Thermal Edge Inc.™

TEMPERATURE CONTROL SOLUTIONS FOR ELECTRICAL ENCLOSURES

A COMPREHENSIVE GUIDE TO THERMAL MANAGEMENT OF TELECOM ENCLOSURES

Introduction: Challenges Facing Telecom Companies

The telecommunication industry is facing a number of disruptive challenges. For starters, there is an explosive growth in data traffic fueled by the 4G rollout and, within a few years, by 5G as this technology becomes available. Other drivers of this growth include the shift toward cloud computing, the increased data demands arising from the growth in smartphones, and data streaming. Technology giant Cisco believes that mobile data traffic will grow at an annualized rate of 61 percent through to 2018, and during this period, network connectivity speeds will more than double.

At the same time, telecom operators are facing lower operating margins while having to invest heavily to meet the demand for data services. They are also facing a shift away from traditional means of telephony toward VoIP-based systems and a move away from fixed telephone lines toward wireless and fiber-based systems. Telecom operators must take bold and decisive steps to cope with these challenges.

Meeting the Digital Demand

In order to meet the growth in demand for digital services, telecom companies are faced with the need to install significant numbers of OSP telecommunication cabinets that are often well away from existing infrastructure. Part of the reason for this is the need to install equipment as close to the customer as possible in order to ensure high data transmission speeds. These cabinets may be padmounted, pole-mounted, or even on rooftops. All share a common problem: The heat load of the digital equipment in these cabinets has been growing exponentially over the last decade. This has fueled the need to install cabinet cooling equipment to ensure that the telecom equipment in these cabinets is operating within a specified temperature range.

Outside plant (OSP) telecom enclosures are expected to operate reliably in all kinds of weather. Although the most rugged types of telecom equipment can operate without heating and cooling, most outdoor telecom cabinets are designed to comply with the GR-3108-CORE Class 1 specification, which requires that the internal temperature of the cabinet is maintained between 41°F (5°C) and 104°F (40°C). The heat load of modern telecom cabinets is often high, and it's usually necessary to install enclosure cooling equipment to maintain the internal temperature below the higher limit specified by GR-3108-CORE. Enclosure heating may also be required in colder regions.

Key Telecom OSP Cabinet Requirements

Apart from the need to ensure telecom equipment conforms to the required specifications, the industry must ensure that solutions devised are such that overall costs are minimized while reliability is enhanced. The technical requirements for telecom equipment are covered in great detail in the various specifications and are beyond the scope of this document; however, three aspects stand out as being especially important in the current environment:

- ***Telcordia specifications GR-487 and GR-3108:*** The telecom industry has a long history of outdoor plant cabinets and has developed detailed specifications such as the Telcordia Requirements for Electronic Equipment Cabinets (GR-487) and the GR-3108, which specifies equipment testing criteria. These specifications are intended to ensure that telecom equipment is robust and reliable. The most onerous conditions specified are the GR-3108-CORE classes 2 and 3, which require that equipment is able to operate over an extreme temperature range of minus-40°F up to 149°F for Class 2 and 185°F for Class 3. However, equipment built to these specifications is extremely costly, which is why the more moderate Class 1 requirements are commonly used.

- ***Efficiency:*** OSP cabinets and their temperature control systems invariably need standby batteries to ensure continuity of service in the event of a mains supply outage. Some remote units are even solar-powered. Consequently, power consumption must be tightly managed, and temperature control solutions need to operate efficiently and provide a high overall coefficient of performance (COP). This means that the cooling power as measured in watts should be as high a multiple of the energy consumption of the cooling unit as is possible.

- ***Lowest overall cost:*** The overall cost as measured by the amortized capital costs plus running cost should be as low as possible. This favors more efficient coolers despite the possibility that they may cost more initially.

Crucial Thermal Design Aspects for Telecom Cabinet Cooling

Several design aspects are crucial if overall cabinet cooling costs are to be reduced while ensuring that the equipment inside the enclosure is adequately protected. These include:

- ***Minimize internal heat load:*** Close attention should be paid to selecting equipment that produces as little waste heat as possible. Special consideration should be given to conversion equipment such as DC rectifiers, battery chargers, and inverters because the waste heat generated is inversely proportional to their overall efficiency. A device with 96 percent efficiency produces half the waste heat of one with an efficiency rate of 92 percent.

- ***Mitigate external heat:*** Solar radiation can increase cabinet temperatures by 20 percent, so steps should be taken to mitigate these effects. Also, locate the enclosure away from places where reflected heat can contribute to internal heating. The installation of shade panels, solar reflectors and panel insulation should be considered.

- ***Minimum and maximum ambient temperatures:*** Pay special attention to the maximum and minimum ambient temperatures expected. These will help indicate what kind of cooling solution is required and whether enclosure heating should be provided. Design for the extremes.

- ***Allowable equipment temperature range:*** The GR-3108-CORE Class 2 temperature limits are 41°F and 104°F, and equipment should be able to tolerate these temperature ranges. However, take into account the effect of high temperatures on equipment life. Conventional wisdom is that the life of electronics is halved for every 18°F increase in temperature. ASHRAE, the Association of Heating, Refrigeration and Air-Conditioning Engineers, investigated this and established that for telecommunication equipment, the service life at 113°F (45°C) is reduced by a factor of 1.8 compared with the service life at 68°F (20°C). The effect of temperature on the lifetime of standby batteries should also be considered. According to battery manufacturers, batteries have an optimum lifespan at a temperature between 68°F (20°C) and 77°F (25°C). Their usable service life is reduced by a factor of 4 if kept at 104°F (40°C). Thus, it makes practical sense to choose an operating temperature below the limit of 104°F both for the electronics and the battery.

- ***Environmental factors:*** Apart from temperatures, the effects of wind, rain, snow, and ice must also be considered. Another factor is the amount of dust and other pollutants in the environment, as well as salt spray in coastal locations. In such instances, the cabinet should be manufactured to comply with the appropriate NEMA enclosure rating.

- ***Humidity:*** In regions with high humidity, steps must be taken to control the humidity inside the enclosure to prevent damaging condensation.

- ***Power availability:*** Depending upon the location of the telecom cabinet, power may or may not be readily available. If connecting to the grid is expensive, solar power is an option. Even when mains power is readily available, it's essential to install a backup power supply, usually in the form of batteries. Nationally, the number of power outages experienced by customers is growing. According to the Eaton Blackout Tracker, there were 3,634 outages in 2014, affecting a total of 14 million people. This represents a 28 percent increase since 2009. The vast majority of blackouts were caused by inclement weather.

- ***Downtime intolerance:*** A decision should made as to whether downtime or outages can be tolerated. In most cases, customer resistance to outages dictates that all reasonable measures, including the provision of standby power facilities, should be taken.

Commonly Available Temperature Control Solutions

There are several commonly available temperature control solutions to choose from, depending upon the enclosure heat load, environmental conditions, and the ambient temperatures. These include:

- ***Natural ventilation:*** Natural ventilation provides cooling through vents provided at the bottom and top of the enclosure. Airflow is assisted by the natural tendency for hot air to rise. Heat is also transferred through the sides of the enclosure. If the heat load is high, natural ventilation will have difficulty keeping the internal temperature below 104°F. The enclosure temperature will always be higher than the ambient temperature.

- ***Fan-assisted ventilation:*** Fans increase the flow of air and, thus, the cooling capacity. However dirt, debris, and pollutants will enter the enclosure, potentially causing equipment damage. Filters may be fitted but will need regular servicing and cannot stop ingress of moisture and pollutants.

- ***Closed-loop cooling:*** With closed-loop cooling, the enclosure is sealed to prevent ingress of dirt and pollutants. Several closed-loop solutions exist, including heat exchangers, thermoelectric coolers, and air conditioning. The efficacy of the different solutions depends upon the heat load and the relationship between the ambient temperature and the desired enclosure temperature.

- ***Hybrid cooling:*** Some companies advocate a hybrid solution that allows external ventilation in cool conditions and a switch to closed-loop cooling in hot weather.

Why Closed-Loop Cooling Makes Sense for OSP Cabinets

Natural and fan-assisted ventilation are by far the cheapest solutions, but both suffer from serious disadvantages. First, they cannot prevent contaminants from entering the enclosure or blocking filters. Second, their limited heat removal capability means the enclosure's internal temperature will be significantly higher than the ambient air temperature—so much so that in hot weather, with the contributory effect of solar radiation, they cannot keep OSP cabinet internal temperatures below 104°F. On the other hand, a cabinet with closed-loop cooling is sealed from the environment. Internal equipment is kept clean, and damage due to contamination avoided. It also permits the use of enclosure air conditioning, which has the ability to bring down the internal temperature even in very hot environments. In locations where the ambient temperature remains below 95°F, an air to air heat exchanger can be used to maintain proper internal temperature with a sealed cabinet.

Benefits of DC-Powered Cabinet Cooling for Enclosures with Standby Batteries

Due to the need to provide uninterrupted service, OSP cabinets serving the telecom industry need standby batteries to ensure power is always available. These batteries must be large enough to ensure power is maintained throughout anticipated outages, especially because in most instances, providing standby generators for OSP cabinets is not economically feasible. During power outages, power for cabinet cooling will be supplied by the batteries. Here are three reasons why using DC powered cooling solutions makes sense.

- ***Efficiency:*** Using DC power directly is more efficient than using inverters to provide AC power. The efficiency of most inverters is between 90 and 95 percent, and even in stand-by mode they draw current from the batteries. A DC-powered solution reduces battery current and does away with the need for an inverter.

- ***Lower peak power demand:*** The starting current of AC compressors is extremely high compared with their running current, and the inverter needs three times more output power than required by the compressor. In contrast, DC compressors are equipped with an electronic softstart control circuit that minimizes the starting current, thus reducing battery drain.

- ***Battery size:*** Because of the greater efficiency and lower standby losses, the battery capacity required to power a DC enclosure air conditioner would be at least 10 percent lower than for an AC solution.

Efficient Closed-Loop DC Cooling Solutions

The key elements of an efficient DC cooling solution should be that it is effective, is economical, and produces significant cooling capacity related to its power requirements. These elements are achievable in two ways. First, there is the air-to-air heat exchanger solution that uses heat pipe technology to exchange heat and, apart from the power required to drive air circulation fans, uses no external energy, instead depending upon the evaporation of a refrigerant driven by the heat inside the enclosure. The second way is a highly efficient DC-powered enclosure air conditioner that achieves an extremely high COP through clever design and the use of efficient compressors. Both these solutions are able to extract significant quantities of heat from an enclosure with relatively low energy input. The overall efficiency of the air conditioner in particular is significantly higher than the alternative method of thermoelectric cooling using the Peltier effect. Whereas the COP of a thermoelectric cooler is always less than 1 and in practice usually around 0.5, the COP achieved by a small DC air conditioner is between 1.7 and 2 and is significantly higher for an air-to-air heat exchanger.

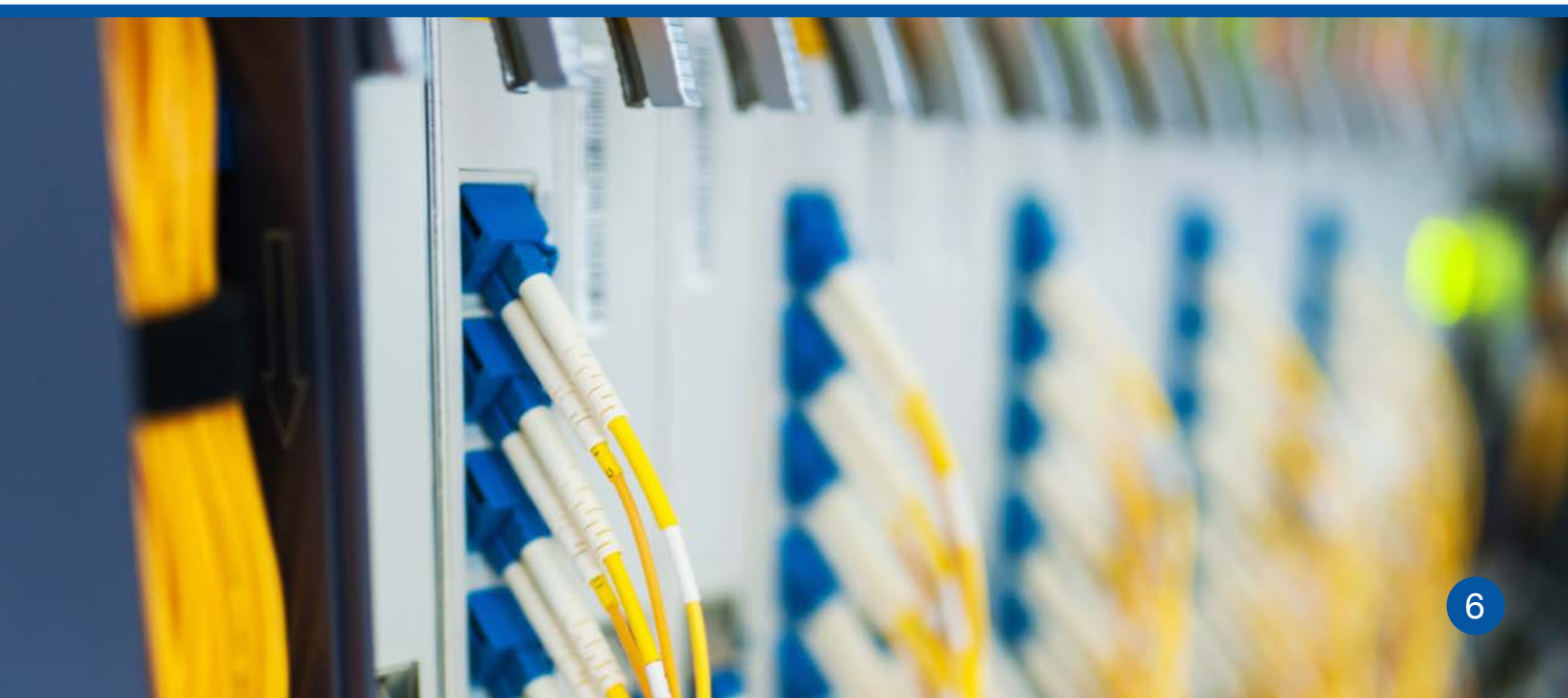
DC-Powered Air-to-Air Heat Exchangers

Thermal Edge manufactures a range of closed-loop DC-powered air to air heat exchangers in various profiles and designed for 24 and 48 volts DC. The heat exchanger uses an innovative evacuated heat pipe filled with a refrigerant. Heat is removed from the enclosure through the evaporation of this refrigerant and discharged to the ambient air when it condenses at the top of the pipe. Features of the air-to-air heat exchanger include:

- ***High efficiency:*** The only power consumed is by two fans that draw less than 1 amp at 48 volts DC, yet the largest unit can remove 400 watts with a temperature difference of 10°F.

- ***Low cost:*** Due to their simple yet elegant design, these units are relatively inexpensive but built to withstand the rigors of an outdoor environment.

- ***Ambient temperature limitation:*** The air-to-air heat exchanger is only effective in ambient temperatures that are lower than the internal temperature of the enclosure.



DC-Powered Air Conditioners

Thermal Edge has launched two 48 Volt DC air conditioners designed for off-the-grid applications. These units are reputed to be the most efficient DC-powered air conditioners available and are specifically aimed at the telecom industry. Features include:

- ***Design for higher heat loads:*** These units are suited for telecom cabinets that have relatively high heat loads, and the models offer nominal cooling capacities of 1,000 and 4,000 BTU/H, respectively.

- ***High efficiency:*** The two units are fitted with special high COP compressors and incorporate energy-saving features, such as a thermal expansion valve, low starting current, and an innovative condensate evaporation system that removes condensate while improving the thermal efficiency of the unit.

- ***High ambient temperature:*** These units are designed to cope with the high ambient temperatures experienced by OSP equipment, yet are able to maintain the interior temperature of the enclosure to within telecom specifications.

- ***Stable temperature control:*** Both units are equipped with a digital programmable controller that maintains the interior temperature while monitoring operating limits and refrigerant pressures. Temperature and alarm status are indicated on the front panel.

- ***Humidity control:*** As a natural consequence of the air conditioning cycle, excess humidity in the air is condensed onto the evaporator coil. This reduces the risk of condensation that could be experienced with other forms of enclosure cooling. Optional heaters are available for humidity control when the air conditioner is not operating.

Other Benefits of Thermal Edge Closed-Loop Coolers

Both the air conditioners and the air-to-air heat exchangers incorporate numerous features to ensure reliable operation in difficult environments.

- ***Remote alarm and control:*** The air conditioners are available with options to remotely monitor and control the cooling and heating functions via Ethernet, ModBUS RTU, or EtherNet/IP.

- ***NEMA enclosure ratings:*** Both of the air conditioners and the air-to-air heat exchangers are available for use with NEMA-rated enclosures that are designed for harsh environments. Ratings that are available for all models include NEMA types 12, 4, and 4X.

- ***Optional heating:*** During winter, telecom cabinets must not get colder than the minimum 41°F (5°C) temperature allowed by GR-3108-CORE Class 1. Thermal Edge offers optional heater packages with integrated temperature control to its enclosure cooling units.

- ***UL recognition:*** The DC air conditioners carry the UL Recognized component mark because they are designed for off-grid applications running on DC power. The air-to-air heat exchangers carry the UL mark.

An Ideal Solution for Telecom Cabinet Thermal Management

The 48 Volt DC air conditioners and air-to-air heat exchangers provide telecom companies with a comprehensive range of closed-loop cooling options for remote OSP cabinets. Thermal Edge cooling units are manufactured to the highest standards and build on the company's extensive experience with electrical enclosure cooling solutions that have earned extensive praise for their robust, no-nonsense design.

All Thermal Edge units are manufactured in the United States at the Thermal Edge facility in Irving, Texas, and backed up by a national technical sales network with representation in every state. Thermal Edge offers a free, easy-to-use enclosure BTUH calculator that simplifies the selection of the correct-sized cooling unit. Our technical support team is always available to provide guidance and help in selecting the right cooling solution for telecom and other cabinets.

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If you need help selecting the right temperature control solution for your application, talk to the professionals at Thermal Edge. Our experts will work with you from beginning to end to ensure that you have the most cost-effective solution for your application. We also work with engineers who design electrical enclosures to help determine the right temperature control solution early in the design process. Get in touch with us today to review case studies that are similar to your application, review product literature, or schedule a consultation.

Get a Quote for an
Enclosure Cooling System