater Temperature should be maintained at a constant value of 40 deg C. There is nothing users can set in this menu. The menu displays the current temperature (Deg C) and the heater power level (0-200).

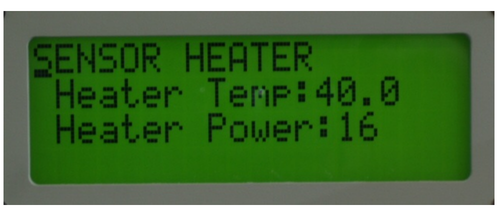


Figure 29: Photo of the SENSOR HEATER menu.

8.15 CALIBRATION

The CALIBRATION menu is used to set the various inlet calibration and operating parameters, display raw sensor readings, and read the measured pressure value for the pitot tube airspeed measurement. See figure 30 for a photo of the menu. The various parameters that may be set in this menu are described in table 6. Turning the data knob allows you to scroll through the various parameters to display currently set values. Note that the parameters with ‘raw’ in their name represent analog count readings from the microcontroller. These parameters are NOT settable but are used when sensors are recalibrated or calibrations are checked to provide the user with the raw sensor readings. The *pito_prs* parameter is provided to give a convenient reading of the analog count data converted to Pascals to facilitate calibrations, this is also NOT a settable parameter.

Sending the ’calib’ command via RS232 returns the first 7 items listed. Sending the ’raw’ command via RS232 returns the last 3 items listed in the table.

Note that although the built-in pitot-static probe to measure true air speed at the CVI inlet probe is obsolete, the differential pressure sensor used to read the pitot-static is still available inside the chassis to read a user-supplied pitot-static probe.

Figure 30: Photo of the CALIBRATION menu showing LFE flow slope parameter.

Table 6: Settable parameters via the CALIBRATION menu or by sending the 'calib' and 'raw' commands. Sending the 'calib' command via RS232 returns the first 7 items listed. Sending the 'raw' command via RS232 returns the last 3 items listed in the table.

Parameter	Description
	Responses to 'calib' Command
lfeslope=XXX	LFE calibration slope
lfeoffst=XXX	LFE calibration offset
lfecaltm=XXX	LFE temperature during calibration (Deg C)
pitoslop=XXX	Pitot differential pressure calibration slope
pitooffs=XXX	Pitot differential pressure calibration offset
pitspcal=XXXX	Pitot speed correction factor (1000=no correction)
cntrprcal=XXX	Counter flow CVI tip pressure correction factor
	Responses to 'raw' Command
lfe_raw=XXXX	raw reading from LFE differential pressure sensor
pito_raw=XXXX	pitot differential pressure, raw reading (0-4095)
pito_prs=XXXX	pitot differential pressure (pascals) used to calculate airspeed

8.16 MANUAL MFC CONTROL

The MANUAL MFC CONTROL menu is used to manually set the flow set points of the MFCs. When "Manual MFC control" is on, users can move the cursor under the add flow setpoint and the excess (XS) flow set point to manually adjust the set points. This is meant for testing and calibration only. For normal operation make sure "Manual MFC control" is off. The temperature display can be toggled to display pressure instead. This menu is also used to calibrate the CVI sample LFE. See figure 31 for a photo of the menu.

Figure 31: Photo of the MANUAL MFC CONTROL menu.

8.17 HEATER PARAMETERS

This menu allows users to fine tune the proportional and differential coefficients for the heater control algorithms. The coefficients for the cone, pylon and counter flow heaters are available for adjustment. "KP" denotes the proportional coefficient and "KD" denotes the differential coefficient for the PID control algorithm. IT IS NOT RECOMMENDED THAT THESE VALUES BE CHANGED.

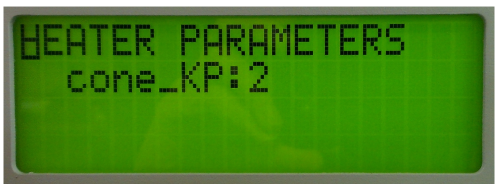


Figure 32: Photo of the HEATER PARAMETERS menu.

8.18 Serial Communication

There is one RS232 serial port used for bidirectional communication accessible via the chassis front panel. Therefore, output data are read from the inlet and serial commands are sent to the inlet using the same serial port. If an external computer will be used to record the 2 Hz output data from the inlet system, then the external computer should be connected directly to the inlet COM port using the provided RS232 data cable (not a crossover cable). The external computer can send commands to the inlet via the same COM port, the valid commands are listed in table 7. The required serial port configuration is described in table 8. All serial commands sent to the inlet return "OK" if the command is accepted or "ERR=Bad Param Name" or "ERR=Value Out of Range" if the command is rejected. Each command should be followed with a carriage return and/or line feed.

It is very important to realize that all numeric values (not parameter names) that are sent via RS232 to set parameters in the firmware must be sent in hexadecimal number

format. All values reported with a single decimal place must be multiplied by 10 before converting to hex and sending the value. Values reported with two decimal places (none for CVI inlet) must be multiplied by 100 before converting to hex and sending the value.

For example, to send an outside air temperature reading of 15.6 C to the inlet, first convert 15.6 to 156 by multiplying 10, and then convert 156 to hexadecimal (9c). The resulting command would be: **oatmpext=9c**.

Table 7: Description of the serial command syntax used to control various parameters of the CVI inlet system.

Command	Description
store	stores defaults and calibration coefficients in EEPROM
autorpt=X	[0=off, 1=on] controls automatic sending of read report every 0.5 seconds
rptlabel=X	[0=off, 1=on] controls whether or not report labels are sent along with values
ver	returns 'BMI CVI Inlet v2.0', the current software version
read	returns current readings (see table of response parameters below)
settings	returns current settings (see table of response parameters below)
time	returns HH:MM:SS (read only 24hour format)
date	returns YY/MM/DD (read only)
calib	returns calibration coefficients (see table 6 for response parameters)
raw	returns raw A/D readings (see table 6 for response parameters)
mfginfo	returns instrument manufacture information (see table of response parameters below)

Table 8: Description of external computer RS232 serial port configuration for proper communication with the inlet data acquisition system.

Parameter	Value
Baud Rate	38.4K, 57.6K or 115.2K
Data Bits	8
Parity	None
Stop Bits	1.0
Flow Control	None
Delimiters	CR (0xD), LF (0xA), space (0x20)

Table 9: Description of the list of response parameters generated by the 'read' command. The listed response parameters in this table cannot be sent as commands, and are only generated in response to the 'read' command.

Command	Description
cnt_flow= XXX	counter flow (lpm, addfFlow - sample flow)
cntflprs=XXXX	absolute pressure at counter flow (mbar)
cntfltmp=XX.X	counter flow temperature (deg C)
cnthtpwr=XXX	counter flow heater power (0-256=0-100%)
instflow=XX.X	instrument total sample flow (0-15 lpm)
tosmflow=XX.X	total sample flow (6-15 lpm)
lfe_flow=XX.X	sample flow at lfe local temperature and pressure (lpm)
lfe_temp=XX.X	lfe local temperature (deg C)
cut_size=XX.X	calculated droplet cut size diameter (micrometers)
airspeed=XX.X	airspeed (m/sec)
oat_temp=XX.X	outside air temperature from external source (deg C)
add_flow=XX.X	add flow rate (lpm)
addflwsp=XX.X	add flow setpoint (lpm)
addflwtm=XX.X	add flow temperature (deg C)
addflwpr=XX.X	add flow absolute pressure (mbar)
xs_flow=XX.X	excess sample flow (lpm)
xsflowsp=XX.X	excess sample flow setpoint (lpm)
xsflowtm=XX.X	excess sample flow temperature (deg C)
xsflowpr=XX.X	excess sample flow absolute pressure (mbar)
conetemp=XX.X	front cone temperature (deg C)
cone_pwr=XX.X	front cone heater power (0-100%)
pylontmp=XX.X	pylon temperature (deg C)
pylonpwr=XX.X	pylon heater power (0-100%)
sensrtmp=XX.X	sensor PC board temperature (deg C) [fixed setpoint=40.0 deg C]
sensrpwr=XX.X	heated sensors heater power (0-100%)
airspint=XX.X	airspeed from internal pitot static sensor (m/sec)
oatmpint=XX.X	outside air temperature from internal thermistor (deg C)

Table 10: Description of the list of response parameters generated by the 'settings' command. The listed response parameters in this table CAN be sent as commands, and are also generated in response to the 'settings' command.

Command	Description
savedata=X	save data to SD Card [0=off, 1=on]
flwcntrl=X	flow control setting [0=off, 1=on]
htrcntrl=X	counter flow heater control setting [0=off, 1=on]
de_icing=X	de-icing setting [0=off, 1=on]
conetmsp=XX.X	front cone temperature set point (deg C)
pylontmsp=XX.X	pylon temperature set point (deg C)
tosmflsp=XX.X	total sample flow setpoint (lpm)
oatmpsrc=X	Outside Air Temperature source [0=internal, 1=via RS232]
airspsrc=X	Airspeed source [0=internal pitot, 1=via RS232, 2=manual airspeed]
cntflwsp=X.X	counter flow setpoint (lpm)
cnttmpsp=XX.X	counter flow temperature setpoint (deg C)
oatmpext=XX.X	Outside Air Temperature external (-70.0 to 55.0 deg C) [via RS232]
airspext=XXX	Airspeed external (0-400 m/s) [via RS232]
sdcardst=AAA	SD Card Status [N/A=not available, OK=installed, ERR=
	SD Card has error] NOTE: 'sdcardst' is **NOT A COMMAND**

Table 11: Description of Time & Date commands.

Command	Description
time	returns HH:MM:SS (read only 24hour format)
clk_hr=HH	set new hour (write only 0-23)
clkmin=MM	set new minute (write only 0-59)
clksec=SS	set new second (write only 0-59)
date	returns YY/MM/DD (read only)
clk_yr=YY	set new year (write only 13-99)
clkmon=MM	set new month (write only 1-12)
clkday=DD	set new day (write only 1-31)

Table 12: Description of response to the 'mfginfo' command. Sending this command only returns values describing the manufacturing information of the inlet system, there are no settable parameters using this command.

Command	Description
firmware=vX.X	firmware version
sernum=XX	instrument serial number
mfg_yr=YY	year of manufacture
mfgmon=MM	month of manufacture (1-12)
mfgday=DD	day of manufacture (1-31)

8.19 Errors Reported by the Inlet System

There are numerous errors that may be reported by the inlet control system. A detailed listing of the errors are shown in table 14. These errors are reported serially as well. The format is:

ERROR: 'error message' CRLF

where in 'error message' the first line only is reported to the front panel while both lines of the error message are reported via RS232. Note that the 'Broken Thermistor' error is only checked at **startup** and occurs when an open circuit is detected, which corresponds to a measured temperature of -37.9 C. This error will not prevent the inlet system from running, but will report the error. If, at startup, the thermistors are actually operating at a temperature between -37.8 and -38.1 C, then the error may be invalid.

The program will continue to run if any error is reported. You must turn the data knob to clear the error in order to view the normal menus accessible during operation. If you cannot clear the error by turning the data knob contact BRECHTEL .

Table 13: List of errors reported by the inlet control system.

Error	Description
EEPROM ERROR:	Only occurs if there is a EEPROM read or write failure.
BAD Stored Value:	Only occurs at startup if one of the stored values
	is outside of its acceptable range.
Clock - Check time:	This occurs if the clock battery is dead or was removed.
Clock ERROR:	Only occurs if there is a clock read or write failure.
SD Card ERROR:	Occurs when there is a SD card failure.
SD Format not FAT32:	Occurs if the format is FAT16
SD Card Space ERROR:	Occurs when the SD card is full
De-Icing ERROR:	Occurs when T setpoint not reached
ADD MFC COM ERROR:	Occurs when communication with Add Flow MFC is lost
XS MFC COM ERROR:	Occurs when communication with XS Flow MFC is lost
ADD Flow ERROR:	Occurs when the Add Flow cannot maintain setpoint
XS Flow ERROR:	Occurs when the XS Flow cannot maintain setpoint
CONE Thermistor ERR:	Occurs when cone temp reading (around -38 deg C)
	which indicates a disconnected or broken thermistor.
PYLON Thermistr ERR:	Occurs when pylon temp reading (around -38 deg C)
	which indicates a disconnected or broken thermistor.
OAT Thermistor ERR:	Occurs when OAT temp reading (around -38 deg C)
	which indicates a disconnected or broken thermistor.
CNTR HTR Thrmstr ER:	Occurs when Cntr Htr temp reading (around -38 deg C)
	which indicates a disconnected or broken thermistor.
LFE Thermistor ERR:	Occurs when LFE temp reading (around -38 deg C)
	which indicates a disconnected or broken thermistor.
Cone De-Icing ERROR:	Cone de-ice heater cannot maintain temperature.
Pylon De-Icing ERR:	Pylon de-ice heater cannot maintain temperature.
CNTR HTR Temp ERROR:	Occurs when Cntr Htr cannot reach the temp setpoint

Table 14: Definition of error numbers reported in "err_rprt" value.

Error	Binary	Decimal
EEPROM ERROR	1b	1
BAD Stored Value	10b	2
Clock - Check time	100b	4
Clock ERROR	1000b	8
SD Card ERROR	1,0000b	16
SD Format not FAT32	10,0000b	32
SD Card Space ERROR	100,0000b	64
De-Icing ERROR	1000,0000b	128
ADD MFC COM ERROR	1,0000,0000b	256
XS MFC COM ERROR	10,0000,0000b	512
ADD Flow ERROR	100,0000,0000b	1,024
XS Flow ERROR	1000,0000,0000b	2,048
CONE Thermistor ERR	1,0000,0000,0000b	4,096
PYLON Thermistr ERR	10,0000,0000,0000b	8,192
OAT Thermistor ERR	100,0000,0000,0000b	16,384
CNTR HTR Thrmstr ER	1000,0000,0000,0000b	32,768
LFE Thermistor ERR	1,0000,0000,0000,0000b	65,536
Cone De-Icing ERROR	10,0000,0000,0000,0000b	131,072
Pylon De-Icing ERR	100,0000,0000,0000,0000b	262,144
CNTR HTR Temp ERROR	1000,0000,0000,0000,0000b	524,288

For example:

if err_rprt = 6144; First convert 6144 to binary; err_rprt = 1,1000,0000,0000b

```
    1000,0000,0000b = XS Flow ERROR
+ 1,0000,0000,0000b = CONE Thermistor ERR
-----------------
  1,1000,0000,0000b = err_rprt
```

8.20 SD Card output data file

If SD Card save is ON or OFF, a data file is created each time the SD Card is inserted. Data is only written to the file if SD Card save is ON. Header information is written every time a file is created. The file contains space-delimited engineering unit parameters from the various system transducers. At the top of each file are lines starting with "#" listing the calibration coefficients for each sensor used during the particular run cycle and the serial number of the inlet. The column headers describing each column of data are written to each file in a single row above the numeric data and the labels use the same naming convention shown in table 15. Delimited data with the same column format are also written out to the RS232 port at 2 Hz for recording by a host computer. Data are saved to the SD Card at 1 Hz. The RS232 port is accessed at the front panel of the electronics chassis. A detailed description of the columns in the data file is provided in table 15. Out-of-range engineering parameter values are reported as '*******' (a series of asterisks) in the data file. The format of data written out to the COM port is identical to that written to the output data file as described in table 15 except the frequency is 2 Hz and NO DATE and TIME STAMP is transmitted. The data file provides a convenient timeline of the inlet parameters that can be used when merging flow rate data with other simultaneous measurements by other instruments. **It is the user's responsibility to ensure that the inlet data system clock is synchronized with any other acquisition system clocks to facilitate data intercomparisons.** Note that volumetric flow rates are reported relative to local temperature and pressure conditions as measured by the system sensors.

The date and time are included in first and second columns, respectively, of the data file. Note that the time must use the 24 hour format. It is the user's responsibility in their calling program to append the correct DATE and TIME to each row of serial data read from the COM port. The various volume flow rates, heater temperatures and power levels, and temperatures are also reported. More detailed descriptions are provided in table 15.

It is highly recommended that the SD Card Save parameter be set to OFF before ejecting the SD Card or powering down the system.

Note that files cannot be deleted directly from the SD Card. The SD Card must be reformatted in FAT32 format to erase all files. Be sure to make copies of all files before reformatting the SD Card.

Table 15: Description of columns in the SD Card data file and the COM port output data. Note that reported air flow rates are at local pressure and temperature conditions. Data and Time are NOT reported via COM port.

Col	Parameter	Description
1	YY/MM/DD	Date
2	HR:MN:SC	Time in (24 hour format)
3	cnt_flow	Counter Flow at CVI Tip (lpm)
4	cntflprs	Counter Flow Pressure at CVI Tip (mbar)
5	cntfltmp	Counter Flow Temperature (deg C)
6	cnthtpwr	Counter Flow Heater Power (0-200)
7	instflow	Instrument Flow (lpm)
8	tosmflow	Total Sample Flow in CVI Body (lpm)
9	lfe_flow	Laminar Flow Element (LFE) Flow (lpm)
10	lfe_temp	LFE Temperature (deg C)
11	cut_size	Theoretical Droplet Cut Size (microns)
12	airspeed	Airspeed (m/s)
13	oat_temp	Outside Air Temperature (deg C)
14	add_flow	Add Flow Supplied by Add Flow MFC (lpm)
15	addflwsp	Add Flow Setpoint (lpm)
16	addflwtm	Add Flow Temperature at MFC (deg C)
17	addflwpr	Add Flow Pressure at MFC (mbar)
18	xs___flow	Excess Flow Supplied by Excess Flow MFC (lpm)
19	xsflowsp	Excess Flow Setpoint (lpm)
20	xsflowtm	Excess Flow Temperature at MFC (deg C)
21	xsflowpr	Excess Flow Pressure at MFC (mbar)
22	conetemp	CVI Cone De-icing Temperature (deg C)
23	cone_pwr	CVI Cone De-icing Power (0-200)
24	pylontmp	CVI pylon De-icing Temperature (deg C)

Table 16: (Table 15 Continued) Description of columns in the SD Card data file and the COM port output data. Note that reported air flow rates are at local pressure and temperature conditions.

Col	Parameter	Description
25	pylonpwr	CVI pylon De-icing Power (0-200)
26	sensrtmp	Temperature of Heated Pressure Sensors (should be 40deg C)
27	sensrpwr	Heater Power Level for Heated Pressure Sensors (0-200)
28	cntflwsp	Counter Flow Setpoint (lpm)
29	cnttmpsp	Counter Flow Temperature Setpoint (deg C)
30	tosmflsp	Total Sample Flow Setpoint (6-15 lpm)
31	conetmsp	CVI Cone De-icing Temperature Setpoint (deg C)
32	pylntmsp	CVI Pylon De-icing Temperature Setpoint (deg C)
33	airspsrc	Airspeed Source (Int=Internal, Ext=Externally Supplied via RS232)
34	oatmpsrc	Outside Air Temperature Source (Int=Internal, Ext=Externally Supplied via RS232)
35	flwcntrl	Flow Control Setting (On/Off)
36	htrcntrl	Counter Flow Heater Control Setting (On/Off)
37	de_icing	De-icing Control Setting (On/Off)
38	manl_mfc	Manual Control of MFCs (On/Off)
39	err_rprt	ERROR Report Value [see ERROR Reporting Section for details]
40	savedata	Save Data to SD Card: (Yes/No) [only in laptop data files]

8.21 RS-232 Output Data Format

For applications where the recorded inlet data will be saved by a remote host computer, the control software provides the current inlet parameter values from the RS-232 serial port of the inlet chassis. The **space** or **tab** delimited engineering parameters are written at 2 Hz (with Auto Report feature ON) to the serial port using the same format described in tables 15 and 16 except that NO DATE and TIME STAMP data are transmitted. It is the user's responsibility to add the appropriate date and time stamp to each of transmitted data. Data and end-of-row delimiters may be set by the user in the defaults menu. The description of the various data columns within the written string is provided in table 15. The format of the column data follows exactly that for the data file written to the SD Card except for the lack of DATE and TIME columns.

9 Maintenance

Regular maintenance of the CVI inlet includes:

1. replace filters in Add Flow line and Sample XS line once every 2 years,
2. replace filters in dry air system once every 2 years,
3. replace inlet filter on vacuum pump once every 2 years,
4. validate sensor calibrations once per year, re-calibrate if spot-check value is greater than 3% different from expected value,
5. methanol wipe outer shroud and probe covers at beginning and end of each field study,
6. check tightness of probe mounting flange bolts and probe cover shroud bolts twice per year,
7. check tightness of all fittings and tube connections at beginning and end of each field study,
8. validate de-icing heater zone heating at beginning of each field study,
9. clean and sonicate CVI tip assembly (porous tube) before each field study and whenever particle breakthrough is observed at low counter flow rates,
10. clean and grease CVI tip assembly O-ring once per year,
11. validate that the inlet manifold is particle leak free at beginning of each field study or whenever manifold has been changed/disassembled,
12. archive and remove old inlet data files from SD card once per year,
13. open top of electronics chassis (with power off) and remove any accumulated dust once per year (use anti-static discharge procedures to prevent damage to electronics),
14. with chassis open, verify tightness of various board connections, air flow fittings and visually inspect components for proper tightness and connector engagement.

Maintenance tasks may need to be performed more frequently if the inlet is exposed to high aerosol mass loadings or other sampling conditions that foul components.

9.1 Cleaning the CVI Tip Assembly

In general, the CVI tip assembly should only need to be cleaned once before each field study or whenever it has been exposed to high aerosol loadings and is clearly dirty. It is convenient to have a spare CVI tip assembly that can be installed while the original assembly is cleaned overnight.

Do NOT use paper wipes as they leave fiber debris behind.

To remove and service the CVI tip assembly follow these steps:

1. Loosen and remove the 3 bolts and 3 washers (Fig. 33) holding the large, rear cone cover assembly to the shroud cover assembly. Note that the rear cone deice heater is attached to the inside of the cone cover, take care to not stress wires.

Figure 33: Photo of the location of bolts holding the CVI cone cover to shroud cover.

2. Carefully and slowly slide the cover off by pulling it forward, once wires are exposed, be sure to pull by the wires and not by the cover itself. Once clear of the CVI tip, allow the cover to dangle from the inlet by the extended wires. Take care not to pull the wires tight that attach the cover to the remainder of the inlet. If the wires do not move freely, see the next step. Store bolts and washers in a secure location.
3. If the CVI cone cover wires are too tight and prevent the cover from sliding over the tip, then the pylon cover will need to be removed to access and loosen or "push" the wires from the pylon side. The pylon cover is a single, welded assembly, so bolts from BOTH sides must be removed so the cover can be slid back

away from the cones. Remove the pylon cover to gain access to the wiring inside the shroud. THIS SHOULD ONLY BE REQUIRED UNDER UNIQUE CONDITIONS. In almost all cases the cone cover should slide off without stressing the heater wires.

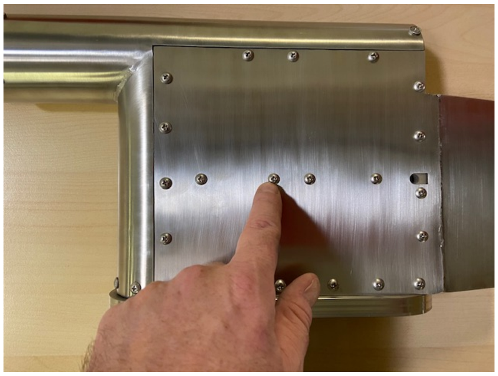


Figure 34: Photo of the bolts to remove to take off pylon cover.

4. If the pylon cover was removed, push on the wires attached to the cone cover from inside the pylon so the cone cover can be slid over the tip. Connectors do not need to be disconnected.
5. Once the CVI tip is exposed, use TWO wrenches, one on the flat surfaces of the stainless steel tip assembly and the second on the aluminum tube the tip screws into to loosen the tip assembly from the aluminum tube. **DO NOT ALLOW THE ALUMINUM TUBE TO ROTATE OR YOU WILL BREAK THE ADD FLOW THERMISTOR.**
6. Once loose, unscrew the tip assembly from the probe by hand, taking care to catch the O-ring inside if it falls as the tip assembly is pulled away from the probe. A six inch tube is attached to the tip on the inside, be sure to pull straight out from the probe to avoid bending the tube.
7. Visually verify the sealing O-ring for the tip assembly is present in the aluminum tube. It may also be on the tip assembly.
8. If the CVI tip assembly is dropped, contact BRECHTEL for assistance.
9. Carefully move the CVI tip assembly away from the inlet tube and place in a clean work space or store in the plastic housing shipped with spare tip assembly.

10. Install the spare CVI tip assembly, if available.
11. Clean the CVI tip assembly by sonicating in IPA for several hours and then clean distilled water for several hours.
12. Allow the tip assembly to dry, or use HEPA-filtered compressed air (5 psig) to gently blow clean dry air on the assembly. Do not blow high pressure air directly into the tip assembly. Only a low flow rate of dry air should be used.
13. Re-install the cleaned tip assembly when the spare tip assembly requires cleaning.
14. Before re-installing the cone cover, carefully wipe away any dirt from the cone cover inside surface that mates with the stainless steel probe cover. Wipe dirt away from the stainless steel probe cover end that mates with the cone cover and apply a thin film of o-ring grease to the area that makes contact with the cone cover.
15. Carefully slide the cone cover over the tip assembly, tucking the wires into the space inside the inlet.
16. Replace the pylon cover if it was removed.

9.2 Cleaning the Sample LFE Assembly

It is recommended that the LFE assembly be cleaned once every year or before each field campaign. Follow the procedure below.

1. Remove power from system
2. Disconnect two silicon tubes from LFE barbs
3. Disconnect LFE thermistor from chassis front panel
4. Loosen compression fitting nuts on both ends of LFE, take care not to lose the mixing orifice on the downstream side of the LFE
5. Fill the LFE with IPA and sonicate in vertical orientation for 4 hours (use a zip loc bag filled with IPA)

6. Drain IPA, blow dry, fill with distilled water and sonicate in vertical orientation for 4 hours (use a zip loc bag filled with water)
7. Drain water, blow dry, confirm air flows from both hosebarbs
8. Re-attach compression fittings, tubing, wire connections
9. Test flow control, verify LFE flow reading with independent flow meter

10 Troubleshooting

Table 17: Common Troubleshooting Solutions

Problem	Likely Cause	Solution
Will not power on	No 28VDC	Check aircraft 28VDC source
	No 28VDC	Check aircraft circuit breaker
	Display failure	Replace display
	No power to PC board	Contact BMI
Heaters don't heat	Breakers pulled out	Push in breakers
	Breaker failure	Replace breaker
	No 28VDC	Check aircraft 28VDC source
	Solid state relay failure	Replace relay
	Interlock failure	Replace interlock
	Overheat condition	Remove power
Flow not at setpoint	MFC failure	Replace MFC
	LFE thermistor failure	Repair/replace thermistor
	LFE diff Pressure sensor failure	Contact BMI
	LFE clogged	Unclog LFE
	Vacuum pump failure	Replace pump
	Dry air system failure	Replace dry air system
	Aircraft erratic altitude	Fly straight and steady
High Particle Counts	Dirty Tip	Clean Tip
	Counter flow too low	Increase counter flow
	Poor flow control	See "Flow not at setpoint"
	Droplet shatter	Sample smaller droplets
Cntr Flow Temp erratic	Thermistor failed	Replace thermistor
	Poor add flow heater control	Contact BMI
	Poor electrical ground	Improve grounding

A CVI Inlet Details

The customer should verify that the inlet position on the platform is not influenced by any upstream components (including propeller wash or engine exhaust). Free stream turbulence intensity measurements just upstream of the cone assembly during sampling may be used to determine if propeller wash or some other factor influences the air sampled by the inlet.

A.1 De-Icing System

The inlet components outside the aircraft may be exposed to icing conditions which can clog the tip and prevent particles and flow from passing into the probe. To help prevent this, heaters are installed on the inside surface of the front of the pylon as well as the inside surface of the front cone cover. All components with frontal area to the ambient air flow are actively heated to help prevent ice build up. Temperature sensors are used to monitor temperatures and the control software varies the 28 volt DC power supplied to the heaters to maintain a user-settable temperature. An over-temperature interlock switch is installed to prevent the heater power from remaining on in an uncontrolled state, for example, if the data acquisition system freezes in a state where power is continuously applied to the heaters. The interlock opens at 70 C and disconnects the digital control signal to the solid state relay that provides power to a given set of heaters. *The actual heater power does not pass through the interlock switch, only the digital control signal energizing the solid state relay passes through the interlock switch.* With this design, if the control system malfunctions leaving the digital control signals energized, when the heaters drive the temperature to 70 C, the interlock will open and cause the solid state relay to remove power from the heater. When the temperature decreases below roughly 60 C, the interlock switch closes automatically, resulting in power being reapplied to the heaters. This cycle will continue until power is removed from the system.

BMI DOES NOT GUARANTEE THAT THE INLET SYSTEM WILL BE DE-ICED UNDER ALL SAMPLING CONDITIONS - IT IS THE USER'S RESPONSIBILITY TO ENSURE THAT POTENTIALLY DAMAGING ICE BUILD UP DOES NOT OCCUR ON THE INLET COMPONENTS. BMI ACCEPTS NO RESPONSIBILITY FOR ANY DAMAGE THAT MAY OCCUR DUE TO ICE BUILD

UP ON THE INLET.

The key components requiring de-icing are the front cone and the forward-facing surface of the pylon shroud. The de-icing system is divided into two heating zones: the first zone is comprised of the front cone cover, the second zone includes the pylon shroud. The heaters and therefore temperature of each of these zones is independently controlled by separate digital control channels that open and close solid state relays to apply 28 VDC power to heaters in each zone. Each heating zone employs a silicon heater and a thermistor is used to measure the zone temperature. The control software reads the current temperatures of the zones and, if the value is less than the user set temperature setpoint, power is applied to the appropriate heaters. Tests of the de-icing heaters in the BMI wind tunnel have verified that a 50 C temperature rise could be controlled at air speeds of 112 m/s, an ambient temperature of 20 C, and a static pressure of 980 mb.

The de-icing system power may be turned on and off through the control software or by opening the circuit breakers on the front panel of the chassis. It is the user's responsibility to verify that the de-icing heater system is activated when needed. The temperature set-points of three heating zones cannot be set to arbitrarily high values, the maximum value is locked out by the software. This limit on the maximum set-point temperature is used to prevent over-heating and damage to the de-icing system.

For de-icing zone temperature setpoints between 0 and 5 C, the system will operate at 100% heater power. With insufficient airflow, for example on the ground, the de-icing system can be damaged if operated with temperature setpoints between 0 and 5 C. For temperature setpoints of 6 C or higher, the software automatically limits the heater power to 30% of full power to avoid damage. We recommend setting the temperature setpoints no more than 10 C over ambient during de-icing heater tests on the ground.

A.2 Flow Control Validation

BMI has tested the flow control accuracy and precision of the inlet system by exposing it to simulated ambient true air speeds in a wind tunnel and verifying that the control software properly adjusts the various flow rates. The results from testing the inlet system show good agreement between the measured and set point flow rates for various true air speeds.

A.3 Updating the firmware

Follow these steps to update your product firmware when instructed to do so by the factory or your regional technical representative:

- Download the microprocessor programming tool to your Windows-based computer (this software may also have shipped on the USB stick with your product): "Setup-Propeller-Tool-v1.3.2.exe"
- Install the microprocessor programming tool on your computer by double clicking on "Setup-Propeller-Tool-v1.3.2.exe".
- Connect the mini-USB port on your product to a USB port on your computer using the supplied USB cable.
- Turn the power on to your product.
- Confirm that you have a copy of a recent data file from your product listing the calibration coefficients (you should not need to re-enter the calibration coefficients after updating the firmware but it is a good idea to have them).
- The large red program/data switch is located on the chassis rear panel. Push the button IN to allow the firmware to be updated. When the update is complete, be sure to push the button OUT again. The firmware will NOT update if the button is in the wrong position.
- Run the installed microprocessor programming tool created by the software installation: "Propeller.exe".
- Click "File->Open" and navigate to the new firmware version eeprom file "CVI Inlet - vX.X.eeprom" supplied by BRECHTEL that has been saved to your computer. Note that firmware version 2.0(OldMFC) is the most current version for CVI Inlets SN's 001 to 015. Later versions of firmware (2.0(NewMFC)) can only be loaded on CVI Inlet SN's 016 and later, or on older CVI's that have newer Mass Flow Controllers.
- Open the file.
- This will bring up the "Object Info" window. Click on the "Load EEPROM" button near the bottom of the window.

- Confirm no errors during installation and that the firmware update runs with a successful message window when completed.
- Push the red button on the rear panel back to the data position (push button so it is OUT).

Navigate to the DEFAULTS CALIBRATION menu and confirm the correct calibration coefficients are entered for your CVI.