Effects of Heat and Airflow inside an Enclosure

Most DeltaV products, such as controllers, I/O cards, and related items, are designed for natural airflow cooling. For maximum product availability and MTBF, 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

In order to prevent problems during control system design, effects of heat and airflow on equipment installed in enclosures must be considered. When effects are not considered, heat-related equipment issues occur or system MTBF does not meet expectations.

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All DeltaV products are designed to operate within a specific temperature range: for example, 0˚C to 60˚C. However, the MTBF of a device is based on a Mil Standard specification of 25˚C.

The MTBF value drops by ½ its value for every 10˚C increase in the ambient temperature around the unit. If a device runs at its upper range value continuously (60˚C in this example), it will have a much lower MTBF. On the contrary, a device running at less than 25˚C does not necessarily have an improved MTBF.

The chart below shows the effective drop in the MTBF value for each 10˚C rise in operating temperature, along a hypothetical period ranging from 3.125 years to 50 years.

Temp	MTBF
25˚C	50 yrs
35˚C	25 yrs
45˚C	12.5 yrs
55˚C	6.25 yrs
65˚C	3.125 yrs

The same issues apply to integrated circuits and other electronic components mounted on the printed wiring board inside the devices. Component MTBF is designed to specifications based on the Mil Standard of 25˚C. Ambient temperature around devices and airflow through them must be maintained at levels which provide adequate component cooling. Proper levels promote component design MTBF and overall system and product availability.

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 availability and MTBF do not occur by accident. Enclosures must be designed and properly located to meet expectations. In some cases, expected MTBF may not be possible, but approaching it is normally possible 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. 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
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 fins
    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

    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.

    c. 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.

    d. 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.

5. High Heat Load Device Mounting

    a. Mount high heat loads toward the enclosure top so the heat does not pass around or through other devices while it naturally rises.

    b. Mount high heat loads near enclosure sides for best heat dissipation through sides instead of through other devices.

    c. 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.

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