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Best Practices in Electrical Switchboard Design
Introduction

Many machine builders and system integrators outsource electrical switchboard design and construction. One reason is that it is not their core competency. Another is that panel building is subject to a variety of arcane standards and practices. Thus, designing and manufacturing a panel requires a specific skill set and knowledge. Having those will help in fulfilling the requirements of appropriate standards organizations and in ensuring customer satisfaction.

Speaking of customers, experienced ones will have specific and exacting expectations when they look at a panel to see how the elements are arranged and how construction is executed. Users appreciate fine workmanship and top-quality components because it ensures trouble-free performance for their project over many years.

Know-how is the critical element to panel building success when starting out and when growing a business. Schneider Electric, as a manufacturer of a comprehensive range of products for electrical switchboards, understands this. It is the reason why we provide many resources to help companies develop expertise.

This eGuide is designed to help direct your initial steps in this important venture, explaining the basics and pointing you at more comprehensive training materials.

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Protecting Equipment from its Environment

The most critical element that shapes a panel design project must be addressed at the very beginning of a project: where is the completed unit going to be installed? This very basic question dictates the type of protection the enclosure must provide to the equipment. The electrical switchgear inside the enclosure must be protected from the environment, and the plant and people around it must be protected from electrical dangers.

There are three types of external threats capable of causing equipment problems:

- Solid objects, which can range from large pieces to dust
- Water, which can come with varying levels of force and multiple directions, and
- Mechanical impact

These threats have been quantified and are described in detail in two standards: IEC 60529 (IP) covering solids and water, and IEC 62262 (IK) covering mechanical shock.

<table>
<thead>
<tr>
<th>1st numeral</th>
<th>Protection against ingress of solid objects</th>
<th>2nd numeral</th>
<th>Protection against ingress of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protected against access with back of hand</td>
<td>Protected against vertically dripping water (condensation)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Protected against access with a finger</td>
<td>Protected against dripping water up to 15° from vertical</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Protected against access with a tool</td>
<td>Protected against splashing water up to 60° from vertical</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Protected against access with a screw</td>
<td>Protected against water jets from all directions</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Protected against access with a wire</td>
<td>Protected against water jets from all directions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Protected against access with a wire</td>
<td>Protected against water jets from all directions</td>
<td></td>
</tr>
</tbody>
</table>

| 1           | Protected against solid foreign objects larger than 50 mm |
| 2           | Protected against solid foreign objects larger than 12.5 mm |
| 3           | Protected against solid foreign objects larger than 2.5 mm |
| 4           | Protected against solid foreign objects larger than 1 mm |
| 5           | Protected against dust (solid protected) |
| 6           | Dust tight |

Table 1

Temperature is also a consideration and covered later in this series.

As Table 1 shows, the IP rating uses a two-digit number. The first numeral describes the degree of protection from solids and the second from water. The higher the number, the higher the level of protection.

The IK rating is similar but has only one number between 0 and 10. Again, the higher the number, the greater the level of protection. Most industrial-grade enclosures are IK08 or better.

What level of protection is necessary?

One approach is to build every enclosure for the highest protection ratings; however, this adds a high level of complexity and cost. Customers not needing high levels of protection will not want to pay for such an enclosure. It is important to offer enough protection without going too far.

In most cases, customers are very specific about their final use environment, in which case the panel builder should choose the most optimized protection level to meet the requirement. Schneider Electric offers helpful information on its Partner Portal, including a detailed instruction set which will guide you through the evaluation, step by step. It considers basic questions such as the environment in which the enclosure will be placed and the nature of the company. It also begins the process of making other choices, such as enclosure size and other appointments.

Where situations are not clearly defined, discussions with the customer will be important to answer the full range of questions.
The importance of determining the protection classifications discussed in the last article will now become clearer as it becomes a major factor in the next phase, avoiding degradation of the IP rating during installation.

If we look at the installation process, questions related to mounting the panel should be: where is it going to go, and how will it be fixed in place?

**What are the mounting methods?**

**Fixed to a wall**—This is a common approach for small electrical distribution boards.

**Fixed to a floor**—This is useful for large and heavy cabinets. Cables can enter through the top or bottom. For bottom entry, the floor can incorporate a trench or false floor, which is often simpler since it provides easier access to the bottom. Additionally, a plinth can be used to raise the panel.

**Mounted on the machinery**—In some cases, the electrical switchboard is mounted directly on the machine. This approach keeps everything close together and avoids problems related to moving the machinery when the enclosure is fixed to the floor or wall. However, some machinery vibrates which can affect the enclosure over time. Where this is excessive, special provisions may be necessary.

**Moveable**—This situation is rare, but possible. Usually casters or a skid can be fixed to the bottom of the cabinet, but the greater complication relates to cabling.

**Cable Entry**

A panel used in an application of any complexity will have numerous cables and/or a busway requiring access.

- Busways are often used as power entries to link the cabinet with the transformer
- Power cables carry the main supply or power to motors and other pieces of equipment, and
- Control and command cables, along with communication cables with multiple conductors for data networking (Ethernet, fieldbus, etc.), extend to sensors and other minimum power devices.

Cable entry points for an enclosure must be designed very carefully, as an incorrect cable gland selection or improper installation degrades the IP rating for the whole panel. Keep in mind that the ultimate rating for a panel is only as good as its worst connection point.

Schneider Electric’s Partner Portal has many resources to help guide your planning, component selection and installation execution. These make all the difference for achieving and maintaining appropriate protection in the long term.
Internal and External Equipment Layout and Installation

As you look at a panel being assembled in your shop, put yourself into the position of the customer and ask some critical questions about the internal and external equipment. Obviously there are specific technical issues that must be addressed, such as circuit breaker selection, but there is also the quality of the overall realization. These points are not as defined, but are capable of making an impression on the customer.

When looking at the front of the enclosure, what impression does it give, both functionally and visually?

- Do all devices that penetrate the enclosure have an IP rating matching the requirements for the whole system?
- Are labels, push buttons and lights placed evenly?
- Are rotary switches placed where they are easy to operate?
- If there is a touch panel, is it located appropriately and mounted straight?
- Do devices on the door respect the maximum supportable weight and avoid conflict with normal operation?
- Is the paint or metal finish intact without deformations or scratches?
- Are devices arranged following sensible ergonomic concepts?

Internal Arrangements Also Matter
A technician looking inside will form opinions about your work based on appearance. Look into the cabinet (see Figure 1) and decide what impression it gives.

- Are racks and rails mounted correctly, straight and level? Are cables arranged and tied neatly?
- Are sensitive communication cables separated from power cables and other EMI (electromagnetic interference) sources?
- Is wire duct sized appropriately for the size and number of conductors?
- Have all metal chips from drilling and grinder dust been removed?
- Does the flow of components follow standard practices and a logical arrangement so that power flows are easy to trace visually?

Function is Critical But Looks Leave an Impression
The ability to create an enclosure that looks as good as it operates will identify your shop as a professional operation. Selection of high quality components also tells customers your enclosures are designed for many years of trouble-free operation. Schneider Electric's Partner Portal offers many practical resources to help make the best design and component selection. When your shop delivers products exhibiting excellence in all areas, customers will return for additional projects.
Managing the Temperatures of a Switchboard

An electrical switchboard is composed of different electrical devices, some of which are more or less sensitive to the temperature outside and/or inside the enclosure. The outside is mainly due to the environment where the switchboard is installed. The inside is more complicated, and can cause concerns related to the IP level, characteristics of components or the location designed.

External Heat Sources
A panel is subject to the temperature of the environment along with anything the local conditions bring. A panel installed at a Middle-Eastern desert oil pumping station could easily reach an ambient temperature of 50°C or more. At the other extreme, one located in Siberia could experience -40 ºC. Even inside the electrical room, you should be cautious if there is other equipment installed nearby that might cause the heat and humidity to impact the new electrical switchboard.

Consequently, the location where the enclosure will be installed is one of the key specification that should be defined as a project is still being planned.

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Internal Heat Sources
Not all temperature problems originate outside. The IP level often has a critical impact the inside temperature. If the enclosure has a low IP rating, cutting ventilation slots and allowing cooling by convection may be enough. A higher IP level may necessitate other techniques and materials to preserve the performance of the equipment, such as fans and grids with an appropriate design to support the IP level.

The positioning of each device should also be considered as various components are more or less sensitive to temperature. Since heat rises, a higher or lower position within the cabinet can impact the performance of some devices. To avoid malfunctions, do not install devices that are sensitive to temperature changes near devices capable of dissipating significant amounts of heat.

In some cases where humidity is high, allowing unrestricted airflow through a cabinet can allow condensation inside, mainly due to the load variation of the network. If the temperature falls it may pass the dew point. In this case, condensation may reduce the insulation value of internal components and cause a short circuit.

Temperature Limits vs. Component Selection
If the customer requires the capability to withstand extremely high or low ambient temperatures, they need...
to look at the capability of components according to their operating temperature ranges. Depending on ambient temperature conditions, installation mode and protection index, some precautions are necessary to preserve device performance.

Environmental Control
Adding mechanisms to overcome the effects of changing temperatures from internal and external sources invariably add to the overall cost. There are several ways to manage the environment inside the enclosure. Cooling is the most common. Natural cooling via convection through grids may be enough if it is suitable for the IP level. Forced cooling with fans may also be required, or a small air conditioning unit for some extreme environments typical in oil and gas applications. Heating may also be necessary in certain situations to control the temperature changes to avoid condensation and other potential risks inside the enclosure.

Condensation may reduce the insulation value of internal components and cause a short circuit.

Schneider Electric’s Partner Portal has many resources to help guide equipment selection. The cost of providing appropriate temperature control is small compared against potential production losses.
Schneider Electric’s Partner Portal has many resources to help guide your planning, component selection and installation execution. These make all the difference for achieving and maintaining appropriate protection in the long term.

For more information, please visit the following resources:

10 Key Points to Define Enclosures

Panel Builder Global Web Site

How to Assemble an Electrical Switchboard Technical Guide