White Paper

August 2014

Environmental Protection of Control Panels

Overview and Standards Compliance

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Introduction

End users rely on a control panel enclosure to protect vital controls and the control panel infrastructure, and eliminate unnecessary risks of downtime or personnel injury. Several environmental factors such as corrosive environments, substance infiltration (e.g., water, dust and oil), electrical noise, and temperature, can have a harmful effect on a control panel. These harmful factors can cause excessive maintenance, costly downtime, or loss of critical systems.

When selecting a control panel infrastructure, it is important to understand the factors relevant to the specific application such as ingress requirements, the ambient environment including the temperature, whether any chemicals are present, and the occurrence of Electromagnetic Interference (EMI), and corresponding standards. Determining whether the control panel will be used in an indoor or outdoor application relies on the evaluation of these factors.

This white paper is the first of three papers that will collectively address the environmental protection of control panels. It also serves as a broad introduction covering the relevant standards associated with environmental protection. The second white paper will discuss challenges and provide best practice solutions for indoor and washdown environmental issues and the third white paper will discuss challenges and best practices for outdoor environmental issues.

Environmental Factors

Environmental elements that have a harmful effect on control panel reliability and performance include human interaction, substance infiltration, washdown, temperature, ultraviolet (UV) rays, and corrosive environments.

Human Interaction

The most basic level of environmental protection is to keep the equipment inside the control panel enclosure separate from human interaction on the outside of the enclosure to ensure personnel and equipment safety. Some human interaction with control panels is required, such as during the initial population of the enclosure or by service technicians after the control panel is operating. Unsafe personnel contact with electrical devices involving dangerous voltages caused by factors such as arc flash, battery acid, and mechanical moving parts can result in injury or death.

Substance Infiltration

Substance infiltration is usually focused on keeping water, snow, dust, oils, etc. outside of the control panel and away from the electronic equipment contained inside the enclosure.

Washdown

Washdown environments can involve high pressure water, high temperature water and abrasive cleaning agents. Additionally, a unique challenge in washdown environments is the high frequency with which the control panels might be subjected to washdown, which often occurs several times a day.

Temperature

Temperature can contribute to an entire range of problems for electronic devices, therefore heat should be controlled and maintained within the active electronics guidelines specified by the manufacturer. There are two different temperatures to consider:

- **Load temperature** is generated inside the enclosure by heat load from active devices inside or from solar load or other sources acting on the control panel enclosure
- **Ambient temperature** is the temperature in which the control panel is operating

The difference between these two temperatures can produce factors that will both create challenges and provide solutions.

Temperature differential can cause condensation. When the temperatures inside and outside the enclosure cross the dew point, condensation is created, potentially causing corrosion inside the control panel and to the electronic devices.

Ultraviolet (UV) Rays

Ultraviolet (UV) light rays from the sun or other sources can degrade enclosure finishes and materials over time.

Corrosive Environments

A corrosive environment can include areas where any combination of salt spray, chemicals, or high humidity is present in the air. Areas with high UV rays or galvanic action, which occurs when two dissimilar metals with a high galvanic potential difference come in contact with one another and moisture is present, will accelerate the rate of corrosion. A more active material such as magnesium will have a higher corrosion potential than a less active material such as gold. A good practice is to keep the galvanic potential difference to less than 0.25 V.

The level of corrosion potential in the area of use is critical to the material choices made for enclosures and has a direct impact on the overall performance of the enclosure. See Table 1.

Table 1. Recommended Materials for Corrosive Environments

	SOLVENTS	ALKALIS	ACIDS
RECOMMENDED	• Type 304 stainless steel • Type 316 stainless steel • Fiberglass (compression molded) • Aluminum • Polyester	• ABS • Polyester • Type 304 stainless steel	• ABS • Polyester • Polycarbonate • Fiberglass (spray-up) • Type 304 stainless steel • Type 316 stainless steel
SATISFACTORY	• Steel (polyester powder coat) • Fiberglass (spray-up) • Polycarbonate • ABS	• Type 316 stainless steel • Polycarbonate • Fiberglass (compression molded) • Fiberglass (spray-up)	• Fiberglass (compression molded)
LIMITED USE		• Aluminum • Steel (polyester powder coat)	• Aluminum • Steel (polyester powder coat)

Specifying the Enclosure

Designing for a control panel environment involves the evaluation of the following elements to ensure proper control panel performance: sealing, material, finish, design features, EMI/RFI and thermal management.

Sealing

Gaskets are mechanical devices that provide a leak-tight seal between two slightly irregular mating surfaces, such as an enclosure and its doors and accessories. In many indoor and outdoor applications, a properly mounted, well-performing gasket is critical to the protection of sensitive electrical and electronic equipment inside the enclosure. While gaskets primarily exclude the external environment such as dust, dirt, water, Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI), from entering an enclosure - they can also be used to contain noise (See the *Noise Mitigation for Control Panels – Managing Electromagnetic Interference Risks* white paper) or other forms of interference generated from internal components.

Material

Gasket material types range from a liquid, two-part mixed foam that can provide a continuous seal once cured, to an open cell strip gasket that is cut into lengths and applied to the enclosure with adhesive.

Environmental elements can have a significant impact on how an enclosure will perform over years of operation. For example, a fiberglass enclosure exposed to direct sunlight for several years will likely experience fiberbloom, (surface erosion, which reduces gloss and increases surface roughness) and a mild steel enclosure will rust in wet or corrosive environments. Other considerations when choosing enclosure material should be price, aesthetics, thermal properties, weight and strength, and the ease with which modifications such as drilling holes can be made to the enclosure.

Finish

Applying the appropriate enclosure finish can considerably improve the enclosure's ability to withstand certain environments. For example, unfinished mild steel will rust immediately, while a mild steel enclosure with an application of powder coat paint can perform very well in many ambient environments. In addition to withstanding the ambient environment, finishes can contribute to other factors of control panel performance such as aesthetics and thermal management. However, materials such as stainless steels and composites do not require additional finish properties to improve the ability to withstand specified environments. Some finishes may serve other purposes such as providing a texture offering less contaminant crevices to make cleaning easier.

Design Features

Specific features can be employed to help a control panel enclosure perform in different environments. These design features might be a drip shield installed over an enclosure door that will have frequent access and will be in an environment with falling liquid, or a flange angled to eliminate standing water near a sealing area.

EMI / RFI

Electromagnetic compatibility (EMC) is the ability of a machine or other electrical device to operate in an electromagnetic environment, often using the technology of shielding or preventing EMI. In sensitive EMI situations, proper EMC shielding around control panel ingress points and proper enclosure material selection can mitigate EMI/RFI issues. See the *Noise Mitigation for Control Panels – Managing Electromagnetic Interference Risks* white paper for more information on this topic.

Thermal Management

Control panels that are in a very hot ambient environment and have active components generating a high amount of heat commonly need to use an air conditioner to maintain a safe thermal level. Cold environments where there is no continuously active electrical equipment may need a heater to maintain a warm, safe operating temperature. Thermal solutions in between these two environments include:

- *Finish* – Reflecting solar energy
- *Solar Shielding* – Insulating from solar heat load with a "false" top
- *Natural Convection* – Removing heat load in sealed and unsealed enclosures to dissipate heat being generated. See Figure 1.
- *Forced Convection* – Same as Natural Convection with the exception of additional fans that improve heat dissipation from the control panel by as much as 10 percent. See Figure 2.
- *Air Conditioner* – Cooling electronics with an external air conditioner system when sensitive electronics need to be sealed off from the environment (dirt, corrosive air, rain, temperature, humidity, etc.). See Figure 3.

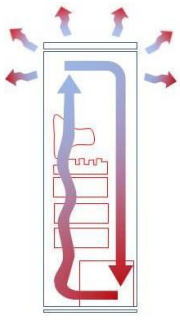

Figure 1. Natural Convection

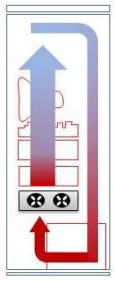

Figure 2. Forced Convection

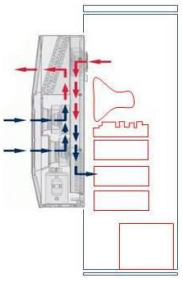

Figure 3. Air Conditioner

See Appendix III for challenging environmental factors and the potential solutions based on environmental standards provided by NEMA, UL, CSA and IEC.

Ingress Requirements

The ingress requirement is the ability level of the enclosure to keep substances and EMI out of the enclosure. Ingress ratings specify the type and amount (if any) of a substance allowed in an enclosure under normal operating conditions. Typical substances include dust/dirt, water/liquids, and human fingers.

There are also enclosure requirements to allow control panel access by technicians or by wires or other devices needing entry. This requirement is known as functional ingress.

There are two types of functional ingress:

- *Permanent Functional Ingress* – Provides wire or cable access; usually solved with external access ports using solutions such as USB Coupler Modules

- *Sealed Entry Points* – Maintain the enclosure type rating; active equipment inside remains protected.
- *Temporary Functional Ingress* – Provides convenient access to the control panel; easy and reliable enclosure applicable gasketing, hinging and latching.

Not All Standards Are Created Equal

Global standards ensure a minimum level of design and performance requirements for enclosures and control panels, and separate them into two main categories, “for use in non-hazardous locations” and “for use in hazardous locations.”

With the complexities of a global economy, design engineers must understand the global standards related to control enclosures. These standards include UL50, UL508A, IEC 60529, CSA, NFPA79, NEMA 250, MICE-TIA 1005/568C, UL 867, and IEC 61439. For enclosures in hazardous environments, standards such as IEC 60079 and NEC 500/505 may apply along with other regional standards such as ATEX, GOST, INMETRO, PESO, and KOSHA. The latest version of the standard should always be used when designing equipment enclosures. See Table 2 for the most common North American and global enclosures/control panel standards for non-hazardous and hazardous locations.

Table 2. North America vs Global Electrical Safety Standards Relating to Control Panels

	North America Standards	Global Standards
Non-Hazardous	NFPA 79 NEMA 250 UL 50, 50E, 508, 508A CSA C22.2 No. 14, 17, 94.1, 94.2	IEC 60529 IEC 62208 IEC 60204 IEC 61439
Hazardous	NEMA 250 NFPA 70 (NEC Class & Divisions) UL 1203, 60079, 698A ISA 12.12.01	IEC 60079

NEMA 250, NFPA and IEC non-hazardous location standards allow for manufacturer self-declaration of product compliance to the standard. Other standards such as UL and CSA require testing to be conducted at an authorized test lab, and final agency approval is required along with continual factory and product inspections. These standards should be primary when considering the human factors and protecting personnel.

Environmental Type Ratings

The two main environmental type ratings systems are NEMA in the US and IP for most of the rest of the world.

- For NEMA Type ratings see Appendix I
- For IP Type ratings see Appendix II

Indoor and Outdoor Use Standards

The standards further segregate enclosures/control panels into “Indoor Use” and “Outdoor Use”, and typically have ratings systems (i.e., Type 12, Type 4 for NEMA, UL, and CSA and IP55, IP66 for IEC). The ratings systems also determine the level of human/tool access protection, dust protection, and liquid protection. See Appendix I for CE and IEC Classifications and a comparison between UL/CSA/NEMA Type Ratings and IEC IP Ratings.

ANSI/TIA-1005-A Telecommunications Infrastructure Standard for Industrial Premises

This standard specifies telecommunications cabling to support industrial premises applications (e.g., voice, data, text, video, industrial and building controls, security, fire alarm, imaging) while allowing for exposure to the wide range of environmental conditions expected in industrial premises (e.g., temperature, humidity, electrical noise, shock, vibration, corrosive gases, dust, liquids). It is important that a control panel design standard references a methodology for determining the plant environmental conditions and planning an equipment strategy.

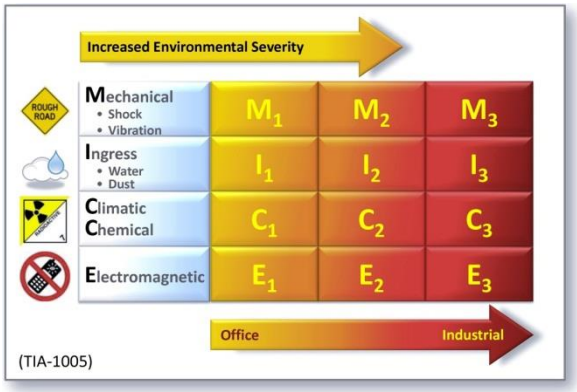

Figure 4. The TIA-1005 M.I.C.E. matrix defines environmental classes in three levels and four parameters.

"Section 4 Industrial Areas" defines industrial premises cabling areas from front office, factory floor, work and automation island areas. This section uses the Mechanical, Ingress, Climatic/Chemical, and Electromagnetic (M.I.C.E.) classification system to describe the severity of environmental parameters typically found and provides a summary of functional design considerations. See Figure 4.

"Section 5.2.3 Industrial Equipment Enclosure" provides guidance and mandatory criteria on application, interior provisioning, location, door, vibration and shock, and HVAC systems. It refers to TIA TSB-185, the TIA Telecommunications Systems Bulletin, and Environmental Classification (M.I.C.E.) Tutorial which provides detailed information on the M.I.C.E. environmental classification system, including examples.

Standards Relevant to Enclosure Design and Deployment

UL 50

UL 50, issued by Underwriters Laboratories, is the safety standard for Enclosures for Electrical Equipment, Non-Environmental Considerations. The standard applies to enclosures for electrical equipment intended to be installed and used in non-hazardous locations in accordance with the Canadian Electrical Code (part 1, CSA C22.1), relevant sections of the National Electrical Code (NFPA 70) and the provisions of Mexico's Electrical Installations (NOM-001-SEDE). The safety standard applies to the following enclosures used in indoor locations: Types 1, 2, 5, 12, 12K and 13 and the following enclosures used in indoor and outdoor locations: Types 3, 3R, 3S, 4, 4X, 6 and 6P. This standard should be consulted in conjunction with UL 50E which addresses Environmental Considerations.

UL 508A

UL 508A is the safety standard for Industrial Control Equipment. The requirements cover industrial control devices, and accessory devices for starting, stopping, regulating, controlling or protecting electric motors. The requirements also cover industrial control devices or systems that store or process information and are provided with an output motor control function. The equipment is designated for use in ordinary locations in accordance with the National Electrical Code, NFPA 70.

Other related UL standards apply to specialized control panels such as UL 845 for Motor Control Centers and UL 698A for Industrial Control Panels Relating to Hazardous (Classified) Locations.

NFPA 79

NFPA 79, Electrical Standard for Industrial Machinery is the code that applies to industrial machinery safety and is aligned with the National Electrical Code (NFPA 70) and Electrical Safety in the Workplace (NFPA 70E). The requirements of NFPA 79 apply to electrical/electronic equipment, apparatus or systems supplied as part of industrial machines operating from a nominal voltage of 600 V or less, and commencing at the point of connection of the supply to the electrical equipment of the machine.

IEC 60529 entitled Degrees of Protection Provided by Enclosures (IP Code)

The standard applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV. The standard gives definitions for degrees of protection provided by enclosures for electrical equipment regarding protection of persons against access to hazardous parts inside the enclosures, and protection of the equipment inside the enclosure against ingress of both particulate matter and water.

IEC 61439 entitled Low-voltage Switchgear and Control Gear Assemblies

This standard is divided into several parts. Part 1 is sub-titled 'General Rules', lays down definitions, states the service conditions, construction requirements, technical characteristics and verification requirements for low voltage switchgear and control gear assemblies. The standard has to be used in conjunction with other parts of the series to assess conformity.

Conclusion

Protecting the control panel from environmental elements that could adversely affect operations is an important consideration when selecting an enclosure and control panel infrastructure. During the selection process, it is crucial to understand factors such as environmental factors, specifying the enclosure, ingress requirements, and standards compliance to achieve proper environmental protection of control panels. Together, Panduit and Pentair leverage their solutions to provide the control panel optimization best practices that can benefit customers by addressing their control system needs to ensure peak performance, productivity and equipment longevity. The enclosure and panel infrastructure to the environment is vital to provide maximum equipment protection, safety, performance and a long lifecycle.

Appendix I NEMA / UL / CSA Type Ratings

INDOOR OUTDOOR INDOOR and OUTDOOR

Type	NEMA	UL	CSA
Type 1	Provides a degree of protection against contact with the enclosed equipment or locations where unusual service conditions do not exist.	Provides protection against contact with the enclosed equipment and against a limited amount of falling dirt.	General purpose enclosure. Protects against accidental contact with live parts.
Type 12	Provides a degree of protection against dust, falling dirt and dripping noncorrosive liquids.	Provides a degree of protection against dust, dirt, fiber flyings, dripping water and external condensation of noncorrosive liquids.	Provides a degree of protection against circulating dust, lint, fibers and flyings; dripping and light splashing of noncorrosive liquids; not provided with knockouts.
Type 12K	Enclosures with knockouts provide a degree of protection against dust, falling dirt and dripping noncorrosive liquids.	Provides a degree of protection against dust, dirt, fiber flyings, dripping water and external condensation of noncorrosive liquids.	Provides a degree of protection against circulating dust, lint, fibers and flyings; dripping and light splashing on noncorrosive liquids; not provided with knockouts.
Type 13	Provides a degree of protection against dust, spraying of water, oil and noncorrosive coolant.	Provides a degree of protection against lint, dust seepage, external condensation and spraying of water, oil and noncorrosive liquids.	Provides a degree of protection against circulating dust, lint, fibers and flyings; seepage and spraying of noncorrosive liquids, including oils and coolants.
Type 3	Provides a degree of protection against windblown dust, rain and sleet; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against windblown dust and windblown rain; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against rain, snow and windblown dust; undamaged by the external formation of ice on the enclosure.
Type 3R	Provides a degree of protection against falling rain and sleet; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against falling rain; undamaged by the formation of ice on the enclosure.	Indoor or outdoor use; a degree of protection against rain and snow; undamaged by the external formation of ice on the enclosure.
Type 3RX	Provides a degree of protection against corrosion, falling rain and sleet; undamaged by the formation of ice on the enclosure.	Not specifically defined.	Not specifically defined.
Type 4	Provides a degree of protection against windblown dust and rain, splashing water and hose directed water; undamaged by the formation of ice on then enclosure.	Provides a degree of protection against falling rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against rain, snow windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure.
Type 4X	Provides a degree of protection against corrosion, windblown dust and rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against falling rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure; resists corrosion.	Provides a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure; resists corrosion.
Type 6	Occasional submersion is encountered; limited depth; undamaged by the formation of ice on the enclosure.	Provides a degree of protection against entry of water during temporary submersion at a limited depth; undamaged by the external formation of ice on the enclosure.	Provides a degree of protection against the entry of water during temporary submersion at a limited depth. Undamaged by the external formation of ice on the enclosure; resists corrosion.

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- This material is reproduced with permission from Underwriters Laboratories Inc. Enclosures for Electrical Equipment, UL 50, 50E and Industrial Control Panels, UL 508A.
- This material is reproduced with permission from the Canadian Standards Association.
- Underwriters Laboratories Inc. (UL) shall not be responsible for the use of or reliance upon a UL Standard by anyone. UL shall not incur any obligation or liability for damages.
- Some enclosures may have multiple ratings.

Appendix II – CE and IEC Classifications and Comparison of UL/CSA/NEMA Type Ratings and IEC IP Ratings

CE & IEC Classifications – 1st Numeral		
IP	Protection of Persons	Protection of Equipment
0	No Protection	No Protection
1	Protected against contact with large areas of the body (back of hand)	Protected against objects over 50mm in diameter
2	Protected against contact fingers	Protected against solid objects over 12mm in diameter
3	Protected against tools and wires over 2.5mm in diameter	Protected against solid objects over 2.5mm in diameter
4	Protected against tools and wires over 1mm in diameter	Protected against solid objects over 1mm in diameter
5	Protected against tools and wires over 1mm in diameter	Protected against dust (limited ingress, no harmful deposit)
6	Protected against tools and wires over 1mm in diameter	Totally protected against dust

CE & IEC Classifications – 2nd Numeral	
IP	Protection of Equipment
0	No Protection
1	Protected gains vertically falling drops of water, e.g. condensation
2	Protected against direct sprays of water up to 15" from vertical
3	Protected against sprays to 60" from vertical
4	Protected against water sprayed from all directions (limited ingress permitted)
5	Protected against low pressure jets of water from all directions (limited ingress permitted"
6	Protected against strong jets of water
7	Protected against the effects of immersion between 15cm and 1m
8	Protected against long periods of immersion under pressure

Comparison of UL / CSA / NEMA Type Ratings and IEC IP Ratings

	UL / CSA / NEMA Access Protection				IEC 60529 – Access Protection				IEC 60529 – Liquid Protection			
	Rating	Protection	Test Probe	Pass	Rating	Protection	Test Probe	Pass	Rating	Protection	Test	Pass
Indoor Ratings	Type 1	Incidental contact, falling dirt	6.4mm (1/4")	No Penetration	IP 1X	Solid objects hands	Ø 50mm	No Penetration	1IP X0	No Protection		
					IP 2X	Solid objects fingers	Ø 12.5mm	No Penetration	IP X0	No Protection		
					IP 3X	Solid objects tools and wires	Ø 2/5mm	No Penetration	IP X0	No Protection		
					IP 4X	Solids objects tools & small wires	Ø 1.0mm	No Penetration	IP X0	No Protection		
	UL / CSA / NEMA Dust & Liquid Protection				IEC 60529 – Dust Protection				IEC 60529 – Liquid Protection			
	Rating	Protection	Test	Pass	Rating	Protection	Test	Pass	Rating	Protection	Test	Pass
		No Comparable Test			IP 1X	No Protection			IP 1X	Vertical falling drops	Drip box, 1mm / min. on rotating enclosures for 10 minutes	Limited Ingress
		No Comparable Test			IP 2X	No Protection			IP 2X	Direct spray 15" from vertical	Drip box, 3mm / min., 4 positions, @15" angle for 10 min.	Limited Ingress
		No Comparable Test			IP 3X	No Protection			IP 3X		Shower spray head partially blocked minimum 5 min.	Limited Ingress
		No Comparable Test			IP 4X	No Protection						
	Type 12	Dust, falling dirt, dripping non-corrosive liquid (condensation)	Atomized water spray 30psi time varies by size	No Ingress	IP 5X	Dust	8 hr. talcum powder test	Limited Ingress	IP X5	Low pressure jets of water any direction	Hose test 6.3mm Ø nozzle, minimum 3 minutes	Limited Ingress
	Type 13	Spraying, splashing, seepage of water, oil, & non-corrosive coolants	Oil exclusion test water & wetting Agent 30 min.	No Ingress		No Comparable Test				No Comparable Test		
	Type 3R	Rain, sleet, and snow	Rain test 3 nozzles @5psi, 1 hr.	Limited Ingress		No Comparable Test						
Indoor & Outdoor Ratings	Type 3RX	Rain, sleet, snow & corrosion		Limited Ingress		No Comparable Test						
	Type 4	Windblown dust, splashing water & hose-directed water	Hose test 240L / min (65 gal / min.) nozzle – 25mm dia. (1in) minimum 5 min.	No Ingress	IP 6X	Dust	8 hr. talcum powder test	No Ingress	IP X6	Powerful jets of water any direction	Hose test 100L / min. (27 gal / min.) nozzle – 12.5mm diameter, min 3 min.	Limited Ingress
	Type 4X	Windblown dust, splashing water & hose-directed water & corrosion		No Ingress								
	Type 6	Prolonged submersion limited depth	Submersion test 2m (6ft) deep pressure 30 min.	No Ingress					IP X7	Temporary submersion limited depth	Submersion test 1m (3ft) deep pressure 30 min.	Limited Ingress
	Type 6P	Prolonged submersion limited depth	Submersion test 6ft deep pressure 24 hours	No Ingress								

Appendix III – Challenging Environmental Factors and the Potential Solutions based on Environmental Standards Provided by NEMA, UL, CSA and IEC

		ENVIRONMENT								
		Indoor		Outdoor			Chemical			
	Environmental Matrix	Dust/Dirt/ Dripping Fluid	Washdown	Rain	Cold Temp	UV	Sea Salt Air	Solvents	Alkalis	Acids
SOLUTIONS	Scaling	FIP Foam-In-Place	Molded Silicone	N/A	N/A	Shielding geometry to protect gasket	FIP Foam-In-Place	Silicone, Nitrile	Silicone, Viton	Any Non-Hydroscopic Synthetic Material
	Material	Mild Steel	Stainless Steel	N/A	N/A	Metallic, PVC	316 Stainless Steel, Non-Metallics	Stainless Steel, Fiberglass, Alum, Polyester	ABS, Polyester, 304 SS	Any Non-Hydroscopic Synthetic Material
	Finish	Polyester Powder Paint	#3 Finish (100-120 Grit) #4 Finish (120-320 Grit)	Painted	N/A	N/A	Finished Stainless Steel	Finished Stainless Steel	Finished Stainless Steel	Finished Stainless Steel
	Features	Drip Shield	Angles, Flange Troughs	Louvers	N/A	Solar Shield	N/A	N/A	N/A	N/A
	Thermal Management	Natural Conduction, Heat Exchanger, Air Conditioner	Natural Conduction, Heat Exchanger, Air Conditioner	Natural Convection, Light or White Paint Color	Heater	Light or White Paint Color	N/A	N/A	N/A	N/A
	EMI	FIP w / Spring Finger	Molded Silicone / w Spring Finger	N/A	N/A	N/A	FIP w / Spring Finger	Silicone, Nitrile w / Spring Finger	Silicone, Viton w / Spring Finger	Any Non-Hydroscopic Synthetic Material
NEMA / UL RATING		TYPE 12	TYPE 4/4X	TYPE 3R	TYPE 4	N/A	TYPE 4X	TYPE 4X	TYPE 4X	TYPE 4X
IP RATING		IP55	IP69K	IP22	IP66	N/A	IP66	IP66	IP66	IP66

Referenced Resources

- UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations
- UL 508 – Industrial Control Equipment
- UL 508A – Industrial Control Panels
- UL 698A – Industrial Control Panels Relating to Hazardous (Classified) Locations
- UL 845 – Motor Control Centers
- UL 867 – Electrostatic Air Cleaners
- UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
- UL 60079 – Electrical Apparatus for Explosive Gas Atmospheres
- UL 698A - Industrial Control Panels Relating to Hazardous (Classified) Locations
- IEC 60529 - Degrees of Protection Provided by Enclosures
- IEC 62208 - Empty Enclosures for Low-Voltage Switchgear and Control Gear Assemblies – General Requirements
- IEC 60204 - Safety of Machinery - Electrical Equipment of Machines
- IEC 61439 - Low-voltage Switchgear and Control Gear Assemblies
- IEC 60079 - Explosive Atmospheres
- NFPA 79 – Electrical Standard for Industrial Machinery
- NEMA 250 – Enclosures for Electrical Equipment
- NEC 500/505 - Intrinsically Safe Entity for uses in Class I, II, III, Div. 1 Groups A-G
- Hazardous Locations/ Class I, Zone 0 AEx d IIC, T4

- CSA C22.2 No. 14, 17, 94.1, 94.2 Standard for Electrical Installations
- ISA 12.12.01 – Non-incendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations
- ANSI/TIA-568-C.0 Generic Telecommunications Cabling for Customer Premises
- ANSI/TIA-1005-A Telecommunications Infrastructure Standard for Industrial Premises
- TIA TSB-185 Environmental Classification (M.I.C.E.) Tutorial
- Mexico Electrical Installation Code (NOM-001-SEDE)

Disclaimer

The information contained herein is intended as a guide for use by persons having technical skill at their own discretion and risk. Panduit and Pentair disclaim any liability arising from any information contained herein or for the absence of same.

About Pentair Equipment Protection

Pentair Equipment Protection, a Pentair global business unit, is the leading provider of worldwide product and service solutions for enclosing, protecting and cooling electrical and electronic systems. Its industry-leading brand – Hoffman, - provides a broad variety of standard, modified and engineered solutions to the commercial, communications, energy, general electronics, industrial and infrastructure markets.

About Panduit

Panduit is a world-class developer and provider of leading-edge solutions that help customers optimize the physical infrastructure through simplification, increased agility and operational efficiency. Panduit Unified Physical Infrastructure^{SM} (UPI)-based solutions give enterprises the capabilities to connect, manage and automate communications, computing, power, control and security systems for a smarter, unified business foundation. Panduit provides flexible, end-to-end solutions tailored by application and industry to drive performance, operational and financial advantages. Panduit global manufacturing, logistics, and e-commerce capabilities along with a global network of distribution partners help customers reduce supply chain risk. Strong technology relationships with industry leading systems vendors and an engaged partner ecosystem of consultants, integrators and contractors together with its global staff and unmatched service and support make Panduit a valuable and trusted partner.