Purging and Pressurization of Multiple Enclosures

Technical White Paper

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Introduction

Implementing purging and pressurization across multiple enclosures presents unique challenges, from maintaining consistent pressure levels to ensuring compliance with safety standards. This approach requires careful planning, proper system design, and attention to installation details to ensure reliable protection in hazardous environments.

Overview of Protection Methods

Purge and pressurization, along with explosionproof/flameproof, encapsulation, and intrinsic safety, are all methods used to protect electronic equipment intended for safe operation in hazardous areas. When safeguarding control panels containing various types of electronic equipment, purge and pressurization is an easy-to-implement, quickly designed, and cost-effective solution. Using an explosionproof or flameproof enclosure for a 48" x 60" x 24" enclosure with electronic controls can be prohibitively expensive due to high costs, weight, and installation challenges.

Advantages of Purge and Pressurization

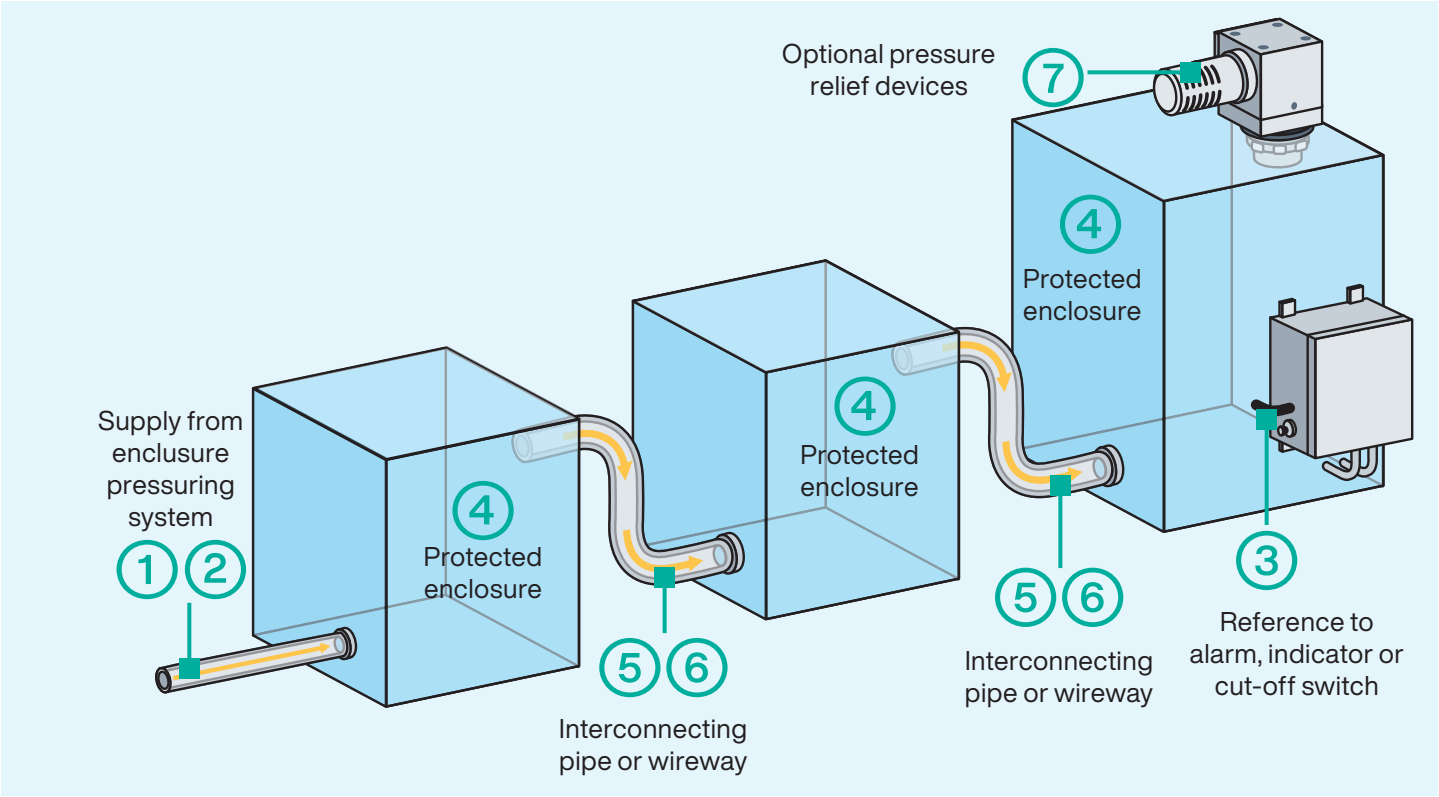
Purging and pressurization provides a cleaner, lighter, and more economical approach to safely using standard enclosures with electronic equipment in hazardous environments. Typically, one enclosure is equipped with the purge and pressurization components to ensure safe operation. This approach reduces installation, material, and labor costs while enabling multiple enclosures to share a single purge and pressurization system for multiple enclosures. By connecting them into one integrated setup, it maximizes overall cost efficiency.

Challenges of Multiple Enclosures

When dealing with multiple enclosures, the aim is to minimize the number of purge and pressurization systems, thereby reducing the system's footprint and overall cost. However, connecting multiple enclosures to a single purge and pressurization system presents various challenges and considerations that must be addressed to ensure safety.

Considerations for Implementation

The diagram on the next page illustrates three enclosures that a customer wishes to protect with one purge and pressurization system. In addition to adhering to the standard rules for purging and pressurization, there are several other factors to consider when managing multiple enclosures. The drawing does not depict a specific model of purge and pressurization system, as these considerations are relevant to all purge and pressurization systems.



Important Considerations for Purging Multiple Enclosures

1 Supply Line Sizing

Ensure that the supply line is appropriately sized to facilitate effective purging of all enclosures. When dealing with multiple enclosures and their connections, the potential for leakage points from the enclosure increases. Therefore, a thorough assessment is crucial to determine the required purge flow rate.

2 Compressor Sizing

The compressor or purge source must be sufficiently sized to purge the enclosures for the necessary duration. To evaluate the compressor size, calculate the purge time needed for a required flow rate by adding the free volumes of all enclosures, including the piping connections, and multiplying this total by the number of exchanges required by the relevant standards. Then divide this value by the flow rate of the purging gas. This calculation will determine how long the compressor needs to provide the required flow rate. In most Pepperl+Fuchs systems, the flow rate can fluctuate based on the regulated pressure and the supply lines connected to the system. Keep in mind that reducing the pressure will decrease the flow rate, which in turn will increase the purge time required.

3 Flow Rate Variability

The pressure reference tubing measures the enclosure pressure to determine if it is operating above the minimum safe pressure and if it has the required flow rate for purging. Since there are multiple enclosures, a scenario could occur where one of the enclosures has too high a leak, but the others are above the minimum safe pressure. If the reference tube is on the first enclosure and the last enclosure falls below the minimum pressure, it could still show a safe pressure in that first enclosure. However, if it is on the last enclosure at the vent, the pressure in the last enclosures will be lowered if an unexpected leak occurs in one of the enclosures. Another scenario would be that if there is a blockage from the first to the second enclosure, the pressure in the last enclosure drops below the minimum safe pressure, while the pressure in the first enclosure could be above the safe pressure. This would not be the case if the reference pressure tubing was located at the last enclosure with the vent. An authorized approval agency must ensure the purge unit recognizes when one of the enclosures falls below the safe pressure. This may require measuring the pressure in each enclosure for the test. Once this is verified, no enclosure requires pressure measurement for operation, and the purge unit determines safe operation. Note: The 6000 and 6500 purge vents have an integrated pressure sensor within the vent, so this reference tube is not required. All vents should be mounted on the last enclosure.

4 Pressure Management

Why is it considered good engineering practice (GMP) to arrange enclosures from smallest to largest when purging? The main reason is to ensure effective flow or protective gas transfer between enclosures. In this setup, the first enclosure must maintain a higher pressure. When dealing with multiple enclosures, it is advisable to create the highest pressure in the smallest enclosure due to its reduced surface area.
For example, take a standard Pepperl+Fuchs enclosure, as shown in the above illustration, with dimensions 48" x 60" x 24". During fast purging, the pressure in this enclosure can rise to 5 inches water column (w.c.), which is equivalent to 0.17 pounds per square inch (psi). While this may not seem significant, it translates to a force of 245 lbs. acting on the sides of the enclosure, which measure 48" x 60" (48 x 60 x 0.17 = 245 lbs). This force can potentially cause issues. Smaller enclosures experience less force due to their reduced surface area.
It is important to note that the purging pressure in all newer Pepperl+Fuchs purge and pressurization systems can be reduced by lowering the purge flow rate for the enclosures. While this may increase the purging time, it helps prevent deformation of the enclosure. Though arranging enclosures from smallest to largest is recommended, it is not always feasible. This should be taken into account when managing multiple enclosures, especially considering their structural integrity.

5 Frequently Overlooked Requirements

Combining multiple enclosures often involves overlooked requirements. In most Pepperl+Fuchs systems, the purge line that supplies the first enclosure is typically a ¼-inch or 3/8-inch tube. The inside diameter of a ¼-inch tube, with a wall thickness of 0.035 inches, is 0.18 inches, while that of a 3/8-inch tube, with a wall thickness of 0.035 inches, is 0.305 inches. This tubing usually operates at a pressure of 20 to 120 pounds per square inch gauge (psig).

The issue arises when users connect each enclosure to the same ¼-inch or 3/8-inch tubing that supplies the first enclosure. If this supply line operates at 20 psig, every enclosure connected with the tubing of the same size will reach nearly 20 psig. For example, if the first enclosure measures 48 inches by 60 inches (#3 above), the force on that side will be significant (48" x 60" x 20") and can potentially cause the enclosure to burst before reaching maximum capacity. Therefore, the connection between enclosures must have an internal diameter at least equal to that of the vent opening.

It is important to note that the 1000 or 3000 series purge and pressurization systems are not recommended for the arrangement of multiple enclosures. While it is possible to use them, verifying airflow through the enclosures becomes more complicated as the flow relies on the regulated inlet pressure. Flow is determined through testing: with a specified regulated pressure and a vent on an enclosure, the flow will be X cfm. If enclosures are improperly connected, the flow rate may be reduced, even if the regulated pressure is accurate. This can lead to inadequate purging, with the operator unaware of the issue.

The 6000, 6500, 5500, and 7500 systems measure flow at the exhaust or at the last enclosure. In the 6000 and 6500 systems, flow is measured through the vent using a flow sensor. Meanwhile, the 5500 and 7500 systems monitor enclosure pressure, which corresponds to flow rate. Since measurements are taken in the last enclosure, any restrictions in previous enclosures become irrelevant. If the flow in the first enclosures is too restricted to allow for effective purging, the correct readings will never be displayed on the last enclosure, and the purge unit will not allow the enclosure to operate unsafely.

It is recommended to use tubing/pipe with an inside diameter of 1 ½" or more between the enclosures for the 6000, 6500, 5500, and 7500 units. If this is not possible, smaller inside diameter tubing can also be used, but this will significantly increase the purge pressure in the first enclosures. However, as long as the flow is detected in the last enclosure and the first enclosures do not burst, proper purging will occur.

Even when appropriate connections are used, it is essential to test the strength of the enclosures, particularly if the tubing is smaller than the recommended diameter.

6 Staggered Piping Layout

When purging multiple enclosures, it is essential to lay out the piping connecting the individual enclosures in a staggered pattern. This design helps ensure that each enclosure is fully purged. If the piping runs directly from one enclosure to another, there is a risk that the entire enclosure may not be properly flushed. Always verify that each enclosure is thoroughly purged. If the flow in the first enclosures is too restricted to allow for effective purging, the correct readings will never be displayed on the last enclosure, and the purge unit will not allow the enclosure to operate unsafely.

It is recommended to use tubing/pipe with an inside diameter of 1 ½" or more between the enclosures for the 6000, 6500, 5500, and 7500 units. If this is not possible, smaller inside diameter tubing can also be used, but this will significantly increase the purge pressure in the first enclosures. However, as long as the flow is detected in the last enclosure and the first enclosures do not burst, proper purging will occur. Even when appropriate connections are used, it is essential to test the strength of the enclosures, particularly if the tubing is smaller than the recommended diameter.

7 Vent Placement

The vent should be attached to the last enclosure so that the flow passes through all enclosures before exiting through the vent of the last enclosure. This setup ensures the correct flow rate is maintained across all enclosures, allowing for accurate calculation of purge time.

8 Pressure Loss Response

f all enclosures are connected to a single purge and pressurization system, the power supply to all enclosures in a Zone 1 or Division 1 area should be disconnected if one enclosure experiences a loss of pressure. If the enclosures have been independently purged and pressurized with their own system, a loss of pressure in one enclosure will still allow the other enclosures to remain operational.

Additional Considerations for Purging Multiple Enclosures

a. When determining the purging time, it is essential to evaluate the total volume of both the enclosures and the piping or tubing connecting the enclosures.

b. If wires are run through the tubing or piping for airflow purposes, the volume taken up by these wires must be subtracted from the circular area of the inner diameter of the tubing or piping. This ensures there is still enough space for proper airflow between the enclosures. If the remaining area is too small, larger tubing or piping may be needed to meet the minimum airflow requirements.

c. For active cooling methods, such as a vortex cooler, the airflow must be directed into the first enclosure. If the vortex cooler is located on any enclosure other than the first, the pressure in the last enclosure will be higher when the vortex cooler is activated compared to the enclosure upstream of the purge flow. This occurs because pressure measurements are always taken at the last enclosure. Introducing an external flow halfway between the enclosures may lower the pressure in the upstream enclosure, potentially dropping it below the minimum permissible value, while the pressure in the last enclosure remains above that minimum.

d. In hazardous dust atmospheres, the enclosures do not need to be purged; only pressurization is required. So why is it important that the piping between the individual enclosures is large enough? Because if the regulator fails in the upstream pressure line, there could be excessively high pressure and flow rates in the supply line feeding the first enclosure. If the connecting tubing is not sized correctly, this situation could lead to dangerously high pressure in the enclosures. Therefore, a pressure relief vent is also necessary. All Pepperl+Fuchs enclosure protection vents (EPVs) are considered pressure relief vents with our component certification.

Insights from Customer Reports

Challenges with Enclosure Connections

Several customers with multiple enclosures have experienced issues that could be corrected, except for one concern: the connection between the enclosures. This is particularly problematic because many applications involve multiple small enclosures. A prime example can be found in the robotics industry, specifically in multi-axis painting robots. Each axis of these robots has a small stepper motor. In the case of a 7-axis painting robot, all seven stepper motors, along with the control panel, need to be purged and pressurized. However, the stepper motors are too small to be connected using 1½-inch piping.

Proposed Solution for Pressure Management

One potential solution is to enlarge the connections between the enclosures as much as possible and to reduce the purging flow. This approach would lower the purging pressure in these motors. Since the motors are significantly smaller than the large control panel, they should be connected to the protective supply line first, with the control cabinet serving as the last enclosure to vent. As the vent is located on the final enclosure, the purging pressures in that larger enclosure are considered normal. The smaller the enclosure, the lower the force exerted on it, which might allow these small devices to withstand higher pressures. However, it is essential to determine the maximum allowed internal pressure for these devices, which may be challenging to confirm or test.

Guidelines for Effective Use of Pepperl+Fuchs Purge and Pressurization Systems

All newer Pepperl+Fuchs purge and pressurization systems, including the 6000, 6500, 5500, and 7500 Series systems, enable users to reduce the flow rate to a minimum while effectively purging the enclosure(s). Many competing systems require a specific regulated pressure or flow rate for purging, which may be higher than the minimum purging rate and regulated pressure of Pepperl+Fuchs systems. By utilizing the lowest flow rate for purging, the enclosures can maintain a lower purge pressure.

Note: Before making adjustments, it is advisable to consult the manufacturer of the stepper motor or device(s) to understand the maximum permissible internal pressure. Additionally, the connections on each enclosure must be larger than the purge supply connection to the first enclosure. It is essential to measure the internal pressure during purging to ensure it remains below the maximum pressure of the device. In some cases, a second regulator may need to be added as a backup to ensure continued operation in the event of a primary regulator failure.

This deviation should only be implemented if all enclosures involved can withstand their designed pressure. Even under normal conditions, if all enclosures are properly connected, the standard purging pressure could be too high for certain devices. For instance, smaller motors or stepper motors that use soft seals on the motor shaft may rupture under normal purging pressures. This is an important consideration and is not limited to systems with multiple enclosures. As with all purge and pressurization systems, a comprehensive evaluation of the entire system should be approved by an authorized agency.

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