Design and Installation Guideline

Allen-Bradley

Control System Packaging for Corrosion Mitigation

Prepared for:

The Tire and Rubber Industry

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Additional Resources

Resource	Description
Preventive Maintenance of Industrial Control and Drive System Equipment, publication DRIVES-TD001	General reference for conducting maintenance on any PowerFlex© enclosure.
ISA 71.04-2013: "Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants"	This standard covers airborne contaminants and biological influences that affect industrial process measurement and control equipment, electronic office equipment, and data center and network equipment.
Conformal Coating Protecting Your Automation Investment, publication IA-PP001	Explains conformal coating to help protect components from moisture, fungus, dust, corrosion, abrasion, and other environmental stresses.
PowerFlex520-Series Adjustable Frequency AC Drive, PowerFlex 523 Catalog Number 25A, Series B, PowerFlex 525 Catalog Number 25B, publication 520-UM001	User manual for the PowerFlex 520 and PowerFlex 523.

You can view or download publications at http://www.rockwellautomation.com/global/literature-library/overview.page. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

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1.0 Introduction

1.1 Document Purpose and Audience

This document provides guidelines for the use of electronics or automation equipment in the tire and rubber industry with respect to the protection of the product from corrosive gases and contaminants that are present in the manufacturing environment. Rockwell Automation studies show that typical tire and rubber environments are rated as G2 to GX per the ISA 71-04 standards for corrosion severity. Most products provided by Rockwell Automation and competitors are specified to be installed in an environment free of corrosive gasses, vapors, and dust. The focus of this document is to provide guidance on how and where to install the products to mitigate the adverse conditions and to achieve a G1 or G2 corrosion severity in a particular environment per the ISA 71-04 standard.

The prime contaminants found in the tire and rubber environment are corrosive gases and carbon black. Corrosive gases cause corrosion of the silver and copper on the circuit boards and components. Carbon black is a contaminant that can build up on components and ultimately cause shorting on circuit boards or contacts. This document focuses only on those contaminants.

IMPORTANT Mitigation of the effects of contaminants and corrosive gases must be addressed in several ways.

First, the product must be installed following all of the manufacturer's specifications and guidelines. Additionally, product options such as conformal coating must be added (where available) to provide further protection from the expected environment. Packaging the product in enclosures with temperature control, humidity control, and filtering devices must also be employed. This document focuses on mitigation via packaging.

This document is intended for all users of electronics or automation equipment that are installed in the manufacturing environments of the tire and rubber industry. This includes OEMs, system integrators, solution providers, panel builders, and the end user.

See the Conformal Coating Protecting Your Automation Investment, publication IA-PP001, for information on the Rockwell Automation conformal coated product offering.

1.2 Document Application and Limitations

Use this document as a guideline for design of the enclosures, implementation of mitigation devices, and management of the contaminants that are present in the tire and rubber industry that effect electrical and electronic devices. Following these guidelines decreases the effects of the contaminants on the electrical / electronic components.

There is no single method to minimize the effects of the contaminants. In all cases, a combination of preventive measures to reduce infiltration to the enclosures and remediation measures to remove contaminants present should be implemented. There is not a complete solution or combination of solutions that will totally prevent the effects of the contaminants and corrosive gases on the products beyond a totally sealed, air tight enclosure, which is difficult to achieve. However, the more mitigation strategies the designer / user employs, the more likely that the product will survive longer in the environment. Mitigation strategies will not stop contamination or corrosion. The goal is to slow down the effects and extend the life of the product in the environment.

Rockwell Automation recommends that on all new and retrofit installations, the user test the environment using coupons (section 3.3.1) to validate that the mitigation strategy employed has been effective and has reduced the silver and copper corrosion to a rating of G1.

See the Conformal Coating Protecting Your Automation Investment, publication IA-PP001, for information on the Rockwell Automation conformal coated product offerings.

1.3 Document Conventions

In this document various terms are used as follows:

End user – Manufacturer of tires or other rubber products and owner of the environment where the product will be utilized.

OEM – Manufacturer of machinery or process equipment that is used by the end users to process and / or assemble rubber components.

System integrator – Control system provider that specifies, designs, implements, and programs electronics or automation equipment used in the end user plant.

Solution provider – Same as system integrator.

Panel builder - Control system provider that may specify, design, and assemble electronics or automation equipment in electrical enclosures that will be placed in the end user plant.

Designer – Any panel builder, OEM, end user, or system configuration specialist

Contaminant – A dust or material that can accumulate and plug an airway for cooling or cause a short circuit on a circuit board. Generally, the most common contaminant in a tire and rubber manufacturing plant is carbon black.

Corrosive gases – A compound that attacks the copper and silver commonly found in circuit boards, electronic components, or contacts, causing corrosion-related crystal structures to form, which result in component failure or short circuits.

Corrosion Rate – An ISA standard (S71.04) designation based on the thickness, in Angstroms, of the accumulation of corroded metal on standard coupons of copper and silver. The thicker the corrosion, the harsher the environment.

2.0 Process Area Considerations

Generally, the tire and rubber industry has multiple processes required for the manufacturing of their products. These processes are not always in the same building or plant. Based on the experience of Rockwell Automation there are varying levels of contamination that can be expected in specific areas of the plant. ISA standard (S71.04) references the following ratings:

Class	Severity	Description
Class G1	Mild	Corrosion is NOT a factor in determining equipment reliability.
Class G2	Moderate	Effects of corrosion are measurable and may be a factor in determining equipment reliability.
Class G3	Harsh	High probability that corrosive attacks will occur. This harsh level should prompt further evaluation and result in environmental controls or specially designed and packaged equipment.
Class GX	Severe	Only specially designed and packaged equipment would be expected to survive. Specifications for equipment in the class GX are a matter of negotiation.

The following table shows what the expected level of contamination are and the primary contaminants.

Process Location	Machine / Process	Corrosion Risk	Contaminant Risk	Corrosive / Contaminant
Mixing	All	GX	High	Corrosive gasses, Solid contaminates, , Carbon black
Component Prep	Extruders / Calenders	GX	Medium	Corrosive gasses, Solid contaminates, , Carbon black
Component Prep	Other	G2 or G3	Medium	Corrosive gasses, Solid contaminates, , Carbon black
Tire Building	All	G2 or G3	Medium	Corrosive gasses, Solid contaminates,
Curing	All	GX	Low	Corrosive gasses, Solid contaminates, , Moisture
Conveyors	Un-cured Product (tire assembly room)	G2 or G3	Low	Corrosive gasses, Solid contaminates, , Moisture
Conveyors	Cured Product (press room)	G3 or GX	Low	Corrosive gasses, Solid contaminates, , Moisture
Conveyors	Final Finish / Test	G1	Low	Corrosive gasses, Solid contaminates, , Moisture
Test / Finish Machines	All	G1	Low	Corrosive gasses, Solid contaminates,
Material Handling	ASRS	G1	Low	Corrosive gasses, Solid contaminates,

3.0 Enclosures

3.1 Enclosure Construction

The following sections provide information on acceptable designs and construction to use for electrical enclosures installed in a tire and rubber manufacturing environment. The key factors to consider in all applications are:

- That the enclosure must be sealed to acceptable standards
- The seals are in place when the doors are closed and must remain intact over the life of the system
- The doors must not be left open for extended periods of time
- The solution can provide an acceptable environment for the electronics housed in the enclosure when the doors are closed.

Enclosing the electronics and electrical components in a sealed enclosure by itself will not help ensure that the effects of contamination or corrosion are fully mitigated. Rockwell Automation recommends that multiple mitigation strategies be employed in all situations. These include:

- Sealed enclosures
- Conformal coating of electronics
- Air conditioners / heat exchangers
- Proper installation practices
- Pressurization of the enclosure
- Corrosive gas and solid absorption devices / filters

ATTENTION: Any one of these by itself may extend the life of the electronics in the environment. Multiple strategies must be employed to achieve a G1 / G2 environment that may result in a long life for the electronic product. In addition, regular coupon testing to verify the strategies are effective is required.

3.1.1 Acceptable Standards

Enclosures installed in electrical / MCC rooms, manufactured E-houses, or other locations within the plant that house devices must maintain an environment free of conductive particle contaminants, and corrosive gases. The use of scrubbers or corrosive gas and solid absorption devices is recommended.

IMPORTANT	Rockwell Automation recommends using sealed IP54 enclosures. It is not acceptable to use IP54 (NEMA 12) enclosures that utilize dust filters and cool the inside of the enclosure by circulating external air into the enclosure via a filter rated to remove dust and other suspended particles.

IP54 is defined as:

- IP54 (NEMA 12) - Enclosures constructed (without knockouts) for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and circulating dust, lint, fibers, and flyings); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

Any enclosure that exceeds this standard is also acceptable. These include NEMA 13, 4, 4X, 6, or 6P Enclosures rated IP54 or higher (55, 62, 64, 67)

3.1.2 Construction Types

There are many electrical enclosure manufacturers globally that provide a wide array of control system enclosure types. All of the manufacturers provide some fully welded enclosures of varying sizes. All provide a version of the frame and panel type construction. Depending on the application and location either type may be acceptable.

Welded

Welded NEMA 12 / IP54 enclosures are recommended for all applications and areas within the plant. The enclosures should be made of cold rolled steel, painted with multiple layers, including corrosion resistant primer and finished with a baked-on paint (for example, enamel, polyester). Welds must be continuous on all seams, cleaned, and ground smooth prior to painting. The enclosure must have a solid bottom and top where cutouts for wire entry are made. Wire entry areas must be filled with acceptable cable / duct seals installed. (Acceptable methods to seal cable entries are defined later in this document.)

Frame and Panel

Frame and panel enclosures (modular) are constructed of steel tubing or frame pieces that are welded to provide a rigid load bearing structure. Gaskets are bolted to the side panels, tops, bottoms and doors to create an enclosure. These are popular as they are a cost effective and flexible way to build small single door enclosures up to large multi-door units. Examples of this type of enclosure are Rittal and Hoffman Proline.

IP54 rated frame and panel enclosures, Rittal, Hoffman Proline 2 or similar, are acceptable in locations where exposure to mechanical damage is not possible. These type of enclosures can suffer from bent frames or panels that result in leaks allowing contaminants to enter the enclosure continuously.

IMPORTANT In high traffic areas welded enclosures are recommended.

3.1.3 Gaskets

Gaskets must be neoprene rubber for chemical and acid / base resistance. Gaskets must be applied in a channel to help ensure that the seal remains in place.

Spray-on foam gasket material, as is used in many modular enclosure systems and some welded solutions, is acceptable as long as the enclosure is protected from mechanical damage.

3.2 Cooling

The key to extending the life of the electronics and electrical components inside of the enclosure is to help ensure the enclosure is sealed and that a method is provided to remove the heat generated by the components. Also critical with respect to temperature control, is maintaining the humidity at acceptable levels within the enclosure. Temperature and humidity affect the rate of corrosion, and if they are not properly controlled it accelerates the corrosion when the same levels of corrosive gases are present.

All enclosures must have heat calculations performed using standard tools that are provided by: Rockwell Automation, the enclosure vendor, or an air conditioner / heat exchanger vendor. After the heat calculations have been completed, the designer is required to select the appropriate dissipation method based on the heat rise and ambient location. This helps ensure that the product is performing at least 5 °C below the maximum rated operating temperature for the lowest rated product in the enclosure.

Cooling a sealed enclosure correctly by itself will not ensure that the effects of contamination or corrosion are fully mitigated. Rockwell Automation recommends that multiple mitigation strategies be employed in all situations. These include:

- Sealed enclosures
- Conformal coating of electronics
- Air conditioners / heat exchangers
- Proper installation practices
- Pressurization of the enclosure
- Corrosive gas and solid absorption devices / filters

ATTENTION: Any one of these by itself may extend the life of the electronics in the environment. Multiple strategies must be employed to achieve a G1 / G2 environment that may result in a long life for the electronic product. In addition, regular coupon testing to verify the strategies are effective is required.

As part of the decision on which heat dissipation method is used the following criteria must be considered:

3.2.1 Conductive Heat Dissipation

Conductive heat dissipation can be used if the heat generated can be effectively transmitted through the sheet metal of the enclosure. Sometimes this type of heat dissipation can be accomplished by circulating the air inside the enclosure to move the heat to the enclosure surface faster. Conductive dissipation isolates the electronics from the outside air and helps ensure a minimum infiltration of contaminants and corrosive gases to the components.

- This solution does not provide humidity control.
- This solution can be used in any location in the plant.

3.2.2 Fans

In locations where the exterior atmosphere meets a G1 rating for corrosion and has been filtered to remove contaminants, heat can be dissipated by forcing the exterior air through the enclosure. This solution does not provide humidity control.

3.2.3 Heat Exchangers

Heat exchangers can be used to remove heat when fans and conductive dissipation are not sufficient. The heat exchangers must be sealed so that exterior air is not mixed with interior air (NEMA 12 or better rating). Rockwell Automation recommends that a more robust heat exchanger be used in the system because a robust heat exchanger improves the uptime for the system. For example, units that are intended to operate in a corrosive environment should use a closed loop cooling system, such as a heat exchanger.

- This solution can be used in any location in the plant.
- This solution does not provide humidity control.

3.2.4 Air Conditioners

Closed loop air conditioners that are designed to operate in corrosive environments can be used to remove heat when fans and conductive dissipation are not sufficient. The air conditioners must be sealed so that exterior air is not mixed with interior air (NEMA 12 or better rating). The units must be non-condensing to avoid any moisture puddling in the enclosure or outside the enclosure.

- This solution can be used in any location in the plant.
- This solution provides humidity control and is designed to remove excess moisture from the environment inside the enclosure.
- Air conditioning is the preferred method for heat dissipation in the tire and rubber industry. A closed system / closed loop air conditioner must be used.

3.3 Air Purification

Air purification has been limited in the past to scrubbers for whole rooms. These rooms are typically data centers at many plants and locations both in and outside of the tire and rubber industry. This strategy is not practical in all situations. Therefore, purification devices and strategies must be developed for individual enclosures.

The air inside an enclosure has corrosive gases and contaminants no matter how well the cabinet is sealed. This is because at best, the doors are opened occasionally for maintenance. As a result, in all cases there must be a device installed inside or on the enclosure to remove contaminants and corrosive gases. This section discusses the requirements for implementation of air purification.

A different process to define design / implementation parameters when the enclosures are going into a new facility versus an existing plant / process must be used. In a new facility, the end user must provide a typical environment for the designer to consider when selecting the purification method to be used. This can be provided in the form of contaminants / corrosive parts per billion content or filtering methods employed in other plants in the same location. The designer can then determine the best mitigation strategy based on this information.

In existing locations, the end user should provide information as noted for the new location or if the end user does not know, a coupon / instrument should be installed to determine the current corrosion and contamination levels. The designer can then determine a solution.

The following defines the process and devices / strategies that can be employed to determine corrosion rates and remove airborne contaminants and corrosive gases.

Use of air purification devices by itself will not ensure that the effects of contamination or corrosion are fully mitigated. Rockwell Automation recommends that multiple mitigation strategies be employed in all situations. These include:

- Sealed enclosures
- Conformal coating of electronics
- Air conditioners / heat exchangers
- Proper installation practices
- Pressurization of the enclosure
- Corrosive gas and solid absorption devices / filters

ATTENTION: Any one of these by itself may extend the life of the electronics in the environment. Multiple strategies must be employed to achieve a G1 / G2 environment that may result in a long life for the electronic product. In addition, regular coupon testing to verify the strategies are effective is required.

3.3.1 Coupon Testing

Coupon testing involves the installation of copper and silver strips on a plastic plate for 30 days. After that period several vendors (for example, Purafil, American Air Filter) provide analysis services to determine the corrosion level. In addition, some coupons provide humidity and temperature logging. Other instruments can be utilized to collect temperature and humidity as well.

Coupon tests must be performed before a solution is installed in new enclosures or existing enclosures to determine the base line starting point. The coupons should be placed in the enclosures once installed to verify the mitigation solution is functioning to provide a G1 environment.

3.3.2 Purification Strategies

Positive Pressure

An enclosure may be pressurized to help ensure that no bad air enters the enclosure. Pressurized air must be filtered and free of contaminants or corrosive gases.

A purging cycle must be provided to remove outside air after a door is opened.

Some filtering solutions also provide a mix of outside air to provide positive pressure. It is acceptable to use these solutions as long as it can be demonstrated that the environment inside the enclosure is meeting the goal of G1.

Scrubbers

Scrubbers are intended for use in rooms where electronics are located. They are available from several vendors and are acceptable to mitigate the air in those rooms.

Temperature and humidity control are provided by other devices / systems in these rooms and also must be implemented in those rooms. Scrubbers are required in electrical rooms if a mitigation strategy is not employed on an individual enclosure.

Recommended Vendor Solutions

- Purafil – Solutions under development
  www.purafil.com
- American Air Filter – Solutions under development
  www.aafintl.com
- Others

4.0 Electrical Rooms

Installing the sealed enclosures correctly by itself will not ensure that the effects of contamination or corrosion are fully mitigated. Rockwell Automation recommends that multiple mitigation strategies be employed in all situations. These include:

- Sealed enclosures
- Conformal coating of electronics
- Air conditioners / heat exchangers
- Proper installation practices
- Pressurization of the enclosure
- Corrosive gas and solid absorption devices / filters

ATTENTION: Any one of these by itself may extend the life of the electronics in the environment. Multiple strategies must be employed to achieve a G1 / G2 environment that may result in a long life for the electronic product. In addition, regular coupon testing to verify the strategies are effective is required.

4.1 Room Construction

4.1.1 Walls and ceilings

The room construction requirements for walls and ceilings in electrical rooms are as follows:

- All walls and ceilings must be continuous with no gaps.
- All entry and exit points for wires, cables, and HVAC must be sealed.

4.1.2 Doors and Seals

The room construction requirements for doors and seals in electrical rooms are as follows:

- Doors must have self-closing devices.
- Doors must have latching mechanism that catches when closed without assistance.
- Doors must have weather seals / gaskets to help ensure minimum infiltration of plant atmosphere.
- Depending on how frequently the electrical room entry door is opened, an airlock type door for the room could be recommended.

4.2 Heating and Cooling

The HVAC system supplying the electrical room air should be sourced from a clean location when possible. Positive pressurization is preferred when a clean source is available. If a clean source is not available, then filtering and purification at the enclosure or for the entire room is required as discussed in section 4.3.

4.2.1 Fans

Dissipation of heat by running air through an electrical room can be used in locations where the exterior atmosphere has already been treated to meet a G1 rating for corrosion and filtered to remove contaminants.

This solution does not provide humidity control and temperature control is limited.

4.2.2 Air Conditioners / Heating

Air conditioners must be used to remove heat when fans are not sufficient. This solution provides humidity control as it removes excess moisture from the environment inside the room.

4.3 Air Purification

Scrubbers must be used in rooms where electronics are located. They are available from several vendors and are acceptable to mitigate the air in those rooms.

It is also acceptable to mitigate each individual enclosure if it is more cost effective in an electrical room.

The vendor must determine the most cost effective alternative based on the size of the room and the number of enclosures that require mitigation.

5.0 Installation

In all locations, the installation of the enclosure either helps ensure that the design for mitigation is successful or fails due to faulty installation practices. This section intends to provide guidance relative to best practices for installation of control panels in various locations.

Installing the sealed enclosures correctly by itself will not ensure that the effects of contamination or corrosion are fully mitigated. Rockwell Automation recommends that multiple mitigation strategies be employed in all situations. These include:

- Sealed enclosures
- Conformal coating of electronics
- Air conditioners / heat exchangers
- Proper installation practices
- Pressurization of the enclosure
- Corrosive gas and solid absorption devices / filters

ATTENTION: Any one of these by itself may extend the life of the electronics in the environment. Multiple strategies must be employed to achieve a G1 / G2 environment that may result in a long life for the electronic product. In addition, regular coupon testing to verify the strategies are effective is required.

5.1 Enclosures

5.1.1 Floor Mounted

Enclosures may be placed on the floor. No trenches or wire ways are acceptable below the enclosure. The bottom of the enclosure must be solid with no cut-outs or holes.

Conduit

The installation requirements for conduit in floor-mounted enclosures are as follows:

- Conduit wire entry must be through sealed, water tight conduit and fittings such as Sealtite.
- Side or top entry is acceptable.
- Conduit and / or fitting must be sealed with putty when gaps are present.

Wireway

The installation requirements for wireways in floor-mounted enclosures are as follows:

- Cable entry must be through sealed NEMA 12 / IP54 wireway.
- Top entry only is acceptable.
- NEMA 12 / IP54 wireway must be filled with a fire-stop sealant or caulk to prevent infiltration.

Wire / Cable Entry Systems

The installation requirements for wire and cable entry systems in floor-mounted enclosures are as follows:

- Wire / cable entry systems designed to allow entry of a single cable or wire in / out of the enclosure are the most desirable solutions.
- These include cord grips and solutions by Roxtec®, icotek®, and others as pictured below.
- Top or side entry is acceptable.

Gland Plates

The installation requirements for gland plates in floor-mounted enclosures are as follows:

- Cable gland plates typically provided by enclosure manufacturers are not acceptable, because they do not provide a sufficient seal to impede the entry of corrosive gases or contaminants. Great care must be taken to help ensure that the cable entry / exit and gland plates are sealed.
- Rockwell Automation suggests a solid enclosure floor combined with a cable management solution from Roxtec, icotek, or others.

5.1.2 Mezzanine Mounted

Enclosures may be placed on a mezzanine, but special attention must be paid to proper sealing of the enclosure. Do not place enclosures above areas where out-gassing of product increases the levels of corrosion or contamination (for example: above a curing press).

IMPORTANT	Bottom entry of conduit or wireway entry is not recommended for a mezzanine mounted enclosure. The bottom of the enclosure should be solid with no cut-outs or holes and special attention must be paid to proper sealing.

Conduit

The installation requirements for conduit in mezzanine mounted enclosures are as follows:

- Conduit wire entry must be through sealed, water tight conduit and fittings such as Sealtite.
- Side or top entry is acceptable.
- Conduit and / or fitting must be sealed with putty if gaps are present.

Wireway

The installation requirements for wireways in mezzanine mounted enclosures are as follows:

- Cable entry must be through sealed NEMA 12 / IP54 wireway.
- Top entry is acceptable.
- NEMA 12 / IP54 wireway must be filled with a fire-stop sealant or caulk to prevent infiltration.

Wire / Cable Entry Systems

- The installation requirements for wire and cable entry systems in mezzanine-mounted enclosures are as follows: Wire / cable entry systems designed to allow entry of a single cable or wire in / out of the enclosure are the most desirable solutions.
- These include cord grips and solutions by Roxtec, icotek, and others.
- Top or side entry is preferred.
- Bottom entry is acceptable, depending on the location. If bottom entry is used, the enclosure should not be installed above any equipment that will expel corrosive gases or contaminants (for example: above a curing press).

Gland Plates

The installation requirements for gland plates in mezzanine-mounted enclosures are as follows:

- Cable gland plates typically provided by enclosure manufacturers are not acceptable, because they do not provide a sufficient seal to impede the entry of corrosive gases or contaminants. Great care must be taken to help ensure that the cable entry/exit and gland plates are sealed.
- Rockwell Automation suggests a solid enclosure floor combined with a cable management solution from Roxtec, icotek, or others.

5.1.3 Electrical Room

Enclosures may be placed in an electrical room. Bottom entry of conduit or wireway entry is acceptable via wire trough if the wire trough is sealed at entry points to the room. If the wire trough is sealed, then openings or gland plates are acceptable.

Conduit

The installation requirements for conduit in electrical room enclosures are as follows:

- Conduit wire entry must be through sealed, water tight conduit and fittings such as Sealtite.
- Side or top entry is acceptable.
- Conduit and / or fitting must be sealed with putty if gaps are present.

Wireway

The installation requirements for wireways in electrical room enclosures are as follows:

- Cable entry must be through sealed NEMA 12 / IP54 wireway.
- Top entry is acceptable.
- NEMA 12 / IP54 wireway must be filled with a fire-stop sealant or caulk to prevent infiltration.

Wire / Cable Entry Systems

The installation requirements for wire and cable entry systems in electrical room enclosures are as follows:

- Wire / cable entry systems designed to allow entry of a single cable or wire in / out of the enclosure are the most desirable solutions.
- These include cord grips and solutions by Roxtec, icotek, and others.
- Top, side, or bottom entry is acceptable.

Gland Plates

The installation requirements for gland plates in electrical room enclosures are as follows:

- Cable gland plates typically provided by enclosure manufacturers are acceptable if the wire trough below the cabinet is sealed where it enters the electrical room.

6.0 Recommendation Matrix by Process Area / Location

The following matrix is provided as a general guideline for reference. The previous sections provide details relative to panel construction, corrosion, and contaminant mitigation. Those sections should be used as reference when executing a mitigation strategy. The columns are defined as follows:

- Process Location – Functional area of the plant.
- Recommended Minimum Panel Rating – Minimum NEMA or IP rating for an enclosure to be placed in the process area. In all cases, the minimum recommended rating of a control panel placed on the plant floor is NEMA 12 / IP 54 with the wireways, conduits, and other entry points sealed.
- Corrosion Mitigation Required – A device required in or on the enclosure to remove corrosive gases from the air inside the enclosure.

IMPORTANT The device is required to achieve a G1 ISA corrosion rate.

- Contaminant Mitigation Required – A device required inside the enclosure to remove carbon black, moisture, or other airborne contaminants.
- Corrosive / Contaminant – The prevailing corrosives and contaminants typically seen in the process location.

Process Location	Recommended Minimum Panel Rating	Corrosion Mitigation Required	Contaminant Mitigation Required	Corrosive / Contaminant
Mixing	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Carbon black
Component Prep – Extruders / Calenders	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Carbon black
Component Prep	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Carbon black
Tire Building	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates
Curing	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Moisture
Conveyors – Uncured Tires	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Moisture
Conveyors – Cured Tires	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Moisture
Conveyors – Finish Area	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Moisture
Test / Finish Machines	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates
Material Handling	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates
Electrical Room without scrubber	NEMA 12 / IP54	Yes	Yes	Corrosive gasses, Solid contaminates, and Carbon black
Electrical Room with Scrubber (assumes the room provides a G1 corrosive environment rating)	NEMA 1 / IP20	No (not in the enclosure. The room scrubber should provide the required G1 rating)	No	N/A assumes that corrosive gasses, Solid contaminates, and Carbon black have been properly filtered by the scrubber.

7.0 Recommended Inspection and Maintenance

After implementing remediation on an existing enclosure or installation of a new enclosure using these guidelines, a maintenance plan needs to be put in place for the enclosures and the devices that have been installed to protect the equipment. The maintenance plan needs to focus on the key elements of the recommendations made in this document. This plan should be put in place immediately and kicked off with a post installation inspection.

Key elements to inspect, maintain, and repair are:

- Overall cabinet construction and condition – Regularly inspect for dents, bent / dented doors, bent / dented side and top panels, that door latches are operating, and gaskets are clean and sealing properly. This should be done per the manufacturer's recommendations.
- Air conditioners / Heat exchangers – Inspect that fans are still operational, air flow is good, compressors and condensers are still operating properly, check for dents or broken seals, and finally that nothing is plugged or blocked in the heat exchangers, coils, or air ducts. These steps should be performed per the manufacturer's recommendations.
- Filters and corrosive gas mitigation devices – Inspect that the fans are still operational, air flow is good, check for dents or broken seals, and finally that nothing is plugged or blocked in air ducts. Regularly replace the filters and corrosive gas removal devices. These steps should be performed per the manufacturer's recommendations.
- Cable entry seals – The cable entry system should be inspected for cuts, tears, and openings per the manufacturer's recommendations.

See Preventive Maintenance of Industrial Control and Drive System Equipment, publication DRIVES-TD001, for general references on conducting maintenance on any enclosure.

In addition, to regular maintenance and inspections on the above items, the enclosure(s) should be tested periodically using coupons (as described in section 3.3.1) or instrumentation per recommendations from American Air Filter, Purafil, or other vendors who provide filtration devices.

Appendix A Tire and Rubber Enclosure Audit

Control Systems Enclosure Audit for the Tire and Rubber Industry

Auditor Name _____ Date _____

Plant Location _____

Machine Name _____

Machine Location _____

OEM or Panel Builder Name _____ Date _____ Enclosure Label _____

Cabinet Model _____ Cabinet Location (*columns x & y*) _____

Pass/Fail Status _____

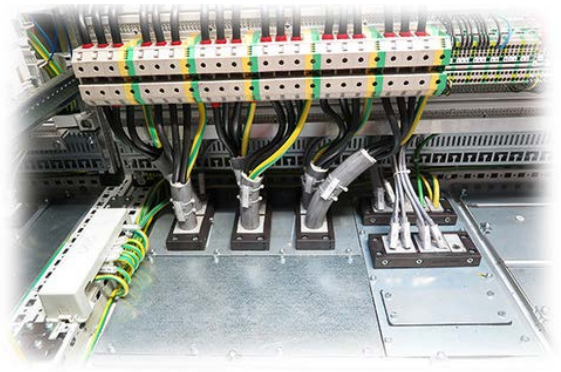
Instructions

- Perform this audit after the enclosure is placed in the final mount location, all wires are routed into the cabinet, and any other installation has been completed.
- Use columns A, B, and C to indicate Pass, Fail, or Not Applicable (N/A) for the criteria this audit lists.
    - If the enclosure under audit meets the criteria statement, the auditor indicates a "Pass" with a check mark.
    - If any part of the enclosure under audit does not meet the criteria statement, the auditor indicates a "Fail" with a check mark.
    - If the criteria statement does not apply to the enclosure under audit for any reason, the auditor indicates "Not Applicable" with a check mark.
- Add pictures and notes where a "Fail" or "N/A" is indicated. If doubt about compliance to the criteria statement(s) exist, take pictures and add notes related to the criteria statement(s) in question.

	Enclosure Compliance Criteria	*Pass*	*Fail*	*N/A*
1.	Enclosure meets or exceeds the IP54/NEMA 12 enclosure rating and does **not** circulate external air into the enclosure. Please indicate the style of enclosure used below: ☐ Welded Frame (Go to #2, skip #3) ☐ Frame and Panel (Go to #3, skip #2) Notes and Pictures:			
2.	**Welded Frame Only** **Enclosure Must Meet all of The Following Criteria to Pass:** ☐ Welds are continuous on all seams, cleaned, and ground prior to painting. ☐ There are no bends, dents, or other damage to any part of the enclosure. ☐ Enclosure is made of cold rolled steel, painted with multiple layers, including corrosion resistant primer, and finished with a baked-on paint (for example, enamel, polyester). ☐ The enclosure has a solid bottom and top. ☐ Gland plates are sealed. Notes and Pictures:			
3.	**Frame and Panel Only** **Enclosure Must Meet all of The Following Criteria to Pass:** ☐ Enclosure must be Rittal, Hoffman, Proline 2, or similar. ☐ There are no bends, dents, or other damage to any part of the enclosure. ☐ Enclosure is **not** exposed to potential mechanical damage from moving vehicles such as, tow motors, fork trucks, or carts. ☐ The enclosure top and bottom are solid plates. ☐ Multi-piece gland plates must be sealed. ☐ All gaskets are applied in a channel to help ensure the seal remains in place. Notes and Pictures:			
4.	Cable entry/exit are sealed, using cord grips, grommets, or fittings. Notes and Pictures:			
5.	Unused cable cut-outs are plugged and sealed. Notes and Pictures:			
6.	Conduit and wire way entries are sealed with a sealing compound such as Fire Block, Killark, Ideal, or Gardner Bender. Silicone based sealants are **not** used. Notes and Pictures:			
7.	Enclosure doors have seal integrity when closed. Notes and Pictures:			
8.	The enclosure doors have a lockable mechanism. Notes and Pictures:			

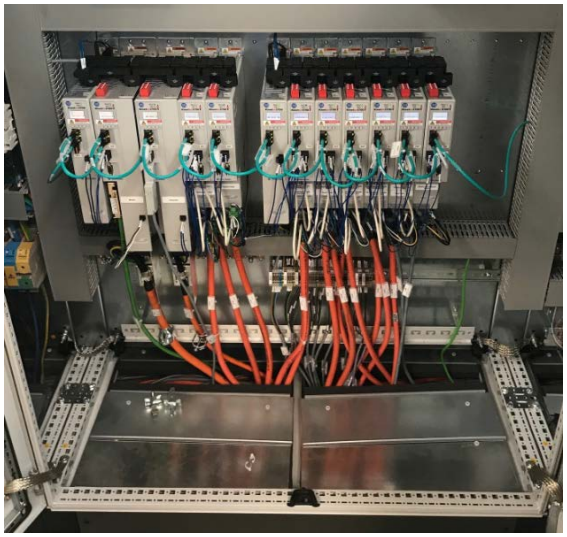
	Enclosure Compliance Criteria	*Pass*	*Fail*	*N/A*
9.	Enclosure doors are closed at the time of inspection. Note and Pictures:			
10.	The gaskets consist of neoprene rubber for chemical and acid / base resistance. Silicone based foams, sealants, or gaskets are **not** used. Notes and Pictures:			
11.	All gaskets are applied in a channel to help ensure the seal integrity. Notes and Pictures:			
12.	The heat dissipation calculations have been performed and are documented. Notes and Pictures:			
13.	Fans, filters, and louvers that would allow external air to mix with internal air of the enclosure are **not** used. Notes and Pictures:			
14.	Cabinet utilizes sealed or closed loop cooling methods such as heat exchangers, panel mounted air conditioning units, or central cooling methods. The cooling methods used must be installed and sealed so that external air ingress is **not** possible. Notes and Pictures:			
15.	There are no visible signs of corrosion, contamination, carbon black, slurry, dust, metal shavings, water, or oil inside cabinet. Notes and Pictures:			
16.	Conformal Coated electronics are used. Notes and Pictures:			
17.	The minimum mounting clearances are met for each product in the enclosure. Cooling fans integrated into the electronics are **not** blocked. Electronics are **not** zero stacked vertically. Notes and Pictures:			

BEST PRACTICE ENCLOSURE DESIGNS



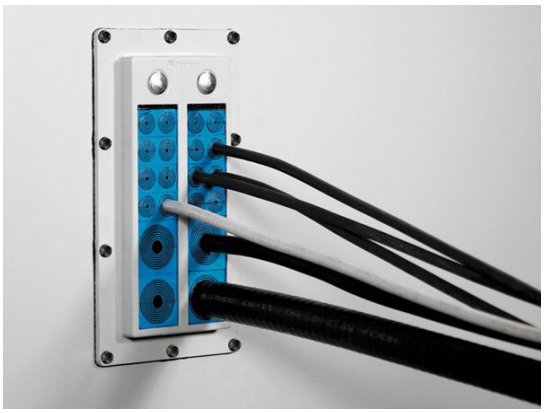
The enclosures shown have a solid bottom, sealed gland plates, and sealed cord grips in order to prevent corrosive gases and contaminates from entering the enclosure.

COMMON ENCLOSURE DESIGN FLAWS



The enclosure bottom and gland plates shown above are not sealed from external air; missing or broken seals make the enclosure susceptible to ingress of corrosive gases and contaminates.

BEST PRACTICE ENCLOSURE DESIGNS



The cable entry points shown, are sealed with cord grips or sealed fittings to protect the electronics on the interior of the enclosure. Unused cord fittings are sealed.

COMMON ENCLOSURE DESIGN FLAWS

Shown are unused cable cutouts that are not plugged and sealed. Also, the used cable entry is not sealed tight around the cable. These installation flaws allow corrosive gasses and contaminates into the enclosure and negatively impact the lifecycle of your electronics.

BEST PRACTICE ENCLOSURE DESIGNS

The cabinet doors shown above have seal integrity when the doors are closed.

COMMON ENCLOSURE DESIGN FLAWS

These cabinet doors have been damaged and no longer have seal integrity when closed. Broken seals allow corrosive gases and contaminates into the enclosure.

BEST PRACTICE ENCLOSURE DESIGNS

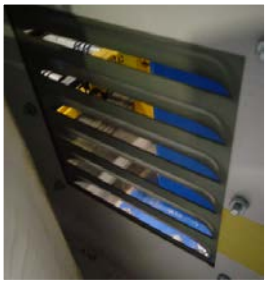
In the image on the left, the air conditioner is a closed loop design that prevents the corrosive / contaminated external air from circulating into the internal air of the enclosure.

In the image on the right, an externally mounted heat exchanger (mounted on the upper left of cabinet) is used to cool the enclosure.

Also in the image on the right, the filter (installed the bottom right of the cabinet) is part of a sealed channel cooling system that does not allow any external air into the cabinet.

Cooling can be designed in multiple ways, the images above are examples of best practice cooling methods. The critical element is not to mix corrosive external air with clean internal air.

COMMON ENCLOSURE DESIGN FLAWS

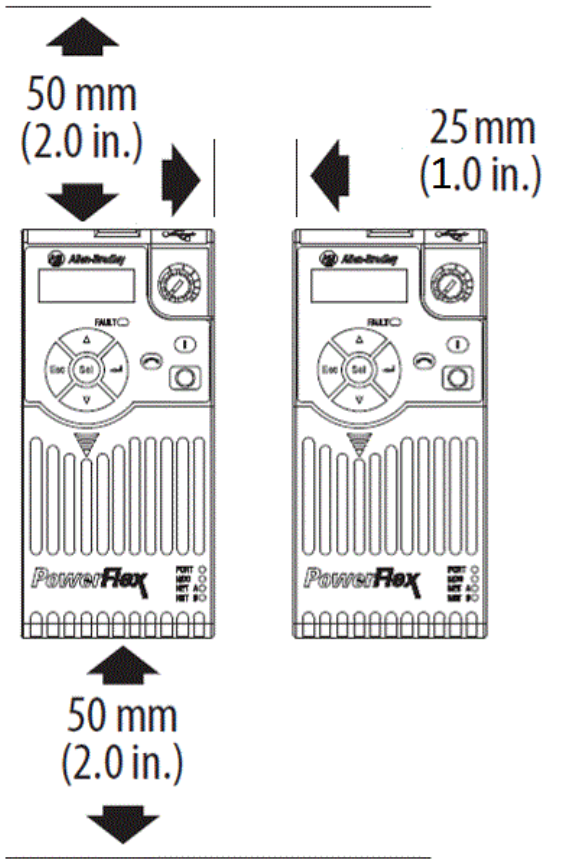


The louvers and fans shown allow external air to circulate inside the enclosure which allows corrosive gases and contaminates into the enclosure.

Fan-filter kits do not prevent corrosive gases or contaminants from entering the enclosure.

Enclosure doors should not be open unless there is active maintenance being performed.

BEST PRACTICE ENCLOSURE DESIGNS



An example of a mounting clearance description is shown. See PowerFlex 520-Series Adjustable Frequency AC Drive, publication 520-UM001, for more information on PowerFlex mounting clearances and mounting variations.

Always refer to the installation instructions from your product manufacturer for minimum mounting clearances and other mounting requirements.

COMMON ENCLOSURE DESIGN FLAWS

The drives shown do not follow the minimum mounting clearances. In order to achieve the longest life and highest reliability of the drives and all electronics, the minimum mounting clearances should be followed.

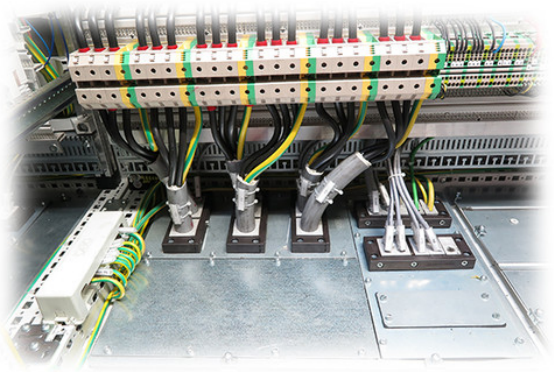
BEST PRACTICE ENCLOSURE DESIGNS

The plenum of the enclosure shown is completely intact and sealed to prevent ingress of corrosive gases and contaminates.

COMMON ENCLOSURE DESIGN FLAWS

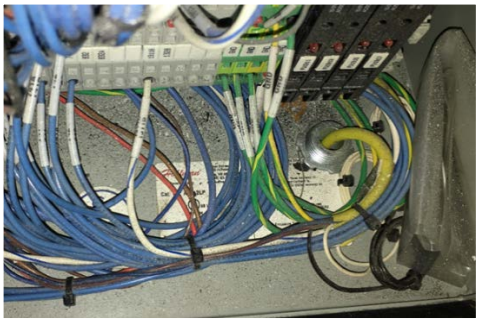
The plenum shown on the bottom of the cabinets are cut out and not sealed. Enclosures with openings that allow outside air to ingress the cabinet are susceptible to the corrosive and contaminated environment.

BEST PRACTICE ENCLOSURE DESIGNS



The enclosure shown is clean without any signs of carbon black, dust, dirt, slurry, water, metal shavings, or oil.

COMMON ENCLOSURE DESIGN FLAWS



These pictures show dust, slurry, carbon black, metal shavings, and water contaminates that have penetrated the enclosure. This occurs because of ineffective sealing to holes or openings, doors being left open, and other mechanical damage to the enclosure.

Appendix B Enclosure Specifications and Requirements

The following information may be attached to a Tire Manufacture's RFQ or Purchase Order to a machine supplier, panel builder, or system integrator to help ensure that the supplier follows the recommendations presented in this document.

B.1 Enclosure Construction

- All enclosures shall meet or exceed IP54. IP54 design that circulates external air through IP54 rated filters is NOT acceptable. These include enclosures rated IP55, IP62, IP64, IP67, for example.
- All cable entry points shall be designed to use cord grips or cable entry management systems that seal each cable or conductor to meet or exceed an IP54 rating.
- All conduit / wire way entries shall be designed to be sealed with fire block or other conduit seal compound.
- Silicon based sealants shall not be used.

B.2 Welded

- Welded IP54 / NEMA 12 enclosures are acceptable for all applications and areas.
- Enclosures shall be made of cold rolled steel, painted with multiple layers, including corrosion resistant primer and finished with a baked-on paint (for example, enamel, polyester).
- Welds must be continuous on all seams, cleaned, and ground smooth prior to painting.
- The enclosure must have a solid bottom and top.

B.3 Frame and Panel

- IP54 rated frame and panel enclosures, Rittal, Hoffman Proline 2, or similar, are acceptable in locations where exposure to mechanical damage from moving vehicles such as, tow motors, fork trucks, or carts is not possible.
- The enclosure must have solid plates installed on the top and bottom.
- Solid is preferable. Multi piece gland plates may be acceptable as long as they are properly sealed.

B.4 Gaskets

- Gaskets must be neoprene rubber for chemical and acid / base resistance. Gaskets must be applied in a channel to help ensure that the seal remains in place.
- Spray-on foam gasket material, as is used in many modular enclosure systems and some welded solutions, is acceptable if it is a material rated for corrosive gas rich environments.
- Silicone rubber based gasket material shall not be used.

B.5 Cooling

- Heat calculations must be performed and submitted with approval drawings for each enclosure.
- Acceptable cooling methods for include:
    - Conductive heat dissipation shall be used if the heat generated can be effectively transmitted through the sheet metal of the enclosure.
    - Heat exchangers or air conditioners shall be used to remove heat when conductive dissipation is not sufficient. The heat exchangers / air conditioners must be sealed so that air external to the enclosure is not mixed with internal air.
    - Heat exchanger / air conditioners shall be conform coated IP66 / NEMA 4 versions of these units.

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	https://rockwellautomation.custhelp.com/
Local Technical Support Phone Numbers	Locate the phone number for your country.	http://www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	http://www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	http://www.rockwellautomation.com/global/literature-library/overview.page
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	http://www.rockwellautomation.com/global/support/pcdc.page

Documentation Feedback

Your comments will help us serve your documentation needs better.
If you have any suggestions on how to improve this document, complete the How Are We Doing? form at
http://literature.rockwellautomation.com/idc/groups/literature/documents/du/ra-du002_-en-e.pdf

Rockwell Automation maintains current product environmental information on its website at http://www.rockwellautomation.com/rockwellautomation/about-us/sustainability-ethics/product-environmental-compliance.page.

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Publication TIRE-RM001C-EN-P - September 2018
Supersedes Publication TIRE-RM001B-EN-P – April 2017