

Effects of Heat and Airflow Inside an Enclosure

Most DeltaV™ DCS and DeltaV SIS™ products, such as controllers, I/O cards, logic solvers and related items, are designed for natural airflow cooling. For maximum product availability and expected unit lifetime, sufficient air flow through them and proper ambient air temperature in and around them must be such that their specified operating temperature range is maintained.



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Introduction

This paper discusses the importance of the site environment – which cannot be understated. Environmental conditions such as elevated temperature can cause gradual performance degradation, intermittent failures, and malfunctions in all electronic equipment. In order to prevent problems during the operation of both control and safety systems, effects of heat and airflow on equipment installed in enclosures must be considered during the system design. This whitepaper is not intended to replace installation manuals or cabinet design but rather provide information about the heat impact on the life of electronic components.

Heat Impact on Mean Time Between Failure (MTBF)

When the equipment is operated within the specified temperature, reliability based on Mean Time Between Failure (MTBF) calculations can be expected. If the equipment is operated at a higher temperature for long periods of time, the failure rate increases. Heat wears out electronic components; as explained by the Arrhenius effect equation, for every 10°C increase in operating temperature, the failure rate will double. This behavior is not specific to Emerson products, the reliability of any electronic component is affected by heat.

The chart below is an example illustration of the effective drop in the MTBF value for each 10°C rise in operating temperature for a hypothetical device, during a hypothetical time period ranging from 12.5 years to 200 years.

Temp	MTBF
25°C	200 years
35°C	100 years
45°C	50 years
55°C	25 years
65°C	12.5 years

The actual operating temperature should be considered when evaluating the useful life of electronic equipment including DeltaV and DeltaV SIS components.

Airflow Considerations

Most DeltaV DCS and DeltaV SIS products, such as controllers, I/O cards, logic solvers and related items, are designed for natural airflow cooling. For maximum product reliability, sufficient air flow through them and proper ambient air temperature in and around them must be such that their specified operating temperature range is maintained. Proper temperature levels promote good system health and product availability.

All DeltaV DCS and DeltaV SIS products are designed to operate within a specific temperature range: for example, -40°C to 70°C. Consult the product datasheet for each product to determine the specific temperature range. The published information indicates the temperature range a particular product is capable to withstand, however, as mentioned earlier, running the product at the higher end of the temperature range for long periods of time will increase the failure rate of electronic components.

Heat-related Issues

Some heat-related issues identified during design reviews and troubleshooting are:

- Enclosure designs that do not allow adequate heat dissipation and air flow, resulting in very high internal temperatures.
- Enclosure designs that lead to hot spots because of lack of air circulation in particular areas of the enclosure.
- Enclosures located in areas of higher ambient temperatures caused by, for example, adjacent heat-producing equipment or direct sunlight.
- Equipment, interconnected wiring, and cabling inside of an enclosure so tightly packed that natural airflow is inhibited.
- Wiring Panduit mounted too close to devices, cutting off adequate airflow, especially if the Panduit is packed with wiring and cabling.
- Devices with opposite-side cooling slots and adjacent products mounted too close for adequate cooling air.
- Devices that should be mounted vertically or horizontally for adequate airflow, but which have been mounted otherwise.
- Mounting of heavy heat-producing devices in the enclosure, such as power supplies generating high internal temperatures.

Solutions

Expected system reliability does not occur by accident. Enclosures must be designed, properly located and maintained to meet expectations. DeltaV products can be installed outdoors in field enclosures and will operate per the specified temperature range. Running any electronics at the higher end of its temperature range for long periods of time will decrease its expected lifetime. In some cases, due to installations constraints, the expected unit lifetime may not be achievable, but approaching it is usually feasible by mitigating heat effects as much as possible.

The Site Design and Preparation for DeltaV Digital Automation Systems manual has information on the effects, data on how to calculate the effects, and suggestions on how to make useful changes to improve heat dissipation.

Some methods to consider for improved heat dissipation are:

1. Proper placement of pieces of equipment in relationship to each other
 - a. Power supplies
 - b. Panduit
 - c. Cable wiring into and out of the enclosure
 - d. Device placement for maximum air circulation

Notes: Enclosure design must consider minimum distances specified by the equipment vendors. For DeltaV equipment, please consult the planning and designing documentation. The wiring must, as a minimum, conform to NFPA and NEC, and applicable local, regional and national codes to ensure that it can conduct load safely without overheating.

2. Auxiliary designs for cooling and air flow
 - a. Use of side and top vents to move cool air in and hot air out
 - b. Use of instrument air and vortex coolers (a filter system may be needed on the input line to ensure clean and dry air)
 - i. Allows positive pressure inside the enclosure
 - ii. Allows small amounts of air to improve airflow beyond convection alone
 - iii. Allows normally cooler instrument air (often used to control dew point) to lower enclosure internal temperature
 - c. Use of heat sinks or cooling fans

- d. Mounting products to take advantage of the natural cooling openings
- e. Making sure the enclosure is not receiving warm moist air from other areas through conduit openings

3. Circuit designs for proper energy dissipation

Design circuits so that all of the power does not dissipate inside an enclosure. For example, some circuits such as an AS-Interface can be wired in parallel or series. Series wiring dissipates more energy inside the unit and enclosure, whereas parallel wiring dissipates more energy in the field devices.

4. Enclosure Fans

- a. Locate fans to move air in such a way that enclosure sheet metal can dissipate heat.
- b. Locate fans to provide maximum airflow over and through all installed devices. Sometimes, fans are mounted so that they are ineffective in actual cooling or providing critical airflow. Fan placement is an important aspect of the enclosure design. Consider the following guidelines when selecting the fan location for your specific application:
 - Place fans in the bottom of the enclosure to create positive pressure, and place vents at the top rear of the enclosure to exhaust the hot air. This method can maximize cooling and airflow since it works with the natural physics of convection currents.
 - Place exhaust fans at the top back of the enclosure and pull air through from the bottom, creating negative pressure. The drawback to this method is that air in connected conduits can be pulled in.
 - Roof cabinet fans have significant advantages over door cabinet fans since roof fans generally have a bigger air displacement capacity than door mounted fans. In addition, the placement of roof fans right above the equipment ensures a bigger cooling effect than door fans.

5. High-Heat Load Device Mounting

- a. Mount high-heatloads toward the enclosure top so the heat does not pass around or through other devices while it naturally rises.
- a. Mount high-heat loads near enclosure sides for best heat dissipation through sides instead of through other devices.
- b. Mount high-heat loads in such a way that natural airflow circulations (higher temperature on one side and cooler temperature on the other) are generated.

6. Installation on a shaded area

- a. Field enclosures exposed to direct sunlight are subject to solar energy absorption which can raise the temperature inside the enclosure. Depending on the environmental conditions, sun shades or sun shields should be considered to lower the temperature for both the enclosure and the electronic components.
- b. The temperature range specified for some field enclosures expects installation in a shaded area. Installation should follow the field enclosure manufacturer's recommendations and if needed, sun shades or sun shields should be installed.

These methods can help maximum system availability and expected unit lifetime by better controlling enclosure heat. Such control is fundamental to good enclosure design.

It is recommended to perform periodic audits to ensure proper temperature levels within enclosures as well as identifying "hot spots." Adequate airflow can be determined by measuring the inside temperature at the top, middle, and bottom of the cabinet or enclosure. However, thermal images are the preferred method to measure temperature. A hot spot reading could be an indicator of a bigger issue that needs to be reviewed and remedied. Among other things the audit should confirm that fan directions, fan speed and that airflow is correct.

Maintenance Considerations

Regular maintenance is very important. Air filters need to be cleaned or replaced periodically. Clogged air filters will lead to poor air cooling, higher temperatures, and shorter expected unit lifetime.

Conclusions

Achieving expected system reliability and longer expected unit lifetime is possible by proper system design and maintenance. Please contact your local Emerson sales office for information about maintenance programs to achieve maximum system availability.

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