Basic Information on Control Panel Design

Know-how on Control Panel Design, from Safety Standards to Preventive Measures against Heat, High Humidity, and Ground Faults

Changes in the market require handling a wide variety of control panel issues. Control Panel Basics describes OMRON’s wealth of knowhow and information and provides easy-to-understand descriptions of the knowledge required to solve these issues through concrete examples.
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Important Points on Control Panel Design

The IEC 60204-1 electrical safety standards related to machine control panels must be considered.

The power supply breakers, device locations, and electric-shock prevention for control panel design are described from the viewpoint of safety standards.

### Power Supply Cutoff (Breaker) Devices
- ON “ ” and OFF “ ○ ” must be indicated.
- There must be an external operation means (e.g., handle).
- There must be a means to lock the device in the OFF position.
- There must be a suitable cutoff capacity. Etc.

### Device Locations
1. Power supply cutoff devices: 0.6 to 1.9 m, recommended max.: 1.7 m
2. Manual operation devices: 0.6 m or higher
3. Terminals: 0.2 m or higher
4. Devices that must be approached for periodic maintenance or adjustments: 0.4 to 2.0 m

### Electric Shock Prevention

#### When Enclosure Is Opened:
- It must be possible to open the enclosure when charged sections are cut off.
- If the enclosure can be opened without cutting off a charged section, all charged sections must have IP2X or IPXXB protection.
  - If a barrier is provided, a tool must be required to remove it or the charged section must be automatically cut off when it is removed.

### Additional Information
- IP2X: Protection against foreign objects with a diameter of 12.5 mm or larger (equivalent to a finger)
- IPX2: Protection against vertically falling water drops when enclosure tilted up to 15°
- IPXXB: Protection against an approaching finger

### Reference Illustration
(Numbers 1 to 4 correspond to items 1 to 4 under Device Locations.)

**Control Panel (Enclosure)**

- **Power supply cutoff device operation handle**
- **Manual Operation Devices** (e.g., Operation Switches)

**Note:** The values are the heights from the working surface.
Control Panel Component Colors

It is important to correctly understand the meaning of the colors of indicators, operation parts, and wires.

<table>
<thead>
<tr>
<th>Color</th>
<th>Meaning</th>
<th>Machine status indicated by indicator color</th>
<th>General meaning of operation device (operation part) color</th>
<th>General rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Emergency</td>
<td>Hazardous situation</td>
<td>Actuate in the event of a hazardous situation or emergency</td>
<td>Human or environment/safety</td>
</tr>
<tr>
<td>Yellow</td>
<td>Caution</td>
<td>Abnormal situation</td>
<td>Actuate in the event of an abnormal condition</td>
<td>Hazard</td>
</tr>
<tr>
<td>Green</td>
<td>Normal</td>
<td>Normal situation</td>
<td>Actuate to initiate normal conditions</td>
<td>Caution</td>
</tr>
<tr>
<td>Blue</td>
<td>Mandatory</td>
<td>Indication of situation requiring operator action</td>
<td>Actuate for a condition requiring mandatory action</td>
<td>Safe</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>Other situations</td>
<td>Initiation of functions</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Application example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate action for the hazardous situation</td>
<td>●Emergency stop&lt;br&gt;●Stopping or turning OFF for emergency stop&lt;br&gt;●Initiation of emergency function</td>
</tr>
<tr>
<td>Monitoring and/or intervention</td>
<td>●Intervention to suppress abnormal condition&lt;br&gt;●Intervention to restart an interrupted automatic cycle</td>
</tr>
<tr>
<td>No specific action required</td>
<td>●White is the most suitable color for a device (operation part) for starting or turning ON something, but green is also acceptable.</td>
</tr>
<tr>
<td>Required action</td>
<td>●Reset function</td>
</tr>
<tr>
<td>Monitoring</td>
<td>●White can be used for any function other than an emergency stop.</td>
</tr>
</tbody>
</table>

Color Requirements for Emergency Stop Switches

- Operation part: Red
- Background: Yellow

Wire Colors (IEC 60204-1)

<table>
<thead>
<tr>
<th>Applicable conductor</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground (earth) circuit</td>
<td>Green-yellow spiral</td>
</tr>
<tr>
<td>Power neutral circuits</td>
<td>Light blue</td>
</tr>
<tr>
<td>Primary power circuits</td>
<td>Black</td>
</tr>
<tr>
<td>DC control circuits</td>
<td>Blue</td>
</tr>
<tr>
<td>AC control circuits</td>
<td>Red</td>
</tr>
<tr>
<td>Excepted circuits (e.g., interlock circuits)</td>
<td>Orange</td>
</tr>
</tbody>
</table>

Recommended Operation Devices

- **Pushbutton Switches A22N**
  - Globally applicable switches conceived for compactness, simplicity, and safety.
  - Search for OMRON A22N for details.

- **Emergency Stop Switches**
  - **A22E**
    - Emergency Stop Switches That Conform to Various Standards
    - Search for OMRON A22E for details.
Heat Measures

The correct Fan must be selected to suppress temperature rise inside the panel.

If the temperature inside the panel increases, the lives of devices and parts inside the panel will be reduced and malfunctions could result. Particularly devices and parts that generate heat are greatly affected by heat. Panel cooling and Fan selection are extremely important to long-term usage of the panel and parts inside the panel.

Selecting Fans

1. **Check the heating values of devices and the panel (kW).**
   - Check the heating value of each device located in the control panel and then find the total heating value.
   - Generally speaking, the heating value indicates the power consumption, so you can assume that the power consumption equals the heating value.
   
   \[
   \text{Heating value (W)} = \frac{\text{Input power} - \text{Output power}}{\text{Efficiency}}
   \]

2. **\( \Delta T \) of devices and panel: Allowable temperature rise (°C)**
   - \( \Delta T \) can be obtained by subtracting the device ambient temperature, \( T_1 \) from the allowable internal temperature, \( T_2 \).
   - Note: As a guideline, you can make the calculation with a value of 10°C.
   - (Use the more severe condition.)
   
   \( \Delta T = 10 \degree C \) (guideline)

3. **Calculate \( Q \), the required flow rate \((\text{m}^3/\text{min})\).**
   
   \[
   Q = \frac{50 \times W}{\Delta T} \text{ m}^3/\text{min}
   \]

4. **Select the size of the required Fan based on the maximum flow rate.**
   - Normally, select a Fan with a maximum flow rate of 1.3 to 2 times the calculated required flow rate \( (Q) \).
   - As the flow rate increases, noise increases. If the Fan is used in an environment where noise is a problem, select a Fan with a lower flow rate.

5. **Selecting Options**
   - If fine foreign matter may enter the Fan, select a Filter.
   - If slender objects such as fingers may enter the Fan, select a Finger Guard.

Note: Actually results may vary from calculations, so measurement and confirmation in the actual panel are required.

**Calculation Example for a Control Panel with Two 100-W Power Supplies**

Note: The S8JK-N10024C (output voltage: 24 VDC, output current: 4.5 A, efficiency: 83% min.) is used for the 100-W Power Supplies.

First, the heating value (power consumption) is calculated.

Heating value (W) = \( \frac{24 \text{ (V)} \times 4.5 \text{ (A)}}{83 \%} - 24 \text{ (V)} \times 4.5 \text{ (A)} \)

\approx 108 \text{ (W)} - 108 \text{ (W)} = 22.120... \text{ (W)}

Two Power Supplies are used, therefore,

22.12 \text{ (W)} \times 2 = 44.2 \text{ (W)} = 0.04 \text{ (kW)}

Q: Required flow rate = \( \frac{50 \times 0.04 \text{ (kw)}}{\Delta T: 10\degree C} = 0.2 \text{ [m}^3/\text{min]} \)

Maximum flow rate calculation: \( 0 \times 2 = 0.2 \times 2 = 0.4 \text{ [m}^3/\text{min]} \)

Therefore, one R87F-A@A83H is required from the table on the right.

Note: This calculation example assumes that the control panel contains only two Power Supplies.
**Airflow Direction and Inlet/Outlet Cooling Effect Differences**

**When the Heat-generating Portions Are Concentrated at One Location**
- You can concentrate cooling on the heat-generating portions.
- The pressure inside the box increases, which reduces dust entry from other openings.

**Advantages of Inlet Installation**

**When the Heat-generating Portions Are at Many Locations**
- A wide area can be cooled.

**Advantages of Outlet Installation**

**Reference Information:**
The Fan airflow is in one direction, which is indicated on the top of the Fan.

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**Recommended Axial Fans**

**R87F AC Axial Fans**

<table>
<thead>
<tr>
<th>Size [mm]</th>
<th>Large</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 × 120 × 138</td>
<td>R87F-AA15HP</td>
<td>R87F-A83H</td>
</tr>
<tr>
<td>120 × 120 × 125</td>
<td>R87F-A13HP</td>
<td></td>
</tr>
<tr>
<td>92 × 92 × 125</td>
<td>R87F-A93HP</td>
<td></td>
</tr>
<tr>
<td>80 × 80 × 138</td>
<td>R87F-A85HP</td>
<td></td>
</tr>
<tr>
<td>80 × 80 × 125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow rate [m³/min]**
- 0.6 (0.7)
- 0.8 (0.9)
- 0.9 (1)
- 1.9 (2.2)
- 2.7 (3.1)

**Options**
- Plug with Cable
- Finger Guard
- Filters

**Models**
- Plug with Cable: R87F-PC
- Finger Guards: R87F-FG
- Filters: R87F-FL(S)

*Not required for Fans with lead wires.*

Search for OMRON R87F for details.
High Humidity Measures

If a control panel is installed in a location with high humidity, measures against short-circuits are required.

Condensation will occur in the control panel as the result of a difference in the device temperature and external air temperature. This condensation may adhere to a PCB and if condensation and dust repeatedly collect on the PCB, short-circuits will occur.

**Examples of Short-circuits Caused by Condensation**

Case 1: **Short-circuit** from Water Drops Generated by Condensation
Case 2: **Short-circuit** Caused by Repeated Condensation and Dust Collection

**Processing Schedule**
- **Morning**
  - Facilities stopped.
  - Aging
  - Facilities operated.
- **Afternoon**
  - Aging
  - Break
  - Facilities operated.
  - Facilities stopped.

Condensation will occur if there is a difference between the temperature resulting from device heat generation and the air temperature while the facilities are stopped.

**Preventing Short-circuits with Products with Coated PCBs or Modifications**

PCBs can be coated to protect them against humidity and reduce the possibility of short-circuit accidents.

**Recommended Products with Coated PCBs**

- **Switch Mode Power Supplies**
  - S8VK-G
- **Timers**
  - H3CR
  - H3Y
  - H5CX
- **Counters**
  - H7CX
  - H7E□-N
- **Micro PLCs**
  - CP1E
  - CP1L
  - CP1H
  - CP1W
- **Digital Temperature Controllers**
  - E5□C
  - E5CB

Ask your OMRON representative for more information on coating.
Why There Are Two Different DIN Track Heights

The two types of DIN Tracks are both made of aluminum, but the heights, which increase the mounting strength, are different. Small, lightweight devices, such as Relay Sockets, can be mounted to the DIN Track with a height of 7.3 mm without concern. Large, heavy devices, such as Power Supplies, require more track strength, so the DIN Track with a height of 16 mm must be used.

Recommended DIN Track

For Mounting Small, Lightweight Devices
DIN Track with a Height of 7.3 mm:
PFP-100N/-50N

For Mounting Large, Heavy Devices
DIN Track with a Height of 16 mm:
PFP-100N2

Let OMRON Solve Your Control Panel Challenges

New Value for Control Panels
A product and service catalog is available to help solve a wide range of control panel challenges, such as downsizing. Ask your OMRON representative for details.

*Solutions to Downsize Control Panels* Catalog
(Cat. No. Y204)