

Purge Applications for Gas Analyzers

Whitepaper



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Statement of Purpose

Analyzers play an important role in real-time process feedback and may be located in hazardous areas or exposed to hazardous gases. Factors such as the type of hazardous gas, location, the chemicals being analyzed, and the enclosure layout affect the purge and pressurization algorithm and analyzer system design.

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Table of Contents

1 Abstract	3
2 Hazardous Location Types	3
3 Types of Analyzers and Their Function	3
4 Modes of Operation	4
4.1 Leakage Compensation	4
4.2 Continuous Dilution	5
5 System Components	6
5.1 Vent Types	6
5.1.1 Dilution	6
5.1.2 Standard Vents	6
5.2 Manifold Valves	7
5.2.1 Digital	7
5.2.2 Analog (Proportional)	7
5.3 Control Unit	7
6 Unique Features	9
7 Example	10
8 Summary	11

1 Abstract

Analyzers are instruments that perform analysis on chemicals or streams of chemicals. They fall into the following categories: liquid process analyzers, gas process analyzers, gas chromatographs, and spectroscopy. For years, these analyzers were offline, confined to laboratories with process feedback provided hours to months after the sample was taken. The goal was to move them closer to the process in order to provide in situ real-time analysis and feedback for control systems. This means the analyzers must not only be ruggedized and operate in a variety of environmental conditions, but often are located in

hazardous areas. The simplest installation method for hazardous locations is to mount a purge and pressurization system on the analyzer. There are two primary pressurization schemes used with analyzers, leakage compensation and continuous dilution. In this paper, we will discuss these methods so that the user can determine which purge and pressurization scheme to use with their analyzer.

2 Hazardous Location Types

When choosing an analyzer for a hazardous location, you need to determine the level of safety required by the environment in which it will be placed. Questions that should be asked include whether the system should be configured to set off an alarm or shut down under certain conditions. For example, if a value indicating the presence of a hazardous gas or dust reaches a predefined set point, the system may be shut down.

- Zone 1 analyzers must meet the requirements necessary for operating in the presence of ignitable concentrations of gases, vapors, or dusts that are likely to exist under normal conditions. Analyzers may need to shut down under critical conditions, such as loss of air, source, or supply.

- Zone 2 analyzers must meet the requirements necessary for operating in environments where ignitable concentrations of gases, vapors, or dusts are not likely to exist under normal conditions, or to exist only for short periods of time. Analyzers can be optionally programmed to set off an alarm or shut down for minor fault conditions, but may need to shut down under critical conditions.

As we can see from above, Zone 1 analyzers must meet higher safety standards than analyzers for Zone 2.

3 Types of Analyzers and Their Function

Gas analyzers, chromatographs, and spectrometers are all common measuring devices found in purge applications including the oil, gas, and petrochemical industry, pharmaceutical industry, and food and beverage industry. These devices allow you to identify the chemical composition of substances used in process automation. They provide either direct information in the form of values showing the amount of chemical present, or indirect information in the form of measurements based on physical attributes indicating that a certain chemical is present. This information offers a way to detect harmful chemicals early on. As a result, analyzers ensure continued safety in hazardous environments, clean air and water, system availability, and energy efficiency.

There are four primary classes of analyzers:

- 1) Liquid process analyzers measure and monitor variables such as pH factor (acidity/alkalinity) / oxidation-reduction potential (ORP), conductivity, turbidity, colorimetric, total organic carbon (TOC), chemical oxygen demand (COD), near infrared (NIR), titration, mixed liquor suspended solids (MLSS), and dissolved gases including oxygen and chlorine.

- 2) Gas process analyzers measure and monitor gaseous substances including carbon dioxide, hydrogen sulfide, nitrogen, oxygen, and sulfur, as well as the amount of moisture that the gas contains.
- 3) Gas chromatographs deal with various process gases and temperature measured in British thermal units (BTU), separating complex gas mixtures into their distinct substances according to color.
- 4) Spectrometers disperse the light of an object into its component colors. They are designed for technologies including near infrared, electron spin resonance, hyphenated mass spectrometry, lasers, nuclear magnetic resonance, Raman, ultraviolet-visible (UV-Vis), and are ideal for measurements at the atomic or molecular level. Spectrometers function much like a prism.

4 Modes of Operation

4.1 Leakage Compensation

Enclosures have leaks, and hazardous materials (gas, dust, etc.) may enter the enclosure if the internal pressure is insufficient. So once the enclosure is purged of hazardous gas, the unit is pressurized to a degree that is a) above the atmospheric pressure, thus there is a positive pressure in the enclosure and b) sufficiently positive to overcome any leaks associated with constructing the enclosure. This enclosure

typically houses the electronic instruments that perform the analysis of the subject material. The hazardous material is typically isolated from the control system electronics in a separate analyzer compartment. The inert gas entry is in the analyzer control system enclosure and the vent is in the analyzer compartment. This type is treated as a multi-enclosure purge system.

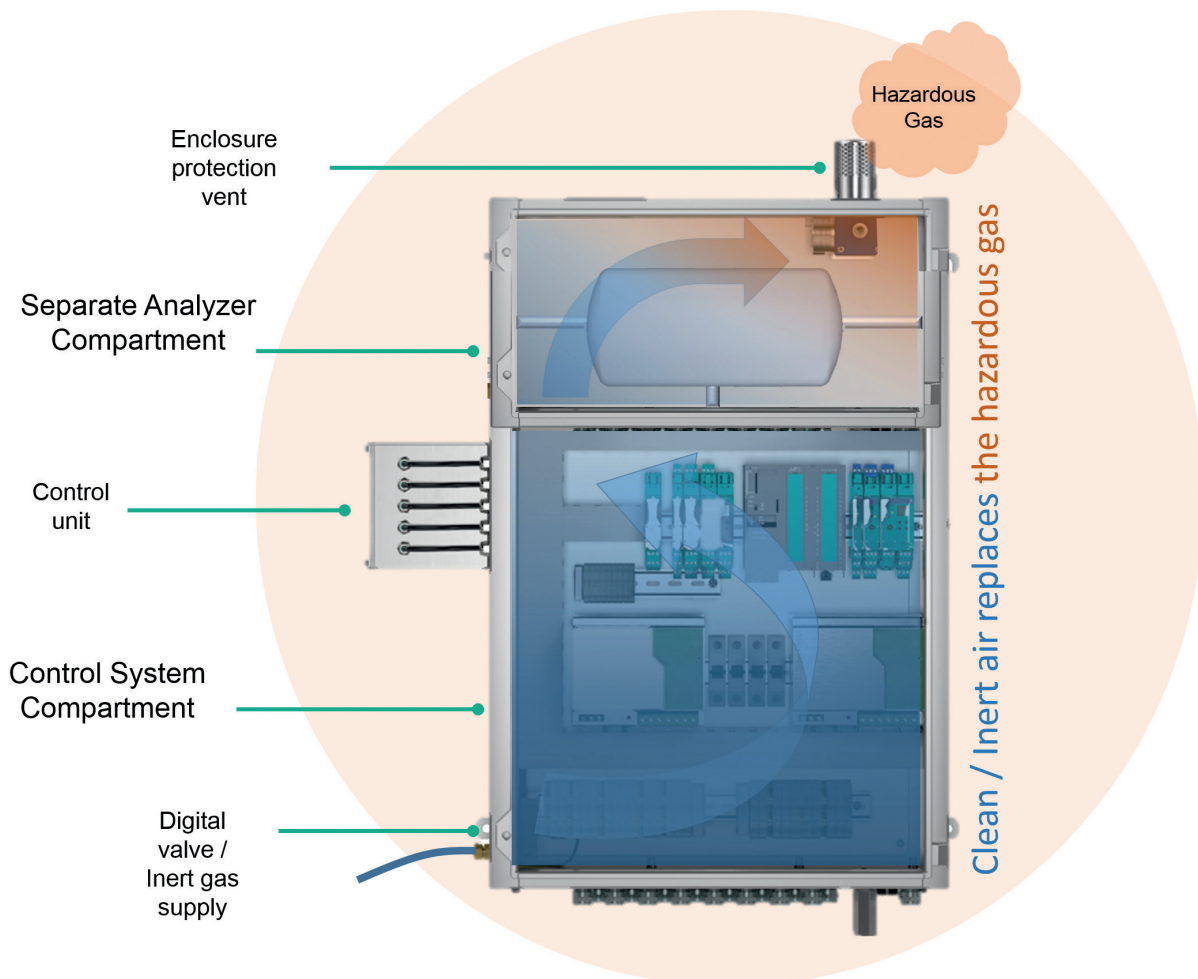


Figure 1: Leakage Compensation

4.2 Continuous Dilution

Dilution applications usually deal with gas analyzers that are located inside the pressurized enclosure and bring in a stream of the hazardous gas for analysis. Any equipment, including piping, which contains hazardous gas within the pressurized enclosure is called the containment system. The containment system has the potential to leak under normal and abnormal conditions, with either a known or unknown leakage rate of hazardous gas. If the leakage rate is known, the 6500 system may be used to dilute the area in general or the specific area within the enclosure to make other equipment safe to operate in the dilution area.

Dilution applications can only be considered with the normal and abnormal leakage rates known, such as with limited release. Please refer to the 60079-2 to determine if dilution can be considered for your applications. In most cases, explosive liquids are not allowed and unlimited releases may require the protective gas supply to be inert gas only, such as nitrogen or argon.

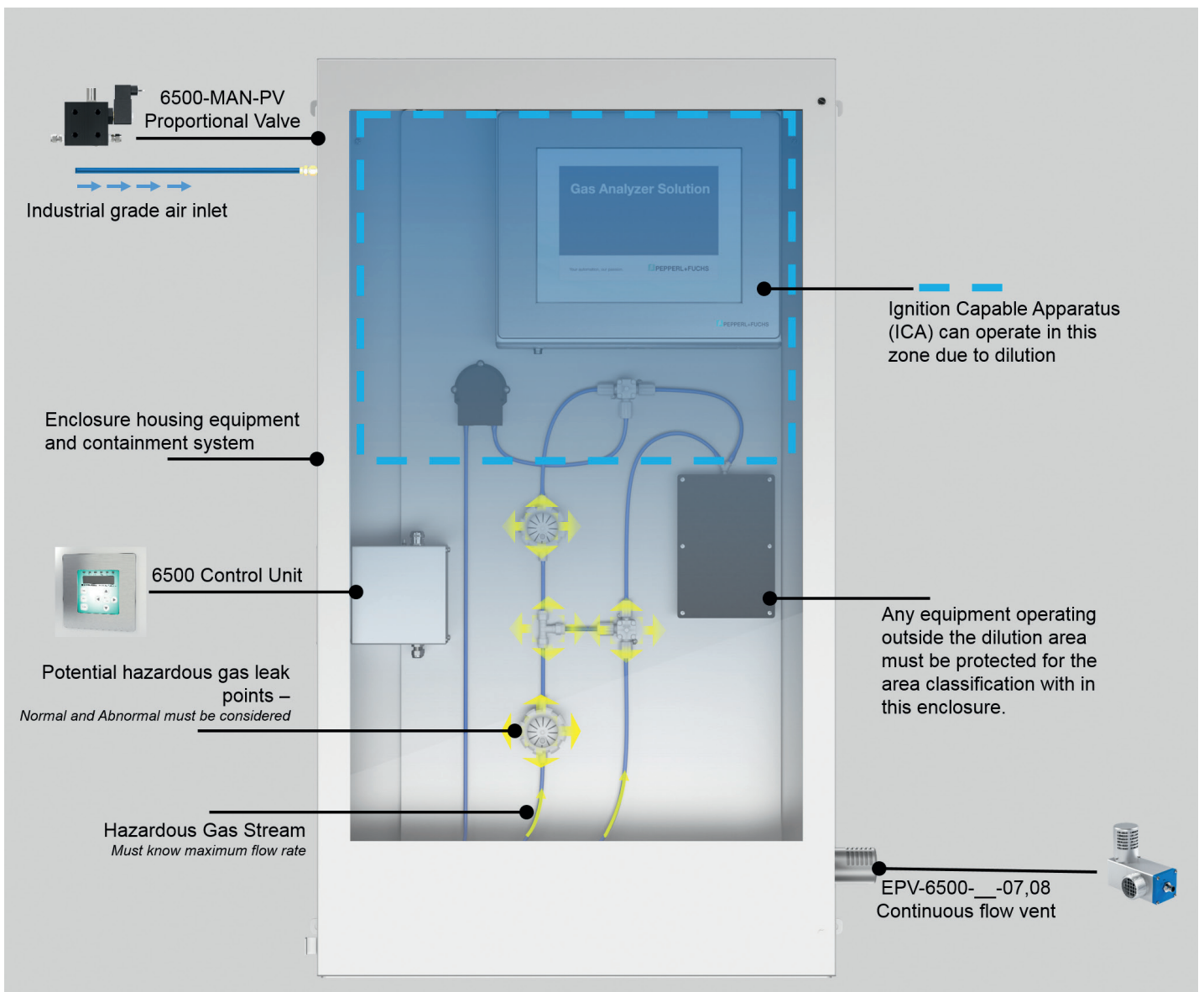


Figure 2: Continuous Dilution

5 System Components

The purge system is composed of three major components: the vent, the manifold, and the control unit. In this section, we explain the purpose of each type.

5.1 Vent Types

There are two general vent types: dilution and standard vents. In the section below, we describe the differences based on various parameters.

5.1.1 Dilution

These vents, used in continuous dilution applications, have an open orifice to allow a constant, free flow of air. This continuous flow maintains proper pressure, and works by using an orifice plate that restricts flow according to pressure requirements. When used with a proportional valve, the control of flow is precisely controlled across the orifice plate. Depending on the requirement to exhaust gases to < 25% LEL, two different-sized orifice plates are available. This technology has over 100 years of use in process flow applications, and existed in a more primitive form during the time of the Roman Empire for the purpose of heating buildings.

Dilution Vent Model	Orifice Plate Size	Minimum Flow Rate	Maximum Flow Rate
EPV-6500- -07	8 mm	17 l/min (0.6 scfm)	85 l/min (3 scfm)
EPV-6500- -08	16 mm	70 l/min (2.5 scfm)	226 l/min (8 scfm)

5.1.1 Standard Vents

Large volume: EPV-6500-...-01

This is the traditional flapper vent designed to move large volumes of inert gas during the purge cycle, and provide a relatively tight seal during the pressurization or operation stage. It is designed for large enclosures, typically greater than 0.71 m³ (25 ft³). This vent has the largest flow rate to minimize forces on the enclosure during purging. It also has the highest leakage rate, but is less than the sum of the enclosure's leakage rates.

Medium to large volume: EPV-6500-...-03

Low leakage rate means conservation of pressure gas during normal operation. This will cover some 80% of applications where leakage rate is critical and a short purge time is desired. The back pressure is higher than the large volume vent, and the leakage rate for pressurization is lower.

Sealed – bottle gas or inert gas: EPV-6500-...-05

This is a plunger type that provides an absolute seal to minimize flow of inert gas through the pressurization phase. As a result, it is ideal for applications with limited inert gas or bottled pressure sources.

They are used with sealed bottles of gas and are designed to have a low leakage rate. Their design makes them extremely useful for pressure supply conservation in inter-gas supplies or bottled pressure sources. While they offer the best seal for pressurization, the downside is that they have the highest back pressure for purging.

5.2 Manifold Valves

We offer two types of manifolds that are used for many applications. Both of these manifolds are intrinsically safe, and the 6500 provides the intrinsically safe power for these valves. No external barriers are required.

5.2.1 Digital manifold 6500-MAN-DV-01

This consists of a ball valve and needle valve all in one assembly. The ball valve, which is a digital (solenoid) valve, is used for purging the enclosure and is automatic through the 6500 control unit. During startup, when the enclosure has safe pressure, the digital valve closes and begins purging the enclosure. When purging is over, the valve opens. The needle valve is a manual valve that the operator sets for pressurization of the enclosure after purging.

5.2.2 Proportional valve (I/P valve) 6500-MAN-PV-01

Where a digital valve is either on or off, a proportional valve is continuously controlled and can supply a range of flow depending on the set point configured by the operator. Proportional valves are mostly used for dilution applications but they can also be used on standard applications where there may be big fluctuations in line pressure that cause increases and drops in enclosure pressure. Proportional valves automatically adjust the flow to maintain the enclosure pressure. If the customer has a bottled purge source like nitrogen and wants to maintain the lowest flow to conserve on the gas supply, constant control is required to not waste nitrogen.

5.3 Control Unit

The 6500 control unit consists of an operator interface, communications, menu-driven configuration, and closed loop controller executing one of several preconfigured control algorithms. Leakage compensation and continuous dilution are the two primary algorithms used for analyzers, depending on the configuration of the analyzer.

Various parameters available to set up the 6500 control unit

Settings	Parameter	Description
Purge System Settings	Enclosure Volume	Enclosure Volume
	# of Exchanges	4-19
	Hazardous Environment Setting	Gas, Dust, Both
	Pressure Set Points	Max Over Pressure, Low Pressure, Min Over Pressure
	Timer Settings	Shutdown Timer, Unlock Door Timer
	Operation Mode Setting	SA, FA
	Vent Flow Control Setting	Standard, Dilution
	Solenoid Valve Setting	Digital, Proportional
	Dilution Settings	Purge Flow, Dilution Flow Set Point, Min Flow Set Point
	Units Setting	Imperial, Metric
	Language Setting	English, Deutsch, Espanol, Francais
	Bypass Control Settings	Enabled, After Purge ON, Before Purge ON
	Bluetooth Settings	Enabled, Bluetooth ID
Input Settings	Input 1 Settings	Disabled, Immediate Shutdown, Overload, Control PWR Relay, Control Output 1, Control Valve, System Bypass
	Pressure As Input Settings	Disabled, Control Output 1, Control Valve, On/Off Pressures, Off Delay Time
	Temperature As Input Settings	Temp 1 Input, Temp 2 Input: Temp Functions – Disabled, Immediate Shutdown, Overload, Control PWR Relay, Control Output 1, Control Valve, Alarm, On/Off Set points
Output Settings	Output 1 Function Setting	Disabled, Immediate Shutdown Alarm, Overload Alarm, Max/Low/Lost Pressure Alarm, Announce Purge, Any Alarm, System Bypass Alarm, Enclosure Door Lock, Temp Input Alarm

NOTE: For more information on PACTware and all the companies that participate in the HART Foundation, please visit the following website: www.icsgmbh.com

The 6500 control system using these components allows the customer to program the required flow for dilution. The unit automatically maintains this flow for safe use. It also warns and shuts off the equipment if the flow drops below the min flow required. All of these parameters are configurable by the customer, thus providing a safe operating system for dilutions applications involving analyzers.

6 Unique Features

Communication

Methods of communication to the outside world for the 6500 include visual, Bluetooth, and RS-485. The communication output for the 6500 is HART via RS-485. PACTware is also available. The 6500 control unit comes equipped with a Bluetooth chip for wireless communication. Several apps are available at our website www.pepperl-fuchs.com.

Visual:

The 6500 unit has a capacitive touch display with a 2x20 LCD screen. The parameters and statistics of the unit are available without any password for the system. The statistics available include the purge settings that were programmed by the user, min/max pressure and flows for purging and pressurization, current and past alarms and faults, hardware and software revisions of the EPCU/UIC/VENT.

Along with the 2x 20 display, we have 5 LEDs that display safe pressure, enclosure power status, rapid exchange status, system bypass warning, and alarm/fault indication.

Bluetooth:

The Bluetooth is available on all units and has the option of turning them on or off depending on the user's requirement. The Bluetooth allows the user to operate the system as if it were the actual display on the 6500 unit. This can be used as a remote display. Access to all the configurable parameters are accessible through a Bluetooth device with the proper app and passwords of the unit. One reason we give the customer the option to turn this off is so it cannot be accessed remotely. The apps are available for the Android and iOS devices and are able to work on Blackberry phones with special application instructions. Note: The device operating the app must be located in a safe area if it is not rated for the area classification.

RS-485:

The 6500 has an RS-485 line that communicates through HART protocol and permits viewing all of the parameters and statistics on the 6500 system via the PACTware software or DTM based software. The 6500 PACTware DTM is available free of charge from the HART Foundation or on our web page for easy connection/viewing on most PCs. Device descriptions (DD) and electronic device description languages (EDDL) are available for connection to any HART device and DCS system.

Other New Features

Bypass mode:

New to the 6500 is the ability to operate in bypass mode. Bypass mode can be accessed either by physically activating a switch or from the front panel. The 6500 also offers a commissioning bypass mode called "bypass with no pressure", for checking electrical connections and operation before any gas is introduced into the system. Because bypass mode allows you to apply power to the enclosure without air, this means that you can turn the power on during commissioning for testing purposes.

Keep in mind that it is not safe to turn on the power to operate the enclosure within a hazardous area.

Password protection:

A feature exclusive to the 6500 is a unique system of password protection. Most systems offer one password that allows full access to the system. Differing from the standard, the 6500 has two sets of passwords: one password for purge, and one password for bypass mode. This allows for different levels of user access, such that some users can access both purge and bypass mode, while other users can only access purge but not bypass mode.

Continuous dilution: a closed loop control system approach

The main point in dilution applications is to protect the electronics by diluting the hazardous gas concentration in the area around the electronics to a point that the ignition levels are safe. The control of the flow of protective gas, which for dilution is compressed air, is important to achieve and maintain proper flow rates. Control of this flow is required to make sure you have the proper flow going into the enclosure for dilution.

7 Dilution Analyzer Example

The following example illustrates the dilution area and how potential leak points in the containment system can affect equipment positioning. It is suggested that any equipment that needs to operate in the enclosure that is an ignition capable apparatus (ICA) should be isolated from the leaking containment system. The example below has some partitions to isolate the ICA from the containment system. The protective gas supply is introduced into the enclosure at the location of the ICA and dilutes the area so that the equipment can operate when the system is operating.

For dilution to properly be applied, the 6500 system would have to use the continuous vent (EPV-6500-...-07 or 08) and a proportional valve like the 6500-MAN-PV. The continuous vent accurately measures the pressure and flow across an open orifice plate inside the vent to give flow vs. pressure curves for setting up the dilution requirement. For the setup, the 6500 purges the enclosure at a user-set flow rate. After purging, the flow settles at a user-set dilution flow. The 6500 menu also has a MIN FLOW SP (minimum flow set point) that can be used to alarm the user if the dilution flow is too low. For shutting down the system, from the vent flow/pressure curves, the enclosure pressure for the shutdown flow in the curves can be used for the minimum overpressure value for de-energizing enclosure contacts.

Below is an example of a dilution application. In this example, the user has set up the enclosure for a dilution area as shown above and has calculated the required flow for dilution by knowing the normal and abnormal releases.

Equipment used

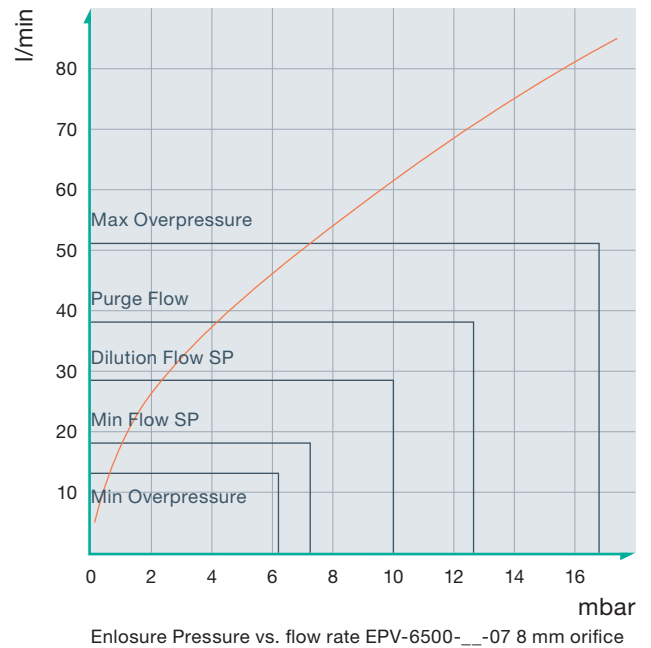
- 6500-01-... control unit
- EPV-6500-AA-07, continuous vent with 8 mm diameter orifice
- 6500-MAN-PV-01 proportional valve
- 6500-CBLG-... cable gland set for 6500 control unit (optional)
- Required flow for dilution = 45 l/min

From the 6500 menu for purge settings, the following dilution parameters are selected. All of these parameters and set points are user selectable.

Menu	Parameter	Description
Vent Flow Control	Dilution	User selects Dilution for the algorithm
Valve Control	Proportional	Proportional valve output on the 6500 control unit is selected for variable control of the valve
Dilution Settings		Set up set points
	Purge Flow	The flow rate for purging the enclosure by the proportional valve
	Dilution Flow Set Point	The flow rate for dilution. This value should be higher than the minimum required flow due to variations in line pressure and reaction time of the process variable (PV)
	Minimum Flow Set Point	If the flow rate drops below this set point, alarm is generated
Pressures	Minimum Overpressure	The pressure associated with the minimum flow for dilution to shut off the enclosure contacts
	Maximum Overpressure	Maximum enclosure pressure will adjust PV below this value

If we look at the flow curve for the EPV-6500-__-07 we can see the enclosure pressures for the various flows. From these curves, if it is required to shut power off to the enclosure if flow drops below the minimum flow rate for dilution, then this pressure for the flow is selected for the minimum overpressure value.

Menu	Flow (l/min)	Pressure (mbar)
Max Overpressure	82	16.6 (user selectable)
Purge Flow	70 (user selectable)	12.5
Dilution Flow SP	60 (user selectable)	9.8
Min Flow SP	50 (user selectable)	7.1
Min Overpressure	45	6.0 (user selectable)



There will always be a delay in the reaction time of the proportional valve to a change in the line pressure to achieve set point. The amount of time depends on the size of the enclosure, the amount of change in the line pressure, the speed of the change, and other factors. These factors also affect the over and under shoot of the proportional valve. Reaction times depend on the complete system, and final adjustments may have to be done while the system is commissioned.

For dilution applications, the procedures are the same but the flow rate is the set point desired for operation of the system. The user interface display can show flow rate. Note that the required flow rate must be greater than the min overpressure set point to operate.

In this case, the hazardous material is inside the enclosure, and sensitive electronics performing the analysis are in direct contact with the material. As a result, the hazardous material is diluted to acceptable levels prior to exiting the vent. This continuous dilution process exists at a pressure between the leakage compensation pressure and the purge pressure, and is determined by the user.

8 Summary

In summary, analyzers are instruments that perform analysis on chemicals or streams of chemicals and traditionally have provided off-line non-real time process analysis. Pepperl+Fuchs has developed the 6500 as a purpose-built, fully automatic, full-featured purge and pressurization system for traditional leakage compensation and continuous dilution applications. It is a complete engineered system for dilution based analyzers, from proportional manifolds and orifice plate based vents, to special software for continuous dilution analyzer applications.

The goal to move the analyzer closer to the process is now realized, providing in situ real-time analysis and feedback for control systems. This provides better control over processes and environmental controls. Product quality is improved by reducing the overall variance of raw materials and finished products.

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- AS-Interface
- Identification Systems
- Logic Control Units
- Connectivity