ISA100 Wireless
THE COMPLETE BROCHURE

ISA100 WIRELESS COMPLIANCE INSTITUTE™

Information about the ISA100 Wireless Compliance Institute (WCI)

ISA100 WCI is a non-profit industry consortium formed under the International Society of Automation (ISA) umbrella to promote the commercial adoption of products that meet the ISA100 Wireless standard.

ISA100 WCI Mission

- To ensure interoperability of all ISA100 Wireless products
- Conduct independent compliance testing and certification activities
- Facilitate ISA100 Wireless technological development by providing tools, technical support, and expert education
- Raise market awareness of ISA100 Wireless by conducting educational activities and promoting educational information

For more information about the ISA100 WCI, visit https://isa100wci.org/

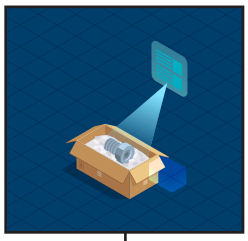
The International Society of Automation (ISA) is a non-profit professional association founded in 1945 to create a better world through automation. ISA advances technical competence by connecting the automation community to achieve operational excellence and is the trusted provider of standards-based foundational technical resources, driving the advancement of individual careers and the overall profession. ISA develops widely used global standards; certifies professionals; provides education and training; publishes books and technical articles; hosts conferences and exhibits; and provides networking and career development programs for its members and customers around the world.

ISA created the ISA Global Cybersecurity Alliance (isa.org/ISAGCA) to advance cybersecurity readiness and awareness in manufacturing and critical infrastructure facilities and processes. The Alliance brings end-user companies, automation and control systems providers, IT infrastructure providers, services providers, system integrators, and other cybersecurity stakeholder organizations together to proactively address growing threats.

ISA owns Automation.com, a leading online publisher of automation-related content. Through a wholly-owned subsidiary, ISA bridges the gap between standards and their implementation with the ISA Security Compliance Institute (isasecure.org) and the ISA Wireless Compliance Institute (isa100wci.org).

Table of Contents

PART 1
Wireless Instrumentation Primer



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1.1: What is Wireless Instrumentation?

Wireless instrumentation is a technology that uses wireless communication to transmit process data and diagnostic data from field instruments installed at the manufacturing site to a control and monitoring system.

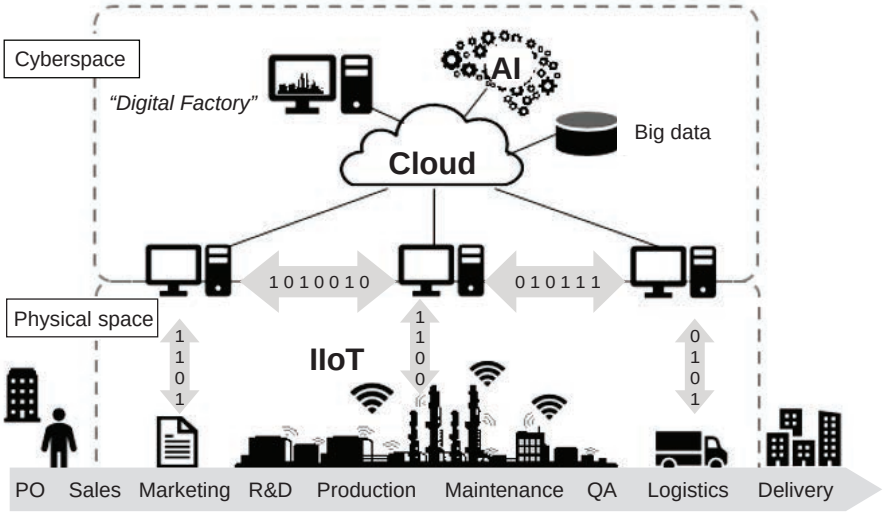

Figure 1.1.1 Visualization of a company which has fully integrated wireless instrumentation into its business processes

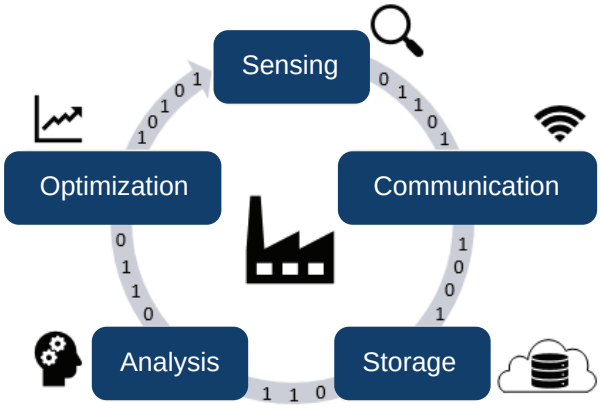

Figure 1.1.2 Wireless instrumentation data flow

1.2 What are the Benefits of Wireless Instrumentation?

Benefits of Introducing Wireless Instrumentation

Wireless instrumentation systems have demonstrated various advantages for users who have installed them, benefits include:

- Lower wiring costs: No signal or power supply wires are needed, and no wiring maintenance is required
- Shorter construction time frames by eliminating the need for wiring design, installation, and testing
- Temporary equipment installation, during an emergency or other need for temporary monitoring, is made easy with a wireless environment
- Maximize space efficiency: Eliminating the need for signal or power lines allows for installation of hundreds of field instruments
- Allows for instrumentation installation in previously impossible locations due to lack of wires, such as a rotating/moving body
- Less physical points of possible failure such as power supplies and cabling in the network makes the overall deployment more resilient

Effects of Wireless Deployment

- Reduces operations and maintenance costs by improving the efficiency of on-site inspections
- Improves plant utilization and reduction of unplanned shutdowns due to enhanced monitoring
- Improves manufacturing quality due to higher number of measurement and monitoring points
- Improves energy efficiency by monitoring and managing the operational efficiency of manufacturing facilities
- Reduces environmental impact using online monitoring of off-site areas
- Reduces greenhouse gas emissions by monitoring emissions trends

Figure 1.2.1 An example of how complex on-site cabling can become

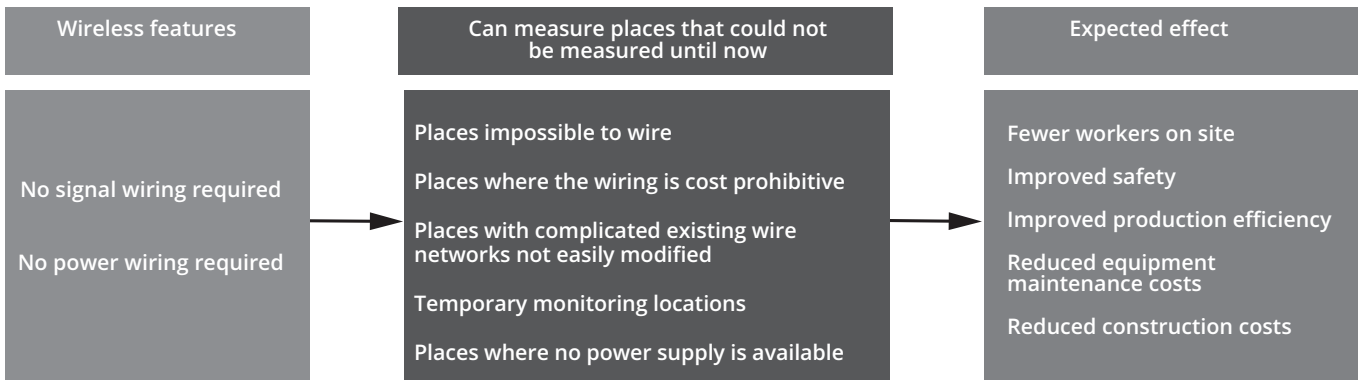

Figure 1.2.2 Benefits of introducing wireless instrumentation

Industrial IoT (IIoT) Applications Using Wireless Instrumentation

Process monitoring

- Purpose: Enhanced visibility of instrumentation systems, improved on-site safety, and improved production efficiency
- Examples of radio instruments: Temperature, pressure, level, flow rate, pH
- Wireless requirements: Constant frequency, reliability, low latency

Condition monitoring

- Purpose: Prediction of equipment failure, improvement of maintenance efficiency, and prevention of unplanned shutdowns
- Examples of wireless instruments: Vibration diagnostics, steam trap diagnostics
- Wireless requirements: Long distance, multi-point monitoring, high data throughput

Safety management and warnings

- Purpose: Ensure health, safety, environmental protection, and safe operation
- Examples of wireless instruments: Gas leak detection, emergency shutoff valve
- Wireless requirements: Reliability, low latency, long distance

Figure 1.2.3 Example of industrial IoT applications using wireless instrumentation

1.3 Which Wireless Technology is Most Suitable?

Wireless Technologies Supporting Industrial IoT

Today, there are a variety of wireless technologies available that support the IIoT. For best results, it is important to choose the wireless technology that is most suitable for the unique challenges of the manufacturing site. In general, wireless technology involves trade-offs with respect to three performance indicators: communication distance, reporting rate, and power consumption. There is no single wireless technology that satisfies all three requirements simultaneously at a high level.

Industrial wireless

Industrial wireless technologies are mainly installed inside wireless instrumentation field devices used for process automation. Purpose-built for the rigors of industrial use; these technologies satisfy the radio performance requirements of the industry in a well-balanced manner. ISA100 Wireless is an industrial Wireless technology suitable for a variety of plant applications such as control and monitoring, asset management, and safety alarms. ISA100 Wireless devices can run on battery power for years before being recharged, can communicate over long distances, can have reporting intervals of seconds, and can be explosion-proof.

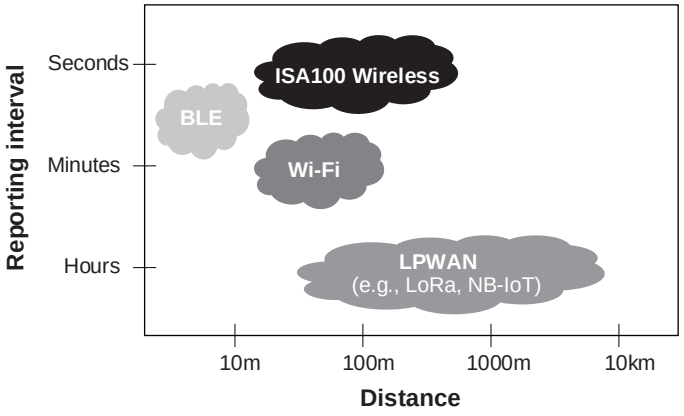

Figure 1.4.1 Relationship between communication distance and transmission speed for various radio technologies

General-purpose wireless

General-purpose wireless technologies such as WiFi and Bluetooth are widely used in home and office environments. In manufacturing sites, these technologies are used to support on-site work. Tablets and smartphones are typically used during on-site inspections and are suitable for high-speed, large-capacity communications such as voice calls and video surveillance. General-purpose wireless protocols are integrated into handheld devices with batteries that are recharged after several hours of use. The cost of explosion-proof products is a downside of these technologies.

LPWAN

Low-power wide-area wireless network (LPWAN) technology features low power consumption and long-distance communication. Its main use in factories is for infrequent IoT data collection of field data over a wide area at low speeds. LPWAN is often used for predictive maintenance, and for management that does not require real-time data. It is also used to collect large amounts of data by AI systems, and for machine learning via cloud applications. The two main options for LPWAN are LoRa (long range), which uses specialized receivers and infrastructure, and Narrowband IoT (NB-IoT), which

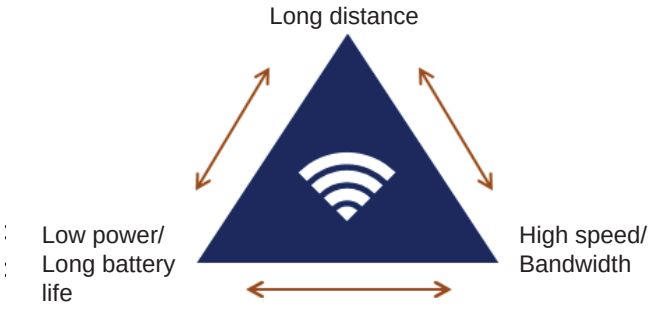

Figure 1.4.2 Tradeoffs between distance, transmission speed, and power consumption

is supported by existing wireless public networks with 5G LTE infrastructure when available at a site.

The primary benefit of LPWAN technology is the ability to transmit small amounts of data over long distances; however, the tradeoff is that data is transmitted at a very low speed. A package of data transmitted in an LPWAN takes longer and uses more energy than the same data transmitted through an industrial wireless protocol, which limits its battery-powered LPWAN devices to very infrequent transmissions, typically measured in hours.

Wireless public networks

Wireless public networks, like 4G and LTE networks, used for mobile phones have recently been used in factories as an alternative to Wi-Fi. In these cases, end users have made commercial arrangements with the cell carriers to implement and use their technology. Local LTE and 5G base stations are installed in the factory, and new wireless applications typically use dedicated wireless lines.

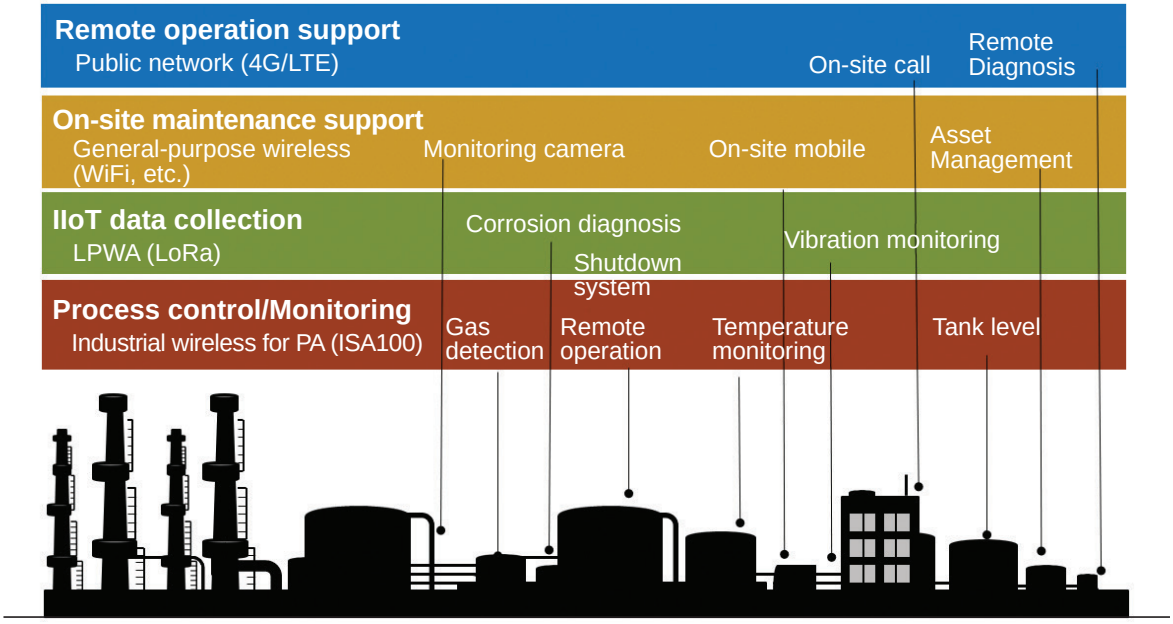

Figure 1.4.3 Various wireless technologies and key applications that support Industrial IoT


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PART 2
Wireless Functionality

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2.1 What is Wireless Communication?

Wireless Terminology and Definitions

In the field of telecommunications, communications that do not use wired paths aka "lines" as transmission paths are called wireless communications. The antonym of "wireless communication" is "wired communication." Wireless communication typically refers to communication using radio waves, such as cellular phones, but in a broad sense, wireless communication may also include communication using light and sound waves.

Allocation of Radio Waves

The radio frequency band used by industrial wireless radios such as ISA100 Wireless is the band from 2.4GHz to 2.5GHz. This band is called the Industrial, Scientific, or Medical (ISM) band. Frequencies in this band can be freely used internationally for industrial, scientific, and medical purposes. This band is not only used by industrial wireless radios but also by Wi-Fi used in homes and offices, amateur radio, etc.. With such broad usage, radio interference is likely to occur. For wireless LAN and amateur radio applications, temporary communication failures can be corrected by retrying the transmission. This may cause some radio wave interference, but in practice, since these communications are not necessarily system-critical, this is not considered a major problem. However, in a wireless system used for industrial purposes, a communication failure due to interference or reflection of radio waves, even if only a momentary failure, can be sufficient to cause an accident or a system stoppage. Therefore, wireless LANs designated for industrial use place greater emphasis on features such as robustness, safety, and availability while using frequencies in this easy-to-access wireless band. These functions are described in Part 3.

2.2 Basics of Wireless Communication

Overview

This section briefly explains the basics of wireless communication and the concept of quality in wireless communication. When a failure occurs in wired communication, one should check the connected wiring in addition to the electrical device itself (e.g., controller, communication device, etc.) to look for damaged, poor, or incorrect terminal connections. Additional tools, such as an oscilloscope, can be used to observe the signal for more insight. However, since a communication path cannot be directly observed when transmitting radio waves, it can be more difficult to know where to look when there is a problem. This may result the incorrect impression that wireless communication is difficult to use or unreliable. Such confusion can be clarified with a greater understanding of the mechanisms and characteristics of wireless communication.

Wireless Propagation

On the following page is a simple diagram and explanation of wireless communication. During the process, wireless communication from Device 1 to Device 2, radio waves are amplified and attenuated at various points including:

1. At the devices' wireless module
2. At the devices' antenna
3. During propagation of the signal through space

After this repeated amplification and attenuation, the power level of the radio waves finally received by the receiving side wireless module determines the quality of the wireless communication. These received signals must have a power level sufficient to ensure healthy wireless communication. The power level is a key factor in the quality of wireless communication. Other factors

that can impact the quality of wireless communication are described in section 2.4.

Data, in the form of a signal with the intensity of X dBm, is transmitted by Device 1 through its antenna. The data flows along the blue path shown below. Follow along as each important step in wireless communication is described.

1. ***Attenuation 1:*** Loss of transmission signal intensity occurs within the circuits and cables of the device.
2. ***Amplification 1:*** The signal is amplified by the transmitting antenna and transmitted as radio wave.

These radio waves are propagated from the antenna of Device 1 to the antenna of Device 2 through space.

3. ***Attenuation 2:*** Attenuation occurs due to propagation through space, as well as reflection and the influence of obstacles in the signal pathway.
4. ***Amplification 2:*** The receiving antenna of Device 2 amplifies the signal.

On the receiving side, the signal is transmitted from Device 2's antenna to its wireless module.

5. ***Attenuation 3:*** During this transmission, loss of transmission signal intensity occurs along the cables and circuits of Device 2.

Receiving wireless module of Device 2 receives a signal with an intensity of Y dBm.

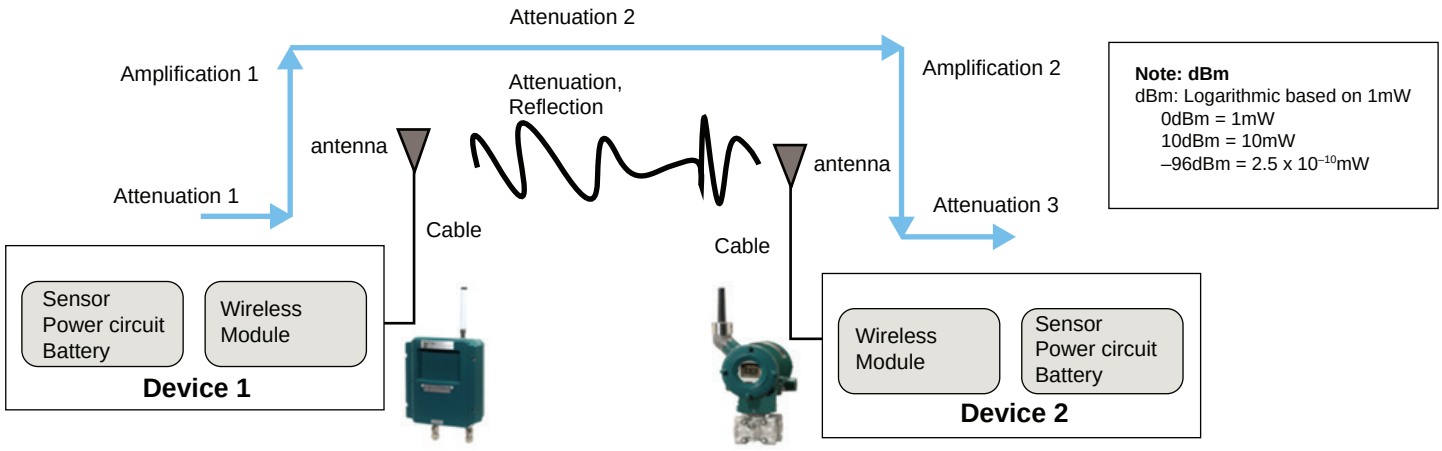

Figure 2.1.1 Wireless propagation

2.3 Radio Components

Figure 2.3.1 shows an example of a wireless module. Typically, a wireless module converts a digital signal into an analog signal or vice versa. For these purposes, a radio module includes:

- An integrated circuit (IC) for radio communication, monitoring, and controlling the radio
- A microprocessor (MPU)
- An antenna and antenna terminal

The wireless module commonly has both receiving and transmitting functions.

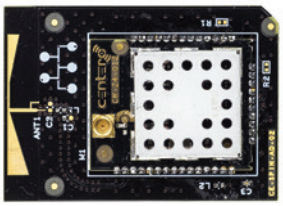

Figure 2.3.1 Example of a radio module

Transmitter-side characteristics

The power level at which a sender can transmit is specified by law in the country of operation. Because of such legal limitations, there is typically little difference in the transmitter-side characteristics between wireless module manufacturers.

Receiver-side characteristics

Because transmitters are limited by law as to how strong their transmission power can be, the reception sensitivity of the receiver (that is, the power level at which the receiving wireless module can identify recaption) becomes an important factor. In general, the wireless module often represents the reception sensitivity with a reception power that satisfies a predetermined bit error rate. For example, a reception sensitivity of -96 dBm @ BER = 1% indicates that, when a radio wave with a power of -96 dBm or more is received, the bit error rate generated is no more than 1%.

Antenna

The key factors for antenna quality are gain and directivity.

Gain is the degree of amplification of the radio wave. The higher the power of the radio wave after amplification by the antenna, the higher the quality of the radio communication. However, as described above, the transmission strength of radio waves is limited by laws restricting power levels.

Directivity measures the degree to which a radio wave is concentrated in a single direction.

High-gain directional antennas are often used in applications where a signal can be transmitted by a thin beam over long distances toward a pinpoint location. This type of antenna has high directivity and is called a directional antenna. Directional antenna systems enable improved telecommunications over longer distances but can be difficult to engineer. Conversely, an antenna having a low gain is often used for communication over a wide range and a shorter distance. Such an antenna is called an omnidirectional antenna. Omnidirectional antennas offer a shorter range than directional antennas but are typically easier to engineer.

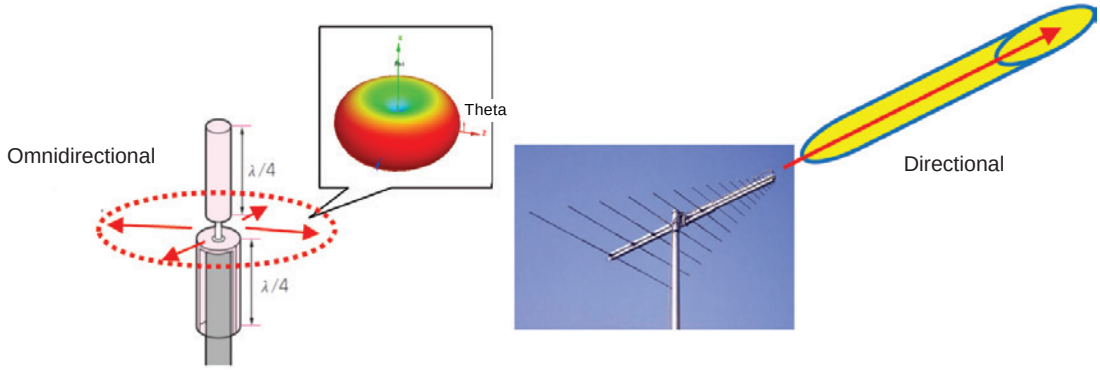

Figure 2.3.2 Radio waves emitted by an antenna

2.4 What Can Affect Wireless Communication Quality?

Factors that Affect Space Propagation

Distance and loss

When a radio wave propagates through space, its power attenuates. Unfortunately, it cannot be amplified during transmission through space. The loss of radio wave intensity during propagation through space is expressed by the following equation:

$L = (4\pi l/\lambda)\ 2$ L: loss l: distance λ : wavelength

That is, the loss of radio waves in free space is equal to the square of the distance, proportional and inversely proportional to the square of the wavelength. However, the equation describes the case when propagating through ideal space. In actual space, the effects vary due to factors such as attenuation by obstacles, reflection, and diffraction, which are not incorporated in the above equation.

Therefore, an approximation formula, ITU-R equation, has been developed as a general formula for calculating the loss of radio waves propagating through real space.

For example, the following link shows an indoor propagation model that considers signal losses due to furniture and office partitions used for short-range communications such as indoor wireless LANs:

Rec. ITU-R P. 1238-6: https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.1238-10-201908-I!!PDF-E.pdf

Rainy conditions

As noted previously, industrial radios use radio waves in the 2.4 GHz frequency band. It is well known that microwave ovens use the same 2.4 GHz band. A microwave oven generates heat by vibrating water molecules using radio waves. This works because radio waves in the 2.4 GHz band are absorbed by water. Based on this, people often surmise that 2.4 GHz radios operate poorly in rainy conditions. However, the resonance frequency of water molecules is approximately 22 GHz, and resonance is not particularly high in the 2.4 GHz band.

The effects of rain on radio waves in the 2.4 GHz band are described in *Radio wave propagation in wireless communication*, published by The Institute of Electronics, Information, and Communication Engineers (IEICE). It states that at a rainfall rate of 150 mm/h (150 mm rain per hour = very heavy rain), the signal loss is less than 0.05 dB per 1 km. This evidence suggests that radio waves in the 2.4 GHz band used by industrial radios are practically unaffected by rainfall. However, it is worth noting that fixed or standing water absorbs radio waves; in such cases, trees and other physical structures can function as shields to block the radio waves from being absorbed by the water.

Reflection, diffraction, and obstacles

As described above, radio waves do not propagate in an ideal space, but within a complex environment containing obstacles, and are subject to various influences such as attenuation, reflection, and diffraction. Therefore, the strength of radio waves depends on the specifics of the location. Because the 2.4 GHz band used by industrial radios has a short wavelength of about 12.5 cm, the intensity/strength of radio waves can vary across a distance of even a few centimeters. For this reason, it is important when designing industrial radio systems to conduct engineering surveys of the radio environment at the time of installation and periodically thereafter to evaluate communication conditions.

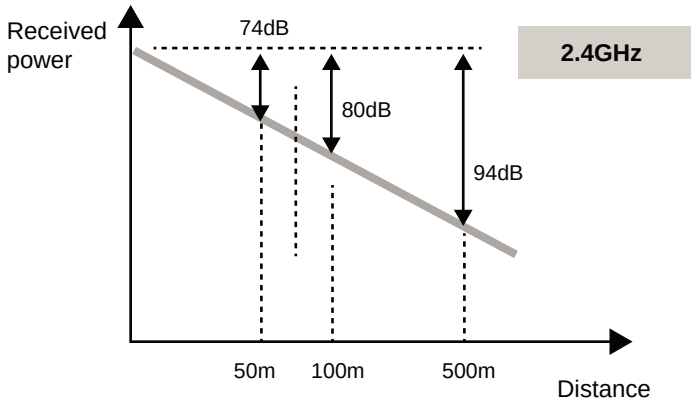

Figure 2.4.1 Radio wave loss in ideal space

PART 3
Wireless Instrumentation Features

Continued on next page

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PART 3 Continued

Wireless Instrumentation Features

3.7 Combining Real-Time Operation and Reliability

3.8 Network Scalability

3.9 Strong Security

3.10 Interoperability

3.11 Multi-Vendor Environment

3.12 ISA100 Wireless WCI Device Certification

3.1: Applying Wireless Instrumentation to Process Automation

Process Automation

Process Automation (PA) refers to the technology used to automate industrial processes, often found in oil refineries, petrochemical plants, steel manufacturing factories, electric power plants, pulp and paper mills, and food and drug mills. Variables such as temperature, pressure, and flow rate are continuously and automatically manipulated to produce the final product. ISA100 Wireless is an industrial wireless sensor network technology that is primarily focused on PA applications.

Characteristics of PA

The PA industry endeavors to increase efficiency by producing products continuously. It is common to operate a factory for 24 hours/365 days until there is a need to stop for maintenance. Examples such as power plants and gas production plants are crucial components of public infrastructure, and their ability to operate continuously is critical. When production stops due to an equipment failure, sizeable economic losses may occur; therefore, highly reliable equipment, including the automation system is required in all factories. PA sites such as oil refineries and petrochemical plants must incorporate safety management systems to manage flammable and toxic gases like hydrogen and ethylene. And by their nature, PA sites must manage and maintain a substantial number of on-site instruments scattered throughout the vast factory premises.

Wireless Technology Benefits for PA

- Safe and secure operations
- Provides visualization of process and provides equipment conditions
  - Monitors and diagnosis of operating conditions of the plant equipment
- Strengthens business competitiveness
  - Reduces construction costs and project duration
- Environmental protection
  - Monitors wide-area emissions and environmental regulation compliance
  - Monitors and manages CO_2 emissions and wastewater

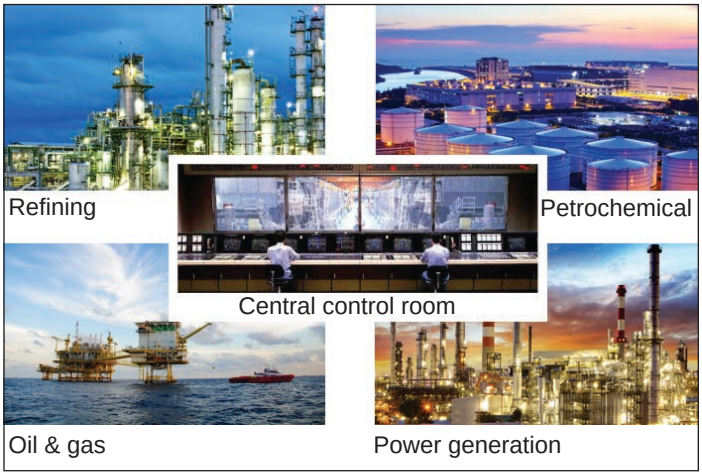


Figure 3.1.1 Process automation examples

Figure 3.1.2 Features of process automation

Points to Consider When Introducing Industrial Wireless Networks

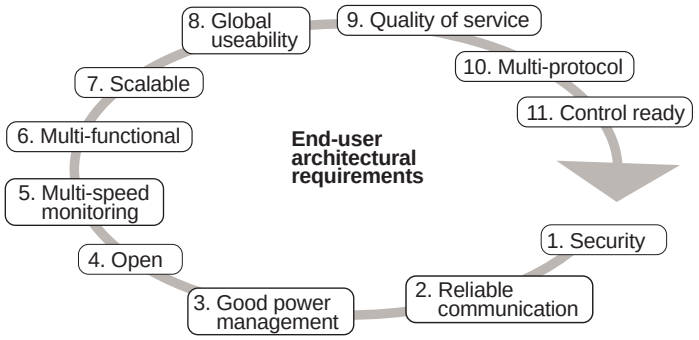
- Project requirements: Project timelines, future
- network scalability, tool integration with wired instruments, etc.
- Compliance with regulations: Radio laws, explosion-proof regulations, electromagnetic compatibility (EMC) standards, safety considerations, etc.
- Other requirements that may affect the selection of a specific technology:
  - Communication specifications: Data size, transmission speed, delay time, and update period
  - Frequency band: The necessity of radio license coexistence with existing wireless system
  - Communication settings flexibility: Variable data update period according to the application (multi-speed support)
  - Security measures: Uses technology to prevent attacks that may include eavesdropping, jamming, impersonation, and tampering
  - Network scalability: Geographic wide-area monitoring, and the maximum number of connections per access point
  - Reliability: Interference immunity, robustness, and avoidance
  - Communication distance: Maximum communication distance without relay (m), maximum extension distance via relay (m)
  - Serviceability: Battery replacement cycle (years), equipment, and network health monitoring
  - Interoperability: Allows for multi-vendor solutions and improved production efficiency
  - Wireless remote monitoring to replace visual inspection: Reduces labor costs, and improves inspection quality

3.2 Background of ISA100 Wireless Standard Development

ISA100 Wireless: An Industrial Wireless Standard Developed with Users to Meet Their Requirements

In 2005, the International Society of Automation (ISA) established the ISA100 Committee. The ISA100 committee's purpose was to develop technical information, guidelines, and standards for wireless systems in the field of automation, with input from over 250 organizations from all over the world including end-user companies, wireless technology providers, control system vendors, field equipment vendors, integrators, consultants, and governments.

In May 2011, the revised version designated ISA100.11a-2011 was approved by the ISA Standards and Practices Board, followed by publication in December 2011 by ANSI (American National Standards Institute) as a US standard. In June 2011, the revised standard was proposed to the IEC TC65/SC65C (Industrial-process measurement, control, and automation/industrial networks) committee to develop the corresponding IEC international standard, which was approved as the IEC 62734 in October 2014.



1	Security	Flawless application of proven cryptography
2	Reliable communication	24x7 operation — high data integrity
3	Good power management	Long and deterministic battery life
4	Open	Select best in class from multiple suppliers
5	Multi-speed	Some devices report frequently, others not
6	Multi-functional	One network, numerous applications with unique needs
7	Scalable	Scalable in numbers, space, and rate
8	Global usability	ISM band wireless technology
9	Quality of service	Controlled latency, low error rate
10	Multi-protocol	Cleanly integrate with existing investment
11	Control ready	Expanding wireless applications

Figure 3.3.2 End user requirements for industrial wireless used for developing the ISA100.11.a standard

3.3: Applications and Requirements for Industrial Wireless Networks

It should be noted that the technical requirements for introducing wireless systems differ depending on the application:

- **Manufacturing:** Improve productivity while maintaining product quality by monitoring process health
  - *Monitoring target examples:* Monitoring process control data like temperature, pressure, flow rate, and level
  - *Communication requirements:* Perform periodic data updates, low latency, and high reliability (usage classes 1 through 3)
- **Maintenance:** Detecting signs of failure before equipment fails and taking appropriate action to maintain operations
  - *Monitoring target examples:* Analyze equipment condition data such as vibration, acceleration, corrosion, temperature, and ultrasonic assessments
  - *Communications requirements:* Includes substantial amounts of data; multi-point data and geographic wide-area monitoring (usage classes 4 and 5)
- **Safety Management:** Avoid or reduce accidents by making repairs when problems are detected before. becoming an emergency
  - *Monitoring target examples:* Emergency shut-off valve operations, gas leaks, earthquake and tsunami warnings, and other emergency warnings

3.4: ISA100 Wireless Features

Key Aspects of ISA100 Wireless

ISA100 Wireless has been developed together with users to simultaneously satisfy multiple mission-critical requirements at the plant level, including the need for high reliability, real-time performance, and expandability for large-scale networks. Aspects of ISA100 Wireless that support this goal include:

- Applicable to a wide range of applications from monitoring to control
- Strong security functions (e.g., authentication, encryption, anti-tampering, spoofing prevention)
- Reliable wireless network operation (using features like mesh, route duplication, and channel hopping)
- IIoT Ready/IP Addressing (compatible with IPv6 networking, which is an open standard with future potential and expandability)
- Wireless network architecture with scalability and flexibility through backbone routing
- Defines a non-relay function device that can support low-cost sensors (extended battery life)
- Supports multiple protocols (e.g., Profibus, FF, HART, Modbus, OPC, etc.)
- Supports an interoperable multi-vendor industrial wireless network environment

Items	Overview of ISA100 Wireless (IEC 62734)	
General	- Industrial wireless system - Developed with end users - Assures interoperability by WCI	- Consensus base standard - End user-driven standard - Multi-vendor environment
Radio	- IEEE 802.15.4 /2.4GHz ISM band - Long distance: 600m (line of sight)	Global usability - Reduces number of relays
Network	- IPv6 addressing - Mesh / star / hybrid topologies - Channel hopping (blacklisting) - TDMA / CSMA modes - Backbone network - Duocast: redundant APs	Future proof (IoT Ready) - Flexible network configurations - Coexistence with Wi-Fi - Deterministic / copious amounts of data - Expandable plant-wide network - Reliable and available network
Security	- AES128 - Join key, network ID, master key	Protect data confidentiality - Device authentication
Applications	- Process monitoring and control - Asset monitoring - Safety monitoring	Supports a variety of applications - Supports existing wired protocols via tunneling

FIgure 3.4.1 Overview of ISA100 Wireless features

3.5: ISA100 Wireless Network Architecture and Components

ISA100 Wireless Compliance Institute

The ISA100 Wireless Compliance Institute (ISA100 WCI) has developed implementation specifications to ensure multi-vendor interoperability between devices that are developed to be compliant with the ISA100.11a (IEC 62734) standard. ISA100 WCI conducts compliance testing of wireless products based on its implementation specifications, provides certification services, and promotes commercial growth and market awareness.

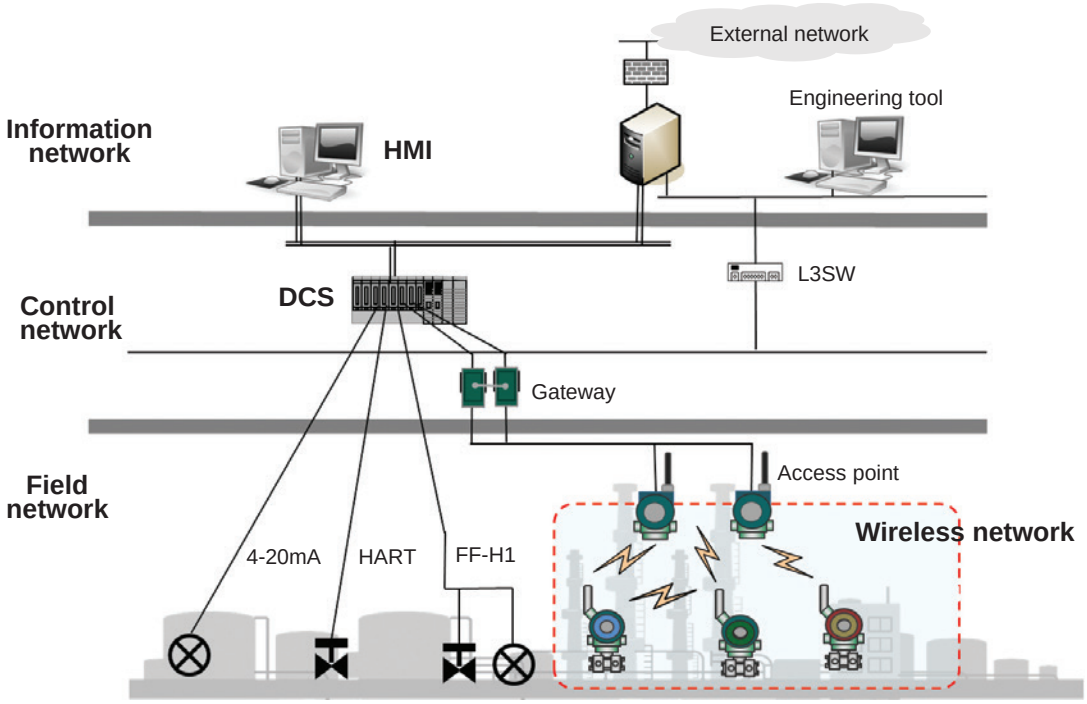


Figure 3.5.1 Wireless network for measurement and control systems

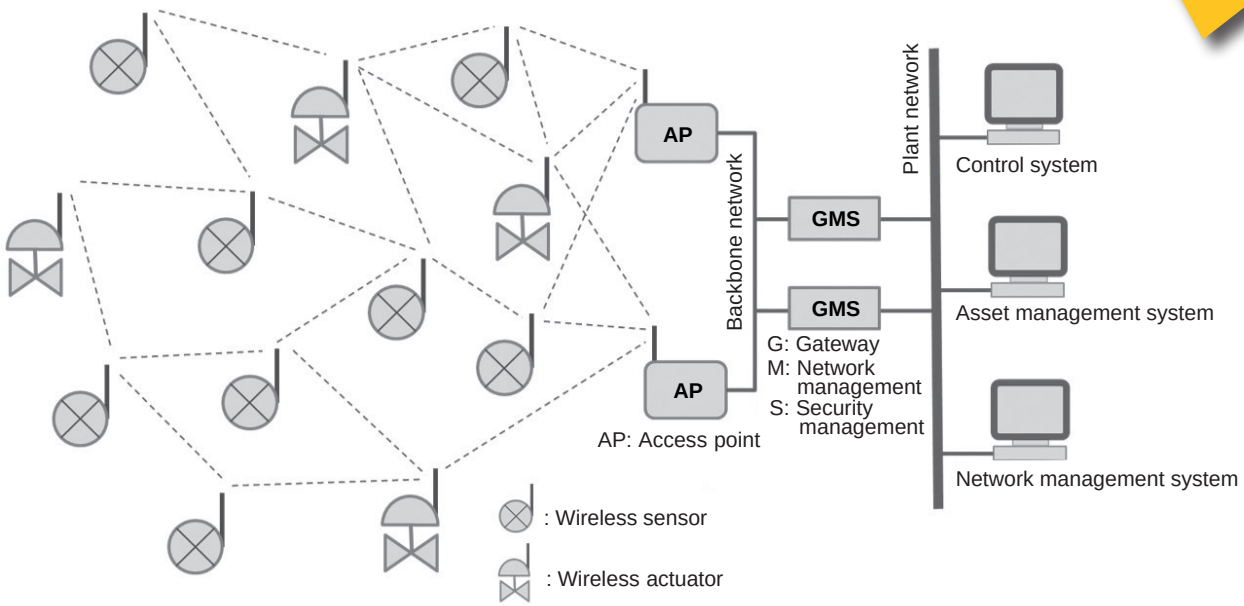


Figure 3.5.2 ISA100 Wireless system architecture

ISA100 Wireless System Architecture and Components

ISA100 Wireless defines, an IP-based backbone network on top of access points, as a mechanism for easily scaling wireless networks. The addition of an access point to the backbone network facilitates the addition of a subnetwork.

Gateway

The process data and self-diagnosis information, measured by a wireless device, are transmitted to the gateway over the wireless network via the access point. The gateway is responsible for translating ISA100 Wireless protocol into a higher-level control network protocol for transmission to process control systems and device management tools.

System Manager

- An ISA100 Wireless network includes at least one system manager and security manager (described below). The system manager monitors the entire network. It has functions to:
  1. Join and leave the network
  2. Report abnormalities that have occurred in the network
  3. Set communication resources (such as frequency channel)
  4. Set and distribute system time
  5. Monitor the status of devices
  6. Monitor and optimize network performance

For example, a wireless device newly added to a network sends the system manager a request for participation in the network, requests assignment of a communication band, and various communication settings. When the system manager and the security manager permit participation in the network, they secure a communication band and set the communication settings of the wireless device. The communication status information sent from the device is stored in the system manager and is used for determining resource management such as a communication path and a channel to be used.

Security Manager

The security manager establishes encryption and authentication security functions in accordance with the security policy defined in ISA100 Wireless to ensure the availability, integrity, and confidentiality of the wireless system and transmission data. In addition to the functions for managing the generation, distribution, and updating of various encryption keys including the Join key, Session key, Master key, etc., the security manager has functions for authenticating devices participating in the network and for authenticating transmitted messages. It helps protect against attacks like eavesdropping, falsification, and spoofing.

Wireless Sensor/Wireless Actuator

Routing device: Wireless device with a relay function

- A routing device repeater relays a message from neighboring wireless devices. To relay messages, a transmission process is required for receiving a signal from a neighboring wireless device and relaying the signal to another neighboring wireless device. Therefore, the power consumption of a routing device is generally larger than that of a device having no relay function

I/O device aka non-routing device: wireless device without a relay function

- An I/O device is defined as a wireless device that does not have a relay function but only a sensor signal input or output function
- Because they do not have a relay function, many products have lower power consumption and longer battery life than routing devices

3.6: Features for Reliability

Reliability Technologies Incorporated in ISA100 Wireless

The wireless device communication system needs to ensure the reliability of communication meets the application requirements. A manufacturing site may have various manufacturing devices, piping, and storage facilities that may be obstacles to radio wave propagation. In addition, there may be numerous sources of radio interference, including electromagnetic noise from manufacturing facilities and field devices, other wireless systems in the factory, and radio waves from nearby Wi-Fi. ISA100 Wireless offers a variety of reliability, robustness, and availability features to provide a reliable path for data transmissions in these harsh electromagnetic environments and to avoid interference. Some features are described below.

Wireless coexistence management: channel blacklisting

As noted previously, ISA100 Wireless uses the 2.4 GHz communications band. This spectrum is unlicensed and available worldwide. The 2.4 GHz band is also used for Wi-Fi and thus ISA100 Wireless needs to avoid interference. To this end, ISA100 Wireless has a feature called *channel blacklisting* that avoids Wi-Fi frequencies to minimize such interference.

Noise avoidance: channel hopping

To avoid electromagnetic noise radiating from manufacturing facilities, ISA100 Wireless has a channel hopping function that switches the communication channel frequency each time data is transmitted, thus reducing the influence of noise.

Communication path avoidance: mesh networks

When parts of the manufacturing plant obstruct the radio pathways or when a temporary obstacle such as a vehicle is present, a neighboring wireless device plays the role of a repeater to provide path redundancy. This type of network structure is

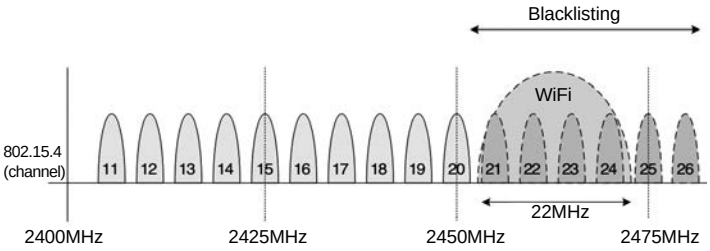


Figure 3.6.1 Channel blacklisting

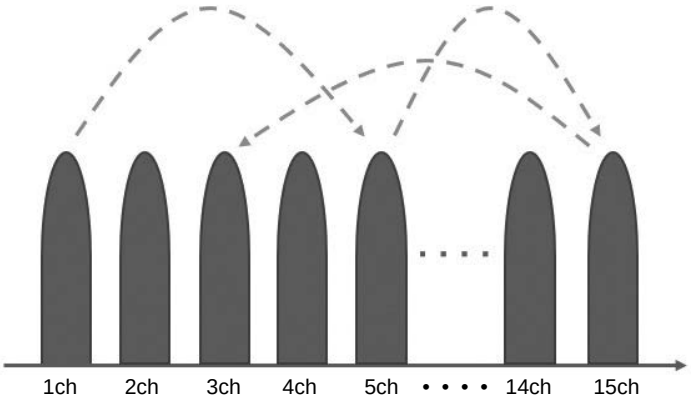


Figure 3.6.2 Channel hopping

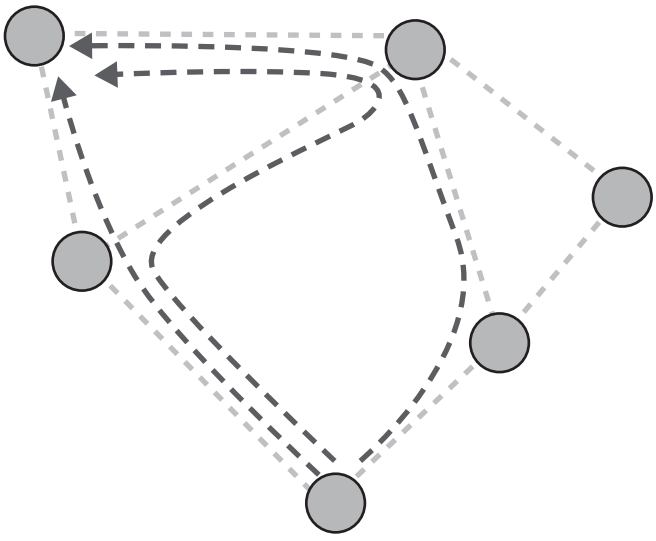


Figure 3.6.3 Mesh network

called a mesh network, and it offers the benefit of dynamically bypassing communication paths.

Boosting insufficient transmission distance: multihop

In applications, like off-site instrument monitoring located far from a central control room, radio signals may be attenuated and thus not directly reach the access point. In such a case, the communication distance can be extended by relaying the signal using a wireless device in the middle of the communication path. This is known as multihop.

Communication path failure avoidance: duocast

Access points can be configured to support dual Access points can be configured to support dual transmission to improve reliability. A wireless device can transmit its data to two access points at the same time, and if either of the two access points receives the data, it can forward the data to the gateway. This is called duocast; this feature is unique to ISA100 Wireless.

Avoiding wireless interference between devices: timeslot communication

To avoid data loss due to radio wave interference, a timeslot for data transmission is assigned, in advance, by a timeslot function for avoiding collisions, so the wireless device can communicate during that timeslot without interfering with other wireless devices.

Improved data transmission success: automatic retransmission

The success of data transmissions can be improved by providing a retry function that automatically retransmits data when a communication error occurs. The number of retransmissions can be set as an engineering variable; the probability of success can be increased by increasing the number of retransmissions.

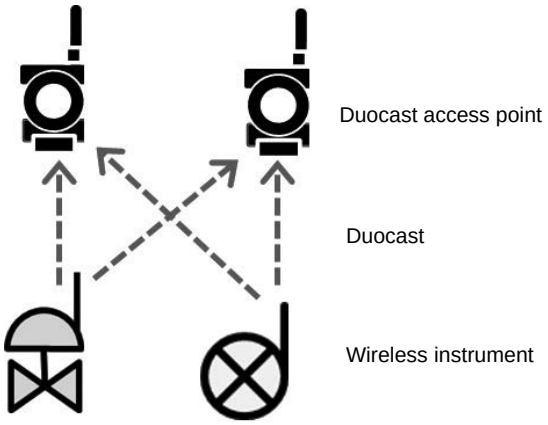


Figure 3.6.4 Duocast

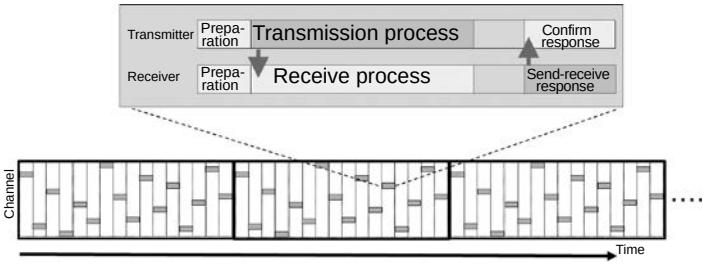


Figure 3.6.5 Timeslot communication

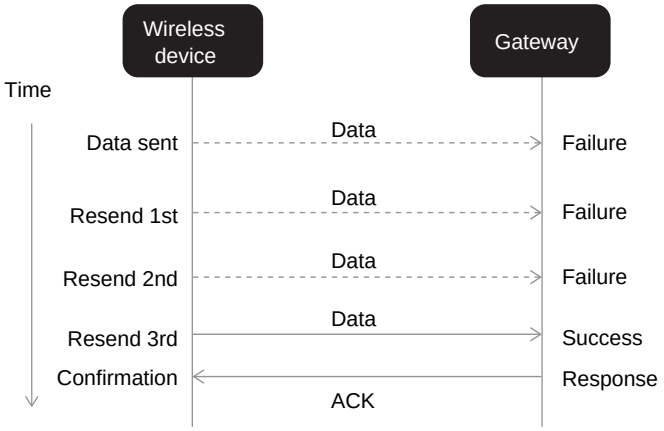


Figure 3.6.6 How retries work

3.7: Combining Real-Time Operations and Reliability

ISA100 Wireless Combines Low Latency and Reliability

ISA100 Wireless is being successfully deployed in mission-critical applications like gas leak detection and emergency shutoff valve operation. To employ wireless technology in these applications, it is necessary to simultaneously satisfy requirements for time-deterministic communication, low delay, and high reliability. The features described below are implemented to fulfill these requirements.

Time-Deterministic Response Using Timeslot Communication

All wireless devices connected to ISA100 Wireless networks employ time division multiplexing timeslot communication schemes that communicate synchronously with each other with an accuracy of <1 msec. By controlling the transmission timing with high accuracy even in an environment where many wireless devices are geographically concentrated, it is possible to achieve stable communication by avoiding communication interference caused by wireless channel collision and radio interference.

Reliability Using Duocast

In the event of transmission failure when using a standard (unicast) configuration, the communication path is switched from the main route to the secondary route, and the data is transmitted during the next communication slot, causing a transmission delay. In contrast, a system with a duocast configuration simultaneously transmits data via two routes, a main route, and a sub-route, so that data can be transmitted from an access point to a gateway with low delay, even if a failure occurs along one of the communication routes. In this way, duocast is an effective communication method for applications requiring real-time and reliability.

The figure below shows an example of a dual wireless system configuration. In this example, the two gateways are dual-connected to lower-order wireless access points and higher-order control and monitoring systems. The two access points form a star topology, that is connected to the wireless device without a repeater, which simultaneously receives transmission data from the wireless device via a main route and a sub-route. Even if the communication between the access point and the wireless device along the main route fails, the gateway can transmit the data received by the access point along the secondary route to the higher-order control/monitoring system.

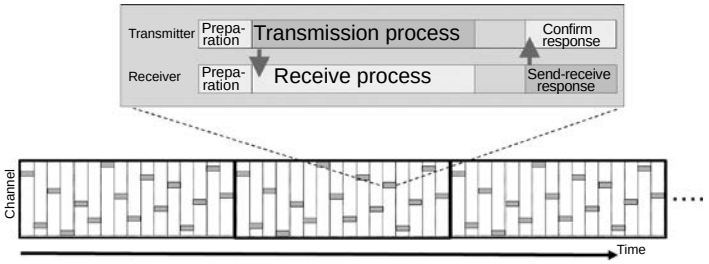


Figure 3.7.1 Timeslot communication

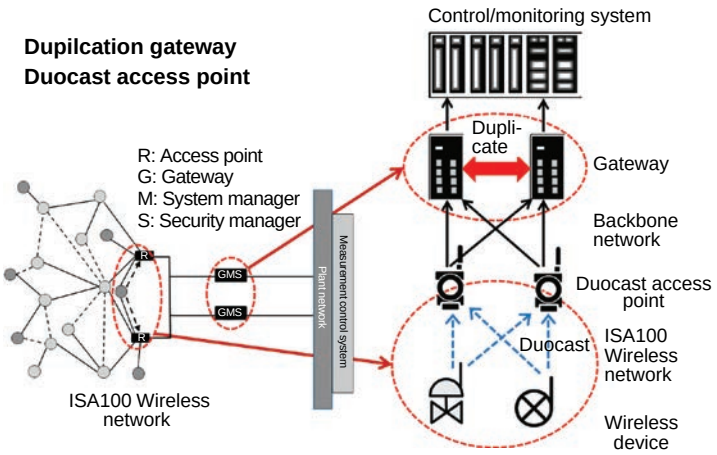


Figure 3.7.2 Duocast: full dual wireless system

3.8: Network Scalability

Easy Network Expansion

Adding devices to mesh networks

Mesh network technology allows wireless devices located in a factory to retransmit data as repeaters. In some parts of the plant, there may be areas where radio waves have difficulty reaching due to the presence of obstacles like manufacturing equipment and piping, or areas with no direct line of sight to the access point. In these environments, a repeater can bypass the obstacle. In the example of off-site monitoring of a tank farm oil storage facility far from the central control room, monitoring of a vast plant can be enhanced by utilizing a multi-hop network in which data is transferred by relay in multiple stages, known as hops.

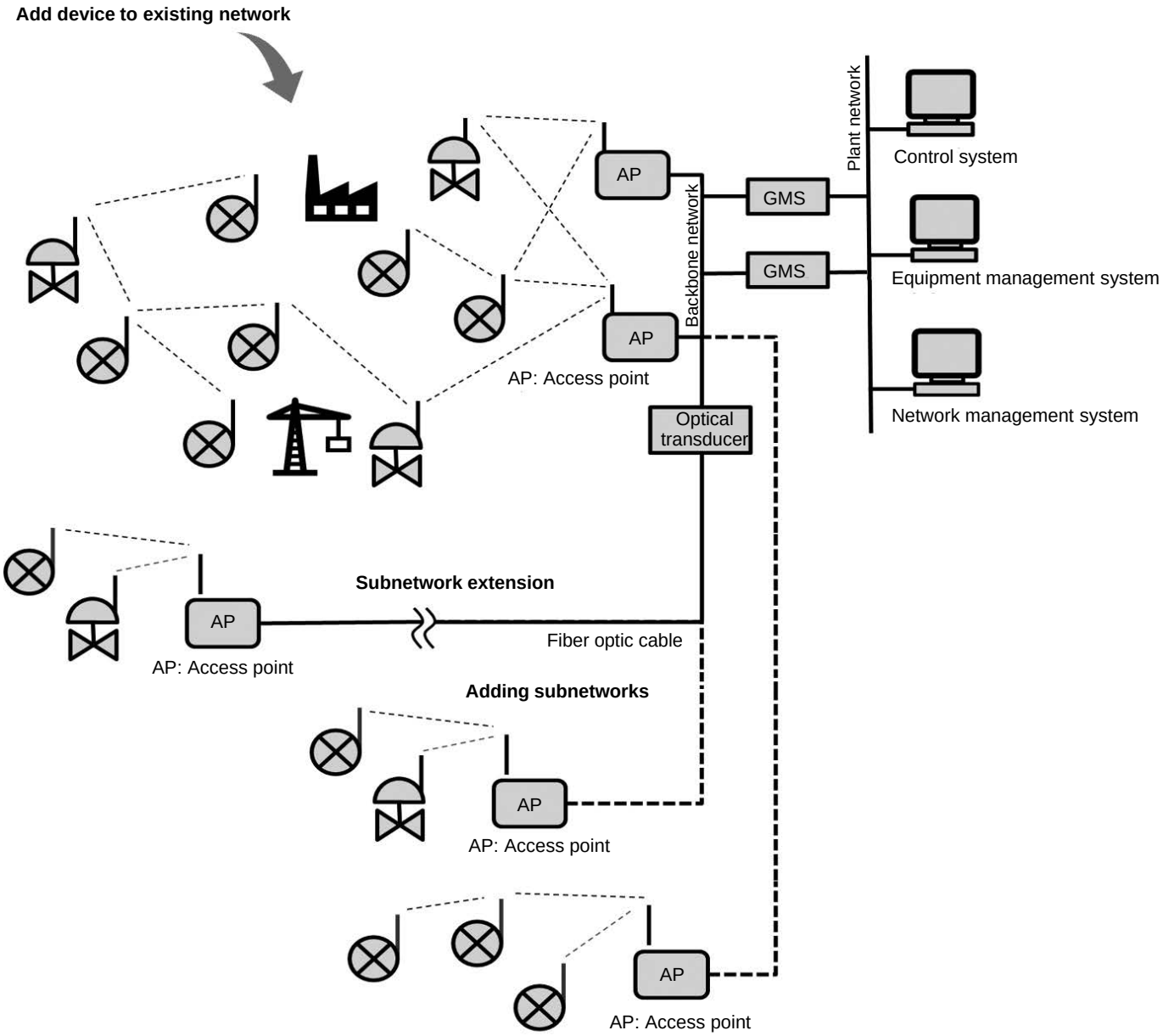


Figure 3.8.1 ISA100 Wireless network expansion

When choosing the number of hops, it is necessary to design the network to account for the limitations of the repeater, as well as the ensuing transmission delay and effects on battery life.

Extending the Backbone Network

An ISA100 Wireless backbone network can use fiber optic Ethernet cables as communication media. Fiber optic cables also enable access points to be placed in remote, explosion-proof areas, offering greater flexibility depending on the application.

Adding Subnetworks and Managing Individual Networks

It is possible to configure a new logically isolated subnetwork, or subnet, by adding an access point to a backbone network. This enables security and device management for that subnet to be managed separately from the existing network. Separating and managing wireless networks for each manufacturing process and area, makes it is possible to minimize the influence of additional devices on the network, balance the load on the network, and manage risks.

Simultaneous Multi-Connection and Time-Deterministic Response

Accommodating an enormous number of wireless devices

ISA100 Wireless is an IoT-ready industrial wireless network technology that can accommodate a large number of wireless devices in a single network with multiple simultaneous connections. ISA100 Wireless specification allows up to 65,535 wireless devices—with 16 bits of address space—to be connected per access point. In actual ISA100 Wireless products, the maximum number of connections differs due to implementation restrictions such as memory capacity. Thus, it is important to check the number of connections possible when selecting devices.

3.9. Strong Security

Wireless Network Security

Before describing the aspects of ISA100 Wireless aimed at strengthening security, it is important to understand industrial security. Devices at manufacturing sites used to operate in a closed environment. With the introduction of broader networks that are more accessible, additional risks have been introduced. Threats like terminals and devices being infected with malware, security threats resulting from information leakage, abnormal operation of devices, and functional deterioration. Because of these risks, some plant operators are to be reluctant to introduce wireless communication networks where a communications path cannot be seen and secured. However, wireless security technology is becoming more sophisticated, with features to protect and maintain the confidentiality, integrity, and availability of information.

- Confidentiality: Ensuring information is accessible only to those authorized to access it
- Integrity: Ensuring information is not subject to destruction, alteration, or deletion
- Availability: Ensuring authorized recipients have uninterrupted access to information and related assets when necessary

Regarding the above three characteristics, the concept of security differs greatly between enterprise information processing technology (IT) and operations technology for control systems (OT). While the emphasis of IT security is on confidentiality, the focus of security for control systems is to secure safe operations, including the protection

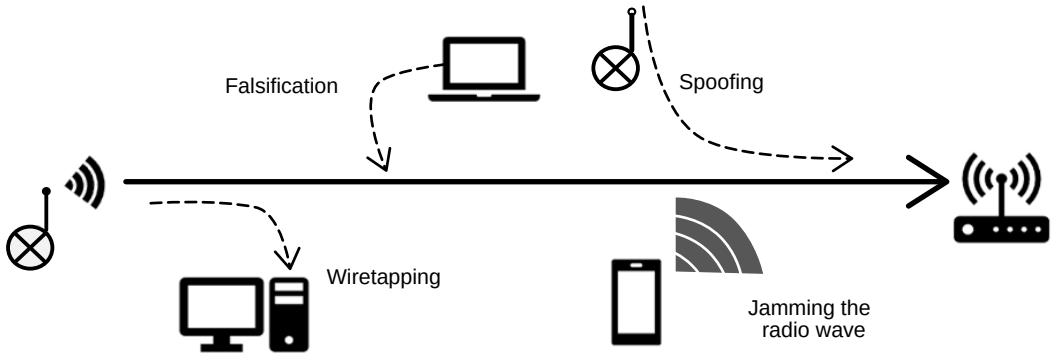


Figure 3.9.1 Wireless network security threats

of human life and the protection of plant operations, thus focusing on availability rather than confidentiality.

Wireless Network Security Threats

Attacks on wireless networks include:

1. Stealing data or wiretapping
2. Destruction or falsification
3. Deceiving or spoofing
4. Interfering or jamming radio waves

The impact of these attacks and the effectiveness of various countermeasures are shown below.

Attack	Security threats	Impact	Retry	Device Authentication	Authentication	Encryption
Steal	• Wiretapping of communications • Data leak	Leakage of confidential processes and manufacturing information	–	✓	–	✓
Break down	• Falsification • Incorporation of counterfeit message	Operational failure of monitoring and control	–	✓	✓	–
Deceive	• Spoofing	Disturbance of process monitoring and control	–	✓	✓	–
Get in someone's way	• Replay attack, denial of service (DOS) attack • Obstruction of radio waves and communication path disturbance	Decline in performance	✓	–	✓	–

Table 3.9.1 Wireless network security threats in detail

Security Measures

Security measures can be classified into three types of actions: countermeasures (avoid, recover); detection (find, notice); and prevention (prevent).

- Countermeasures: Resend, change the communication channel, or change the communication path in response to an attack like jamming, which interferes with communication
- Detection: In the case of spoofing attacks, device authentication and message authentication are used to verify the health of devices and data
- Prevention: Encrypt transmission data to prevent against eavesdropping attacks

ISA100 Wireless Security Technologies

ISA100 Wireless security technologies aim to meet requirements for availability, integrity, and confidentiality.

Availability

Wireless transmission control technology

A variety of wireless transmission control technologies have been developed to avoid interference. ISA100 Wireless employs the following technologies:

- Spread spectrum modulation: A narrowband and sensitive noise modulation scheme
- Channel hopping: Moving the channel each time a radio wave is transmitted to avoid interference
- Mesh networks: Redundant communication paths through repeaters to improve reliability
- Resend: Try sending again if communication fails, thus increasing the likelihood that messages reach their target

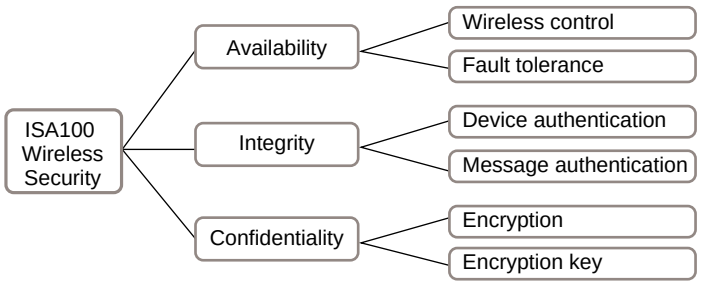


Figure 3.9.2 Technology for security measures

Fault Tolerance

Fault tolerance is the ability of the entire system to continue to operate normally in the event of a failure or error in part of the wireless infrastructure. ISA100 Wireless offers a fault-tolerant duocast system configuration with dual access points and dual gateways for high reliability and availability.

Integrity

Device authentication

Device authentication is a mechanism that prevents unauthorized devices from entering the network. To join a network, a wireless device requires authentication by a security manager. The wireless device sets a Join key and a network ID during provisioning before joining a network; it shares the information with a security manager. When the system manager receives the message with the network participation request from the wireless device, the system manager verifies whether the device is an authorized device by checking against the registration information.

Message Authentication

Message authentication is a mechanism used to verify the soundness of the communication content, it recognizes if the data has been tampered with in the middle of the communication path, or if it has been sent from the correct communication partner. To perform message authentication, the source device generates an authentication code, grants it to the message, and transmits it. The receiving device uses the authentication code to verify whether the received message has been falsified.

Confidentiality

ISA100 Wireless uses AES-128 encryption technology based on the Advanced Encryption Standard (AES). AES-128 is a symmetric key encryption technology that uses a 128-bit pseudorandom number as an encryption key for encryption/decryption. Even if the plain text is the same, with the key the message becomes a different ciphertext, so it is exceedingly difficult to decipher. The AES has discovered no effective attacks against this method, other than brute force attacks, which repeatedly try encryption keys.

The 128-bit key pair yields 3.4 x 1038 possible combinations, which would require hundreds of millions of years for today's supercomputers to crack. ISA100 Wireless specifies the expiration date for cryptographic keys, which can be renewed until max 48.5 days. Therefore, even if an encryption key is decrypted in several years by a brute force attack, the encryption key would be invalid and thus the message could not be decrypted at that time.

ISA100 Wireless Encryption Keys

ISA100 Wireless defines a variety of encryption keys, such as a Join key, DL (data link) key, and Session key to ensure a high-level data confidentiality.

- Join Key
  - Used when joining the network, this key is stored in the wireless device during provisioning
  - Each wireless device has a different Join key
- Master Key
  - Used to encrypt the DL and Session keys
  - Shared between the wireless device and system manager
- DL key
  - Used for encryption/decryption of communication between wireless devices and to calculate message authentication
  - Shared by devices that belong to a wireless sub-network
- Gateway Session Key
  - Used for end-to-end encryption and authentication of communication of process-related data and messages between wireless devices and gateways
- System Manager Session Key
  - Used for end-to-end encryption and authentication of communication of network management messages between wireless devices and the system manager

The Master, DL, and Session keys have expiration dates and are updated regularly to keep the security strong.

Wireless System Management

Even if the wireless network technology adopted has strong security functions, it will not be perfect without proper operation and management.

In addition to intentional and malicious attacks from outside third parties, one must also be aware of and protect against unintended incidents within the organization

Daily execution of security management is important. For example, if an encryption key is used for a long time without being updated (e.g., using factory default join keys), the risk of being decrypted increases. Security risks can be reduced by selecting wireless network technologies and communication standards that do not depend on on-site operations, like mechanisms that renew cryptographic keys automatically on a regular basis.

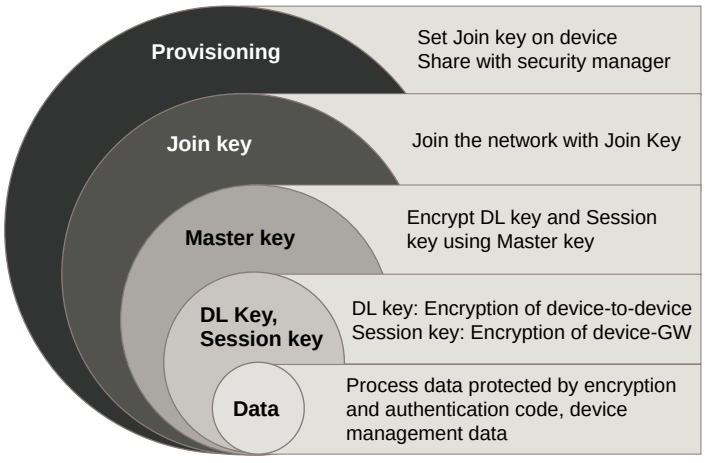


Figure 3.9.3 Various encryption keys

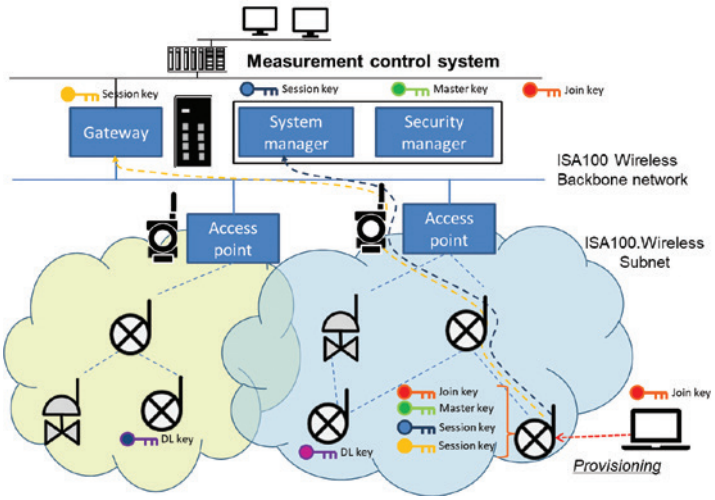


Figure 3.9.4 ISA100 Wireless encryption keys in action

3.10: Interoperability

ISA100 WCI Comprehensive Operational Validation Events: "Plugfests"

ISA100 WCI organizes interoperability verification events for products that have passed certification tests. These events are called plugfests, in which wireless devices and gateway devices from different vendors are combined to verify interoperability in a variety of network configurations to improve the quality of certification tests and prevent problems in the field.

Facilitating a Multi-Vendor Environment with Interoperability

The ISA100 WCI operates a certification program to ensure product interoperability. Products from different vendors which have achieved ISA100 Wireless certification can interoperate with each other in the same networks. Users have the advantage of being able to select the most appropriate device from a plurality of vendors according to the requirements of the application.

ISA100 WCI Interoperability Certification Process

ISA100 WCI verifies the interoperability of ISA100 Wireless products through the certification process, shown below. ISA100 Wireless devices that pass the certification test can be registered and viewed on the ISA100 WCI website https://isa100wci.org/en-US/ End-User-Resources/Product-Portfolio

Certified Device Interoperability Verification

The ISA100 WCI Japan Branch conducted tests connecting 42 ISA100 Wireless devices to the same network. These interoperability tests verified that good communication was maintained even when devices from multiple vendors were intermingled on the same network. In these tests, various network topologies such as mixed star, mesh, and star mesh were configured, and the wireless communication function of each device was confirmed. The figures below show examples of the network topology verified in this event.

Figure 3.10.3 Devices under test at the time of interoperability testing: 42 units from 8 companies

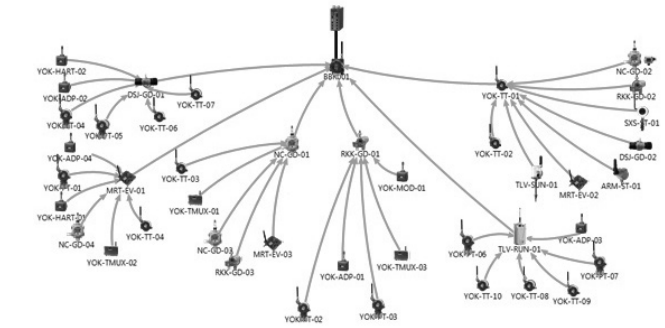


Figure 3.10.4 Network connection status image

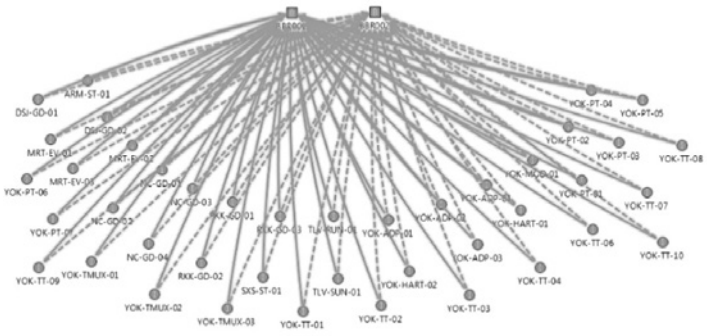


Figure 3.10.5 Example of connection with path redundancy using duocast

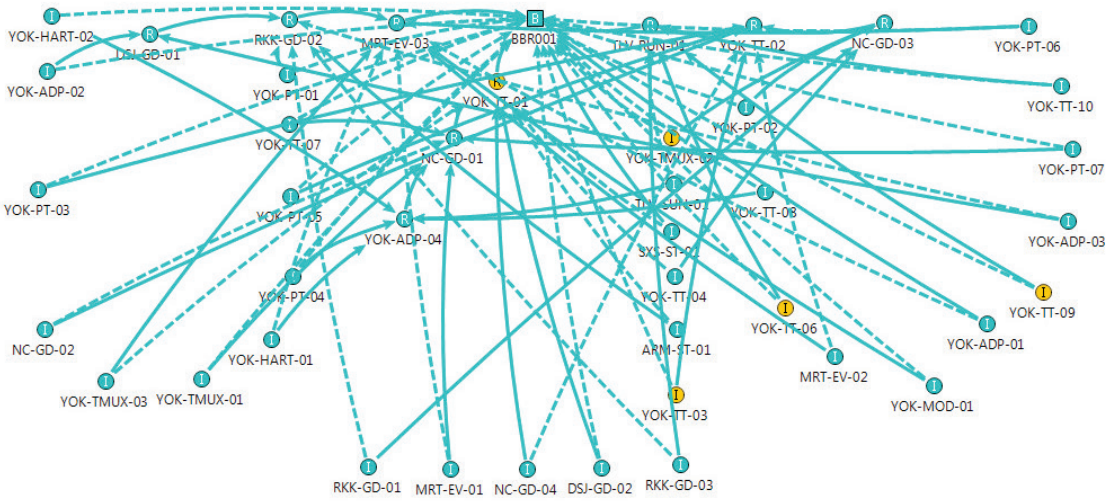


Figure 3.10.6 Example of mesh network connection

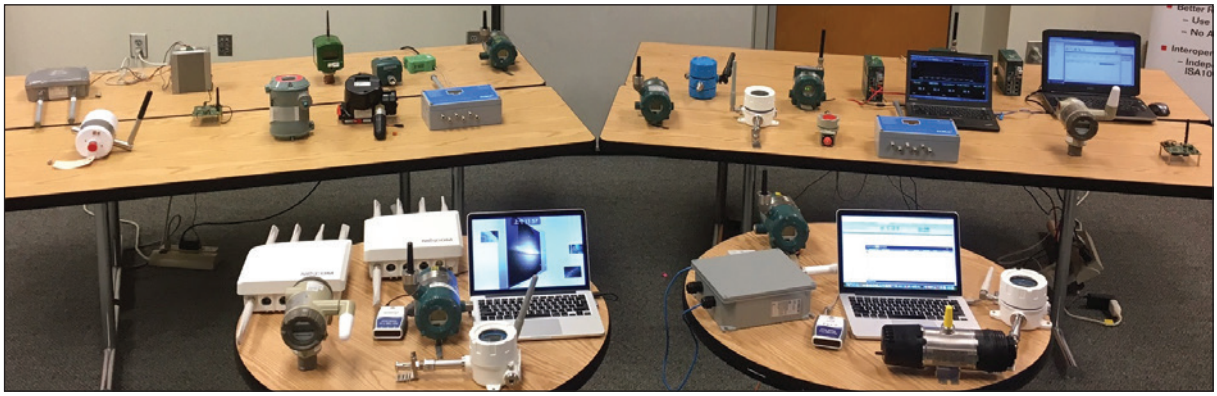


Figure 3.11.2 ISA100 WCI-sponsored plug festival at ISA100 WCI US headquarters

3.11: Multi-Vendor Environment

Product Variety

The following figure shows examples of ISA100 Wireless infrastructure devices, process monitoring instruments, device monitoring, and diagnostic instruments, and security detectors. The same type of instrument is often offered by multiple vendors as an ISA100 Wireless-compliant product. Detailed product information can be obtained from the home pages of these vendors.

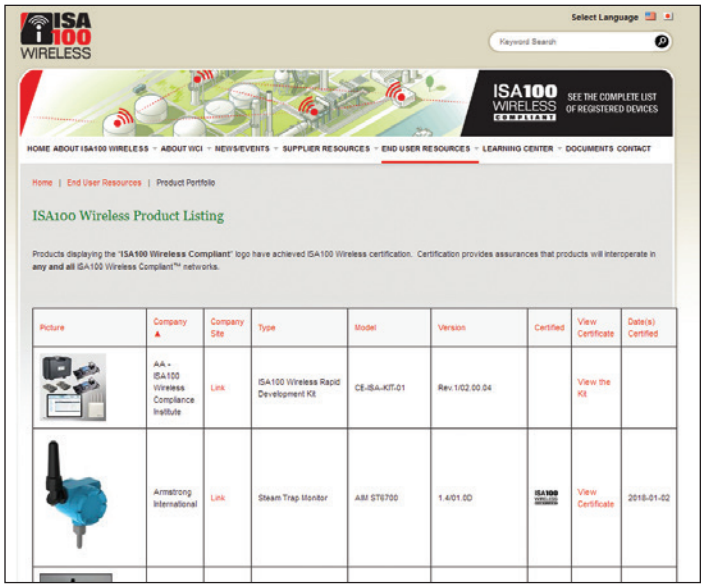


Figure 3.10.2 ISA100 WCI certified device list

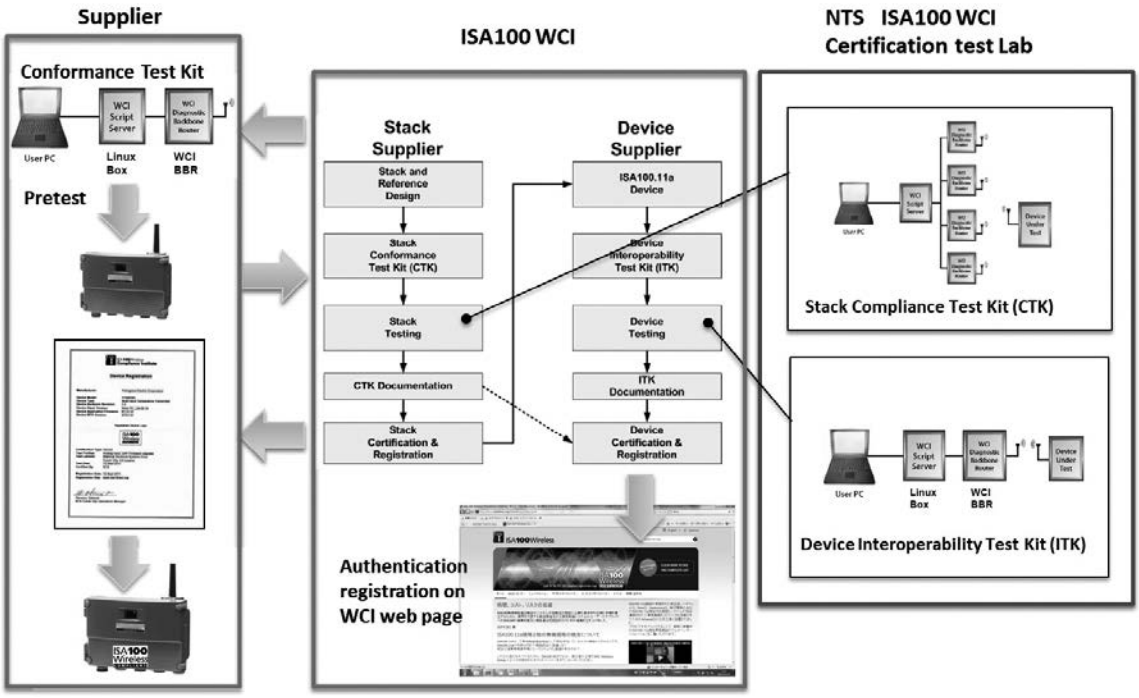


Figure 3.10.1 ISA100 WCI certification process

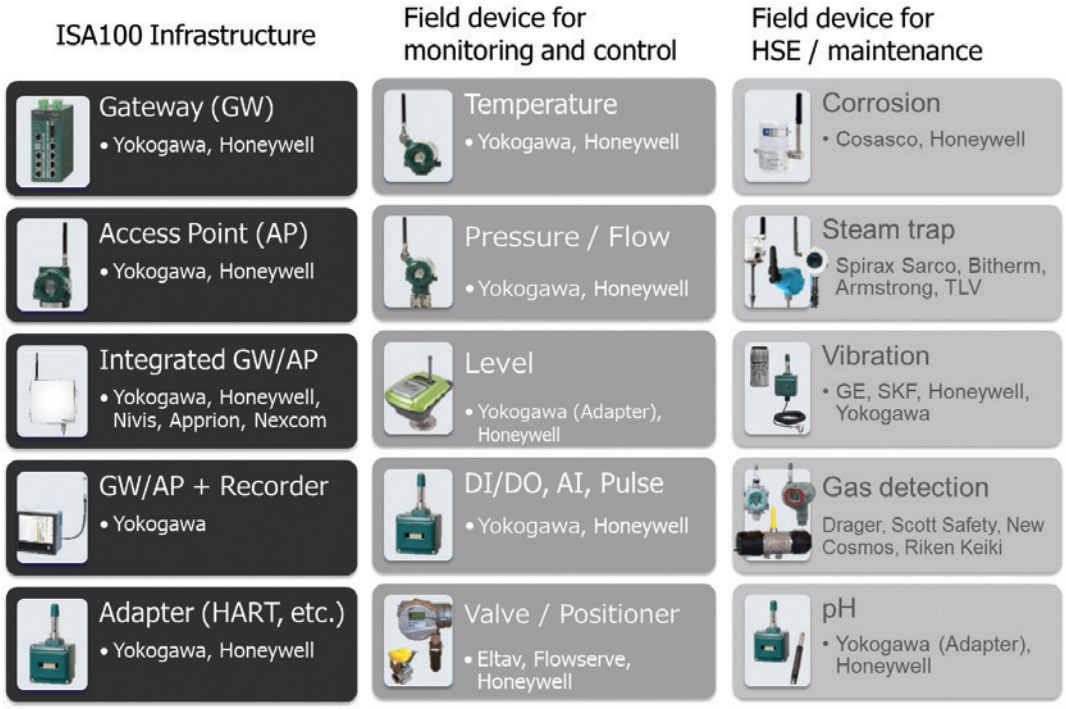


Figure 3.11.1 ISA100 Wireless product examples

3.12: ISA100 Wireless WCI Device Certification

Certification Benefits to Device Suppliers

The simple certification process reduces the cost of a multi-vendor environment, brings products to market early, and develops and engineers products.

- Enabling a multi-vendor environment: An ISA100 Wireless network consists of devices from different vendors that are certified as ISA100 Wireless compliant devices to ensure interoperability and enable multi-vendor solutions
- Marking the product with "ISA100 Wireless Compliant" can demonstrate compliance to customers with industry-accepted, open industry standards
- Technical support is offered as part of the certification process for the development and implementation of ISA100 Wireless products and systems
- Membership in ISA100 WCI enables developers to purchase the Device Test Kit for pre-verification of device certification at the member price

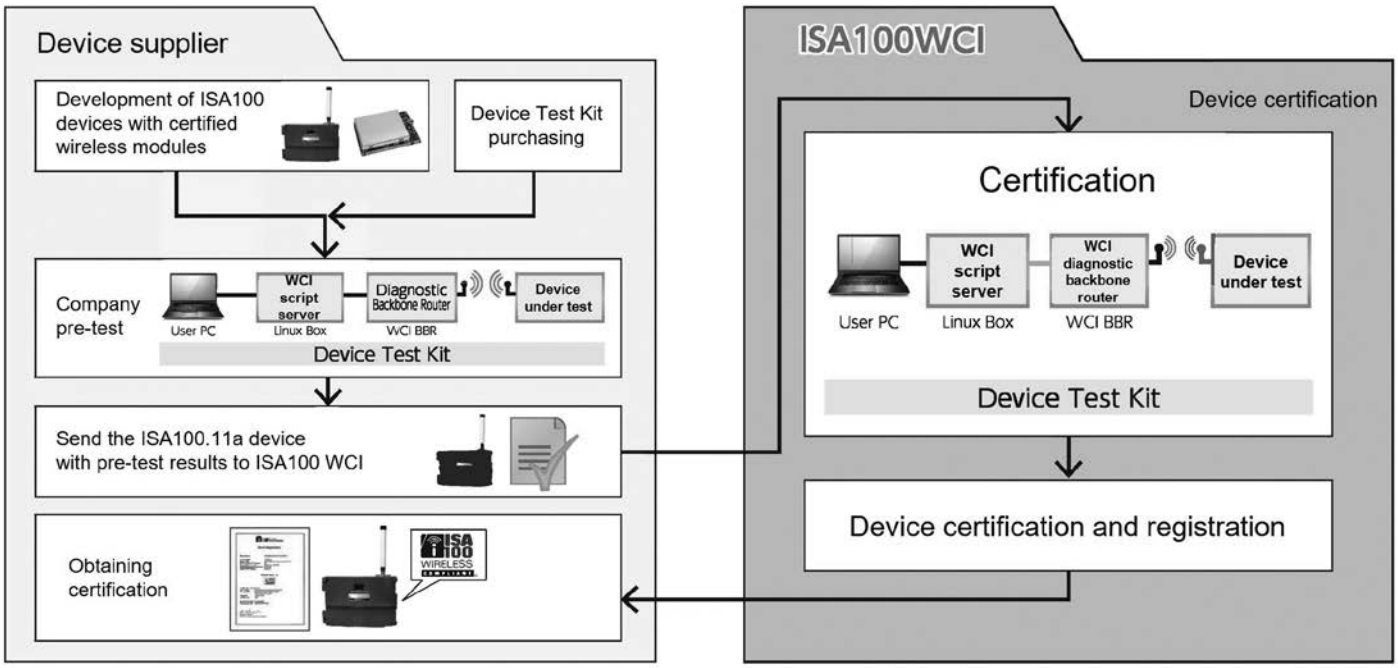


Fig 3.12.1 Device certification with ISA100 WCI

Web Links

Please refer to the link below for the latest information.

Summary of ISA100 WCI Certification Exam Duration and Costs
https://isa100wci.org/en-US/Supplier-Resources/How-to-Certify-ISA100-Wireless-Product

Purchase of ISA100 WCI Device Test Kit
https://isa100wci.org/en-US/Supplier-Resources/ISA100-Wireless-Test-Kits

Contact Us
https://isa100wci.org/en-US/Contact

PART 4
Implementation Procedures

ISA100 WIRELESS COMPLIANCE INSTITUTE™

4.1: Wireless Network Deployment Procedures

A typical wireless network deployment procedure is described below.

1. Pre-Visit Planning

- Determine specifications (frequency, communication speed, etc.)
- Determine antenna characteristics (directivity, gain, etc.)
- Determine distance
- Review the frequencies used by other nearby wireless systems, e.g., Wi-Fi Review the application requirements
  - Check the installation environment around the instruments using plant design drawings
  - Review process data refresh cycle and other requirements
  - Locate manufacturing devices, pipes, roads, and buildings
- Network design
  - Design layout of repeater(s)
- Design the layout of three-dimensional space considering the ground height
  - Design the communication path
- Balance the communication load on the repeater
- Set the device role settings, e.g., on/off status on the relay function of each wireless device
- Consider the network topology and required redundancy based on communication delay time and reliability requirements

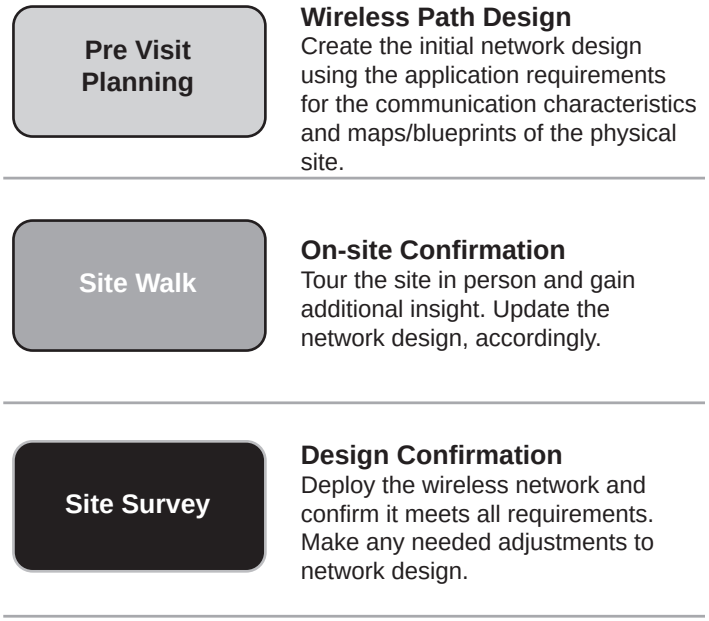


Figure 4.1.1 Wireless network deployment procedures

2. Site Visit Preparation and Visual Inspection

- Verify design at the physical site
  - Verify the route design considers the actual physical layout and location of the manufacturing equipment at the site
  - Ensure the correct antenna position of wireless devices (Fresnel zone)
  - Are there nearby obstacles that are not on the map or on the design? (these could cause reflection, diffraction, and multipath effects)

3. Site Survey and Radio Environment Mapping

- Construct a network and verify communication characteristics
  - Is stable communication possible according to the route design?
  - Is the packet error rate (PER) within tolerance?
- Perform wireless strength survey of neighboring wireless systems
- Verify the source of any wireless interference (e.g., Wi-Fi)
- If communicating across a body of water, investigate the effect of transient sea level changes

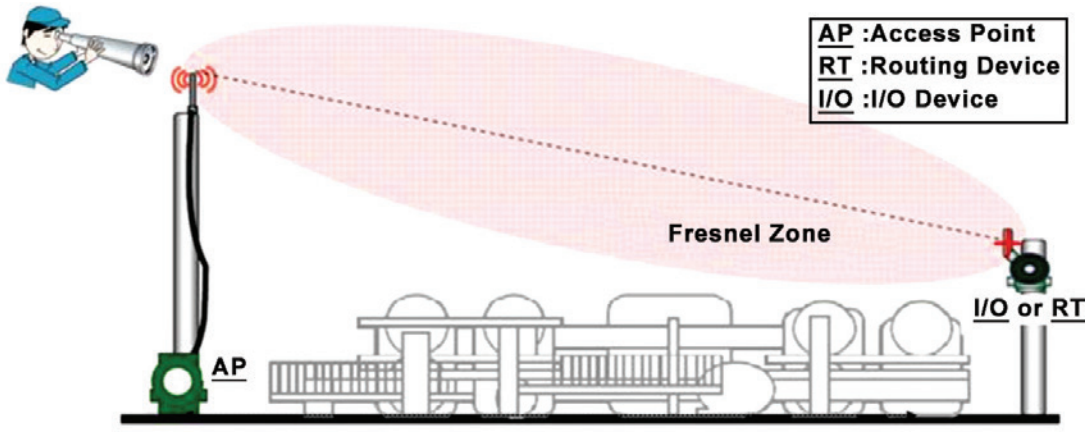


Figure 4.1.2 Securing the Fresnel zone

Designing Wireless Networks for Reliability

The figure on the right shows an example of ISA100 Wireless network configuration. This is an example of a network that takes advantage of both mesh and star topologies to drive both reliability and low latency. The backbone network is built above the plant and communicates with each measurement point by way of on-site repeaters placed at the high point.

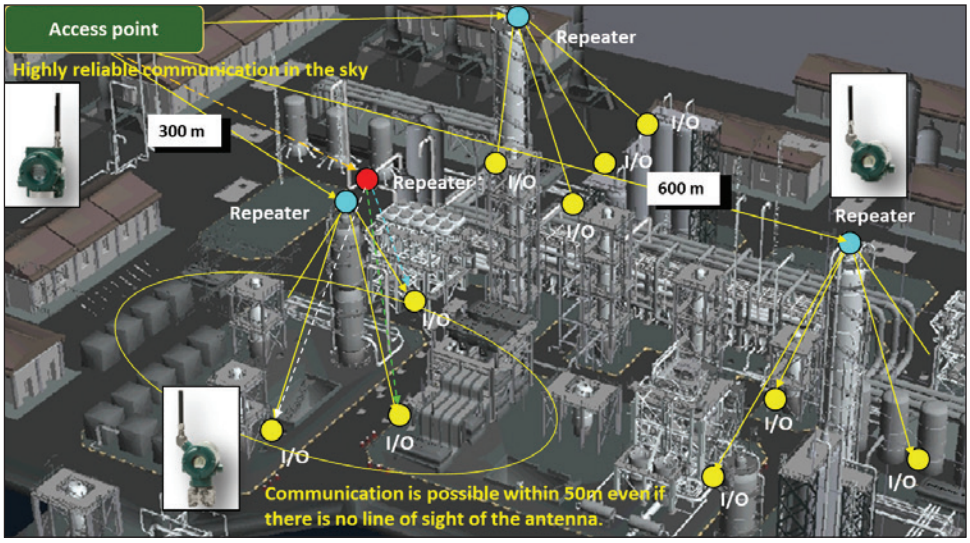


Figure 4.1.3 Example of network construction

4.2: Wireless Engineering Procedures

Wireless Device Network Initializtion: Provisioning

Wireless device management tool

Provisioning is the act of setting an authentication encryption key (AKA join Key) and a network ID and sharing it with a security manager to connect a wireless device to a network. Provisioning allows the security manager to share the encryption key for device authentication to combat spoofed/unauthorized device join attempts.

Provisioning techniques include infrared communication, Bluetooth, and wired USB. Infrared communication with a narrow signal range is often used to set a device's joint key and/or network ID. An infrared communication unit is connected to the USB port of a PC which is running an ISA100 Wireless device management tool. A join key and a network ID are generated by the device management tool and are then set in the device.

When the wireless device makes a participation request to the network, the device and the security manager mutually verify and authenticate the join key for device authentication.

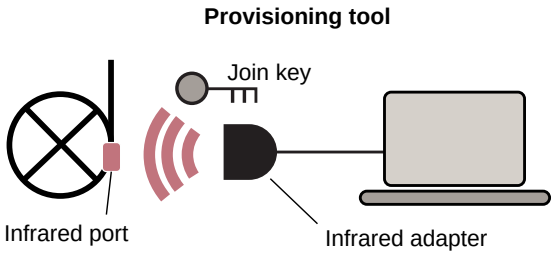


Figure 4.2.1 Configuring join keys during provisioning

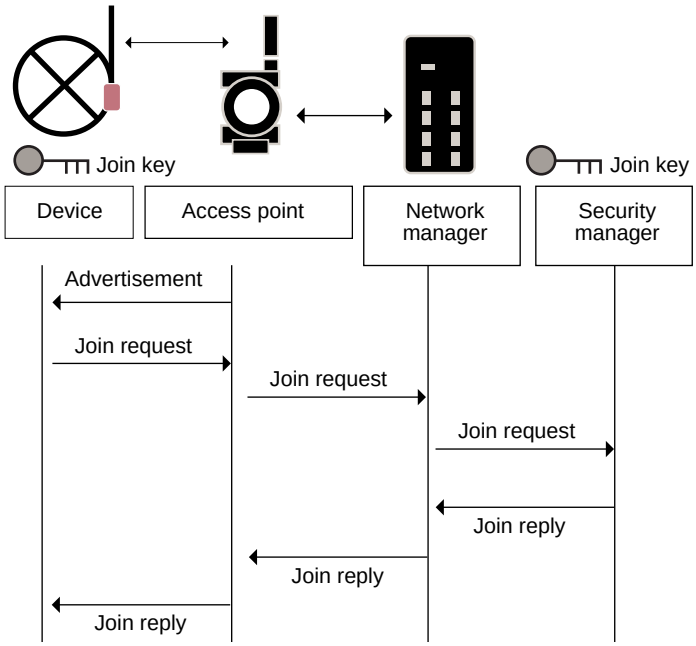


Figure 4.2.2 Device authentication procedure when joining a network

Host System Engineering

Wireless network setting tool

Communication with the host system of the gateway is performed via Modbus/TCP or OPC interface. These interfaces have been widely used in process control systems in the past, and the same engineering can be performed without using any special tools.

Configuring wireless devices

Device management tools can be used to set various parameters such as the display of self-diagnostic information from the wireless device, measurement range and units, and alarm threshold.

Wireless network engineering

Often, the system management functions and the security management functions, are implemented on the same hardware using a product called a gateway. Network management tools are installed on the gateway. Using a computer connected to the gateway, the network settings can

be adjusted to fit application requirements. The following is a list of the common settings adjusted via the gateway's network management tool:

- Device tags
- Configuring redundancy
- Communication path topology
- Update cycle
- Number of retransmissions
- Channel blacklisting

Installation, Adjustment, Loop Check, Commissioning

Based on the results of the site survey, wireless devices are installed at the site. Once installed, it is time to validate if the wireless communication is healthy. A network management tool monitors and records wireless communication status by observing the Received Signal Strength Indicator (RSSI) and Packet Error Rate (PER). If the desired PER is exceeded, adjusting antenna positions can improve the quality of the network.

4.3: Wireless Network Maintenance and Management

Network Management Tools to Monitor and Maintain Network Health

The wireless network is collectively managed by the system manager function within the gateway. Each wireless device receives information such as a communication slot, a communication channel, a communication path, and an encryption key from the system manager when participating in a network. The wireless device also reports the Received Signal Strength Indicator (RSSI) and Packet Error Rate (PER) from its communication partner to the system manager. The system manager receives diagnostic data from the network devices such as RSSI, PER, and battery life and can route this information to a network management tool.

The network management tool displays this diagnostic information and functions for maintaining and managing the network. The figures below show the flow of ISA100 Wireless network management data and an example of the display screen of the network management tool.

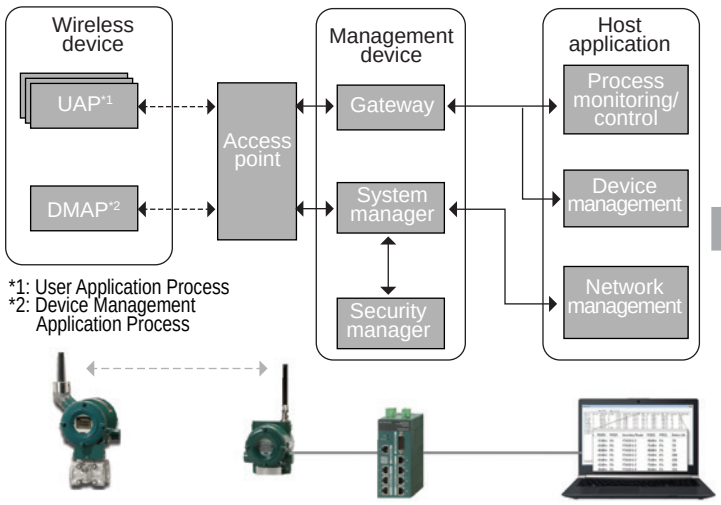


Figure 4.3.1 Network management data flow

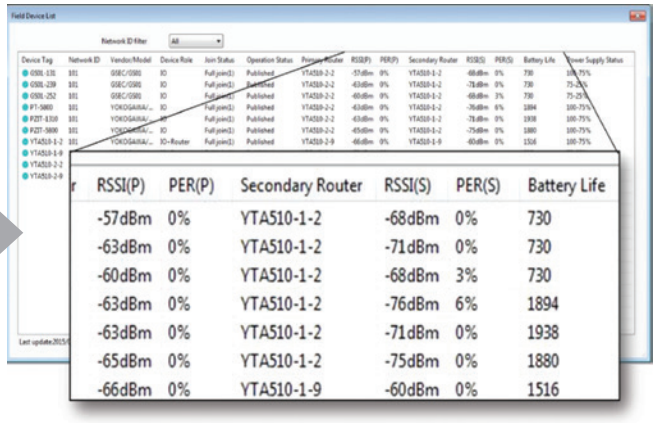


Figure 4.3.2 Network management

Network Health Management Metrics

The wireless communication environment is affected by radio obstacles and any changes in the electromagnetic environment. For stable operation, it is desirable to periodically monitor and respond to the following indicators:

- Signal strength: RSSI dBm
- Packet error rate: PER %
- Battery life: years

Examples of Engineering Elements for Improving Network Quality

- Device role settings, i.e., (I/O Device, Routing Device)
- Update cycle: As the update cycle becomes shorter, the operation frequency and the power consumption increase, and the battery life decreases
- Number of retries: As the number of retries increases, the probability of data arrival increases, and reliability improves
- Channel blacklisting: This feature can be used to prevent ISA100 Wireless from using the same channel as Wi-Fi to avoid interference
- Hopping pattern: The pattern of channel movement when switching the communication channel/ frequency
- Communication path/topology: With a large-scale mesh network, it is important to manage the communication path so that the path is not concentrated on a specific repeater. This can reduce performance and battery life
- Repeater location: The communication load must not concentrate on a specific repeater thus creating a network bottleneck
- Position of antenna: Pay attention to the polarization plane relative to surrounding obstacles when positioning an antenna

4.4: Wireless Device Management

Maintenance and Management Using Management Tool

Device management tools are host applications that monitor conditions related to instrument health. They enable early identification of potential problems with the devices and help to identify risks affecting plant operations and processes. Early identification reduces maintenance costs, reduces downtime, and improves production quality. The wireless device transmits self-diagnostic data and device management information to the gateway and the device management tool. Device management systems for process automation often support the following device description languages and device adjustment/setting software for managing field instruments:

- Field device tool/device type manager (FDT/DTM)
- Electronic device description language (EDDL)

The figures below show the flow of ISA100 Wireless device management data and an example of the display of the device management tool. FDT/DTM technology can be used to set, monitor, and adjust various device parameters such as wireless range, calibration, and diagnostic data. Wireless and wired device data from multiple different vendors can be displayed and managed all within the same device management tool. ISA100 Wireless also supports NAMUR NE 107 and displays four standardized instrument diagnostics: failure status, function check status, out-of-specification status, and maintenance required status.

Multivendor integration with a single device management environment is enabled by CF/DD files. These are files created by instrument vendors. The CF contains information about the field instrument vendor, model, revision, what process data is provided (e.g., flow rate, temperature, pressure, etc.), and the number of sensors it has. The DD also contains information on the data structure and attributes. Each device vendor writes the source code of the DD in accordance with the IEC 61804-3 EDDL standard and then generates a binary format. A CF file is a text file with a structure similar to that specified by the Foundation Fieldbus specification. ISA100 WCI has created and maintains the implementation specifications for CF/DDs.

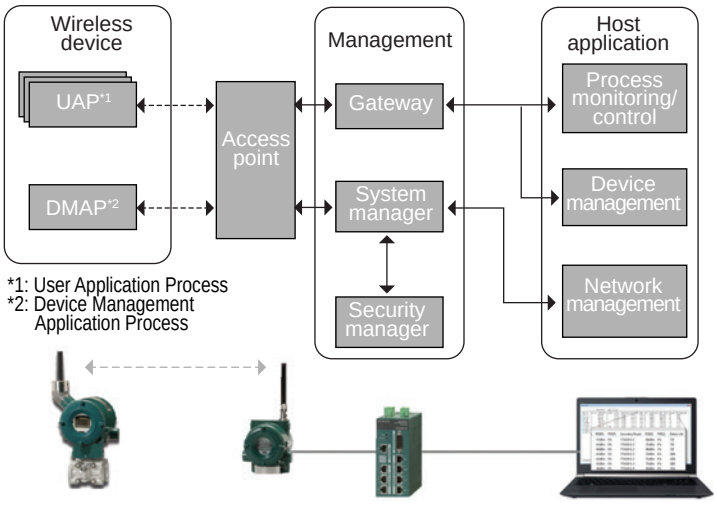


Figure 4.4.1 Device management data flow

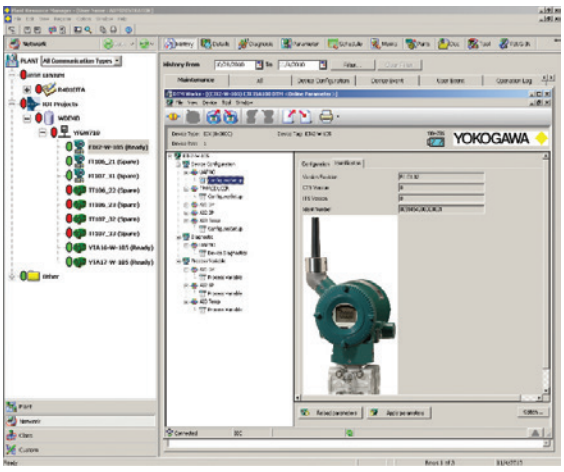


Figure 4.4.2 Example of ISA100 Wireless device management tool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PART 5.1
Case Study: Manufacturing Operations

ISA100 WIRELESS COMPLIANCE INSTITUTE™

5.1.1: Monitoring Strainer Clogging Trends at Refineries

Site Type: Refinery **Product:** ISA100 Wireless Differential Pressure Transmitter

Summary: The clogging tendency of the circulating cooling water strainer was monitored by a wireless differential pressure transmitter, enabling better scheduling of cleaning, eliminating unscheduled maintenance, and reducing costs.

Challenges

Using remote monitoring to better understand how to efficiently time the cleaning cycles for the strainers inside a circulating water cooler.

Background

- The strainer in the cooling water system must be cleaned every time a substance such as sludge is mixed
- When the circulating cooling water strainer becomes clogged during business hours, the maintenance staff cleans it. If the strainer gets clogged in the middle of the night, it becomes costly and burdensome to dispatch workers to perform the necessary maintenance
- The refinery was seeking a less expensive solution to monitor the clogging situation

Solution

- A wireless differential pressure transmitter was installed to monitor the amount of clogging of the circulating cooling water strainer
- Monitoring indicated that the strainer often became clogged immediately after washing and water passing. Based on this knowledge, the shape of the strainer was improved, and cleaning was rescheduled

Results

- It was possible to optimize cleaning schedules and reduce maintenance costs
- It became possible to visualize the circulating cooling water strainer's clogging history over time and determine its frequency. Cleaning was previously conducted about five times a month but after improving the shape of the strainer, the frequency of cleaning required was dramatically reduced
- By visualizing the condition of the strainer, it became possible to shift the cleaning work to the daytime, thus lessening the cost and burden of maintenance due to an unplanned need for cleaning during the night

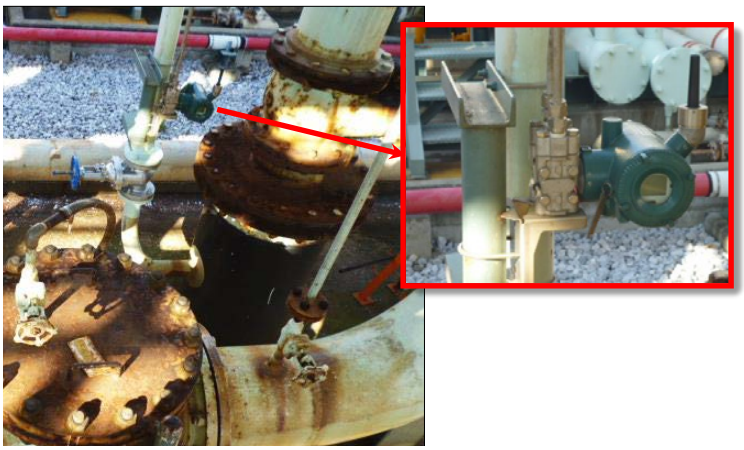
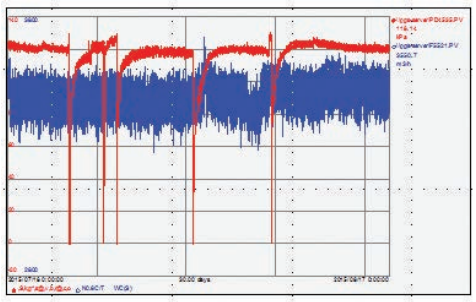


Figure 5.1.1.1 Site installation



Through visualization of clogging frequency using data collected by wireless instruments, it was proven that the strainer clogged about 5 times per month. Red Line - state of clogging over time

5.1.1: Monitoring the Clogging Tendency of Heat Exchangers at Refineries

Site Type: Refinery **Product:** ISA100 Wireless Differential Pressure Transmitter

Summary: The clogging tendency of a heat exchanger was monitored by a wireless differential pressure transmitter. Based on the resulting data, optimum maintenance timing was determined, which was useful for balancing maintenance with production.

Challenges

Heat exchangers are critical pieces of equipment to the oil refining process. Any potential blockages to the exchangers must be detected early because the damage blockages can cause can be crippling to production.

Background

- The heat exchanger is a device used to exchange heat energy between two different fluids—a hot fluid and a cold fluid
- The heat exchanger gets clogged from the crystallized precipitate of the liquid solution. Therefore, it is necessary to stop operations periodically to perform cleaning
- Monitoring the corrosion and clogging of the breakouts inside the heat exchanger is critical maintenance work for stable plant operations

Solution

A wireless differential pressure transmitter was installed at the exit of the heat exchanger tube to monitor its clogging tendency

Results

- The clogging tendency could be monitored by setting a threshold value in advance and setting an alarm to be generated when the differential pressure exceeds a prescribed threshold value
- The installation of a wireless instrument enabled online monitoring of the differential pressure, making it possible to understand maintenance needs

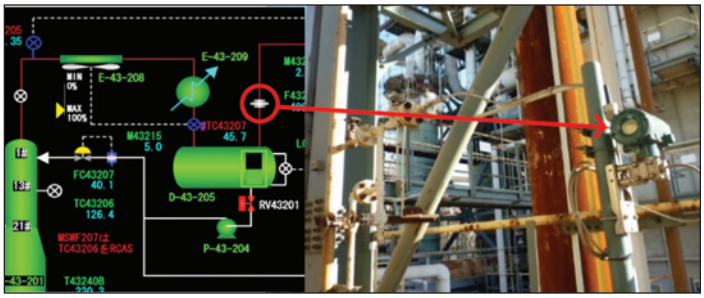


Figure 5.1.2.1 DCS screen and site installation

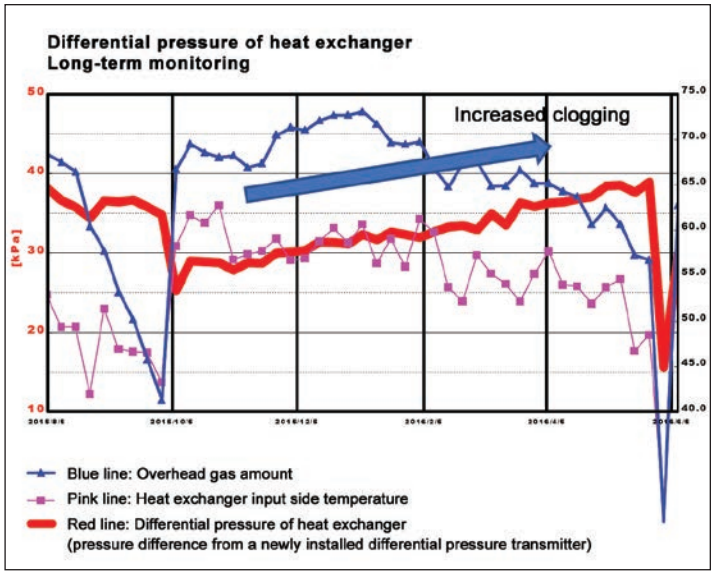


Figure 5.1.2.1 Clogging trend monitoring

5.1.1: Reducing Operating Time by Optimizing the Activated Carbon Extraction at Refineries

Site Type: Refinery **Product:** ISA100 Wireless Differential Pressure Transmitter

Summary: Online monitoring of steam purge temperature and holding time using a wireless temperature transmitter enables standardization of preparatory work prior to extracting activated carbon.

Challenges

Improve the efficiency of a steam purge process by standardizing preparatory work. In refining plants, when opening equipment containing gases such as ammonia, it is necessary to purge the internal gas with steam.

Background

Steam purge time varied depending on the operator's experience, therefore the time required was not clearly quantified nor standardized.

Solution

- A wireless temperature transmitter was installed in the activated carbon adsorption tank. The temperature and holding time of the steam purge were controlled, and the cooling time after the purge was visualized
- The purging operations during activated carbon extraction were visualized

Results

- Since the purge temperature and the holding time can be controlled on the DCS screen, this eliminates differences between workers; and the purge process can be managed as a standard work procedure. Therefore, both experienced and young employees can conduct the same work process
- Using the data from the wireless temperature transmitter, it became possible to quantify the work needed, facilitating teaching less experienced employees
- The team was able to create standardized work processes

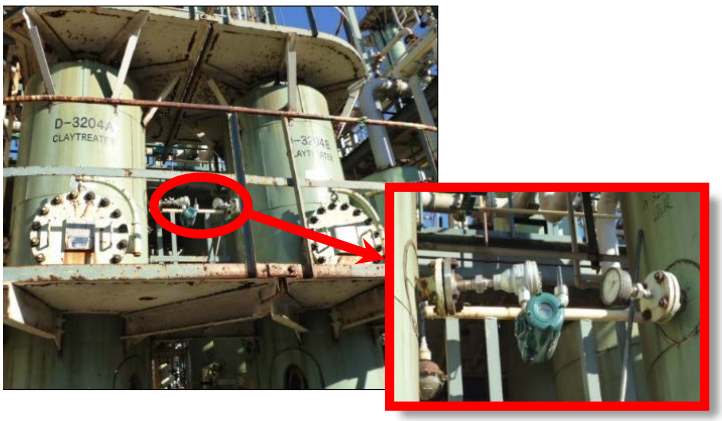


Figure 5.1.3.1 Site installation

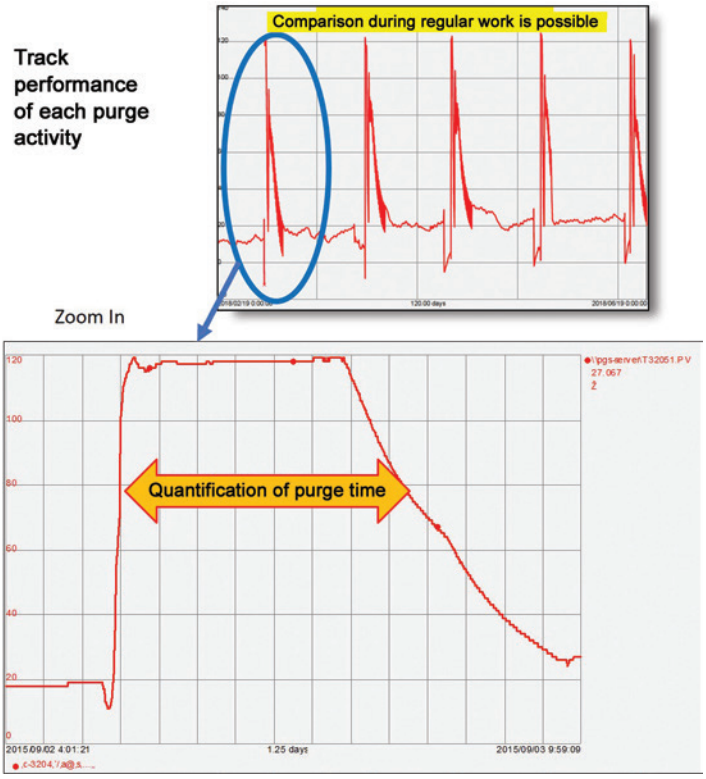


Figure 5.1.3.2 Trend purge temperature and retention time

PART 5.2
Case Study: Facility Management

ISA 100 WIRELESS COMPLIANCE INSTITUTE™

5.2.1: Vibration Monitoring of Reciprocating Compressors at Refineries

Site Type: Refinery **Product:** ISA100 Wireless vibrometer

Summary: A Wireless vibrometer was installed on a reciprocating compressor to verify its effectiveness and detect early signs of failure.

Purpose

Reciprocating compressors, one of the most important pieces of equipment in the refinery, have many failures. Therefore, a wireless vibrometer was installed to detect signs of failure.

Background

Reciprocating compressors are compressors that use the reciprocating motion of a piston. In general, in the event of a failure, it takes significant time to repair the compressor. A reciprocating compressor in a refinery transports hydrogen, which is indispensable for the desulfurization process. If a compressor failure occurs, it will cause serious damage. Therefore, detecting warning signs of failure is highly desirable.

Results

The vibration tendency of the reciprocating compressor can be monitored using wireless instrumentation, enabling plant operators to detect signs of failure before they occur.

Future development (user requests)

"It is desired to install wireless vibrometers in other important rotating equipment to measure vibration values in the DCS and to detect warning signs."

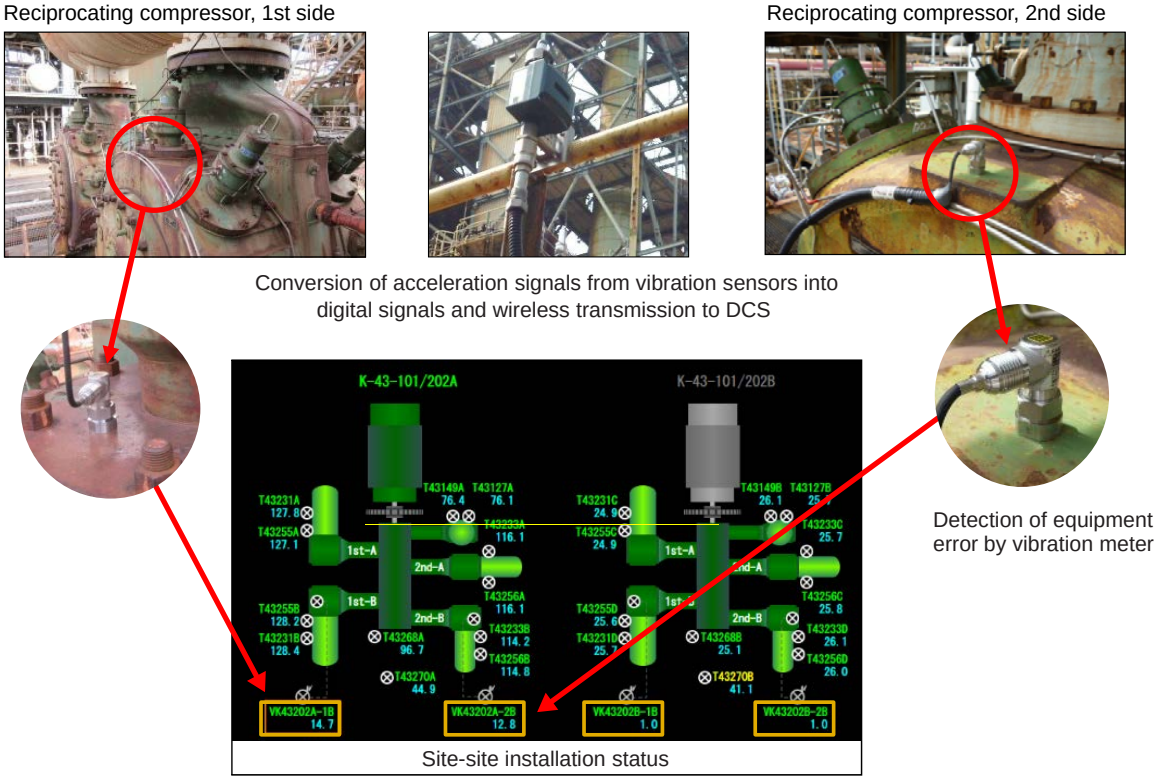


Figure 5.2.1.1 DCS remote monitoring of reciprocating compressor vibration (acceleration)

5.2.2: IoT for Pneumatic Instruments

Site Type: Refinery **Product:** ISA100 Wireless differential pressure transmitter

Summary: A wireless differential pressure transmitter enables online monitoring of a pneumatic level meter.

Challenges

Workers often went to the site and recorded data from the pneumatic instrument manually. But the fact that manual measurement was not consistent across workers caused problems.

Background

- Pneumatic instruments are still used in the petrochemical industry today
- Air-powered instruments are completed in a field loop, and many parts do not integrate their data into the DCS. For small loop locations, pneumatic instruments are cheaper than wired instruments
- In other cases, pneumatic instruments are used and installed as backups for wired instruments in case the power supply becomes unavailable in an emergency

Solution

A differential pressure transmitter was installed on the pneumatic instrument to measure the level in the tank. The wireless capabilities of the transmitter enabled centralization and remote monitoring by DCS.

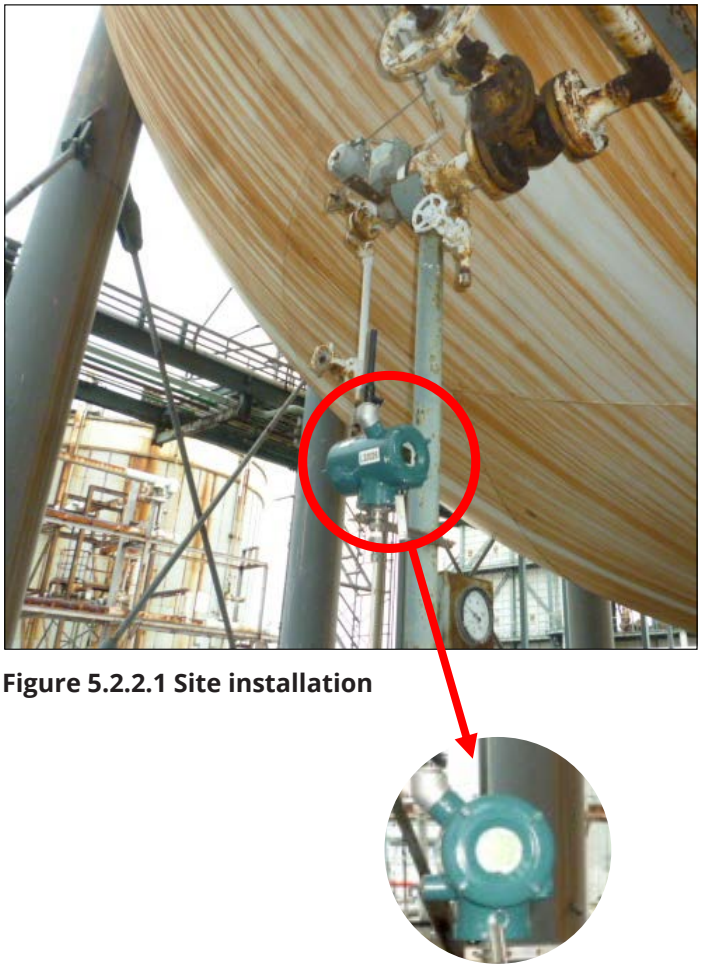


Figure 5.2.2.1 Site installation

Results

- With digitized information, it became possible to monitor the condition of the inside of the tank remotely from the control room
- It became possible to emit an alarm early when an abnormality was detected, enabling stronger safety management
- The battery-powered radio was perfect for the installation, as most of the areas with pneumatic instruments were not covered by a power supply

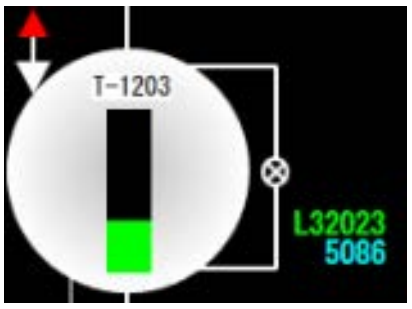


Figure 5.2.2.2 DCS monitoring screen

5.2.3: Advanced Condition Monitoring for Low-to-Mid Criticality Rotating Machinery

Bently Nevada
a Baker Hughes business

Baker Hughes Energy Japan, Ltd.

Challenge

Machinery condition monitoring enhancement and cost reduction at the same time

In many refineries and petrochemical plants in Japan, it is common practice to install a vibration monitoring system as a protection system for critical machines to prevent catastrophic machinery failure and to use a portable data collector to understand the condition of other low/mid-criticality machines. In recent years, predictive maintenance using machine condition monitoring has been highlighted again with the advance of IoT technology. Many users are considering optimization of predictive maintenance using wireless condition monitoring devices.

Condition monitoring by a portable data collector is performed on average once every 1 to 2 months in these plants, and at most twice a month because more data collection requires more worker hours. Although it may be sufficient to grasp abnormalities in rolling bearings at that frequency, this data frequency is insufficient to detect the early stage of failure. If the frequency is increased, it will immediately increase labor costs. As a result, unless significant returns are expected, it will be difficult to obtain approval for an investment to increase the frequency of data measurement.

With a wireless vibration monitoring system, the plant can start to collect data automatically, once an hour. This will provide more data for more insights and may help to improve the plant maintenance schedule and to detect early signs of equipment failure.

Solution

Wireless vibration monitoring system

A management station, YFGW 410, and an access point, YFGW 510, are installed as an ISA100 wireless infrastructure, and an ISA100 wireless Bentley Nevada wireless vibration monitoring system, Ranger Pro, is installed on the bearings of the rotating machine. Measured values can be transmitted to the DCS via Modbus communication. If waveform and spectrum data are necessary, these dynamic data can be sent to condition monitoring software System 1. Since the sensor and transmitter are integrated, cable installation around the machine

Figure 5.2.3.1 Vibration monitoring with a portable data collector

Figure 5.2.3.2 Sensor installation on the machine

is not required and installation work is much easier than with a wired solution.

Cost

Wireless vibration monitoring systems require an initial investment for the infrastructure and sensors that are larger than the investment required for a portable system. However, the annual operating cost is only for battery replacement, and batteries can last at least 2 to 3 years, depending on the frequency of use. The average battery price is approxmately 45 USD. In the case of a portable data collector, labor costs are required for every measurement, and the cost will increase over time.

As an example, a company has been managing 500 rotating machines currently using a portable data collector. They will instead start to manage 50 machines, which are relatively important, with a wireless vibration monitoring system. Over a period of 3-5 years, the initial investment is projected to be 10% of the portable data collection labor cost.

Figure 5.2.3.3 Sensor outline (diameter 40 mm x height 88 mm)

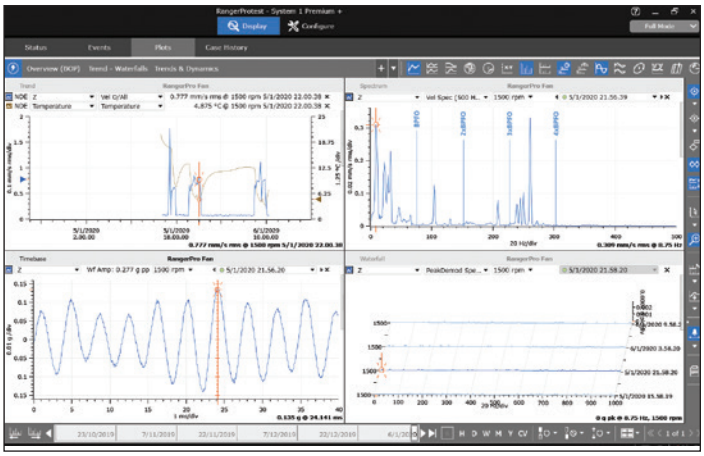


Figure 5.2.3.4 Machinery management software: system 1

Data quality

The Bently Nevada wireless vibration monitoring system can measure the same type of data as a high-performance portable data collector.

5.2.4: Monitoring Steam Pipes in a Tire Manufacturing Process

Armstrong International

Challenges

- A global tire manufacturer has struggled to maintain a constant temperature during rubber press molding and thus has struggled to maintain product quality. This press process is called the vulcanization process, in which heat and pressure is added to the rubber raw material for a certain length of time, and sulfur or sulfur chloride is mixed with the raw rubber and heated to increase the elasticity of the rubber. The vulcanization process is an important process for producing a high-quality tire. The minimum level of quality cannot be met unless pressure and temperature of the press are kept constant for a long time
- During operation, the steam system often had steam trap failures. This was caused by backflow of condensate in the steam piping and the water hammer effect. Water hammers are phenomena in which the speed of fluid flowing in the piping changes rapidly due to the rapid opening and closing of valves and the pressure in the piping, causing a large impact. This phenomenon may lead to a rupture of the piping itself or a large accident. Steam trap failures and related steam piping problems resulted in increased production downtime and excessive waste. There was also an increased likelihood that water hammers would result in safety issues during production
- At the plant, it was difficult to access the steam traps during operation, and engineers could not identify and repair the steam traps safely or in a timely manner

What is a Steam Trap?

When steam cools and condenses into condensate, steam and condensate coexist in the steam piping and the equipment. If a hole is drilled at the lowest point to remove the condensate, the condensate will be discharged, but the steam will also be discharged, causing loss. Steam traps are used to prevent this steam from escaping.

Background

Figure 5.2.4.1 Wireless sensor for monitoring steam trap

- Users wanted a solution that would safely monitor the performance of all steam traps in real time to prevent production stoppage
- The internal temperature of the tire press equipment in the vulcanization process was high, potentially high enough to melt any wires associated with wired instrumentation. In addition, there was a problem determining the wiring route due to space restrictions around the equipment. These issues made wireless instrumentation a better choice
- The user wanted the operator to be able to safely monitor the operation of the steam traps while the press process was running. If a problem does occur during the press operation, the steam trap can be bypassed to maintain the proper temperature in the vulcanization process

Solution

- The Armstrong ST6700 ISA100 Wireless steam trap monitor enables non-invasive monitoring of all critical traps
- By integrating real-time alerts on the local HMI, operators were able to confirm the steam system was operating properly and eliminate the risk of waste and loss of production time. With real-time monitoring, problematic steam traps identified in the steam system could be flagged for investigation during the next maintenance period
- ISA100 Wireless sensors were placed in the factory as repeaters (to enable a relay function of externally supplied sensors) to create a fully redundant wireless network. This wireless network configuration reduces latency (transmission delay time), improves battery life and performance of the steam trap monitoring unit (ST 6700) and achieves wire-like performance

Results

- With the introduction of an ISA100 Wireless network, process information was delivered in a short time and in a very cost-effective manner. As a result, the user was able to reduce daily MRO costs (maintenance, repair, and operation) caused by condensate remaining in the steam system during conventional operation by about 5% per year, and further reduce the waste level by 20%
- By using the open ISA100 Wireless architecture, a wireless network can be constructed using devices from multiple, specialized manufacturers. Available Process information can easily be expanded and monitored throughout the plant without requiring difficult wiring work

Figure 5.2.4.2 Example of a tire manufacturing plant

5.2.5: Optimizing Management of Steam Tracing Systems

TLV CO., LTD.

Avoiding the risk of production opportunity losses due to steam tracing failure and reducing steam tracing management workload

Examples of wireless monitoring at a petroleum refinery and a chemical plant will be described in the following paragraphs. In these two plants, steam tracing systems (Figure 5.2.5.1) are used extensively to maintain high temperatures and prevent solidification of high pour point or high melting point fluids. Steam traps are used at the outlets of steam tracing lines to discharge condensate without leaking steam.

Because failure of tracing steam traps, or associated valves, indicate impending tracing system problems, it is important that these steam traps are properly managed. The tracing system in a plant may comprise 500-2000 tracing system steam traps or as many as 50-90% of the total steam trap population. In many cases, failure of a steam tracing system can lead directly to production stoppage. To prevent this, plant operators may be tasked with checking 30–180 steam traps on a weekly or even daily basis. Due to the magnitude of work, these checks are sometimes deferred when labor resources are limited.

In steam tracing, copper tubing is commonly used to fit the shapes of the piping and equipment. The copper tubing is wound around the piping or equipment, then covered with insulation, with only limited sections visible externally to workers onsite. Very commonly, copper tubing installed under pipe insulation deforms due to workers walking on the pipes. Over time, tubing may also become blocked by deposits due to erosion or corrosion (which is generally caused in copper tubes by ammonium salts from pH adjuster or oxygen scavenger chemicals that are added to boiler feed water). This tubing will then need to be replaced or have the blockages cleared by unplugging. When additional equipment must be heat-traced, new tracing lines are tapped from existing branches. Such minor modifications may not be clearly documented, gradually making it impossible to identify what exactly each tracing line is heating, or which isolation valve is used for each tracing line.

Challenges

1. Large trap population
2. Insufficient labor to fully manage
3. Unable to avoid tracing failures
4. Unable to identify the traced target
5. Location of isolation valve unknown

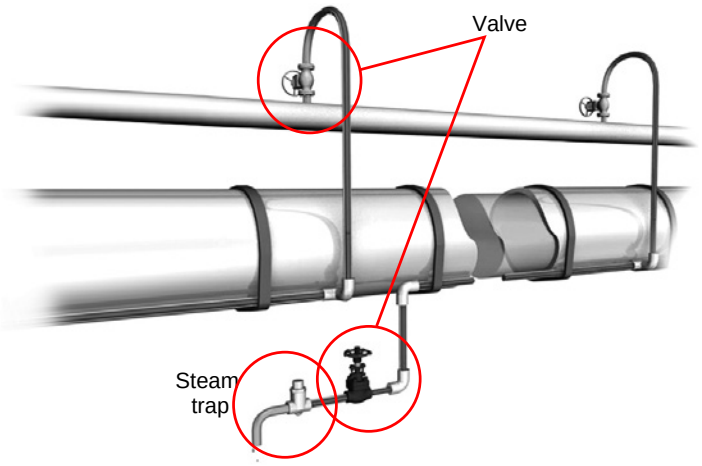


Figure 5.2.5.1 Steam tracing

Solution

Establish a management program accounting for criticality and enabling clear mitigation actions when anomalies are detected

Selection of inspection and maintenance methods based on criticality

Using wireless sensors to monitor the large population of steam traps used on steam tracing lines can address the problems described above but is not necessarily a cost-effective solution if all steam traps are monitored unconditionally. Additionally, if the workflow actions based on the monitoring results are not clearly defined, the full functionality of the monitoring system cannot be realized. Therefore, the criticality of the tracing lines and the current distribution of labor was evaluated first. Wireless monitoring was applied to high-criticality and resource-intensive locations, while other locations were left to be covered by regular or outsourced visual inspections.

- High criticality: Monitoring using wireless sensors Medium criticality: Scheduled field checks
- Other locations: Regular steam trap inspections, outsourced or by in-house personnel

Establish a database of steam traps and associated valves

Anomaly identification by itself, whether performed through monitoring, field checks, or inspections, is meaningless unless countermeasures are taken afterward. How quickly a countermeasure can be established is a key factor in its effectiveness. If the response is delayed, especially in the case of a critical location, it can result in an emergency shutdown or production disruption. A failure at a single steam tracing location will usually not lead to a large problem, but multiple failures occurring at the same time can cause significant issues. Therefore, it is essential to realize the importance of maintaining steam tracing lines and understanding their relationship to the traced process or equipment (Figure 5.2.5.1). In addition, to allow the countermeasure to be taken as quickly as possible, the response actions need to be defined, together with a clear indication of the associated isolation valves and the maintenance specifications if the steam trap needs to be replaced (for the scenarios that require steam trap replacement). These are all detailed in the database established as part of the management program.

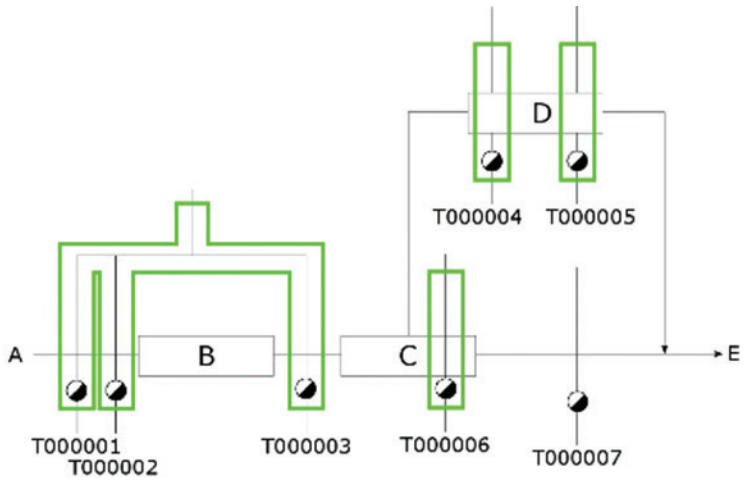


Figure 5.2.5.2 Flow diagram indicating the criticality and application of steam tracing lines

In Figure 5.2.5.2, the steam tracing line for C is critical as there is only a single line, but the same risk occurs if the 2 lines for D fail at the same time.

Establish a database of steam traps and associated valves

- Tracing lines' criticality and relation to traced process or equipment (Figure 5.2.5.2)
- Identification of isolation valves (Figure 5.2.5.3)
- Maintenance specifications and work guide (Figure 5.2.5.4)

Summary

While some plants have installed monitoring systems and accumulated sensor data but have not been able to take advantage fully of their capabilities, these two plants have successfully implemented monitoring for critical locations and established countermeasures to achieve clear improvements. As a result, mitigation actions can be taken before any failures result from steam tracing issues. In the petroleum refinery, loading operations that used to be disrupted once every 3 years on average have now been running without stoppage for 4 years since the monitoring system was implemented. In the chemical plant, 10 temperature anomaly events were detected and mitigated in a year, preventing any major problems from occurring. The sensor data accumulated is being used to review current management practices and further reduce risks.

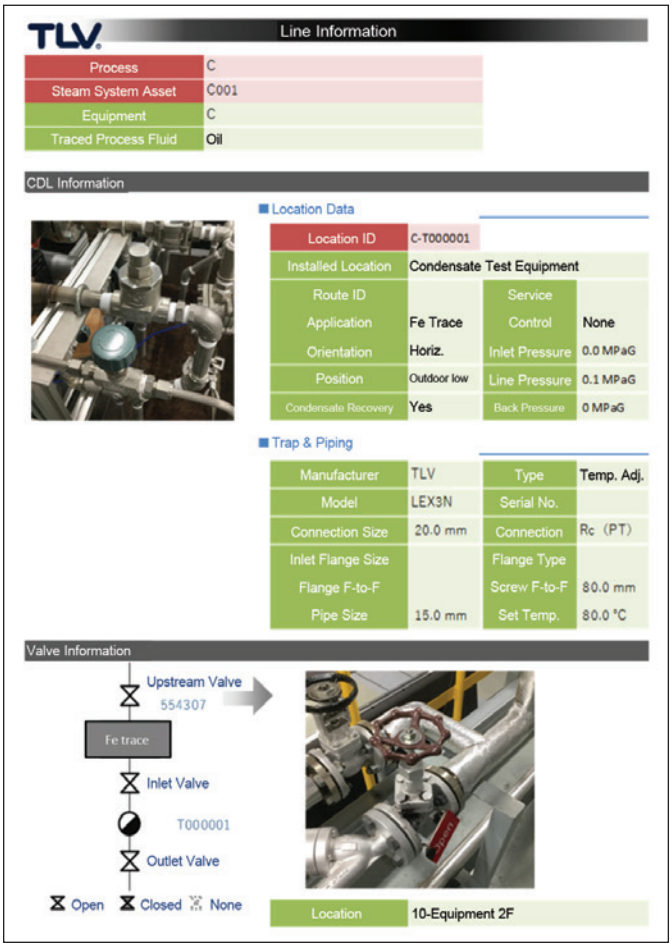


Figure 5.2.5.3 Identification of isolation valves

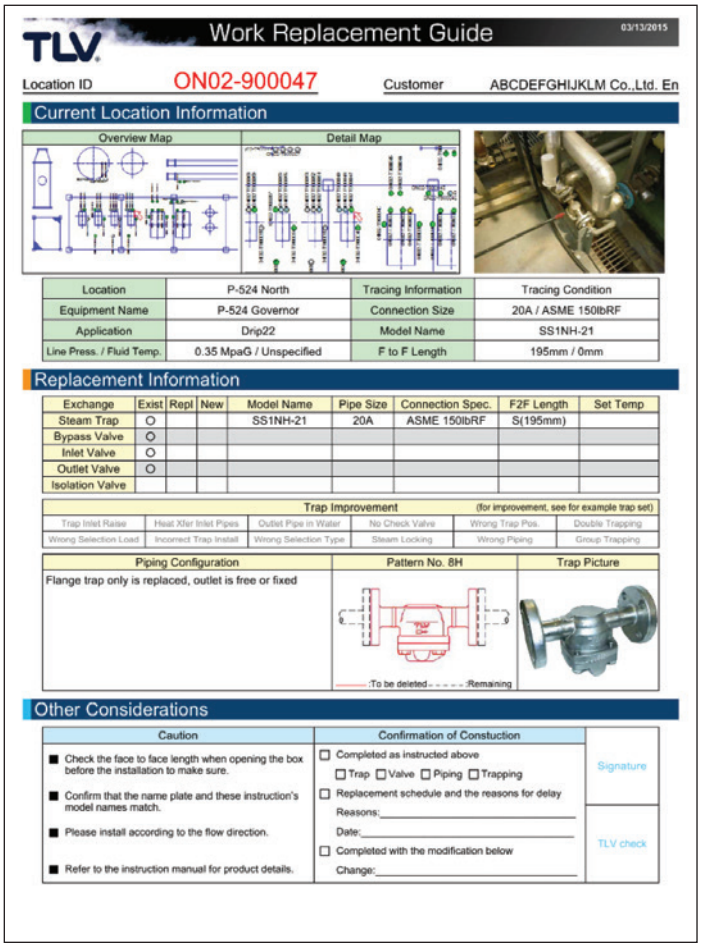


Figure 5.2.5.4 Maintenance specifications and work guide

5.2.6: ISA100 Wireless Distance Test

Distance Test

The communication distance of the radio is a representative index that shows the performance of the radio equipment. The communication distance of the radio is defined by the maximum distance at which a desired packet error rate (PER) threshold is not exceeded. It can be said that the performance of the radio equipment is higher when it can communicate at a longer distance without exceeding the desired PER. The PER measurement is an index for evaluating the rate at which transmitted packets (data) do not reach the receiver correctly. In addition, the radio communication quality may be estimated based on the radio wave strength (RSSI) received by the device. The PER can be estimated from the RSSI value in an ideal interval or in an environment where the influence of obstacles is small and can be easily evaluated. However, in an environment such as a plant with many pipes throughout the facility, there is no correlation between RSSI and PER.

Therefore, PER can be used more reliably for radio evaluation at the plant site. In the design of the field radio system, the required number of retries can be determined from the required reliability if the PER is known.

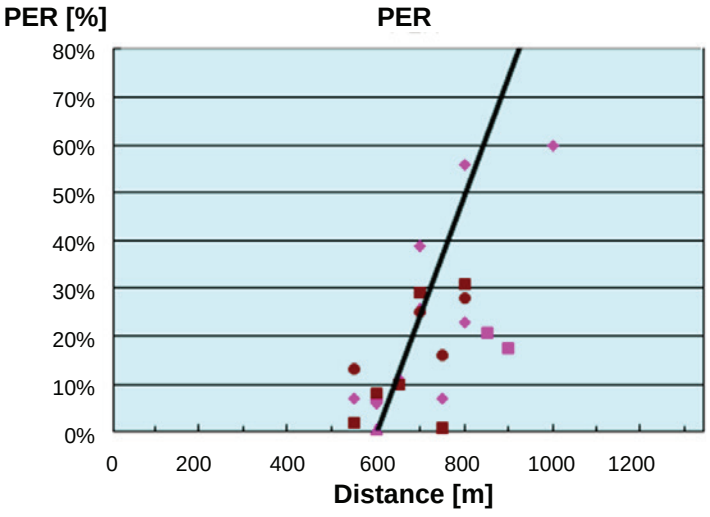


Figure C2-1 Distance and PER

Distance Test with ISA100 Wireless Equipment

An actual communication distance test using ISA100 Wireless equipment from Yokogawa Electric is introduced below. In this experiment, the PER was measured after the process value was communicated between the gateway and the device for about 10 minutes while extending the communication distance in a location with good visibility. As a result, it was confirmed that packet errors hardly occurred up to 600 m and that the coverage of wireless communication could be extended beyond the original estimation at this location. If no packet error occurs, the number of retries decreases, resulting in an increase in the battery life of the device. This demonstrates that the infrastructure cost, including battery cost and battery replacement work, can be drastically reduced.

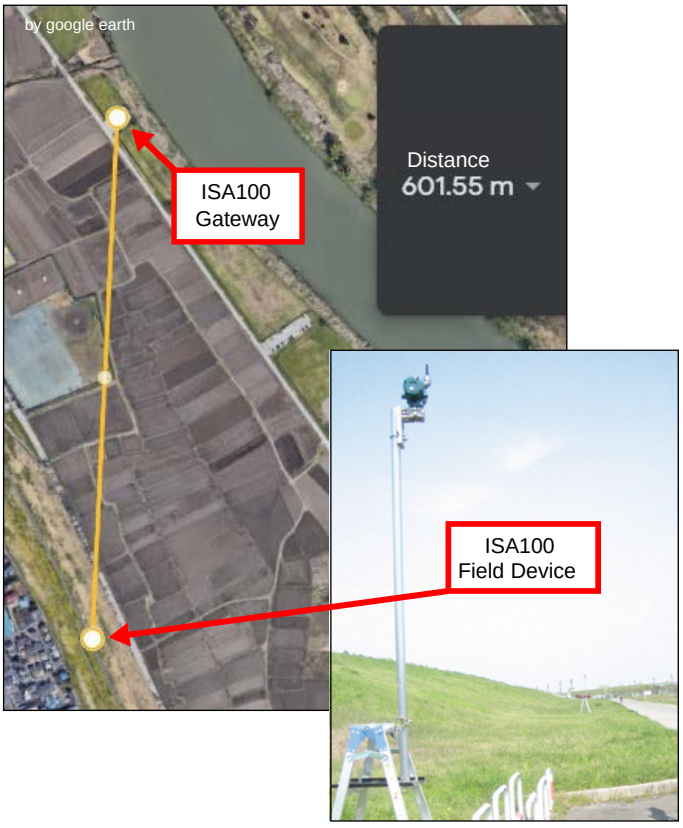


Figure C2-2 Communication distance test

PART 5.3
Case Study: Safety Management

ISA100 WIRELESS COMPLIANCE INSTITUTE™

5.3.1: Reciprocating Compressor Seal Monitoring

Site Type: Refinery **Product:** ISA100 Wireless Gas Detector

Summary: Verifying the effectiveness of equipment maintenance management by monitoring the state of the seals around the piston in a reciprocating compressor assembly.

Purpose

Evaluating the effectiveness of equipment maintenance managament for a reciprocating compressor.

Background

The suction actuator for adjusting the load capacity of the flammable gas carrier was changed from the pneumatic type to a stepless electric drive type. Since this is the first time that an electric type was adopted, a wireless gas detector was installed on a trial basis to enhance equipment maintenance management.

Solution

- The wireless gas detector was installed in the bleed piping of the actuator packing rod of the reciprocating compressor to constantly monitor the seal condition
- A wireless gas detector was installed in the box to detect even a small amount of gas leakage

Results

By detecting the leakage of gas contained in the bleed piping, the degradation of the packing rod seal can be visualized.

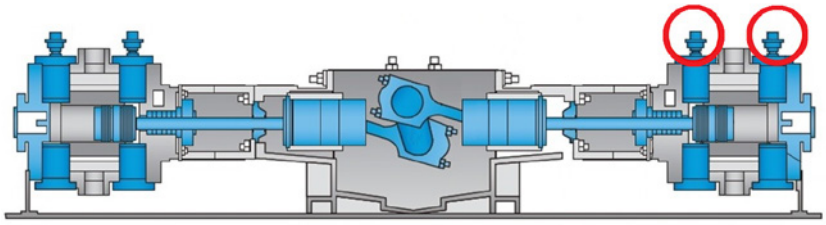


Figure 5.3.1.1 Cross-section of reciprocating compressor

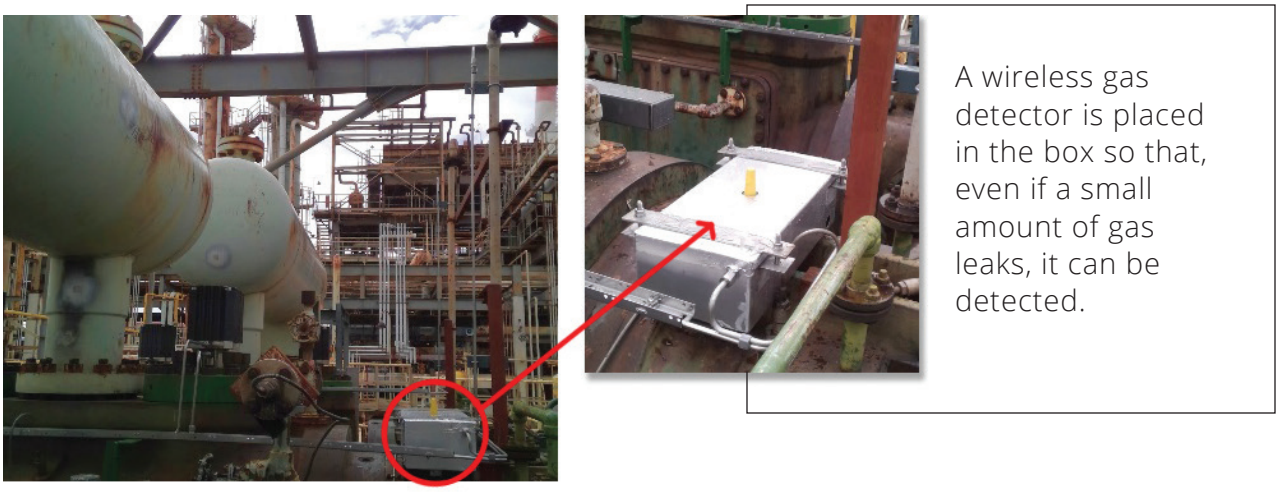


Figure 5.3.1.2 Site installation

5.3.1: Strengthening Safety Measures Against Volcanic Gases

RIKEN KEIKI CO., LTD.

Challenges

Developing tourist entrance regulations and ensuring the safety of tourists against volcanic gas

The Japanese archipelago belongs to the Circum-Pacific Volcanic Belt, one of the world's most volcanically powerful and active regions. There are more than 100 active volcanoes in the country. Volcanoes are popular with many tourists in Japan due to their striking visual landscapes and hot springs. However, in volcanically active regions, there is a risk of the volcano producing a high concentration of gases even in areas where tourists are allowed to enter, presenting a life-threatening situation. To ensure the safety of tourists, it is important to monitor the quantity and concentration of daily gas emissions from volcanic vents.

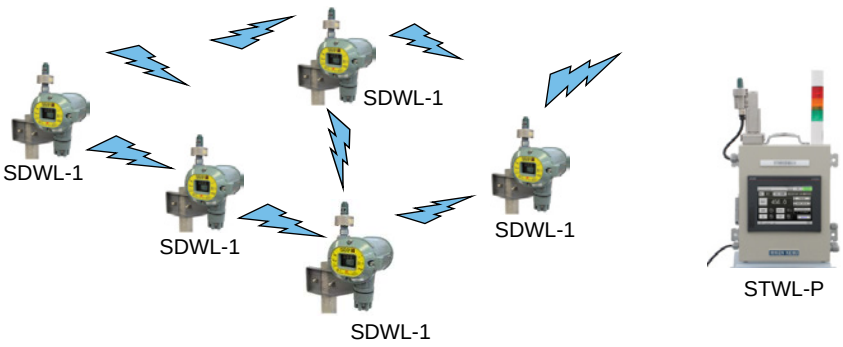
Solution

Fixed type wireless gas detection system

Riken Keiki Co., Ltd. provides solutions to monitor standard gas concentrations to help regulate tourist entrance and ensure the safety of tourists entering the mountain by continuously monitoring volcanic gas concentration. To accomplish this, it is necessary to detect low concentrations of volcanic gas emissions as early as possible.

The fixed type wireless gas detector unit, SDWL-1, can detect volcanic gases (H2S: hydrogen sulfide, SO2: sulfur dioxide) at low levels. The volcanic gas concentration value is transmitted at high speed in real time remotely using ISA100 wireless communication. This enables high reliability and high-speed response; the wireless performance of SDWL-1 also supports long-distance communication. In addition, SDWL-1 is the country's first fully stand-alone wireless gas detection unit, which can be installed anywhere without the need for external power. The units can be installed in important places such as volcanic gas vents, at a starting point for a climb, and in any place where tourists gather.

When the monitoring station, STWL-P, is connected to the SDWL-1, the system puts out an alert using a rotating warning light and a buzzer if volcanic gas levels exceed the standard level. Its external alarm output function enables alarm activation in remote places. In the future, this system will be able to transmit data regarding volcanic gas concentration from the STWL-P to the cloud. Safety management will become more advanced by combining this with cloud-based data from the Japan Meteorological Agency regarding volcanic earthquakes, volcanic tremors, and mountain swelling.



5.3.3: Expanding and Enhancing the Gas Leak Monitoring Area

NEW COSMOS ELECTRIC CO.,LTD.

New Cosmos Electric Co., Ltd.

Challenge 1

Enhancing safety measures in plants

A gas detector is equipped with a gas sensor and monitors the occurrence or absence of a gas leak. For this reason, it is used for plant safety management, including for the prevention of accidents due to gas leaks and for status monitoring of facilities.

In recent years, the petroleum refining, petrochemical, electric power, and iron and steel sectors have begun to notice the effects of their plants' aging. Many of these plants are over several decades old. As a result, the risk of a gas leak is increasing. Against this background, it is necessary to enhance the functionality of gas leak monitoring in these existing facilities. It is critical to be able to check the safety status of the areas in which employees work in case of a leak. However, the cost of laying wires to add wired gas detectors is huge, which presents a major problem. Installations in a wide or hazardous area can increase the cost even further.

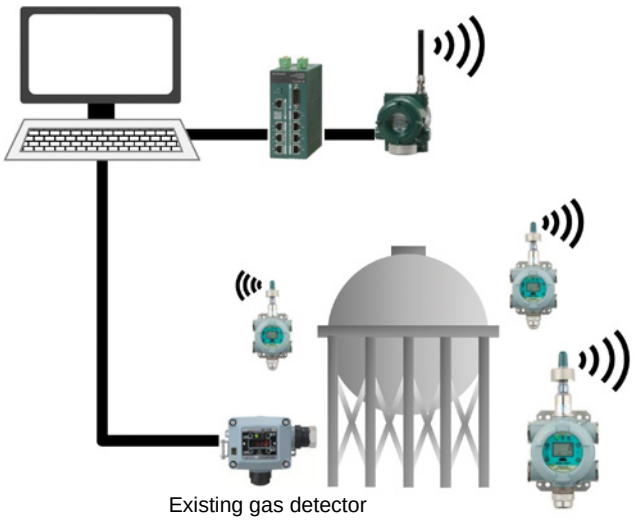


Figure 5.3.3.1 Increasing the number of wireless gas detectors to improve surveillance

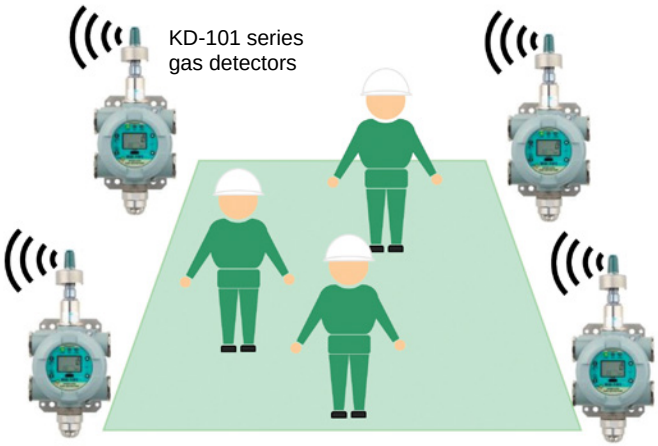


Figure 5.3.3.2: Monitoring the borderline between safe and non-safe zones

Solution 1

Expanding and reinforcing the monitoring area by using wireless gas detectors

We propose a wireless gas detection solution.

Since the KD-101 series wireless gas detectors are cordless, they can be installed at a low wiring cost. Monitoring capability can be improved by increasing the number of wireless gas detectors (Figure 5.3.5.1a). Placing wireless gas detectors so they surround the working area can also ensure the safety of the workers by enhancing the monitoring capability (Figure 5.3.5.1b).

Wireless communication may raise concerns about delays in communication. However, the KD-101 series gas detector can transmit gas concentration data at a minimum of 2-second intervals. This provision allows for the configuration of a wireless gas leak monitoring system that performs as well as a wired one. Moreover, ISA100 Wireless employs redundant communication paths (sending the same signal to two different gateways), which provides high communication reliability. For these reasons, the wireless solution can be used for important applications in the operation of a plant, such as safety management. The KD-101 series gas detectors can detect flammable gases, carbon monoxide, hydrogen sulfide, and oxygen; thus, they can be applied for safety management in various industries.

Challenge 2

Enhancing the condition monitoring of facilities

In recent years, there has been a growing need for enhanced plant condition monitoring. A key reason is the need to reduce manufacturing downtime by preventing facility failures (e.g., machinery, equipment, and piping). Such monitoring also aims to reduce maintenance costs by shifting to CBM (condition-based maintenance).

To this end, a gas detector is sometimes required to be installed as near as possible to the target equipment. However, the detection point can be very difficult to access at times. The installation location for the gas detector may be restricted for ease of maintenance. When the detection point is located at a place that is difficult to maintain (e.g., extremely near to the equipment, at a high place, or in a pit), the gas is usually drawn by a pump and carried to a gas detector that is placed at a distance. Thus, the sampling pipe to the gas detector can at times be long to maintain a better signal line route to the control center, which will, as a result, impair the performance of gas detection.

Solution 2

Enhancing the condition monitoring of facilities using a combination of ISA100 Wireless and gas sampling technology

We propose a gas leak monitoring solution using a combination of ISA100 Wireless and gas sampling technology. This new solution uses a PD-12 extractive type gas detector (a stationary gas detector with a built-in pump) in combination with a KD-100M wireless transmitter that converts 4-20 mA analog signals into radio signals. With this solution, the signal line from the detector to the control center is no longer required. This enables the installation of the detector at its optimum gas sampling location. In addition, ISA100 Wireless supports channel hopping. Therefore, communication quality can be maintained even when the KD-100M is in a place where it cannot communicate directly with the gateway, if the number of hops is within the limit designed into the network. This enables the gas detector to monitor gas leaks at more effective locations than ever.

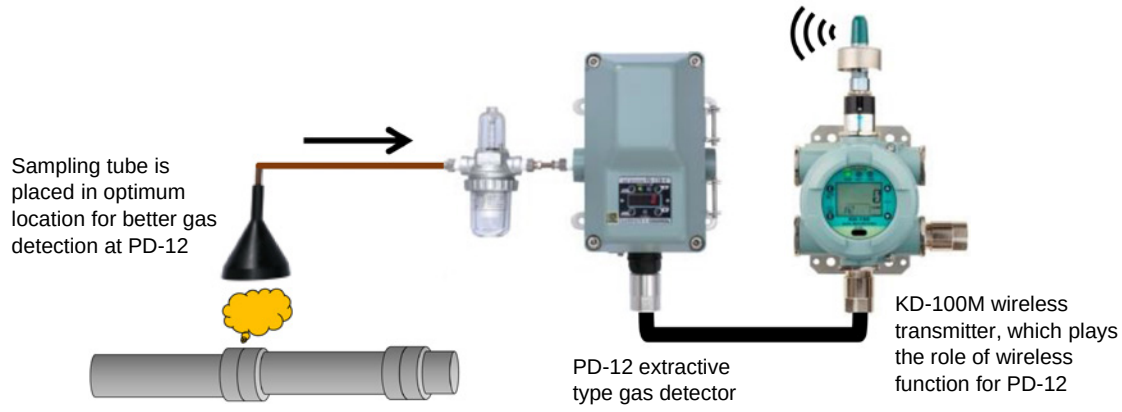


Figure 5.3.3.3 Enhancing plant condition monitoring using a combination of ISA100 Wireless and gas sampling technology

Challenge 3

Enhancing gas monitoring in the event of an emergency or during facility maintenance work

Periodic checks and inspections or adjustments to equipment is performed at plants at regular intervals. To prevent an accident due to a gas leak during maintenance, gas detectors are connected with a signal tower light and a buzzer is temporarily installed onsite to warn of the presence of a gas leak. However, such gas detectors are intended for temporary use and are usually not connected to a gas monitoring system. To enhance safety management in such situations, it is important to establish a system for monitoring the gas detectors collectively. However, the cost and time to accomplish this present a challenge because the detectors typically need to be wired to the system for each maintenance event.

Solution 3

Safety management with a transportable gas leak monitoring system

We propose an enhanced monitoring solution that provides a gas leak monitoring system for temporary use.

The VCW-100 transportable gas leak monitoring system has a gateway function that can communicate with KD-100/KD-101 wireless gas detectors via an ISA100 Wireless network. The VCW-100 unit is equipped with a touch panel that displays gas concentrations, device statuses, etc. It is also equipped with a buzzer and a signal tower light to alert people in the area in the event of a gas leak or device failure. The registration of these devices (gas detectors) in the gateway (VCW-100) is done only once. Since registration is completed before shipping the devices to the plant site, one can immediately use the devices just by turning them on. No extra setting adjustments are required on-site. Thus, a temporary monitoring system can be established easily and immediately in an emergency or during maintenance work for enhanced safety management onsite.

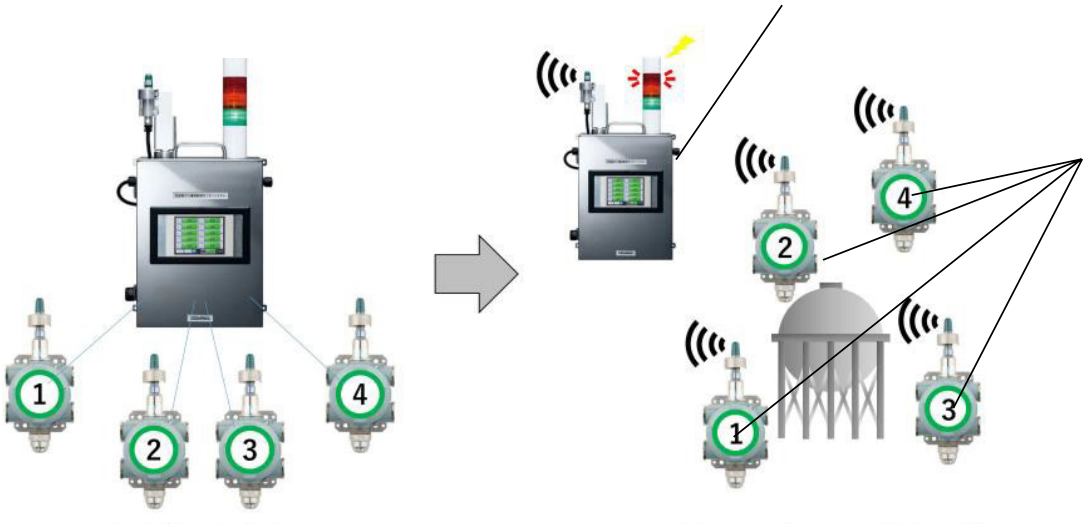


Figure 5.3.3.4: Temporary gas leak monitoring system

PART 5.4
Case Study: Monitoring and Maintenance

ISA100 WIRELESS COMPLIANCE INSTITUTE™

5.4.1: AD6000: Acoustic Monitoring

Site Type: Refinery **Product:** ISA100 Wireless Steam Trap Monitoring

Summary: Improved maintenance efficiency and reduced costs by monitoring SRVs 24/7.

Armstrong International

Background

- Safety relief valves (SRVs) are in hard-to-reach locations and not easy to test
- Leaking SRVs can cause safety and environmental concerns as well as potential regulatory compliance issues and fines
- SRVs opening erratically can be related to process or system issues

Challenges

The customer wanted to:

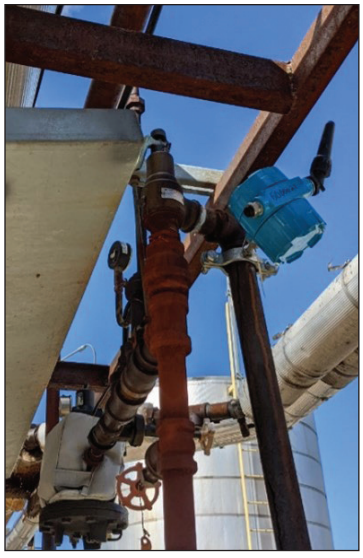
- Monitor the SRVs remotely and continuously
- Identify any failures quickly (what, when, and where)
- Avoid regulatory compliance issues and fines
- Monitor SRVs for popping or leaking, track down upsets in the system easily, and record the occurrence time and length

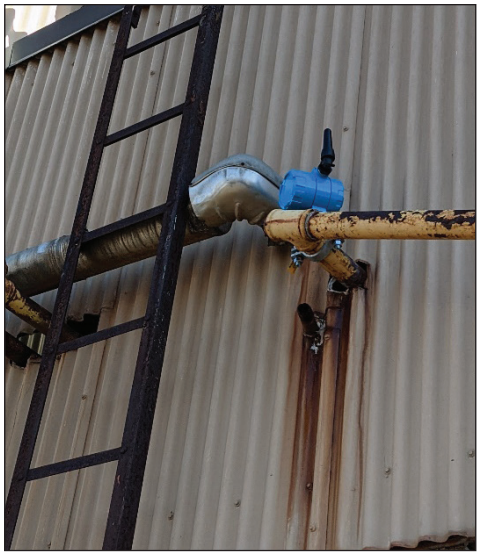
Solutions

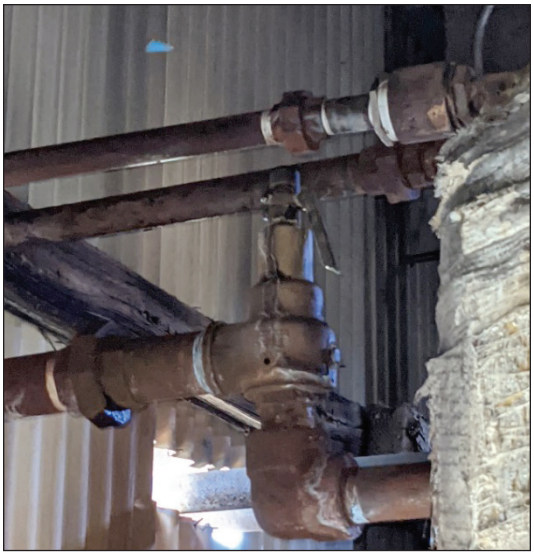
- Wireless acoustic transmitters were installed to monitor the SRVs continuously
- By monitoring the SRVs 24/7, the customer can receive instant notification when an SRV is opening or leaking and use maintenance resources more effectively

Benefits

- Instead of checking all the SRVs annually, the customer only needs to focus on the failing SRVs
- There is an increase in process reliability, and management can avoid unplanned downtime with instant notifications







5.4.1: ST6700: Steam Trap Monitoring

Site Type: Refinery **Product:** ISA100 Wireless Steam Trap Monitoring

Summary: Improved maintenance efficiency and reduced costs by monitoring steam traps 24/7.

Armstrong International

Background

- Steam traps are tested manually once or twice a year
- 90% of the steam traps tested are in good condition, wasting valuable maintenance resources by checking all of them
- A steam trap that has tested "good" can fail the next day and go unnoticed for weeks or months, leading to unplanned downtime and process issues

Challenges

The customer wanted to:

- Monitor the steam traps remotely and continuously
- Identify any failures quickly (what, when, and where)
- Reduce energy losses and CO2 emissions
- Avoid unplanned downtime and improve the process efficiency

Solutions

- Wireless steam trap transmitters were installed to monitor the steam traps continuously
- By monitoring the steam traps 24/7, the customer can receive instant notification when a trap is failing to use maintenance resources more effectively

Benefit

- Instead of checking all the steam traps annually, the customer only needs to focus on the failing traps
- There is an increase in process reliability and management can avoid unplanned downtime by fixing the failing traps quickly

5.4.1: Petrochemical Large-Scale Steam Trap and Valve Monitoring

Site Type: Refinery **Product:** ISA100 Wireless Steam Traps and Valves Monitoring System

Summary: Implementation of Large-Scale ISA100 Wireless Applications to Improve Reliability and Energy Efficiency by Monitoring the entire population of Steam Traps at the ILBOC Petrochemical Complex. This project was awarded the "2019 ISA100 Wireless Excellence in Automation" granted by the Wireless Compliance Institute.

Iberian Lube Oils Company, Sa (Ilboc) (Spain)

Background

- Energy efficiency in steam networks is influenced by the efficiency of their steam traps, the overall failure rate of which, including the steam leakage rate, typically exceeds 25%. Steam leaks increase maintenance and production costs, increase CO2 emissions, generate the water hammer effect, and make it difficult to return condensate to boilers
- ILBOC was looking for a solution that could efficiently monitor 904 steam traps and 29 safety valves at the lowest cost
- Before adopting the wireless monitoring solution, an annual steam trap survey was conducted, followed by repair of detected faults and leaks. This solution did not allow ILBOC to reduce the rate of failures and leaks below 10%

Figure 5.4.3.1 BiTherm ISA100 Wireless Monitor

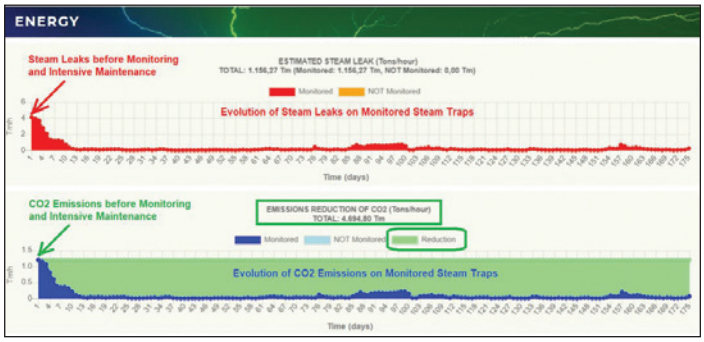


Figure 5.4.3.2 Evolution of steam leaks and CO_2 emissions before and after monitoring

Challenges

- ILBOC wanted to monitor remotely its large population of steam traps to reduce its leak rate to less than 0.5%
- ILBOC wanted to increase the reliability of its steam network, increase condensate return to the boilers, reduce steam trap maintenance costs, and detect dangerous internal and external gas leaks in relief and safety valves as soon as possible
- ILBOC wanted to conduct the project at no upfront cost (ESCO business model)

Solutions

- An ISA100 wireless system was installed to monitor ultrasound and temperature in each steam trap and relief & safety valve to detect faults and internal / external steam and gas leaks
- Using this information, it was possible to implement the Smart Leak Detection & Repair Methodology (SLDAR), which managed to reduce the leak rate in steam traps to less than 0.5% permanently and reduce leaks in safety valves immediately

Benefits

Before monitoring, the leak inspection/repair was performed every 6 months. After monitoring, any faults or leaks are repaired within 24 hours. Results:

- Steam leak rate < 0.5% permanently
- Great steam savings and CO2 reduction achieved
- Return on Investment (ROI) = 26 months
  - The project was conducted by BiTherm under the ESCO business model (monthly payments corresponding to the partial amount of savings achieved)
- Ongoing improvements: By avoiding the water hammer effect and reducing back pressure in the return lines, reliability has been increased and the return rate of condensates to boilers has increased

5.4.2: Oil Refinery Gas Detection

Site Type: Onshore Refinery **Product:** GS01 wireless gas detectors

Summary: The world's first full-scale wireless Safety Integrity Level 2 (SIL2) gas detection system was installed at Equinor's* Kalundborg Refinery in Denmark.

GAS SECURE A Dräger Company | Dräger

GasSecure, A Dräger Company

INSTALLATION DETAILS

END USER
Equinor

LOCATION
Kalundborg, Denmark

COMPLETION DATE
June 2017

TYPE OF INSTALLATION
Onshore Refinery

INSTALLATION DETAILS
122 pc GS01
8 pc GS01-EA
3 pc Wireless gateways
18 Pc Wireless Access Points
Siemens S7

COMMUNICATION
PROFsafe on ISA100 Wireless™

Background

- Toxic and flammable gases can present a high risk of explosion, as well as health risks to personnel. To improve the safety of refinery assets and personnel, improvements in gas detection coverage are extremely important
- However, installing a traditional wired gas detection monitoring system in a congested refinery presents its own risks and obstacles and is likely to incur high costs and considerable downtime during installation. The wiring itself can also present hazards within an explosive environment

Challenges

- The project's main objective was to improve gas detection coverage in three process areas identified by a risk analysis. The Equinor team faced

issues with installation in an already congested plant area, as well as detection in enclosed spaces
- Initial studies indicated a project with wired devices would require an investment of tens of millions

Solutions

- A more cost-effective solution was needed, and a local team was established at the refinery to work side-by-side with Equinor's safety discipline specialists. Over a three-month period, it became apparent that a wireless device installation could be easily implemented and would quickly overcome physical and logistical obstacles, with flexibility for later additions or modifications
- Large installation of GasSecure GS01 wireless gas detectors: Initially, one hundred and twenty-two GS01 wireless gas detectors were spread across the three process areas. This required the installation of several gateways and multiple access points that were placed according to a survey and design for optimum wireless communication. The first phase of the installation included areas with heavy machinery and enclosed structures that impacted the wireless signals. To overcome this communication challenge, GS01-EA detectors with extended antenna were chosen to transmit data securely past the structures. The remaining devices were all GS01 detectors with standard antennas
- System designed and configured for wireless Safety Integrity Level 2 (SIL2): The SIL2-certified GS01 detectors were deployed as the world's first complete wireless SIL2 gas detection safety system. This is achieved with safe end-to-end communication between field devices and the control system. This is currently only possible with the ISA100.11a wireless protocol and the SIL3 certified PROFIsafe application layer over PROFINET. PROFIsafe covers the entire communication path between each detector and the control system and integrates both process value and safety function communication parameters. The combination of ISA100.11a and PROFIsafe meets IEC 61784-3 requirements for SIL through various mechanisms including the tunneling of safe data

Benefits

- Reliable wireless was achieved in a congested refinery with multiple structures. The benefits of fixed wireless gas detection versus traditional cabled systems were clearly demonstrated in terms of both safety and cost reduction at the Kalundborg refinery
- The project's original cost estimate was significantly reduced, while also providing the required gas detection coverage
- The world's first full-scale wireless SIL2 gas detection system
- The success of wireless gas detection at the Kalundborg refinery, across wide and occasionally congested areas, is promising for other installations

PART 6
Device Development

ISA100 WIRELESS COMPLIANCE INSTITUTE™

6.1: ISA100 Wireless Device Development Highlights

Introduction

To develop an ISA100 Wireless device, engineers who have not developed wireless products need to acquire a great deal of technical knowledge, such as a basic knowledge of wireless and an understanding of the communication specifications of ISA100.11a (IEC 62734) standard. In this section, an example of the configuration of an ISA100 Wireless device and the key points of its development are described.

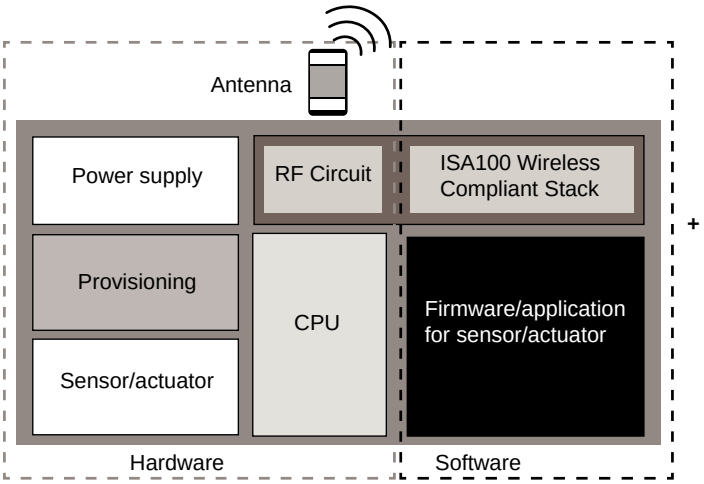


Figure 6.1.1 Example of ISA100 Wireless device configuration

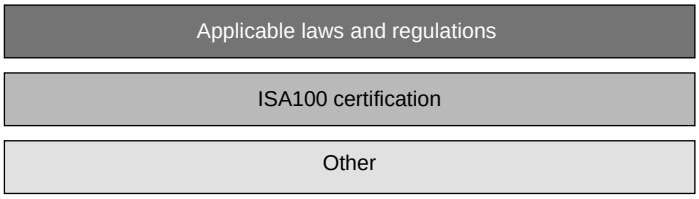


Figure 6.1.2 Example of certification

Example of ISA100 Wireless Device Configuration

Examples of ISA100 Wireless device configuration and product certification are shown below. The configuration example is divided into hardware and software aspects. Since the sensor/actuator shown in the figure is a function provided by the device manufacturer and the development contents of the firmware of the CPU depend on the function, a description thereof is omitted here.

ISA100.11a was developed as an ANSI/ISA standard, then proposed to IEC and approved as an international standard, IEC 62734, after international deliberation. Detailed technical specifications and requirements such as radio communication procedures are described in this standard. Therefore, it is recommended to refer to the latest IEC 62734 standard when developing products. The ISA100.11a (IEC 62734) standard is available from the following sources:

- ANSI/ISA (ANSI/ISA-100.11a-2011) https://www.isa.org/products/ansi-isa-100-11a-2011-wireless-systems-for-industr
- IEC (IEC 62734: 2014) https://webstore.iec.ch/publication/7409&preview=1

In addition to the above, ISA100 Wireless implementation specifications for interoperability can be obtained by joining the ISA100 WCI.

Development Points in Each Functional Block

The points of development in each functional block shown in the above configuration are described below.

Development element	In-house development		Use of commercially available modules	
	Labor required	Details	Labor required	Details
RF circuit design	Large	2.4 GHz IEEE 802.15.4	Zero	No design required
Response to applicable laws and regulations	Large	Certification is needed to meet regulations in each country of use	Small	Some products are supported
Communication stack development	Large	Developed according to ISA100.11a	Zero	Has an authenticated stack
Application development	Medium	Develop elements required for devices	Medium	Develop elements required for devices
Stack certification	Large	Requires stack certification process	Zero	Not required

Table 6.1.1 Number of RF circuits and stacks

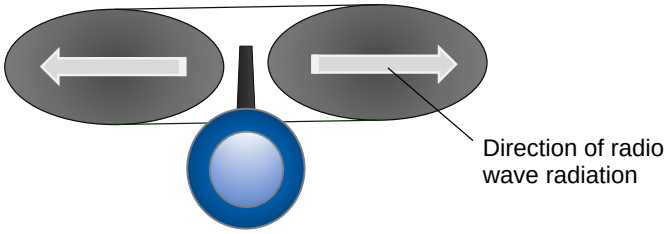
RF circuit and communication protocol stack

The RF (radio frequency) circuitry and communication protocol stack can be developed either in-house or using commercially available ISA100 Wireless modules. The development effort varies depending on which approach is selected, as shown in the table below.

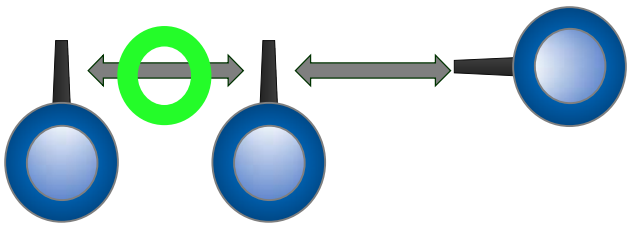
Antenna

Depending on the environment in which the wireless device is used, the antenna should be designed with the following in mind:

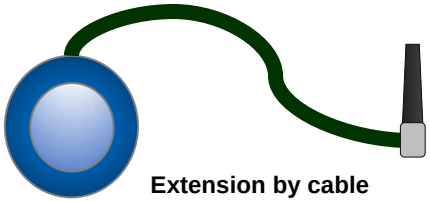
- Directivity: Affects equipment location
- Gain: Communication distance, affecting error rate
- Polarization plane: Consider the polarization plane of the other antenna(s) with which communication will occur
- Structure: Consider environmental resistance (e.g., corrosion, light, temperature, etc.), waterproofing, dustproofing, physical strength, explosion-proofing, etc.



Antenna directivity



Polarization plane of the antenna

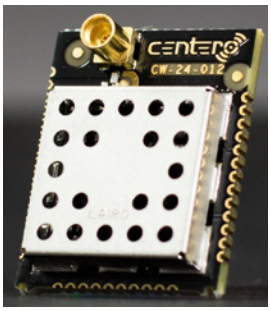


Extension by cable

Figure 6.1.4 Antenna design considerations

ISA100 Wireless Radio Module Examples

Manufactured by CENTERO



Manufactured by Yokogawa Electric Corporation

Figure 6.1.3 ISA100 Wireless modules

Power Supply

Wireless products expand the available options for power supply. In addition to the conventional external power supply, the drive system can be powered by an internal battery, which reduces the cost of wiring work and expands the range of possible installation sites within a factory, such as temporary installation and installation on mobile objects. The features of each power supply are as follows:

- Internal battery: Power supply is supplied by inserting a battery pack into the device
- External power supply (line power): Power supply is externally cabled. Data may still be sent wirelessly
- Energy harvest: The power may be generated from solar power, vibration power, etc.

Power supply		Points for consideration
Battery (example: thionyllithium chloride primary battery)	Battery capacity (mAh) and size	To extend the battery life, it is necessary to install a large-capacity battery. However, depending on the application, consideration of the size may be required.
	Discharge characteristics and detection of remaining capacity	Discharge characteristics differ depending on the type of battery. A function to detect the remaining capacity is required to determine when to replace the battery.
	Replacement method	A safe replacement method may be required depending on the usage environment. (example: explosion-proofing, waterproofing, dust proofing, etc.)

Table 6.1.2 Design points when using an internal battery

Provisioning

Provisioning is the process of configuring an ISA100 Wireless device to connect to a wireless network. The following is an overview of the provisioning of devices and gateways.

Registering to an ISA100 Wireless device

On the ISA100 Wireless device side, the provisioner is used to register the device Tag name (Device Distinguished Name), the Network ID (the identification number of the wireless network to which the device will connect), and the Join Key (used to encrypt and decrypt data transmissions over the air). At the same time, a provisioning file is created for registering with a gateway (with System Manager and Security Manager functions) that is managing the wireless network in which the device participates.

Registering with the gateway

The gateway registers the provisioning file generated by the provisioning ISA100 Wireless device. By registering the provisioning file, the gateway learns which devices are registered to be able to connect with the gateway's network; by sharing a common encryption key (Join Key), encryption, and secure wireless communication are enabled.

Provisioning Interface

ISA100 Wireless devices must have provisioning capability; therefore, an interface for provisioning is required. Different device vendors may implement different provisioning interfaces. Here are two typical provisioning methods:

- OTA (Over the Air)

  OTA provisioning means provisioning over the radio used by ISA100 Wireless. This capability is required by the ISA100.11a standard.

- OOB (Out of Band)

  OOB provisioning means provisioning via an interface other than radio communication. For example, connection by IR (infrared) communication is often used, but it is also possible to prepare and implement a dedicated tool for PC connection other than IR (such as Bluetooth or USB). Under the ISA100.11a standard, OOB is specified as an option. However, compared to the OTA method, OOB provisioning information is not transmitted in a wide range but is transmitted only in a limited area. Therefore, there are many devices on the market that adopt OOB to enhance security.

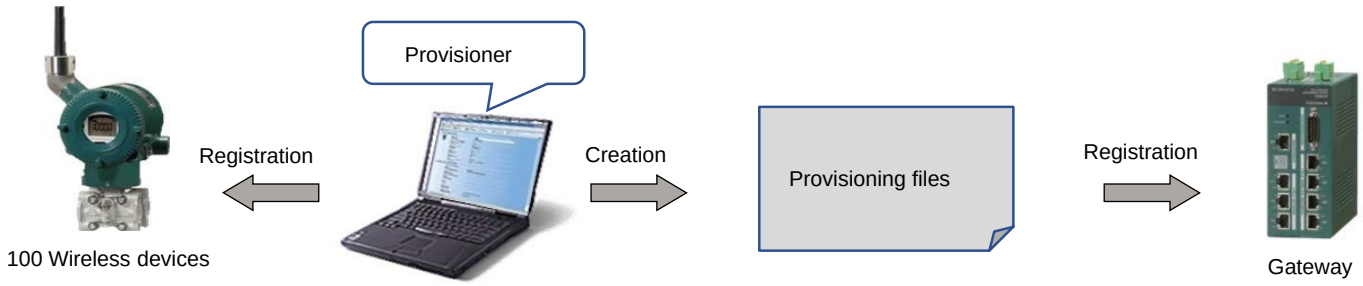


Figure 6.1.5 Registering provisioning information

Figure 6.1.6 Example of OTA provisioning

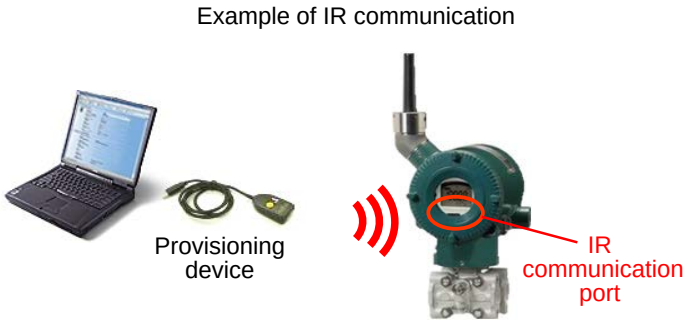


Figure 6.1.7 Example of provisioning with OOB interface

Key Points of Laws, Regulations, and Certification

Laws, regulations, and certification differ depending on the equipment such as sensors and actuators, and it is necessary to prove that devices conform with requirements in the country of manufacture and use. Here are some points common to ISA100 Wireless products.

Radio laws

These laws are designed to ensure the fair and efficient use of radio waves and to regulate such aspects as the establishment of radio stations and the protection of classified information. ISA100 Wireless uses the 2.4 GHz band and requires a visible certification to prove compliance with the standards set forth in such laws. Regulations vary from country to country.

Reference: ***https://www.fcc.gov/engineering-technology/policy-and-rules-division/general/radio-spectrum-allocation***

Export and import

Trade control efforts from a security perspective are being implemented through foreign exchange and trade laws.

Security requirements such as cryptography are often specified in such laws. ISA100 Wireless uses encryption technology, so one must be careful when importing and exporting these products.

Reference: ***https://www.bis.doc.gov/index.php/policy-guidance/encryption***

Battery transport (transport regulations for lithium batteries)

Under transportation laws, the shipper is responsible for all shipments, and the shipper is responsible for safety checks and labeling. One must use caution when using lithium batteries as the device power supply.

ISA100 WCI certification

Acquiring ISA100 WCI certification can demonstrate the proven interoperability of devices with third-party equipment. ISA100 Wireless device certification is divided into stack certification of communication protocols and device certification. See below for details on the ISA100 WCI certification program.

Reference: ***https://isa100wci.org/Supplier-Resources***

6.2: ISA100 Wireless Product Development Kit

ISA100 Wireless Rapid Development Kit (RDK)

ISA100 WCI developed the ISA100 Wireless RDK (Figure 6.2.1) in cooperation with Centero, a WCI member company, to provide a development environment that facilitates the development of ISA100 Wireless compliant products. The RDK aims to reduce the time-to-market for ISA100 Wireless products.

Figure 6.2.1 ISA 100 Wireless RDK

RDK Features

The RDK enables users to enter the world of ISA100 Wireless quickly and easily. The following RDK features shorten the product development period and reduce the effort required to obtain ISA100 WCI certification:

- Equipped with an ISA100 Wireless module that operates in compliance with local radio laws and the ISA100 Wireless certified communications stack. No need to develop wireless communication functions
- Includes application processor source code package
  - Includes training materials and step-by-step instructions to develop an ISA100 Wireless connected field instrument
    - Works right out of the box to enable hardware validation
- Various sensors are mounted on the development board (Figure 6.2.2), and the system functions can be confirmed using the web-based gateway with rich functions (Figure 6.2.3)
- External processors, sensors, etc. are connected via the external connector of the development board and combined with the application source code for the ISA100 Wireless provided development board, making it easy to shift to original device development

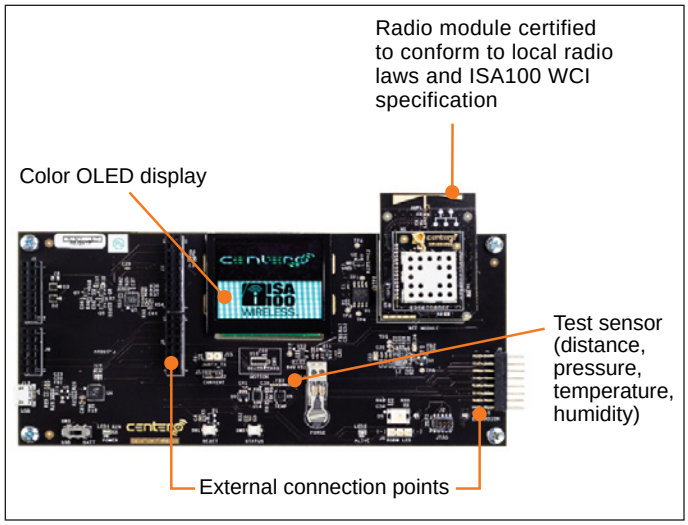


Figure 6.2.2 Development board

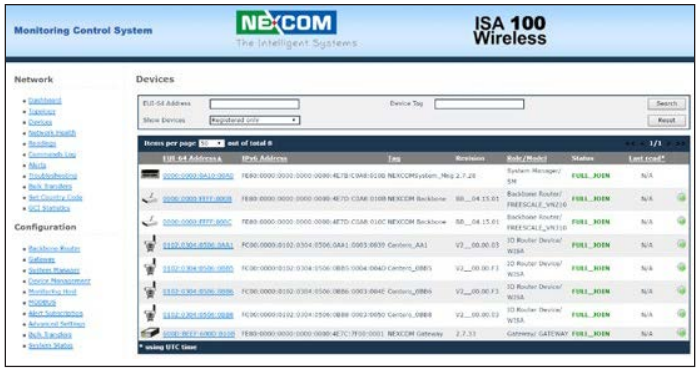


Figure 6.2.3 Gateway sample monitoring screen from a web application

Contact information for the RDK

Centero: https://centerotech.com/contact/
ISA100 WCI: https://isa100wci.org/en-US/Contact

PART 7
ISA100 Wireless Product Briefs

Continued on next page

ISA100 WIRELESS COMPLIANCE INSTITUTE™

PART 7 Continued

ISA100 Wireless Product Briefs

7.1.1: Baker Hughes Energy Japan, Ltd. / Bently Nevada

About Bently Nevada (http://Bently.com)

Bently Nevada is a software, hardware, and services company that partners with world-class industrial customers for asset protection, condition monitoring, and reliability. We are dedicated to asset protection and driving innovation, and we provide industry-leading training to our customers all along the way. Bently Nevada leverages over 60 years of expertise to design, develop, and drive the manufacturing of high-caliber, edge-to-cloud plant-wide hardware and software solutions that enable customer operations to become safer, more dependable, and more productive.

Bently Nevada is a division of Baker Hughes Energy, an energy technology company.

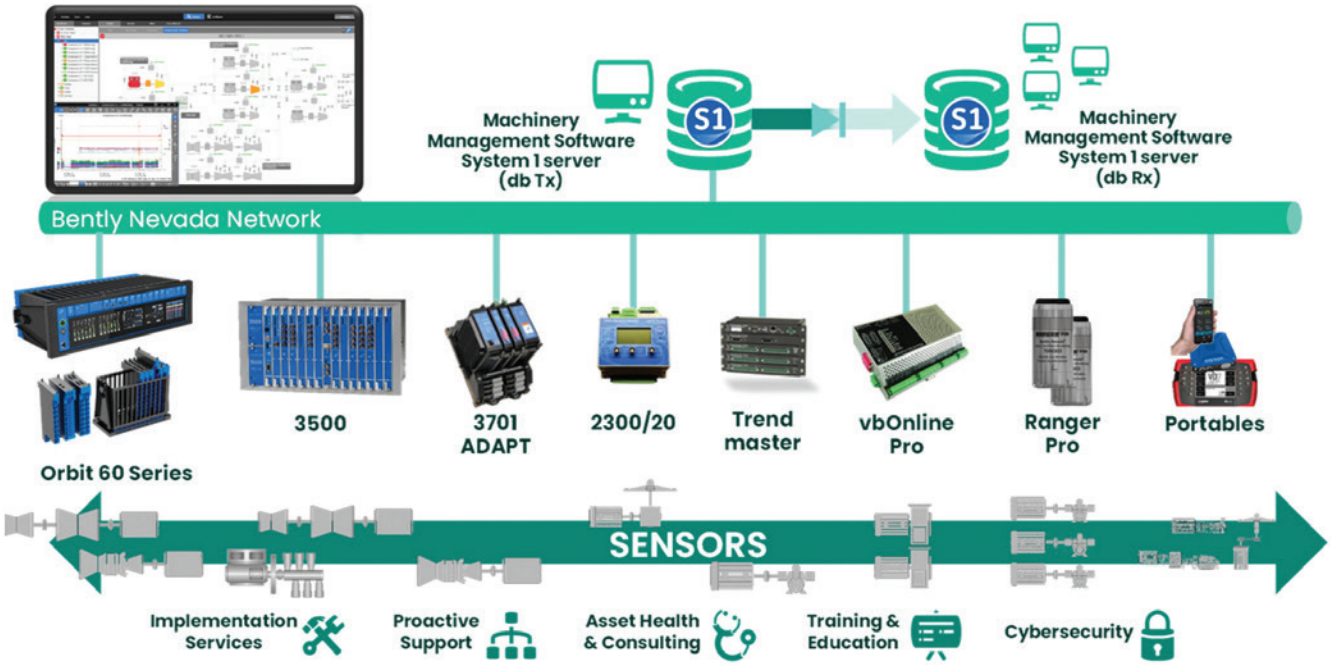
Wireless Condition Monitoring Ranger Pro

The Bently Nevada Ranger Pro vibration solution can reliably collect more data than a portable data collector at a lower cost than a wired solution.

- ATEX/IECEx Zone 0 [ia I/IIC T4] Class 1 Div 1
- Truly wireless: Easy mounting with integrated sensor + transmitter
- IP67 hermetically sealed electronics, ambient temperature: -40C to +85C
- Trended variable: Velocity (5-2 kHz), acceleration (5-10 kHz- Z direction, 5-4 kHz- X, Y direction), PeakDemod acceleration, temperature
- FFT spectrum data for triaxial velocity, triaxial acceleration, Z-axis PeakDemod acceleration
- Ideal condition monitoring for rolling element bearings and gearbox machinery

For more information:

Baker Hughes | Digital Solutions
Contact Us: https://www.bakerhughesds.com/contact



7.1.2: Baker Hughes Energy Japan, Ltd. / Bently Nevada

The Ranger* Pro Condition Monitoring wireless vibration sensor allows the user to monitor velocity, acceleration, and temperature. It is built for plant managers and operators in the power generation, oil, and gas industries and related industrial markets.

The Bently Nevada Ranger* Pro Wireless Condition Monitoring sensor enables the user to:

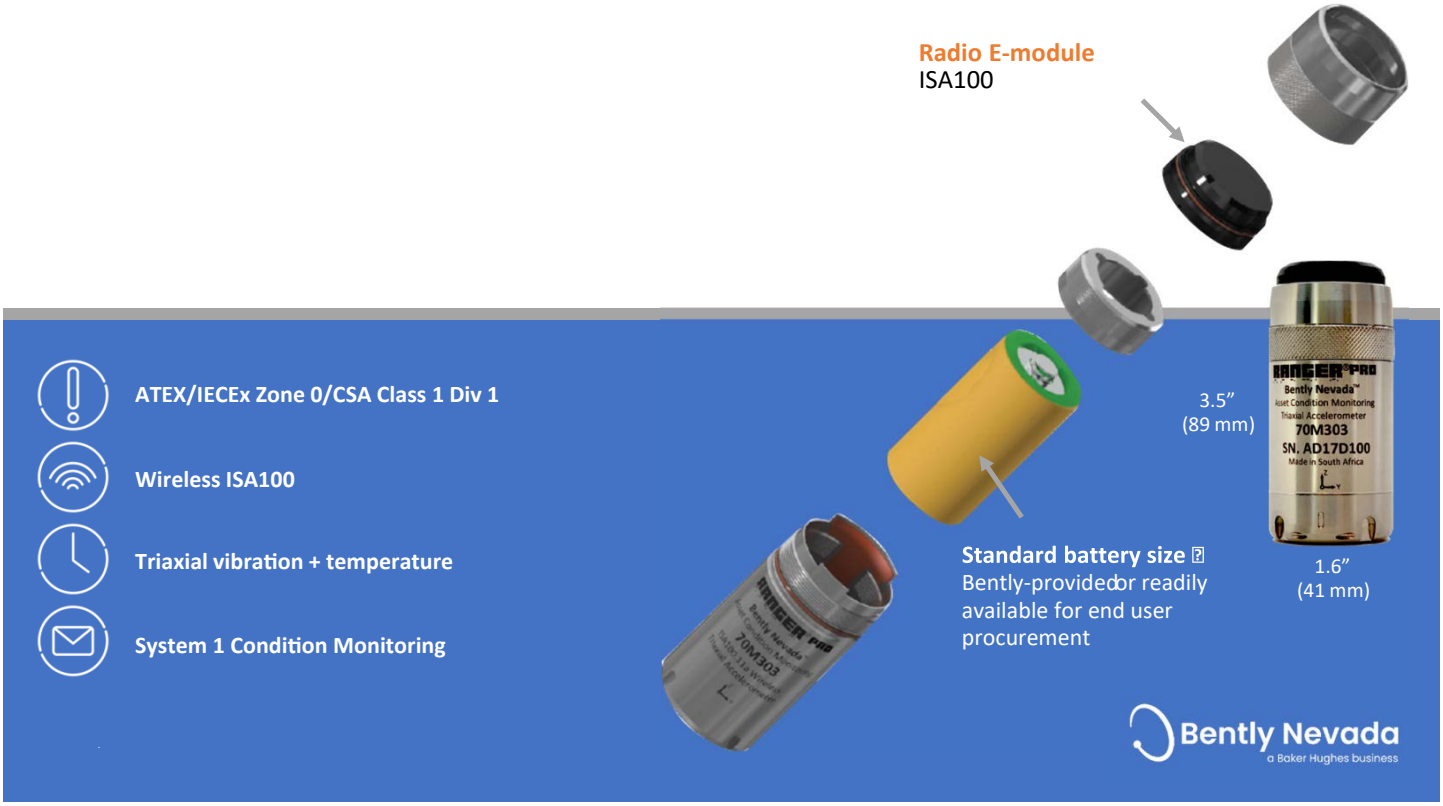
- Monitor and optimize the reliability of low- and medium-criticality machines
- Establish or expand existing reliability programs
- Make maintenance decisions based on current data
- Reduce maintenance costs
- Decrease unplanned machine failures
- Increase machinery life

Ranger* Pro Wireless Condition Monitoring is a simple, easy-to-implement solution for use in hazardous or difficult-to-access environments where wired solutions are impractical.

Use Ranger* Pro Wireless Condition Monitoring to get immediate notifications, short- and long-term trending data, and diagnostic reporting. No more "reporting by walking around." Quickly publish data through OPC Data Access to Bently Nevada System 1 or other third-party tools.

For more information:

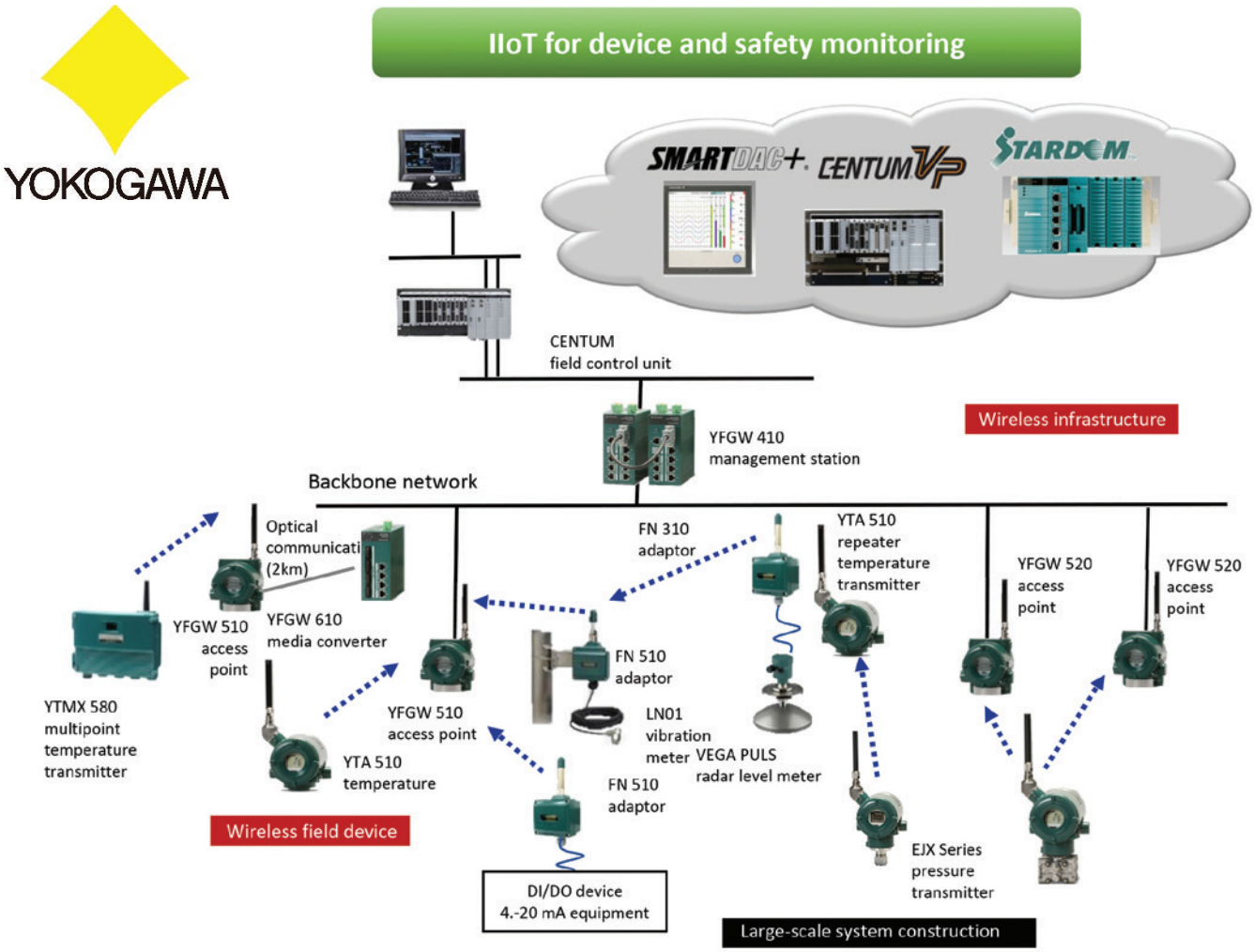
Bently Nevada
Ranger Pro: https://www.bakerhughesds.com/bently-nevada/online-condition-monitoring/ranger-pro-wireless-sensor-system

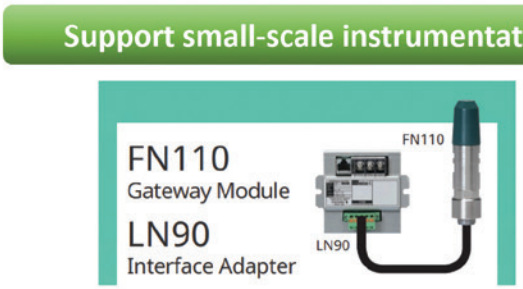


7.2: Yokogawa Electric Corporation

Yokogawa offers an assortment of ISA100 Wireless compliant field wireless products in the area of process automation, addressing various requirements such as wireless network security, reliability, safety, robustness, and real-time operation, functionality, and scalability.

We provide our customers with reliable wireless network infrastructure for a wide range of applications, from small to large scale, from plant operation to maintenance, and from monitoring to control.





FN110 and LN90 are optimized for small-scale instrumentation (less than 20 devices) and allow users to configure wireless infrastructure with few steps. LN90 is an interface adapter connecting a gateway module and a host system.

Product Line and Services

EJX-B series
Wireless Pressure Transmitter

The EJX-B series devices measure differential pressure, absolute pressure, or gauge pressure of liquid, gas, and steam flow, as well as flow and liquid level. The accuracy of these products is the same as wired transmitters. The low power consumption design achieves long battery life. Extension coaxial cables allow flexible antenna installation.

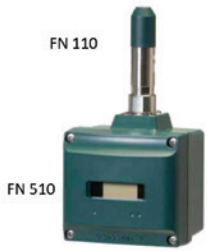
YTMX 580
Multi-Input Temperature Transmitter

YTMX580 can accept up to 8 points of measurement from thermocouples (8 types) or RTD signals (3 types). It can also accept DC voltage, resistance, and 4 to 20 mA DC signal input in non-hazardous locations.

FN 310
Field Wireless Multi-Protocol Module

FN 310-J and FN110 convert a wired device to a wireless device. The built-in batteries power the FN110. The connected wired device can be powered by this module or an external power source. This module supports HART and Modbus protocols. Extension cables allow for flexible FN110 installation.

FN 510
Field Wireless Multi-Function Module



FN510 and FN110 convert a variety of I/O signals to a wireless device. FN 110 Batteries are included to power the FN110. External power may be required for some I/O uses. Extension cables allow for flexible FN110 installation.

FN 110
Gateway Module

This product supports 2 device roles: a field wireless device and a field wireless gateway. When utilizing this device with the FN310 Field Wireless Multi-Protocol Module or the FN510 Field Wireless Multi-Function Module, this product is connectable with a field wireless network as a field wireless device. When utilizing this device with the LN90 Interface Adapter, this product acts as a field wireless gateway.

YFGW 520
Field Wireless Access Point

YFGW520 provides a backbone router function specified in ISA100 Wireless and functions as an access point for field wireless devices. A pair of YFGW510/YFGW520 offers route redundancy without degrading network latency.

YFGW 410
Field Wireless Management Station

YFGW410 manages ISA100 Wireless networks and security and works as a gateway for host applications. A pair of these will form a redundant gateway. The YFGW410 manages up to 20 YFGW520 to support a large system with up to 500 field devices.

For more information:

Yokogawa Electric Corporation
http://www.field-wireless.com/

The product names listed are trademarks of Yokogawa. Product specifications are subject to change without notice for improvement purposes.

7.3: TLV Co., Ltd.

TLV A Steam Specialist Company

TLV was founded in 1950, specializing in steam system products including instrumentation and control equipment. Through developing products and solving steam system problems, TLV continues to provide solutions to improve productivity, energy conservation, and reliability of steam-using plants.

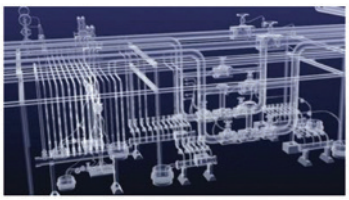
Manufacturing and Sale of Steam System Equipment

We manufacture and sell equipment such as steam traps, steam or air valves, control valves, steam and condensate energy recovery systems, and vacuum steam heating & cooling systems.

Consulting - Engineering - Services

We provide consulting, engineering, and services to solve problems that steam-using plants face, increasing energy efficiency and improving reliability, productivity, and product quality.

Steam System Optimization Program



Issues in the steam system can be indicators of potential problems in the production process. We enable detection of these issues through condition monitoring of the steam system, enabling timely optimization and contributing to the safe and reliable operation of the steam-using plant.

Introduction: iTrapSensor® Monitoring Sensor

The iTrapSensor® wireless monitoring sensor is installed on steam equipment such as steam traps, measuring ultrasound and surface temperature simultaneously. This device incorporates intrinsically safe construction. With this device, steam trap diagnosis can be performed for a global range of steam trap products.

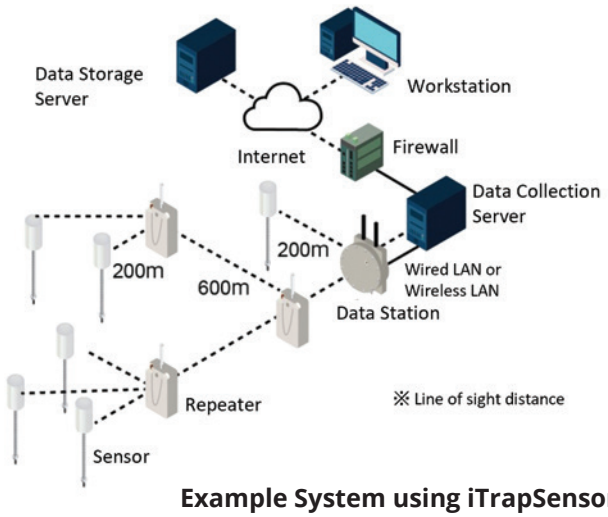
Features

- Measurement of ultrasound and surface temperature or internal pressure and temperature
- Intrinsically safe
- Steam trap diagnosis for a global range of steam trap products
- Wireless system utilizing lithium-thionyl chloride batteries and
- TLV's original power-saving technology to maximize service life (approx. 10 years)

Configurations are available for wireless (2 types) or wired systems. Wireless configurations use the ISA100.11a industrial wireless communication standard or TLV's proprietary wireless communication protocol specialized for steam trap monitoring.

For more information:

TLV Co., Ltd. Technical inquiries:
079-422-8833 https://www.tlv.com



Example System using iTrapSensor®

7.4: Riken Keiki Co., Ltd.

"We are a Pioneer in Creating Safe Working Environments for Workers."

As a specialist manufacturer of industrial gas detectors, Riken Keiki Co., Ltd. develops and supplies products for the prevention of explosions caused by combustible gases and for the monitoring of hazardous gases in the working environment.

Our explosion-proof gas detector SDWL-1 series units comply with the ISA100.11a wireless communication standard. As our solutions can be newly installed in existing wireless fields, we can provide customers with the best solution for safety and disaster prevention control.

SDWL-1RI
(for flammable gas)

SDWL-1EC
(for hydrogen sulfide and carbon monoxide)

SDWL-1OX
(for oxygen)

Fixed type wireless gas detector
Model: SDWL-1 series

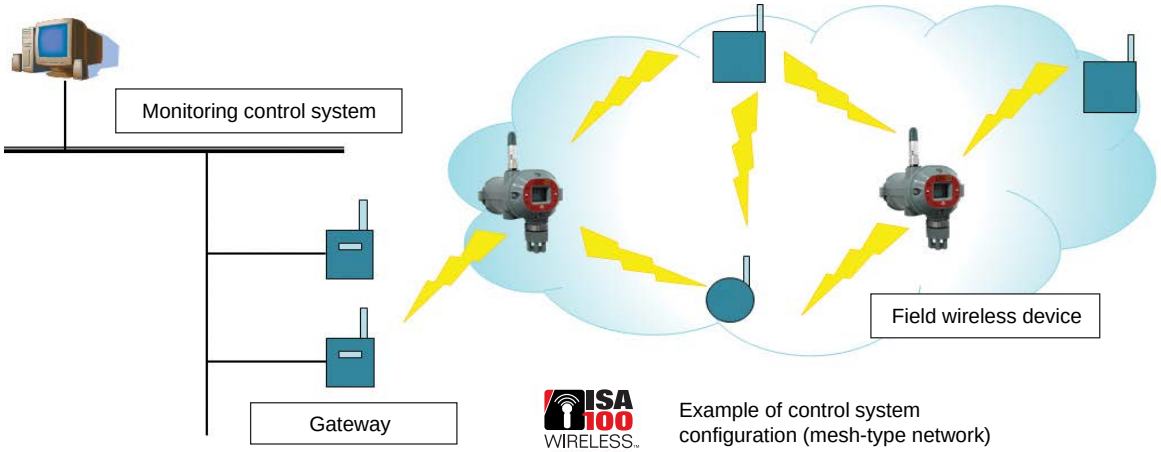
Features

- **Wireless communication functions: Ideal for enhancing safety management on work sites where wiring is difficult** Wireless communication standard: ISA100.11a (IEC62734 compliant) Frequency range: 2400MHz ~ 2483.5MHz Max. communication distance: 600 m
- **Battery pack for stand-alone wireless operation** Battery powered: thionyl chloride lithium battery Continuous operating hours: SDWL-1EC/OX: 2 years SDWL-1RI : 1 year
  *In 25°C environment with no alarm
- **Mounting structure: Flexible installation** Can be installed on horizontal/vertical 50A(2B) poles or on wall using mounting brackets
- **TIIS explosion-proof inspection accepted** Pressure resistance + intrinsically safe explosion-proof construction Ex ia d II C T4 (SDWL-1RI) / intrinsically safe explosion-proof construction Ex ia II C T4 (SDWL-1EC/OX)
  *TIIS: Technology Institution of Industrial Safety

For more information:

RIKEN KEIKI CO., LTD. https://www.rikenkeiki.co.jp/

System example



Example of control system configuration (mesh-type network)

7.5: New Cosmos Electric Co., Ltd.

New Cosmos Electric Co., Ltd. utilizes its unique gas sensor technology to provide a wide range of products, including household gas alarms, industrial stationary gas detectors, portable gas detectors, odor sensors, and other applied products. Moreover, the company provides a wide range of ISA100 wireless products, including KD-100 and 101 series wireless gas detectors, a KD-100M wireless transceiver, and a VCW-100 transportable gas leak monitoring system.

Household gas alarm

Industrial stationary gas detector

Portable gas detector

KD-100 and KD-101 Series Wireless Gas Detectors

The KD-100/101 series devices detect the target gas and transmit gas concentration measurements via radio signal. This range of devices allows various target gas options and power supply type options.

- Various target gas options

KD-100Series	KD-100A	KD-100B	KD-100D	KD-100O	KD-100R
KD-101Series	-	-	KD-101D	KD-101O	KD-101R
Gas to be detected	Flammable gases in ppm	Flammable gases In % LEL	CO, H2S	Oxygen	Methane, propane

- Power supply type can be selected depending on the installation environment:
  - KD-100 series: 24 VDC
  - KD-101 series: Built-in batteries
- Multi-output support: ISA100 Wireless, contact output
- Explosion-proof certified

KD-100M Wireless Transceiver

The KD-100M wireless transceiver is designed to convert a 4-20 mA signal to a radio signal. It is connected to a non- wireless gas detector on-site with a cable. As a result, the non-wireless gas detector effectively becomes wireless.

- Power supply: 24 VDC
- Multi-output support: ISA100 Wireless, contact output
- Explosion-proof certified

VCW-100 Transportable Gas Leak Monitoring System

The VCW-100 unit has a gateway function that can receive radio signals from multiple KD-100 and KD-101 series gas detectors. Moreover, it is equipped with a touch panel that displays gas concentrations, alarm statuses, device errors, etc., a signal tower light, and a buzzer; thus, it can easily establish a temporary small-size gas leak monitoring system onsite for use during maintenance work, etc.

- User interface: Touch panel, signal tower light, buzzer, etc.
- Power supply: 100 VAC

For more information:

New Cosmos Electric Co., Ltd.
http://www.newcosmos-global.com

7.6.1: Armstrong International AIM® AD6000 Acoustic Monitor

Armstrong International, Inc. designs, manufactures, and distributes control systems for steam, air, and hot water utility applications. The Company offers steam trapping and steam tracing equipment, steam system testing and monitoring products, and condensate recovery equipment. Armstrong International markets its products to customers worldwide.

AIM® AD6000 Acoustic Monitor

Armstrong Intelligent Monitoring Model AD6000 is a wireless monitoring technology that efficiently monitors and evaluates valves. The AIM® AD6000 identifies the conditions of a valve to determine significant problems that could put your operation at risk. It can accurately detect potential issues with Safety Relief Valves and other types of process equipment, which can cause safety and environment concerns as well as potential regulatory compliance issues and fines. Immediate failure notification from the AIM® AD6000 helps identify the root cause while minimizing production losses and reducing potentially harmful emissions. Using non-intrusive technology combined with ISA100 Wireless, the AIM® AD6000 is the ideal solution for any temporary or permanent 24/7 valve monitoring.

Theory of Operation

The AIM® AD6000 transmitter is designed to continuously monitor any type of valve. It utilizes a combination of hardware and integrated algorithms to measure acoustic emissions from the valve. The hardware consists of an acoustic sensor (Piezo) and a temperature sensor (Thermistor). When applied to a valve, the device will wirelessly transmit a measurement of ultrasonic sound emissions from the valve indicating flow. The AIM® AD6000 is mounted onto the outlet pipe of the valve by an Armstrong designed waveguide.

The AD6000 has built-in algorithms to determine the behavior of the valve.

- Channel 9 = 0-255 value of the level of sound detected by the monitor.
- Channel 10 = The temperature detected at the tip of the stem of the monitor.
- Channel 11 = Number of occurrences where the level exceeds a defined threshold (with reset).
- Channel 12 = Calculate the total time that a lift is detected between resets (in minutes).
- 100+ NAMUR NE107 diagnostics available.

Specifications	
Protection Rating	IP66
Ambient Temperature	-40°F to 158°F (-40°C to 70°C)
Min. Operating Pressure	15psig (1barg)
Max. Process Temperature	824°F (440°C)*
Battery Type	Epoxy Lithium-metal Battery Pack
Pipe Diameter	½" to 12"
Weight (without waveguide)	4.1lbs (1.9kg)

*** See IOM, not derated on ambient temperature using specific installation kit**

For more information:

Armstrong International AIM® AD6000 Acoustic Monitor www.armstronginternational.com

7.6.2: Armstrong International AIM® ST6700 Steam Trap Monitor

Armstrong International, Inc. designs, manufactures, and distributes control systems for steam, air, and hot water utility applications. The Company offers steam trapping and steam tracing equipment, steam system testing and monitoring products, and condensate recovery equipment. Armstrong International markets its products to customers worldwide.

AIM® ST6700 Steam Trap Monitor

Armstrong Intelligent Monitoring Model ST6700 is a wireless monitoring technology that efficiently monitors and evaluates steam trap operation. The AIM® ST6700 identifies the conditions of a steam trap to determine significant problems that could put your operation at risk. It can accurately detect potential issues such as plugged and blow-through steam traps, which can cause a range of issues including, but not limited to, failed equipment, loss of product, and safety concerns. Immediate failure notification from the AIM® ST6700 helps identify the root cause while minimizing production losses and reducing energy consumption. Using non-intrusive technology combined with ISA100, the AIM® ST6700 is the ideal solution for any temporary or permanent 24/7 steam trap monitoring.

Specifications	
Protection Rating	IP66
Ambient Temperature	-40°F to 158°F (-40°C to 70°C)
Min. Operating Pressure	15psig (1barg)
Max. Process Temperature	824°F (440°C)*
Battery Type	Epoxy Lithium-metal Battery Pack
Pipe Diameter	½" to 6"
Weight (without waveguide)	4.1lbs (1.9kg)

*** See IOM, not derated on ambient temperature using specific installation kit**

Theory of Operation

The AIM® ST6700 transmitter is designed to monitor continuously any type of steam trap. It utilizes a combination of hardware and integrated algorithms to detect steam trap conditions accurately. The hardware consists of an acoustic sensor (Piezo) and a temperature sensor (Thermistor). The integrated algorithms are patented, proprietary code developed by Armstrong to provide actual steam trap conditions based on inputs from the hardware. When applied to a steam trap, the device will display and/or wirelessly transmit the current condition of the steam trap. The device is mounted onto the inlet pipe of the steam trap by an Armstrong-designed waveguide.

The ST6700 has built-in algorithms that perform a series of diagnostic checks to determine the condition of the steam trap:

- Channel 9 = Steam Trap Condition: 1=OK, 2=COLD, 3=BLOW-THRU
- Channel 10 = Current Temperature (°C or °F)
- Channel 11 = Temperature Setting (°C or °F)
- 100+ NAMUR NE107 diagnostics available.

For more information:

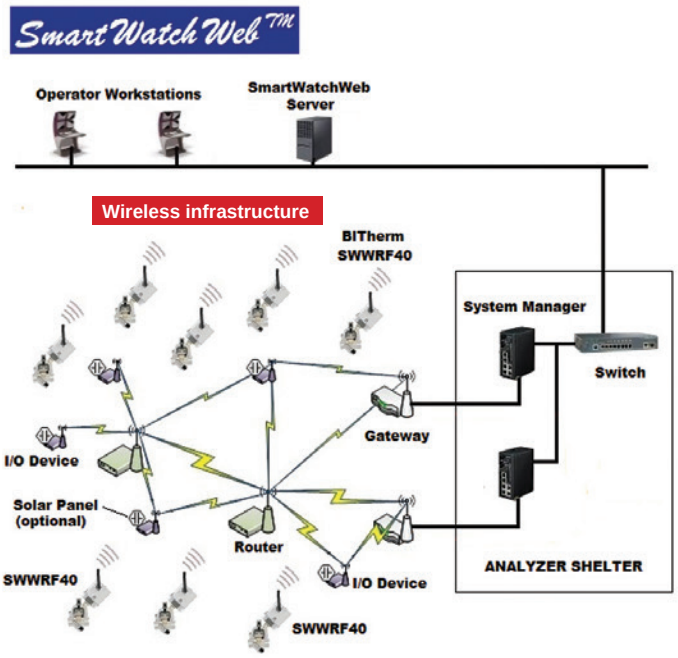
Armstrong International, Inc.
www.armstronginternational.com

7.7: BiTherm

BiTherm offers tremendous experience in wireless monitoring (ISA100.11a standard) of steam traps and safety valves, with more than 60 success stories in refineries over more than 20 years. We provide our clients with highly-reliable and scalable monitoring systems, from small to large scale. Our patented monitoring system SmartWatchWeb™ has won multiple prestigious international awards (https://www.bitherm.com).

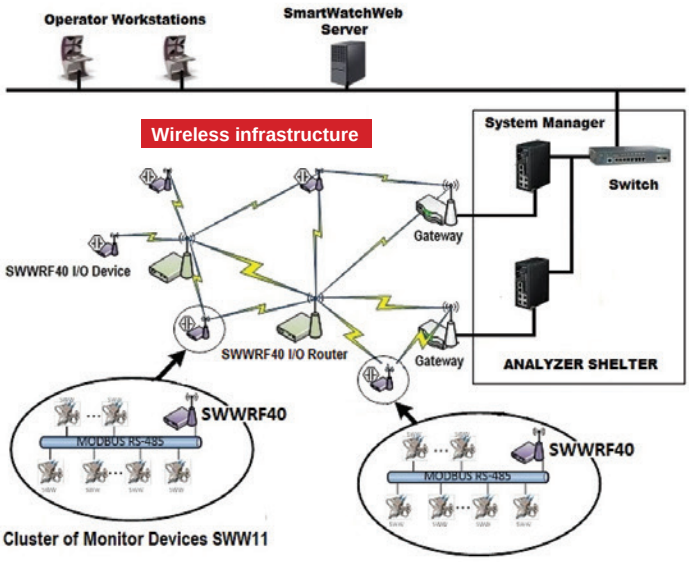
The BiTherm SWWRF40 transmitter and sensor can be powered by battery or rechargeable battery with small solar panels. In addition, it has the following advantages:

- Wireless networks can be built in a brief period of time with minimal configuration
- Easily build monitoring systems
- Housing made of stainless steel AISI 316L.
- Housing with integral fin radiator



Steam traps with BiThrem wireless transmitter & sensor SWWRF40

Example of large-scale system



Cluster of Monitor Devices SWW11 with a common wireless transmitter SWWRF40

Example of small-scale wireless system

Lineup and Services

SWWRF40

ISA100.11a Compliant Wireless Transmitter and Router

Wireless transmitter and router compatible with wireless gateway Nivis 900/950.

Options:

- SWWRF40.10 powered by battery 3.6V lithium battery
- SWWRF40.11 powered by intrinsically safe solar charger SCHLP1X
- SWWRF40.12 powered by intrinsically safe power source FS10.1X Ex certification: Ex ia IIC T4 Ga, -20 < Ta < 70 ºC

Enclosure: IP67 made of cast aluminum or stainless steel AISI 316L

SWWRF40 can manage input signals from a cluster up to 20 field units SWW11/12

It helps to reduce up to 20 times the costs of wireless network deployment and maintenance.

SWWRF41

ISA100.11a Compliant Wireless Field Unit (sensors) and Transmitter

Wireless transmitter compatible with Yokogawa infrastructure ISA100.11a standard, powered by battery (3.6V Lithium-thionyl chloride Li-SOCl2).

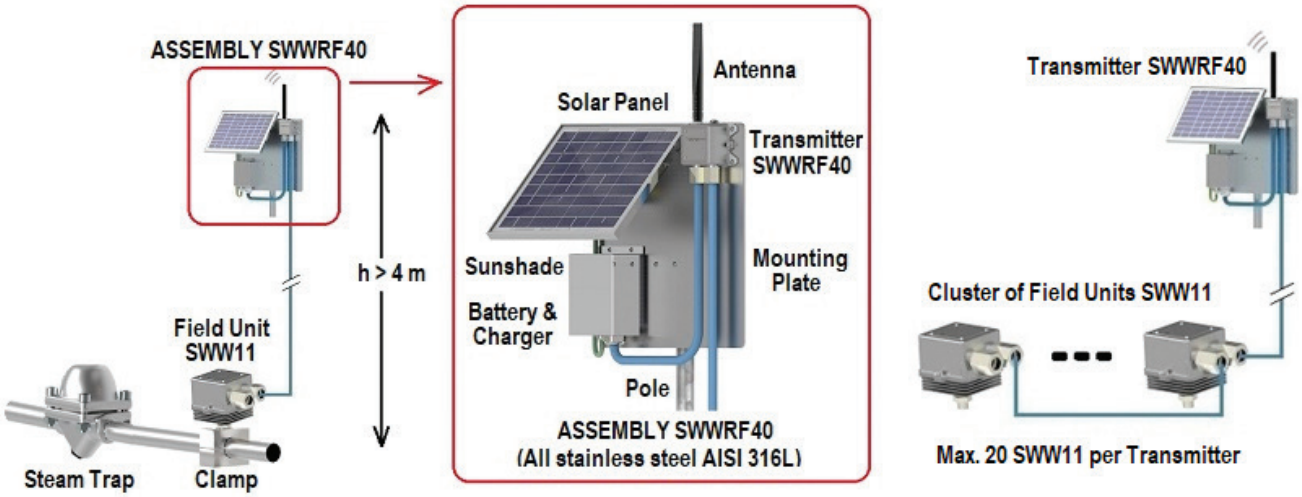
Ex certification: Ex ia IIC T4 Ga, -20 < Ta < 80 ºC

Enclosure: IP67 made of cast aluminum or stainless steel AISI 316L

For more information:

BiTherm
https://www.bitherm.com

The product names listed are trademarks and registered trademarks of BiTherm.

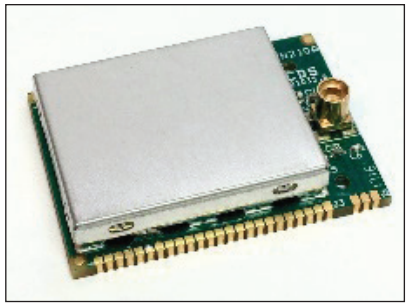


Example of SWWRF40 with a cluster of field units (ultrasound & temperature sensors) SWW11/12

7.8: Control Data Systems SRL (CDS)

Control Data Systems SRL (CDS) is a developer of wireless products and technologies for industrial applications in areas such as aerospace, oil & gas, and environmental monitoring. The company focuses on developing standards-based components, such as ISA100 Wireless radio modems and wireless gateways that bring industrial wireless sensor networks into the Internet of Things. The radio modems and wireless gateways designed by CDS adhere to the standards and regulations required by the main industrialized regions of the world in terms of safety and electromagnetic compatibility.

VN210 ISA100 Radio Modem



Designed for ATEX Zone 2 and C1D2 non-incendive environments, the VN210 offers a full API for easy integration into sensing field devices. From temperature sensors to gas monitors, the VN210 helps organizations unlock vital information about their operating environment. Leveraging AES 128-bit security, the VN210 is a low-power, 10dBm, 2.4GHz radio frequency transceiver with a 32-bit ARM7 core-based MCU. The VN210 is also FCC, IC, R&TTE, and Giteki approved.

- 3VDC nominal
- Operating frequency 2.4 GHz
- Operating temperature -40 to +85C
- Modulation O-QPSK
- Raw data rate 250 kbps
- Output power 9 to 12 dBm
- Sensitivity -98 dBm

VR950 Wireless Gateway

The VR950 is a wireless network controller, or gateway, designed for mission-critical industrial applications in the oil & gas, mining, and manufacturing sectors where safety, security, and reliability are necessary. The VR950 is an all-in-one, dual-standard infrastructure device architected to manage ISA100 networks. It contains all the necessary components for network management and comes with advanced features such as redundancy and network collocation. The VR950 Gateway runs a Linux operating system and can be configured via a web application or a command line interface. For connectivity to the backend systems, there is 1 GB Ethernet port available. Optionally, a 3G/4G modem or Low Earth Orbit satellite modem can be installed. The interface for accessing the data from the network devices can be Modbus TCP, GCI, or OPC-UA (under development). Custom applications for local data pre-processing can run in a sandbox accessible via an API that provides access to the connectivity and data storage functions.

- Voltage ranges from 20 to 27 VDC
- TI SITARA AM5728
- RAM DDR3 2GB
- Flash 4GB
- VN210 Backbone Router included

For more information:

Control Data Systems SRL (CDS)
http://www.cds.ro

7.9.1: Centero Rapid Development Kit (RDK)

Centero is a provider of wireless technologies, products, and services for Internet of Things connectivity. Our offering includes end-to-end, standards-based communication platforms that can be swiftly integrated into novel or existing products or systems. Our target markets include industrial process automation, smart grid metering and distribution, commercial lighting and building automation, home automation, and connected healthcare.

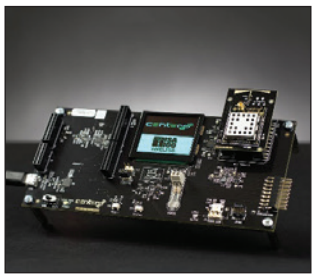
The Rapid Development Kit (RDK) includes everything needed to develop ISA100 Wireless certified field instruments with minimal development effort. It is a comprehensive, user-friendly, end-to-end development platform that includes pre- configured and fully integrated hardware, firmware, and software components. It also includes training materials and step-by-step instructions to develop an ISA100 Wireless connected field instrument. The ISA100 Wireless Industrial IoT standard (ISA100.11a and IEC 62734) meets the rigorous requirements for field instruments and infrastructure devices engaged in process automation, including monitoring and control.

Product Highlights

- Develop ISA100 Wireless (IEC 62734) compliant and certifiable field instruments with minimal effort using application layer code provided
- Includes reference hardware design for ISA100 Wireless (IEC 62734) field instrument implementation
- WISA wireless modules included run ISA100 Wireless certified communication stack
- Gateway boasts feature rich web-based Network Operation and Management System
- User friendly SPiN development board includes OLED display and a large variety of sensors
- Connect external processors, sensors, or actuators via Arduino and Freedom form factor connector
- All firmware and software components are remotely upgradeable
- Supports BLE provisioning

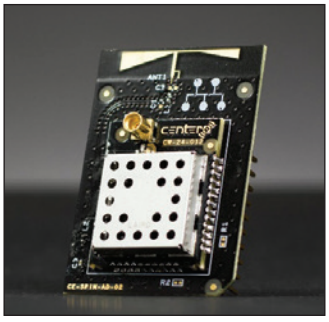
Development Kit Components

SPiN Development Board



- ISA100 Wireless roles: Router and/or I/O device
- Includes WISA wireless modules that run ISA100 communication stack
- Hosts application processor Arduino board that runs ISA100 application layer firmware
- On-board sensors: Temperature, humidity, LIDAR range and motion, tactile/force, and RGB LED
- Connect other sensors, processors, or actuators via Arduino or Freedom form factor connector
- Graphic OLED display for local notifications
- USB, DC, or battery powered
- Quantity included: 2
- Add more SPiN development boards via expansion pack

X-Mikrobus WISA Adapter



- Hosts WISA surface mountable wireless module
- Compliant with Mikrobus form factor
- Exposes all WISA module communication ports and pins
- Suitable for inclusion in designs where module needs to be easily removed or replaced
- Hosts high-performance PCB Bow-tie antenna
- Quantity included: 2
- Add more X-Mikrobus adapters via expansion pack

NIO200 RDK Gateway

- ISA100 Wireless compliant Network/Security Manager, Gateway, and Access Point
- Supports data traffic with strict latency requirements
- Hosts intuitive web-based interface for:
  - Process data monitoring/control
  - Device management and configuration
  - Network topology and health status
- Over-the-air upgrades of all platform components
- MODBUS server and intuitive process value mapping
- IPv4/IPv6 routing
- Quantity included: 1

Target Vertical Markets and Applications

The WISA development platform and its components have been architected, designed, hardened, and tailored to meet the requirements for a wide variety of products in several markets and verticals:

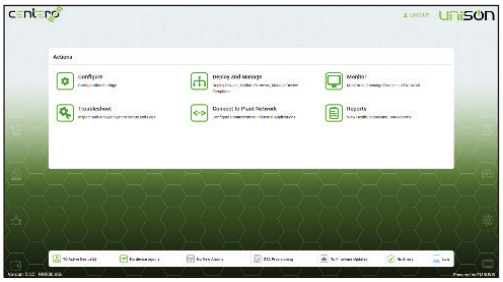
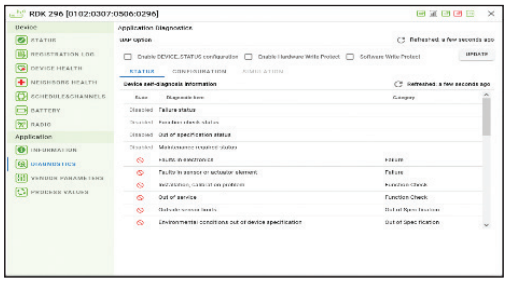
- Process automation and control
- Oil and gas
- Offshore platforms and maritime applications
- Mining
- Petrochemical plants
- Paper and pulp

For more information:

Centero
https://centerotech.com/product/wci-isa100-rapid-development-kit/

7.9.2: Centero UNISON™ ISA100 Wireless Gateway and Backbone Router



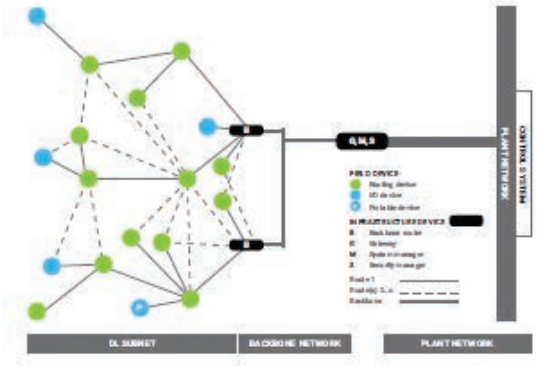
UNISON™ is a re-imagined, user-friendly approach to IIoT connectivity in process automation. It is a new generation of ISA100 Wireless infrastructure products that combines ISA100 Wireless and WiFi Mesh+ connectivity and security. Combining ISA100 Wireless and WiFi Mesh+ allows for full process transparency by bridging the IT and OT domains for a comprehensive, end-to-end digital transformation.

The UNISON Monitoring and Control application is a suite of apps modeled after a field instrument's life cycle. It provides clear functional segregation between the deployment, configuration, and routine monitoring/management phases of the field instrument's life cycle. Clear functional segregation that follows the device life cycle combined with user-friendly, intuitive interfaces results in minimal personnel training needed.

UNISON IAG is an all-in-one ISA100 Wireless (IEC62734)-compliant System and Security Manager, Gateway, and Backbone Router. UNISON IDR is an ISA100 Wireless-compliant Backbone Router that allows for larger-scale distributed network topologies that cover larger geographical areas.

ISA100 Wireless compliance allows UNISON to establish full mesh field network topologies to ensure robust and reliable communication for mission-critical industrial wireless applications. The integration of both WiFi Mesh+ and ISA100 Wireless technologies allows for the formation of a fully redundant, mesh-powered infrastructure for both the field network (ISA100 Wireless) and the backbone infrastructure (WiFi Mesh+). It is CID2 and ATEX-compliant for deployment in hazardous environments and is a perfect solution for critical data monitoring and control in process automation verticals. All software and firmware components are remotely upgradeable.

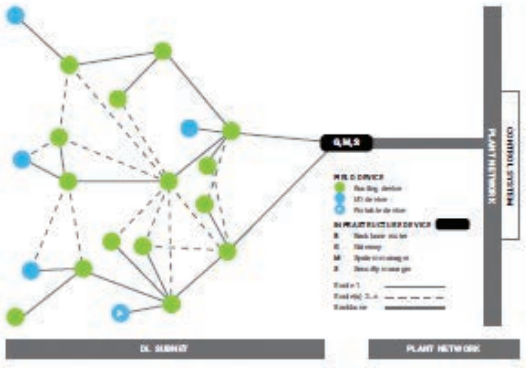
- Scalability: Supports up to 200 ISA100 Wireless field instruments distributed in up to 20 subnets
- Process data publish rates supported: 1, 5, 10, 20, 30, and 60 seconds
- High throughput WiFi Mesh+ backbone infrastructure connectivity
- Hosts intuitive web-based interface for process data monitoring and device management (network topology, device health, diagnostics)
- High throughput and mobility for simultaneous data, audio, and video surveillance transmission
- Over-the-Air provisioning with enhanced security mechanisms
- DD/CF file parsing including all ISA100 Wireless native objects and WCI extensions
- Suitable for deployments in hazardous locations



MULTIPLE SUBNET "DISTRIBUTED" DEPLOYMENT TOPOLOGY

Key Characteristics:

- Multiple subnets connected via IPv6 enabled backbone networking infrastructure
- Complex network
- Typically consists of hundreds of field instruments
- Instruments deployed are scattered throughout the facility



SINGLE SUBNET "ALL-IN-ONE" DEPLOYMENT TOPOLOGY

Key Characteristics:

- Single subnet - no backbone networking infrastructure
- Simple network
- Typically consists of less than 100 field instruments
- Instruments deployed are typically in close proximity to each other

- C1D2 or ATEX
  - UL: Class I, Division 2, Groups A, B, C, D and T4
  - ATEX: Class I, Zone 2; EX nA II, T2
- Supports both monitoring and control for mission critical application
- Supports data traffic with strict latency requirements
- Plant network interfaces: MODBUS, GCCI, OPC UA, Profinet/PROFIsaf
- Power redundancy (DC and PoE)

Target Vertical Markets and Applications

- Process automation
- Oil and gas + petrochemical
- Condition monitoring and predictive maintenance
- Safety – gas monitoring
- Factory automation
- Power distribution automation

For more information:

UNISON IAG:
https://centerotech.com/product/nio200iag-isa100-wireless-all-in-one-gateway/

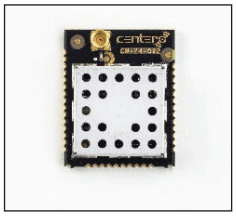
UNISON IDR:
https://centerotech.com/product/nio200idr-isa100-wireless-backbone-router/

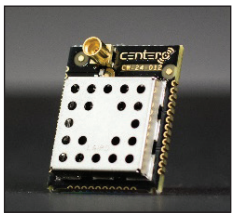
7.9.3: Centero WISA ISA100 Wireless Module

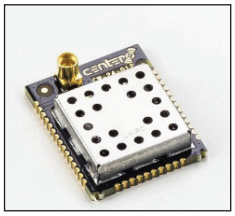
The WISA ISA100 Wireless certified module is designed for swift hardware and firmware integration within process automation field instruments or adapters. The ISA100 Wireless standard (ISA100.11a and IEC62734) was architected for field instruments and infrastructure devices engaged in process automation and control. High data communication reliability is ensured through frequency hopping, time diversity, and path redundancy (mesh), which are integral parts of the standard. It is highly secure, being based on a two-layered security construct that includes AES-128 encryption as well as advanced authentication schemes. Build your ISA100 Wireless compliant field instrument without the need of an in-depth understanding of novel and complex IoT technologies. The communication stack and wireless module is configurable and accessible via a feature rich API. Various low- power operation modes ensure extended product battery life. The ISA100 communication stack can be configured to fulfill various roles such as router or I/O device.

Empower your Product with ISA100 Wireless Mesh Connectivity and Security

- Runs an ISA100 Wireless certified communication stack
- Swift integration within products with a minimal learning curve for complex IoT technologies
- Designed for integration in intrinsically safe and explosion-proof field instruments
- Market leading sensitivity of -108 dBm and link budget of 122 dB
- Onboard RF front-end module with an adjustable output power of up to +14 dBm and selectable RX gain modes





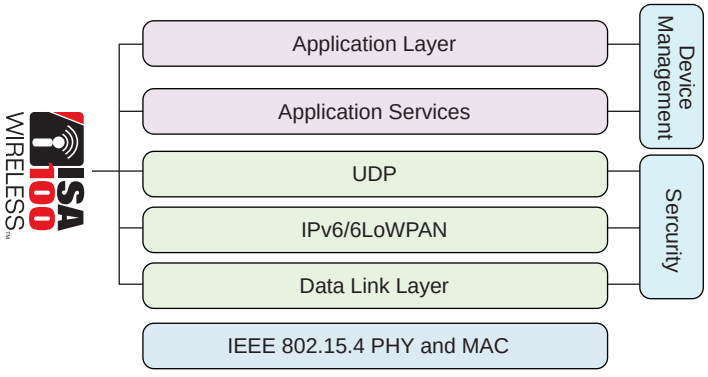


- Tested for interoperability with Centero's NIO200, Honeywell's WDM, and Yokogawa's YFGW710 gateways
- Supports remote OTA (Over-the-Air) and wired serial communication stack upgrades
- Suitable for real estate-constrained products
- Minimal power consumption adaptive to desired wireless communication range

Target Vertical Markets and Applications

The WISA module can be deployed in any Industrial IoT project, large or small. The ISA100 Wireless compliant and certified stack along with the module's size makes the WISA module a viable solution for your connected field instruments and products.

- Process automation
- Oil and gas
- Condition monitoring
- Safety – gas monitoring
- Predictive maintenance
- Petrochemical
- Factory automation
- Power distribution automation



For more information:

Centero
https://centerotech.com/product/wisa-isa100-wireless-module/

7.10: GasSecure / Dräger

GasSecure – now part of Dräger – was established in 2008 to develop the world's first wireless infrared hydrocarbon gas detector. Since then, GasSecure and Dräger have extended their portfolio to include wireless detection of more than 100 toxic gases and oxygen. All our applications are about protecting life. Therefore, our customers must be able to depend on the quality and reliability of our equipment at all times. High quality in design and performance is at the core of our business. Our products are built to live up to the most rigorous standards in the industry.

Gs01 Detector For Flammable Gases And Vapors

The GS01 is a wireless infrared gas transmitter for continuous monitoring of flammable hydrocarbon gases and vapors in the oil and gas industry. The intrinsically safe and SIL-rated transmitter features completely wireless signal transmission and power supply. Infrared sensor technology is taken to the next level using proprietary MEMS (Micro Electromechanical System) optical filters. MEMS is very long-term stable and eliminates the need for re-calibration, which directly reduces the maintenance costs.

- Performance: 5 sec response time
- Battery lifetime: Up to 2 years (depending on operating conditions)
- Operating temperature: -30 C to +55 C (up to +65 C on request)
- Humidity: 0 to 100 % RH
- Protection Class: IP66 and IP67
- Approvals: ATEX, IECEx, FM, EN/IEC 60079-29-1 certified, Safety Integrity Level SIL2 (IEC 61508, Ed.2.0)

Dräger Polytron® 6100 EC WL

The Dräger Polytron 6100 EC WL is a wireless transmitter for continuous monitoring of toxic gases and oxygen. The intrinsically safe design of the Wireless Gas Detector allows all maintenance work, such as battery replacement or sensor replacement, to be conducted even in hazardous areas. The Polytron 6100 EC WL uses the proven Dräger sensors optimized for industrial applications. They cover a spectrum of 140 different sample gases in a temperature range of up to -40 C to +65 C.

- Battery lifetime: Up to 24 months (depending on operating conditions)
- Operating temperature: -40 C to +65 C
- Humidity: 0 to 100 % RH non-condensing
- Protection Class: IP66 and IP67
- Approvals: ATEX, IECEx, UL, CSA, Safety Integrity Level SIL2

For more information:

Gas Secure / Drager www.gassecure.com and www.draeger.com

7.11: Metal Samples

Metal Samples offers battery-powered, intrinsically safe, wireless corrosion monitoring transmitters capable of measuring and transmitting data from all types of electrical resistance corrosion probes. The instruments are microprocessor-based and feature an intuitive menu-driven interface.

Corrosion rate measurements are made using a high-resolution electrical resistance method, measuring up to 65,535 probe units. The instruments measure the resistance of the probe element, which changes over time as metal loss occurs. The rate of change is directly proportional to the corrosion rate. This method has a wide variety of applications since it can be used in conductive and nonconductive environments such as petroleum, chemical, water, soil, or even the atmosphere.

The MS5000E-ISA and MS5500E-ISA wireless corrosion monitoring transmitters take probe readings on a user-programmable interval. Readings are then transmitted wirelessly using the ISA100 protocol. Between readings, the instruments remain in a "sleep" mode to conserve main battery power. The instruments are supplied with a lithium battery pack that has a standard life of 3 years under normal working conditions and is certified to be replaceable in hazardous locations.

The instruments are housed in a stainless steel NEMA 4X / IP 66 enclosure and all external connections are weatherproof. This makes them suitable for use in almost any indoor or outdoor environment. The instruments support star or mesh network topology with a wireless range of 450 meters with clear line of sight to another instrument or gateway.

These wireless transmitters can be seamlessly integrated into existing or new process networks using equipment from Honeywell, Yokogawa, CDS, etc. The easily configurable Metal Samples gateway (sold separately) helps to interface Metal Samples wireless transmitters to the process automation host system and improves connection scalability. The gateway can be directly interfaced to PAC/DCS systems through a MODBUS/OPC interface.

Communication

ISA100 Wireless Protocol
Range: 450 Meters (Line of Sight)
Network Type: Star or Mesh

For more information:

Metal Samples http://www.metalsamples.com

MS5000E-ISA Corrosion Monitoring Transmitter

MS5500E-ISA Corrosion Monitoring Transmitter

7.12: Spirax Sarco

Spirax Sarco is the world leader in steam system management. The company provides a broad range of fluid control products, engineered packages, systems expertise, and site services for its diverse range of over 100,000 industrial and institutional customers. Spirax Sarco helps its customers to optimize production capacity, reduce energy costs and emissions, improve product quality, and enhance the safety of their operations.

The STAPS ISA100 Wireless steam trap monitoring device has been designed to monitor and evaluate steam trap operation efficiently. It can diagnose both failed-open steam traps that leak live steam and those that have failed—closed or are blocked, resulting in waterlogging, leading to plant damage, product spoilage and health and safety concerns.

The Benefits of Wireless Steam Srap Monitoring

- Enables previously inaccessible parts of a plant to be monitored, for example, high-level pipe racks
- Saves time on maintenance, as the condition of a trap can be checked remotely
- Provides accurate steam loss data
- Prevents costly downtime and loss in production by identifying traps that need to be replaced
- As the plant grows, the wireless network can be expanded
- Meets the ISA100.11a standards on connectivity and security
- Accurate and rapid leak detection—no need for manual inspection, saving time and money
- Lower installation costs than a wired solution
- Long-life battery—trap requires little maintenance.
- ATEX & IECeX certified for use in explosive environments

Sizes And Pipe Connections

The STAPS wireless monitoring system is suitable for connecting to pipework up to 100 mm (4”), via an adjustable clamp.

Materials	
Head casing	Epoxy-coated copper-free aluminum (less than 0.4% copper)
Sensor housing	Stainless steel 316
Sensor	PZT
Clamp	Stainless steel 316
Winged nut	Stainless steel 316
Probe	Stainless steel
Antenna	Stainless steel 316
Antenna casing	ABS
'O' ring	Oil proof TPE rubber

For more information:

Spirax Sarco www.spiraxsarco.com
https://www.natural-technology.com/en/

Appendices: Information

Appendix 1 Glossary

Appendix 2 References and Citations

ISA 100 WIRELESS COMPLIANCE INSTITUTE™

Appendix 1: Glossary 1/3

PART 1

Internet of Things (IoT)
Abbreviation of Internet of Things. Products such as cars, home appliances, robots, facilities, etc., are connected to the Internet and exchange information. In doing so, products can share data and achieve automation, creating new added value.

Digital Transformation (DX)
A generic term referring to measures taken to reduce costs by developing new services and business models along with the evolution of IT, leading to work reform and social reform.

Augmented Reality (AR)
A technology that displays digital information superimposed on a real scene. For example, in a construction site, the situation of the building during or after the renovation can be confirmed on the spot through a visual representation.

Virtual Reality (VR)
A virtual space that does not actually exist but can be perceived as existing by humans, or a hardware/software technology that creates such a virtual space.

Machine Learning
A technology that improves a computer's ability to learn rules and knowledge from a data set and perform tasks.

Sensor Network
A network in which sensors embedded throughout a room, factory, or road detect the surrounding environment and feed that information back to the user or control device.

ISA100.11a
An industrial wireless network standard developed by the International Society of Automation (ISA). Its official name is "Wireless Systems for Industrial Automation: Process Control and Related Applications." It was adopted as IEC 62734 in 2014 and approved as an IEC international standardization standard.

Low Power Wide Area (LPWA)
A generic term for wireless communication technologies characterized by low power consumption, low bit rate, and wide area coverage.

Wireless LAN
A local area network (LAN) that is built over the air. Such communication systems include IEEE 802.11 b (up to Transmission speed 11 Mbps) using the 2.4 GHz band and IEEE 802.11 a (up to Transmission speed 54 Mbps) using the 5.2 GHz band.

Wi-Fi
A brand name given by WECA (currently Wi-Fi Alliance), an industry group, to increase consumer awareness of the wireless LAN standard IEEE 802.11 a/b/g/n.

Bluetooth
Using radio waves in the 2.4 GHz band according to the Bluetooth standard, it is possible to communicate at a speed of 1-2 Mbps, and the communication range is about 10m. Unlike infrared communications, Bluetooth uses radio waves, so it can communicate even if it is shielded.

Long Term Evolution (LTE)
A standard that evolved from HSPA, an extension of W-CDMA. The main features are:
1. Higher data transmission speeds
2. Shorter delays
3. Significantly improved frequency utilization efficiency

PART 2

Bit Error Rate (BER)
A measure of data transmission quality, expressed as the number of erroneous bits received/the number of total bits transmitted. BER of 1% = 100-bit transmission loses 1 bit.

Appendix 1: Glossary 2/3

dBm
A unit of measurement expressed in decibels (dB) with 1 milliwatt (mW) as a reference value. It is used to indicate the strength of a signal in radio waves and optical fibers. In dBm, a very large value to a very small value can be expressed simply by a small number of digits.

Attenuation of Radio Waves
Since radio waves are transmitted diffusely from a radiation point, the energy (power) density of the radio waves per unit area differs depending on the distance from the radiation point. The electric power density of the radio wave shows the strength of the radio wave; the electric power density becomes smaller and the radio wave becomes weaker as the distance becomes longer. In free space, radio waves have the characteristics of being inversely proportional to the square of the wavelength, in addition to decaying proportionally to the square of the distance.

Reflection of Radio Waves
When there is a boundary of different media such as a metal plate in the passage of the radio wave that travels in a straight line, a reflection of the radio wave occurs. Radio waves are reflected at the same angle as the incident angle to the interface.

Diffraction of Radio Waves
A phenomenon in which a moving radio wave travels around the shadow of an obstacle.

Interference of Radio Waves
A phenomenon in which a receiver is affected by the reception of a desired wave signal due to a disturbance signal.

Fading
The strength of radio waves transmitted through radio communications fluctuates. This is caused by a change in the reflection due to obstacles or ionosphere or due to the movement of the radio or the passage of time, resulting in a change in the interference of radio waves that have arrived with a time difference.

Interfering Wave
A radio wave that interferes with the desired wave.

ITU-R
Abbreviation of International Telecommunication Union-Radiocommunication Sector, the International Telecommunication Union wireless communications sector, which promotes the global standardization of telecommunications, conducts research on telecommunications, and enacts and revises regulations.

PART 3

Channel/ch
In this document, the radio communication frequencies are arranged at equal intervals.

Time Division Multiple Access (TDMA)
A technology that allows for multiple access by dividing radio waves into timeslots and assigning them to radio stations.

Carrier Sense Multiple Access (CSMA)
A communication technology for avoiding interference that checks whether there is a radio wave currently communicating before starting a new communication. Communication starts only when there is no current communication.

IPv6
Internet Protocol version 6 is the next version of the Internet Protocol (IPv4), which is widely used at present. Compared with IPv4, the number of addresses can be greatly increased, security can be enhanced, and various settings can be simplified.

Cryptography Technology
A technology that converts and conceals data in accordance with prescribed procedures for the purpose of preventing third parties from stealing information during data communication, storage of documents, images, etc.

Appendix 1: Glossary 3/3

Advanced Encryption Standard (AES)
An encryption standard established by the US government as an internal standard. It is said that the strength of common key cryptography is extremely high among the methods currently in practical use.

Malware
A shortened term for malicious software, this generally refers to any harmful software such as a computer virus.

PART 4

Received Signal Strength Indicator (RSSI)
A measure of received signal strength.

Packet Error Rate (PER)
A measure of data transmission quality, expressed as: the number of packets received incorrectly/the total number of packets transmitted. PER of 1% = 1 packet of 100 is missed in packet transmission.

Fresnel Zone
In wireless communications, a spatial area of "outlook" required for radio waves to reach without power loss. This zone becomes a spheroid whose center axis is two points. If there is an obstacle in this area, the strength of the signal is not ensured. The radius of the central portion of the Fresnel zone is called the Fresnel zone radius, and it is generally said that the same characteristics as the free space can be obtained by securing 60% or more of the Fresnel zone radius.

Network Topology
This describes how terminals and various devices are connected in the communication path(s) of a wireless network. Types of network topologies include bus, star, ring, tree, mesh, composite, and hierarchy.

Field Device Tool/Device Type Manager (FDT/DTM)
FDT is a software interface that integrates various environments (tool palettes) for setting up and operating various indirect field instruments, devices, and machines connected to networks of various communication protocols and provides an environment for setting up, operating, and diagnosing equipment with a unified operability (look and feel). DTM refers to intelligent field instruments-specific application software with digital communication capabilities.

Electronic Device Description Language (EDDL)
A text-based language for describing the digital communication characteristics of intelligent field instrumentation and equipment parameters, such as device status, diagnostic data, and configuration details.

NAMUR NE 107
A requirement specification compiled by NAMUR, a user organization of German process automation, addressing the self-diagnosis function of field instruments.

Distributed Control System (DCS)
A computerized control system for a process or plant in which autonomous controllers are distributed throughout the system but there is no central operator supervisory control.

Human-Machine Interface (HMI)
A user interface or dashboard that connects a person to a machine, system, or device. While the term can be applied to any screen that allows a user to interact with a device, HMI is most often used in the context of an industrial process.

Appendix 2: References and citations

Note: The original version of this document was in Japanese, so some references are in Japanese.

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