Purge and Pressurisation: Advantages, Methods and Guidelines.

Simplifying Complexity. Delivering Safety.

Contents

What is Purge and Pressurization?

Hazardous locations provide some of the greatest challenges to facility and enclosure safety. Engineers must determine and mitigate the dangerous effects present when designing and employing enclosures in these situations. Fortunately, there are many protection concepts that can be utilized when placing equipment into hazardous locations. Some of the most widely used are Explosion-Proof or Intrinsically Safe concepts which focus on containment or prevention.

However, one of the easiest to understand and use is purge and pressurization. Purge and pressurization is an alternative hazardous location protection concept that allows lesser rated equipment to be used in hazardous areas by segregating the equipment from the hazardous material.

Advantages of Purge and Pressurization over other protection methods

Purge and pressurization systems offer many advantages over specialized explosion proof or intrinsically safe protection concepts.

Since purge and pressurization uses general purpose enclosures and electrical equipment which are readily available, it makes system design, assembly and commissioning much faster than other methods. This is because general purpose enclosures are easier to modify and do not require special drill/ tap procedures. They also use less "system" engineering than intrinsically safe equipment.

Purge and pressurization systems are also more reliable and have greater longevity since they can utilize features not found in other methods. These systems can be used with larger footprints that allow for both passive and active cooling elements to reduce heat and humidity. Additionally, by using general purpose enclosures, it allows for modifications such as white paint or sun shields to reduce heat absorption.

Ex p Electrical Panel at BAE

Standard enclosure designs also allow purge and pressurization systems to use hazardous rated vortex coolers or air conditioners. Components constructed of corrosion resistant material are also readily available for these types of enclosures. Access and indication status is also improved using purge and pressurization. Electrical control panels are easily accessible for maintenance to increase productivity of your people, plus can also offer continuous status indication with local indicators and outputs not found in other methods.

Lastly, purge and pressurization allows for greater design flexibility and lower cost. Larger control panels can be used, covering a wider variety of applications. These systems are generally a lower cost solution for larger enclosure requirements when compared to Explosion-Proof or Flameproof enclosures. They also can be lighter weight than their explosion proof counter parts.

Potential Disadvantages

Purge and pressurization systems are not without their disadvantages though. These systems require a clean and moisture free supply of instrument quality air or inert gas. The cost of the protective gas supply may also be more prohibitive. We will cover this cost later within this white paper.

How does Purge and Pressurization Work

Purge and pressurization is a two-step process done prior to energizing the electrical equipment inside the enclosure. The goal is to ensure that once an enclosure is purged and pressurized with a protective gas supply, only then can the enclosure be energized or powered up. The protective gas supply needs to be free of any hazardous or explosive gas and have the capacity to sustain the purge and pressurization process. In some special applications, an inert gas is used as the protective gas supply (argon, nitrogen, or some mixture of inert gasses) instead of a standard atmospheric air mixture.

Purge is the process used to remove any potentially hazardous gas from the interior of the enclosure prior to pressurization. The purge cycle performs "air-exchanges" that displace any explosive (hazardous) gas with inert, protective gas instead. Once completed, all potentially explosive gas has been removed from the enclosure's interior. This can be done either manually or automatically.

To meet NFPA requirements, 4 complete air exchanges must be done prior to pressurization while IEC/ATEX requires 5 air exchanges prior to pressurization. The volume of air needed for replacement is based on the interior volume of the enclosure (Height x Width x Depth), what type of protective gas used, and the ambient conditions. An exterior label is provided for the system specifying the exact time needed for purging prior to pressurization and powering equipment.

Pressurization is the process of creating a higher internal pressure that is provided by a protective gas supply, preventing any hazardous gas or dust from entering the enclosure. Any penetrations or leak areas will have protective gas exiting the enclosure rather than hazardous gas or dust migrating into it. This segregates any external explosive or hazardous material from the energized internal equipment. NFPA requires a minimum pressure of 0.1 inches of water column (25Pa) for class I applications and 0.5 inches of water column (125Pa) while IEC/ATEX requires a minimum pressure of 50 Pa (0.2 inches of water column) for type X and Y and 25 Pa (0.1 inches of water column) for type Z.

Typical Purge & Pressurized Motor System

Energization of the enclosure happens only after the purge and pressurization process eliminates the potential for internal explosive gas inside the enclosure. The completion of this process makes the interior of the enclosure safe for the appropriate devices to be energized. If at any time the pressurization is lost, the enclosure must be d-energized and the purge and pressurization process must be repeated before the enclosure can be re-energized. Type X systems also require the power be automatically disconnected if pressurization is lost. Both NFPA and IEC/ATEX do allow for alarm only options with Type X purge systems if it is known to be more dangerous to cut power off automatically.

Methods of Purge and Pressurization

The two methods of purge and pressurization utilized to place equipment in hazardous locations are continuous flow and leakage compensation.

In the continuous flow method, a steady, uninterrupted constant flow of air travels into the pressurized enclosure, and is even maintained after the purge time has elapsed. During the purging phase, the flow of air serves to clear any potential gas from the enclosure. After purge phase, the flow of air maintains the enclosure at a higher pressure than the surrounding atmosphere.

Leakage compensation uses an initial high flow rate purge to clear the enclosure of flammable gasses; it then maintains the minimum required pressure using a controller to regulate a smaller flow of air into the enclosure to compensate for any leaks in the enclosure system.

Continuous Flow

Continuous Flow systems are normally used with smaller enclosures having a volume of less than 17 cubic feet (0.4 m) or with enclosures that are infrequently placed into service. Advantages of these systems include the simplicity of their operation and lack of any action (automatic or manual) between purge and pressurization phases. The simplicity of CF products also leads to lower upfront costs. However, these systems constantly consume compressed air resulting in higher running or operating costs. (see cost of protective gas supply) They also typically have a lower flow rate that can result in unacceptably high purge times on larger enclosures before equipment can be energized or used.

Leakage Compensation

Most users consider 30 minutes or less as a reasonable purge time making Leakage Compensation systems suitable for all sizes of enclosures, including those greater than 17 cubic feet in volume (0.4m). These systems consume less compressed air which results in lower operating costs. The benefit of a high initial purge flow rate also means that even large enclosures can be purged in a reasonable time. On the downside, Leakage Compensation equipment is slightly more complex and therefore has a higher upfront cost. Further the cost savings on less compressed air can be eliminated if the enclosure that is being used has excessive leakage. Understanding the differences between the two systems is important when making the initial purchase and corresponding effect it will have on your operations.

Purge & Pressurization Systems Components

Both Leakage Compensation (LC) and Continuous Flow (CF) systems are comprised of the following two major components:

- A Control Unit that measure and monitors flow and pressure. The control unit supplies a dry contact signal showing if the enclosure pressure is at a proper level. For type X systems, the control unit also includes a fully automatic purging controller and automatic electrical power disconnect.

- A Relief Valve, which is fitted to the enclosure, to provide a means of limiting the maximum pressure in the enclosure during operation. On Leakage Compensation systems the relief valve also poses as the known outlet that flow is measured from to ensure proper purge timing. All relief valves incorporated a spark arrestor to prevent sparks from being ejected from the enclosure through the relief valve aperture.

In addition to the above, Continuous Flow (CF) purge and pressurization systems include:

- An outlet orfice, which has been pre-calibrated so that the pressure drop at the desired flow rate is known. Utilizing the minimum pressure sensor in the control unit, the system provides adequate flow to maintain proper enclosure pressure. A spark arrestor is also installed in the Continuous Flow exit orfice.

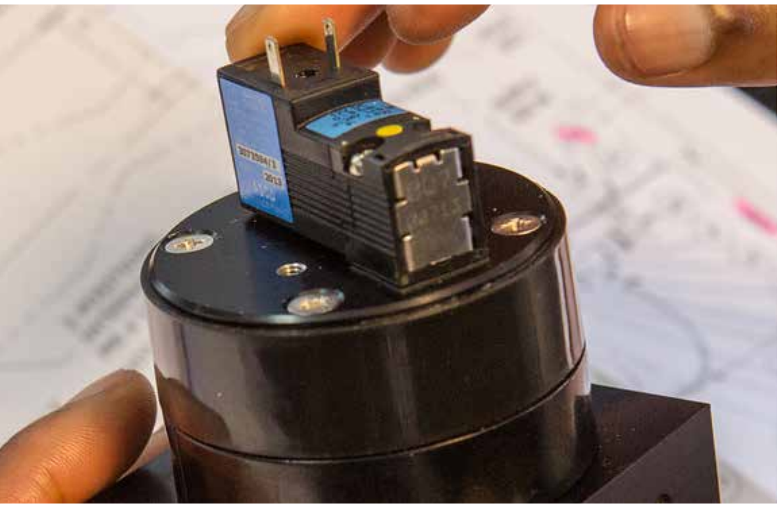
Purge and pressurization systems also can be classified into 3 types, type X, Y, or Z. Type X purging devices reduce the zone classification within an enclosure from Division 1 or Zone 1 to non-hazardous, Type Y reduces the classification from division 1 or Zone 1 to division 2 or Zone 2, while Type Z reduces division 2 or Zone 2 to non-hazardous.

Enclosures for Purge and Pressurization Applications

Many types of enclosures can be used for purge and pressurization applications, but there are attributes that create a more robust and economical system. As electrical enclosures are rated by their ability to keep external contaminants out, not for keeping a pressurized gas in, system designers must recognize what attribute an enclosure should have in the ability to withstand an internal pressure of 4 inches of water (typical pressure during purge operation) without permanent deformation. (Note: 4 inches of water is over equal to a pressure of .145 PSI. For a 60” x 60” surface, the resulting force is over 520 lbs.)

The IEC also recommends a minimum enclosure rating of IP40. However, UL Type 4 (IP65) enclosures are recommended as they are robust and provide additional latching points that assist in preventing leakage. Even with some Type 4 (IP65) enclosures additional latching may be required. UL Type 12 (IP54) enclosures may also be used, but they may have a higher rate of leakage and are not as suitable when latch points are separated by a distance of greater than 15.0 inches.

Gaskets used for typical UL type 4 and 12 sealing are usually adequate and the use of a seamless foam-in-place gasket works as well. Additionally, enclosures with multiple doors may be used but enclosures with overlapping doors (no separating center-post) should be avoided due to high leakage potential. Fully welded enclosures also offer the best performance for purge and pressurization applications as modular (frame and skins) style enclosures are generally not suitable for purging applications due to the many potential leakage points present.



The enclosure must also be capable of withstanding any corrosive elements that the application may present. This generally means that mild (carbon) and stainless steel are the preferred enclosure materials as non-metallic enclosures are not usually suitable for hazardous locations due to not meeting requirements for the prevention of static build-up. Enclosures must meet the requirements of IEC 60079-0 (2011) for ATEX and IECEx applications.

Enclosures may also have windows installed for viewing of equipment on the inside or for HMI/PLC usage. Windows must be made of the appropriate materials for the area of classification they are being used in. They must also be sealed properly to prevent excessive leakage in the enclosure.

Protective Gas Supply

An effective purge and pressurization system needs to be connected to a protective gas supply suitable for this purpose. The gas supply can be air or inert gas but must be clean, nonflammable, originate from a non-hazardous area and be free of water and oil per BS ISO 8573-1 or relevant local standards. These requirements are typically referred to as instrument air quality with the following properties:

Solid particles:

Particle size	Maximum count/ m3
0.1to 0.5 µm	20,000
0.5 to 1 µm	400
1 to 5 µm	10

Humidity / Pressure Dew Point

The dew point , at line pressure, will be at least 10°C below the minimum local recorded ambient temperature at the plant site. In no case will the dew point be above +3°C.

The minimum gas supply pressure should be 4 bar/ 60 psig/4MPa. It is a necessity that the gas supply is capable of delivering sufficient quantity for purging the pressurized enclosure, otherwise the protection the system is designed for is compromised.

Cost of Protective gas supply

Though there are many variables that affect the amount of airflow required, the following guide can be used to estimate a cost range for the annual operation of CF and LC pressurized enclosure systems. This example is based on a 17 FT³ enclosure and assumes continuous operation for the year:

	Normal System Flow (SCF / NLPM)	Typical Minimum Leakage (SCF / NLPM)	Typical Maximum Leakage (SCF / NLPM)	Minimum Total Airflow (SCF / NLPM)	Maximum Total Airflow (SCF / NLPM)	Estimated Minimum Annual Cost		Estimated Maximum Annual Cost	
						@$.18*	@$.32*	@$18*	@$32*
CF	2.3 / 65	0.6 / 17	1.8 / 50	2.9 / 82	4.1 / 116	$275	$488	$388	$690
LC	0 / 0	0.6 / 17	1.8 / 50	0.6 / 17	2.4 / 68	$57	$101	$170	$303

**According to Compressed Air Challenge of the U.S. Department of Energy's Office of Industrial Technologies, the total cost of 100 psig compressed air has been calculated to be in the general range of 18 to 32 cents per 1,000 cubic foot. (Source: Best Practices for Compressed Air Systems by Compressed Air Challenge (www.compressedairchallenge.org)*

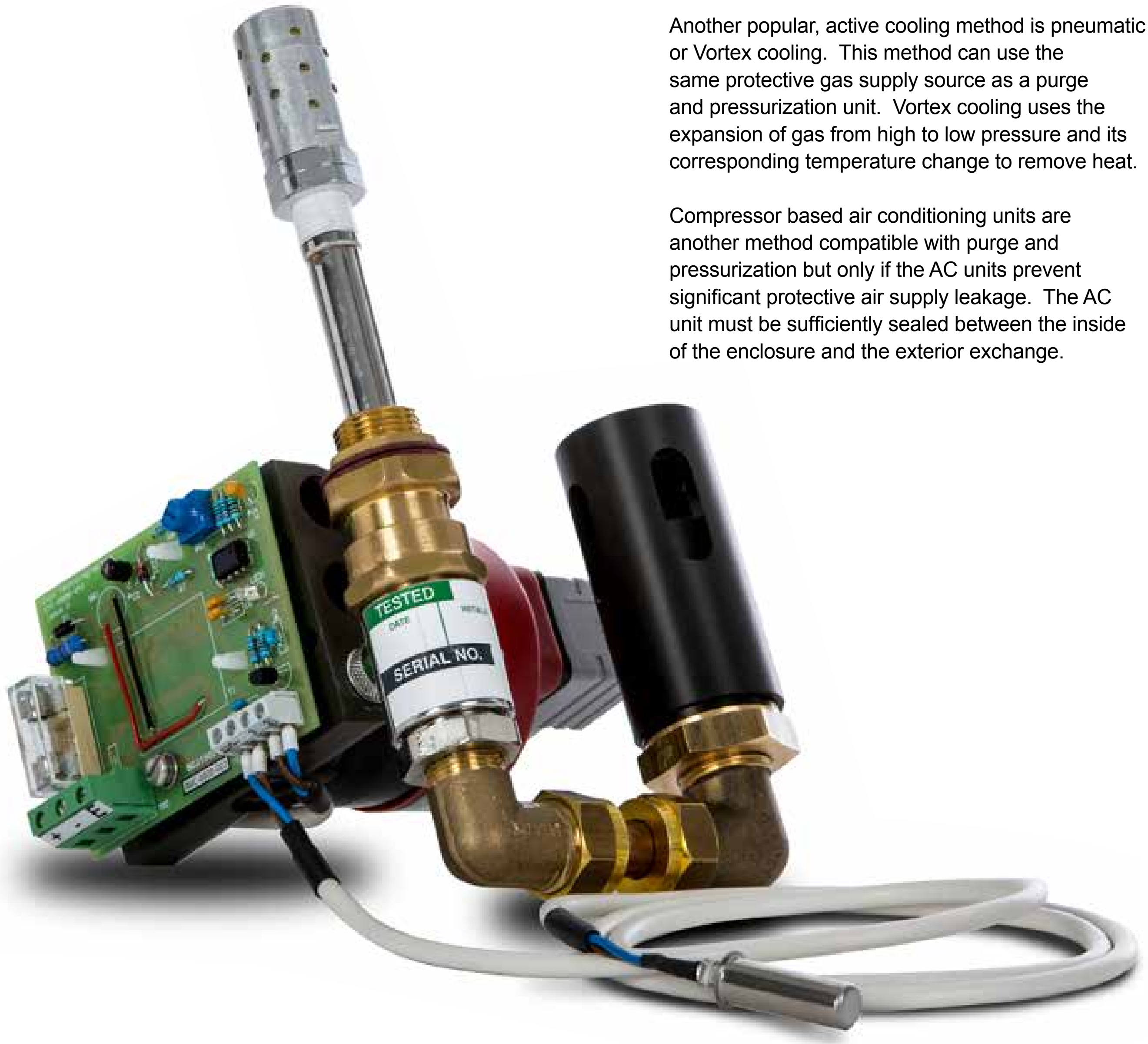
Cooling methods used in conjunction with pressurization enclosure systems

Cooling the equipment inside a pressurized enclosure does present some challenges but complementary solutions rated for use in hazardous areas are available. The purge and pressurization system itself cannot be relied on to provide cooling.

The simplest method to cool an enclosure is via passive heat transfer. With this method, the temperature rise internal to the enclosure is determined by the amount of enclosure surface area available to dissipate the heat. Simply increasing the size of the enclosure gives an accompanying increase in surface area which results in lower temperature rise for a given heat load.

Another popular, active cooling method is pneumatic or Vortex cooling. This method can use the same protective gas supply source as a purge and pressurization unit. Vortex cooling uses the expansion of gas from high to low pressure and its corresponding temperature change to remove heat.

Compressor based air conditioning units are another method compatible with purge and pressurization but only if the AC units prevent significant protective air supply leakage. The AC unit must be sufficiently sealed between the inside of the enclosure and the exterior exchange.



Guideline on Certification

Certifications are dependent on the local laws, geographic regions, standards, laboratories (Notifying bodies), and ultimately by the local authority having jurisdiction (LAHJ). The following table provides general guidelines for many regions of the world.

Geography	Certification	Classification system	Class 1 Division 1	Class 1 Division 2	Zone 1	Zone 2
North America United States Canada Mexico	cULus and FM NFPA 496 Groups A, B, C, D	z		X_d		
		y	X_a			
		x	$X_{c,d}$			
European Union	ATEX, IECEx 60079-2 Ex p(x, y, or z), Ex pD Category 2 or 3 GD	z				X_d
		y			X_b	
		x			$X_{c,d}$	
Global Many regions of the world	IECEx 60079-2 Ex p(x, y, or z), Ex pD Category 2 or 3 GD	z				X_d
		y			X_b	
		x			$X_{c,d}$	

a-Devices inside the cabinet must be rated to Division 2

b-Devices inside the cabinet must be rated to Zone 2

c-Devices automatically disconnects power if pressure is lost

d-General purpose devices are permitted for use inside the cabinet

For ATEX and IECEx :

Any equipment that penetrates through the wall of a pressurized enclosure must have approval from the required agency.

For NFPA 496:

Any equipment that penetrates through the wall of a pressurized enclosure must meet one of the following:

- Explosion-Proof
- Intrinsically Safe
- For Division 2 locations only – does not provide sufficient energy to cause ignition of hazardous environment
- Sealed from the hazardous environment and ventilated to the pressurized enclosure
- Isolated from the hazardous environment and suitably sealed window or door that is ventilated to the pressurized enclosure

While needing to meet the above criteria, consideration must also be given to the ability of the enclosure to maintain both its' ingress and egress integrity in regards any penetration source's ability to pass through the enclosure walls.

The Local Authority Always Has Jurisdiction and Responsibility over the Acceptability of an Installation

Non-Hazardous Applications

Purge and pressurization often can be used for nonhazardous applications. A Common application is to keep fine dust particles from entering the enclosure. Chemical and manufacturing plants of non-hazardous fine dust materials commonly use purge and pressurization systems to keep these harsh materials from entering the enclosure.

It's been shown that dust accumulation inside an enclosure greater reduces electronics' efficiency and increases its heat production. By using purge and pressurization to prevent dust from an entering an enclosure, companies can increase the life of their equipment and the safety of their employees and operations.

Conclusion

Finding cost effective and functional solutions to meet the requirements for enclosures in hazardous locations can be troublesome. Cast iron enclosures that meet exposition proof requirements are heavy and expensive. Additionally, even though they save your facility from further damage, the equipment inside is destroyed if an incident occurs.

Using intrinsically safe systems requires considerable up-front engineering work and documentation and these systems aren't easily modified at a job site. They also aren't very suitable for high power equipment or devices. Fortunately, purge and pressurization systems are globally accepted and a cost effective way to install electrical and electronic equipment in these hazardous applications. For many companies, it allows the use of lower cost, readily available general purpose equipment to be housed in standard, off-the-shelf enclosures, saving considerable time and resources. Job-site modification is more easily done and since these systems segregate the hazardous gases from the internal equipment, they prevent accidents instead of just containing them.

By using a purge and pressurization system, work stoppages and downtime are kept to a minimum, helping your business become more efficient and productive. We hope the information provided in this white paper has helped inform you on the benefits of a purge and pressurization systems and look forward to helping you find solutions that add value for your business needs.

About Expo

Expo Technologies is the market leader in the supply of Purge and Pressurization systems into the global market. Drawing on our significant knowledge of safety standards around the world, we deliver our clients' capabilities in hazardous and extreme environments.

Expo applies its experience in developing engineered solutions to our customer's needs –whether it's supplying a standard product from our extensive range, or creating an innovative solution to a particular challenge.

Our products are certified and approved to international and national standards (IECEx / ATEX / cULus / cFMus / INMETRO / KOSHA). We service our customers through our principal operations in the UK and the USA, and via a worldwide network of authorized distributors and representatives.

Expo Celebrates 60 years of building products and providing services to our loyal customers.

2014

2012 Expo UK moved to new and expanded premises in Sunbury-on-Thames, TW16.

2010 Expo received Brazilian INMETRO certificate on the MiniPurge and MIU range of products.

2008 Expo opened manufacturing facility in United States of America.

2007 Expo received IECEx certification to the IEC standards for its Global Market on the range of MiniPurge and MIU products for both Gas and Dust potentially explosive atmospheres. This range was also certified to the latest ATEX/En standards at the same time.

2004 Expo celebrated their 50th anniversary with members and clients from all over the world.

2003 Re-branding program introduced a new company name, Expo Technologies, and a distinctive new identity that reflected the company's core values of creativity, quality, reliability and service.

2000 Expo expanded its US presence to include stockholding, technical and sales support and local manufacture.

1999 A new purge system for large electric motors is successfully developed and marketed.

1998 Telektron acquires Expo Safety Systems to create Expo Telektron Safety Systems, the industry's most extensive supplier of purge and pressurization systems worldwide.

1995 Telektron set up a branch office in the USA.

1994 Expo Safety Systems expanded its sales and support network to the USA, Europe and the Far East.

1993 Telektron sold its actuator business and focuses on hazardous area products.

1993 Expo Safety Systems introduces MiniPurge range of products.

1976 Expo Safety Systems is founded by Andy Owler, an international expert in purge and pressurization techniques.

1976 Telektron entered the UK's emerging offshore oil and gas industry in the North Sea and the specialist field of hazardous areas.

1971 Development of Telektron's "friction-free" pneumatic valve.

1960 Telektron supplied pneumatic, remote and automatic control systems for ship's engines for nearly all the Royal Navy's steam-powered ships.

1954 Telektron, a specialist manufacturer of rotary valve actuators for use in precision control in the process industries is founded by Peter Nissen.

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