GRACE TECHNOLOGIES

GP-GP-EB-EN 2111

MAKING YOUR INDUSTRIAL CONTROL PANELS

SAFER AND MORE PRODUCTIVE

GRACE PORT®

Every industrial facility is touched by two entities; electricity and the equipment powered by it. One cannot envision an industrial setting both large and small without the use of these two elements. Maintenance workers and machine operators are common personas involved in keeping the productivity outcomes and uptime of the associated equipment. With increased use of both electricity and its associated equipment, comes the greater risk for people working around them, both directly and indirectly.

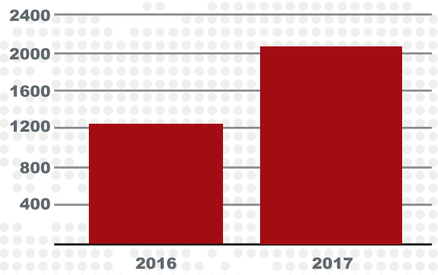
Most facilities have robust safety programs, Lockout/Tagout procedures, and PPE in place to mitigate the hazards while performing tasks around this equipment. However, having a safety policy and procedure built around equipment does not necessarily constitute an incident free facility.

The Department of Labor and the Bureau of Labor Statistics reported a total of 56,390 injuries among electricians' occupations alone within a seven-year period from 2011 to 2017, accounting for an average of 8,056 injuries a year. The data further reveals that there is a significant jump of 77% in incidents among the "Helpers in Electricians" category from 2016 to 2017 alone. This incident data also points to maintenance, installation, repair, and mechanic occupations on industrial machinery as 57,250 injuries in a seven-year period with an average of 8,178 injuries a year. Injuries as a result of electrical burns increased by 32% from 810 to 1070 between 2016 and 2017. Additionally, non-fatal injuries because of electric shock and electrocutions increased significantly by 67% from 1240 to 2080 injuries (2016-2017). It is also critical to note that the primary source for 90% of these non-fatal injuries is from machinery, parts, and materials.

Non-fatal injuries because of
electric shock and electrocutions
increased
67%
in one year

- Department of Labor and Bureau of Labor Statistics

Non-Fatal Injuries Due to Electric Shock and Electrocutions



90%
of these Non-fatal injuries are from **Machinery**, **Parts** and **Materials**

EFFECT OF SAFETY INCIDENTS FROM PAST, PRESENT, AND FUTURE

The National Safety Council (NSC) estimates that the total cost of work injuries in 2017 was $161.5 billion USD. NSC also estimates that a cost per medically consulted injury was $39,000, while the direct cost of a fatality was $1,150,000. These are only costs of the economic impact of these preventable injuries that represents either income is not received, or expenses incurred as a result of fatalities and non-fatal preventable injuries. Furthermore, NSC estimates the time lost due to work related injuries as 70 Million days in 2017, with an additional 34 Million days as a result of the disabling injuries that occurred in the prior years. The council further estimates a 55 million days in future years as a result of disabling injuring and deaths that occurred in 2017. The compounding effects of these preventable injuries goes beyond just the day of the incident and adversely affect the future of our economies.

Based on the analysis of the Bureau of Labor Statistics data, 2003-2016, compiled by the Electrical Safety Foundation, the top three scenarios of fatal injury from electrical hazards are:

1. Contact with overhead electric lines.
2. Contact with wiring, transformers, or other electrical components.
3. Contact with electric current of machine, tool, appliance, or light fixture.

Most common reasons for **Electrical Accidents** in the **Workplace**

- Unqualified and Underqualified Persons performing the task
- Production pressure from management
- Complacency
- Work culture

Electrical Safety starts with a profound organizational culture. Though safety is everyone's responsibility, it must start at the top of the leadership pyramid and be ingrained into the shop floor. It is impossible to sustain a safety culture without senior management support in any organization. Unlike many other things, when it comes to safety practices, there is no such thing as a middle ground. Safety culture either exists or it does not in an organization.

When it comes to **safety practices,** there is **no such thing as middle ground.** Safety culture **either exists** or **it does not in an organization.**

A very common expression that we often hear in our conversations from maintenance workers and supervisors is "we kind of follow safety policies and procedures" or "we have a safety program in place". When deeper questions are asked around safety, it is clear that safety procedures and programs exist more so as a compliance requirement. Organizations that truly believe in safety programs either deeply care for their workforce, or through their realization from unfortunate experiences in the past.

WHY INDUSTRIAL CONTROL PANELS POSE HIGHER RISK FOR WORKERS

To better understand why the Industrial Control Panels (ICPs) pose a higher risk, one must have a good understanding of the ICP definition. NFPA 70 (NEC) defines Industrial Control Panel as an assembly of two or more components consisting of one of the following:

1. Power circuit components only, such as motor controllers, overload relays, fused disconnect switches, and circuit breakers.

2. Control circuit components only, such as push buttons, pilot lights, selector switches, timers, switches, and control relays.

3. A combination of power and control circuit components.

These components, with associated wiring and terminals, are mounted on, or contained within, an enclosure or mounted on a subpanel.

The various types of construction practices and components housed in an ICP, along with numerous types of workers involved in installation, operation, and maintenance of these panels makes them high risk. Further, the operational criticality of ICPs as they relate to productivity metrics, plant throughput, and uptime puts them at a higher risk. Most workers involved with maintenance/operation functions of the ICPs include machine operators, PLC programmers, controls engineers, electrical engineers, service personnel, machine operators, and electricians. This is one of the primary reasons why this equipment poses a greater level of safety risk when it comes to workers. Other electrical equipment such as switchgear, MCCs, power distribution equipment, and other electrical lighting panels, the access is primarily restricted to qualified electrical workers.
The unique factors that puts ICPs at higher risk is the various voltages present within an ICP such as programmable logic controllers (PLCs), network devices, Human Machine Interfaces (HMIs), control power supplies, relays, push buttons, timers, etc.
To protect workers from injuries caused by electricity, control panels that are used in the United States are required to meet a number of regulatory requirements including compliance to specified standards and listings. In the US, the ICPs must be built and listed to UL 508A and further comply with NEC Article 409 and Article 110.16 and 110.28. A panel without approvals which gets tagged by the local AHJ (Authorities Having Jurisdiction) can prove costly to a facility.

UL 508A, and NFPA 79 design guidelines for ICPs combined with installation requirements from NFPA 70 (NEC) protects the workers performing tasks around this equipment from direct contact of electricity. This means that no live parts can be touched under normal operating conditions.

In order to protect unqualified workers and operators from the hazards associated with ICPs, standards such as NFPA 79 and UL 508A specify that the enclosure doors must be provided with interlocks in accordance with specific guidelines for panels operating at or above 50V AC/DC. The standards further require the door interlock mechanisms must be capable of interlock defeat, snap lock function, and blocking disconnecting means which provides accessibility for maintenance and service by qualified personnel. This is exactly where the complacency, production pressures, availability of the qualified workers, and other cultural factors make an unqualified persons use of those features to bypass interlock mechanisms and gain access to the ICP while the equipment is still energized. Though the intent of the operator, PLC programmer, or controls engineer are valid and practical to either trouble shoot or optimize the machine process as efficiently as possible without relying on qualified worker, data clearly reveals that incidents primarily occur at these junctures.

An arc flash can cause injury to anyone nearby and destruction of equipment with temperatures exceeding 35,000 °F (19,500 °C) at arc terminals.

Any person who has **not received training** to perform a task or recognize that an electrical hazard exists and how to avoid that hazard or who has **not shown demonstrated ability** is an **unqualified person**.

WORKER QUALIFICATION AS IT APPLIES TO ICPS & THE IMPORTANCE OF WORKER QUALIFICATION FROM NFPA 70E, 2018 EDITION

Qualified Person: One who has demonstrated skills and knowledge related to the construction, installation, and operation of electrical equipment having received safety training to identify hazards and reduce associated risk.

Unqualified Persons: There are two types of unqualified persons. First, an unqualified electrician who does not know the equipment or has not received safety training on the potential hazards involved. Second, a non-electrician, such as a general maintenance worker or painter, who is not expected to work on live electrical equipment.

Facilities are often either not fully staffed with qualified electrical workers to perform tests, repairs, and other maintenance activities around electrical equipment or do not have qualified persons in their staff at all. These situations lead to incidents when an unqualified person takes up the additional responsibility that requires a qualified electrical worker to do the job. For example:

MEET JOE

Joe, controls engineer and PLC programmer, has substantial knowledge and experience in process optimization using PLCs. When Joe is performing a task of programming updates or modifications to PLC while the system is running/energized, while the door of an ICP is open. This task is construed as energized work if any one of the two conditions are not met; a. the ICP main power supply is disconnected and locked out (or) b. the main disconnect is completely isolated/sequestered from the PLC/ control components within his reach.

MEET JEN

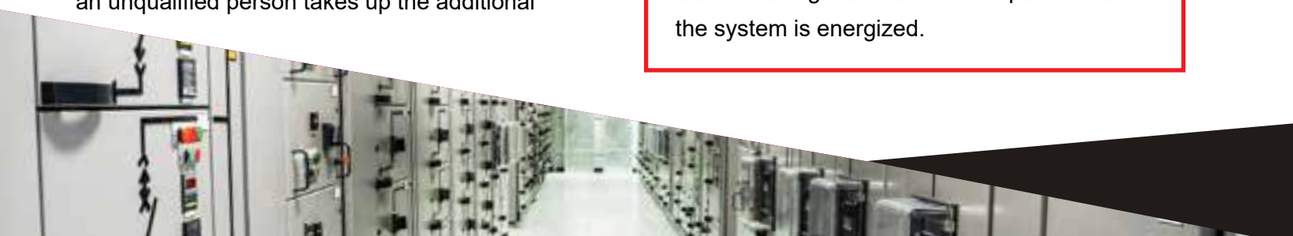
The same applies to Jen, a machine operator who is adjusting a timer setting inside the control panel when the system is energized.

It is important to note that while both Joe and Jen are extremely capable of performing their own specific tasks inside an ICP, **they will still be considered unqualified if they have not demonstrated skills and knowledge and received safety training to identify the hazards and associated risk per 70E.** This is one of the key areas that people often overlook while considering only the qualification and experience associated with their specific tasks within ICPs.

Any person who has not received training to perform a task or recognize that an electrical hazard exists and how to avoid that hazard or who has not shown demonstrated ability is an unqualified person. An employee qualified to perform a specific task may be unqualified to perform other tasks and on different types of equipment. The characteristic of being qualified or unqualified for a specific work is often times task dependent.

EFFECT OF COMPLACENCY ON ELECTRICAL SAFETY

Complacency affects both qualified and unqualified workers. A common saying among many maintenance technicians is “I have done it this way my entire career”. Which is a saying that has a touch of irony, considering their entire career can often times go back to when certain safety standards didn’t even exist yet. In other situations, it is very common to see maintenance technicians not donning the right amount of PPE per arc flash labels as they are either uncomfortable to wear or the PPE restricts their ability and comes in the way to complete their tasks faster.



The **compounding effects** of these **preventable injuries** goes beyond just the day of the incident and adversely affect the **future of our economies**

IMPORTANCE OF EQUIPMENT MARKING & LABELS IN ICPs

Equipment marking and labels play a significant role both in operation and maintenance of ICPs. In addition, the accuracy of the information and details provided within those markings can make an ICP, either safe or unsafe for both workers and their surroundings.

UL 508A defines the marking requirements for the ICPs its section 52.1. Also, NFPA 70 (NEC), Article 409.110 requires the ICPs to be marked with the following information:

1. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified.
2. Supply voltage, number of phases, frequency, and full-load current for each incoming supply circuit.
3. ICPs with more than one electrical source where more than one disconnecting means it's required to disconnect all circuits with 50-volts or more within a control panel shall be marked to indicate more than one disconnecting means is required to de-energize the equipment. The location and means to disconnect the circuits shall be documented and available.
4. Short-circuit current rating based on one of the following:
   a. Short-circuit current rating of a listed and labeled assembly.
   b. Short-circuit current rating established utilizing an approved method.

Exception to (4) SCCR markings not required for ICPs with only control circuit components:

5. If the ICP is used as service equipment, shall be marked as suitable for use as service equipment.
6. Electrical wiring diagram or the identification number of a separate electrical drawing.
7. An enclosure Type number (i.e. environmental rating).

Additionally, NFPA 79, Chapter 16 requires the electrical equipment for industrial machines shall be marked with the safety signs in accordance with ANSI Z535.4 to warn qualified persons of potential shock and arc flash hazards both at the ICPs and enclosures for disconnecting devices.

NFPA 70E, 2018, Article 130.5(H) requires the ICPs with the following information:

1. Nominal system voltage.
2. Arc flash boundary.
3. At least one for the following:
   a. Available incident energy and corresponding working distance or the arc flash PPE category in Table 130.7 (C)(15)(a) or Table 130.7 (C)(15)(b) for the equipment, but not both.
   b. Minimum arc rating of clothing.
   c. Site-specific level PPE.

Note: It is also important to note that equipment should not have both incident energy and PPE category on the same equipment as it creates misunderstanding and puts a worker at greater risk of injury.

Article 205.11 requires equipment with warning signs that are visible, securely attached and maintained in legible condition that informs both qualified and unqualified persons of the potential hazard condition that exist with the equipment.

Importance of Equipment Labeling, per NFPA 70 (NEC), 409.110 for Marking, 409.22 for ICP SCCR

It is crucial to acknowledge the fact that you may not be qualified for the task that you are assigned. As a qualified employee, you should recognize that new equipment, a different set of procedures, or the ability to perform a similar task may make you unqualified to perform the scheduled task on the specific equipment.

IMPORTANCE OF GROUND-FAULT CIRCUIT INTERRUPTERS (GFCI) IN INCREASING SAFETY WITH ICPs

To understand the importance of GFCIs in ICPs, one must understand the distinction between an Accessory Equipment and Associated Equipment. NFPA 79, defines accessory equipment as one that is "not required" for the normal operation of the

Given the **types of the industrial machinery** and the various **types of maintenance personnel** performing testing, troubleshooting, calibration etc., **all receptacle outlets on the ICP must be GFCI protected.**

equipment and, associated equipment is the one that is required for the normal operation of the equipment. Given the types of the industrial machinery and the various types of maintenance personnel performing testing, troubleshooting, calibration etc., all receptacle outlets on the ICP must be GFCI protected. Examples of accessory equipment include power tools, test equipment, laptops, etc.

NFPA 79, 2018 edition requires:

1. Any receptacle used in an ICP, mounted either internally or externally to the enclosure shall be GFCI protected.
2. Supply voltage cannot exceed 125 volts and shall be grounded AC source.
3. 15A outlets that are listed for the voltage.
4. All ungrounded conductors connected to the receptacle shall be protected against overcurrent and shall not be connected to other machine circuits.
5. Receptacles mounted externally to the enclosure must meet the enclosure type rating.
6. Receptacles mounted inside the enclosure are not required to be covered.

The exception (b) in section 66.6.1 of UL 508A also allows the plugs and socket outlets (receptacles) for exclusive connection of repair maintenance tools and programming equipment to be connected to the “line-side” of the disconnecting means.

THE GRACEPORT® GFCI SOLUTION

GracePort® features an Inside-Outlet™ which is unique because it has three GFCI-protected receptacles; two outside and one inside the panel. Additionally, this GFCI receptacle’s purpose provides a trouble-free step toward complying with NFPA 79, which states all externally-mounted utility receptacles must be GFCI protected and tested every 30 days. Accomplishing this directive is simple and time efficient with Inside-Outlet.

GracePort® featuring GFCI-Protected Receptacle

Mitigating Safety Risks in Industrial Control Panels using Additional Protective Measures

To come up with a best safety strategy for your ICP, consider the following steps during the design phase of the panel:

Step 1: Discovery

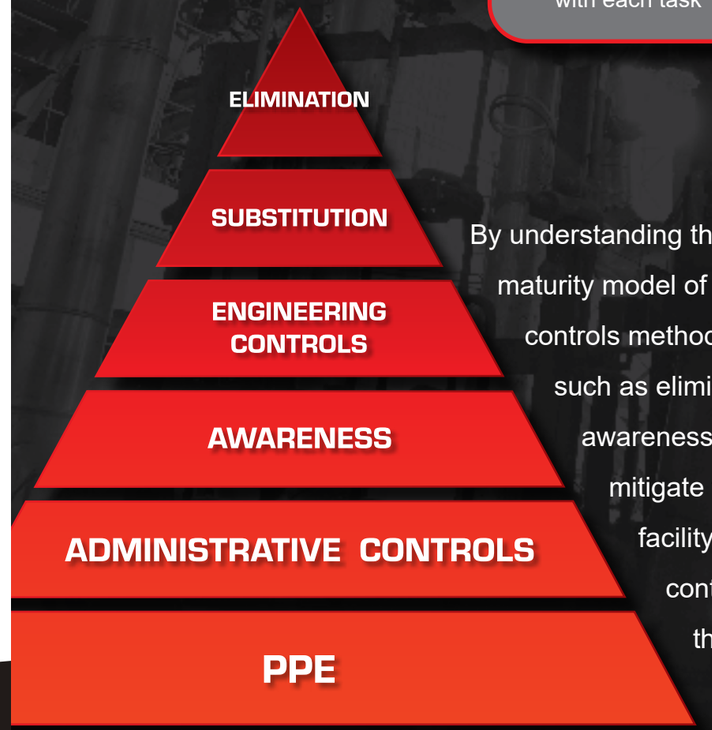
1. Type of equipment
2. Persons involved in operation and maintenance activities
3. Hazards involved
4. Qualification of workers
5. Criticality of the equipment
6. Frequency of the tasks

Step 2: Plan

1. List all activities involved during normal operation
2. List all components and devices that need to be accessed in energized condition
3. List workers involved and their qualification
4. List all tasks and qualifications required
5. List hazards associated with each task

Step 3: Execute

1. Bring the accessible components to the door
2. Use a rated housing or enclosure that meets the type rating of the enclosure
3. Update the procedure required for the employees performing the tasks
4. Train the employees on safely performing tasks
5. Define PPE requirements



By understanding the above factors and considering the safety maturity model of the organization, one can use the risk controls methods described in the risk control hierarchy such as elimination, substitution, engineering controls, awareness, administrative controls, and PPE to mitigate the risks. If you are a safety conscious facility or an OEM, you always start with the controls on the top of the RCH pyramid as they are applied at the “source” and not impaired by human error.

Panel Interface Connectors can improve **task productivity by about 90%**

The non-GFCI outlets inside a panel can be wired through the Inside-Outlet™ which is then externally mounted on the panel door. Now testing is easy and more efficient. Simply walk up to the door, flip the protective cover, and push the button to complete your monthly self-test.

Regulatory Requirements:

In the United States, Canada, and the European Union, ICPs are required to meet a number of regulatory requirements including compliance to specified standards and listings. In the US, the ICPs must comply with NEC Article 409, Article 110.3(B), and ANSI/NFPA 70. A panel without approvals which gets tagged by the local Authorities Having Jurisdiction (AHJ) can prove costly to a manufacturer.

Regulatory standards that are applicable to ICPs include:

- UL508A (US)
- CSA C22.2 No. 14 (Canada)
- EN 60204-1 and EN 61439-1 (Europe)

DIFFERENCE BETWEEN ENERGIZED WORK AND NORMAL OPERATION IN AN ICP

NFPA 70E, 2018, Article 130.2(B)(3) allows “exemptions” to an energized work permit that allows qualified workers to perform certain tasks if the worker uses appropriate safe work practices and PPE per the equipment labels. Testing, trouble shooting, or voltage measurements are allowed in this specific category. However, it is very important to note that the work performed only by a qualified electrical worker is allowed in this case, and not by a machine operator, PLC programmer, or a controls engineer.

NFPA 70E, 2018, Article 130.2(A)(4) allows tasks to be performed around electrical equipment in Normal Operation.

when “ALL” of the following conditions are met:

1. The equipment is properly installed.
2. The equipment is properly maintained.
3. The equipment is used in accordance with instructions included in the listing and labeling and in accordance to manufacturers’ instructions.
4. The equipment doors are closed and secured.
5. All equipment covers are in place and secure.
6. There is no evidence of impeding failure.

Three-fold Benefit of Panel Interface Connection/Programming

Safety

- It allows the unqualified/task qualified persons (other than qualified electrical workers) to access the control components inside the panel safely without opening the door.
- Perform a programming task from outside the panel in a Normal operating condition.

Productivity

- Improves the task productivity by about 90%. In a normal scenario, it would take up to 20-30 minutes to perform an electrical Lockout/Tagout, including the time to suit up fully arc-rated PPE and verify absence of voltage inside the panel. Also, in a typical facility it may take an additional 45 minutes to an hour long wait for a qualified electrical worker to show up based on other work priorities.
- With a panel-interface or programming port installed, it makes the interface process simply plug and play.

Compliance

- By having a task qualified person performing the work on an ICP with the doors closed and secured meets the requirements of NFPA 70E, Article 130.2(A)(4).
- By having a GFCI protected outlet with the programing interface, one can also meet the requirements of UL 508A and NFPA 79 for accessory equipment receptacles.

Typical Work Task Flow in an Industrial Control Panel

Perform programming updated to a PLC or Configuring a network device

What components are present inside the Idustrial Control Panel?

Control circuit components only

Components with operating voltage below 50 volts AC/DC

Disconnect the EID/Main Switch

Open the panel and proceed to work

If the task on the control circuit is performed while the sequester disconnect is "ON," enbsure there are no exposed terminals feeding from the load-side of the sequester disconnect in the panel. And the terminations are completely guarded against inadvertent contact.

YES

Is the incoming power to the panel sequestered?

NO

Power **and** control circuit components

Components with operating voltage up to 1000 volts AC/DC

Perform the work while system is energized

YES

Is panel interface access available on the enclosure door?

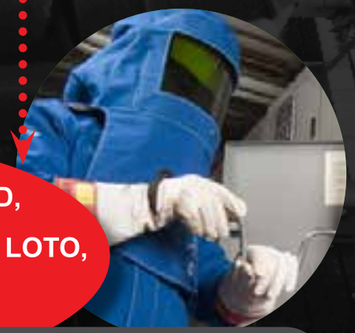
With GracePort®
Task Duration: 2 minutes

YES

Does panel meet Normal Operation per Article 130.2(A)(4), NFPA 70E?

NO

Don PPE, disconnect EID, verify for absence of voltage, LOTO, and proceed to work



If the task performed reqquires the system in energized condition, follow the "Energised Work Permit" procedure as defined in Article 130(2)(A)(2), NFPA 70E, 2018.

Task Duration: 25- 30minutes

NO

In simple terms, an unqualified worker per NFPA 70E definition is allowed to perform tasks on electrical equipment when a “Normal Operating Condition” exists, and where all the six conditions mentioned above are met. This greatly helps the PLC programmers, controls engineers, or machine operators to make changes to process settings or make programming updates to PLCs and other controls when access to the components are provided outside the cabinet.

Task: Perform programming updates on a PLC module inside an ICP:

1. What components are present inside the ICP?
2. Only control circuit components less than 50Volts; open the panel and proceed to work.
3. Panel has both Power and Control circuit components.
4. Are the power circuit components sequestered? If yes, disconnect the EID as needed, open the panel, and proceed to work.
5. If the panel is NOT sequestered and has both power and control circuit components, disconnect the EID, don PPE, open EID, then verify for absence of voltage and proceed to work (Qualified electrical work) .
6. If the panel has programming interface connectors, perform the work in Normal operation. Work can be performed by anyone other than a qualified worker in both energized and de-energized conditions.

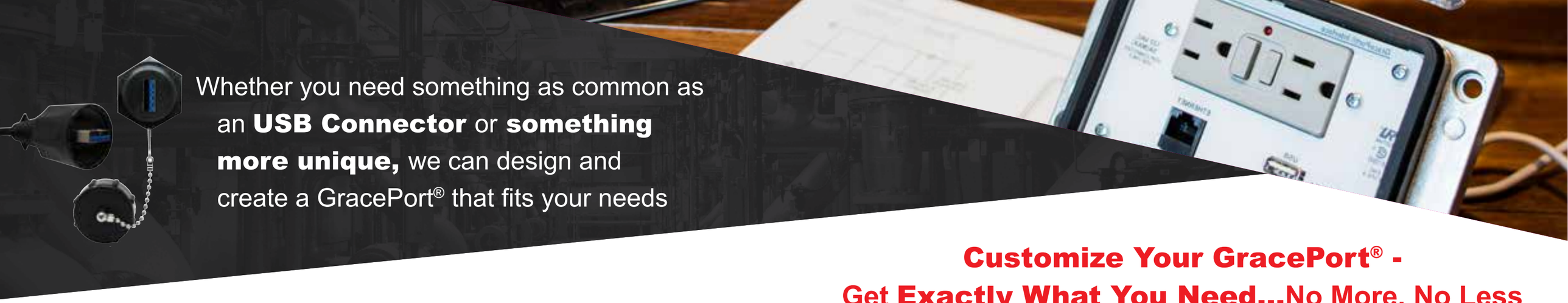
Note that programming interfaces provided on an ICP to access the panel components must meet the same UL type rating for the enclosure.

HOW GRACEPORT® PANEL INTERFACE CONNECTORS CAN FIT INTO YOUR ICP APPLICATION

GracePorts® are unique panel interface connectors that are fully customizable to meet your precise application. With a wide array of components, we can configure any connection into your unique Graceport®.

Top **10 Considerations** For A **Safer ICP**

1. Understand that ICPs pose a significantly higher risk than your other electrical panels as it involves multiple voltages.
2. Clearly evaluate worker qualifications and the task they are assigned to do.
3. Perform risk analysis and implement control measures that are appropriate by evaluating the type of task, worker qualification, and equipment condition.
4. Always try to implement elimination, substitution, and engineering controls in the order of hierarchy from the Risk Control Hierarchy chart as they are applied at the source of the hazard.
5. Always use the equipment in accordance with manufacturers’ instructions for all the listed and labelled components.
6. Ensure that your ICPs are provided with accurate equipment labels and description per UL 508A, NFPA 79, and NFPA 70 (NEC) standards.
7. Ensure that your equipment is marked with appropriate warning labels with arc flash hazard information to include either Incident energy or PPE category.
8. Provide GFCI receptacles that meet the enclosure type rating for all the accessory equipment for maintenance personnel.
9. Keep electrical drawings up to date, avoid energized work permits and open door work while the system is energized.
10. Follow all your equipment and facility LOTO procedures.



Whether you need something as common as an **USB Connector** or **something more unique,** we can design and create a GracePort® that fits your needs

We also carry power options to meet the needs of our domestic and international customers and numerous housing types are also available with environmental ratings such as Type 1, 3R, 4, 4X, and 12.

The GracePort® line has a variety of housing sizes to fit your application

COMPLETE CUSTOMIZATION

Each GracePort® is uniquely built for you and your specific application. You'll be hard pressed to find a component we don't have available and in the rare cases where customers have presented us with an application we didn't have a component for, we added it to our inventory. You can pack your unique GracePort® with countless varieties of components are available and can also be paired together in your fully customizable GracePort® for any application. Whether you need something as common as an USB Connector or something more unique, we can design and create a GracePort® that fits your precise needs.

NEW TECHNOLOGY

One of our latest GracePort® configurations features a component with USB-C charging functionality that allows service technicians and PLC programmers to safely charge their laptops and other handheld devices from outside the door with a USB-C cable. Under OSHA directives and NFPA 70E guidelines, there must be 50 Volts or above for shock hazards to exist in a typical work environment, and voltages operating at below 50 Volts do not require guarding against accidental contact which is required by OSHA under 29 CFR 1910.303(g)(2)(i). Thus, having a 24VDC-powered USB-C charging option can completely eliminate shock hazard risk and give users a unique ability to transition from their current GFCI protected accessory outlets to a much safer and compact option with minimal wiring complexities.

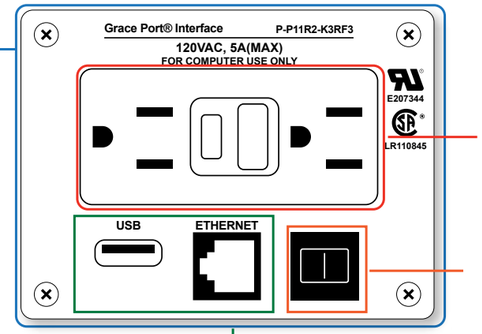
GracePort® featuring a USB-C Charging Component

Customize Your GracePort® - Get Exactly What You Need...No More, No Less

You can even specify additional needs including special text, logos, cable lengths and hole cut-outs.

Housing Size & UL Rating

Several housing types are available to meet your needs. The size of your housing depends on several variables including the kinds of components you choose, the power option you want and, in some cases, the UL rating you need. UL ratings offered include UL Type 1, 3R, 4, 4X, and 12.



Power Option / Circuit Breaker

Many power options for international and domestic use are available and are represented by a one to two or three letter code. Because circuit breakers offer the ability to limit what devices can be run through the GracePort®, we offer different amperages, which is represented by the amperage number following the power option code.
P-P11R2-K3RF3-UXXX

Components

There are various connectors available and are represented by a 2- to 3-digit code found in between the first two dashes of our GracePort® part number layout. Multiple connectors in a GracePort® are listed alpha-numerically, as seen here: P-P11R2-K3RF3-UXXX