How to Improve Powering Reliability in Inclement Weather
by Rick Marcotte

"There is no trifling with nature; it is always true, grave, and severe..."
- Goethe

Nature, in spite of all of its splendor, can produce harsh weather conditions. Most parts of the world, including the U.S., experience temperatures ranging from below freezing to dangerously hot in the course of a year. While many people have the luxury of shelter and regulated air temperature, outside plant equipment cannot go indoors. The equipment must be able to work properly under extreme weather conditions.

Of all the components in a network, power is one of the most crucial, yet potentially unstable. Weather has a direct effect on the power supplying a network. Lightning activity, for example, can be dangerous not only to power supplies but the entire network. Heat can damage batteries and electronic components in power protection systems. Utility grids can quickly become overloaded from increased use of air conditioners, causing erratic voltages, brownouts or power outages. These anomalies, in turn, can increase the chance for network interruption or downtime.

When designing for reliability, especially during the summer, you need to consider three factors: heat, lightning and utility grid variations. This article will discuss the effects all three factors can have on network powering equipment and how to avoid service interruption or equipment failure. Without "weather-proofed" powering equipment, the reliability of your network is in jeopardy.

Heat
Heat is a power protection unit's worst enemy, affecting both the electronic components and back-up batteries. It is critical to deploy systems that can withstand elevated temperatures and design your network to minimize the impact of heat.

Batteries
Battery service life is especially sensitive to temperature fluctuations. Manufacturers normally rate batteries with a 10 year life span based on an optimal operating temperature of 25ºC (or 77º F). For approximately every 8°-10° C (16°-18° F) average increase in ambient temperature above the optimal level, battery life is reduced by 50%. (see Figure One) For example, a 10-year design life battery operating in a 33ºC (90º F) environment could operate for 5 years while a battery operating at a temperature of 41ºC (103º F)

could only perform for 2.5 years. With many parts of the world easily exceeding the optimum battery temperature, reducing accumulated heat in a system is very important.

Make sure there is adequate air flow in the battery compartment by leaving space in between the individual batteries and the cabinet walls. The space provides an area for air to properly flow. Next, position the batteries such that they will not receive heat from the electronic components. Because heat rises, many power protection vendors house the batteries below the electronic circuitry.

Storing batteries underground is an option to consider, especially in regions that experience very hot summers. Underground storage is more expensive than above-ground cabinetry, but battery temperatures are kept at more moderate levels, maximizing service life. "The biggest factor in maximizing useful battery life is temperature stability," states Pat Hourigan, VP of engineering for Time Warner Cable of NC. "We have systems with nine to 12 battery strings and it gets rather expensive replacing batteries more often than needed. Underground storage also creates a low profile in our service community." Hourigan's division will oversee 2,000 locations with over 12,000 batteries after their upgrades are complete. When considering underground batteries, be sure to check with the local Department of Transportation (DOT) for vault lid load ratings since each state varies. North Carolina, for example, requires a minimum load capability of 45,000 lbs when vaults are placed in or near DOT right of ways. Also be aware that you will need to use a bell jar inside the vault. The bell jar protects the battery contacts from water damage if the vault becomes filled with water.

Proper ventilation is another consideration when designing for summertime conditions. Cabinets housing electronics and batteries need to have a efficient convection design that draws air from the bottom and releases from the top. Fans are recommended in extreme environments to ensure air flows in and around the compartment.

To further increase reliability and save money in the long-run, it is important to use a power supply which includes a battery charger designed to compensate for temperature changes. Float voltage level, typically 2.30 volts per cell in outdoor applications, should automatically adjust to compensate for temperature fluctuations. Most battery manufacturers recommend decreasing the charge voltage by -2.8 millivolts (mV) per cell, per degree Celsius above the optimal temperature level (25° C). If the batteries have not reached float voltage level within 38.5 hours, the system should inhibit the charging circuit to prevent damage to the batteries due to overcharging.

Electronics

Like batteries, power switching devices are manufactured to properly run within a certain temperature range and high heat can dramatically effect performance. For example, insulated gate bipolar transistors (IGBTs) or silicon controlled rectifiers (SCRs) may

experience long-term degradation or premature failure. In extreme cases, a device could burn up, experiencing a "catastrophic" failure and resulting in system shutdown.

Proper ventilation and airflow are necessary for reliable operation. The intake and exhaust should be located separately to avoid recirculating hot air. The placement of the cabinet is another factor to consider. Place the cabinet in shady areas whenever possible and away from walls, bushes or any other items that can restrict air flow.

Cabinet color and finish also help reduce internal temperature. You should use white or other light colors that absorb less heat, avoiding dark colors that typically absorb more heat. Cabinets with a glossy finish reflect sunlight better than flat finishes and will further aide in reducing heat build-up.

Heat becomes even more of a concern if deploying back-up generators. Combustion exhaust reaching 150° C (302° F) can be produced when operating at full load. It is advisable to thoroughly gasket seal the generator compartment and provide separate intake and exhaust routes. Keep the generator heat contained and away from the electronic components. Ideally, the high temperature combustion exhaust out of the generator muffler should be mixed with the normal cooling air being drawn over the engine. This process will help reduce the heat in the combustion exhaust. The combined air mixture can then be safely exhausted out of the cabinet. Be mindful that if not properly designed and installed, a running generator can be dangerously hot to the touch. Be aware of local ordinances and ensure that powering cabinets meet proper UL ratings where required.

Lightning

Lightning is a common summertime occurrence and is one of nature's most powerful elements. Approximately 20 million lightning strikes occur in the U.S. each year. One lightning strike can contain over one million volts and 10,000 to 20,000 amperes of current. Given that lightning will strike, proper grounding of your network is a must. "Good bonding is very important," adds Hourigan. "Many regions of the country experience frequent lightning. North Carolina, for example, is ranked second in the nation for lightning activity." CATV networks are especially vulnerable to lightning strikes because the coaxial sheathing is sometimes a better ground than the vertical copper wiring used by utility companies. You should be familiar with grounding standards (like NFPA 70 (NEC), IEEE C62.41 and NCTA) that apply to your type of network. You need to also use high-quality surge suppressors placed on both the input and output side of the power protection systems. The more numerous surge suppressors are within a network, the better they can protect the overall network from the brunt of a lightning strike.

Lightning strikes, even though they carry high voltage and current, are short in duration. (A lightning waveform is very tall and skinny.) Perceived to be the most severe type of transient, lightning is actually a relatively easy phenomenon for network designers to

protect against. Most good quality surge devices on the market today can absorb the surge from a lightning strike and continue to protect the network. However, it is still wise to use powering equipment that has high attenuation or isolation. A 1,000:1 rating is typical of ferroresonant transformers and will reduce a 1,000 volt input voltage strike to one volt on the secondary/output side of the device. Attenuation can be achieved two ways. One method is to completely separate the input and output, known as galvanic isolation. The LorTec telecom rectifier by Exide Electronics uses this method. Attenuation can also be achieved by using devices that have naturally good isolating properties. Ferroresonant transformers found in CATV power protection units are a good example even though the input and output windings of the ferroresonant transformer are both tied to ground (i.e. no true galvanic isolation).

Utility Grid Variations

Hot weather typically puts a burden on the generating capacity of local utilities due to the increased use of air conditioners, causing overloaded utility grids. The result is typically excessive voltage drops across the utility line and voltage spreads over the length of the utility wires. The power protection equipment deployed in a network needs to be able to handle a wide input voltage range without constantly switching to battery. The batteries are best saved for prolonged outages for maximum back-up time.

Utility transformers are also more apt to fail when ambient temperature is high and the grid is overloaded. If this happens, a huge current is produced that will eventually make its way to the power protection systems on your network in the form of a low-frequency, high-energy surge. The same type of surge can also be caused by construction equipment cutting and shorting a buried utility cable or tree branches falling on and shorting utility lines. Low-frequency, high-energy surges are very difficult to protect against (even more so than lightning!) because of their relatively long duration and can cause considerable damage both to the power protection system and to other network components. Be aware that not all power protection systems can adequately handle a low-frequency, high-energy surge, such as the 200% low-frequency, high-energy ringwave as defined in IEEE C62.41 (1991 revision). The surge may pass through the network powering system, transferring the damaging energy directly to the network components and exposing them to potentially harmful consequences. A sturdy power protection system handles low-frequency, high-energy surges by preventing them from passing beyond the powering system. Power topologies which eliminate the bulk input capacitor (known as a "bulkless" front end) avoid many of the problems resulting from low-frequency, high-energy surges. Exide Electronics uses a bulkless front end architecture in its telecom rectifier family.

Conclusion

Even though the precautionary measures discussed in this article may cost a little more or take more time to implement into a network, the reassurance is worth it. All networks, whether CATV, cellular, PCS or telephony, depend upon utility power to operate. None of the communication services which are part of our everyday lives would work without

power. Today's era of rampant competition further increases the importance of power protection. You cannot take a myopic view of the communications industry. Your network has to be reliable to attract and maintain loyal customers. The use of robust power protection equipment placed within a network designed to withstand environmental challenges is the main line of defense against network interruption or outages. Don't jeopardize the quality of your service by overlooking proper power protection measures. A small amount of time or money saved in the short-term can cost considerably more in the future.