VENTBUSTER INSTRUMENTS

TECHNICAL WHITE PAPER

A SCIENTIFIC ADVANCEMENT IN POINT-SOURCE EMISSIONS MONITORING

Ventbusters Instruments Inc. progresses the oil and gas industry through exceptional engineering and cutting-edge technologies, enabling the industry to reduce its methane emissions.

The Ventbuster® is a ground-breaking technological advancement in point-source emissions testing and monitoring. Never has the energy industry been able to accurately, intuitively, and continuously measure, monitor, and record venting methane emissions with such precision. We have filled this technology gap.

Ventbuster Instruments Inc. is committed to furthering the knowledge and methodology around point-source emission monitoring, ensuring the protection of our land, our groundwater, and the air we breathe.

NOVEMBER 2022

Section 1: The Ventbuster® Vent Gas Metering Device

1.1 Overview:

The Ventbuster® is a two-piece instrument intended to measure gas flow rates, flowing pressures, flowing temperatures and shut-in pressures of venting gases to the atmosphere from surface casing vent assemblies as per the requirements established in Alberta Energy Regulator's Directives 020 and 087. The Ventbuster® consists of a vent mounted sensing head, and a control or communication unit. The device logs data both locally on the device and remotely to an IoT cloud platform and measures flow from 0.04 ml/min to 720 m3/day (25.4 mcfd), in ambient conditions between -40°C to +55°C (-40°F to +130°F). The Ventbuster® is pressure rated up to 7000 kPag (1000 psig).

The patented Ventbuster® has since been deployed onto numerous other testing scenarios where precision measurement and monitoring of venting gas emissions are critical.

1.2 Principle of Operation:

The Ventbuster® flow sensor technology operates based on a novel and cutting-edge advancement of the principles behind the science of thermal mass flow, as per Figure 1.1.

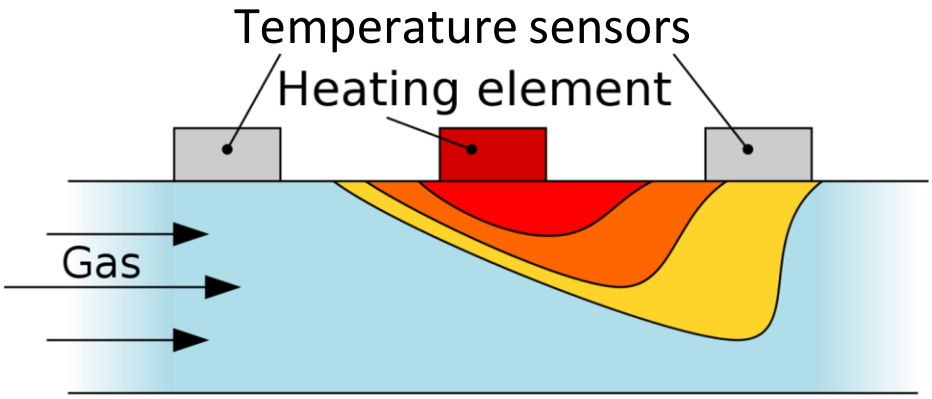

Figure 1.1: Thermal Mass Flow sensor

Thermal mass flow sensors are based on a variation of the heat transfer coefficient, which is a function of the flow speed. Thermal mass flow sensors utilize heat transfer principles to determine the flow velocity of a medium. Flow speed changes the thermal energy loss by the heater as a medium, passes across the sensor, heat is carried from the sensor to the medium. As flow increases, so does the amount of heat that is transferred, meaning an increase in flow speed results in a higher cooling. This effect leads to a heat transfer coefficient change. Hence, cooling is a function of the mass flow.

By adapting controllers, a constant temperature difference between the heater and the temperature sensor can be achieved. This measuring principle is called Constant Temperature Anemometer (CTA). The supplied electrical power, which controls the temperature difference, is a function of the flow speed.

The power is converted into a voltage output signal with a bridge circuit and can be easily read. Knowing the temperature of the medium, the flow rate can be determined from the amount of voltage compensation needed to maintain a constant temperature differential.

The Ventbuster® innovation of design takes this proven scientific principle and advances it beyond any existing gas metering technology for unprecedented accuracy and reliability.

For pressure sensing, the Ventbuster® uses a piezoresistive based pressure sensor and sampling electronics to interpret pressure measurements. The shut-in pressure is recorded using the raw data for pressure logging throughout the period. The Horner method is used to extrapolate the shut-in pressure of the vent system when there are long periods of time needed to achieve a stabilized shut-in pressure.

1.3 Design Features of the Ventbuster®:

The Ventbuster® was designed to provide the following capabilities:

- Real time, automated monitoring and recording of vent gas emission rates, flowing temperatures, flowing pressures and shut-in pressures.
- Transmits all recorded measurements via mobility to a secure cloud based IoT Platform, enabling clients 24/7 private and secure access to live and historical data.
- By logging into the internet web portal, the user can observe output readings and graphical presentation of the ongoing monitoring in real time and the ability to download archived testing results in CSV Data and PDF formatted reports.
- Lightweight and highly portable for mobile testing and remote location deployment.
- Intrinsically safe with Class 1 Zone 0 Group IIB T3 Hazardous Area Certification.
- Equipped with Radio Frequency (RF) Safe functionality to disable all mobility and Bluetooth transmitting frequencies.
- IP 54 Ingress Protection.
- An expansive dynamic range or turndown ratio of flow measurement.
- Two range settings are incorporated into the device:
    - A high flow range: 0.60 m3/day to 720 m3/day (22 cfd to 25.4 mcfd)
    - A low flow range: 0.04 ml/min to 0.80 m3/day (0.002 cfd to 28.3 cfd)
- Operating temperature range between -40°C to +55°C (-40°F to +130°F).
- Operating pressure rating up to 7000 kPag (1000 psig).
- Automatic zeroing function by the Communications Unit to reset for varying atmospheric conditions.
- Shut-in valving and pressure relief safety burst disk.
- On board GPS for location verification.
- Bluetooth® enabled with Ventbuster® APP from an Android™ device for operator interface on site and enabling remote downloading of data to a supplied Android™ tablet.
- On-board LCD on the Comms Unit for current status and measurement results display.
- On-board keypad on the Comms Unit with status LEDs for analyzer control and information display.
- Equipped with self-sustaining 12V 100mA, solar power source to enable long duration measurement and monitoring.

1.4 Operating System Control:

The Ventbuster® is controlled by a dedicated data acquisition system which provides supervisory control, performs all calculations and provides a user interface. The Ventbuster® Control or Communications Unit includes an onboard computer system which provides full screen display of the various parameters, including flow rate, flow and shut-in pressures, and temperatures, as selected by the user, along with alarms, monitoring conditions and other status measurements.

A keypad is provided on the front panel of the Ventbuster® Communications Unit for an intuitive user interface with the Ventbuster® Measurement Unit. Operation of the system with the keypad or alternatively with the Bluetooth® based Android™ APP are used to enter testing parameters, information details, and download stored data when in a remote testing location.

Section 2: The Ventbuster® Components

2.1 Overview:

The Ventbuster® System is a modular instrument consisting of a "Control or Communications Unit" (Comms Unit) and "Sensor Head or Meter" (Vent Unit). Both Units are connected together via a signal and power cable with the Vent Unit mounted directly in-line to a gas vent assembly for point-source quantification and the Comms Unit situated outside the hazardous area in the safe zone, commonly referred to as the general-purpose area. The Vent Unit is certified and designed for installation into a Class 1 Zone 0 Group IIB T3 Hazardous Area environment; where explosive gasses are typically present. An intrinsically safe barrier is incorporated into the Comms Unit which protects the Vent Unit. An overview of the system is shown in figure 2.1.

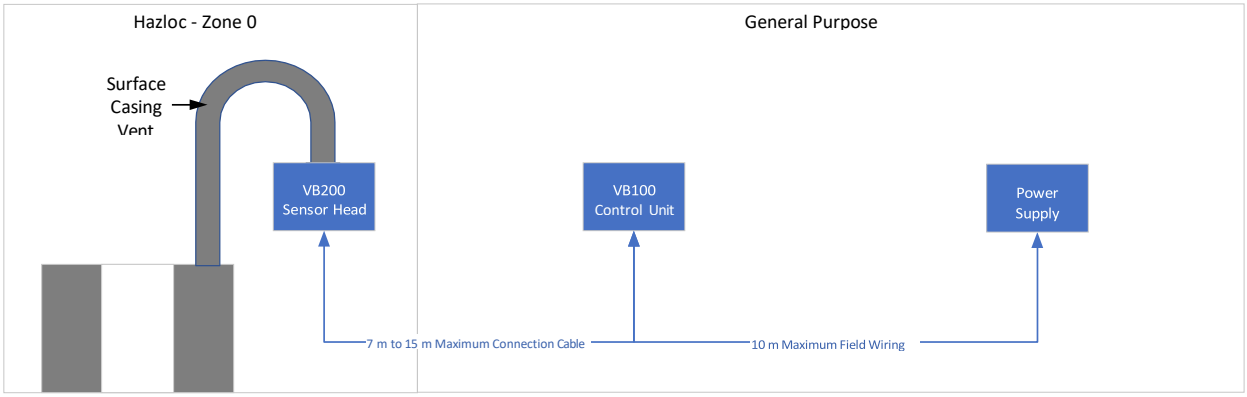

Figure 2.1 Block diagram of the Ventbuster® Unit

- ***NOTE:*** *an external battery is normally connected to the control unit for extended field testing and monitoring timelines. A unitized battery box is supplied with every Ventbuster® kit, that meets all standards requirements for this oil and gas field application.*

2.2 Ventbuster® Vent Unit:

The Ventbuster® Sensor Head or Vent Unit, houses the pressure and temperature sensors, the flow sensor, and valves for the flow and shut-in modes along with a high to low flow range valve range selection.

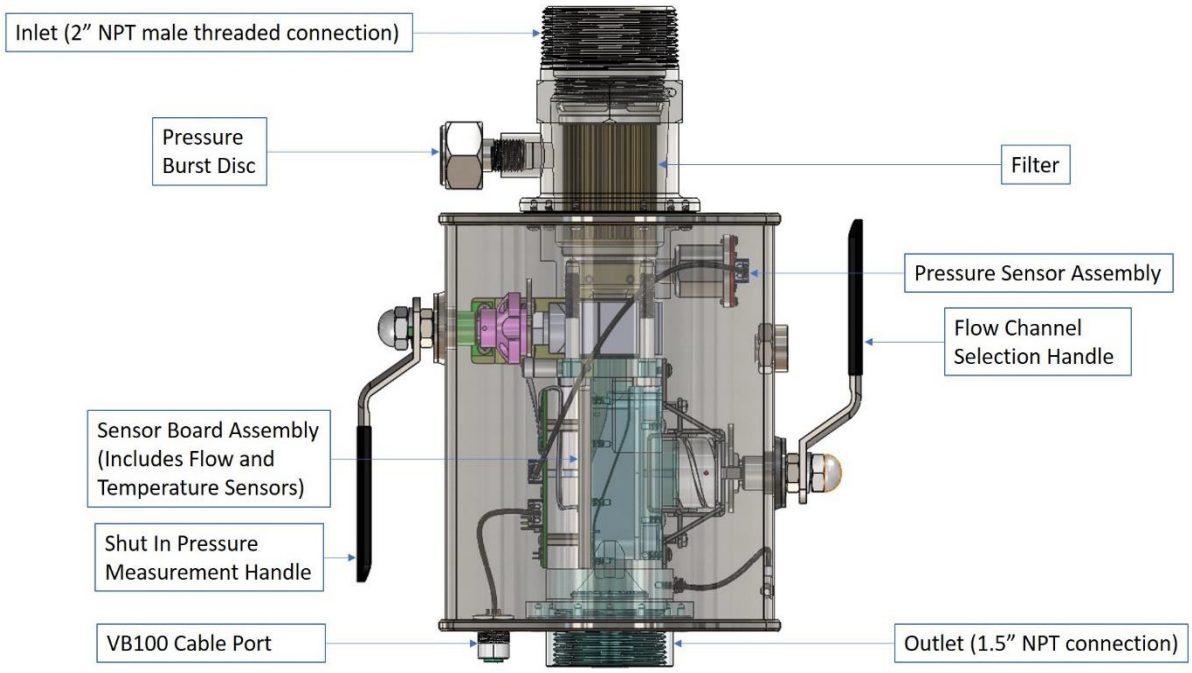

Figure 2.2 Ventbuster® Vent Unit Flow Mode Selection Handle

The flow mode selection handle can move through 180º of travel and is intended to be either operated in a fully high flow mode or fully low flow mode positions.

NOTICE

Operating the Ventbuster® flow mode selection handle in intermediate positions will invalidate calibration and any associated flow testing results.

The flow mode handle has sensors incorporated into the Vent Unit to detect fully activated positioning over the travel range of the valve stem. Again, the flow mode handle must be opened fully to the high flow or low flow positioning at 180º from each other. The Comms Unit will indicate whether the unit is configured for high flow or low flow mode. This status is relayed to the Ventbuster® IoT platform and displayed in real time on the Ventbuster® Dashboard.

Flow and Shut-in Selection Handle

The shut-in pressure measurement valve handle moves through a 90° rotation from fully opened to fully closed and is used to open the flow through the flow channel for flow rate measurement and monitoring or to close the Vent Unit in to initiate shut-in pressure measurements. The flow/shut-in handle has sensors incorporated into the Vent Unit to detect fully activated positioning over the travel range of the valve stem. The Comms Unit will indicate whether the unit is configured for flowing or shut-in mode. This status is relayed to the Ventbuster® IoT platform and displayed in real time on the Ventbuster® Dashboard.

NOTICE ***Operating the Ventbuster® flow and shut-in selection handle in intermediate positions will invalidate calibration and invalidate any flow or shut-in pressure testing results.***

Process Inlet and Outlet Connections

The Ventbuster® Vent Unit was designed to be attached to the outlet connection of a typical SCV assembly, affixed to an oil and gas wellhead having a 50.8 mm (2") NPT female thread connection. The Ventbuster® kit comes equipped with a 50.8 mm (2") NPT male thread adaptor fitting and quick connect, for easy deployment of the Vent Unit onto the SCV assembly point-source. The outlet connection of the Ventbuster® Vent Unit is a 38.1 mm (1.5") NPT female connection that can be fitted with an adapter for gas sampling equipment.

NOTICE **The outlet must always remain open and unrestricted to ambient or atmospheric conditions while in the flowing mode.**

Ventbuster® Vent Unit and Comms Unit Cable Ports

The Ventbuster® Vent Unit and Comms Unit Cable Ports facilitate the connection of the data and power source interface cable between each Unit. This cable provides an intrinsically safe connection for power and data between the Zone 0 hazardous area to which the Vent Unit is located and the general-purpose area to which the Comms Unit is located.

2.3 Ventbuster® Comms Unit:

The Ventbuster® Comms Unit includes the communications, power distribution, and hazardous area safety barriers required to retrieve data from the Ventbuster® Vent Unit and transmits data over the mobility network to an IoT cloud-based data acquisition and storage system. If mobility coverage is not available, the Comms Unit has the ability to store the data which can be downloaded to an Android™ device on site or transmit to the to the IoT database when brought into a mobility service area. The system uses MODBUS to transmit data and secure cellular communications to send data to the IoT platform. The Comms Unit is a SMART device with a Bluetooth® user interface, a keypad, LCD display, and Android™ tablet APP. The Comms Unit is also equipped with an internal rechargeable battery for standalone operation without the requirement for auxiliary power. This battery is not user serviceable.

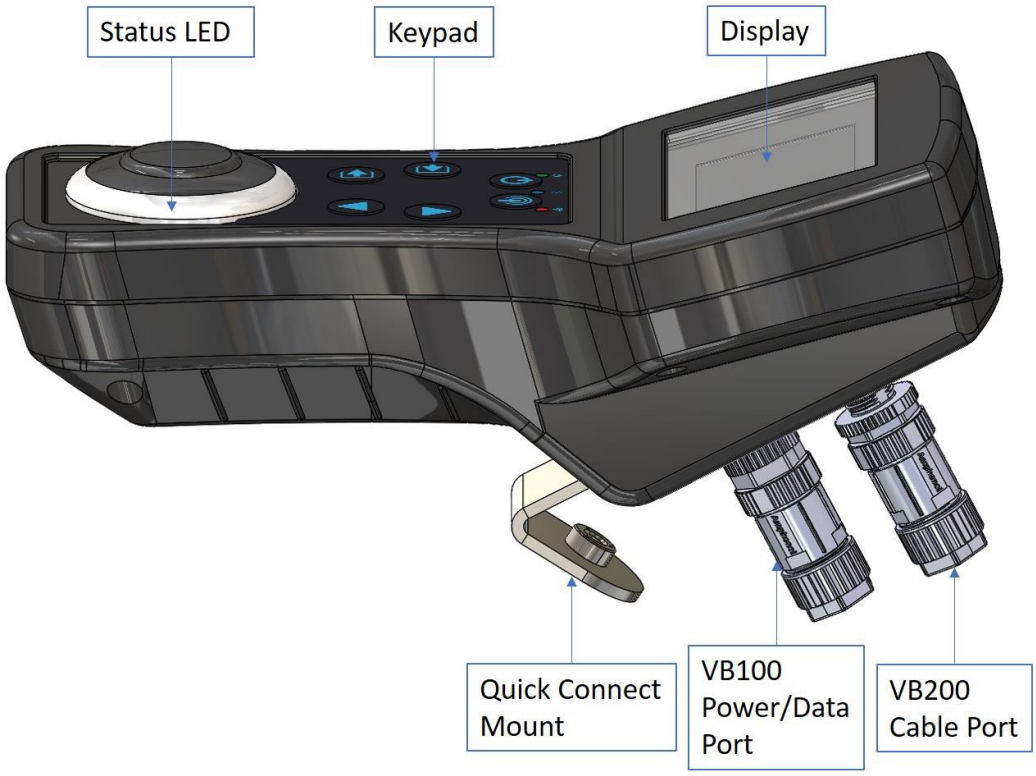

Figure 2.3 Ventbuster® Comms Unit

Figure 2.4 Ventbuster® Comms Unit Keypad and Display

Comms Unit Keypad and Display

The Comms Unit keypad and display are the main user interfaces for the Ventbuster® System. The display identifies key system parameters and identifies any user prompts, and the keypad includes standard Up/Down, Enter/Escape button architecture plus, Bluetooth® connectivity status, RF mode Arm/Disable button status, and a power button with power status.

Comms Unit LED Status Bezel

The status LED ring is used to convey the data messaging transmission status on device, status of the electronics functionality and overall operation to the user.

Ventbuster® Vent Unit Port and Cable

The Vent Unit cable port on the back of the Comms Unit connects both Units together through the provided intrinsically safe power/data cable. The connection cable is a 6.0 mm diameter cord that carries power to the Vent Unit from the Comms Unit and data signals from the Vent Unit back to the Comms Unit. The maximum length of this cable is either 7 or 15 metres in order to comply with hazardous area rules.

The connector is a thread style cable which must be fully threaded into the mating connector.

NOTICE

The Connection Cable is not a user replaceable or serviceable part. Please contact Ventbuster Instruments if a replacement is required.

Ventbuster® Comms Unit Power/Data Port

The Comms Unit Power/Data Port connects the Comms Unit to supplied/plant power or the Ventbuster® Auxiliary Solar Power Battery Unit. This cable also facilitates any requirement for SCADA connectivity.

The connector is a thread style cable which must be fully threaded into the mating connector.

The auxiliary power supply for the system must have a converter providing 100mA @ 12VDC. Alternate options for power supplies include plant power or the included Ventbuster® Auxiliary Solar Power Battery Unit.

The Ventbuster® Comms Unit can be powered by 12 VDC sources. The power requirement is 12 watts.

⚠WARNING

Use only CSA certified SELV/PELV power supply 30V MAX. Contact the manufacturer if more information is required when selecting power supply.

Ventbuster® Tripod Mounting Connection

The Comms Unit has a 6.35 mm (1/4”) x 20 threaded aperture to facilitate the included tripod mounting with the attachment of a standard threaded aperture connection.

Figure 2.5 Ventbuster® Comms Unit Tripod Mount

Section 3: Ventbuster® System Installation Requirements

The Ventbuster® System comes shipped to the user in a portable carrying case along with a tripod and auxiliary solar battery unit, for easy transportation and storage.

3.1 Precautions with Installing the Ventbuster® Vent Unit:

The Vent Unit is a gas metering device and is designed for installation onto dry gas emission vent assemblies. If it is anticipated that there will be free water or other liquids contained within the vent gas stream, please consult Ventbuster Instruments for suitable upstream liquid knockout requirements or options.

DO NOT FLOW WATER, OIL OR OTHER LIQUID THROUGH THE FLOW CHAMBER.

The Vent Unit is designed for sweet gas point-source quantification, monitoring and reporting.

DO NOT EXPOSE THE VENT UNIT TO H_2S OR WET CO_2.

3.2 Flow Orientation of the Ventbuster® Vent Unit:

The Vent Unit can be installed horizontally, or vertically is should NOT be installed at other angles. it is very important that the sensor is installed as indicated in Figure 3.1. The outlet should be directed downwards to prevent water or other contaminants entering the device.

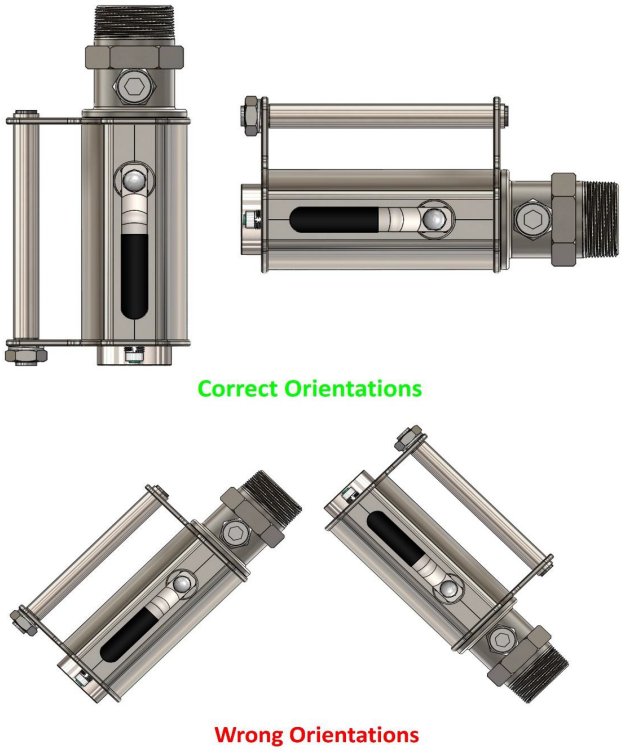

Figure 3.1 Handling the Ventbuster® Vent Unit

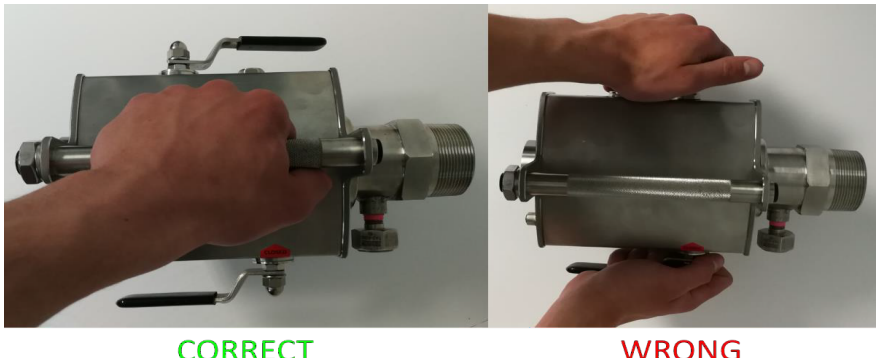

Figure 3.2 Handling the Ventbuster® Vent Unit

NOTICE

When handling the Vent Unit DO NOT under any circumstances lift the Unit by the valve handles. This may cause irreparable damage to the internal components. Lift using the integrated handle only. Refer to Figure 3.2.

3.3 Installation of the Ventbuster® System:

The Ventbuster® System is designed for quick installation, intuitive test start and stop procedures and Bluetooth® interface for inputting testing parameters and live monitoring of the ongoing emissions flow and/or shut-in pressure build-up testing.

For the step by step detailed information and procedures to install the Ventbuster® Unit, initiate a test, stop a test, interfacing with the Ventbuster® Comms Unit and to troubleshoot any installation difficulties, refer to:

Ventbuster® Field User Guide, Ventbuster® Quick-Start Checklist,

On-line Ventbuster "How To" Videos Available on YouTube

Both the Field User Guide and Quick-Start Checklist are contained within the Ventbuster® Unit Kit and have also been downloaded onto the included Android™ Tablet.

3.3.1 Spacing Requirements of the Vent Unit:

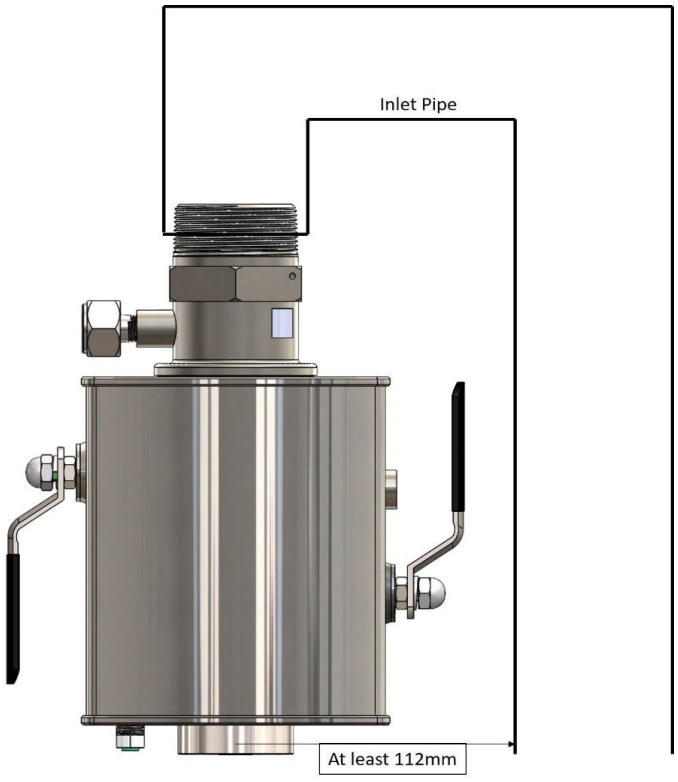

Figure 3.3 Side View of the Ventbuster® Vent Unit Installation Space Requirements Relative to a Typical Surface Casing Vent Assembly

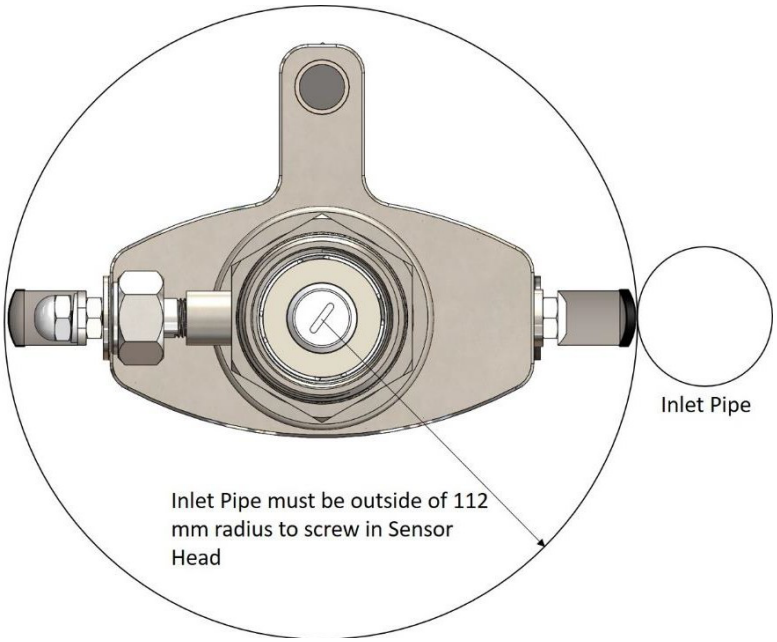

Figure 3.4 Top View of the Ventbuster® Vent Unit Installation Space Requirements Relative to a Typical Surface Casing Vent Assembly

3.3.2 Installation Requirements of the Vent Unit:

Once a suitable location has been chosen for the installation of the Vent Unit, it should be installed onto a 50.8 mm (2") NPT threaded mount or swage adaptor. Typically, the Vent Unit is installed using the included quick connect mounting hardware, depending on the specific user requirements.

With installation onto a typical surface casing vent assembly, use the included quick connect mounting hardware and first install the 50.8 mm (2") NPT male thread adapter fitting with quick connect hardware onto the 50.8 mm female thread connection of the vent assembly. Follow the instructions of the Ventbuster® Field User Guide.

⚠WARNING

Use only the designed and approved quick connect hardware contained within the Ventbuster® Kit. Using random quick connect hardware may result in a serious mechanical failure that can cause severe injury or property damage.

⚠CAUTION

The outlet or exhaust of the Vent Unit MUST NOT be connected to any back-pressure restriction and must vent directly to atmosphere.

Before quick connecting the Vent Unit onto the vent assembly, always ensure the shut-in valve handle is placed in the open position and the flow mode valve handle is placed into the high flow position. Significant back pressure may result in damage to the flow channel, if the Vent Unit is connected to a high flow or high-pressure vent with the flow mode handle set into the low flow position.

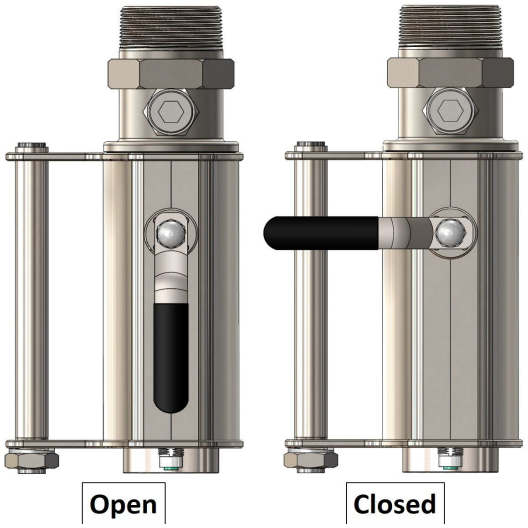

Figure 3.5 Shut in pressure handle positions and subsequent measurements

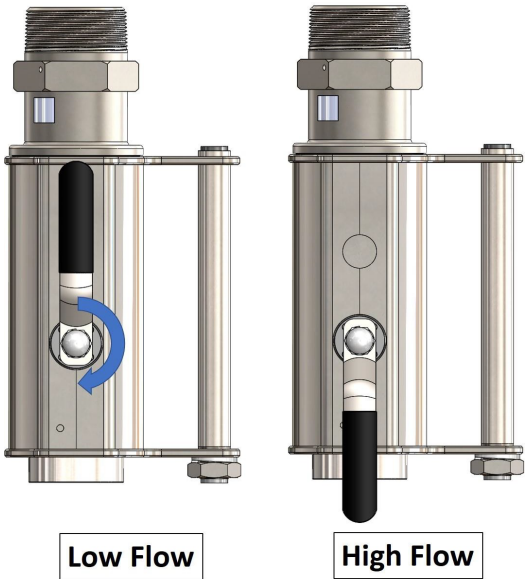

Figure 3.6 Flow Channel Selection Handle positions and subsequent measurements

The Ventbuster® Kit comes equipped with grounding hardware. As required by local or federal electrical codes, ground the Vent Unit using the threaded grounding connection to the wellhead or other electrically conductive vent piping connected with the earth.

NOTICE

Before installing the Ventbuster® Vent Unit, always ensure the shut-in valve is open and the flow mode valve is in high flow position to prevent damage to the flow channel from excessive surging effects or risking over pressuring the system.

WARNING

Always comply with local and federal codes and all electrical equipment installation standards when installing the Ventbuster® Vent Unit.

CAUTION

Always orient the Ventbuster® Vent Unit so that the pressure safety rupture disk is directed towards a safe area. High velocity gas may cause injury in the event of an over-pressure disk rupture.

3.3.3 Ventbuster® Comms Unit Installation:

Ensuring the Location of the Comms Unit into the General-Purpose Area

The Comms Unit is designed to be operated at ambient temperatures from -40°C to +55°C (-40°F to +130°F). The Comms Unit is intended to be tripod mounted for longer duration testing and monitoring or handheld when conducting short duration testing and monitoring. The Comms Unit data/power cable allows for the proper set back out of the Hazardous Area in accordance with local and federal governing body recommendations.

See figure 3.7 below, for a typical setback requirement after first checking with local and federal workplace and/or Hazardous Area governing bodies to ensure that the required setback distance has been confirmed, prior to installation and set-up.

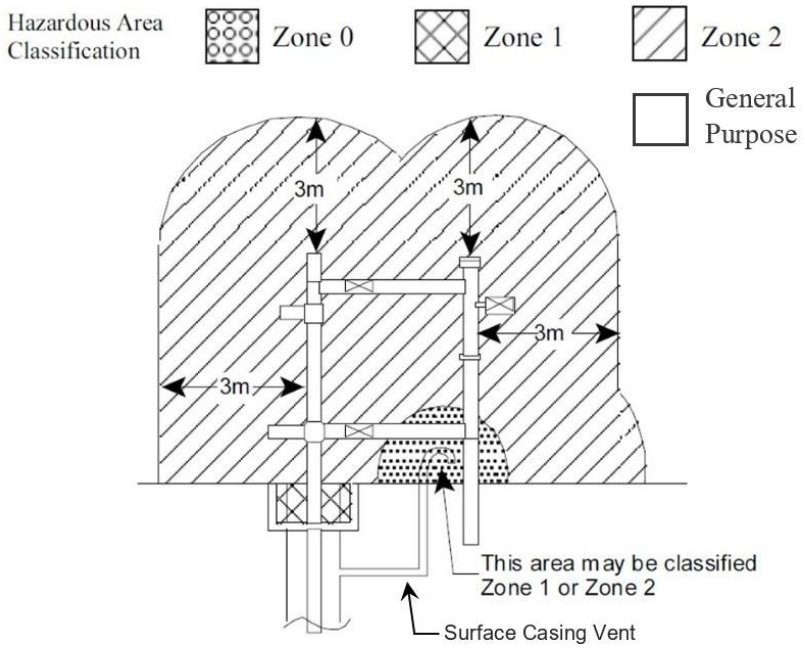

Figure 3.7 General-purpose setback distance from wellhead vent showing the typical > 3 metre (> 7 feet) from the wellhead emission source.

3.3.4 Hazardous Area Classification Information:

Ventbuster® Comms Unit	Ventbuster® Vent Unit
Canada: [Ex ia Ga] IIB USA: [AEx ia Ga] IIB -40°C < Ta < +55°C	Canada: Ex ia IIBT3 Ga USA: Class 1 Zone 0 AEx ia IIB T3 Ga -40°C < Ta < +55°C

⚠WARNING

Improper setback distances may result in explosion and injury. While the Vent Unit is designed and rated to be operated within a Class 1 Zone 0 area, the Comms Unit MUST BE installed in the designated general-purpose area.

NOTICE

If the provided cable is too long, DO NOT splice it. Splicing to a different length will affect the system performance and intrinsic safety. Neatly bundle or wrap up the excess cable length and affix to the tripod. If the cable is too short, contact Ventbuster Instruments to receive a longer cable.

⚠WARNING

Do not drop, upset or impact the Vent Unit or Comms Unit in any way. Both are very sophisticated and sensitive electronic devices and MUST BE HANDLED WITH CARE.

⚠WARNING

Do not leave, store or expose the Vent Unit or Comms Unit ton a high temperature environment nor apply heat any attempt to dry it or thaw it out.

The Ventbuster® Kit comes equipped with grounding hardware. As required by electrical codes, ground the Comms Unit using the threaded grounding connection to the earth via the included grounding stake.

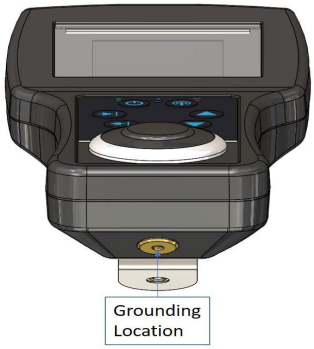

Figure 3.8 Control Unit Grounding Location

⚠WARNING

If external power is provided to the Comms Unit and the Vent Unit is located in a hazardous area the Comms Unit MUST be grounded as per local and federal codes and standards for the installation of Intrinsically Safe Electrical Systems before connecting the data/power cable.

3.3.5 Dimension of the Ventbuster® Units:

Figure 3.9 Top - Ventbuster® Vent Unit Dimensions
Figure 3.10 Bottom - Ventbuster® Comms Unit Dimensions

Section 4: Troubleshooting Ventbuster® System

The current release of the Ventbuster® System does not contain user or field serviceable components. Contact Ventbuster Instruments, if there are any questions or concerns associated with functionality or evidence of malfunction. Servicing any components or opening either the Units will result in damages to be borne by the operator.

Error messages have been known to occur which are not necessarily a malfunction:

- Cable unplugged or damaged. Vent Disconnect message will display on the LCD screen of the Comms Unit In the event a Vent Unit to Comms Unit cable connection is lost. Inspect the cable connections to ensure they are correctly inserted to the respective cable receptacle. If a cable connector has been damaged or come loose from the cord, replace with another cable and reconnect. If the problem persists, contact Ventbuster Instruments and return the unit for repair and replacement.

- Sensor Fouling. Sensor Fouled message will be displayed on the Comms Unit LCD if the flow channel sensor becomes contaminated from liquids or dirt and particulate matter entering the flow channel of the Vent Unit, fouling the sensors. If the contamination is minor, the Vent Unit may clear the contamination with continued flow of clean dry gas. If the Sensor Fouled message persists, contact Ventbuster Instruments and return for repair and replacement.

Section 5: Technical Specification

5.1 Ventbuster® System Performance Specifications:

Flow Range	0.04 ml/min to 720 m3/day (25.4 mcfd) over two selectable range modes
Flow Accuracy	+/- 5% of reading or +/- 2% of full scale
Pressure Rating	7000 kPag (1000 psig)
Pressure Accuracy	± 5 kPag
Response Time	Real Time Analysis
Analysis Frequency	~10Hz
Operating Temperature Compensated	-40 °C to +55 °C (-40ºF to + 130ºF)
Back Pressure at Maximum Flow	Negligible
Max Working Pressure During Shut-in	7000 kPag (1000 psig) - Outlet must be vented directly to atmosphere
Over Pressure Relief	User selectable burst disk (refer to Field User Guide)

5.2 Ventbuster® System Communications Interface:

Outputs	1 – RS485/MODBUS Serial Port Cellular Cloud Connectivity and Bluetooth® Connectivity
Inputs	12VDC, 1A Power Port
Operator Interface	LCD Graphic Screen Front panel 6 button membrane keypad 3 visual indicator LEDs for quick status Android™ Tablet configuration and monitoring APP

5.3 Ventbuster® System Instrument Specifications:

Size	Comms Unit: 228 mm (H) x 117mm (W) x 114 mm (D) Vent Unit: 283 mm (H) x 220 mm (W) x 138 mm (D)
Weight	Comms Unit: 0.7 kg (1.5 lbs.) Vent Unit: 4.3 kg (9.5 lbs.)
Power Consumption	1 Watt @ 12 VDC
Electrical	ETL, C/US Certified
Classifications	Comms Unit: Canada: [Ex ia Ga] IIB USA: [AEx ia Ga] IIB -40°C < Ta < +55°C Vent Unit: Canada: Ex ia IIBT3 Ga USA: Class 1 Zone 0 AEx ia IIB T3 Ga -40°C < Ta < +55°C
Ambient Temperature	-40°C to +55°C (-40ºF to +130ºF)
Storage Temperature	-40°C to +60°C (-40ºF to +140ºF)
Chemical Contact	Metallurgy is suitable for contact with typical sweet wellsite liquids and gasses including liquid and gaseous hydrocarbons, oils and lubricants.