Ethernet in Harsh Environments

Industrial-strength Ethernet comes of age

Ethernet is the most prevalent LAN application worldwide, offering the benefits of standardization, low-cost components, and high-performance switching technology. It's easy to configure and install.

Ethernet has steadily migrated from the office environment onto the factory floor for automation and industrial control, in industries as wide ranging as food processing, mining and automotive and heavy-equipment manufacturing. As the technology becomes increasingly efficient and affordable, even small manufacturers are now transitioning to Ethernet. The shift from only legacy field-bus communication systems to new protocols on an Ethernet backbone not only improves the ease of process control and automation, but also gives management visibility into real-time production information, allowing them to streamline operations and improve productivity.

While there are many similarities between corporate and industrial Ethernet networks, there are also crucial differences. The standard corporate Ethernet cannot simply be "teleported" into an industrial environment and succeed.

Whether you are considering Ethernet for your factory floor, are a system integrator whose customers are asking you to install Ethernet, or you've already deployed Ethernet to automate production, this white paper will help you assess the three most important areas: the network, electrical signals, and cabling infrastructure. Planning and prevention, as well as selecting equipment that best suits your environment, will go a long way towards ensuring your network runs reliably, and minimizing the impact of downtime.

What makes the industrial setting so different?

The biggest issues in industrial Ethernet stem from the hazards to which networks are exposed. Two major factors contribute to these hazards: lack of climate control and the presence of other electrical equipment. While the network in an office or data center is protected from nature's elements by air conditioning and shade, most industrial environments lack such climate control. Excessive heat and humidity, for example, can impact the transmission media. Unshielded twisted pair cable, commonly used in office networks, can be damaged by prolonged exposure to sunlight. The electromagnetic interference (EMI) generated by electrical equipment causes noise that impedes network traffic. RJ-45 connectors, a mainstay of corporate networks are not designed for long-term performance in excessive heat or stress and their contacts can corrode and locking tabs easily break off.

Here are some of the factors that can impact your network:

Environmental factor	Impact
Ambient humidity and direct moisture	Cable corrosion
Vibration	Cable wear, disconnects
Temperature extremes	Application failures, cable wear
Chemical exposure	Cable corrosion
Dust	Poor outlet/plug/connector contact, particularly with fiber optic cable
Electromagnetic interface (EMI)	Degraded transmission

The distances over which signal must be transmitted is another key difference. Industrial Ethernet cable may need to run ¼ of a mile or more as it is routed through a large plant, around hazards, and from machine to machine and switch to switch. Unshielded twisted pair cable, typically used in offices, has a 100-meter maximum distance. While this specification originated to separate user transmissions and prevent collisions, today the distance limitation is the result of power transmission. Network Interface cards (NICs) are designed for 100 meters. Beyond this distance, extra power is required and it generates noise that interferes with data transmission. Multimode fiber is sufficient for up to two kilometers. For distances over 2-3 kilometers, singlemode fiber optic cable may be required. Yet fiber optic cable brings its own set of requirements. The diameter of a single mode fiber is smaller than a red blood cell. Fingerprints, or even dust in the air can sit on the fiber optic end-face, causing reflectance and inhibiting signal transmission.

Finally, something as basic as power can affect an Ethernet installation. Office-grade Ethernet components may not function in an industrial environment powered by 24 or even 48 volts, with AC and DC sources. Industrial grade components will probably be required.

A difference in the nature of the work: The need for determinism

In the industrial environment, the nature of the work being done and the functions of the devices are very different from the office network. Lost traffic takes on much greater significance. In most office networks, the stakes are not nearly so high if data is lost, and there are many ways to compensate for lost packets. At the least, a user can re-send a data file that has been corrupted in transmission. If the office network is running a little slow, it is annoying and it impacts personnel productivity, but people can usually work around it.

In the industrial world of high-speed production and precise processes, correct and timely delivery of communication is extremely important. A data packet might contain an alert warning of excessive heat or even fire. It might be a command to turn on a cooling system. Corrupted, lost, or untimely packets -whether delivered too fast or too slow– cause serious consequences: production errors, reduced throughput, waste, and downtime. All these translate into significant costs.

For these reasons, industrial Ethernet must be "deterministic". This means the network must guarantee that an event will occur within a specified time period. This is not the rule in corporate environments and there was a time when this was not so in the industrial world. Today it is mandatory.

Understanding Ethernet standards and ratings

Knowledge of some of the Ethernet standards and ratings that have evolved over the years can help you design a more robust and resilient network.

Classify your environmental conditions with MICE tables

To describe possible environmental conditions within industrial sites, the Telecommunications Infrastructure Association (TIA) has created Mechanical, Ingress, Climatic/Chemical, and Electromagnetic (MICE) tables. MICE Level 1 describes a typical office environment. MICE 2 describes a slightly harsher setting. MICE 3 describes a heavy industrial environment.

Approximately 80% of environments are addressed by the tables, excepting only the most extreme or specialized environments. The Mechanical section of each table provides values for shock/bump, vibration, tensile force, crush, impact, and bending/flexing. Ingress specifies the size of particulates (dust). The Climatic/Chemical section provides values for temperature, humidity, radiation, and liquid and gaseous pollution from common industrial contaminants. Finally, the Electromagnetic section provides specific values for electrostatic discharge, radiated and conducted radio frequency (RF), surge (transient ground potential difference) and magnetic field.

The MICE tables do not constitute a set of requirements for cabling, but they do provide a helpful context for evaluating your specific environment and selecting cabling systems that are compatible. Also consider that your cabling run may pass through multiple MICE environments. If you establish environmental boundaries, you can minimize the need for the highest-rated cabling throughout your entire facility.

Determine the degree of protection offered by connectors, devices, and other equipment with the protection ratings. An IP (Index of Protection) rating indicates the degree of protection offered by equipment. The rating is always specified with the letters IP followed by two numbers. The first number indicates the degree of protection against solid foreign bodies. The second number is the degree of water protection. A lower rating of IP 55, for example, indicates that a device provides enough protection from dust particles and water spray that operation won't be disrupted. A higher rating of IP 68 indicates the device is dust-proof and can be immersed in water over time without adverse effects.

The commonly used RJ-45 connector in a typical patch cable is not IP rated. It is not designed to provide any protection from dust or to be at all waterproof. Ethernet cable in harsh environments will either require specially designed RJ45 connectors with protective sealed boots, or you'll need to move up to another type of connector altogether such as the M-12. With an IP-68 rating, the M-12 connector offers some of the highest levels of physical protection against solids and liquids. A pharmaceutical wash-down room is a good example of an application that requires not only connectors with high IP ratings, but also specially designed equipment enclosures that carry high IP ratings.

Learning from the examples of others

The Network
The biggest mistake plants make in installing an industrial network is thinking that the office network can be the same network used for the production floor. You don't want the variable traffic and address schemes of your corporate network to interfere with the consistent, structured, and less variable nature of your production network. Corporate traffic may bring down, or slow down, your production traffic and jeopardize the deterministic nature of your production network.

A VLAN (virtual local area network) is one way to segment network traffic. Set it up so that the corporate and production networks can communicate with one other but not share the other's highway. Think of it as two major highways with a tunnel providing access between the two.

The second mistake is trying to save money by buying office-grade Ethernet switches. Industrial environments require industrial-rated switches; they are designed to stand up to the rigors of the industrial world, and help the network run more efficiently. In production, it's critical to get information from point A to point B reliably. The end result of poor network performance in an office may only be users' PCs running slowly. On the production floor, the difference between a communication being sent in four versus six seconds could be the difference between a high-speed bottling line working or not. Or, in a sheet metal plant, it might determine whether or not the material is cut in the correct lengths.

The proper flow of information keeps the belt moving at exactly the right speed, and keeps the temperature consistent over a 140-foot span.

Electrical signaling

The devices on the network such as switches can be impacted by many of the same issues that affect cabling. Harsh electrical environments can cause transients, disturbances, and static discharge. Extreme humidity and temperature changes, vibration, and inconsistent or inefficient power delivery can all disrupt signaling. Appropriately IP rated devices can mitigate many of these problems.

Cabling infrastructure: Protecting the cable from exposure to hazards

In a typical data center, you'll probably find a server with unshielded twisted-pair cables hanging from the back and running unprotected to the ceiling; and that is perfectly fine. In an industrial environment, cables need to be protected with plastic or metal conduit. It is acceptable to run Ethernet along the ceiling in open trays. But when those cables reach the wall or anywhere they can be sprayed with water, get hot, or be hit by a lift truck, put it in conduit.

You also need to consider EMI shielding. For example, one machine might be filling bottles and another machine loading them into the boxes. The Ethernet line needs to be separated and shielded from the EMI field that machines, cables, motors, and transformers generate. Excessive electronic noise will interfere with signals. It usually manifests itself as particular types of easily recognizable network errors, and indicates that the transmitted frame has been corrupted somewhere along the path.

What can be done about it? UTP (unshielded twisted pair) cabling is by nature fairly immune to lower levels of EMI. An opposite signal is transmitted on each leg of pair, and because the pair is located in the same place, any interference is the same on both legs, effectively canceling out EMI. For higher levels of EMI, you can use a cabling type called shielded twisted pair (STP, also known as CAT 5 cable). Or for even greater protection, use fiber optic cable, which is immune to EMI.

Using enhanced, higher-rated cabling is not the only means of dealing with harsh environments. Consider using a combi-nation of separation, isolation, and enhancement strategies. For example, when there is a risk of liquids, separation can be achieved by running cabling in cable trays at ceiling height as opposed to on floor pathways. Isolation can be achieved by using appropriate conduits or raceway, such as properly grounded metal conduit that helps isolate some EMI noise.

When operating under harsher conditions, take preventative measures such as regularly replacing patch cords and connec-tors well before their rated life to help avoid downtime. By establishing and documenting the baseline of your network and doing regularly scheduled preventative maintenance, you can not only keep your network running more reliably, but also track down and correct problems more quickly when they do occur.

Fluke and Fluke Networks: Helping you take control of your industrial network

Network uptime is crucial to profitability and the quality of your output. One failure can trigger another, resulting in a significant loss of time and money. Regardless of what stage of Ethernet adoption you're in, Fluke and Fluke Networks are committed to keeping your network up and running. We offer a full solution set of rugged, dependable, and easy-to-use tools that address the needs of your unique industrial environment and the application expertise to help you quickly solve the challenges you face everyday.

For applications notes and more information about industrial Ethernet go to: www.flukenetworks.com/industrial.