WHITE PAPER

BUILT TO BLAST

INDUSTRIAL INTERNET OF THINGS INFRASTRUCTURE FOR HAZARDOUS ENVIRONMENTS

aruba
a Hewlett Packard Enterprise company

TABLE OF CONTENTS

INTRODUCTION 3

REGULATIONS AND STANDARDS FOR EQUIPMENT OPERATING IN EXPLOSIVE ATMOSPHERES 3

CATEGORIZATION OF EXPLOSIVE ATMOSPHERES 4

MAXIMUM SURFACE TEMPERATURE CLASSIFICATION 5

EXPLOSION PROTECTION METHODS AND CATEGORIES 7

INTRINSIC SAFETY 8

WIRELESS TELECOM APPLICATIONS IN HAZARDOUS LOCATIONS 9

ENCLOSURE CONSTRUCTION MATERIALS 10

PROTECTING WIRELESS INFRASTRUCTURE IN POTENTIALLY EXPLOSIVE ENVIRONMENTS 11

SENSOR NETWORK MONITORING: INTEGRATE OR SEPARATE? 13

EXTENSIBLE NETWORKING 14

CONCLUSION 15

REFERENCES 15

INTRODUCTION

In 1874 Cadwallader Washburn, a Wisconsin businessman from La Crosse, Wisconsin built the seven story A Mill flour mill in Washburn, Minnesota. The largest industrial building in the city, the A Mill employed 200 workers and was powered by Mississippi River water diverted to a canal running through the lower floor. At 7PM on 2 May 1878, an hour after the start of the night shift, the mill burst into a ball of flames accompanied by a series of explosions. An eyewitness described seeing brilliant flashes and blown out windows, starting with the basement floor and progressing upwards to the roof. The source of the disaster: flour dust.[1]

Dust explosions caused by flour, sugar, and dried milk have a long history. The first recorded explosion was 14 December 1785 at Giacomelli's Bakery Warehouse in Turin, Italy. Flour dust generated during normal handling operations allegedly contacted a worker's lamp. It's not unusual to drive by farms of flour silos and see one or more missing or twisted silos, testaments to the ongoing challenge presented by explosive dust.[2]

Other industries have to contend with their own explosion hazards: methane in mining, acetylene in shipyards, metal filings in machine works, hydrocarbon vapors in refineries, gunpowder in ammunition depots.

Industry groups and standards bodies have collaborated to address these issues by classifying explosive materials and defining standards under which networking equipment and Internet of Things (IoT) devices can be safely operated in their presence. The work has been conducted by different organizations, in different regions, and it can be challenging to understand which standards are applicable under different scenarios.

In this paper we'll examine the different categories of explosive risks, which standards to apply under different scenarios, how network infrastructure can be deployed in explosive environments, and how sensor systems can be integrated with this infrastructure. The goal is to enable end customers and resellers to select the network infrastructure, enclosures, and associated systems that are best suited to each scenario. We'll start this journey with a look at the different categories of explosive atmospheres.

REGULATIONS AND STANDARDS FOR EQUIPMENT OPERATING IN EXPLOSIVE ATMOSPHERES

A potentially explosive atmosphere exists when air gas, vapor, mist, or dust – alone or in combination – are present under circumstances in which it or they can ignite under specified operating conditions. Places with potentially explosive atmospheres are called "hazardous" or "classified" areas or locations.

Multiple local and international regulations are in place to mitigate the risk posted by operating networks and IoT devices in potentially explosive atmospheres. Increasingly these regulations are becoming harmonized under a framework developed by the International Electrotechnical Commission (IEC) and European and US standards.

ATEX Directives

ATEX, derived from the French phrase "Atmosphères Explosibles," is a European regulatory framework for the manufacture, installation, and use of equipment in explosive atmospheres. It consists of two European Union (EU) directives:

- 1999/92/EC which defines the minimum safety requirements for workers in hazardous areas; and
- 2014/34/EU which covers equipment and protective systems intended for use in potentially explosive atmospheres.

These two directives define the essential health and safety requirements, as well as the conformity assessment procedures, that need to be applied before products can be used in the EU market.

IEC Ex System (IECEx)

IECEx is a voluntary certification program that validates compliance with IEC standards related to safety in explosive atmospheres. Details about IECEx, its coverage areas, and conformity mark system can be found at www.iecex.com.

European Committee for Electrotechnical Standardization (CENELEC)

CENELEC was formed to facilitate a consensus-building process between European and international electrical standards activities. In 1996 CENELEC and the IEC formalized a framework of cooperation through an agreement on common standards planning and parallel voting that is known as the Dresden Agreement. As a result of this initiative both CENELEC and IEC have similar standards for explosive environments.

National Electrical Code (NEC)

NEC defines the standards for the safe installation of electrical wiring and equipment in the United States, and its standards are coordinated with those of the National Fire Protection Association (NFPA). NFPA 70 Articles 500 thru 510 address safe practices for the location and operation of electrical equipment in hazardous locations installations.

Additional national standards relating to hazardous environments may be in effect in different countries, however, there has been a concerted effort in recent years to harmonize local standards with the standards referenced above.

CATEGORIZATION OF EXPLOSIVE ATMOSPHERES

Potentially explosive atmospheres are categorized in one of two ways: in North America they are categorized using the "Class/Division/Group" system defined in NEC Article 500, whereas in Europe and the rest of the world they are categorized using the "Zone" system based on IECEx and NEC Articles 505 and 506.

Class/Division/Group System

Classes define the general nature or properties of the hazardous material in the surrounding atmosphere. There are three different Classes:

- Class 1: locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures;
- Class 2: locations that are hazardous because of the presence of combustible dust; and
- Class 3: locations that are hazardous because of the presence of easily ignitable fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures.

Divisions define the probability of the hazardous material being present in the surrounding atmosphere:

- Division 1: the substance referred to by Class has a high probability of producing an explosive or ignitable mixture due to it being present continuously, intermittently, or periodically, or from the equipment itself under normal operating conditions; and
- Division 2: the substance referred to by Class has a low probability of producing an explosive or ignitable mixture and is present only during abnormal conditions for a short period of time – such as a container failure or system breakdown.

Groups define the type of the hazardous material in the surrounding atmosphere:

- Groups A, B, C, and D apply to gases (Class 1 only);
- Groups E, F, and G apply to dusts and ignitable fibers also known as "flyings" (Class 2 or 3).

Table 1 presents the gas types by Class/Division/Group and Zone. For additional details on the hazardous materials included in each Group and their ignition temperatures, please refer to Chapter 5 of the NEC.

TABLE 1: GAS TYPES BY CLASS/DIVISION/GROUP AND ZONE/GROUP

Gas	Class/Division/Group	Zone
Acetylene	A	II C
Hydrogen	B	
Ethylene	C	II B
Propane	D	II A

Zone System

A Zone defines the hazardous material's general nature or properties – gas or dust – and its probability of being present in the surrounding atmosphere. Continuously present hazardous materials present a greater risk, and therefore require greater protective measures, than is required when their presence is transitory.

Gases, vapors, and mists (NEC 505)

- Zone 0: present continuously (constant danger);
- Zone 1: likely to occur under normal conditions (potential danger);
- Zone 2: abnormal conditions (minor danger).

Dusts (NEC 506)

- Zone 20: present continuously (constant danger);
- Zone 21: likely to occur under normal operating conditions (potential danger);
- Zone 22: abnormal conditions (minor danger).

Groups define the type of the hazardous material and (partly) the location of the surrounding atmosphere:

- Group 1: reserved for mining locations;
- Group 2: explosive gases (Zone 0, 1 and 2);
- Group 3: explosive dusts (Zone 20, 21 and 22).

Now that we've outlined the definition of Class/Division/Group and Zone categories, Table 2 presents them side-by-side to show how they overlap.

MAXIMUM SURFACE TEMPERATURE CLASSIFICATION

Equipment temperature is a critical consideration in hazardous atmospheres because too high a temperature can trigger an explosion. Any exposed part of the electrical equipment must not exceed 80% of the auto-ignition temperature (in degrees C) of the explosive element in the area in which it will be used. The auto-ignition temperature is the point at which the substance will ignite without an external heat source.

A detailed list of the auto-ignition temperatures of gases and vapors can be found in NFPA 497-2012, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* and in IEC 60079-20-1:2010, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapor classification – Test methods and data*.

TABLE 2: RECONCILING CLASS/DIVISION/GROUP AND ZONE

Hazardous Material	Class/Division	Zone
Gases/Vapors	Class 1 Division 1	Zone 0/Zone1
	Class 1 Division 2	Zone 2
Dusts	Class 2 Division 1	Zone 0/Zone1
	Class 2 Division 2	Zone 2
Fibers/Flyings	Class 3 Division 1	No Equivalent
	Class 3 Division 2	

Table 3 shows how the different standards classify maximum surface temperatures.

TABLE 3: RECONCILING IEC/ATEX AND NEC MAXIMUM SURFACE TEMPERATURE REQUIREMENTS

IEC/ATEX		NEC		
Temperature Class	Maximum Surface Temperature °C	Temperature Class	Maximum Surface Temperature	
			°C	°F
T1	450	T1	450	842
T2	300	T2	300	573
		T2A	280	536
		T2B	260	500
		T2C	230	446
		T2D	215	419
T3	200	T3	200	392
		T3A	180	356
		T3B	165	329
		T3C	160	320
T4	135	T4	135	275
		T4A	120	248
T5	100	T5	100	212
T6	85	T6	85	185

EXPLOSION PROTECTION METHODS AND CATEGORIES

Table 4 summarizes the most common protection methods employed to ensure the safe operation of electrical equipment under different Ex conditions.

TABLE 4: TYPES OF EQUIPMENT PROTECTION

Type of Protection	Ex Code	Zone Suitability	Definition
General Requirements	Ex	0, 1, 2	General requirements for the type and testing of electrical equipment intended for an Ex area.
Increased Safety	EX eb	1, 2	Protection for electrical equipment that does not produce arcs or sparks in normal service and under specified abnormal conditions, and for which additional measures are applied to increase protect against excessive temperatures and the occurrence of arcs and sparks.
	EX ec	2	
Non-Arcing (Sparking)	Ex nA	2	Protection for electrical equipment that in normal operation is not capable of igniting a surrounding explosive gas atmosphere, and for which a fault capable of causing ignition is not likely to occur.
Protected Facilities and Components (Containment)	Ex nC	2	Prevents sparks by containing the device using a non-ignitable, hermetic seal or encapsulant compound designed for this purpose.
Restricted Breathing	Ex nR	2	Reduces the possibility of ingress of a surrounding explosive atmosphere to a low level so the concentration of flammable gas inside the enclosure does not exceed the lower explosive limit of the gas while it's present in the external atmosphere.
Flameproof (Explosion-Proof)	Ex d	1, 2	The enclosure will withstand, without damage or causing ignition, an internal explosion of a flammable mixture that has penetrated into the interior, through joints or structural openings in the enclosure, from an external explosive gas atmosphere containing one or more of the gases or vapors against which it is designed to afford protection.
Powder Filling	Ex q	1, 2	Electrical parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by glass or quartz powder filling material to prevent the ignition of an external explosive atmosphere.
Intrinsic Safety	Ex i	0, 1, 2	Protection method whereby any spark or thermal effect is insufficient to ignite a mixture of flammable or combustible material in air under prescribed test conditions.
	Ex ia	0, 1, 2	
	Ex ib	1, 2	
	Ex ic	2	
Pressurized Enclosure	Ex px	1, 2	Guards against the ingress of an explosive external atmosphere into an enclosure by filling the enclosure with a protective gas therein at a pressure above that of the external atmosphere.
	Ex py	1, 2	
	Ex pz	2	
Encapsulation	Ex ma	0, 1, 2	Electrical parts that could ignite an explosive atmosphere by sparking or heating are enclosed in a compound in such a way as to preclude ignition.
	Ex mb	1, 2	
	Ex mc	2	
Oil Immersion	Ex o	1, 2	Electrical equipment is immersed in a protective liquid in such a way that an explosive atmosphere above the liquid or outside the enclosure cannot be ignited.

INTRINSIC SAFETY

Intrinsic safety is a design approach in which electrical and thermal energy is limited so it can't ignite a potentially explosive atmosphere under normal or abnormal conditions. It applies to electrical equipment or parts of electrical equipment within the explosive atmosphere, as well as to equipment outside that atmosphere that could impact those operating within it. Intrinsically safe systems fall under NEC articles 504 and 505, and IEC 60079-11 standard, and are the only safe technique for Zone 0 applications and the preferred approach for Zone 1 Division 1 applications.

Intrinsic safety differs from most other standards because it focuses on preventing the release of electrical and thermal energy at its source. For this reason, intrinsic safety is considered by many to be the safest and most technically elegant approach to electrical protection. Safety comes at the price of limited power for running electrical equipment, a disadvantage that has diminished with the advent of ultra-low power electronic devices.

There are three IEC standards for intrinsic safety under fault conditions:

- "ia" – safety is maintained with up to two faults, suitable for Zone 0;
- "ib" – safety is maintained with up to one fault, suitable for Zones 1 and 2;
- "ic" – safety is maintained in normal operations and under conditions specified in IEC 60069-11, suitable for Zone 2.

This contrasts with the US which maintains only one standard for intrinsic safety under fault conditions – all hazardous area equipment must maintain safety with up to two component faults.

Categories define the protection level under which equipment can be used:

- Category 1 equipment suitable for zones 0/20 are also suitable for use in zones 1/21 and 2/22;
- Category 2 equipment suitable for zones 1/21 can be used in zones 2/2;
- Category 3 equipment suitable for use in zones 2/22 can only be used in those zones.

The Equipment Protection Level (EPL) identifies products according to the ignition risk they present. Table 5 below provides a summary of the Zones, Categories, and EPL.

NEMA classifies equipment according to whether it is suitable for hazardous and non-hazardous areas. Type 7 and 10 enclosures are designed to contain an internal explosion without causing an external hazard. Type 8 enclosures prevent combustion through the use of oil-immersed equipment, while Type 9 enclosures prevent the ignition of combustible dust.

TABLE 5: INTRINSIC SAFETY EQUIPMENT PROTECTION LEVEL

IEC				ATEX	
Group	**EPL**	**Protection Level**	**Zone**	**Equipment Group**	**Equipment Category**
I (Mines)	Ma	Very High	No zone class in Mines	I (Mines)	M1
	Mb	High			M2
II (Gas)	Ga	Very High	0	II (Surface)	1G
	Gb	High	1		2G
	Gc	Enhanced	2		3G
III (Dust)	Da	Very High	20		1D
	Db	High	21		2D
	Dc	Enhanced	22		3D

TABLE 6: NEMA HOUSING CLASSIFICATION	
NEMA Classification	
Type	**Use**
Type 7	Indoor use in Class 1, Division 1, Groups A, B, C, or D as defined in NEC
Type 8	Indoor or outdoor use in Class 1, Division 1, Groups A, B, C, and D as defined in NEC
Type 9	Indoor use in Class 2, Division 1, Groups E, F, or G as defined in NEC
Type 10	Meet the requirements of the Mine Safety and Health Administration, 30 CFR, Part 18

WIRELESS TELECOM APPLICATIONS IN HAZARDOUS LOCATIONS

Under the ATEX standard electromagnetic radiation is treated as a possible ignition source. Ignition requires a source that emits electromagnetic radiation, an explosive atmosphere, and a metallic object that functions as antenna and has a contact point. IEC standard 60079-0 limits the amount of continuous and pulsed radio energy that can be emitted to avoid an explosion. The threshold power from 9 kHz to 60 GHz must not exceed the values shown in Table 7, and the limits must be hard-coded – programmable limits or software control are not permitted.

For pulsed radar and other equipment in which pulses are short compared with the thermal initiation time, the threshold energy values Zth must be further limited as shown in Table 8.

Radios are approved to transmit thru specific Zones, and must not pass through Zones lower than approved. For example, a Zone 1 approved transmitter can pass thru Zones 1 and 2, but not Zone 0.

TABLE 7: IEC 60079-0 THRESHOLD POWER AND THERMAL INITIATION LIMITS		
Group	**Threshold Power (w)**	**Thermal Initiation Time (µs)**
Group I	6	200
Group IIA	6	100
Group IIB	3, 5	80
Group IIC	2	20
Group III	6	200

TABLE 8: PULSED RF THRESHOLD ENERGY LIMITS	
Group	**Threshold Energy Zth (µJ)**
Group I	1,500
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1,500

IEC 60079-0 states that radio signals which in normal operation are below specified Threshold Energy Limits are not subject to failure analysis that causes excessive power of the radio signal. This formulation is particularly helpful when normal industrial radio solutions are to be made suitable for use in hazardous areas by encapsulating them in an enclosure. Wi-Fi access points or BLE Beacons that use the ISM band, which has 10-100mW limits, are highly unlikely to exceed the mW limits in case of a fault. Embedding the access point or BLE Beacon in a suitable enclosure and using an Ex-approved antennae will typically be sufficient to provide safe communications.

The limit values listed in the tables above refer to the equivalent isotropically radiated power (EIRP) or the radiated power on the radio device, i.e., effective radiated power (ERP) radiated by the antenna. The capability of the antenna to concentrate the signal in a certain direction is referred to as antenna gain. Antenna gain and the attenuation of the antenna cable/plug-in connector between the radio module and the antenna is the difference between ERP and EIRP.

Radio Frequency ID (RFID) tags are widely used in industrial applications for asset tracking, and tags operating above 10MHz may be deployed in accordance with IEC 60079-14 rules. Passive tags don't contain an energy source and are typically excited by an external transmitter located at or near entry and exit portals. Active tags with batteries are considered complete electrical equipment, and their use in Zone 0 and 1 hazardous areas requires an ATEX or equivalent certificate. Tags operating at 125kHz present a greater electrostatic discharge risk in Zone 1 (21) and Zone 2 (22) applications, and may not be used except with special approval.

Like Wi-Fi access points, RFID tags are classified as transceivers if they can both receive and transmit RF energy. The antenna and the transmitter must both be approved for use in the intended environment, and the tag housing – as well as any equipment with which the tag is interfaced – must not enable or generate an electrostatic discharge above allowable limits. Passive RFID tags may be allowed into hazardous areas under conditions specified in IEC 60079-14 if the tags are not operated.

ENCLOSURE CONSTRUCTION MATERIALS

IEC 60079-0 permits enclosures to be constructed of non-metallic materials, in whole or in part, depending on the required protection level. For example, non-metallic seal rings can be used in an "e" or "t" enclosure, non-metallic filling compounds in an "d" or "e" cable gland, and non-metallic seals of switch actuators in an "e" enclosure. Bartec Ex enclosures are fabricated of RF-transparent polycarbonate, allow RF to pass thru the case and doing away with the need for external antennas.

Clause 24 of the standard mandates that manufacturers must document and specify the material from which the enclosure, or part(s) of the enclosure, are constructed. Plastic enclosures must specify the following:

A. Name or registered trademark of the resin manufacturer or compounder;

B. Identification of the material, including its color, type and percentage of fillers and other additives, if used;

C. Surface treatments, such as varnishes;

D. Temperature Index (TI) which corresponds with the 20,000 h point on the thermal endurance graph without loss of flexural strength exceeding 50 %, determined in accordance with IEC 60216-1 and IEC 60216-2 and based on the flexing property in accordance with ISO 178. If the material does not break in this test before exposure to heat, the index will be based on the tensile strength in accordance with ISO 527-2 with test bars of Type 1A or 1B. As an alternative to the TI, the relative thermal index (RTI – mechanical) may be determined in accordance with ANSI/UL 746B;

E. Compliance with resistance to ultraviolet light, as applicable.

Similar requirements apply to elastomers:

A. Name or registered trademark of the resin manufacturer or compounder;

B. Identification of the material, including its color, type and percentage of fillers and other additives, if used;

C. Surface treatments, such as varnishes;

D. Continuous operating temperature (COT) in accordance with clauses 26.8 and 26.9 of IEC 60079-0;

E. Compliance with resistance to ultraviolet light, as applicable.

Equipment may have different service temperatures on different parts of the equipment, so the selection and testing of individual materials is based on the specific service temperature of that part, but may also be based on the maximum or minimum service temperature of the complete assembly. Plastic materials need to have a temperature index at least 20K greater than the maximum service temperature of the enclosure or any part of the enclosure.

Non-metallic materials need to be resistant to ultraviolet light exposure so they don't degrade upon exposure to sunlight, and must not store or build up an electrostatic charge capable of igniting explosive environments. Electrostatic discharge is addressed by clause 7.4 of IEC 60079-0.

Clause 24 of IEC 60079-09 addresses metallic enclosures. Due to autoignition concerns as a result of elevated temperatures, say due to a fault condition, materials used in the construction of non-portable enclosures of Group I electrical equipment for EPL Ma or Mb are not permitted to contain more than 15 % total mass of aluminum, magnesium, titanium and zirconium, and no more than 7.5 % total mass of magnesium, titanium and zirconium. These limits don't apply to portable measuring equipment so long as it is marked "X" in accordance with item e) of 29.3 of IEC 60079-0 and any specific conditions of use are noted.

Materials used in the construction of non-portable enclosures of Group II electrical equipment for EPL Ga are not permitted to contain more than 10% total mass of aluminum, magnesium, titanium and zirconium, and 7.5 % total mass of magnesium, titanium and zirconium. Electrical equipment for EPL Gb are not permitted to contain more than 7.5 % total mass of magnesium, titanium and zirconium, while for EPL Gc fan impellors, fan hoods, and ventilating screens must comply with the requirements for EPL Gb.

If material limits are exceeded for EPL Ga or Gb equipment then the gear must be marked with an "X" in accordance with section (e) of 29.3 of IEC 60079-0, and the suitability of the equipment for the particular application must be sufficiently described.

Materials used in the construction of non-portable enclosures of Group III electrical equipment for EPL Da or Db are not permitted to contain more than 7.5 % total mass of magnesium, titanium and zirconium.

If material limits are exceeded for EPL Da or Db, then the gear must be marked with an "X" in accordance with section (e) of 29.3 of IEC 60079-0, and the suitability of the equipment for the particular application must be sufficiently described.

Additional restrictions apply to batteries incorporated into explosion-protected equipment. Batteries may only be connected in series, never in parallel, and battery cells must be arranged to prevent any leakage of electrolytes. Tables 11 and 12 of IEC 60079-0 list approved types of battery cell construction. All cells in a battery must use the same electrochemical system, cell design and rated capacity, and all batteries must be produced by the same manufacturer.

If separate primary and back-up batteries are used then to avoid intermixing they must be placed in separate enclosures if they are readily interchangeable. Primary batteries may not be recharged, and care has to be taken to avoid any electrical contact between the primary batteries and any voltage sources within the enclosure.

PROTECTING WIRELESS INFRASTRUCTURE IN POTENTIALLY EXPLOSIVE ENVIRONMENTS

Many chemical, defense, flight line, food processing, fueling, mining, petrochemical, and pharmaceutical applications require high-performance Wi-Fi access in potentially explosive environments. Whether for device telemetry, network access, site-to-site connectivity, or unified communications, these applications require the highest available Wi-Fi performance in the harshest of environments.

Wi-Fi access points can be designed to operate directly in explosive environments without an additional protective enclosure, or they can be designed for use in non-explosive environments and operated inside of an enclosure rated for the application. The former approach is cost-effective when the underlying technology driving the equipment is established, stable, and unlikely to need an upgrade for years; IoT speed, position, pressure, and temperature sensors fall into that category.

The latter approach – using an external enclosure – is the most practical if the underlying wireless technology is changing rapidly. That's because the cost of purchasing and installing an explosion-proof enclosure can represent from 4 to 20 times the cost of the access point the enclosure is designed to protect. It's substantially less expensive to swap out the access point, leaving the protective enclosure untouched, than to install a completely new enclosure with every technology upgrade.

In less than ten years the Wi-Fi industry has moved from 802.11n to 802.11ac Wave 1 to 802.11ac Wave 2. Just as no customer would buy a new truck based on a 10 year old design, neither would they consider deploying 802.11n access points based on technology from 2007. At a minimum they would use 802.11ac Wave 1, especially in industrial environments, because of 802.11ac's outstanding multipath performance in the presence of metal.

Using typical amortization rates a customer that wants to stay abreast of the latest Wi-Fi technology would update equipment roughly once every four years. If we assume that an access point designed for uncontrolled outdoor environments with wide temperature range operation has a List price of $1,500, the associated Class 1 Division 2 enclosure Lists for $3,500, and the installation of just the enclosure (excluding access point set-up and commissioning) costs $2,500, then customers will save $4,500 with every turn of access point technology if the enclosure is retained.

Bartec, Analynk, and Extronics make ATEX Zone 1, Class 1 Division 1, ATEX Zone 2, and/or Class 1 Division 2 enclosures for use with a broad range of Aruba Wi-Fi access points. The Bartec enclosure has the advantage of passing Wi-Fi, Bluetooth 5, 802.15.4, and other RF signals from the Aruba access point without requiring any external antennas. Most of the enclosures from these three vendors also support the AP-318 80211ax Access Point which features a harsh weather-protected design and -40 to +60 degrees C operating range without a heater or fan. These characteristics make the AP-318 suitable for both extremely hot and cold climates.

The AP-318 is available with an integrated controller for managing the network. Called the IAP-318 Aruba Instant Access Point, this variant provides for zero-touch private or public cloud provisioning; the installer only needs to connect power and a wide-area network. Remote provisioning, monitoring, diagnostics, and management significantly reduces the cost of deployment and on-going operating costs.

For customers that want to convert CAPEX into OPEX, the AP-318/IAP-8 can be provided as part of a Network-as-a-Service (NaaS) offering underwritten by Hewlett Packard Enterprise Capital. NaaS radically changes the economics of an industrial deployment, which are typically CAPEX-intensive projects.

Figure 1: Aruba AP-228 802.11ac Harsh Weather-Protected Access Point

Figure 2: Bartec Wireless X ATEX Zone 1 / IECEx Zone 1 Enclosure with Aruba AP-325 Access Point

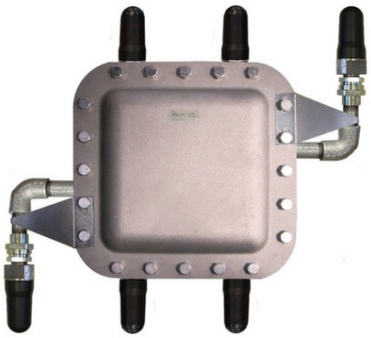

Figure 3: Analynk AP-616 Class 1, Division 1, Groups C & D Enclosure with Aruba AP-318 Access Point

Figure 4: Extronics iWAP107 Zone 1, Class I, Division 1, Groups B, C D, and Class II, Division 1, Groups E, F, G With Aruba AP-318 Access Point

SENSOR NETWORK MONITORING: INTEGRATE OR SEPARATE?

Deterministic behavior has long been a requirement for critical control networks in potentially explosive environments, and industrial customers have relied on ATEX Zone 2 or Class 1 Division 2 WirelessHART or ISA100a for years to monitor flow, pressure, temperature, and other wireless sensors. These rudimentary control standards lack advanced cybersecurity features but are very high-speed and low power, making them attractive to oil and gas customers in particular.

Customers are often confused about the pros and cons of purchasing an access point with an integrated 2.4GHz WirelessHART or ISA100a sensor network transceiver, or purchasing a separate control gateway and access point. One of the issues with an integrated access point is that the ideal location for a sensor network antenna can be very different than for a Wi-Fi antenna. The former needs to be within line-of-site of the sensor mesh, while the latter needs to be in line-of-site of roaming client devices and potentially other backhaul access points.

A second reason for remotely locating the sensor network antenna is to avoid interference between the 2.4GHz WirelessHART or ISA100A sensor network and the 2.4GHz Wi-Fi network. WirelessHART uses 2.4GHz 802.15.4-2006 (ZigBee) radios with a channel hopping mesh and time-synchronized messaging. ISA100a also has a single physical layer using 2.4GHz 802.15.4-2006 radios with listen-before-talk operation, short messages, low duty cycle, and adaptive frequency hopping. While both control networks are intended to operate near other wireless network, the reality is that the RF signal degrades with in-band interference, and also interferes with 2.4GHz Wi-Fi channels. Frequency planning, antenna location, and antenna separation must all be considered during the design and implementation phases.

Typically the sensor and Wi-Fi network antennas must be separated by at least one meter, potentially more depending on the frequency of sensor transmissions and the power output and antenna propagation pattern of the Wi-Fi access point. By definition that means one of the systems will require an external antenna and lead-in cable.

Another reason for separating the sensor gateway and Wi-Fi access point was touched on earlier: Wi-Fi is changing at a very fast clip whereas WirelessHART and ISA100a are not. Staying current with technological changes in Wi-Fi requires more frequent updates than do sensor networks, for which change has been very slow. That calculus may start changing after 2021 by which time the new 802.11ax standard could start displacing WirelessHART and ISA100a, leading to hybrid deployments in which new 802.11ax devices have to coexist with WirelessHART and ISA100a. Until that time, separating the sensor gateway from the access point allows RF performance to be optimized for each system while minimizing the impact of RF technology transitions to existing infrastructure.

Technology suppliers have recognized the benefits of building separate sensor gateways for use in potentially explosive environments, and there are multiple vendors for these devices. For example, ArubaEdge technology partners build ATEX Zone 2, Class 1 Division 2 gateways for WirelessHART and ISA100a control networks. These gateways can be connected to a nearby Aruba switch or access point using an Ethernet interface cable up to 100 meters in length, longer if a fiber optics adapter and cable is used. Gateways with a built-in antenna and don't require a remote antenna or lead-in cable.

If the sensor gateway and Aruba access point must be co-located for cost, convenience, or antenna positioning, an ArubaEdge partner gateway circuit card can be installed in the same explosion-proof housing as the Aruba access point. That design requires an external sensor network antenna and lead-in cable, however, it allows the Wi-Fi access point to be updated as needed without needlessly replacing the sensor gateway.

Figure 5: Analynk AE-902 ALEX Zone 2 and Class 1, Division 2 Groups A, B, C & D Enclosure with ISA100a/WirelessHART Gateway and Aruba AP-318 Access Point

EXTENSIBLE NETWORKING

Deploying wireless networks in potentially explosive environments is expensive, so selecting infrastructure that can perform multiple tasks will yield significant savings over the life of the network. Mesh networking for connecting difficult-to-reach locations, unified communications for voice/video/messaging, location-based services for safety and asset tracking, video optimization for site security, and edge compute are among the many services that could potentially be run in these environments. Deploying separate infrastructure for each would be prohibitively expensive, but omitting any could hamper operational efficiency.

Aruba's wireless infrastructure is designed to be both extensible and adaptable to different uses, locations, applications, and security requirements. Mesh networking is supported in even entry-level products to simplify challenging deployment scenarios like fuel storage and dispensing locations. FIPS 140-2 compliant versions of Aruba wired and wireless networks are available for government and other high-security applications. Regardless of the access point selected for use in an explosion-resistant enclosure, the deployment will be mesh ready.

To enhance industrial workplace productivity, Aruba wireless networks are Skype for Business certified, and will deliver toll-quality voice, jitter-free video conferencing, instant messaging, file transfer, and desktop sharing to Ex compliant tablets and computers in explosive environments. The networks can also recognize and establish bandwidth contracts for nearly 2200 applications – including Office 365, Azure, and SharePoint – to deliver a better user experience. Call-in-flight diagnostics and built-in spectrum analyzers allow remote personnel to identify issues prior to dispatching service personnel.

Aruba infrastructure offers a range of location-based services including wayfinding, geofencing, and personnel and asset tracking. The Analytics & Location Engine (ALE) can trilaterate the position of Wi-Fi based equipment, while location data from compatible active Wi-Fi tags, used in conjunction with third party location applications, can identify the location of people and physical assets.

Zone 1 rated Wi-Fi tags from Extronics extend location services to potentially explosive environments to help direct first responders in the event of an emergency and optimize labor dispatch and loss reduction. Tag and ALE location accuracy outdoors is substantially lower than in controlled indoor environments, a factor that needs to be accounted for during the planning phase of location-based services.

Figure 6: Extronics iTAG100 Zone 1 Wi-Fi Tag

Aruba's wireless networks are ideally suited for IP video surveillance applications. Point-to-point, point-to-multipoint, and mesh networking support provide deployment flexibility and allow cameras to be placed in the ideal vantage point without regard for the availability of network cabling. Strong encryption, network access control, auto-adapting RF interference control, and video Quality of Service further enhance the value proposition.

Figure 7: Axis Communications XF40-Q1765 Class 1 Division 1 IP Camera

Some applications require the ingestion and processing of sensor, actuator, and/or video data at the network edge to deliver a low-latency reaction. Aruba's Edgeline EL-10 and EL-20 gateways supervise serial and analog inputs/outputs (I/O) and run a wide range of applications that can process these data. The EL-20 features Power-over-Ethernet (PoE) ports for powering IP video surveillance cameras. The gateways are small enough to fit into an Analynk and Extronics protective enclosure, and their wide operating temperature range supports use in unconditioned environments.

CONCLUSION

In this paper we examined the different categories of explosive risks and how network infrastructure can be applied in explosive environments. Deploying networking equipment in potentially explosive environments is a highly specialized field that requires deep knowledge of local code, industrial applications, and networking infrastructure. For those so skilled, Aruba and its technology partners offer comprehensive solution toolsets that address a host of oil and gas, chemical, petrochemical, food processing, fuel distribution, munitions, and flight line applications.

REFERENCES

1. National Electrical Code (NEC), *Chapter 5 Special Occupancies, articles 500 thru 510.*
2. International Electrotechnical Commission (IEC) 60079-0: *Explosive atmospheres – Part 0: Equipment – General requirements*.
3. International Electrotechnical Commission (IEC) 60079-1: *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*
4. International Electrotechnical Commission (IEC) 60079-11: *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*
5. European Commission, "Equipment for potentially explosive atmospheres (ATEX)" [Online]. Available: http://ec.europa.eu/growth/sectors/mechanical-engineering/atex_en. [Accessed: Jan. 30, 2017].
6. Occupational Safety and Health Administration, "Safety and Health Regulations for Construction; standards number 1926.449" [Online]. Available: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10750
7. National Electrical Manufacturers Association, NEMA, "NEMA Enclosure Types" [Online]. Available: https://www.nema.org/Products/Documents/nema-enclosure-types.pdf
8. European Committee for Electrotechnical Standardization (CENELEC). [Online]. Available: https://www.cenelec.eu

aruba
a Hewlett Packard Enterprise company

© Copyright 2019 Hewlett Packard Enterprise Development LP. The information contained herein is subject to change without notice. The only warranties for Hewlett Packard Enterprise products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. Hewlett Packard Enterprise shall not be liable for technical or editorial errors or omissions contained herein.

WP_BuiltToBlast_022619