System Engineering Guidelines
IEC 62591 *Wireless*HART®

Process Management

1.1 Preface

These “System Engineering Guidelines” apply to end user adoption of *Wireless*HART self-organizing mesh networks to automate process manufacturing. Following the guidelines will help users take full advantage of *Wireless*HART systems.

The document provides complete technical guidance for using *Wireless*HART devices and applications. The information presented applies to all IEC 62591 *Wireless*HART installations, independent of brand. Vendor-specific ‘value added’ features are not included.

PART I of the guideline addresses use of *Wireless*HART technology in project execution from the Appraise (conceptual design) stage through to the Pre-FEED (Front End Engineering and Design), FEED, Execute and Operation stages. PART II describes the Field Network components that comprise *Wireless*HART networks.

The guidelines describe *Wireless*HART system functions and capabilities, networks and alternate modes of operation, and step-by-step procedures for system access and use. This document assumes the reader is proficient with HART® instrumentation. Therefore it focuses on the unique aspects of deploying *Wireless*HART systems. Unless stated otherwise, the reader should assume the project phases and steps are the same for HART and *Wireless*HART instrumentation.

This guideline summarizes the essential pre-requisites and general guidelines necessary for smooth execution of the project that contains *Wireless*HART Technology. The guidelines are applicable for small and large scale projects.

The technical guidelines are for use only by qualified personnel capable of observing the safety instructions from device manuals. The document is provided on an “as is” basis only and may be subject to future revisions without notice. The authors and contributors will not be responsible for any loss or damage arising out of or resulting from a defect, error or omission in this document or from personnel use or reliance on this document.

We want to hear from you

Your comments and suggestions will help us to improve the quality of system engineering guidelines. If you have any suggestions for improvements, comments, recommendations or a query, feel free to send feedback to a Wireless Specialist at WSEGSupport@Emerson.com.

1.1.1 Definitions and acronyms

The following definitions are used within this document.

Ancillary device

Any device that does not contain measuring sensor or output to the process for actuation.

Gateway

Enables communication between wireless field devices and host applications connected to an Ethernet, Serial, or other existing plant communications network; management of the wireless field network; and management of network security. Conceptually, the Gateway is the wireless version of marshaling panels and junction boxes. The Gateway functionality may also exist in native *Wireless*HART I/O cards with field radios.

Host system

Any system accepting data produced by the *Wireless*HART Field Network (WFN). This could be a DCS, PLC, RTU, Data Historian, asset management software, etc.

Join key

A 128 bit security key used to authenticate wireless field devices when joining the network, including encryption of the join request.

A common Join Key may be used among all devices on a given network, or each device may have a unique join key.

Note
When displayed in hexadecimal format via a browser or handheld, this results in a 32 character hexadecimal field.

Network ID

Each Gateway at a facility or location should be programmed with a unique Network ID. All authenticated wireless field devices with the same Network ID will communicate on the same network and Gateway.

Update rate

The user specified interval at which a wireless field device will detect a measurement and transmit the measurement to the Gateway (i.e. sample rate). The update rate has the largest impact on battery life due to the powering of the device sensor. Update rate is independent of radio transmissions required for mesh peer-to-peer communication, “hopping” via multiple devices to transmit a measurement back to the Gateway, and downstream communications from the host system to the wireless field device.

Wireless adapter

Enables an existing 4-20 mA, HART-enabled field device to become wireless. Adapters allow the existing 4-20 mA signal to operate simultaneously with the digital wireless signal.

Wireless field devices

Field device enabled with a *Wireless*HART radio and software or an existing installed HART-enabled field device with an attached *Wireless*HART adapter.

Wireless field network

A self-organized network of wireless field devices that automatically mitigate physical and RF obstacles in the process environment to provide necessary bandwidth for communicating process and device information in a secure and reliable way.

Wireless repeater

Any wireless field device used to strengthen a wireless field network (by adding additional communication paths) or expand the total area covered by a given mesh network.

1.1.2 Acronyms

The following acronyms are used within this document.

Abbreviation	Description
AMS™	Asset Management System
CSSP	Control Systems Security Program
DCS	Distributed Control System
DD	Device Descriptor
DSSS	Direct-Sequence Spread Spectrum
FAT	Factory Acceptance Test
FEED	Front End Engineering and Design
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
LOS	Line of Sight
NFPA	National Fire Protection Association
PDF	Process Flow Diagram
P & ID	Piping and Instrument Design
PLC	Programmable Logic Controller
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
SIT	Site Integration Test
SPI	Serial Peripheral Interface
SPL	Smart Plant Layout
TSMP	Time Synchronized Mesh Protocol
TSSI	Temporal Single-System Interpretation
UDF	User Defined Fields
WFN	*Wireless*HART Field Network

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PART I

*Wireless*HART® Project Execution

Section 1 Introduction

*Wireless*HART is a global IEC-approved standard (IEC 62591) that specifies an interoperable self-organizing mesh technology in which field devices form wireless networks that dynamically mitigate obstacles in the process environment. The *Wireless*HART field networks (WFN) communicate data back to host systems securely and reliably, and can be used for both control and monitoring applications.

The similarities between traditional HART® and *Wireless*HART allow end users to leverage the training of existing process organizations when adopting *Wireless*HART. As a result, change is minimized. In addition, the reduced installed cost of *Wireless*HART extends the benefits of automation to end user applications that previously were out of reach since they could not justify the costs associated with typical wired capital projects.

The opportunity for long-term benefit makes it compelling for end users to expand process manufacturing project planning to evaluate the impact of *Wireless*HART on maintenance, safety, environment, and reliability. Additionally, by removing the physical constraints of wiring and power as well as reducing weight and space, wireless networks increase flexibility in project execution, providing solutions which can mitigate risk and improve project schedules.

1.1 Purpose

This IEC 62591 *Wireless*HART System Engineering Guideline applies to end user adoption of *Wireless*HART self-organizing mesh networks to automate process manufacturing projects of any size. The guidelines are intended to help users take full advantage of *Wireless*HART systems.

1.2 Scope

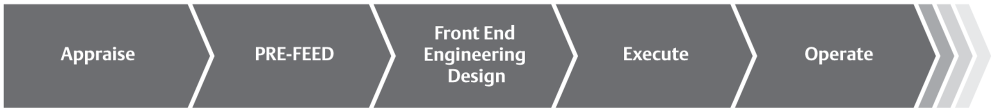
The guidelines apply to use of *Wireless*HART technology through all stages of project execution as well as throughout the lifecycle of facility operation.

Differences between HART and *Wireless*HART specifications and device types are highlighted.

1.3 *Wireless*HART in project execution lifecycle

Figure 1-1 illustrates a typical framework for project execution. It will be used as a basis for describing application of *Wireless*HART in each phase of a project. Although *Wireless*HART can be introduced at any phase, a strategic benefit is realized by its introduction during the early part of the project execution cycle.

Figure 1-1. Project Execution Lifecycle



Section 2 Project Concepts

2.1 Section overview

As described in this section, use of *Wireless*HART® over traditional technology reduces project risk during execution and provides greater flexibility and benefits to the plant during its life cycle.

2.2 Traditional approach

Traditional methods of wired control networks make use of conventional communications like 4-20 mA, HART®, FOUNDATION™ Fieldbus, PROFIBUS® and other bussed solutions. Planning and Installation of these wired networks is complex due to inflexibility of wiring. Significant effort is required in the pre-FEED and FEED phases for planning long run cables including room for spares to accommodate changes during project execution. Beyond laying long run cables, wired system complexities include cable routing, connectors, and additional materials associated with wired technology that are greatly simplified with wireless.

Use of traditional technology also restricts measurement of parameters in locations inaccessible to cable trays and therefore wired connection. Such wired measurements could improve operations but are eliminated from the design process as being too costly to implement.

Since use of wired connections reduces the number of measurements and instruments during the initial execution phase, modifications may be needed to add some of these at a later stage. Increased spares would be needed to allow the expansion. In a typical project environment, frequent changes in I/O database, addition/deletion or reallocation of instruments, change in instrument types, delayed or late changes in package vendor data etc negatively impact project time and cost.

If instruments and therefore I/O points need to be added/changed/moved during operation, then lengthy procedures need to be followed for wired signals such as HSE, work permits, correct isolation procedures, and requisite cabling to connect the field instrument to the control system. These activities require coordination between multiple plant departments. Furthermore, routine inspection to ensure that the cable and associated infrastructure continue to operate trouble free, can be costly and time consuming and divert valuable resources away from operating the plant.

2.3 *Wireless*HART approach: technology assessment

*Wireless*HART technology may provide an opportunity to execute and build a more efficient plant compared to the traditional approach.

The project technical authority can decide whether to use wireless based on the following criteria:

- Economic advantages
- Application capability
- Operational savings
- Benefits of additional process insight from new measurements previously out of reach economically or physically - example: monitored safety showers
- Benefits of flexibility in project execution – example: ease of moving or adding I/O points during construction to cost effectively manage onsite changes

The high cost of traditional field wiring limits the number of points that are able to be connected in a project for process monitoring, control and safety applications. However, as the project proceeds and over the lifecycle of the plant, additional points may need to be added to resolve critical problems. Since *Wireless*HART does not require wires for communication or power, the lower costs enable inclusion of more process points during the project. The financial impediment in determining whether a point is automated or not is redefined,

Special consideration should be given to automation needs of new process plants. *Wireless*HART may provide significant advantages in enabling automation to ensure they meet stricter safety, environmental, reliability and performance criteria. Below are a few examples:

- Many new plants are designed to operate with fewer personnel. Upgrading simple gauges to wireless field devices can automate the manual collection of data from the field in order to increase worker productivity and reduce field trip exposure to hazardous environments.
- Many existing facilities have been modified in order to meet emerging environmental regulation. Real time monitoring of volatile organic compound release (VOC) from wireless monitoring of pressure safety valves and of conductivity and temperature of effluent waters can ensure environmental compliance.
- Wireless remote monitoring of safety showers and gas detectors during construction and operation can provide new levels of safety response.
- New environmental regulation often requires redundant monitoring systems on assets like tanks that were not required in the past. *Wireless*HART can provide a cost effective, reliable secondary communication and monitoring method.
- Wireless monitoring of steam traps and heat exchangers can provide real time information for minimizing plant energy consumption.

Cost effective field information accessible via *Wireless*HART field devices enables non-traditional end use of automation to be considered in the FEED and design phases. A designer should be aware of initiatives for safety, environmental protection, energy consumption, and reliability in addition to the traditional considerations for process automation. The *Wireless*HART architecture extends the benefits of automation to multiple plant initiatives without the need for multiple forms of I/O infrastructure.

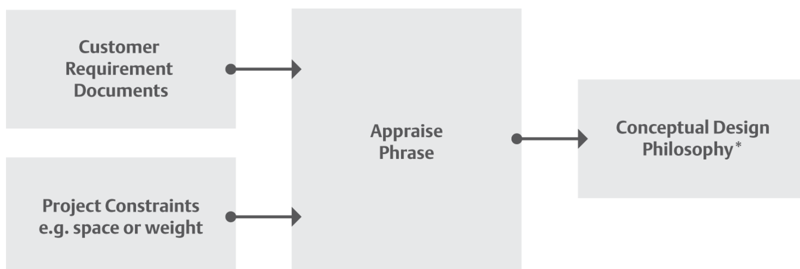
Traditional wired architecture is limited in ability to mitigate risk of project execution. Innovative *Wireless*HART architecture provides greater flexibility with minimum engineering effort and greater savings in cost and time during any project phase, as compared to the traditional approach.

Active projects should optimize measurement and control technology by establishing design rules to define which points are suitable for *Wireless*HART versus traditional technology. These design rules will help to enable consistent and efficient engineering for subsequent project phases.

Section 3 Appraise

The Appraise phase (conceptual design) requires high level customer requirements or project constraints as input. In this phase a simple statement of requirements with identified constraints or objectives will suffice. Selection of wireless technology in this phase allows a simple generic design philosophy statement to be made on how the architecture can be used to meet the needs of both the business and the project. Figure 3-1 shows the inputs and outputs of the Appraise phase.

Figure 3-1. Conceptual Design Phase



Templates Available from Emerson

During the Appraise phase it is likely that a summary of the technology and its application will be required by the project stakeholders in order for them to formulate a practical view of applicability to the project. Plant personnel engaged in the early phase of the project should also be part of this appraisal.

3.1 Application

*Wireless*HART® can be applied to a wide variety of process applications in all process industries spread over differing geographical terrain. Evaluate the following factors for potential *Wireless*HART application:

- Process monitoring and measurements which are remote and uneconomical to consider for wired monitoring
- Equipment health monitoring
- Environmental monitoring, energy management, regulatory compliance
- Extreme environmental conditions for wired installations (hot, wet and corrosive)
- Moving rails and test skids
- Rotating equipment

- Asset management, diagnostics and predictive maintenance
- Simple closed-loop control (when appropriate)
- API seal flush plans
- Secondary systems

3.2 Technology

Evaluate the following factors for benefit by application of *Wireless*HART technology:

- Minimizing the cost
- Ease of installation
- Reduced time for installation and commissioning
- Ease of maintenance
- Ease of expansion for future I/O points (scalability)

3.3 Operations

*Wireless*HART field networks can help optimize contiguous or remote process operations by collecting data in organized manner and enabling operators, shift supervisors, production/field management, and facilities engineers to collaborate. Delivery of the right information to the plant operations team helps them make the right decisions to improve plant throughput.

Evaluate *Wireless*HART operations for benefits in each of the following:

- Access to monitoring points which are normally unavailable to plant operators
- Increased safety by minimizing plant operator rounds in hazardous locations
- Better alarm handling and reporting
- Better insight by use of wireless transmitters for trending rather than gauges and switches

3.4 Maintenance

There are no special maintenance requirements for *Wireless*HART devices apart from changing the batteries. Diagnostic information provided to the Asset Management System alert technicians of the need for maintenance.

*Wireless*HART devices provide advantage for maintenance in hazardous areas. The batteries are intrinsically safe and power-limited, so they can be changed with the device locally without risk of causing a source of ignition.

3.5 Appraise phase documentation

The Appraise phase documentation presents conceptual design that is referenced to customer and project requirements, supported by economic analysis, and satisfies project imperatives.

3.5.1 Reference documents

- Customer requirement specification (customer statement of requirements)
- Project constraints

3.5.2 Deliverables from the philosophy document

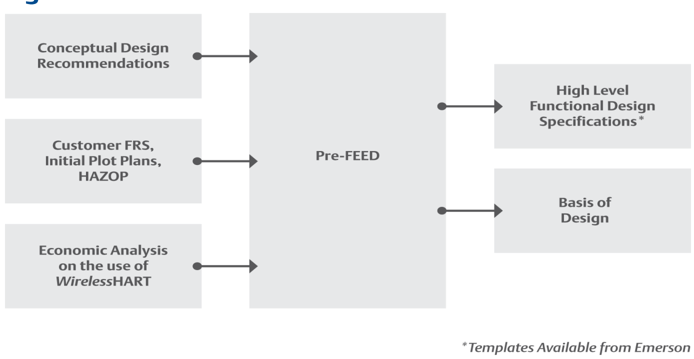
- Conceptual design philosophy/architecture
- Economic analysis of technology and solutions
- Project imperatives

Section 4 Pre-FEED

4.1 Section overview

In Pre-FEED, the requirements, philosophies and imperatives established in the Appraise phase are further elaborated. Deployment of *Wireless*HART® for identified applications can be explored and verified in further detail during this phase. Figure 4-1 shows the inputs and outputs of the Pre-FEED phase.

Figure 4-1. Pre-FEED Phase



An integrated approach should be used for incorporating wireless into a project. Wireless should be merged with wired technology in the project procedures. It is essential to use the right field device technology for the right application. New end user communities may be added as the cost advantages of wireless expand applications during the FEED process.

4.1.1 *Wireless*HART for control and monitoring applications

*Wireless*HART is designed for both control and monitoring applications. Most current use cases emphasize monitoring applications due to conservative adoption of new technology in the process manufacturing industry. The use of wireless control applications is continuing to evolve with the introduction of discrete output devices for performing simple control functions. The Table 4-1 provides a high level summary for selection of the right protocol when factoring in loop criticality; cost to engineer and implement; and location of field devices relative to main process areas and host systems.

Table 4-1. Selecting the Right Protocol

	Safety systems	Critical control	On-off control	In-plant monitoring	Remote monitoring
Conventional					
Fieldbus					
***Wireless*HART**					

Legend	Based on technical and/or cost considerations
	Most appropriate solution
	Appropriate in some cases
	Lease effective solution

Table 4-2 shows the available technology solution for different signal types.

Table 4-2. Selecting Signal Types with the Right Protocol

	Analog inputs	Analog output	Digital inputs	Digital outputs
Conventional	✓	✓	✓	✓
Fieldbus	✓	✓	✓	✓
***Wireless*HART**	✓	N/A	✓	✓

4.2 Cost benefit study

*Wireless*HART and wired solutions need to be evaluated during the Pre-FEED phase for comparison from a cost and time perspective. Furthermore, assessments on the benefits to schedule improvement (by phase) and of change management should be an input to this cost benefit study.

The following factors can be considered for this comparison:

- Main junction box requirements
- Secondary junction box requirements
- Main cable tray requirements
- Secondary cable tray requirements

- Multi-core cable requirements
- Mechanical and civil work for cable routing
- Power supply in system cabinets
- System cabinet requirements
- Marshalling cabinets
- 3D modeling review for cable tray routing, cable tray engineering, and location of junction box
- Cost of change request management
- Time and efforts for installing cable trays and cables
- Power consumption requirement
- Space requirements
- Material weight reduction
- System design time requirements
- Material consideration based on area classification and protection concept

In addition to the above criteria, accommodating changes is cheaper and more efficient with *Wireless*HART during any project phase. Typical case studies for cost, time, power, space and weight savings are shown in Figure 4-2 and Figure 4-3. These case studies should consider the criteria listed above.

Figure 4-2. Case Study for Cost and Time Savings

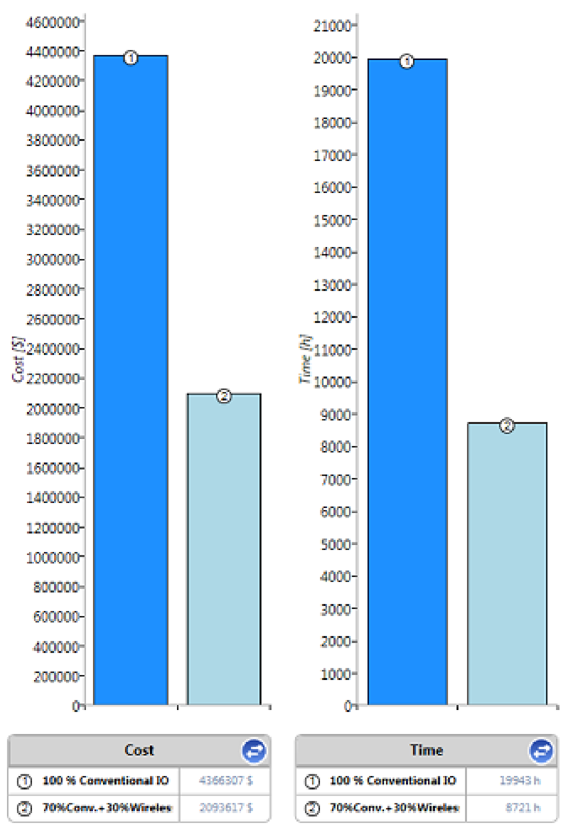
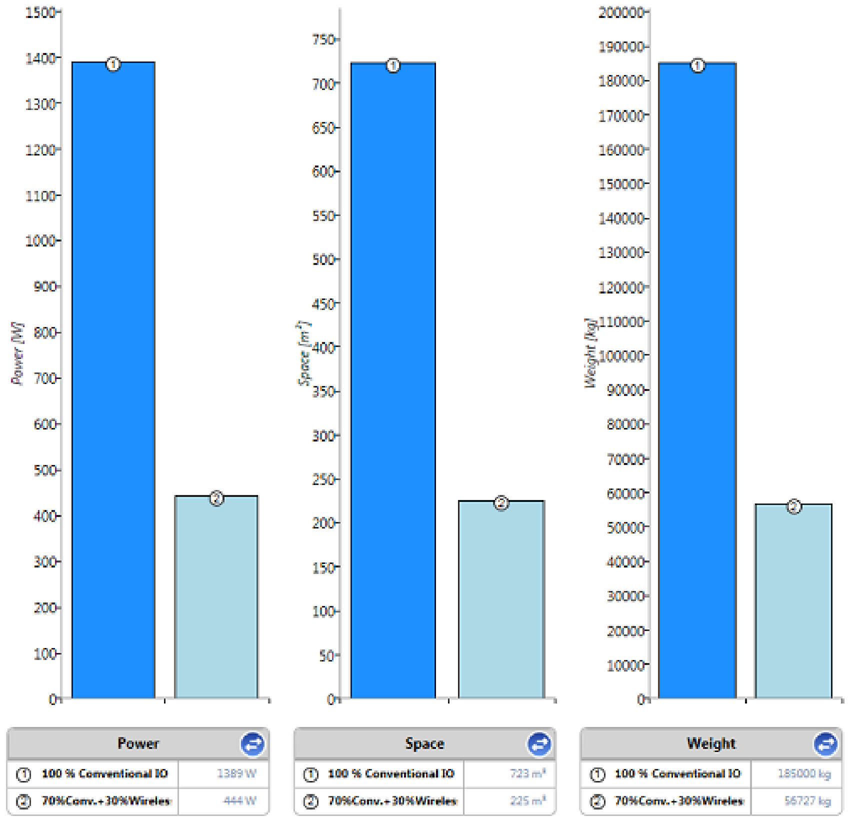


Figure 4-3. Case Study for Power, Space, and Weight Savings



4.3 Preliminary design basis

Determine a preliminary design basis using the Customer Requirement Specification updated in the Appraise phase along with the preliminary conceptual design documents available from Appraise like site plan/layout, P&IDs, instrument index etc. This includes the quantity of *Wireless*HART instruments, Gateways and repeaters needed to create a pervasive sensing network. Assumptions on the basis of experience for similar plants/units can be made in absence of requisite inputs.

Considering requirements of *Wireless*HART for indoor, outdoor and remote locations, develop a preliminary network topology for the Wireless Field Network.

Develop a suitable interface solution for connection of the multiple Wireless Field Networks to the host system and asset management system.

Verify spectrum approvals for the end-user and any intermediary locations. Refer to Appendix A: Example ISA Specifications for more details.

4.4 Project references

Previous projects operating with *Wireless*HART are a rich source of information and reference for new planned *Wireless*HART implementation. Look towards these references as the first line of help to overcome specific issues encountered in new installations.

4.5 Pre-FEED documentation and tools

Documentation from the Pre-FEED phase records use of conceptual design reference inputs to develop high level functional design deliverables.

4.5.1 Reference documents

- Initial plot plan
- Initial 3D layout drawings
- Initial P&ID
- Instrument index
- Customer specification documents
- Proposal documents for cost estimates

4.5.2 Deliverables

- Initial wireless field network system architecture
- Measurement signal types
- Bill of quantity

Section 5 Front End Engineering Design

5.1 Section overview

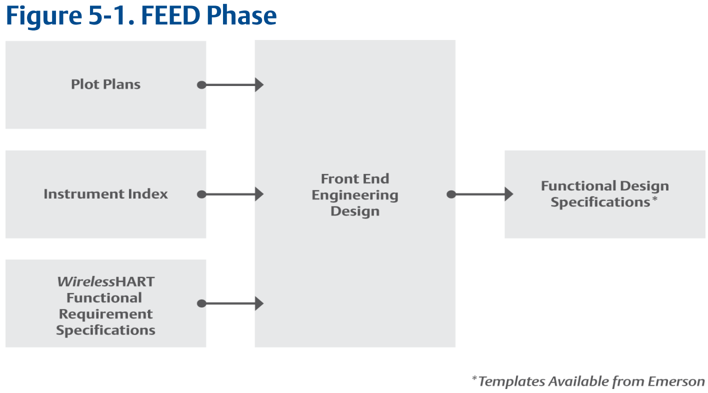
Front End Engineering Design (FEED) is an important stage where key deliverables exist for wireless including cost estimation, design guidelines, and specifications. Collaborative efforts put in by all stakeholders during FEED, will help in capturing all project specific requirements and avoiding significant changes during the Execution phase.

The following factors can be evaluated during the FEED phase for *Wireless*HART® deployment in the project.

- Environmental considerations
- *Wireless*HART functional design requirements
- Scope definition of engineering execution
- *Wireless*HART infrastructure requirements
- Operational requirements
- Design inputs documents review
- Development of basis for design
- Risk assessment and initial design philosophy review

Figure 5-1 shows the inputs and outputs of the FEED phase.

Figure 5-1. FEED Phase



5.2 Scope definition of engineering execution

Stakeholder meetings are important to ensure all disciplines understand the scope of wireless applications. Agenda items should include the following:

- Review potential benefits in key areas of the work structure
- Put in place appropriate training and strategy to achieve potential benefits.
- Clearly distribute project work to optimize dependencies within the project team so that schedule efficiencies can be achieved.
- Identify In-house wireless network requirements to define the scope of Integration of WFN and WPN network.
- Clearly define wireless communication network availability, redundancy, *Wireless*HART equipment supply, installation, configuration and commissioning site work activities, and spare requirements scope

Define and include in the scope: overall wireless network architecture design, wireless device location, minimum distance and coverage between access points, network coverage and performance requirements.

Identify and include in the scope: supplementary wireless network devices such as *Wireless*HART handheld communicator, mobile worker supply.

Determine the field device types and *Wireless*HART signal types for project implementation, including consideration of the following signal and device types (refer to Emerson™ Process Management literature for the most up to date measurement types and innovations).

- Pressure
- Temperature
- Flow
- Level
- Tuning fork level
- Conductivity
- pH
- Corrosion
- Tank gauging
- Guided wave radar
- Discrete position monitoring
- Discrete inputs
- Discrete outputs
- Acoustic (steam trap and PRV monitoring)
- Vibration
- Flame detection

5.3 Environmental considerations

Check for compliance with hazardous area classification requirements, temperature class, and ambient temperature of plant.

Ensure compliance with regional and country specific RF frequency usage norms.

5.4 *Wireless*HART functional design requirements

During the initial stage of FEED, translate owner-operator's functional requirements into a network infrastructure, device characteristics, host interfaces, and applications. Document these in the design specification; also include boundary conditions (e.g. all monitoring points on this project will be wireless) associated with *Wireless*HART applications.

5.4.1 *Wireless*HART functional requirements

Develop the *Wireless*HART design, including the following:

- Network environment and area classification
- *Wireless*HART system architecture
- Operational requirements
- Data requirements
- Interfaces
- Testing
- Spares consideration
- Documentation requirements
- Training
- *Wireless*HART network Security, reliability and interoperability requirements

5.5 *Wireless*HART infrastructure requirements

Conduct plot plan reviews and determine the infrastructure requirements for the following:

- System architecture
- Wireless
- Field network design including IEC62591 *Wireless*HART Field Instruments
- Automation
- Host system interface
- Process control network interface
- Asset management system diagnostics including those for field device and the field network configuration

5.6 Operational requirements

Determine operational requirements for the following:

- Process monitoring and signal types
- Device diagnostics
- Loop response time
- DCS HMI
- Redundancy
- *Wireless*HART network components
- Reduction in field inspections of physical wired infrastructure (IECC60079)
- Elimination/reduction of operator rounds

5.7 Design inputs documents review

Collect initial design documents that describe project requirements including plot plans, equipment layout plans, preliminary instrument index, and three-dimensional layout drawings.

Project team shall make sure inputs are sufficient to define the project initial design philosophy. If documentation is inadequate then project team needs to seek technical clarification from the facility owner-operator.

5.8 Development of basis for design

5.8.1 Design guidelines for *Wireless*HART

During the FEED process, all project stakeholders should be made aware of the capability and benefits of *Wireless*HART so that design engineers can identify potential application candidates. The project team should develop a wireless design and circulate to all project stakeholders.

For example, the process design engineer can use a set of criteria as shown in Table 5-1 to identify wireless application candidates.

Table 5-1. Example Criteria of Wireless Application Candidates

	Safety systems	Critical control	On-off control	In-plant Monitoring	Remote Monitoring
***Wireless*HART**					

Legend	Based on technical and/or cost considerations
	Most appropriate solution
	Appropriate in some cases
	Lease effective solution

Ideally, *Wireless*HART application candidates are identified early in the FEED process design phase. This could be during development of the Process Flow Diagram (PFD) or Piping and Instrument Design (P&ID) Diagram. However, if an early decision is not taken, this should not preclude the use of the technology later in the project.

The basis for *Wireless*HART design should be shared among all stakeholders so that other technical design authorities can identify potential wireless applications and benefit from the installed wireless infrastructure. Furthermore, this process ensures consistent implementation across all design authorities and allows for an efficient decision process for use of wireless technology.

Include the following steps when developing the *Wireless*HART design guidelines:

- Determine which categories of points are eligible to be wireless: safety, control, monitoring, and local indication.
- Determine if new users are eligible for automation: process efficiency, maintenance, reliability, asset protection, health/safety/environmental, and energy management.
- Determine percent spares required and necessary spare capacity.
- Factor in distance considerations between Gateways and wireless field devices. Distance considerations are elaborated on in Section 0, Designing.
- Determine whether *Wireless*HART field network backhaul is required.

5.8.2 Specifications

Specifications for *Wireless*HART field devices are nearly the same as for wired HART® devices. See Appendix B: Design Resources for key differences.

Table 5-2. Differences Between Wired and *Wireless*HART

Specification field	Typical HART specification	Typical *Wireless*HART specification
Output signal	4-20 mA HART	IEC 62591 *Wireless*HART
Power supply	24V DC Loop Powered	Intrinsically Safe Battery
Update rate	1 second	1 second to 60 minutes
Protection/enclosure	Explosion Proof	Intrinsically Safe

IEC 62591 *Wireless*HART is an international standard for wireless process automation devices. Devices that comply with the standard include advanced provisions for security, protocol, and other features essential to wireless networks and therefore specification of such attributes covered in the standard are not necessary.

Appendix A: Example ISA Specifications provides example specifications for a *Wireless*HART Gateway and wireless adapter that can be generically specified as transceivers/receivers.

5.8.3 Proof of concept test

*Wireless*HART is well established in a comprehensive range of process plants and environments. On occasion it may be necessary to conduct a proof of concept test to familiarize stakeholders with the capability and applications of the technology; this can be done in a workshop setting.

5.9 Initial design review

Upon completion of site plot plan review, gather the report results from various *Wireless*HART tools, proof of concepts and compliance to customer requirements, and discuss these with all stakeholders. Also discuss any requirement changes, deviations or assumptions with the stakeholders. Since *Wireless*HART is extremely flexible it is easy to incorporate necessary architecture changes.

Section 6 Execute

6.1 Section overview

During the Execute phase (Detailed Design and Testing) of a project, the engineer must account for *Wireless*HART® devices per the guidelines established in the FEED, add wireless specific fields to the project database, and follow wireless field network design procedures to ensure best practices are implemented.

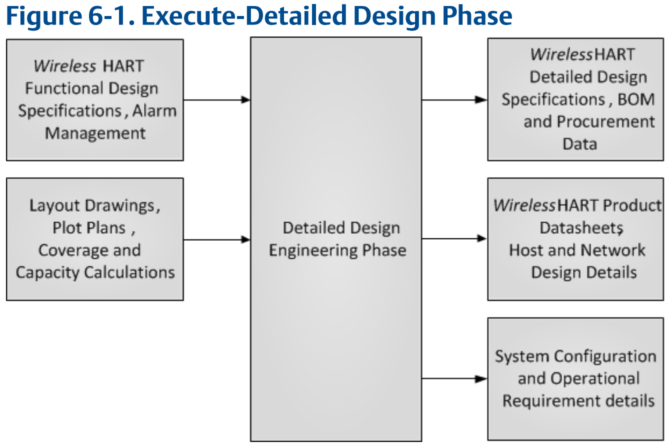
This section addresses the following aspects of Execute Detail design phase.

- Design resources

- Design guidelines
- Wireless field networks design description
  - Key components of the wireless field network solution
  - Wireless devices and Gateway
  - Wireless device selection criteria and data sheets
- Field network deployment
  - Project environmental considerations, intrinsic safety requirements
  - Equipment environmental specification
  - Radio regulatory compliance
  - Plant areas and candidate areas for further wireless deployments
- Host system interface
  - Host/DCS components and architecture
  - Network identification
  - Asset management software interface
- Third party interface
- Wireless field network infrastructure
  - Typical architecture,
  - Equipment location
  - Power specification and power distribution philosophy
  - Cable specifications and types
  - Field data backhaul philosophy and backhaul specification
- Design philosophy deployment
  - Topology, wireless field network control philosophy
  - Monitoring, closed loop control
  - Module design and scan rates
  - Alarm and status Information

Figure 6-1 shows the inputs and outputs of the Execute-Detailed Design phase.

Figure 6-1. Execute-Detailed Design Phase



6.2 *Wireless*HART Field Network – Design Engineering Overview

Follow these three key steps for designing a network:

1. Scope – Decide if you need to reference wireless field networks by process unit or subsection of a process unit. Factors include:
   - Number of devices in the process unit
   - Update rates need for wireless devices
   - Capacity of the Gateway
2. Design – Apply design rules to ensure optimum connectivity.
3. Fortify – Identify and correct any potential weaknesses in the network design.

The three basic steps apply for all process environments in all industries, although the context may vary slightly depending on the physical structure of the process environment. The basic steps also apply regardless of the vendor of the *Wireless*HART devices. Since *Wireless*HART networks become stronger as more devices are added, the Scope step is the most critical for high density applications.

*Wireless*HART is designed for both control and monitoring applications. Refer to Section 2: Project Concepts for detailed recommendations on using wireless control systems and devices.

In general, control with *Wireless*HART is appropriate for most cases of open loop control that require manual interaction with the process and some cases of supervisory control for set point manipulation and process optimization. Applications for closed loop regulatory control of a critical loop may be evaluated case by case.

6.3 Design resources

See the Design Resources Appendix for more information. Contact your respective *Wireless*HART vendor for automated design tools to aid:

- Wireless network planning
- Network design
- Gateway capacity planning
- Device type availability and battery life estimation

6.4 Wireless device selection based on process measurement

*Wireless*HART devices are available for various process measurement applications including those described below.

6.4.1 Process monitoring and control

- Hard to reach locations
- Process efficiency calculations
- Better insight into the process
- Ad-hoc measurements
- Additional measurements from multivariable devices
- Calculated variables in devices

6.4.2 Equipment measurement

- Vibration
- Corrosion
- Oil pressure
- Air flow

6.4.3 Health and safety systems

- Gas detectors
- Analyzers

6.4.4 Environmental

- Steam traps (energy usage)
- Water/discharge treatment
- Flow
- pH
- Stack emissions
- Relief valves

*Wireless*HART devices can be deployed in harsh environments and hazardous areas. Table 6-1 lists examples of *Wireless*HART application deployment. For a comprehensive list of applications, refer to the Wireless Application Guide available through your local Emerson™ Project Specialist.

Table 6-1. *Wireless*HART Applications

Steam Cracker	Diesel and Kerosene Production Monitoring
Treated Water Usage	Rotating Calciner
Filter Condition	Pipeline Leak Detection
Pipeline System	Compressor Emissions Compliance
Remote Storage Tanks	Rotating Roaster
Cold Box	Boiler and Heater Gas Flow
Steam Distribution Lines	Bitumen Tank Farm
Rotating Alumina Kiln	Gas & Diesel Tank Inventory Management
Power Industry Applications	NOx Emissions
Storage Tank Monitoring System	Critical Oil Movement Tank Gauging
Pipelines	Sugar Bin Motor Monitoring
Fuel Supply Systems	Gas Storage
Remote Tanks	Steam Trap and PRV Monitoring

6.5 Design criteria development

Each wireless field network should be scoped to a single process unit.

Minimize the number of hops to the Gateway in order to reduce latency. A minimum of five wireless instruments should be within effective range of the Smart Wireless Gateway.

A mesh network gets its reliability from multiple communication pathways. Ensuring each device has multiple neighbors within range will result in the most reliable network. Each device in the network should have a minimum of three devices within range to provide a potential communication path.

Include 25 percent of each network's wireless instruments within effective range of the Smart Wireless Gateway. Other enhancing modifications include creating a higher percentage of devices, up to 35 percent or more, within effective range of the Gateway. This clusters more devices around the Gateway and ensures fewer hops and more bandwidth available to *Wireless*HART devices with fast scan rates.

6.6 Identify candidate measurement points

Using the wireless guidelines established in the FEED, the design engineer should segregate all points in the project database to identify the eligible wireless I/O points. For example, if monitoring is deemed to be an eligible category, these points should be sorted from the control and other points. Afterwards, further requirements of the field devices can be applied. For example, some control and monitoring points may be excluded from wireless eligibility because the required update rate exceeds either the desired life of the battery or the capability of the field device.

Typical control applications may require 1 second or faster update rates. There is a trade-off for wireless devices between update rate and battery life; the faster the update rate, the lower the battery life will be. It is recommended that the update rate of the measurements shall be three times faster than the process time constant. As an example, a typical update rate for measuring temperature changes with a sensor inside a thermowell can be 16 seconds or longer given how much time is required for heat to penetrate the thermowell.

6.7 Database field for wireless network assignment

Each wireless field device must be assigned to a Gateway that manages a specific wireless field network.

Each Gateway will manage its own wireless field network and can have an assigned HART Tag like any HART device. Each wireless field network in a plant must have a unique Network ID to prevent devices from attempting to join the wrong network. In order to ensure the desired security level is achieved, a decision must be made whether to use a common join key for all devices in a given field network, or unique join keys for each field device. The combination of these two parameters provides identification and authentication down to the field device.

Table 6-2 presents definitions of network Parameters when using a common Join Key, including examples of a Gateway HART Tag, Network ID and Common Device Join Key.

Table 6-2. Definitions of Network Parameters When Using a Common Join Key

Parameter	Parameter options	Example	Technical details
Gateway HART Tag	Field	UNIT_A_UA_100	32 characters – any in ISO Latin-1 (ISO 8859-1) character set
Network ID	Integer	10145	Integer between 0 and 65535

The Join Key is the most important parameter for implementing security. Users can know the Gateway HART tag and the Network ID for the network that the Gateway manages, but a wireless field device cannot join the network without a Join Key. The design engineer should be sensitive to the security policies of the design firm and the security policies of the future owner-operator and, as a minimum, treat the Join Key with the same sensitivities as a password for a server to a DCS or database. For this reason, storing the join key as a field in a design database is not prudent.

Fields should be added to the project database to indicate that a field device is wireless and to describe its association with a Gateway by using the Gateway HART tag or other labeling convention. Parameters required to be managed confidentially should be controlled in a secure means in alignment with established security policies. Staff members with IT security or process security responsibilities are well suited to provide consultation into the handling of sensitive information.

Finally, the design engineer should be aware of available *Wireless*HART devices. Many come with multiple inputs, enabling fewer devices to satisfy the total number of points in a project. For example, several vendors have a multiplexed *Wireless*HART temperature device that reduces costs.

6.8 Network design

Once wireless candidate devices have been identified in the instrument database, the field network design can begin.

Ideally wireless points should be organized by process unit and by subsection of process unit as typically depicted in the master drawing. This information can be used to determine the number of Gateways required. Additional Gateways can be added to ensure spare I/O capacity per guidelines or other project requirements. From here, the Gateways should be logically distributed throughout the process unit like junction boxes. Wireless field devices should be assigned to the closest Gateway, or to the Gateway that is assigned to the process unit adjacent to the unit where the field devices reside. Once this is complete, network design best practices should be checked to ensure reliability of the network. This will be covered in detail in the *Wireless*HART Field Network Design Guidelines.

Drawings should be created per existing standards. In most instances, a wireless field device is treated identically to a wired HART device. Most drawings do not indicate wires or the type of communication protocol, thus nothing unique needs to be done for wireless field devices. Section 10: Ancillary WirelessHART Devices provides examples unique to *Wireless*HART such as Gateways and wireless adapters. Fundamentally, it will be up to the design engineer to adhere to or provide a consistent convention that meets the needs of the contractor and the owner-operator as is true for wired HART projects.

Existing HMI (human-machine interface) design guidelines for integration also apply to wireless with no change required since data points connected from the Gateway into the host system are managed like any other source of data.

6.8.1 *Wireless*HART field network – design guidelines

The *Wireless*HART network specification enables a reliable, secure, and scalable architecture. Contrary to legacy systems and point-to-point wireless networks, *Wireless*HART is a truly scalable automation technology that gets more robust as more devices are added to an existing network. Design guidelines support the deployment of small networks with less than 10 *Wireless*HART devices for monitoring and control, as well as installations supporting thousands of devices.

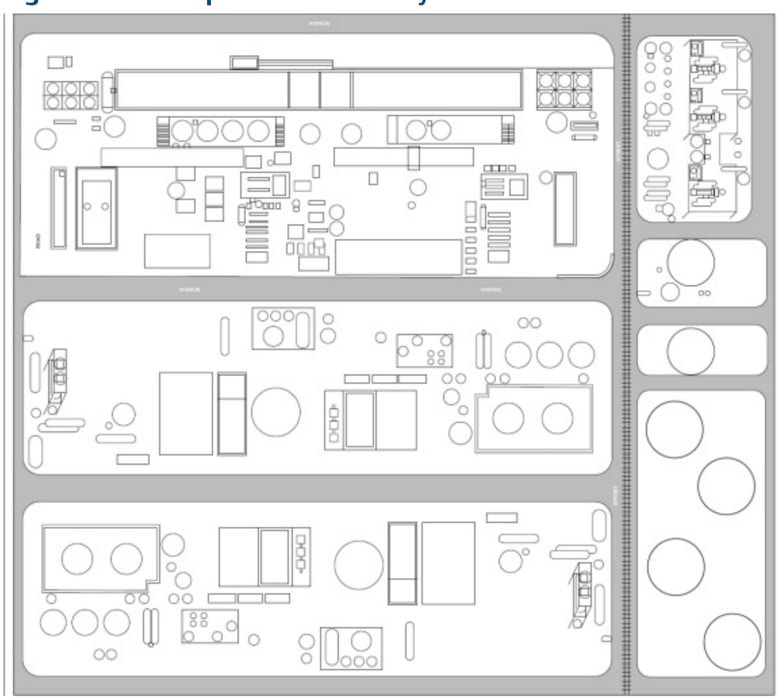
This section includes recommendations to support the long-term, sustainable adoption of wireless applications including *Wireless*HART as well as Wi-Fi, Wi-Max, and more.

The best practices for network design are applicable for networks operating with a mix of *Wireless*HART devices for monitoring and control with update rates from 1 second to 3600 seconds (60 minutes). A site survey is not normally required or even possible in the case of a Greenfield site. For an overview on spectrum usage refer to Appendix C: Wireless Spectrum Governance.

6.9 Scoping

The same design rules that govern the segmentation of wired HART networks apply to *Wireless*HART. From a very simple perspective, all process facilities have an architecture that organizes the infrastructure as well as the automation and the people. *Wireless*HART not only self-organizes to the process environment, but also to this inherent organization of the process facility. For example, the process facility shown in Figure 6-2 is organized into seven process units separated by roads.

Figure 6-2. Example Process Facility



If the process facility is not an outdoor production environment, there is still a natural organization that should be used for scoping networks. For example, power plants and biopharmaceutical manufacturing facilities are typically completely enclosed with multiple floors. One option is to scope *Wireless*HART field networks to a floor. If there are seven floors, then there are potentially seven *Wireless*HART networks.

The benefits of scoping a *Wireless*HART field network to a process unit are:

- Aligns the data flow from the *Wireless*HART devices through the Gateway to the host system with existing data architecture.
- Aligns *Wireless*HART tagging convention with wired HART tagging convention.
- Aligns *Wireless*HART documentation practices with the process unit and support device location. If you know device A is on Network A and in process unit A, then one should not look in process unit B to find device A.
- Aligns work processes of managing *Wireless*HART device lifecycles with wired HART lifecycles including organizational responsibilities.
- Sets reasonable expectations for range between *Wireless*HART devices. Most process units do not have a footprint greater than a few hundred feet (<0.2km) by a few hundred feet (<0.2km).

While scoping the number of networks and Gateway placement, the design engineer should factor in considerations for Gateway capacity and spare capacity. At a minimum, each process unit should have its own Gateway with spare capacity for problem solving in real time. If a project is small and application focused and total numbers of I/O points are less than the capacity of Gateways, then typically a single Gateway is required. If the project is large or has wireless field devices with update rates faster than four seconds, use the following process to determine the total number of Gateways and modify the scope of a network.

1. Filter the Instrument Index List by process unit and determine how many I/O points are in each process unit that are wireless so that the WirelessHART networks can be segmented by process unit.

- For example, out of 700 total I/O points, let's assume process unit A has 154 wireless points requiring 154 *Wireless*HART devices. We need to determine how many Gateways are needed.

Note

Some *Wireless*HART devices support more than one wireless point and so there may be instances when fewer devices are required to satisfy the number of measurement points. A key example is a *Wireless*HART temperature transmitter where two or more temperature elements are used as inputs. Networks can support a mix of device types and update rates. The method outlined here is a simple method that determines max capacity with very limited design information.

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2. Identify the necessary update rate of each *Wireless*HART device to meet the specifications of the application as well as battery life.

- Typical *Wireless*HART devices can update from once per second to once per hour.
- The update rate should be 3-4 times faster than the time constant of the process for monitoring and open loop control applications.
- The update rate should be 4-10 times faster than the time constant of the process for regulatory closed loop control and some types of supervisory control.

- The faster the update rate, the shorter the battery life. Use an update rate that meets the needs of the application, but does not oversample in order to maximize battery life.
- Update rates faster than four seconds can impact the total number of wireless devices that can be put on a Gateway. Consult the specification of the Gateway vendor for additional constraints and consultation.

3. Determine the capacity of the Gateway determined by the maximum update rate to be used in the network. Be conservative and assume all devices are operating at the same, fastest update rate network for the purpose of estimation. Example output: 100 *Wireless*HART devices per Gateway if all devices are updating every eight seconds or slower and the Gateway can support 100 devices at eight seconds.

Note

Some Gateway vendors have advanced capacity planners that can provide detailed capacity estimate based on the required updates of individual update rates. *Wireless*HART networks can support a mix of device types and update rates. The method outlined here is a simple method that determines max capacity with very limited design information.

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4. Determine and apply any guidelines on spare capacity. If the design rules for the project state that I/O components should have 40 percent spare capacity, then note this value for the following calculation.

5. Use the following calculation to determine the number of Gateways:

$$\#\ gateways = ROUNDUP\left(\frac{Total\ WirelessHART\ devices\ in\ process\ unit}{gateway\ capacity * (1 - spare\ capacity\ requirement)}\right)$$

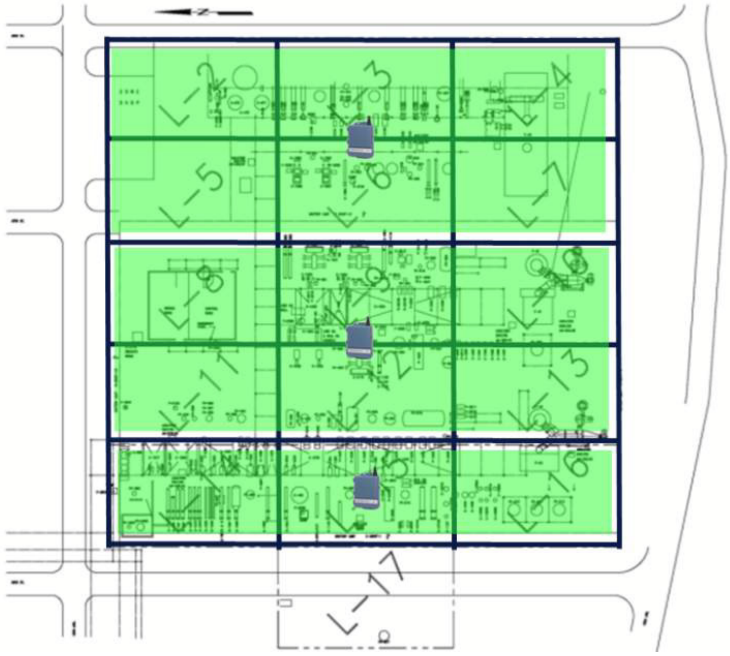
   For the example above, three Gateways are needed.

$$\#\text{gateway} = \text{ROUNDUP}\left(\frac{154}{100*(1-0.40)}\right) = 3$$

   This formula can be entered into Microsoft® Excel®.

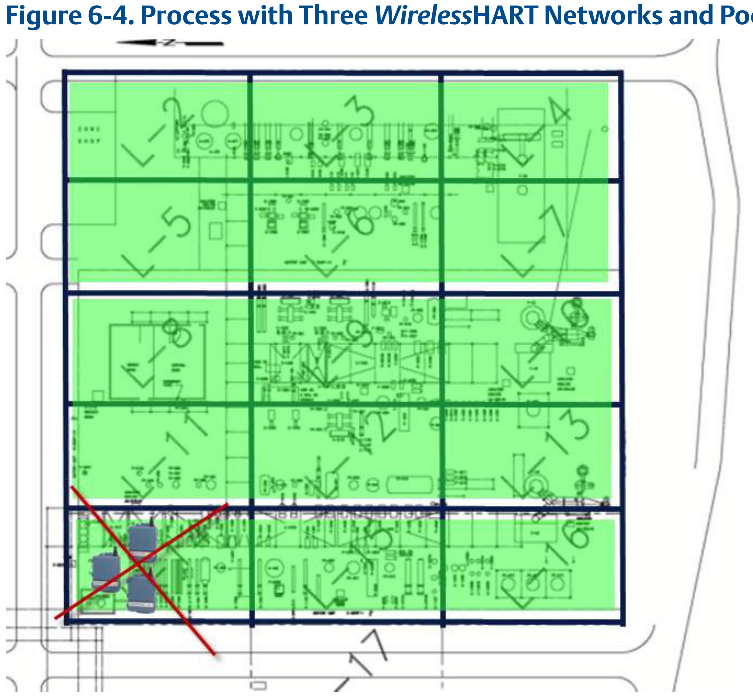
6. Scope the number of required Gateways into subsections of the process unit. If more than one Gateway is needed per process unit, then the design engineer should segment the networks such that the Gateways are distributed in the field like marshaling panels and junction boxes. In Figure 6-3, the master drawing, the process unit has 16 subsections labeled L-2 through L-17 that should be logically segmented for coverage by Gateways. Not every Gateway needs to have the same number of wireless points. If redundant Gateways are to be used, then double the number of Gateways based on the output from the above formula.

Figure 6-3. Process with Three *Wireless*HART Networks and Good Gateway Placement



This example shows three *Wireless*HART Gateways supporting three *Wireless*HART networks in the same process. This is analogous to having three FOUNDATION™ Fieldbus segments in the same process unit. In this example, the process unit subsections were grouped horizontally instead of vertically to minimize the distance of the process unit. A key consideration is that the Gateways, regardless of manufacturer should always be in the process space for which they supply I/O capacity. Figure 6-4 shows an image of what not to do.

Figure 6-4. Process with Three *Wireless*HART Networks and Poor Gateway Placement



Do not place all Gateways in the same location just because connecting into the host system is convenient. The next section on network design will show that this is inefficient and can lead to unreliable networks in the long term. The Gateway should be centralized to the field network to maximize the number of connections to wireless devices.

*Wireless*HART networks can be logically aligned with existing documentation and automation engineering practices following this procedure.

Key things to remember:

- Scoping is the most important design rule. Use it to ensure wireless capacity, long term scalability, high reliability, and alignment of *Wireless*HART devices and management with existing process facility, organization, and work practices.
- Every *Wireless*HART Gateway in a facility must have a unique Network ID to properly segment the *Wireless*HART field networks.
- The output from the scoping phase should be a scaled drawing showing the relative locations of assets and processes to be automated and potential integration points for the *Wireless*HART Gateways.

6.10 Detailed design specifications

Upon completion of site study report review, prepare detailed design specifications in accordance with the control system requirements. Detailed design covers the following:

- Overall wireless mesh architecture including the detailed network infrastructure
- *Wireless*HART devices and network hardware and software specifications
- Network integration method
- Network security specification
- Network monitoring tools
- Documentation requirements

6.10.1 Designing

Effective device range

The following design rules are intended to be very conservative and are based on real-world deployments of *Wireless*HART field networks. The effective range of a device is the typical linear distance between *Wireless*HART field devices when in the presence of process infrastructure. Typically, if *Wireless*HART devices have no obstructions between them, have clear line of sight (LOS), and are mounted at least 6 feet (2 meters) above the ground, then the effective range with 10 mW/10 dBi of power is approximately 750 feet (228 m). Obstructions decrease the effective range. Most process environments have high concentrations of metal that reflect RF signals in a non-predictable manner bouncing the signal off of the metal of the surrounding environment. The path of an RF signal could easily be 750 feet (230m) even though the neighboring device separation is only 100 feet (31m) away. Below are three basic classifications for effective range in the process environment.

- Heavy obstruction – 100 ft. (30 m). This is the typical heavy density plant environment; where a truck or equipment cannot be driven through.

- Medium obstruction – 250 ft (76 m). This is the less light process areas where lots of space exists between equipment and infrastructure.
- Light obstruction – 500 ft (152 m). Typical of tank farms. Despite tanks being big obstructions themselves, lots of space between and above makes for good RF propagation.
- Clear line of sight – 750 ft (228 m). The antenna for the device is mounted above obstructions and the angle of the terrain change is less than five degrees. Some *Wireless*HART vendors provide options and techniques for obtaining even further distances for long distance applications.

These values are practical guidelines and are subject to change in different types of process environments. Conditions that significantly reduce effective range are:

- Mounting field devices close to the ground, below ground, or under water. The RF signal is absorbed and does not propagate.
- Mounting field devices inside or outside of a building relative to the main network and Gateway. RF signals do not propagate well through concrete, wood, etc. Typically, if there are wireless devices nearby on the other side of the enclosure, no special design rules are needed. If there is a high volume of *Wireless*HART devices isolated from the network by an enclosure, consider scoping a network inside of the facility. Small, fiberglass instrument and device enclosures often deployed in very dirty or harsh environments show minimal impact on propagation of RF signal and can be used. Large Hoffman-style metal enclosures will prevent RF signals and are not recommended without additional engineering considerations.

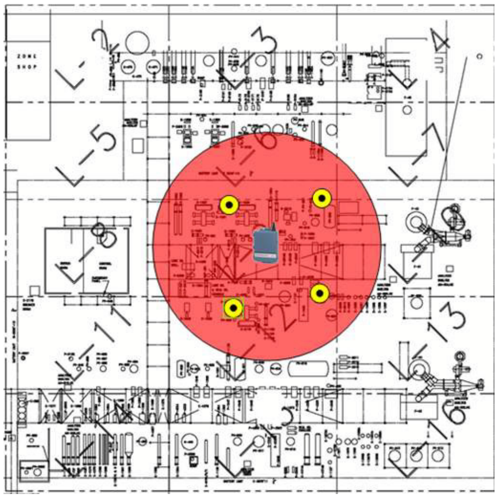
The low power nature of *Wireless*HART devices allow operation for several years without replacing a battery module, but also limit the output power of the radio and maximum range. Because *Wireless*HART devices can communicate through each other to send messages to the Gateway, the self-organizing mesh naturally extends the range beyond that of its own radio. For example, a wireless device may be several hundred feet or meters away from the Gateway, but power efficient "hops" through neighboring devices closer to the Gateway ensure reliable, extended range.

The effective range is used to test the validity of network design by applying the following design rules.

There are four fundamental, recommended network design rules.

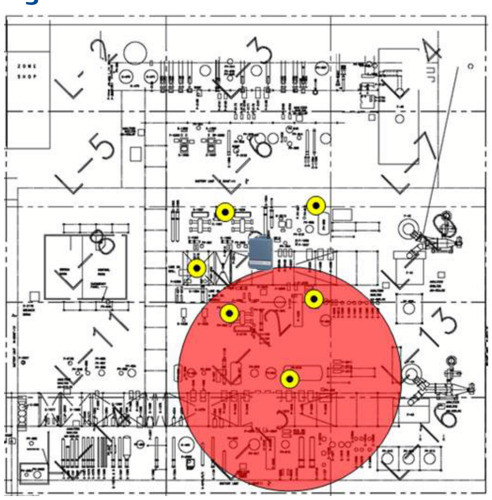
1. "Rule of Five Minimum" - Every *Wireless*HART network should have a minimum of five *Wireless*HART devices within effective range of the Gateway. Networks will work properly with less than five *Wireless*HART devices but will not benefit from the intrinsic redundancy of a self-organizing mesh network and may require repeaters. In a well formed, well designed network, new *Wireless*HART devices can be added to the interior or perimeter of the network without affecting operation or extensive consideration for design.
   Figure 6-5 is a simple design example. The network has been properly scoped to a process unit and four *Wireless*HART devices have been placed with a Gateway on a scaled process drawing. The red circle around the Gateway represents the effective range of the Gateway. We see in this example, the "Rule of Five Minimum" is broken in that there are only four devices within effective range of the Gateway. This network will likely perform to specification, but it is optimal to fortify for long term scalability and reliability by adding more devices.

Figure 6-5. Process with Rule of Five Broken



2. “Rule of Three” – Every *Wireless*HART device should have a minimum of three neighbors with in effective range. This ensures there will be at least two connections and the potential for connections to change with time.
   Continuing on from the previous example, we fortified the network by adding another field device within the effective range of the Gateway and added another device as another measurement point. Now, as shown in Figure 6-6, the red circle represents the effective range of the *Wireless*HART device that does not have three neighbors. For reliability, it is essential for every *Wireless*HART to have two paths during operation to ensure a path of redundancy and diversity. The “Rule of Three” when designing ensures concentration of devices.

Figure 6-6. Process with Rule of Three Broken



3. "Rule of Percentages"– Every *Wireless*HART network with greater than five devices should have a minimum of 25 percent of devices within effective range of the Gateway to ensure proper bandwidth and eliminate pinch points. *Wireless*HART networks can work with as little as 10 percent, and actual implementation may yield less than 25 percent, but experience shows this is a practical number. Example, a 100 device network implies 25 within effective range of the Gateway.

- Networks with greater than 20 percent of wireless devices with update rates faster than two seconds should increase the percentage of devices with in effective range of the Gateway from 25 to 50 percent.

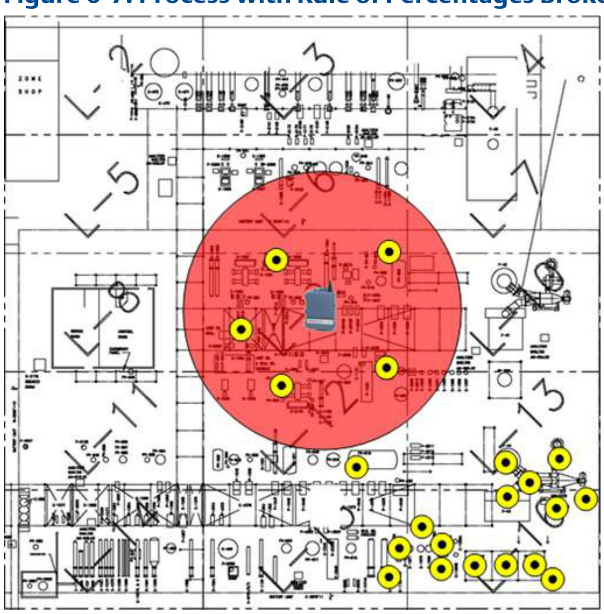
4. "Rule of Maximum Distance"– Wireless devices with update rates faster than two seconds should be within two times the effective range of wireless devices from the Gateway. This rule maximizes speed of response for monitor and control applications requiring high-speed updates.

Applying network design recommendations

*Wireless*HART devices are located according to their process connection. Only an approximate location is required for location on the scaled drawing since the self-organizing mesh technology will adapt to conditions as they exist and change from the point of installation. The design rules ensure a concentration of *Wireless*HART devices for ample paths between the devices. This allows the self-organizing mesh to optimize networking in a dynamic environment.

When the "Rule of Three" is broken, it can be fortified by adding more devices. As networks grow, "Rule of Five Minimum" and "Rule of Three" become irrelevant as there are many devices in the process space. "Rule of Percentages" becomes dominant for large networks to ensure there is ample bandwidth for all devices in the network. Figure 6-7 shows an example of a network design where "Rule of Percentages" is broken.

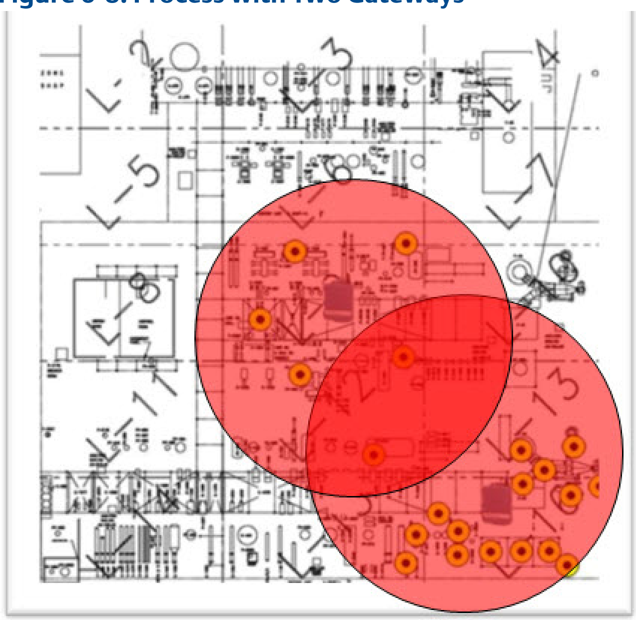
Figure 6-7. Process with Rule of Percentages Broken



A deviation from the “Rule of Percentages” can be resolved in several different ways. Below are three options to fortify this network design, each with its own consideration.

1. Add more devices within the effective range of the Gateway. While this is a good solution, there may not be more points of value within effective range of the Gateway.
2. Move the Gateway into a more central location relative to the distribution of *Wireless*HART instrumentation. In this case, there may not be a convenient host system integration point at the center of the network.
3. Add another Gateway. This increases overall capacity for the process unit, addresses the needs of that specific concentration of field devices, and ensures long-term, trouble-free scalability. There may still be the issue with convenient host system integration point as with option 2.

Figure 6-8. Process with Two Gateways



If a wireless device requires update rates faster than two seconds or is used for control and does not meet the “Rule of Maximum Distance”, consider adding a Gateway as shown in Figure 6-8 or moving the existing Gateway closer to the wireless device. If the process control loop is tolerant of latency, or if it was previously a form of manual control, it may be acceptable to have devices further from the Gateway.

6.10.2 Post installation considerations for control and high speed networks

It is recommended that wireless field devices used for control and high speed monitoring have a higher path stability than general monitoring devices with updates slower than two seconds. Path Stability is the measure of successfully transmitted messages on any given path relative to the attempted transmissions. General requirements are 60 percent path stability, but 70 percent is recommended for control and high speed monitoring. The addition consideration provided in this text ensures higher path stability that can be confirmed once the network is deployed. Most *Wireless*HART vendors provide the means to verify after installation.

6.10.3 Minimizing downstream messages for wireless output control devices

Digital control signals sent from a host system to a wireless output control device via the Gateway require a downstream message. In order to minimize the time for the downstream message to arrive at the wireless control device, downstream messages initiated by non-control applications should be minimized. Maximum downstream message time form Gateway to wireless control device is independent of the update rate and should be no more than 30 seconds when network design best practices are followed.

Techniques for limiting miscellaneous downstream messages are as follows:

- Limit remote configuration of wireless devices when control is in service.
- Limit device scans by asset management software.
- Limit other actions that require a remote poll and response from the wireless field device.

The update rate of the wireless control device determines how fast the host system receives notification that the control command was received and executed.

6.11 Spare capacity and expansion

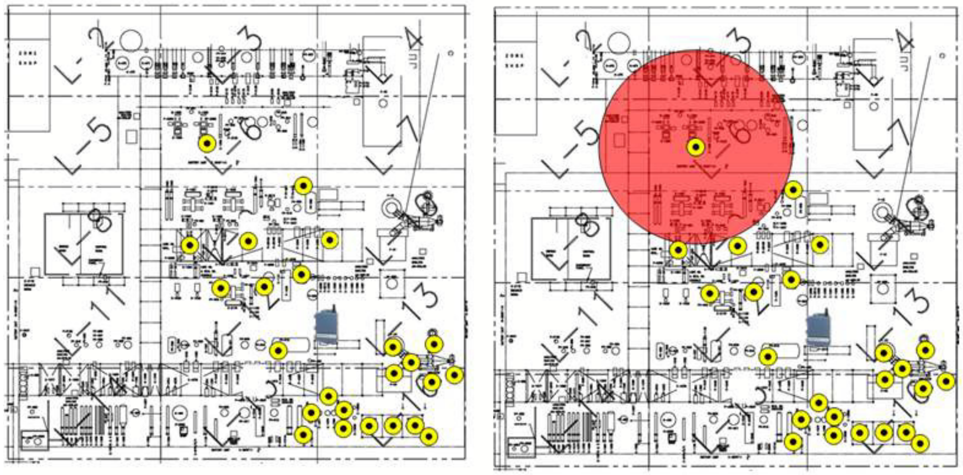
During a typical project there is often a requirement to provide installed spare hardware (marshaling, I/O cards, and terminations) and additional spare space. Typically these figures could vary between 20 and 30 percent. The consideration when designing with wireless is different as no cabinetry marshaling, I/O cards, and terminations are required. Additional Gateways can be added to the network to increase capacity.

6.12 Fortifying

It is recommended to stress test the network design by altering the effective range of devices in order to identify potential weaknesses in the network design. To stress test the network, reduce the effective range of the devices in 10% increments. For example, suppose an effective range of 250 feet (76m) was used for initial design. Reducing effective range by increments of 25 feet (8m) (10%) could reveal where the weak spots will exist. It is the discretion of the network designer to determine what level the network will be stressed; there is a limit of diminishing return.

The example shown in Figure 6-9 reveals that one *Wireless*HART device fails the Rule of 3 under a 20% stress test of the effective range. Effective range is set to 250 feet (76m) for the design test on the left and 200 feet (61m) for the stress test on the right.

Figure 6-9. Process Standard Design (Left) and Stress Tested (Right)



The self-organizing mesh technology allows for more *Wireless*HART field devices to be added to a network for the purposes of automation, and provides the means for simple design correction to also exist. A stress failure can be fortified by moving the Gateway location, adding a new Gateway to segment the network, adding more devices or adding repeaters.

Repeaters are an alternative to support the fortification of a network. Instead of another *Wireless*HART device with a specific measurement purpose, any *Wireless*HART device can be used specifically for the purposes of providing more connection within the network. Repeaters can be used effectively within dense infrastructure if they are placed above the infrastructure to maximize the effective range while maintaining connection with wireless devices in the infrastructure. *Wireless*HART adapters may make cost-effective repeaters if local power is available

6.13 *Wireless*HART availability and redundancy

The *Wireless*HART field network is inherently redundant between the wireless field devices and the Gateway if the network design recommendations are applied. The user should expect no less than 99 percent reliability in the flow of data from each *Wireless*HART field device with typical performance approaching 100%.

The following are considerations for maximizing system availability between the host system and the *Wireless*HART Gateway:

- Always properly ground Gateways and field devices per local/national electrical codes and manufacturer recommendations.
- Always employ proper lightning protection on Gateways.
- Always use an uninterrupted power supply (UPS) to power the Gateway. This is the primary source of Gateway failure.
- Deploy redundant Gateways for the field network if measurements are critical.
- Make host systems connections to Gateways redundant, especially if redundant Gateways are used. This includes physical connections, Ethernet switches and power supplies.

6.14 *Wireless*HART security

*Wireless*HART (IEC62591) is a single purpose standard in which devices have been specifically designed to take process measurements and communicate those measurements securely through a mesh network. Industry experts, device vendors, and end users have collaborated to ensure the protocol was built with security measures and features in mind from the very start.

*Wireless*HART is a multivendor, interoperable protocol that is secure out of the box with no user configuration. The *Wireless*HART protocol keeps data secure by implementing strong AES-128 bit encryption (NIST/IEEE compliant) with multiple encryption keys. The confidentiality of device data is ensured as the data travels through the mesh network. Even though a field device may route data from a neighboring device, it won't have access to the encryption keys and therefore cannot read the data as it passes through the device.

Although no user action is required for secure communication, there are some mandatory actions required before a device can join a network. When designing networks, every network must have a unique network ID and join key before a device can join the network. This join key can be common for each device on the network or it can be unique to each device, creating an Access Control List (ACL). Emerson strongly recommends using an ACL since this will add an additional layer of security. Emerson *Wireless*HART networks also support network key rotation as a risk mitigation strategy. Using the secure web interface, the user can select the timeframe for network key rotation.

Use the following best practice guidelines to maintain and manage the *Wireless*HART network:

- **Never use default keys.** Default keys are generally not as safe as a strong, randomly generated key so it is recommended that randomly generated keys are used.
- **Use robust key management measures.** Treat encryption keys as private and confidential information and protect them against unauthorized access.
- **Do not neglect physical security.** Physical security is a vital part of any security program and fundamental to protecting your system. Restrict physical access by unauthorized personnel to protect end users' assets. This is true not only for *Wireless*HART systems but all systems used within the facility. Unauthorized personnel can potentially cause significant damage to end users' equipment. This could be intentional or unintentional and needs to be protected against.
- **Use an Access Control List.** It is best practice to use a unique Join key for each device; reconfigure existing networks that use a common join key to use an ACL.

6.15 Alarm handling with *Wireless*HART devices

Most modern industrial complexes will have a range of different methods for bringing sensor related data back in to the central automation system. This may range from conventional analog (4-20mA) and discrete signals to more sophisticated digital transmission methods such as FOUNDATION Fieldbus, PROFIBUS® and *Wireless*HART. While all signaling methods have some degree of fallibility the important consideration should be that whatever technology is used, a process deviation is correctly detected, communicated and acted upon in a timely manner.

Digital devices have rich features which are not traditionally available with non smart 4-20mA devices. Smart devices using HART or Foundation Fieldbus technologies are capable of providing predictive alerts to warn of potential sensor failure which may lead to degraded process and operations. Additional non process related stresses may also impact the measurement quality; for instance:

- Crushed cables
- Excessive length
- Mechanical fatigue
- Poor glanding
- Cable routing complexity
- Routing between moving components
- Supporting cable weight
- Grounding

Intermittent and potentially unrevealed failures can be difficult to trace, costly to fix and lead to poor decisions by operators

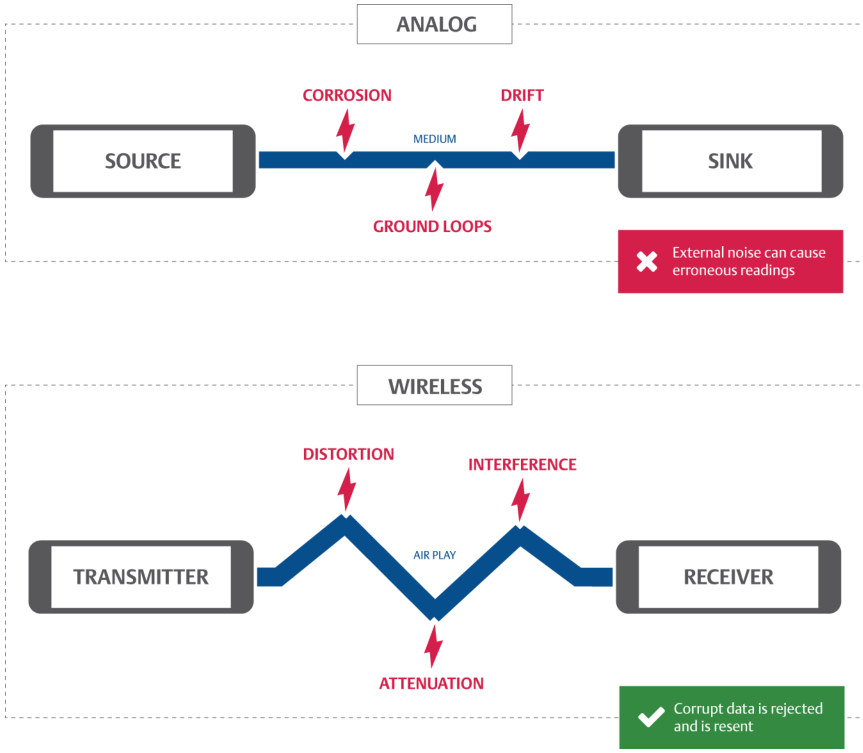
Wireless technology is also susceptible to environmental influence; for instance:

- Propagation
- Attenuation
- Distortion
- Interference

The benefit of IEC62591 *Wireless*HART is that failures are detectable. Erroneous data is not possible due to corruption of the data payload as measuring integrity checking indicates bad data. The sensing technology and process interface arrangements are identical to wired sensor transmitters therefore sensor erosion/drift issues are the same as conventional analogue non smart devices. As previously mentioned IEC62591 *Wireless*HART provides a predictable capability to detect and advice on potential failure.

In either case wired or wireless, utilizing best practice recommendations can reduce the probability of failure.

Figure 6-10. Alarm Propagation to the System



6.15.1 Alarm recommendations for process plant

Wireless devices have periodic updates which vary from one second to many minutes. For the purpose of this discussion it is considered that the wireless point will have a fixed scan rate. That is, a pre-configured rate at which the device sensor is energized and a reading of the process is made (i.e. smart updates are not applicable). When assigning an alarm to a process variable consider the following factors when determining an appropriate scan rate (DCS control algorithm or wireless device):

- Process time: what is the expected rate of change for the process variable? How rapidly does a process variable approach abnormal operating conditions? This should accommodate sudden process swing which may move the process variable outside the normal operating range.
- Operator response time: what is the time for an operator to respond to an alarm and correct the fault?

Generally to satisfy the conditions, the device scan rate must be at least {4} x times the process time constant (including dead time). In practice the operator response time is likely to be several scans longer than this and does not need to be included in this calculation.

Factors affecting the multiplier are:

- Ability to synchronize communications with alarm processing functions
- Ability to send data by exception

6.15.2 Alarm priority

Assignment of alarm priority must follow the criteria as defined in the alarm philosophy for the plant (refer to Table 6-3). The subsequent alarm rationalization exercise will define the purpose, intent and consequence of each alarm.

Table 6-3. Alarm Priority

Priority	EEMUA[1] %	Comment
Low	80	Wireless possible: monitoring and assessed control loops
Medium	15	Conventional wired
High	5	Conventional wired

1 EEMUA 191 (The Engineering Equipment and Materials Users' Association Publication 191 for Alarm Systems).

Generally between 65 and 80 percent of alarms will be low priority with minimal risk and consequence, and therefore these points are all possible candidate points for *Wireless*HART devices.

6.16 Data sheet parameters for *Wireless*HART transmitter

Shows part of a typical *Wireless*HART transmitter specification section of a data sheet.

Figure 6-11. Part of WirelessHART Transmitter Specification of Data Sheet

TRANSMITTER	22	Scan Rates	1 Second ☐ 2 Seconds ☐ 4 Seconds ☐ 8 Seconds ☐ 16 Seconds ☐ 32 Seconds ☐ 1 to 60 ☐
			1 Minute ☐ (Note: 2.4GHz DSSS *Wireless*HART allows for 1,2,4,8,16, 32 seconds or 1 to 60)
	23	Operating Frequency and...	2.4GHz DSSS, IEC 62591 (*Wireless*HART)
	24	Antenna Type	Omnidirection Antenna ■ High-Grain Antenna ☐ Directional Antenna ☐
	25	Diaphragm / Wetted Material	Hastealloy C276
	26	Type of Protection	Intrinsic Safety
	27	Communication Protocol	*Wireless*HART
	28	Body Material	316L SST
	29	Encloser Type Class	IP66
	30	Transmitter Output	Wireless with User Configurable Transmit Rate
	31	Hazardous Protection	ZONE 2 IIC T4
	32	Loop Power Supply	Lithium Battery ■ Energy Harvesting ☐ Wired Power ☐
	33	Accuracy	=/-0.055% of F.S.
	34	Network ID	☐ ☐ ☐ ☐ (0000-32000)
	35	Join Key	☐ ☐
			☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
	36	Body Type	
	37	Digital Communication	IEC 62591
	38	Digital Display	Pressure ■ % of Range ☐ Scaled Variable ☐ Sensor Temperature ☐ Supply Voltage ☐
	39	Output Information	Write Project: Enabled ☐ Disabled ■
ALARM	40	Pressure Process Alert	LRL ≤ LO LO Alert ≤ LO Alert HI HI Alert ≤ URL
			ON ☐ OFF ■
			LO LO Set Point: Deadband: (Engineering Units)
			LO Set Point: Deadband: (Engineering Units)
			HI Set Point: Deadband: (Engineering Units)
			HI HI Set Point: Deadband: (Engineering Units)

Note
Inclusion of "join key" in the data sheet above is optional.

6.17 Tools and documentation

This section explains the input documentation and tools required in the detailed design phase.

6.17.1 Functional design specifications

Use the Functional Design Specifications developed in the FEED stage as reference for detailed design.

6.17.2 Instrument index/database

Refer to SPI 2009 documentation for recommendations for additional fields not typically included in wired HART specifications.

6.17.3 Instrument data sheets

Use standard data sheets created for wired HART devices. Update the specification fields shown in Table 6-4 to reflect *Wireless*HART.

Table 6-4. *Wireless*HART Specifications for Instrument Data Sheets

Specification field	Typical HART field
Update Rates	1, 2, 4, 8, 16, 32, 64+ sec
Power Supply	Intrinsically Safe, Field Replaceable Battery
Communication Type	IEC 62591

No special ISA or other specification sheets are required since the same sheets can be used to specify HART, FOUNDATION Fieldbus, or *Wireless*HART. See Appendix A: Example ISA Specifications for a specification sheet example for a *Wireless*HART Gateway.

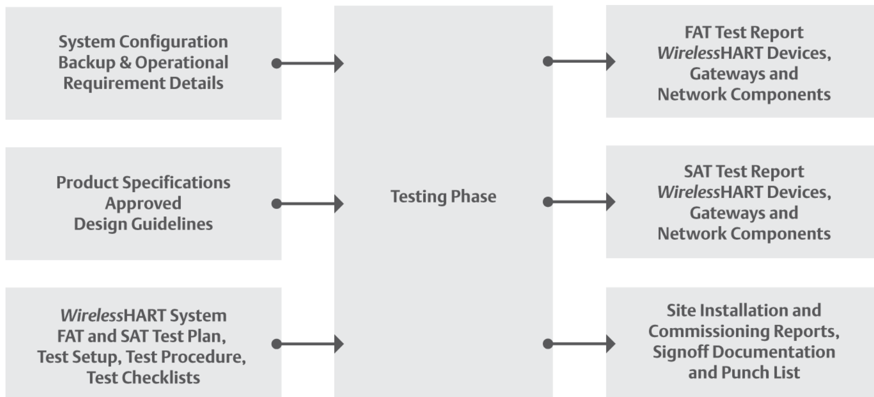
6.18 Testing

This section explains the *Wireless*HART testing during Factory Accepting Testing (FAT), site installation and commissioning, and Site Acceptance Testing (SAT).

The testing phase is important to confirm that the delivered *Wireless*HART solution meets the customer requirements and design references used in the project. Prepare the test plan which shall include a description of the stages of *Wireless*HART scope testing, hardware FAT, software FAT, and 3rd party interface testing.

Figure 6-12 shows the inputs and outputs of the testing steps within the execute phase.

Figure 6-12. Execute–Testing



6.19 Factory Acceptance Test (FAT)

FAT requires establishing a connection between the Gateway and the host systems. *Wireless*HART Gateways typically have standard output communication protocols that directly connect to any host system. The design team should keep a library of these integration options for reference.

The key deliverable of a FAT is the integration of data from *Wireless*HART instruments into the host system via the Gateway. The scope of the FAT should be agreed with the end user. Typically, only a subset of the field devices and Gateways to be installed is used during the FAT.

6.19.1 Factory staging

The following are basic requirements for factory staging:

- Include a sample of all applications, Gateways and *Wireless*HART devices.
- Use an approved test plan, test procedure and test acceptance criteria.
- Verify a HART Field Communicator and user interface to the *Wireless*HART Gateway.

6.19.2 Assumptions

Below are assumptions for FAT:

- Network topology testing is covered as part of the SAT.
- *Wireless*HART network design does not need to be tested at the factory if network design recommendations are implemented. The conservative nature and ability to fortify the network with repeaters upon installation ensures high confidence of reliable operation.

6.19.3 FAT requirements

The following are key requirements of the FAT:

- Physical connection between the Gateway and the host system is verified. Can the Gateway be accessed from the host system with the proper security policy in place?
- Protocol connection between the Gateway and the application that resides on the host system is verified. Can the data seen in the Gateway be seen in the application? Can the standard parameters be properly mapped?
- Gateway can support all necessary connections to all required applications with appropriate timing.
- Device Descriptor (DD) for all field devices in any asset management solution is tested. This ensures the correct DD is installed and valid. This is especially important for *Wireless*HART devices that are new to the market.

6.19.4 FAT network configuration

*Wireless*HART device shall be configured with the Network ID and Join Key and sufficient time for network polling. The transmitter shall be detected by the network. To verify connectivity, open the host interface and check if *Wireless*HART device is available.

- FAT network shall cover testing aspects for hardware, configuration, communication, security.
- Before setting up the network, carry out the pre power up check for each component on the network.

6.19.5 Wireless network troubleshooting

If a *Wireless*HART Device is not joining the network then follow steps listed below.

1. Verify network ID and join key.
2. Wait longer (30 min.).
3. Enable high speed operation (Active Advertising) on Smart Wireless Gateway.
4. Check battery.
5. Verify device is within range of at least one other device.
6. Verify network is in active network advertise.
7. Power cycle device to try again.
8. Verify device is configured to join. Send the *Force Join* command to the device.

6.19.6 FAT procedure

Since there are no physical IO modules, software testing is performed by simulation of I/O at the processor level. This level of simulation is adequate to verify the application software within the host control system.

As per IEC 62381 standards on FAT, general guidance as described for testing of bus interfaces and subsystems shall apply. A subset of instruments (at least one of each type) shall be connected to the Gateway as a proof of concept demonstration of integrated system functionality. This test should ideally verify the connectivity of the field device to the Gateway and from the Gateway to the host systems.

Where physical devices will not be tested at the factory, emulation of the interface will be performed if required.

Below is a high level procedure for performing FAT.

1. Power the Gateway.
2. Add one of each type of *Wireless*HART device to the network and verify proper connectivity. All Gateway fields for data from the *Wireless*HART device should be properly populated.
3. Create first physical connection to the first required host system application.
4. Verify connectivity between the Gateway and the host system application.
5. Integrate necessary data from each sample *Wireless*HART device into the host system application.

- Optional additional procedure is to change process variables in the *Wireless*HART device through direct stimulation or through simulation. All devices, once properly connected to the Gateway, should integrate identically over protocols like Modbus® and OPC.

6. Repeat Step 4 through Step 6 while adding host system connections to the Gateway until all expected connections to the Gateway are complete.
7. Test integration into an asset management solution if applicable.
   a. Verify each *Wireless*HART device can be properly accessed and configured via the asset management solution.
8. Add any additional procedures to verify control narratives and monitoring narratives.

6.19.7 FAT tools

- Handheld communicator
- Multi-meter
- Computer setup with Gateway/card interface software

6.19.8 FAT documentation and reports

- FAT plan
- FAT procedure
- FAT checklist

6.20 Site installation

In general, *Wireless*HART devices are installed exactly like wired HART devices. Emphasis should always be placed on making the best possible process connection for accurate measurement. The self-organizing mesh technology in *Wireless*HART enables wireless field devices to self-route through the process environment and reroute when the environment changes. Always refer the instruction manual of the *Wireless*HART device for specific considerations. This is covered in detail in *Wireless*HART Field Network Design Guidelines.

*Wireless*HART adapters are typically installed on an existing HART enabled device or somewhere along its 4-20 mA loop. Refer the manual of the *Wireless*HART adapter for specific considerations.

*Wireless*HART Gateways are typically placed 6 feet (2 meters) above the process infrastructure (typically above cable trays) and located in the process unit where the maximum number of direct connections with wireless field devices can be achieved. Gateways may have an integrated or remote antenna for installation flexibility.

*Wireless*HART repeaters are typically mounted 6 feet (2 meters) above the process infrastructure and should be located in areas of the wireless network that need additional connectivity.

It is recommended to install the Gateway first in order to allow host system integration and wireless field device installation and commissioning to commence in parallel. Wireless field devices can be commissioned as soon as process connections are in place and a device is joined to a network. Once the wireless device is activated with proper configuration, update rate, and security provisions for Network ID and Join Key, it will form a network that compensates for the current condition of the process unit and will adapt as the unit is built. The project manager can have wireless device installation occur in parallel with construction to maximize project time buffers or pull in the project completion date.

6.21 Site installation plan

6.21.1 Installation considerations

- Use the device specific instrument manuals for installation instructions.
- Install instruments and process connections. Take cautions to keep the antenna from being directly mounted against metal surfaces.
- Fiberglass instrument enclosures provide no significant impact to wireless performance.
- If wireless instruments are mounted inside a building, relative to the majority of the wireless instruments, a passive antenna or additional repeaters should be used to ensure good connectivity.

Installation practices for *Wireless*HART devices follow very closely to the installation practices of wired HART instruments. Since there are no wires, *Wireless*HART devices can be installed as soon as the asset or infrastructure is in place and secure.

6.22 Network installations

Always install the Gateway first so that integration and field network installation and commissioning can occur in parallel.

Field devices can be commissioned into the Gateway and then commissioned into the host system application.

In general, *Wireless*HART devices are installed per the practices of wired HART devices. Always refer the product manual for details.

*Wireless*HART devices close to the Gateway should always be installed and commissioned first to ensure connections for potential devices that cannot directly connect to the Gateway. This is the easiest way to establish the self-organizing mesh.

*Wireless*HART devices can be installed in close proximity to each other without causing interference. The self-organizing mesh scheduling of *Wireless*HART ensures devices in close proximity to each other are silent, talking to each other, or talking on different RF channels when other devices are communicating.

If a *Wireless*HART Gateway antenna or *Wireless*HART device antenna is to be mounted near a high power antenna of another wireless source, then the antenna should be mounted at least 3 feet (approximately 1 meter) above or below to minimize potential interference.

For achieving better network bandwidth check for the following:

- Reduce update rate on transmitters
- Increase communication paths by adding more wireless points
- Check that device has been online for at least an hour
- Check that device is not routing through a “limited” routing node
- Perform wireless connection test procedure

6.23 Wireless connection test procedure

Before beginning the wireless connection test procedure, verify the *Wireless*HART device has basic connectivity to the network either through the Gateway interface, a local user interface on the device, or a local connection via a HART Field Communicator. If the device is not joining the network within a reasonable time period, verify the presence of power and the use of proper Network ID and Join Key. This assumes the Gateway is installed properly, powered and accessible, that the network is designed per best practices, and that there are devices to which the new device being commissioned can connect.

1. Wait a minimum of at least one hour from initial powering of the *Wireless*HART device before performing the wireless connection test procedure. This dwell time ensures the device has had time to make several connections for self-organization. Multiple devices can be tested at the same time. Since they rely on each other, it is optimal to have as many on the network as possible for initial connection testing.
2. Verify that network diagnostics indicate proper bandwidth of the device. The Gateway should have an indication.
3. Verify each device has a minimum of two neighbors. The Gateway should have an indication.
4. Verify device reliability is 99 percent or greater. Statistics may need to be reset and re-certified to remove any anomalies incurred during start up and not indicative of long term performance. Allow at least one hour for the network to gather new network statistics.
5. Verify sensor configuration per the loop sheet or other form indicating designed configuration.
6. Perform any necessary zero trims for sensors.

7. Repeat for each device in the network.

If a device does not pass the wireless connection test, follow the basic steps below:

1. Wait until entire network is built and operating for 24 hours before considering further action. This will give the Gateway time to maximize its self-organization for best communication. If 24 hours is too long to wait, allow a minimum of four hours.

2. For the non-compliant device, verify proper path stability and RSSI values. Path stabilities should be greater than 60 percent and RSSI should be greater than -75 dBm. Wireless control devices and devices with update rates faster than two seconds should have a path stability of 70 percent or greater. If all the devices on the network have very low path stabilities, but high values for RSSI, this could be an indication of broadband interference.

3. Look at the location of the non-compliant device in the network. Verify there is not a broken network design rule or an unexpected installation resulting in poor RF signal propagation.
   a. Add repeaters if necessary to fortify the network if the device is isolated from the network with poor connections.

4. Verify the device has proper power and is working properly as a sensor.

5. Verify the device update rate is not faster than the fastest allowed by the Gateway.

6. Either reduce the update rate of the field device or increase the fastest allowed update rate on the Gateway.

6.24 Network checkout procedure

Below are basic steps for checking out a network. Allow a minimum of four hours for the network to self-organize (24 hours is preferred).

1. Verify that all devices connected pass the wireless connectivity test. The Gateway should have an indication.

2. Verify a minimum of 15 percent of devices are directly connected to the Gateway. The design parameter is 25 percent; the minimum acceptable is 10 percent. Networks with more than 20% of devices with update rates faster than two seconds or wireless control devices have a design parameter of 50 percent and 40 percent should be connected after installation. The Gateway should have an indication.

3. Verify overall network reliability is greater than 99 percent. The Gateway should have an indication.

6.25 Lightning protection

1. Ensure the *Wireless*HART device bodies are correctly grounded.
2. The installation manuals of all *Wireless*HART devices should be consulted prior to installation.
3. In general, *Wireless*HART devices should not be the tallest feature in the plant to maximize protection against lightning.
4. Ensure adequate protection is provided between the *Wireless*HART Gateways and host system connection as a lightning strike could damage more than just the *Wireless*HART Gateway.
5. In general, wireless devices may provide better protection of the system than wired, as the energy from a lightning strike will not be able to travel through the wiring and cause potential damage to other components. Standards such as NFPA 780 provide classification for zones of protection from lightning as well as techniques for proper implementation.

6.26 Device parameter configuration verification

Device parameter verification is important before putting in to service. Device parameter list will change based on device type. However, following is the list of common *Wireless*HART parameters that can be used for verification. These parameters can be verified along with device datasheet specifications.

- TAG
- Device ID
- Network ID
- Network Join status
- Wireless mode
- Join Mode
- Number of available neighbors
- Number of advertisements heard
- Number of Join attempts
- Manufacturer
- Device type
- Device revision
- Software revision
- Hardware revision
- Identification
- Revisions
- Radio
- Sensor information
- Electronics temperature
- Supply voltage
- Supply voltage status
- Last update time

6.27 Loop checkout/site integration tests

Once *Wireless*HART devices are connected to the Gateway and the network is checked out, the loop checkout may not be necessary in the traditional sense.

Wireless connection testing verifies that each field device has the proper configuration. Since there are no wires to get confused and swapped, there is no need to do the traditional loop check. Alternative loop checks could be to ensure each field device is reporting to the correct Gateway and each Gateway is connected into the correct host system. Traditional applications of sensor stimulus can be performed for confidence, but are less valuable in a pure digital architecture if there is complete assurance a field device was commissioned with the correct tag and configuration.

6.28 Bench simulation testing

Each *Wireless*HART field device is compliant with the IEC 62591 protocol which has provisions for simulation. Each device can be put into a simulation mode. Bench simulation testing should also verify that all HART Field Communicators have the proper configuration and device descriptors (DDs) for accessing the local user interface of field device when in the field.

6.29 Provision of spares

Below are the recommended spares to have on-site:

- Spare lightning arrestor components for Gateways, if lightning protection is used
- Spare Gateways should be kept according to spares policy for host system equipment (e.g. I/O cards). Configurations for Gateways should be convenient for rapid replacement if necessary.
- Spare battery modules
- Spare field devices as determined by the policy for wired field devices. Consideration should be given for additional devices to be used as repeaters, if necessary.

6.30 Removal of redundant equipment

Repeaters used temporarily to fortify a network can be removed and reused if the *Wireless*HART network grows to a point where repeaters are no longer needed.

6.31 Pre-commissioning

6.31.1 Pre-commissioning requirements

1. Determine which *Wireless*HART instruments and *Wireless*HART Gateways are installed correctly. Crosscheck instrumentation against Instrument Data Sheets.
2. Conduct site walk-through to determine *Wireless*HART Gateway location and any infrastructure barriers. Ensure local power is available for *Wireless*HART devices and Gateways and Plant Network radios.
3. Determine smart wireless Gateway connection back to host system (Serial, Ethernet, Wi-Fi Network).
4. Determine if other forms of existing wireless present in and around the location that may cause interference (cell phone towers, high power radio transmitters)

6.31.2 Defining *Wireless*HART pre-commissioning methods and acceptance

Define the pre-commissioning activities for the following:

Devices

Confirm device installation and configuration as per customer requirements and specifications.

Network

Confirm the network is up and running in the smart wireless Gateway. Verify each device is connected and network meets best practices (neighbors, hops etc.).

Security

Verify security set-up and configure. Configure firewall as per requirements (optional).

Power up sequence

The battery should not be installed on any wireless device until the wireless Gateway is installed and functioning properly. Wireless devices should also be powered up in order of proximity from the wireless Gateway, beginning with the closest. This will result in a simpler and faster network installation. Enable active advertising on the Gateway to ensure that new devices join the network faster.

6.32 Site Acceptance Test (SAT)

The site acceptance shall cover primarily all *Wireless*HART infrastructures, associated hardware, software and operational checks.

1. Verify the installed infrastructure as BOM.
2. Verify network communication.
3. Verify the correct configuration of *Wireless*HART network components.
4. Verify data communications between wireless devices and DCS.
5. Verify faceplates and all HMI elements for connected wireless devices.
6. Prepare SAT report and sign off with owner-operator.

Documentation for site acceptance test documentation:

- SAT plan
- SAT procedure
- SAT checklist

6.33 Commissioning and start-up

*Wireless*HART Gateways segment the commissioning process. Since Gateways connect the wireless field devices to the host system, *Wireless*HART devices can be commissioned to the Gateway to ensure proper connectivity independently of verifying integration into the host system. A wireless loop check can confirm connectivity from the wireless field device through the Gateway to the host system. Interaction with the process and the *Wireless*HART device can confirm the device is operational.

6.33.1 Wireless network integration with HMI and loop check

Verify device variables in the smart wireless Gateway. Also check parameters like TAG, Device ID, network ID, network Join status and device status. Verify device operation from three places:

1. At the device via the local display
2. Using the handheld communicator
3. Host system user interface

6.33.2 Integrating host and field networks

1. Configure the wireless Gateway or wireless interface network ID and join key and verify connection.
2. Check the installation of the wireless Gateway and power up.
3. Host integration of Gateways through Ethernet connectivity.
4. Host integration of Gateways through Serial connectivity.
5. Host integration Gateways through fiber optics.
6. Host integration over Wi-Fi link.

6.33.3 On-site wireless network reliability tests

- At device level check:
  - Join status
  - Wireless mode
  - Join mode
  - Number of available neighbors
  - Number of advertisements heard
  - Number of Join attempts
- Duration based tests (carry out the following tests):
  - Loop response time
  - Consistency in process data update
  - Network and device uptime confirmations
  - Obstruction tests
  - Network uptime test for 2,4,8,12, 24 Hours
- Wireless site execution (maintain the records for the following topics):
  - System files (including diagnostics)
  - Diagnostics
  - Validation form
  - Wireless deviation register
  - Punch lists
  - Final bill of material list

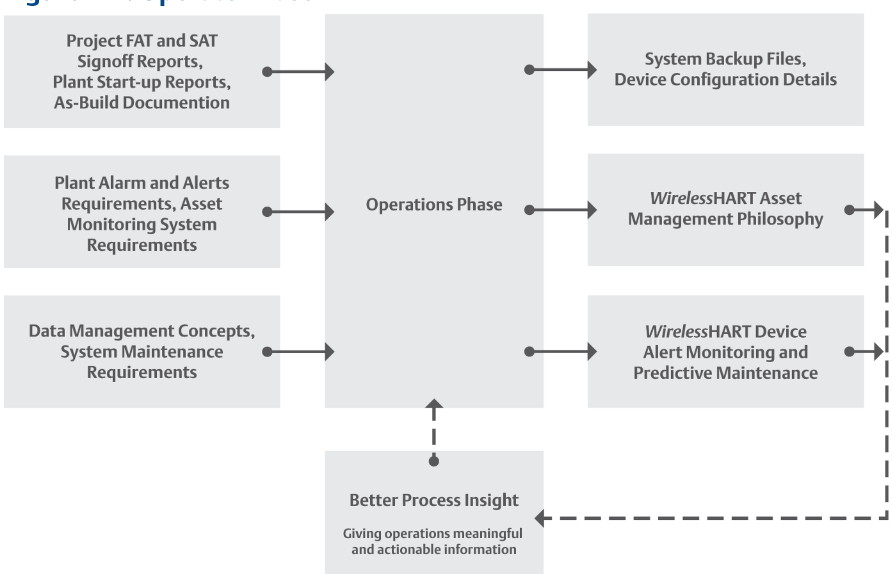
Section 7 Operate

7.1 Section overview

Operate phase for *Wireless*HART® network covers aspects like *Wireless*HART asset management, data management concepts, maintenance practices, etc.

Figure 7-1 shows inputs and outputs of the operation phase.

Figure 7-1. Operate Phase



7.2 Asset monitoring

With the use of wireless asset management applications, users can plan, customize, visualize and manage smart wireless networks. The asset management system handles predictive diagnostics, documentation, calibration management, and device configuration for managing field instruments. The asset management system allows changing, storing, comparing, and transferring device configurations without ever going into the field. Streamline the calibration by defining device test schemes, scheduling device calibration, and managing device calibration data.

With the asset management system, wireless diagnostics are organized across multiple wireless Gateways. The asset management system provides detailed reports. Below are the lists of fields you can use in your reports:

- Device tag/Gateway
- Battery voltage
- Update rate
- Ambient temperature
- Status
- Parents/children/neighbors

7.3 Alarm and alerts philosophy

7.3.1 Configure process alerts

Process alerts allow the transmitter to indicate when the configured data point is exceeded. Process alerts can be set for process variable and secondary variable. For example, for pressure transmitter, process alerts can be set for pressure, temperature, or both. The alert will reset once the value returns within range.

Device Alert displayed:

- On the Field Communicator
- On the Asset Management System Status screen
- In the error section of the LCD display of instrument

The following alarms configuration can be used for *Wireless*HART device:

- HI HI Alarm
- HI Alarm
- LO Alarm
- LO LO Alarm

7.4 Data management concepts

Maintain *Wireless*HART system configuration data during normal operation. Periodic system backup should be used from system software. Maintain device configuration and audit trails.

Use maintenance, calibration, and inventory documentation requirements from host system capabilities.

7.5 Maintenance practices

Maintain each *Wireless*HART device per the device manual.

The network will self-organize and provide alerts for changes requiring intervention. The Gateway should have an indication of performance issues in the network or field devices.

Section 8 Project Management

8.1 Section overview

This section explains project management aspects for *Wireless*HART® projects.

8.2 *Wireless*HART project management overview

This section summarizes the overall concept of *Wireless*HART project management.

8.2.1 Customer requirements, compliance, and assumptions

Customer requirements document should be evaluated thoroughly based on parameters like past project knowledge base, system and technology capabilities, project best practices etc. Regional and country specific requirements must be understood correctly.

Prepare compliance to customer requirements document. Use valid assumptions and discus uncertain information with the owner-operator.

8.3 Work breakdown structure and cost estimation

Vendors of *Wireless*HART field devices may have cost calculators and capital project studies that can be referenced and compared to support the cost justification of wireless in a project or an all wireless project. For a large capital projects, wireless can reduce costs by switching wired monitoring points to wireless.

Design Engineers should assess and incorporate the following factors in their project cost estimating calculation model:

- Reduced engineering costs (including drawing and documentation, and Factory Acceptance Test)

- Reduced labor (field installation, commissioning, supervision)
- Reduced materials (terminations, junction boxes, wiring, cable trays/conduit/trunking, power supplies, and control system components)
- Reduced cost of change order management (including adding, removing, and moving field devices)
- Reduced project execution time (including commissioning of wireless field device simultaneously with construction)
- I/O capacity management (each *Wireless*HART Gateway essentially provides spare I/O capacity)

8.4 Subcontractor scope management

Wireless enables simplified subcontractor scope management. Packages can be easily tested and commissioned separately, requiring only minimal integration and testing to occur. Additionally, the subcontractors will also benefit from fewer components and engineering. Tender contracts should be amended to recognize reduced complexity and eliminated work.

8.5 Project scheduling

1. Review schedules to recognize.
   a. Limited infrastructure installation and hence reduced material and installation scope.
   b. Remove some electrical and instrumentation checkout processes.
2. Amend contracts to reflect simplified installation handover processes.
3. Simplify installation schedule management.
4. Reduce material coordination management and simplified construction schedule.
5. Eliminate scheduling and expediting associated with marshaling cabinets.
6. Reflect in the schedule: eliminated activities and simplified FAT, SAT, and SIT (site integration test) on areas where wireless has been extensively deployed.

8.6 Responsibility and skills matrix

1. Amend roles and responsibility matrix to reflect reduced/eliminated responsibilities.
2. Ensure engagement of all project stakeholders/sub-contractor so that wireless can be applied efficiently to improve schedule and material costs.
3. Develop a responsibility and skills matrix for each phase of the project.

- End user, EPC Contractor, and Main Automation Vendor shall define the roles and responsibility matrix for each task of the project lifecycle like pre-FEED, FEED and Execute phase of project.

4. Assign stakeholders with role description like:

- Responsible
- Accountable
- Consulted
- Informed

8.7 Managing project change requests

For project change orders and other late design changes, wireless should be considered as the primary solution unless other design considerations exist. Using wireless will result in the fewest changes to the documentation, I/O layout and other detailed design as well as faster commissioning since you can move wireless devices without having to also re-engineer the wiring.

8.8 Progress reviews and reporting

Define the project execution stages for review. Prepare review reports and inform all stakeholders.

8.9 Customer deliverables

Prepare the list of documentation to be submitted to customer.

8.10 Training

Include the training requirements for plant operators, maintenance team and engineering team.

8.11 *Wireless*HART procurement and contract plan

Check completeness of contract documents like technical specifications, delivery requirement (time and location), quote requirement (expected date and validity, regional regulations for *Wireless*HART other T&C's), and documentation and certification requirements.

8.12 Material requisitions

Given the need for security and RF emissions, vendors must acquire approvals for importation to the country of end-use for compliance with local spectrum regulation and encryption regulation. The vendor can verify whether importation compliance exists for any given country.

The batteries are commonly made using a high energy compound using Lithium Thionyl Chloride. The Material Safety Data Sheet or equivalent should always be available as well as awareness of any shipping restriction; notably most countries do not allow the transportation of lithium batteries on passenger aircraft.

8.13 Documentation requirements in project execution

- Equipment 3D layouts
- Site plan
- Drawings
- Control narratives
- Project management plan
- Site execution plan
- Testing (FAT and SAT)
- Installation procedure and checklists
- Commissioning and start-up checklists
- Sign off documents

Every project will require the establishment of local standards for implementing consistent documentation.

See Section 13: Documenting in Intergraph SPI 2009 for a complete treatment of documentation.

8.13.1 ISA documentation

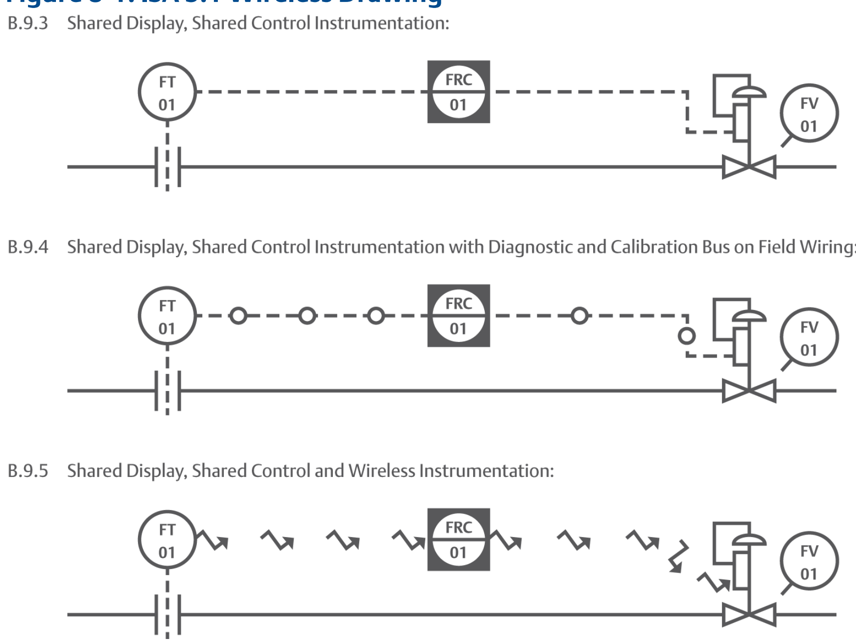
The American National Standard document ANSI/ISA-5.1-2009: Instrumentation Symbols and Identification provides basic guidelines for wireless instrumentation and signals.

Key points

- There is no difference in the symbol between a HART®, FOUNDATION™ Fieldbus, and *Wireless*HART device. An instrument is an instrument.
- The line style for indicating a wireless signal is a zig zag and not a dash.

Below is an image from the ISA-5.1 document showing some comparative examples. Reference ISA-5.1 for complete details.

Figure 8-1. ISA 5.1 Wireless Drawing



- The implementation of *Wireless*HART requires far fewer components, making drawings simpler.

PART II

*Wireless*HART® Field Network Components

Section 9 Field Device Requirements

9.1 Support for *Wireless*HART functionality

All *Wireless*HART devices support methods to allow remote access to device configuration, backwards compatibility with existing field communicators, full implementation of *Wireless*HART security provisions, and *Wireless*HART interoperability.

9.1.1 Device diagnostics

HART® diagnostics

*Wireless*HART devices contain similar or a subset of all of the diagnostics of wired HART devices. Diagnostics information is available through HART commands as well as accessible through Device Descriptions (DD) either locally through a field communicator or remotely using asset management software.

Wireless field device network diagnostics

Every *Wireless*HART field device should have diagnostics that indicate whether or not the device is connected to a network.

Wireless field device power diagnostics

Wireless field devices may have one of three power options: battery, energy harvesting (including solar), or line power. Batteries will have a life determined by the update rate of the wireless field device, network routing for other wireless field devices, and efficiencies of the sensor and electronics.

Typically, the primary consumer of power is the process sensor and electronics in the wireless field device. Using the *Wireless*HART radio or acting as a repeater for other *Wireless*HART field devices requires minimal power. Wireless field devices report their battery voltage and have integrated low voltage alarms such that the user can either schedule maintenance or take a corrective action.

Gateway network diagnostics

Gateway network diagnostics should indicate whether field devices are connected and functioning properly, and whether devices are missing from the network. In order to be connected properly, appropriate bandwidth must be allocated based on the update rate of the device. A device connected but with service denied may indicate the device has an update rate that is too fast for the network capability or the network conditions. With Gateways capable of serving 100 devices or more, clear indication of device availability is crucial.

Additionally, Gateways should be able to detect, regardless of host system integration, whether a wireless field device is connected. This information should be continually updated and indicate if network or device reasons are responsible for a device to not be connected. Simple device states should be made available for integration into the host system to indicate online/offline status regardless of output protocol from the Gateway.

9.2 Mounting

9.2.1 Device mounting considerations

Verify the process application such as gas, liquid and steam flowing through the process lines.

Check for device process connection requirements and ensure the process line isolation before installation.

If the transmitter installation requires assembly of the process flanges, manifolds, or flange adapters, follow Device Manual assembly guidelines to ensure a tight seal for optimal performance characteristics of the transmitters.

9.2.2 Antenna position

Position the antenna vertically, either straight up or straight down. The antenna should be approximately 3 ft. (1 m) from any large structure or building to allow clear communication to other devices.

9.2.3 Mounting high gain remote antenna

The high gain, remote antenna options provide flexibility for mounting the *Wireless*HART device based on wireless connectivity, location, and lightning protection requirements.

Choose a location where the remote antenna has optimal wireless performance. Ideally this will be 15-25 ft (4.6 - 7.6 m) above the ground or 6 ft (2 m) above obstructions or major infrastructure.

Check for weather proofing/lightning arrester requirements.

9.3 Power

Wireless field devices may have one of three power options: battery, energy harvesting (including solar), or line power and there may be several options with in each category.

9.3.1 Batteries

The most common will be the use of a battery for low power field devices due to ease of deployment. Most vendors will use battery cells incorporating Lithium Thionyl Chloride chemistry since it has the highest energy density, longest shelf life, and widest working temperatures that are commercially viable. Although typical cells look like battery cells for consumer electronics, precautions should be taken to ensure batteries are safely transported and introduced into the process environment. Refer to “Vendor documentation” for safe handling practices.

Battery requirements include the following:

- Cells should be assembled by a manufacturer into a battery module to ensure safe handling and transportation.
- Module should prevent a depleted cell being introduced in a circuit with a charged cell, since this can cause unintended electrical currents and heat.
- Module should provide ease of replacement. Battery replacement should take minimal time and training.
- Module should be intrinsically safe and not require removal of the wireless field device for replacement.
- Module should prevent intended and unintended short-circuiting that could lead to heat or spark.
- Module should be designed for the process environment with mechanical properties that provide drop protection and operation over normal process temperatures expected for devices.
- Module should come with necessary Material Safety Data Sheets (or equivalent) and warnings and be disposable per local governmental regulation.
- Module should not be capable of connecting to consumer electronics or non-designed applications to prevent a high-capacity supply from being connected to incompatible electrical systems.
- Modules should be applicable to several *Wireless*HART field devices to maximize inventory management efficiencies in the local warehouse for spare parts.

The design engineers and end users of the wireless field network should use update rates that maximize the life of the battery module and minimize maintenance.

For achieving longer battery life check for the following recommendations:

- Check that *Power Always On* mode is off.
- Verify device is not installed in extreme temperatures.
- Verify device is not a network pinch point.
- Check for excessive network rejoins due to poor connectivity.

9.3.2 Energy harvesting

Vendors may provide energy harvesting options as alternatives to batteries that may include solar, thermal, vibration, and wind solutions. Current energy conversion techniques for thermal and vibration are relatively inefficient. In many cases, energy harvesting solutions also utilize rechargeable batteries to maintain constant back-up power supply. Today’s rechargeable batteries have a life expectancy of only several years during which they can maintain a full charge and are often sensitive to temperature change for supplying power and recharging.

Requirements for energy harvesters are as follows:

- Energy harvesting device should have a designed connection to the wireless field device.
- Energy harvesting device should have means for providing multiple days of back-up power in the event the energy source is discontinued for several days.

- Energy harvesting device should be mounted such that it is not negatively impacted by changes in the season, process conditions, and according the vendor recommendations.
- Energy device should be intrinsically safe and installation should follow local practices for low voltage wiring.
- Energy harvester should have the means for the user to know the state of the device via the wireless field device.
- The lifetime and maintenance of rechargeable batteries should be understood and incorporated into a maintenance routine.

9.3.3 Wired power

A wired power option for wireless field devices is an emerging option from vendors since the cost of local power can be less than the cost of a control signal wire with power or a power module. Some *Wireless*HART adapters may harvest power off of the 4-20 mA loop to wired HART devices. Applications with high power sensors may need to be wireless to meet a communications specification, but require more power than a battery or energy harvester can provide.

Requirements for a wired power option are as follows:

- *Wireless*HART adapters harvesting power from the 4-20 mA signal of the wired device should not affect the 4-20 mA signal during normal operation or failure mode.
- Low voltage powered wireless devices (<30 VDC) should be capable of operating over a range of voltages – example: 8-28V using standard low voltage wiring practices.
- Wired powered option may require the use of Intrinsically Safe barriers between the DC voltage source and the wireless field device.

9.4 Security

Security is a new consideration for wireless field devices that is driven by an increased focus on the protection of critical infrastructure by governments and other security authorities.

The requirements for wireless field device security are as follows:

- Wireless devices should be compliant with all *Wireless*HART security provisions including correct usage of Network ID and Join Key.
- The user or unintended user should not be able to physically or digitally read the Join Key from the wireless device. The Join Key(s) should be treated as confidential and subject to the requirements of any local security policy.
- The wireless device should be receptive to security changes initiated by the Gateway, including Network ID, Join Key, and the network, session, and broadcast keys that validate packets sent through the network and prevent tampering and eavesdropping.
- The Gateway and any management program connected to the *Wireless*HART network through the Gateway should protect all security parameters according to a local security policy.
- Wireless field devices should not have a TCP/IP address in order implement a layered security policy. The exception is the Gateway with a TCP/IP connection to the host system via a firewall.

9.5 Approvals

Every *Wireless*HART device must have the appropriate hazardous area approval to meet the conditions of the process environment as well as the appropriate spectrum and encryption approvals. Spectrum and encryption of wireless signals are regulated by government agencies, such as the FCC in the United States. Typically, verifying with the *Wireless*HART device manufacturer that the device has proper approval for importation into the country of usage is sufficient. Spectrum and encryption approval are a procurement issue and do not represent a design parameter like a hazardous area approval.

9.6 Accessibility

*Wireless*HART devices are subject to the same mechanical and electrical specifications as wired HART devices are they operate in the same process environments.

General requirements for *Wireless*HART field devices are as follows:

- *Wireless*HART devices shall be locally accessible with HART field communicators that support wired and *Wireless*HART devices.
- *Wireless*HART devices shall be manageable with remote asset management systems that access the WirelessHART device via the Gateway and through the *Wireless*HART network.
- *Wireless*HART adapters shall extend the benefits of a *Wireless*HART network to wired HART devices that may or may not be operated on a 4-20 mA loop.

9.7 Manufacturer documentation

Every *Wireless*HART device should have the proper documentation, including a manual, as would be expected with a wired HART device.

Section 10 Ancillary *Wireless*HART Devices

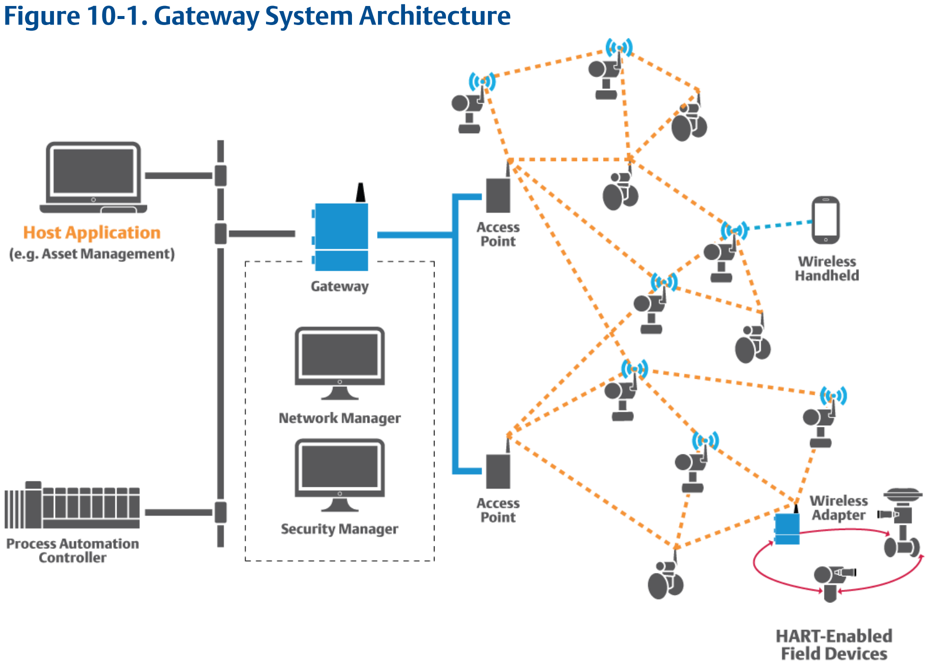
10.1 Section overview

An ancillary device is defined as any device that does not contain a measuring sensor or output to the process for actuation. These include wireless Gateways, local indicators, wireless repeaters, and/or *Wireless*HART® adapters.

10.2 Gateways

The Gateway enables communication between wireless field devices and host systems connected to an Ethernet, serial, or other existing plant communications network. *Wireless*HART manufacturers have typically chosen to integrate the network manager, security manager and access point functionalities into one product. Conceptually, the Gateway is the wireless version of marshaling panels and junction boxes

Figure 10-1. Gateway System Architecture



Requirements for a *Wireless*HART Gateway are as follows:

- Provide an easy to manage solution for enabling Gateway, network management, and security management functionality.
- Have controlled access for a security policy. Gateway should have multiple user accounts with differing access to critical security and configuration parameters such that there can be secure network administration.
- Have multiple output protocols to ensure integration to a range of host applications. In any given process facility, there can be several types of DCS, PLC, and data historians requiring multiple protocols. Multiple output protocols allow convenient connectivity with a standard Gateway.
- Support multiple connections and, in effect, act like a server. Typical *Wireless*HART applications require data to be sent to multiple host applications in order to provide data to multiple end users.
- Support the secure transfer of all protocols over an Ethernet connection through a robust encryption process.
- Be interoperable and support the network management of *Wireless*HART devices from multiple vendors.

10.3 Wireless repeaters

There are no special requirements for a *Wireless*HART repeater. If a repeater is a *Wireless*HART device with a configurable update rate, then minimizing the update rate shall maximize the life of the battery module without impacting the network reliability.

If a vendor chooses to develop a *Wireless*HART device for the specific purpose of acting as a repeater, then that repeating device should be managed like any other *Wireless*HART device and subject to all the specifications of a *Wireless*HART device. *Wireless*HART adapters can be used effectively as repeaters if local power or a wired HART® device is available.

10.4 WirelessHART adapters

*Wireless*HART adapters connect to wired HART devices that are not inherently wireless and provide parallel communication paths through the 4-20 mA loop and the *Wireless*HART field network. The four main use cases for *Wireless*HART adapters are as follows:

- Access HART diagnostics that are not accessible due to limitations of the host system which may not detect the HART signal on the 4-20 mA loop.
- Provide wireless communications for HART devices which are not natively wireless.
- Enable device information to be accessed by multiple users who may not have direct access to the control system. In this scenario, the 4-20 mA signal is sent to the control room while the *Wireless*HART signal is used to access parametric and diagnostics data by maintenance or other personnel.
- Act as a wireless repeater.

*Wireless*HART adapter specifications are as follows:

- Should not affect the 4-20 mA signals under normal operation or in failure mode.
- Should operate like any other *Wireless*HART field device in the *Wireless*HART field network.
- Should have a HART tag.
- Should pass through the wired HART device process variable as well as remote access for configuration and calibration.
- Should employ the same security functions and methods as a standard *Wireless*HART device.

10.5 *Wireless*HART handheld communicator

The handheld communicator is useful for the following:

- Carrying out device configuration
- Viewing network diagnostics and health reports
- Installing session keys

Section 11 Measurements and Choosing *Wireless*HART Devices

11.1 Use of *Wireless*HART® for multivariable process measurements

*Wireless*HART multivariable transmitters provide benefits including the following:

- Lower installed cost
  - Cost savings since fewer instruments are needed and the number of pipe penetrations is reduced.
- Increased accuracy
  - Accuracy improvement due to single transmitter.
- Multivariable measurements
  - Differential pressure
  - Static pressure
  - Temperature
- Calculation parameters for multivariable transmitter
  - Density gas expansion
  - Velocity discharge coefficient
  - Viscosity velocity of approach
  - Beta ratio Reynolds Number
- Parameters available to read at HMI
  - Mass flow
  - Volumetric flow
  - Energy flow
  - Totalized flow
  - Differential pressure
  - Static pressure
  - Temperature

11.2 Use of *Wireless*HART in various process applications

*Wireless*HART devices are available for pressure, flow, level, valve position, pH, conductivity, vibration, temperature, multi-input temperature, acoustic monitoring, level switches and contact inputs. Applications include:

- Safety and environmental monitoring
  - Pressure relief and safety valves
  - Monitor safety shower activation
  - Accurately measure emissions
  - Ensure environmental compliance
  - pH monitoring on effluent waste water
  - Rotating equipment
- Tough installation conditions for wires/remote locations
  - Hot
  - Corrosive atmosphere
  - Wet
- Movement
  - Rail cars
  - Skids
  - Flexible manufacturing
- Asset monitoring applications
  - Bearing and lube temperature
  - Filter differential pressure
  - Vibration monitoring on rotating equipment
  - Surface temperature

Section 12 Host System Requirements

12.1 Use of standard protocols

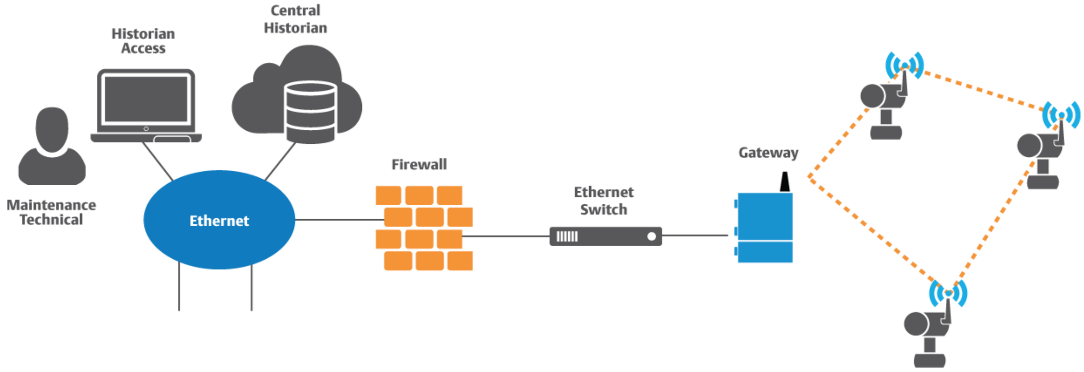
Standard protocols should be used to ensure the most cost effective installation – examples include OPC, Modbus® TCP, Modbus RTU, HART® IP, etc. The *Wireless*HART® Gateway should convert data from the *Wireless*HART field network into the desired protocol and physical layer needed for integration into the host system.

12.2 Wireless host system

Data from *Wireless*HART field networks can be integrated into any existing host system. However, many wireless automation applications are not for control or process monitoring and may not be required to be accessed by the DCS or PLC system. This information may be useful to non-control room based personnel including reliability engineers, maintenance personnel, and energy engineers. Careful consideration should be observed for determining which information should be placed on control operations screens to prevent the dilution of critical information.

For example, suppose a wireless field network is used to replace a manual inspection round where a maintenance technician manually collects temperature and vibration data from a series of pumps and then manually enter the collected data into a data historian. Using *Wireless*HART, Figure 12-1 shows one possible way the Gateway can be integrated into the application, in this case a historian, for the automated collection of data.

Figure 12-1. Gateway Integration into Host System

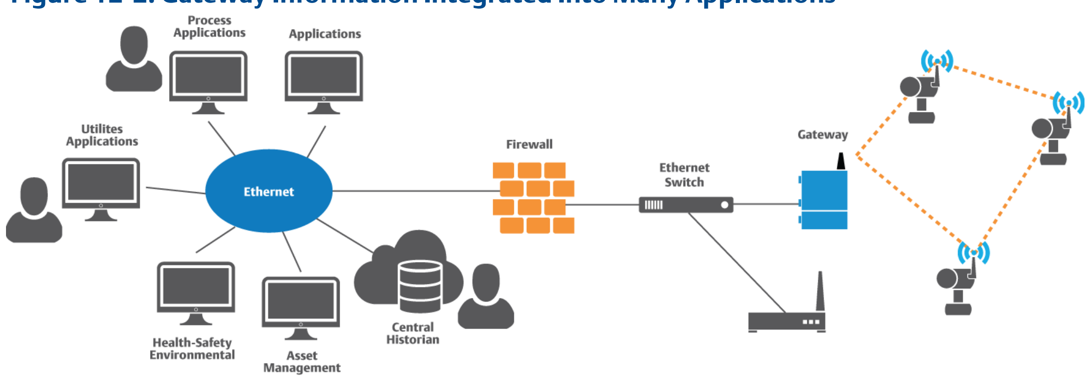


For *Wireless*HART networks that support users in different roles, the potential exists for each end user to have their own application for collecting and analyzing data. For users who manually collect data, *Wireless*HART provides the missing piece to automation.

For long term scalability, where there may be 1000's to 10,000's of *Wireless*HART devices in a single plant. It is important to have a coordinated effort and standard process to enable end users with different roles and responsibilities to share the I/O capacity of Gateways. Representatives from maintenance, utilities, operations, health/safety/environmental, and asset management can share *Wireless*HART network resources.

One architecture to consider is a centralized historian and centralized asset management program shown in Figure 12-2. In this scenario, multiple Gateways are connected on the same Ethernet network and server. The data from multiple *Wireless*HART networks is sent to a centralized historian who can then be connected to the applications for each of the end users. In this way, host system resources can be shared, all *Wireless*HART instruments can report to the same asset management solution, uniform security policies can be enforced, and end users can see *Wireless*HART data in applications specific to their roles

Figure 12-2. Gateway Information Integrated Into Many Applications



Developing a host system integration and data management strategy is essential to maximizing return on investment for wireless that is adopted on a large scale. Successful implementation means that data is going to the right people and being turned into information for action. Often times, multiple users will see the same data, but in the context of their applications. This also means that every time a new WirelessHART device is introduced to the plant, host system and integration issues do not need to be solved again and again.

*Wireless*HART is truly scalable; *Wireless*HART devices can be added to a network without disrupting operation and more Gateways can be added to increase I/O capacity. This ability allows automation to be added and expanded to solve problems without large project budgets once wireless network infrastructure is in place. For example, a *Wireless*HART device can be connected in minutes, configured in minutes, and integrated in minutes if a host system strategy is in place.

12.3 Host integration

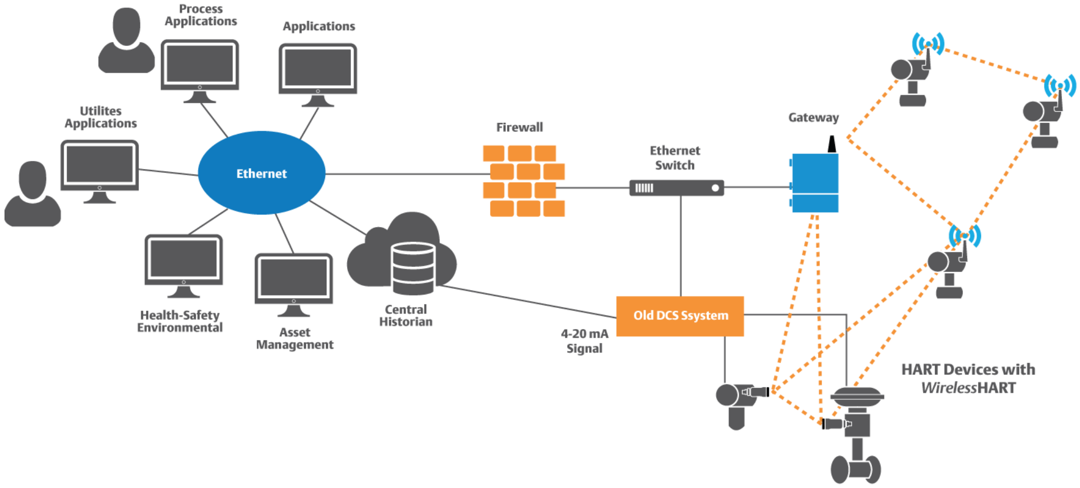
Integration of data originating from the wireless Gateway into a host control system is normally performed in one of two ways - through native connectivity directly to the host system or using standard protocols such as Modbus or OPC.

For native connectivity including vendor specific I/O cards, contact the host vendor.

OPC and Modbus are non-proprietary protocols and use standard data exchange and integration techniques to map data from the Gateway into the host control system. Typical data that is mapped to the host are process variables (PV, SV, TV, QV), time stamps (if using OPC), and overall device status. Diagnostic information is typically passed to an asset management system via Ethernet. Check with the Gateway vendor for compatible asset management packages.

Often, existing host systems can be a combination of legacy DCS and PLC components and modern data management solutions such as data historians. *Wireless*HART Gateways should support multiple connections into multiple host systems over multiple protocols. This enables *Wireless*HART networks to support modernization of an existing host system. For example, suppose the existing DCS has no spare capacity and can only receive the 4-20 mA signal from wired HART devices. A *Wireless*HART network could be connected to the DCS to bypass the need for more Analog Input Cards to receive more process variables, while in parallel, HART diagnostics flow to an asset management program from existing wired HART devices with *Wireless*HART adapters. This type of modernization project could enable incremental modernization with an older host system and when the scheduled turnaround occurs to upgrade the DCS, the existing *Wireless*HART networks would transition to the new host system (see Figure 12-3 for an example transitional architecture).

Figure 12-3. *Wireless*HART Gateway to Bridge Information from Non-HART Host



A key output from working with host system administrators is an integration strategy to incorporate a plant-wide wireless infrastructure. If doing a small application, a key output is the physical locations of where to connect the Gateways. These will be needed for the network design process.

Key outputs for network design include:

- Identifying a host system administrator and system integrator who supports integration of *Wireless*HART data into the host system
- Potential physical connection points for *Wireless*HART Gateways

12.4 Interoperability

Converting *Wireless*HART data from the Gateway into standard protocols like Modbus and OPC ensures interoperability of all *Wireless*HART networks with all host systems. Host systems based on proprietary protocols will be more difficult to implement, maintain, and expand.

12.5 Host system support for *Wireless*HART functionality

A *Wireless*HART Gateway typically performs all management of the *Wireless*HART network and manages communications to and from the *Wireless*HART field devices. The host system should not require any special software to support the *Wireless*HART field network.

12.6 Device descriptions files (DD)

Host system, asset management system, or a handheld field communicator to communicate with a device needs to know the type of data exchange that takes place between host and device. It is also essential to know how to represent it on the user interface. DD file for the device provides this function.

*Wireless*HART DD files can be downloaded from the following HCF link:

HartCommProduct.com/Inventory2/index.php?action=list

12.7 Configuration tools

*Wireless*HART devices are based on the HART protocol; therefore, existing HART Field Communicators will work for configuration of the field devices. Field Communicators will require the proper device descriptor for configuration, which is the same for any other new HART device, wired or wireless. Host system configuration will be dependent on the host system. HART vendors with asset management software may extend the benefits of remote management from wired HART to *Wireless*HART devices connected to the Gateway.

12.8 Control system graphics

Not all data collected from the *Wireless*HART field network belongs on the operator screen as part of control system graphics. The risk is that non-pertinent information distracts the operator from critical information.

The host system integration should be configured such that data from a *Wireless*HART field network is delivered to the proper end-user even though network resources are shared. To give some examples:

- Data collected on consumption of power from rotating equipment should go to the utilities manager.
- Data collected on vibration spectrums of rotating equipment should go to asset management.
- Data collected on temperature alarms for rotating equipment should go to operators in a non-obtrusive way and to the reliability manager.

Properly defining an integration strategy will ensure an efficient collection of data from *Wireless*HART network and dissemination to proper end-users. Many end users are not typically receptive of the benefits of automation and have application specific databases into which data is manually collected and uploaded. With the ability to integrate *Wireless*HART data using standard interface protocols, these existing end-user specific databases can be automatically populated.

12.9 Node addressing and naming conventions

A *Wireless*HART device should follow naming conventions of wired HART devices.

12.10 Alarms and alerts

Alarms and alerts should be directed to the appropriate end-user and their associated application and software. Alarm and alert dissemination should be reflective of the end user and their responsibility. For more details refer to "Alarm recommendations for process plant" on page 43.

12.11 Maintenance station and asset monitoring

*Wireless*HART devices provide internal diagnostics and process variables like any wired HART device. Additional local diagnostics for network connectivity should be accessible locally via a HART Field Communicator with the correct Device Descriptor for the *Wireless*HART field device.

The *Wireless*HART Gateway should also provide additional diagnostics for network performance. The data from *Wireless*HART devices will not propagate to the host system if the data is deemed questionable from either a HART diagnostic or due to an extended delay in reception at the Gateway from the *Wireless*HART field device. The Gateway can notify the host system if communication problems exist. Additionally, the Gateway is responsible for *Wireless*HART network management and network diagnostics.

Diagnostics between the Gateway and the host system will depend on the host system and the Gateway.

12.12 Historian

Historic data collection can be treated the same as any conventional source (e.g. OSIsoft PI or any DCS historian package).

Section 13 Documenting in Intergraph SPI 2009

13.1 Section overview

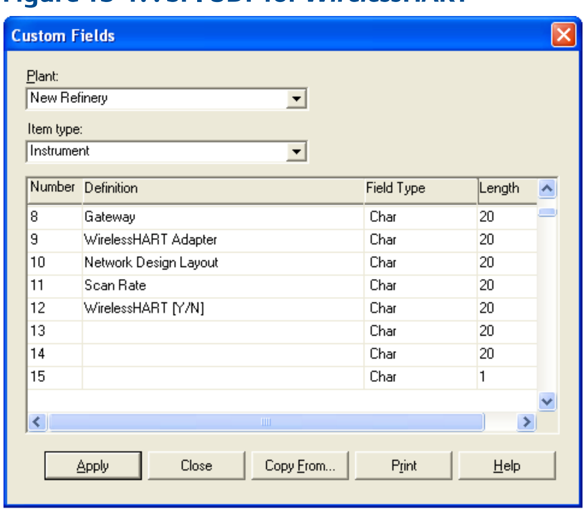
*Wireless*HART® devices can be fully documented in Intergraph SPI with minimal customization. Below is an example of how to document *Wireless*HART in a logical, linear order and assumes the reader is skilled in working with Intergraph SPI. This is just an example to illustrate the methodology. Ultimately, it is the responsibility of project management to create and reinforce the application of standards and guidelines within the project environment.

13.2 User defined fields (UDF)

The first step is to create user defined fields that allow for the accounting of *Wireless*HART engineering parameters that are necessary for defining whether a point is wireless and how that point will be connected to a network.

Global UDFs should be created as illustrated in Figure 13-1.

Figure 13-1. : SPI UDF for *Wireless*HART



Type refers to the type of value that can be entered for the value of the UDF. In the case of all the *Wireless*HART parameters, these are all just CHAR (or characters, also meaning text). Likewise, the length refers to the max length that can be entered into the field

Detailed definitions of *Wireless*HART SPI UDFs are presented in Table 13-1.

Table 13-1. Definitions for *Wireless*HART SPI UDFs

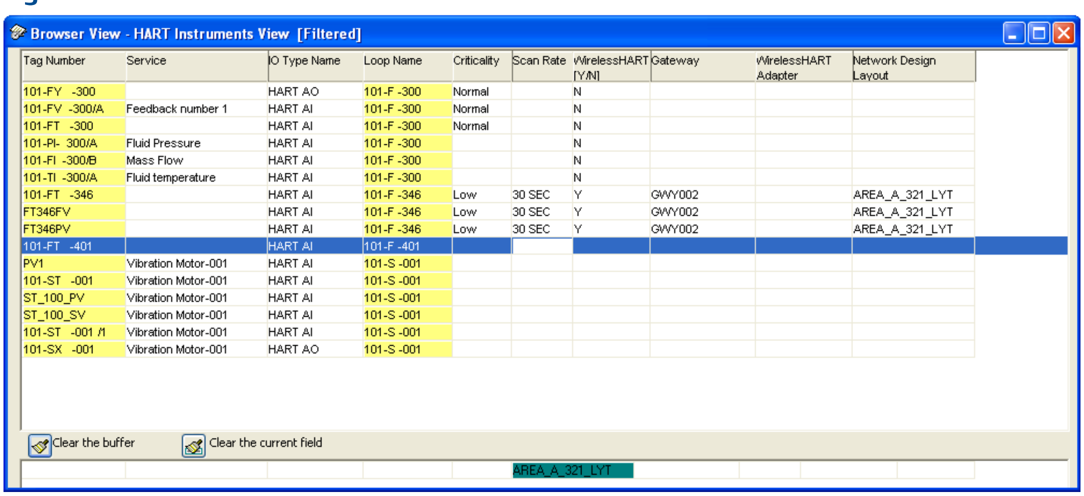
UDF	Field type example	Purpose
*Wireless*HART (Y/N)	Char Y	Identify a point as wireless at a high level. Will be used for quickly applying design guidelines to determine what is and what is not wireless.
Update Rate	Char 1, 2, 4, 8, 16, 32, 64+	*Wireless*HART devices will not all scan at 1 second like wired HART® devices. This value will be important for determining what devices may be *Wireless*HART as well as setting configuration parameters.
Gateway	Char GWY002	Defines which Gateway a *Wireless*HART device is to be associated.
*Wireless*HART Adapter	Char WHA001	Defines which *Wireless*HART adapter a wired HART device is associated with if a device does not have integrated *Wireless*HART capability.
Network Design Layout	Char A101.DWG	This is a reference field to a drawing or document that was used to validate network design best practices.

If the user chooses, SPI rules can be created such that these custom fields only appear for points that are HART or checked to be *Wireless*HART. This minimizes exposure to non-pertinent information for non- *Wireless*HART devices.

13.3 Filtered views

A custom view of the Instrument Index will be useful for applying design guidelines for selecting the instruments that are to be wireless as well as for seeing the organization of networks. Figure 13-2 is a sample view leveraging the UDFs shown in the previous section.

Figure 13-2. Custom View of SPI's *Wireless*HART UDFs


Browser View - HART Instruments View [Filtered]

Tag Number	Service	IO Type Name	Loop Name	Criticality	Scan Rate	WirelessHART [Y/N]	Gateway	WirelessHART Adapter	Network Design Layout
101-FY -300		HART AO	101-F -300	Normal		N			
101-FV -300/A	Feedback number 1	HART AI	101-F -300	Normal		N			
101-FT -300		HART AI	101-F -300	Normal		N			
101-PI- 300/A	Fluid Pressure	HART AI	101-F -300			N			
101-FI -300/B	Mass Flow	HART AI	101-F -300			N			
101-TI -300/A	Fluid temperature	HART AI	101-F -300			N			
101-FT -346		HART AI	101-F -346	Low	30 SEC	Y	GWY002		AREA_A_321_LYT
FT346FV		HART AI	101-F -346	Low	30 SEC	Y	GWY002		AREA_A_321_LYT
FT346PV		HART AI	101-F -346	Low	30 SEC	Y	GWY002		AREA_A_321_LYT
101-FT -401		HART AI	101-F -401						
PV1	Vibration Motor-001	HART AI	101-S -001						
101-ST -001	Vibration Motor-001	HART AI	101-S -001						
ST_100_PV	Vibration Motor-001	HART AI	101-S -001						
ST_100_SV	Vibration Motor-001	HART AI	101-S -001						
101-ST -001 /1	Vibration Motor-001	HART AI	101-S -001						
101-SX -001	Vibration Motor-001	HART AO	101-S -001						

Clear the buffer
Clear the current field
AREA_A_321_LYT

The “Criticality” and “Update rate” are foundations for any engineering guidelines that determine whether a device is *Wireless*HART. Some low criticality loops may have update rates faster than four seconds; include these with the design guidelines. Note that because *Wireless*HART devices primarily run on batteries, *Wireless*HART may not be suited for all fast update rate applications.

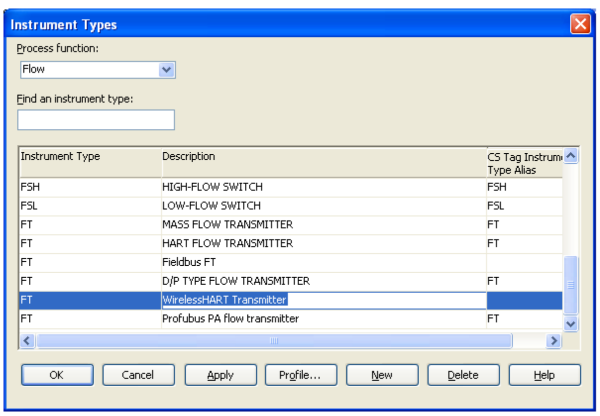
At a high level, using the “Criticality” and “Update Rate”, engineers can determine whether a device should be *Wireless*HART. If wireless, the device will need to be associated with a Gateway. If a device can only be specified as a wired HART device and requires a *Wireless*HART adapter, then the “*Wireless*HART Adapter” tag information should be defined.

Validate every *Wireless*HART field network against network design best practices. “Network Design Layout” provides a reference field to link to the drawing on which network design best practices were checked.

13.4 Creating instrument types

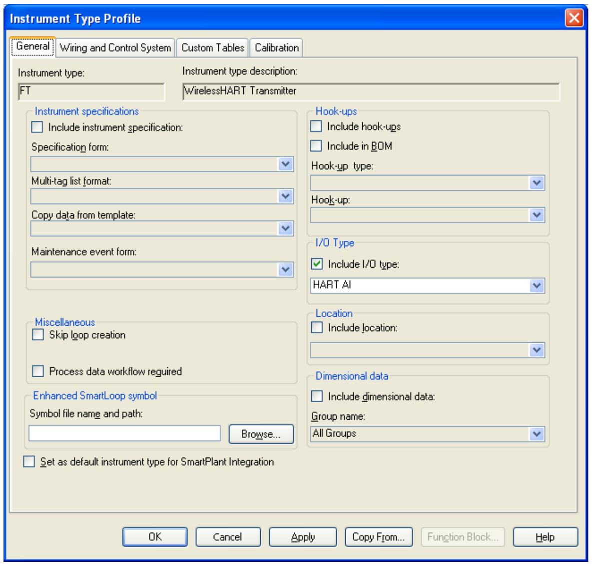
Early in the process, define symbols and instrument types and develop a *Wireless*HART instrument library. Figure 13-3 illustrates the basic modifications to a HART device to create a *Wireless*HART instrument type.

Figure 13-3. Defining *Wireless*HART Instrument Type In SPI



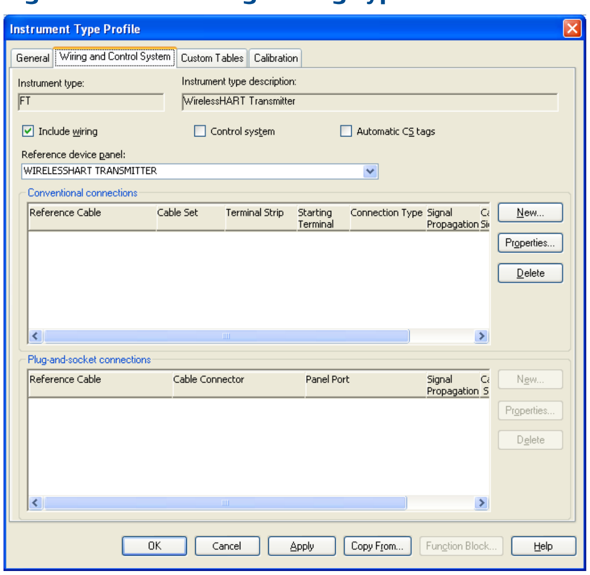
The first step is to create a new device with a new description. In this example, a *Wireless*HART flow transmitter is created. Please note that if the device will be specified as a wired HART device with a *Wireless*HART adapter, no new instrument types are necessary

Figure 13-4. Defining a New *Wireless*HART Instrument in SPI



Nothing needs to change on the general tab. Be sure to leverage that the device is a HART AI or a HART AO so that all of the basic parameters of HART apply. Manage the wiring, or lack of wiring separately. The fact that *Wireless*HART is based on HART allows leverage of these pre-defined variables.

Figure 13-5. Defining Wiring Types in SPI

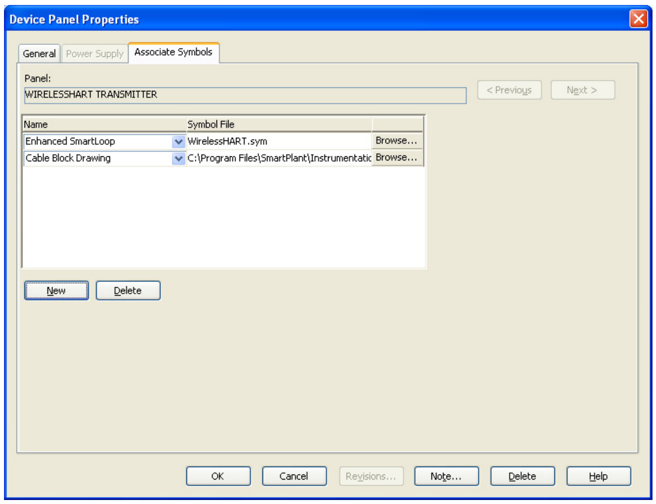


Check the box to include the wiring. If this box is not checked when SPI generates loop drawings, the device cannot be added to loop drawings. This also allows for flexibility for different wiring configurations, to be defined elsewhere. Examples include wiring *Wireless*HART adapters in series with the loop and line power for *Wireless*HART devices.   This process should be repeated for each unique *Wireless*HART instrument type.

There are only two instrument types that are unique to *Wireless*HART and could be considered ancillary - the *Wireless*HART Gateway and the *Wireless*HART adapter. To create these instrument types, it is recommended to use the symbols YG for a *Wireless*HART Gateway and YO for a *Wireless*HART adapter.

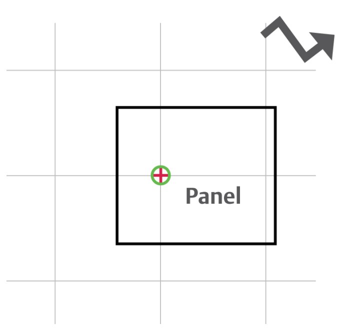
Once the instrument type is defined, the device panel properties can be modified to include reference symbols. It is recommended to assign symbols for both the Enhanced SmartLoop and the cable block drawing.

Figure 13-6. Assigning Symbols In SPI

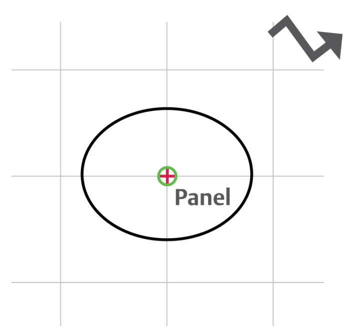


Basic symbols can be created in SPI using the editing tools. Below are examples for *Wireless*HART field devices and a *Wireless*HART Gateway. The zig-zig symbol shown below is defined by ISA. For more documentation, nothing special is required since signaling is typically not well indicated. For auto-generated documents, it may be useful to include the update rate by referencing the UDF, although this is not an absolute requirement. Most importantly, the project management team decides on a symbol convention and remains consistent throughout the project.

***Wireless*HART Gateway Symbol**



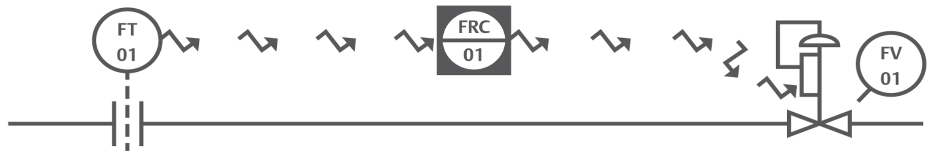
***Wireless*HART Device Symbol**



*Wireless*HART devices can be connected to a *Wireless*HART Gateway using the User Defined Field. This type of drawing does not show the path through the *Wireless*HART network, but does show the relationship of the *Wireless*HART device and the *Wireless*HART Gateway; Figure 13-7 is an example from the ISA-5.1.

Figure 13-7. ISA 5.1 Drawing Example

B.9.5 Shared Display, Shared Control and Wireless Instrumentation:



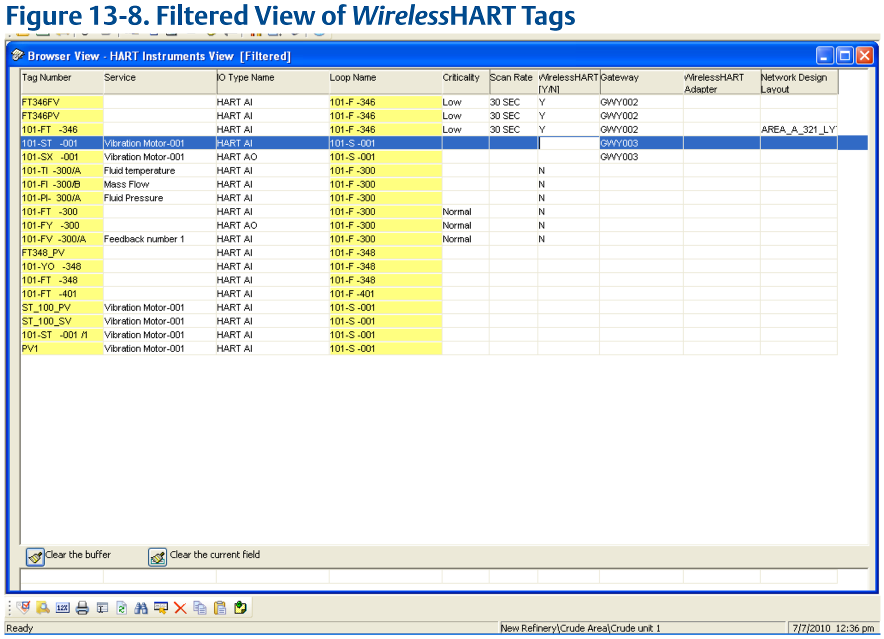
Note that inclusion of update rates and the wireless signal symbol are optional. The authors of this document found the practice of including such information supportive of adopting and managing the unique attributes of *Wireless*HART.

13.5 Loop drawings

Given that *Wireless*HART field devices do not require signal cabling, the documentation of the equivalent of wireless loop drawing is very simple to create.

The key information is to relate each wireless field device to the respective Gateway. It is recommended that a basic wireless loop drawing show the traditional tag information as well as the *Wireless*HART UDFs. This way, it is very clear to see which wireless devices are associated to which *Wireless*HART Gateway. Currently, Intergraph SPI 2009 does not have the means to implement this in a specific drawing, thus it is recommended to use the Instrumentation Index showing the *Wireless*HART UDFs.

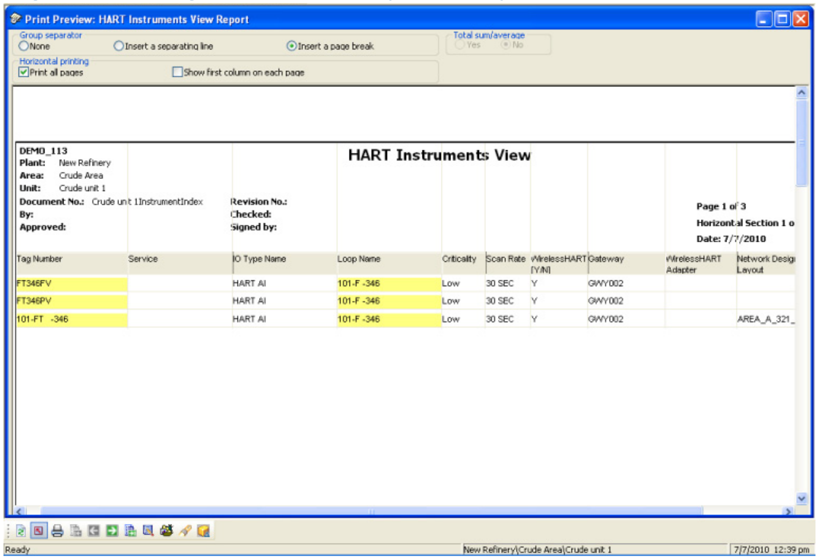
Figure 13-8. Filtered View of *Wireless*HART Tags



Tag Number	Service	IO Type Name	Loop Name	Criticality	Scan Rate	WirelessHART [Y/N]	Gateway	WirelessHART Adapter	Network Design Layout
FT346FV		HART AI	101-F -346	Low	30 SEC	Y	GWY002		
FT346PV		HART AI	101-F -346	Low	30 SEC	Y	GWY002		
101-FT -346		HART AI	101-F -346	Low	30 SEC	Y	GWY002		AREA_A_321_LY
101-ST -001	Vibration Motor-001	HART AI	101-S -001				GWY003		
101-SX -001	Vibration Motor-001	HART AO	101-S -001				GWY003		
101-TI -300/A	Fluid temperature	HART AI	101-F -300			N			
101-FI -300/B	Mass Flow	HART AI	101-F -300			N			
101-PI- 300/A	Fluid Pressure	HART AI	101-F -300			N			
101-FT -300		HART AI	101-F -300	Normal		N			
101-FY -300		HART AO	101-F -300	Normal		N			
101-FV -300/A	Feedback number 1	HART AI	101-F -300	Normal		N			
FT348_PV		HART AI	101-F -348						
101-YO -348		HART AI	101-F -348						
101-FT -348		HART AI	101-F -348						
101-FT -401		HART AI	101-F -401						
ST_100_PV	Vibration Motor-001	HART AI	101-S -001						
ST_100_SV	Vibration Motor-001	HART AI	101-S -001						
101-ST -001 /1	Vibration Motor-001	HART AI	101-S -001						
PV1	Vibration Motor-001	HART AI	101-S -001						

This list can then be filtered and printed by Gateway. A key piece of information is the link to a drawing verifying that best practices have been verified which can also include physical instrument location.

Figure 13-9. Tag View Filtered By Gateway



13.5.1 Loop drawings for *Wireless*HART adapters

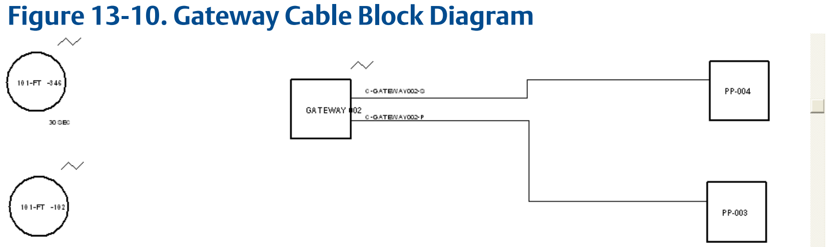
A *Wireless*HART adapter is an accessory to a loop and should be treated as a loop accessory like a multiplex or transient protection. Loop accessories are traditionally not indicated on the loop drawing and are installed on site. It is recommended for simplicity that there are no modifications for the loop drawing of a wired HART device to reflect the presence of a *Wireless*HART adapter.

The *Wireless*HART adapter would be properly documented and accounted for on the Wireless Loop Drawing that shows the Gateway and all associated *Wireless*HART devices.

13.5.2 Gateway cable block drawings

A useful drawing to create is a Gateway cable block drawing (refer to Figure 13-10) showing the Gateway power and communication connections. All *Wireless*HART Gateways, regardless of vendor, should have uninterruptable power supplies to maximize system reliability.

Figure 13-10. Gateway Cable Block Diagram



In addition to a cable block diagram, another useful drawing could show all Gateways assigned to an area on the same document.

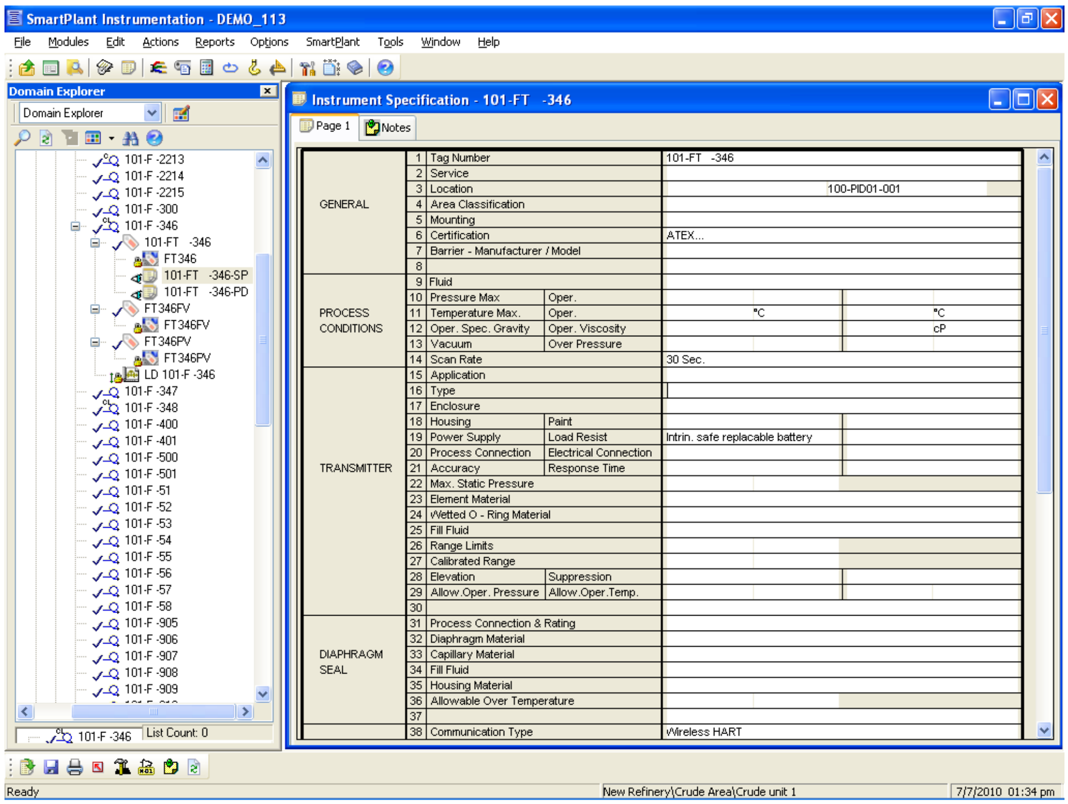
Table 13-2 documents *Wireless*HART configuration parameters.

Table 13-2. *Wireless*HART Configuration Parameters

Specification field	Typical value
Update rate	4, 8, 16, 32, 64+
Power supply	Intrinsically safe, field replaceable battery
Communication type	*Wireless*HART

Since *Wireless*HART is derived from wired HART, other specification fields should be completed as if it is a wired HART device.

Figure 13-11. *Wireless*HART Instrument Specification Sheet



13.6 Drawings in smart plant layout (SPL)

All *Wireless*HART devices can be indicated in drawings without deviation from the practices used for wired HART devices.

*Wireless*HART Gateways should be located according to the network design guidelines.

13.7 Documenting security information

The *Wireless*HART security parameters of Network ID and Device Join Key(s) should not be a part of a wireless loop drawing or in the SPI design environment. These are security parameters used to protect the network and should be managed per a local security policy implemented by the Owner/Operator. The Network ID and Device Join Key(s) are not required for the design. The wireless loop drawing associates the WirelessHART device with the *Wireless*HART Gateway tags. Separately, secure documents containing WirelessHART security provisioning including the *Wireless*HART Gateway tag can be used to cross reference the Network ID and Join Key(s). Remember, all Network IDs and common Device Join Keys (if used) should be unique for every Gateway and every *Wireless*HART field network. This type of security management is similar to the management of security information for control systems and servers.

Appendix A Example ISA Specifications

A sample specification for a *Wireless*HART® Gateway is shown below.

Figure A-1. ISA Sample Wireless Gateway Specification Sheet

RECEIVER INSTRUMENTS (Wireless Gateway)				SHEET ____ OF ____	
NO	BY	DATE	REVISION	SPEC. NO.	REV.
				CONTRACT	DATE
				REQ. P.O.	
				BY / CHK'D	APPR.

	1	Tag No.	Service
GENERAL	2	Function	Record ☐ Indicate ☐ Control ☐ Blind ☐ Integ ☐ Deviation ☐ Other IEC 62591 wirelessHART Network Administration/Setup
	3	Case	MFR STD ☒ Nom Size 229mmX283mm Color: MFR STD ☒ Other Blue
	4	Mounting	Flush ☐ Surface ☐ Rack ☐ Multi-Case ☐ Other Field mounted with or without remote antenna For Multiple Case, See Spec. Sheet
	5	Enclosure Class	General Purpose ☐ Weather Proof ☒ Explosion-Proof ☐ Class Class I Div II For Use in Intrinsically Safe System. ☐ Other IEC 62591 wirelessHART field Network
	6	Power Supply	117 V 60Hz ☐ Other ac ____ dc ☒ 24 Volts
	7	Chart	____ Strip ☐ ____ Roll ☐ ____ Fold ☐ Circular ____ Time Marks ____ Range ____ Number ____
	8	Chart Drive	Speed ____ Power ____
	9	Scales	Type ____ Range 1 ____ 2 ____ 3 ____ 4 ____
CONTROLLER	10	Control Modes	P = Prop (Gain), I = Integral (Auto Reset), D = Derivative (Rate), Sub: s = Slow, f = Fast P ☐ PI ☐ PD ☐ PID ☐ I_f ☐ D_f ☐ I_s ☐ D_s ☐ Other ____
	11	Action	On Meas. Increase Output: Increases ☒ Decreases ☐
	12	Auto-Man Switch	None ☐ MFR STD ☐ Other ____
	13	Set Point Adj.	Manual ☐ External ☐ Remote ☐ Other ____
	14	Manual Reg	None ☒ MFR STD ☐ Other ____
	15	Output	4-20 mA ☐ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☒ Other OPC, Modbus RTU, Modbus TCP, HART, HTML
INPUTS	16	Input Signals	4-20 mA ☐ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other IEC 62591 wirelessHART
	17	No. of Inputs	1 ☐ 2 ☐ 3 ☐ 4 ☐ X 100 devices
	18	Power for XMTRS	External ☒ This Inst ☐ No. of Independent Supplies ____ For Transmitters. See Spec Sheet. ____
ALARMS	19	Alarm Switches	Quantity ____ Form ____ Rating ____
	20	Function	Meas. Var. ☐ Deviation ☐ Contacts To ____ On Meas ____ Other ____
	21	Options	Filter-Reg ☐ Supply Gage ☐ Charts ☐ Int. Illumination ☐ Other Multiple Ethernet connections, remote mount antenna, additional output protocols, additional hazardous area approvals
	22	MFR & Model No.	____

Notes:

1. Support device burst (scan) rates from 4 seconds to 60 minutes.

ISA Form S20.1a

Appendix B Design Resources

B.1 Section overview

*Wireless*HART® vendors develop network design tools to support:

- Network design
- Gateway capacity planning
- Battery life estimation by device type

Below are known network design tools. Contact your *Wireless*HART vendor for more information.

B.1.1 Network design tools

Wireless planning tool

Use this tool to upload an aerial image of plant (or a segment of a facility) and design a wireless network. The wireless planning tool checks the wireless network for compliance with industry best practices.

AMS™ Wireless SNAP-ON™

Use this automated tool for designing and testing network design, and also to monitor networks after installation.

- Click here for more information.

Emerson Process Management™ power module life estimator

Use this tool to estimate battery life by wireless device type, factoring in update rate and environmental variables.

- Click here to access the tool.

Emerson Smart Wireless estimator

Use this tool to estimate and compare cost and time savings for wired verses wireless automation.

- Click here to access the tool.

Emerson Smart Wireless tools and resources

Current and future tools and resources can be found by clicking here.

Appendix C Wireless Spectrum Governance

Wireless applications have been deployed in the process industry for over 40 years. In any process facility, applications exist using RF signals including personnel communications, RF ID systems, ad hoc systems, and cell phones. The essential ingredients that have made wireless automation feasible were solving the problems of power to enable devices to operate on batteries for multiple years; self-mitigating RF obstacles in the process environment so expert wireless knowledge was not a requirement for adoption; and coexisting with other RF sources.

*Wireless*HART® operates in the 2.4 GHz Industrial, Scientific, and Medical (ISM) radio band that typically operates from 2.400-2.480 GHz. The exact frequency limitations and RF output power levels may be slightly different country by country. *Wireless*HART employs limitations that allow for universal operation in almost all countries with exceptions being noted for specific products by device manufactures. The ISM radio bands are license-free, but do require approval from governmental regulating agencies. These approvals are typically obtained by the *Wireless*HART vendor. Since vendors for multiple applications can use the same spectrum, *Wireless*HART must be able to successfully coexist.

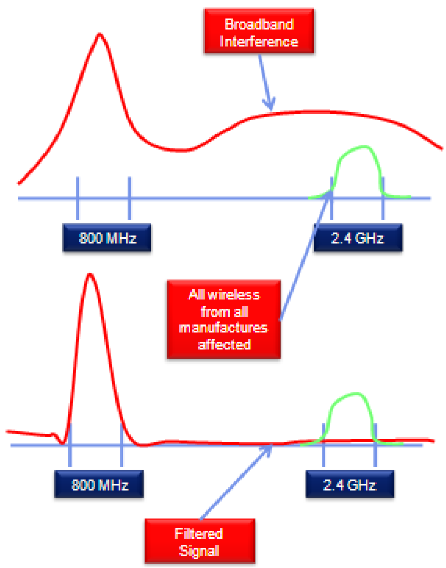
*Wireless*HART uses multiple techniques to coexist with other wireless applications:

- Network segmentation – allows thousands of *Wireless*HART devices to exist in the same physical space, provided each network has a unique network ID.
- Spectrum isolation – wireless applications in different portions of the RF spectrum do not “see” each other and thus do not interfere with each other.
- Low power – *Wireless*HART devices are very low power relative to handheld personnel communicators, Wi-Fi, and RFID readers. This helps prevent *Wireless*HART interference with these high power applications.
- Spatial hopping – self-organizing mesh networks can hop on different paths that may be exposed to different RF conditions. The *Wireless*HART devices self-organize paths through the process environment that mitigate RF obstacles the same way as physical obstacles.
- Channel hopping – *Wireless*HART devices use 15 channels within the 2.4 GHz spectrum. Pseudo-random channel usage ensures that interference on one or several channels does not prevent reliable communications.
- DSSS coding – allows transmissions to be modulated with unique encoding for the purposes of jamming resistance, channel sharing, and improved signal/noise level. DSSS Coding extends radio receiver sensitivity through digital processing.
- Time Synchronized Mesh Protocol (TSMP) – provides the synchronized time slots which schedule coordinated network communication, only when required in order to preserve battery life and reduce interference.

Despite these coexistence features, it is still beneficial to have some form of wireless governance. *Wireless*HART can be interfered with, but only under severe conditions that likely will disrupt all wireless applications operating in the 2.4 GHz spectrum such as Wi-Fi and Bluetooth®.

A key example is broadband interference. Many legacy wireless systems have high power. As an example, consider a personnel communication system using high power two-way radios operating in the 800 MHz frequency range. Although the system is legal and operating according to specifications, it can emit broadband interference that spans several GHz in the spectrum. This broadband interference then affects all applications in other RF bands by reducing the signal-to-noise ratio. The simple solution is to place a band pass filter on all systems such that they only emit RF energy in the spectrum licensed for usage. See the illustrative diagram below showing broadband interference before and after the implementation of a low pass filter.

Figure C-1. Installing a Low-Pass Filter



Most government agencies make the licensing of high power radios public information since there is the potential to interfere with private and public entities other than the licensee. In the United States, the federal government makes all licensed radios searchable at http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp. If a facility has licensed radios, efforts should be made to verify low-pass filters are in place on high powered system in all RF bands. The regulations were created before the advent of low-power systems, including Wi-Fi, and future consideration was not given to coexistence of low power with high power systems. Other countries are also likely have a similar type of searchable database.

Installing passive low pass filters is straight forward and typically requires insertion of the filter in series with existing RF cabling and proper resealing of RF connections. All existing wireless will benefit by the installation including Wi-Fi.

The emerging 802.11N Wi-Fi standard may emit broadband interference if operating a non-802.11N application in the 2.4 GHz ISM radio band. Relative to 802.11B or 802.11 G which use a single Wi-Fi channel (typically 1, 6, or 11 in North America), 802.11N will use multiple adjacent channels to enable increased bandwidth for demanding applications such as bulk data transfer, security cameras, and streaming video. 802.11N can be operated in either the 2.4GHz ISM band or the 5.8 GHz ISM band. Operation in the 5.8 GHz band applies the principle of spectrum isolation and comes with the additional advantage that 5.8 GHz RF signals can transfer information much faster than 2.4 GHz RF signals due to the much faster modulation.

Another emerging standard is Wi-Max, which operates in the 2.3 GHz, 2.5 GHz, or 3.5 GHz radio bands. Although these spectrums do not overlap the 2.4 GHz spectrum, there are no provisions in the Wi-Max standard to adopt or enforce the usage of low-pass filters in either clients or Access Points. The high power of Wi-Max has the potential to interfere with all wireless applications specifically designed for operation in the 2.4 GHz spectrum. Wi-Max clients should have limited deployment in or near the process facility. Installing passive low-pass filters on each segment of a Wi-Max antenna will further mitigate potential interference problems.

Aside from managing potential broadband interference sources, below is a summary of key considerations for wireless governance:

- A local wireless governance policy should serve the purpose of documenting all wireless sources in a plant and enforcing best practices for wireless coexistence.
- Enforce proper installation and compliance with regulation for all wireless applications with regards to power levels, spectrum usage, and encryption in accordance with government regulation.
- Provide guidelines for wireless applications spectrum usage.
  - Limit 802.11N Applications to 5.8 GHz ISM radio band.
  - Use low-pass filters on all high-power RF systems.
  - Put high bandwidth wireless applications such as security cameras in the 5.8 GHz radio band.
  - Ensure all RF coaxial cables are properly installed with weather sealant tape or comparable method to mitigate reduction in performance due to exposure to the environmental elements.
- Support proper segmentation of *Wireless*HART networks.
  - Every network in the process facility should have a unique Network ID and Join Keys.
  - *Wireless*HART networks can overlap in the same physical space without causing interference problems with each other. Gateway antennas should be installed at least 1 meter apart.

Appendix D References

Topic	Reference
*Wireless*HART®	FieldComm Group™: en.hartcomm.org/hcp/tech/wihart/wireless_overview.html - Protocol Specifications, Overview, Member Companies *Wireless*HART: Real-Time Mesh Network for Industrial Automation www.amazon.com/gp/product/1441960465?ie=UTF8&tag=easydeltavcom-20&linkCode=as2&camp=1789&creative=9325&creativeASIN=1441960465, Comprehensive resource on *Wireless*HART
Security	ANSI/ISA-TR99.00.01-2007 – "Security Technologies for Industrial Automation and Control Systems" (ISA Technical Report provides an "assessment of various cyber security tools, mitigation counter-measures, and technologies..." as of the publish date) www.isa.org/Template.cfm?Section=Standards2&template=/Ecommerce/ProductDisplay.cfm&ProductID=9665 DHS – Main Control Systems Security Program (CSSP) website: http://www.us-cert.gov/control_systems (An actively supported government resource for Industrial Control System security information, many links to other resources) DHS – Recommended Practice for Patch Management of Control Systems www.us-cert.gov/control_systems/practices/documents/PatchManagementRecommendedPractice_Final.pdf (an example of the Recommended Practices documents available) DOE – "21 Steps to Improve Cyber Security of SCADA Networks" (an oldie but a goodie) www.oe.netl.doe.gov/docs/prepare/21stepsbooklet.pdf Emerson™ Process Management– "DeltaV System Cyber-Security" www2.emersonprocess.com/siteadmincenter/PM%20DeltaV%20Documents/Whitepapers/WP_DeltaVSystemSecurity.pdf NISCC/BCIT – "Firewall Deployment for SCADA and Process Control Networks" (from 2005, but still a great reference) http://www.oe.energy.gov/DocumentsandMedia/Firewall_Deployment.pdf CPNI – "Deployment Guidance for Intrusion Detection Systems" (lots of good stuff from UK's Centre for the Protection of National Infrastructure) www.cpni.gov.uk/Documents/Publications/2003/2003011_TN1003_Intrusion_detection_deployment.pdf NIST – SP 800-53, Revision 3 "Recommended Security Controls for Federal Information Systems and Organizations" (this latest version includes Appendix I: Industrial Control Systems, Security Controls, Enhancements, and Supplemental Guidance) csrc.nist.gov/publications/nistpubs/800-53-Rev3/sp800-53-rev3-final.pdf NSA – "Defence in Depth" (excellent whitepaper on this important security concept) www.nsa.gov/ia/_files/support/defenseindepth.pdf NSA – "The 60 Minute Network Security Guide (First Steps Towards a Secure Network Environment)" (The NSA's Information Assurance website has a lot of useful information) www.nsa.gov/ia/_files/support/I33-011R-2006.pdf SANS – "20 Critical Security Controls – Version 2.0, Twenty Critical Controls for Effective Cyber Defence: Consensus Audit Guidelines" (note link to printer friendly version) www.sans.org/cag/

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