White Paper

December 2013

Space Optimization for Control Panels

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Introduction

In manufacturing organizations, real estate is typically one of the biggest expenses associated with running the business. As a result, production facility managers are under pressure to manage their space in the most effective and efficient manner to minimize capital and operational expenses. This can mean placing as much equipment as possible into a given area in the facility, which challenges equipment designers and builders to reduce the size and footprint of the machines they create. This, in turn, challenges the controls engineers to design and build control panels within a smaller footprint or fit more equipment into an existing space.

There are many challenges associated with designing smaller control panels. Considerations for cable segregation, thermal management, cable entry, Electromagnetic Interference (EMI), cable bend radius and space for future expansion must be addressed when attempting to reduce the size of control panels. In addition, safety considerations such as arc flash hazards, complying with codes and standards and adhering to minimum separation requirements for electronic components all complicate a controls engineer's job. Whether you are designing a control panel for your own facility or for a customer, best practices and addressing design challenges with new tools and solutions should be considered before any build documents are issued to the panel shop.

This white paper explores solutions from Panduit and Pentair that can help save up to 40% of control panel space in comparison to conventional approaches. It presents options for reducing enclosure size by fitting more equipment into existing enclosures, which provides greater design flexibility and cost savings to the equipment and panel builder.

Applying more effort in the beginning of the design process can result in significant space savings. Along with innovative products, both Panduit and Pentair offer CAD tools and 3D step files to help you through the design process. Both companies' products are also included in automation supplier configurators such as the Rockwell Automation® ProposalWorks and Integrated Architecture Builder (IAB).

Utilizing Three Dimensions for Control Panel Space Savings

An area that is almost never used in the control panel is the space between the enclosure door and the components mounted to the sub-panel in the rear of the enclosure, sometimes referred to as the three-dimensional (3D) space. Both Panduit and Pentair offer products that help the designer tap into this space.

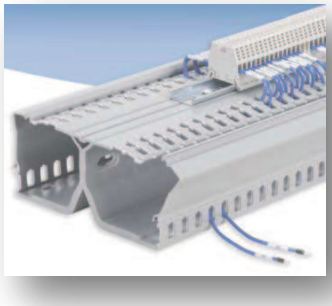

Figure 1. Panduit PanelMax™ DIN Rail Wiring Duct.

The Panduit DIN Rail Wiring Duct (Figure 1) has two separate wiring channels and enables the user to mount a DIN rail with components that would normally be installed directly to the sub-panel, thereby utilizing the 3D space. *The PanelMax™ DIN Rail Wiring Duct and Shielded Duct from Panduit have the potential to save up to 40% of the space on a sub-panel.* Being able to fully utilize the 3D space inside an enclosure often means having the correct access to install or service the equipment inside. The ability to access the front and rear of the installed equipment reduces installation and service time.

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The innovative PROTEK™ product by Pentair utilizes a unique three-piece body and double-hinge design that allows the front door to open on hinges connected to the middle section, and the middle section to swing open on hinges connected to the rear section. Both the front door and the middle section are removable.

The separation of these sections allows for an easier installation because the un-populated individual sections are much easier to manipulate. The installer can begin by mounting the rear portion of the enclosure to a wall or pole and then mount an already populated sub-panel into the rear section. Next, the installer can mount the middle section of the enclosure to the rear section and populate the EIA-310, 19” spaced rack angles with the active rack mounted equipment. Lastly, the installer can mount the front door onto the middle section to complete the installation.

Once the equipment is installed, the PROTEK™ design offers the service technician easy access to all sections of the control panel. Unlocking the front door allows access to the front of the rack mounted equipment. Releasing the latches in the middle section allows the middle section to pivot open from the rear section on a load bearing hinge. Once open, the middle section reveals access to the back of the rack mounted equipment in the middle section as well as access to the components mounted on the sub-panel in the rear section.

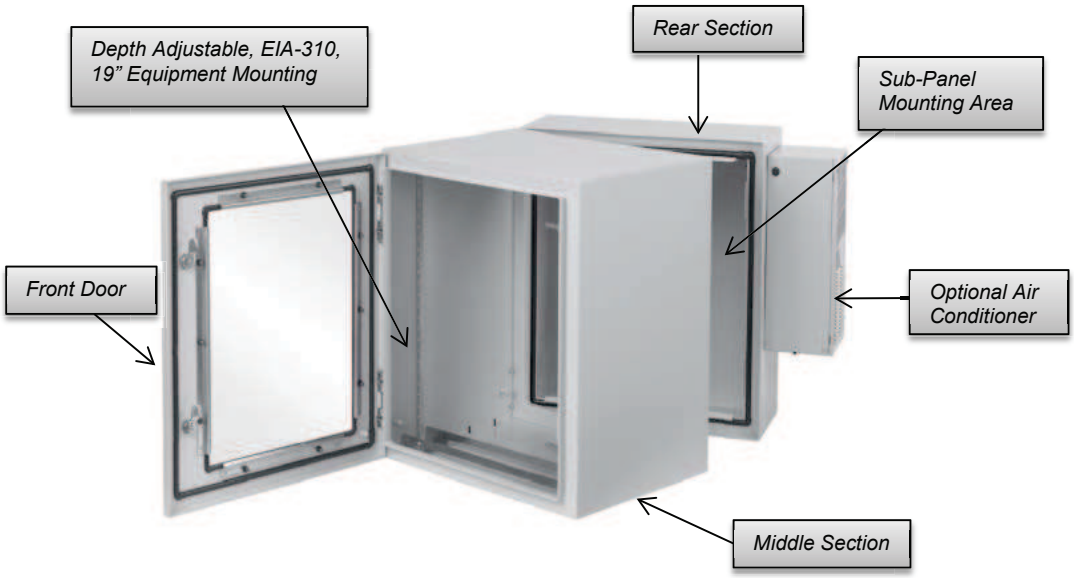

Figure 2. The PROTEK™ design allows the control panel designer to utilize the 3D space and combine both 19” rack mount equipment with sub-panel mount equipment into a succinct 3D-spaced system.

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Various depths and adjustable rack angles allow the designer to choose the enclosure that houses the correct volume for the needed components and make all the space within the enclosure functional, as shown in Figure 2. The PROTEK™ product provides: (A) a 3D platform, allowing flexible design for the designer, (B) an easy to manage modular installation experience for the installer and (C) easy access to the appropriate areas of the equipment inside for the service technician.

Noise Mitigation Facilitates Space Savings

Products normally used for noise mitigation are not typically considered to be space saving tools. However, a fresh look at approaches to control panel layout can result in improved reliability and performance along with optimized usage of panel space. Bringing wiring closer together that normally would need to be separated by at least six inches of air space can be accomplished with the Panduit PanelMax™ Noise Shield and Shielded Duct. Both products are effective as an EMI barrier and provide an equivalent of six inches of air space. Figure 4 illustrates how the Noise Shield and Shielded Duct can be used to separate noisy motors or drive cables from sensitive Ethernet or control cables. The Noise Shield can be used on its own, mounted and bonded to the sub- panel, installed in a conventional wiring duct with the included bonding clips or used in conjunction with the Shielded Duct. A subsequent white paper from Pentair and Panduit will provide further information on noise mitigation within the control panel.

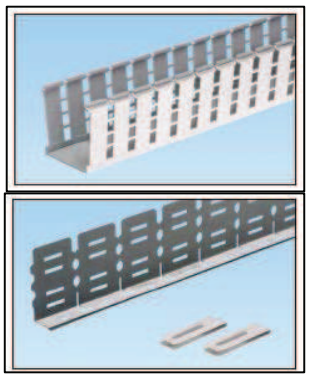

Figure 3. PanelMax™ Shielded Wiring Duct and Noise Shield with bonding clips.

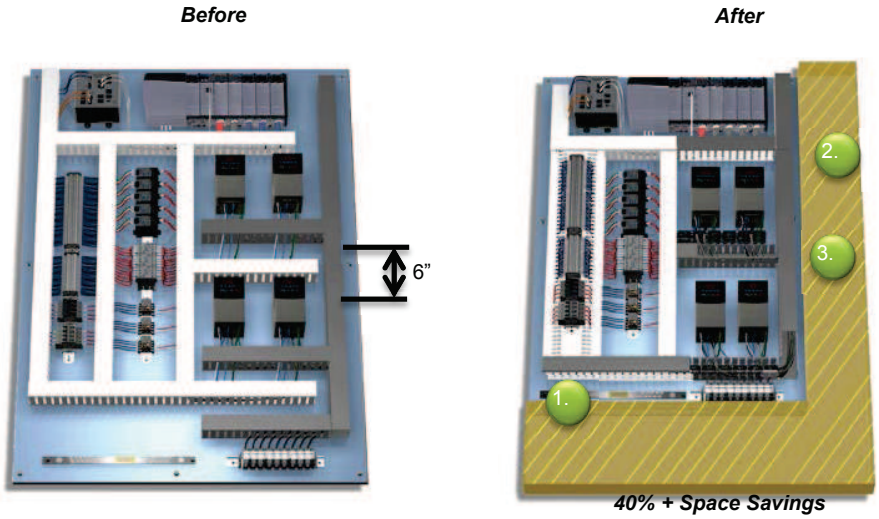

Figure 4. The effect of space saving solutions: A 40% or greater panel space savings is achievable with components that utilize 3D space such as (1) PanelMax™ DIN Rail Wiring Duct to provide robust EMI noise protection with closer pathway placement, (2) PanelMax™ Shielded Wiring Duct and (3) PanelMax™ Shielded Noise Barriers.

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Enclosure Flexibility Maximizes Available Space

Selecting the proper control enclosure is an important factor when the objective is to optimize space. Enclosures are designed to support a variety of accessories that facilitate component mounting based on the targeted application. Different enclosure platforms can offer more flexibility and greater space saving capability when designed for a wider range of accessories.

Examples of enclosure platforms that afford greater space saving capability are those that allow full 3D utilization of the space inside versus only using the sub-panel of the enclosure. To accomplish this, the enclosure must be designed to accept supporting structural members along the sides, top and/or bottom of the enclosure and ideally, on the door as well. This offers the designer full use of the interior for component mounting and cable and wire management. With an enclosure platform designed for the purpose of flexibility and scalability, an engineer can create a customized packaging solution from standard components that optimizes the control panel space.

Pentair's FUSION product line is an example of an enclosure system that is designed to accept front and rear vertical mounting rails in addition to a rear sub-panel. The mounting rails can accept a wide variety of accessories for installing components in non-traditional locations.

Figure 5 shows the FUSION vertical mounting rails in the front and rear which can be used to support versatile side mounting rails, full and partial height side mounting panels, and DIN rail adapters. These accessories create an internal infrastructure that maximizes use of most surfaces inside the enclosure.

Figure 5. FUSION enclosure platform with internal grid system.

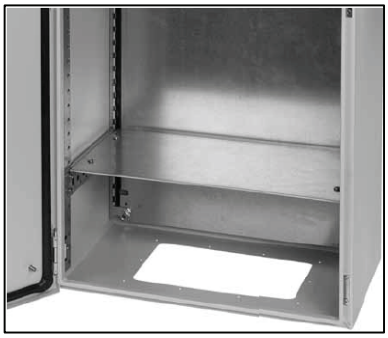

Figure 6. FUSION enclosure with a horizontal barrier installed.

This type of infrastructure can also be used to install barriers within the enclosure to separate it into multiple compartments which can isolate high voltage from low voltage, provide an additional panel mounting surface, or a shelf for batteries or power supplies, as shown in Figure 6.

In Figure 7, the FUSION enclosure includes a full side mount panel with additional wire duct, relays, and grounding provisions that traditionally would have been mounted on the rear sub-panel.
This application allows the designer to save up to 20% of the wall or machine space when compared to a more common sub-panel mounting application.

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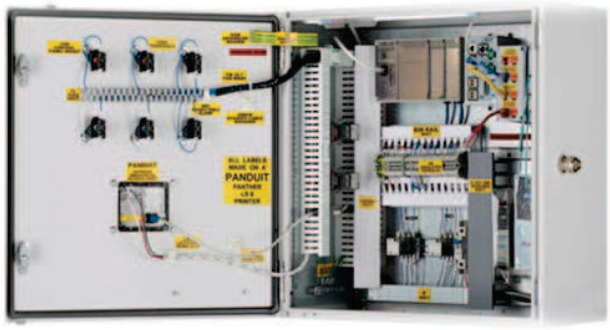

Figure 7. FUSION enclosure with a full side panel application.

Another enclosure platform that offers full 3D space utilization is Pentair's PROLINE modular enclosure system. PROLINE is designed for larger control system applications and is based on a strong, versatile frame (see Figure 8) with a grid pattern and a wide range of accessories that enclose the frame and allow components to be mounted to the grid. Frames can be joined together to create multi-bay configurations that allow system expansion. A complete range of internal components such as rack angles, sub-panels and grid mounting options is available to install equipment securely within the enclosure on several planes utilizing virtually all the interior space. Mounting options accommodate rack mount equipment, operator interfaces, industrial control equipment and computer systems, as well as manage wiring and cabling (see Figure 10).

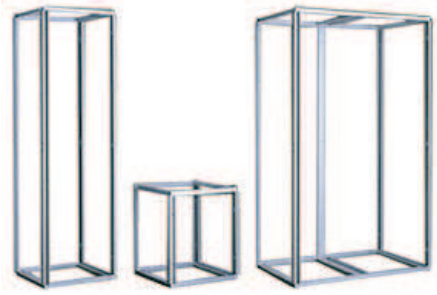

Figure 8. Basic PROLINE frame.

Figure 9. PROLINE frame with doors, tops, and mounting panel assembled.

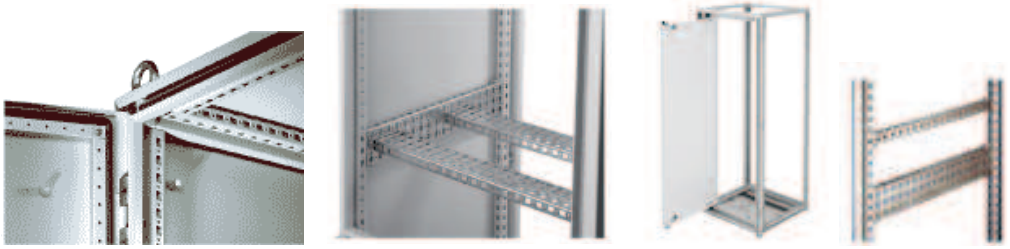

Figure 10. PROLINE internal grid system with examples of accessories mounted to the grid.

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In some cases customers utilize the enclosure door for mounting additional devices to optimize space. Examples include shelves, document storage, cable management, air conditioners, or partial mounting panels. The grid system included in the PROLINE door adds strength to the door and accommodates a wide variety of accessories for device mounting and cable management (see Figure 11).

Figure 11. PROLINE door grid system for mounting additional devices.

Utilizing the Enclosure Corner Space

There is space inside the control panel that goes unused in most traditional panel layouts. Panduit PanelMax™ Wiring Duct Solutions are designed to tap into that space. An example is the corner space which is either unused or underutilized in control panels that are using side equipment mounting plates. Panduit PanelMax™ Corner Wiring Duct is designed to fit into corners and utilize that space while providing good wiring transition from rear sub-panels to side sub-panels. Figure 12 shows how this space is reclaimed from the traditional panel layout, providing more room for more components or the ability to downsize an enclosure. *The PanelMax™ Corner Wiring Duct has the potential to save up to 12% of space on the sub-panels and decrease the enclosure footprint by 18%.*

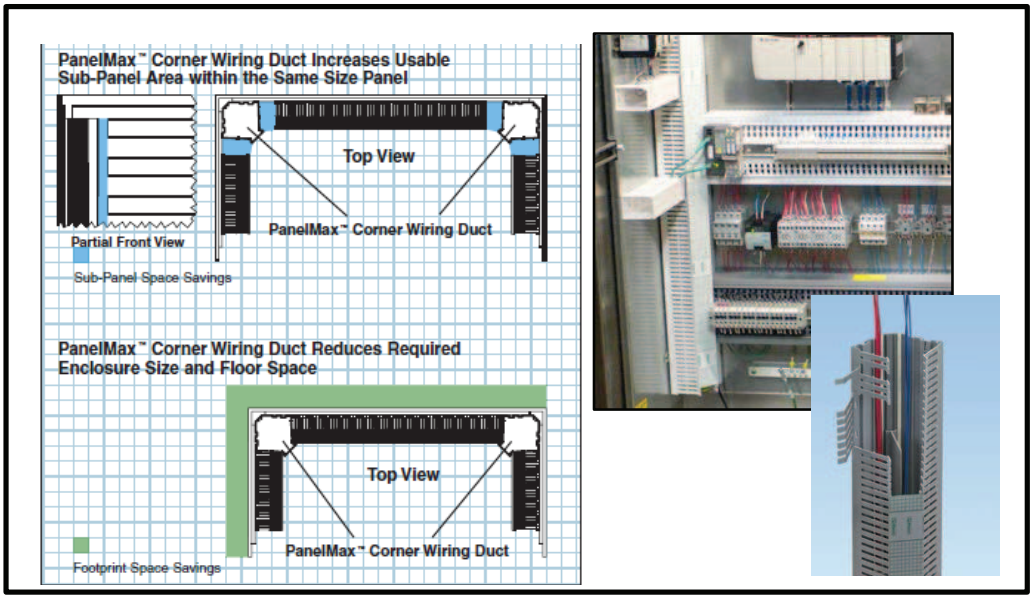

Figure 12. The Panduit PanelMax™ Corner Wiring Duct is designed to fit into the enclosure corners and utilize this space while providing wiring transition from rear sub-panels to the side sub-panels.

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Space Saving Strategies using Modular 60mm Busbar Systems

Panel design optimization is important to the strategy of minimizing equipment size, which affects the protective enclosure containing the sub-panel, and represents the outer envelope of the power distribution and control housing in equipment design. The approach for introducing electrical power into and distributed throughout an enclosure will also impact its size. Pentair's 60mm Modular Busbar System offers an alternative approach to distributing power in an electrical control panel that can save valuable space while reducing labor costs and installation time.

Modular busbar systems can distribute power of less than 150 amperes to well over 1800 amperes at system voltages of up to 600 volts, and are relevant for virtually all power distribution and control panels in machine design today.

The busbar system structure is fastened to the sub-panel and spans a distance through the enclosure. The ultimate distance the structure spans is determined by the number of branch circuits it will feed and the physical width of these components.

System depth is dependent upon the current requirements of the design. System designs of less than 800 amperes are built on a structure of approximately 70mm (2.8") in depth. Higher current ratings will require additional depth. Generally, enclosure depth is the least utilized of the three dimensions and, when more fully utilized, can help minimize the enclosure height and width.

Three space saving strategies can be employed individually or in concert with the others through the use of these modular system components.

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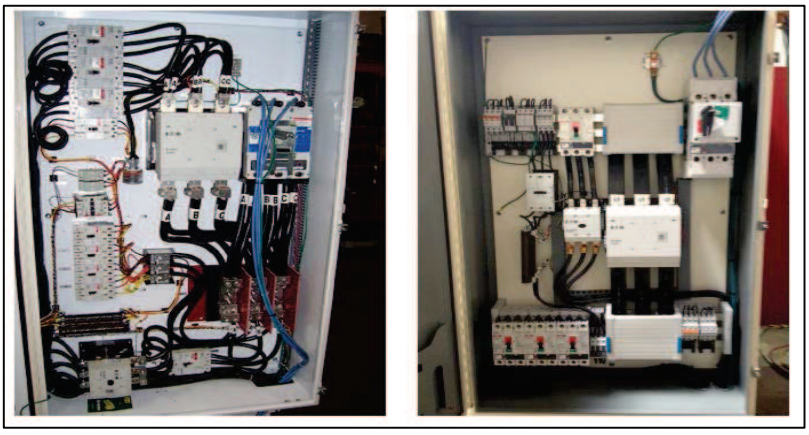

Figure 13. Two horizontal busbar structures (right) utilizing molded case circuit breaker and DIN adapters employ the available depth of the enclosure. Vertical flat flexible busbar connections eliminate the challenges of shaping parallel DLO conductors and the use of a power distribution block.

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Strategy #1: Elimination of "Old-School" Components

Traditional wiring methods employ the use of "old-school" components such as power distribution blocks (PDB) where large conductors enter one side of the PDB and small conductors exit the other side. This method relies on point-to-point wiring from the secondary side of the PDB to the primary side of the power control components fuse holders or circuit breakers. The measuring, cutting, terminating, bundling and labeling of these discrete wires require significant labor. The wiring is typically accomplished by one technician because there is little space for two technicians to compete in the same space. The wiring process also anchors a power control component to a specific location in the panel design, leaving little room for variation or modification.

Conversely, the busbar structure replaces all of these discrete insulated conductors that run from the PDB to the controls. This custom wire harness is replaced with a very basic busbar structure, making separation of labor possible. Mounting of the power control components on suitable adapters can happen on a work bench, away from the sub-panel, by one technician. Mounting of the component can be accomplished by another technician, by simply snapping it onto the busbar structure and locking it into place. *A labor savings of 40% can be achieved and the adapter can be positioned anywhere along the length of the busbar.* Unused sections of busbar can be covered with insulating, protective covers, making the entire assembly IP20 touchsafe.

Strategy #2: Using Flat Flexible Busbars

The UL508 standard stipulates the bending radius of individual or parallel conductors in a panel design. From the five-inch radius of a single 1/0 conductor (suitable for 150 amperes) to the 16-inch radius of parallel 600MCM cables (suitable for over 800 amperes), these dimensions add a margin of unused space throughout a panel design. Beyond the physical space constraints of these conductors, panel builders often struggle to bend American Wire Gauge (AWG) cables into a permissible shape and they often resort to expensive, high strand count cables to make these bends, which sometimes leads to termination issues.

Conversely, insulated flat flexible busbars complement the modular busbar system and are rated by UL for a bending radius of twice the thickness of their insulation jacket. They can be folded and bent into much tighter spaces and often can be effectively applied in straight shots to the rigid busbar structure, eliminating the need to shape the material. Compression connections serve as a termination method to either power the rigid busbars or tap power to a branch circuit, without the need for drilling holes through either set of busbars. The flat flex conductor can, however, be drilled to make connections to molded case circuit breakers, fusible switches or National Electrical Manufacturers Association (NEMA) contactors without the use of lug kits. This strategy will often eliminate the need for parallel AWG cables.

Strategy #3: Innovative Adapter Technology

A variety of modular busbar system adapters have been developed to mount components directly to the rigid busbar structure. The system can mount molded case circuit breakers up to 630 amperes and Class J fuses up to 400 amperes. DIN adapters have been developed for mounting IEC motor control components (to 80 amperes) and Class CC fuses (to 30 amperes) as well. These adapters allow the components to be raised off the sub-panel, eliminating the drilling, tapping and fastening of most components.

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Added Benefits

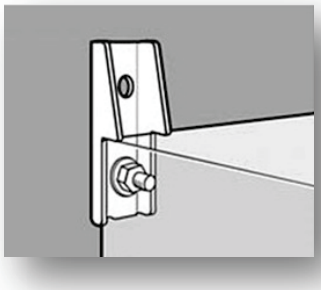
Today's modular busbar systems carry a UL508 listing and can achieve short circuit current ratings of up to 100kA. Additionally, the UL listing of the modular system carries higher current ratings than the UL default value for unlisted raw copper stock. While UL permits up to 1000 amperes per square inch, the UL rating of the modular system permits much higher current density. *In the case of 30x5mm busbar, the 500 ampere rating is 115% higher. In the case of 30x10mm busbar, the 756 ampere rating is 62% higher.* This allows the modular system to achieve higher ratings with less copper content.

Modular busbar systems, through their space saving strategies, can deliver upwards of 25% space savings in traditional motor control applications, variable frequency drive applications and power distribution panels for industrial equipment. This space savings can often allow the designer to select the next smaller enclosure.

Saving Space Outside the Control Panel

While much can be done to maximize the space inside of the control panel, there are also considerations to be made that can minimize the external footprint. One consideration is how the control panel will be mounted to the floor, wall or pole, (see Figure 14). The ability to be flexible with the mounting of the control panel allows the designer to put the control panel anywhere in the design, making the control panel enclosure part of the integrated system solution.

Pentair Enclosure Floor Stand Kit



Pentair Enclosure Wall Mounting Foot

Pentair Enclosure on Pole Mount Kit

Figure 14. Enclosure mounting options from Pentair.

The use of an air conditioner or other added cooling device can affect the control panel footprint. While air conditioners might allow for a more compact control panel solution, they add space to the overall footprint of the control panel. Pentair offers a compact line of air conditioners with a minimal footprint. The small size of the compact air conditioners also allow them to be mounted onto smaller enclosures used in condensed control panel designs. Pentair's thermoelectric coolers allow you to cool small indoor or outdoor enclosures. Pentair thermoelectric coolers are an ideal solution for demanding or low-maintenance environments because they are compact and reliable, and require no refrigerant, compressors or filters.

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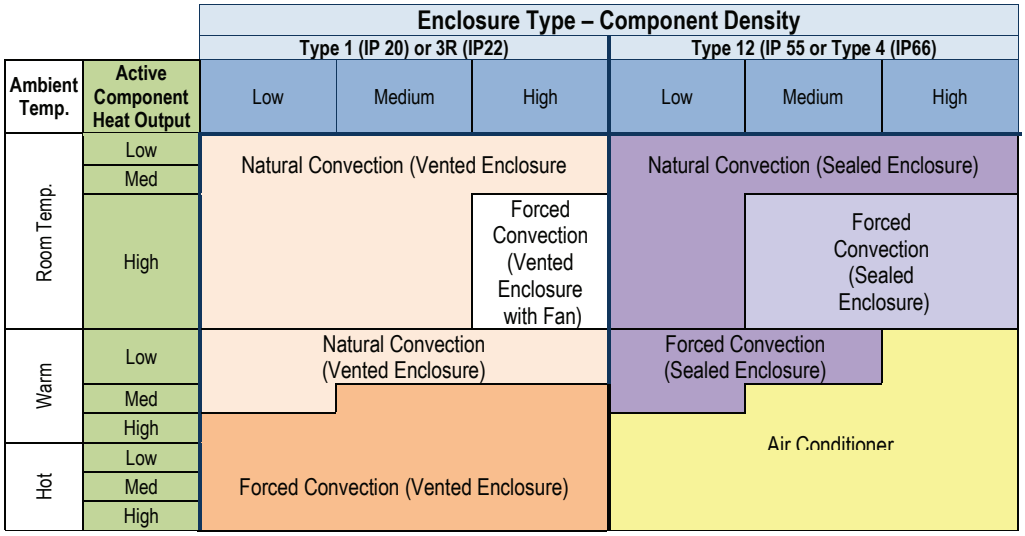
Thermal Demands of a Compact Design

Saving space in a control panel often means mounting active heat generating devices in close proximity with one another, and putting them into a smaller, more compact enclosure. While this is desirable for saving space, it creates a problem for heat dissipation because there are more heat generating devices in a smaller enclosed space. Understanding the thermal needs of a control panel is a key component to control panel design. There are several levels of thermal management solutions, depending on the amount of heat being generated inside the panel, the environment the control panel is in, and the type and size of the enclosure being used for the control panel design. Table 1 summarizes the considerations and possible control panel design solutions.

Table 1. Guide for selecting cooling solutions under varying ambient conditions and active component densities.



Pentair offers several products that can help manage thermal demands on a control panel design. Fans mounted on an opening on the surface of the enclosure such as Pentair's 4" compact cooling fan which can move 118 CFM of air, internal circulation fans such as the Pentair fan which can move 500 CFM of air, and air conditioners such as the T-15 can remove 800 BTU/Hour (234 watts) from a control panel. These are products that if used in the right application can allow the designer to fit more heat generating devices into a smaller space.

The topic of thermal design considerations will be covered in depth in the Environmental Protection white paper in this series, but it is mentioned here to highlight the need to consider the thermal impact of a more compact control panel.

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Conclusion

Controls engineers must overcome a tremendous amount of complexity when designing control panels in today's industrial environments. Whether the application is in the oil and gas, food and beverage, automotive, water treatment, or pharmaceutical market, competing design criteria make decisions about optimizing the control panel critical to the success of the project. Working together, Panduit and Pentair solutions provide control panel optimization best practices that address emerging control system needs.

More Information

This white paper is the second in a series of six papers on the topic of Control Panel Optimization. For more information on this topic, including copies of the white papers as they become available and more information on Panduit or Pentair Equipment Protection (Manufacturers of the Hoffman brand of enclosure), please visit www.Hoffman-Panduit.com.

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 brands – Hoffman®, McLean®, Schroff® - provide a broad variety of standard, modified and engineered solutions to the commercial, communications, energy, general electronics, industrial, infrastructure, medical, and security and defense 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's Unified Physical Infrastructure℠ (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's 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.

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