Solar Powered Oil Well Site

Final Project Report

ME 430 – Spring 2011

June 3, 2011

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Executive Summary

The need for grid power to operate the equipment of oil wells adds additional cost and wiring to oil fields across the country. Santa Maria Pacific Holdings of Santa Maria, California desired another way to power the sensor equipment at their wells along with the motors that powered each well. Furthermore, wireless data transmission of pressure and temperature data was desired to get more accurate information of the oil wells. A senior project group at Cal Poly San Luis Obispo was assigned the task of developing a piece of equipment that powered the sensors and motor of each well along with providing well data via wireless transmission.

After review of different solar options, it was considered too expensive to try and implement any solar option into the field. Furthermore, diesel generators were looked at as a possible alternative, but the steady manual attention that would be required for each generator was considered too much of a burden and unfeasible. With all options considered, Santa Maria Pacific Holdings decided to abandon this part of the project and focus solely on the wireless network for the field.

Research was conducted on individual sensors, power units, and transmitters to accomplish the objectives for the project. A full concept was developed that integrated a solar unit to power the pressure and temperature sensors and WiFi transmitter. It consisted of a housing for all of the necessary equipment that would be placed around the pipe coming from the well head. The data would be collected by the sensors and sent to the WiFi transmitter to be sent back to the field office.

However, after further investigation and research, an alternative solution was discovered. Process automation equipment offers battery powered transmitters that can automatically record pressure and temperature data and transmit the data back to another location. Other systems also exist that utilize separate battery packs, sensors, and radios for data transmission. This new find changed the scope of the project from building a workable prototype to determining the best type of sensor network for our application.

After reviewing many different network options, Santa Maria Pacific Holdings decided to implement the wireless mesh network produced by Rosemount. This network combines all necessary components (radio, sensor, and battery) into one unit. The units are part of a self-healing network that allows for reliable and efficient data transmission. The system is also easily expanded with additional sensors if desired. The system provides the most reliable network along with the leading manufacturer of sensors in the oil and gas industry, Rosemount. Implementation of the sensors is set for summer of 2011.

1. Introduction

CP Solar Wells is a group of Mechanical Engineering students from California Polytechnic State University in San Luis Obispo, California. As part of graduation requirements, the students must complete a capstone project that integrates theory and application from undergraduate educational experiences.

To complete this project, CP Solar Wells will be working with Santa Maria Pacific Holdings based out of Santa Maria, California. Santa Maria Pacific Holdings is an oil and gas company made up of several independent companies and consultants and is currently developing untapped oil and gas fields in Santa Barbara County. With an emphasis on innovation, Santa Maria Pacific Holdings looks to develop new technologies that can be used out in the oil field by all companies in the oil industry. As part of this innovation, CP Solar Wells has been asked to design and build a prototype for a Solar Powered Oil Well Site.

Currently, most oil well sites are run off electricity provided by the electrical grid. In order to reduce costs and leave a smaller energy footprint, Santa Maria Pacific Holdings wants to produce an oil well site that can be run off a renewable energy source such as solar power. CP Solar Wells will be responsible for designing a system that contains pressure and temperature gauges and can wirelessly transmit readings back to Santa Maria Pacific Holdings. The pressure and temperature gauges will also be located closer to the well head in order to collect more accurate data than is currently collected. This system will have to be durable and operate in an oil field with a coastal climate. Santa Maria Pacific Holdings will be the primary stakeholder behind this project and cover the costs of all materials needed.

The implementation of Solar Powered Oil Well sites will save Santa Maria Pacific Holdings the expense of connecting each well to the electrical grid, which can cost tens of thousands of dollars. Gas generators can also be used to power well sites, however noise pollution from these machines can be bothersome to those living or working nearby. It is important to Santa Maria Pacific Holdings to reduce noise pollution in order to preserve good relations with those living near well sites.

The addition of more accurate pressure and temperature data with wireless transmission back to Santa Maria Pacific Holdings' offices will help Santa Maria Pacific Holdings create a more detailed and reliable analysis of their wells. These improvements will allow Santa Maria Pacific Holdings to run each of their wells more efficiently, and identify problems faster.

All of these benefits suggest that solar powered oil wells will result in less spending, more oil production, and more profits for Santa Maria Pacific Holdings.

2. Background

During a personal meeting with Santa Maria Pacific Holdings, CP Solar Wells visited the Orcutt Oil Field to learn about the specifics of the project. The Orcutt field was founded in 1901 and is currently the largest onshore producing field in Santa Barbara County[1]. The field uses both primary and enhanced oil recovery (EOR) methods to extract oil and gas. The oil is primarily heavy with lighter oils found throughout the field and the wells are primarily shallow[1].

Figure 1: Primary pump in Orcutt oil field

Primary wells use standard beam pumping units for oil recovery, as seen in Figure 1. These units are smaller than the industry standard and use smaller motors powered off of the electrical grid. The pressures and temperatures found on the primary wells should be relatively low in comparison to those found at the thermal wells. The primary wells have to be turned on manually by a switch located about 50 feet from the well. These wells are diurnal and only operate during the daytime hours.

Thermal wells use steam injection to lower the viscosity of heavy oil for recovery. Steam is produced from a large steam generator and piped to all of the thermal injectors across the field. Thermal wells, such as the one seen in Figure 2, encounter much higher pressures and temperatures due to the injection of hot steam. The thermal wells continuously operate both day and night. Pressure gauges are currently attached to the well head while temperature and flow gauges have been placed downstream of the wellhead.

2.1 Applicable Standards

This project will require the use of electrical equipment such as the pressure and temperature sensors as well as a WiFi transmitter for the transmission of data from the well head. The equipment will be located on an active oil field and must meet safety requirements set forth by the American National Standards Institute (ANSI). As classified by ANSI, electrical equipment that is located in a hazardous location where ignitable concentrations of flammable gases, vapors, or liquids are present within the atmosphere are given the classification of Class I[2]. Whether the gases or liquids are present under normal or abnormal operating conditions is what determines if the equipment needs to be Division 1 or 2, respectively. Sensors located close to the wellhead must be able to withstand high pressures and temperatures. Oil fields can potentially be a dangerous place, especially with the possibilities of kicks and blowouts from the

Figure 2: Thermal well in Orcutt oil field with pressure sensor

wells. Since the equipment will be consistently operating close to the well head and flammable gases and liquids will be present, Class I Division 1 electronics should be used for this project.

The sensors and WiFi equipment will be operating in potentially harsh conditions in the oil field and such close proximity to the ocean. We have looked into sensors which have been built and designed specifically for the oil and gas industry to accommodate such environments.

Other standards we will have to look at include classifications of locations given by the American Petroleum Institute (API). The API Recommended Practice 500 provides guidelines for classifying locations at petroleum refineries, production and drilling areas, and pipeline transportation facilities for the selection and installation of electrical equipment.[3] Due to the limited time for research, the standards given by the API will have to be looked at more in depth at a later date. The classification of the location will effect what transmitter is used with the system as it must be able to transmit all data back to Santa Maria Pacific Holdings without interference from location obstacles.

2.2 Existing Products

Looking into different energy production methods, the weather of Santa Maria plays a key role in what possibilities exist. On average, Santa Maria has 176 clear days of sunshine and roughly 275 days of clear or partially cloudy weather a year[4]. The average solar radiation index is 5 kilowatts per meter squared per day[5]. This makes the opportunity for solar use plausible as this is sufficient energy to power the components necessary for a solar oil well. Wind speed in Santa Maria averages 3.2 meters per second[5]. Depending on the efficiency of wind production and the capability to produce sufficient power this may be another viable option to look into. More research will be conducted on this design possibility.

A short meeting was held with a representative from REC Solar, a company that produces and installs solar panels, like the ones in Figure 3, in San Luis Obispo, California[6]. It was estimated that each square foot of solar panels would be able to provide 2.5 Watts of power. This power would be sufficient to power the sensors and transmitter on both the primary and thermal projects. However, many solar panels would be required to power a 3 hp motor for the primary wells. Early calculations have shown that 3 hp is equivalent to 2250 Watts and that approximately 1,000 square feet of solar panels would be needed to accomplish this task. While the possibility exists to use this many solar panels to power the motor, the scope of this project will most likely not make the powering of the motor feasible. Furthermore, the cost of solar panels was estimated to be around 6 dollars per Watt produced. This means that total power consumption will be critical to keeping costs low.

Figure 3: Typical Solar Panels

While speaking to REC solar the team was comparing other means of acquiring the solar powered system. The three methods to choose from are purchasing through a solar installation company like REC,

purchasing a solar kit which fits our requirements, or individually purchasing each component of the system and building it ourselves. By comparing average costs of the systems we will determine which method will produce the best results for the project. A large expense for solar powered systems which we also want to address is the batteries which will be used. Most solar systems use absorbed glass mat (AGM) batteries which offer longer life and no memory effects which can be associated with NiH. The batteries which are being looked at are manufactured by Trojan and UPG which have been shown to be two of the leading manufacturers.

Similar technologies of using solar power in the oil fields were found to be used today but mainly in large solar fields that provided power to many rigs. Companies such as Chevron have invested billions of dollars into large solar fields to produce electricity for their equipment.[7] These fields can cover acres and take up a large amount of space. No information could be found about solar panels that were used to power individual well sites. The idea of using solar energy to power oil wells has definitely been considered but not at a level this project will be taking a look at. Wireless transmission of data from well sites is currently being researched by Dr. Mason Medizade of California Polytechnic State University in San Luis Obispo. A paper published on wireless surveillance by Dr. Medizade and his colleagues describes the components necessary to transmit data and explains the cost benefits of having such a system[8]. As this was one of the few sources that provided detailed information about wireless transmission of data, Dr. Medizade will be used as a resource throughout the project for further information on this topic.

2.3 Objectives

Our goal for this project is to design two solar powered well sites. The first design will be for a thermal well site, and will require pressure and temperature sensors at the well head, a method of transmitting this data to a central database, and a self-sustaining method of powering these components. In designing this system we will have to ensure that the pressure and temperature sensors are as close to the well head as possible. This is necessary to ensure that the data collected is reliable enough that it can be used for more accurate reservoir analysis. While the current position of these sensors is hundreds of feet from the well site, our goal is to place the new sensors within 20 feet of the site. As shown in the quality function deployment (QFD) chart (Appendix A), keeping the sensors as close as possible to the well head is one of our most important design requirements. QFD is a tool that translates customer's needs and expectations into quantifiably engineering requirements. Also shown in the QFD is a relationship between the distance away from the well head and the pressures and temperatures that our sensors will encounter. This relationship accounts for the inaccuracies in the data that is currently being collected by Santa Maria Pacific Holdings.

The second design will be for a primary well pump. Similar to the thermal site, this design will also require pressure and temperate sensors, however they will not operate under the same extreme conditions, and can be located a longer distance away from the well head. The primary well site also requires wireless transmission at a range of one mile.

Analysis was done on the pressure drop from the wellhead to the proposed location of the unit. The calculations include both major and minor losses due to friction from the piping, bends in the piping, and valves along the piping. These calculations along with a summary of the results are included in Appendix B. Using overestimates of the system parameters to insure all specifications will be met; the pressure drop from the well head to a location 50 feet away is around 3 psi. This leads us to believe that this is a suitable distance to not interfere with facilities while still providing reliable data.

Table 1 summarizes the technical specifications for the project. It lists the various parameters that need to be analyzed for this project as well as their target range, risk level, and how they will be checked for compliance. One of the highest risk items that we will encounter is the powering of the primary well. A 3 hp motor would require a large square footage of solar panels to produce sufficient power for operation. Whether or not these panels can be incorporated into the design with the other necessary components is a challenge due to the small size of the base unit.

Table 1 - Technical Specifications for Solar Powered Oil Well Site

Spec. #	Parameter Description	Target (units)	Tolerance	Risk	Compliance
1	Temperature	600 (F)	Max	M	S, I
2	Pressure	1500 (psi)	Max	L	S, I
3	Power (thermal)	3 (W)	Min	L	A, T, S
4	Power (primary)	2253 (W)	Min	H	A, T
5	Distance from well head	50 (ft)	Max	L	I
6	Transmission distance	1 (mile)	Min	M	T, S, I
7	Percent error of sensors	1 (%)	Max	L	S, I
8	Battery supply time (12V)	48 (hours)	Min	M	A, T, I
9	Weight	100 (lb)	Max	L	A, I
10	Size (w/o solar panels)	3 (ft^3)	Max	L	A, S, I
11	Installation time	8 (hours)	Max	L	A, T, S
12	Cost	8,000 (dollars)	Max	M	A, S
13	Component free radius	30 (ft)	Min	M	A, I
14	Efficiency	60 (%)	Min	M	A, T, S, I
15	Operating height	5 (ft)	Max	L	S, I

Legend

L – Low
M- Medium
H- High
A – Analysis
T – Test
S – Similarity to existing products
I - Inspection

3. Design Development

3.1 Initial Sketches

Over the course of the quarter, CP Solar Wells developed numerous ideas for the solar powered oil well site and the features that were necessary to make this concept a reality. The following figures display some of the ideas developed by CP Solar Wells. Figure 4 shows one of the initial concepts of the components necessary for this project. It is a simple layout of where the sensors, WiFi transmitter, battery, and solar panel were considered for placement. Aesthetics and other features were not considered at this time as a base model is all CP Solar Wells was looking for.

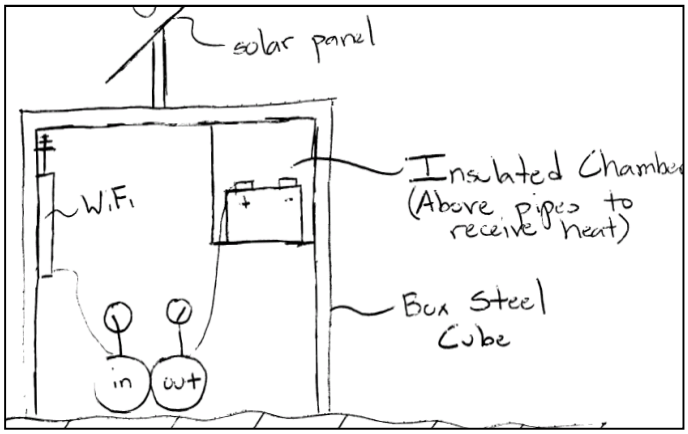

Figure 4: Initial Concept with Necessary Components

Next, CP Solar Wells began looking at additional features that were to be added to satisfy the rest of the project requirements. Figure 5 shows ways that would make the unit easy to transport. Handles were added to the side of the unit and wheels were added to move the unit from one location to another. To insure that the solar panel would always be in the best position to receive sunlight, ideas were generated to make the solar panel rotatable and angle adjustable. These drawings can be seen in Figure 6.

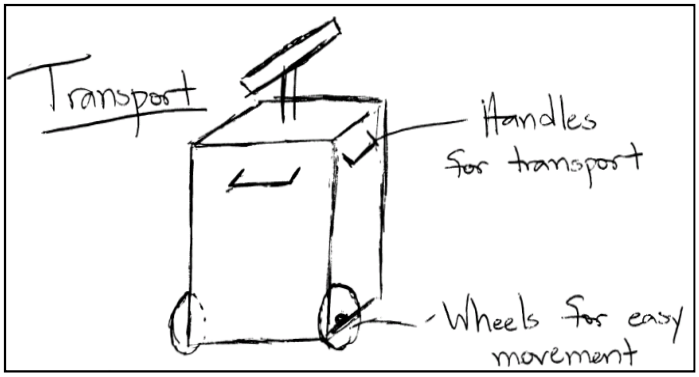

Figure 5: Concept Drawing with Transport Features

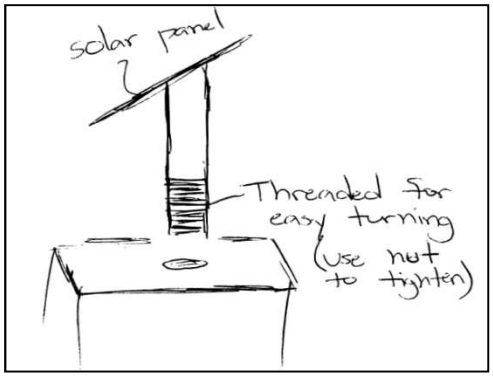

Figure 6: Concept Drawing with Solar Swivel

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Having the unit be able to attach to existing piping is critical for this project to work. Pipes in the field vary in height and our product needs to accommodate for the differences in pipe height. Brackets that could be placed at different heights as well as adjustable legs for the unit were considered for the design. Figure 7 shows how the adjustable bracket system would work. Sketches have continuously been drawn up as new ideas have been developed for this project.

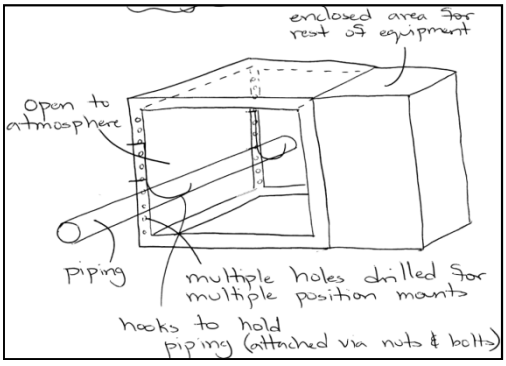

Figure 7: Concept Drawing with Adjusting Pipe Height

3.2 Idea Generation

Brainstorming sessions were held to develop other ideas that could be incorporated into the concept design. After the brainstorm, different ideas were selected to pursue further and more drawings were developed. Decision matrices were produced in order to narrow down similar ideas. These matrices typically compare different ideas against already existing products. Since there is no common solar powered oil site to compare against, ideas were judged against one another and given a score for different categories. The idea that received the highest score overall was chosen and worked into the design.

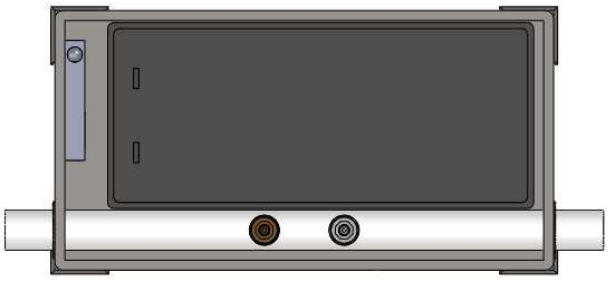

Figure 8: Top View of Initial Final Concept

Once our top ideas were selected through the use of the decision matrices, a final concept was established and drawn up in SolidWorks. Figure 8 shows a top view of what CP Solar Wells envisioned the solar powered oil well unit to look like. The design utilized a case that would contain the required components for the project: solar panel, battery, sensors, and WiFi transmitter. The case would protect the electrical components from weather and oil field elements.

3.3 New Research Findings for Sensors

After developing different concepts to obtain well data and transmit it back to the field office, new sensors were found that could accomplish both of these tasks. Additionally, these transmitters were powered by a battery pack that would be good for up to 10 years in the field. This took away the need to power the sensors via solar power. This greatly changed the scope of what we needed to accomplish as these transmitters took care of the wireless data transmission. The focus of the project turned to finding the best sensor network for our application along with a way to power the well motor by solar power. The following sections highlight the three main types of sensor networks found. Document Specifications for all components in these sections can be found in Appendix D.

3.3.1 Fixed Signal Network

Control Microsystems produces the Accutech line of pressure and temperature transmitters for oil field applications. These sensors utilize a radio to transmit data back to a receiver at a field office. The sensors and radio are powered off of an external battery that has a battery life of roughly 10 years. The life span of the battery can change depending on the rate the sensors take data measurements and send them back to the field office. A 1 minute update rate will result in a 10 year battery life. With separate components, replacing parts is rather easy if any part of the system ever were to fail.

Figure 9 - Accutech Wireless Pressure Transmitter

To transmit data back to the field office, measurements would be taken by the pressure and temperature sensors at the well head. These measurements would be sent to the radio to be sent directly back to the field office. Each well would have its own individual radio to transmit data. All of the radios would operate off of the same frequency. This would increase noise and interference in the field and could potentially cause problems with data transfer.

This network is not self-healing and may have challenges if obstacles ever were introduced to the radios line of sight. Blocking a radio's line of sight would interrupt the transfer of data back to the field office and up to date information would not be available until the obstruction was removed. There are still some questions to ask Control Microsystems about obstructions to line of sight, but they have confirmed that their products are not self-healing. The self-healing network is an important feature to consider when choosing the appropriate network type because it eliminates the chance of lost data and insures accurate data from the well head is always available.

This network is not the most ideal due to the lack of a self-healing network. The sensors and radios for this type of network are less costly than some of the other options but without the self-healing network, important data could be lost. Efficiency and reliability are a crucial component to this system and we want to minimize down time for the network. With only one path to and from the radio, there are greater chances of obstructions and down time. This is not a desired characteristic for a wireless system that will cost thousands of dollars.

3.3.2 Banner Network

Banner Sensors makes a wide variety of sensors for a multitude of industries. They have a custom set of wireless transmitters for oil field applications. These sensors utilize a radio to transmit data back to a receiver at a field office. The sensors and radio are powered off of an external battery that has a battery life of roughly 10 years. The life span of the battery can change depending on the rate the sensors take data measurements and send them back to the field office. A 1 minute update rate will result in a 10 year battery life. With separate components, replacing parts is rather easy if any part of the system ever

were to fail.

To transmit data back to the field office, measurements would be taken by the pressure and temperature sensors at the well head. These measurements would be sent to the radio to be sent directly back to the field office. Each well would have its own individual radio to transmit data. One of the main differences from the fixed signal network is that all of the radios operate on their own frequency. The gateway back at the field office cycles through the different frequencies and collects the data from each radio one at a time. This reduces the amount of noise and interference in the field.

Figure 10 - Banner Network Nodes and Gateways

Another difference is that this network is self-healing and would be able to get around obstacles if they ever were introduced to the radios line of sight. Blocking a radio's line of sight would interrupt the transfer of data back to the field office and up to date information would not be available until the obstruction was removed. With the self-healing network, and more directly the Banner network, the data would recognize it is being blocked and be sent to another radio to be sent back to the gateway. The self-healing network is an important feature to consider when choosing the appropriate network type because it eliminates the chance of lost data and insures accurate data from the well head is always available.

The Banner network would be a good choice for the wireless network system due to the self-healing network. Efficiency and reliability are a crucial component to this system and the Banner network would minimize down time.

3.3.3 Wireless Mesh Network

Rosemount sensors are largely considered the top quality of pressure and temperature transmitters for oil field applications. These sensors come fully equipped with a transmitter and battery all in one unit. The life span of the battery can change depending on the rate the sensors take data measurements and send them back to the field office. A 1 minute update rate will result in a 10 year battery life. With all components in one self-contained unit, adding additional devices to the network is just a matter of getting another sensor and putting it onto a well.

To transmit data back to the field office, measurements would be taken by the pressure and temperature transmitters at the well head. These measurements would be sent back to the field office by using other transmitters as repeaters and relaying the data until it reached its final destination. Each transmitter would have its own individual radio to transmit data. All of the radios would operate off of the same frequency. This would increase noise and interference in the field and could potentially cause

problems with data transfer.

This network is self-healing and would be able to get around obstacles if they ever were introduced to the radios line of sight. Blocking a radio's line of sight would interrupt the transfer of data back to the field office and up to date information would not be available until the obstruction was removed. With the self-healing network, and more directly the wireless mesh network, the data would find an alternate path using different transmitters to get back to the gateway at the field office. The self-healing network is an important feature to consider when choosing the appropriate network type because it eliminates the chance of lost data and insures accurate data from the well head is always available.

Figure 11 - Rosemount Wireless Pressure Transmitter

The wireless mesh network would be a good choice for the wireless network system due to the self-healing network. Efficiency and reliability are a crucial component to this system and the wireless mesh network would minimize down time.

3.3.4 Other Network Considerations

The three networks described above are the best options available for implementing a wireless data network for your oil field. However, other companies were contacted and more types of sensors were reviewed. These options were left out of this report due to their inability to meet the specifications for this project as well as not having the proven record of the companies described above. These companies included:

- ABB Instrumentation
- Omega Engineering
- Digi-Key
- Paine Electronics
- Systemation Incorporated

Many of these companies did not have wireless options available for their sensors and would require wiring throughout the field. Removing wiring from the field and having wireless data transmission was one of the main objectives for this project so not having wireless options made these companies less desirable.

Also, reliability is of extreme importance for this system. If thousands of dollars are going to be spent on components for the system, we want to make sure that everything works and works well. Control Microsystems, Banner, and Rosemount are proven and have much experience with oil field applications. The other companies are smaller and have been involved with oil field applications for a smaller amount of time. This is not to say that these companies could not get the job done, but for this network it is best

to go with experience and the companies who have been dealing with wireless networks for the longest amount of time.

The contact information for all of these companies, including the recommended companies, can be found in Appendix C of this report.

3.4 Motor Power Options

3.4.1 Powering Current Motor

The most economical way to power the current 3 phase 380 volt 3 horse power motor using solar panels would to incorporate a piece of a equipment called a Universal Pump Controller manufactured by AeroVironment, $10,000. Along with this piece of equipment there would be approximately 20 solar panels, $14,000, and racks. The installation for such a project would be $10,000. This number is on the lower end of installation cost because utilizing the pump controller eliminates many components which reduces the complexity of the system. This brings the total cost of the system to $34,000.

3.4.2 Changing to DC Motor

To change to a DC motor offers the most room for cost savings. DC motors typically have 7% better efficiency than AC motors in pumping application. This would allow for the removal of many components as well as an earlier start up time in the morning and later runtime in the evening. The solar panels produce DC current and if the motor is DC, this would allow for the elimination of 3 inverters. There would also be no need for batteries which can be a significant cost. The cost breakdown for the system would be 20 solar modules and racks, $14,000, controller, $5,000, Installation, $10,000, plus the costs for a new DC motor. A new 3 horsepower DC motor can range from $2,500-6,000. Estimating a $5,000 motor this project would cost $34,000. In order to better estimate the exact DC motor which would be necessary a further evaluation of motor requirements must be done.

3.4.3 Power Controller by AeroEnvironment

The Universal Pump Controller manufactured by AeroVironment is a unique piece of equipment. It allows for the elimination of batteries, inverters and a controller by combining these items all into a single package. The only caveat with this piece of equipment is that AeroVironment is in the process of discontinuing production. They are doing this because the manufacturing and design of components for electrical vehicles seems to be more lucrative that pump controllers. This severely hampers this possibility but it leaves room to explore options using similar technology to AeroVironments.

3.4.4 Diesel Generators

Diesel generators are an option being investigated to compare the costs of renewable sources versus the costs of what a traditional method might be. To quantify diesel generators into a few paragraphs is a difficult process because there are so many generators out there which could meet the project requirements.

Some portable generators which meet the requirements with the capability of power a 3 horsepower motor are made by Husky, Powermate, and ETQ. Evaluating the ETQ generator, it has a 3.2 gallon, 5,000 watt and capable of running 11 hours at 50% capacity with a cost of $1,200. To look at the fuel costs associated with this equipment it will be using 3.2 gallons of diesel/ day at a cost of $3.50/ gallon. This comes to $11.20/day to run the motor or $4,088/ year to run the motor. Something which also must be taken into consideration is the fact that these generators would have everything done to them manually. This means that each day there will have to be a worker to refill each one, turn it on and off, and change the oil and other maintenance on them. This will increase the costs of operation.

Permanent standby generators are at least twice as expensive and generally much larger. They are more difficult to move from well to well. They also require similar amounts of maintenance. These generators are not designed to run everyday so the life cycle could be relatively short.

4. Final Design

4.1 Sensor Network

After reviewing the three types of networks considered for this project, the alternatives with the self-healing network are the best options for Santa Maria Pacific Holdings. This insures the most up to date data will be available whenever it is needed. The fixed signal is a good option with many nice features, but without the self-healing network it lacks the reliability of the other systems.

Between the Banner Network and the wireless mesh network, CP Solar Wells believes the Banner Network provides the greatest flexibility for Santa Maria Pacific Holdings while still having an attractive price. Rosemount, the company with the wireless mesh network, makes a top quality product that is sure to be both reliable and effective. However, the Banner Network has many features that are comparable to the wireless mesh network and even some advantages. The following sections are going to provide a detailed outline of how the system would work, component specifications and pricing, and safety considerations.

It is important to note, recommendations made are a result of phone conversations and emails with representatives of the different companies. Further meetings with each network representative should be held to compare each system type and have all questions answered by a licensed professional.

4.1.1 Network Set-up

The Banner Network utilizes three main components at each well head: the sensors, a base radio, and a battery. The battery is connected directly to the base radio. Power is provided to the sensors once they are plugged into the base radio. Separate sensors will be needed for pressure and temperature data. Each sensor will take data measurements from the well at a constant time interval determined by Santa Maria Pacific Holdings. Process Instruments, the supplier of the Banner Network components, estimates that a 1 minute update rate would result in a 10-year battery life. The sensors would provide an analog output of data to the base radio which would then digitally send the data back to a gateway receiver at a specified location.

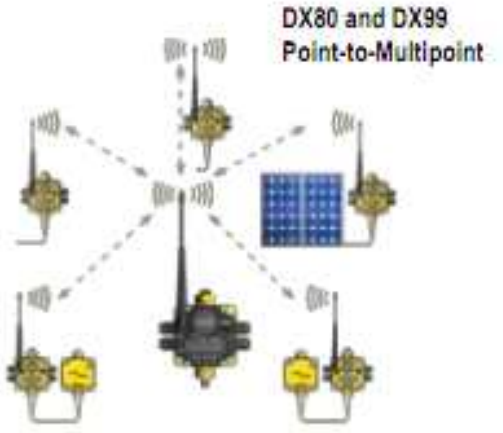

Figure 12 - Banner Network Field Communication

This is a radio frequency (RF) network that utilizes radio waves to pass along data. The gateway uses a type of modulation known as Frequency Hopping Spread Spectrum (FHSS). In these systems, the bandwidth is broken up into multiple smaller frequency bands or channels. The gateway is synchronized with the base radios and listens to the unique channels in the order of the hop code pattern. In this fashion, the data is reassembled and output from the RF system.

CP Solar Wells

In summary, every base radio at each well head would have its own slot to send back data. FHSS minimizes interference in the field and allows for easier communication between the base radios and gateway. If all radios were to be sending back data at once, the radio waves would bounce off of one another and limit the distance the waves could travel. Having FHSS allows data to be transmitted over a longer distance.

The gateway would be placed back at the field office and connected to the programmable logic controller (PLC) which would take all the data and display it in an organized format. The gateway can handle 64 nodes, or radios. That means 64 separate wells, assuming one radio at each well, could be hooked up to send data back to the gateway. If information was desired for more wells, another gateway could be added to the system. The output of the gateway to the PLC could be either Modbus or Ethernet depending on the system already in place.

4.1.2 Component Specifications and Pricing

Every Banner system is different and depending on the amount of obstacles in the field, different products will be recommended for your application. A representative from Process Instruments would do a field visit to the Orcutt Oil Field and evaluate the site for radio line of site capabilities. From there the exact equipment necessary for the field would be identified. This section will provide a general idea of the equipment needed along with the estimated pricing.

The gateway and radios that would be needed for this project would be the DX80 line of nodes and gateways by Banner. A variety of options are available that could be integrated into the current system. For the gateway, there is the option between EtherNet/IP and Modbus TCP Gateways as well as Modbus RTU Gateways, 10–30V dc. A table of the gateways is provided in Appendix D. The current PLC will determine what type of gateway is needed for your system. The cost estimate for the gateway from a Process Instruments representative was approximately $1,500.

The radios, or nodes, would also come from the DX80 line. The battery powered nodes would be the ones best suited for the field due to their long life and ease of replacement. These models are classified under the 10-30V dc—Analog section of nodes. A table of the nodes is provided in Appendix D. The nodes also come with an option for an internal antenna that would add a week to the lead time. Each node can handle up to 4 analog inputs. The cost estimate for the node from a Process Instruments representative was approximately $1,000.

The battery would attach to the node and be between 10 to 30V dc. One battery would be purchased per well. Unfortunately, there is no product information for the battery at this time. The cost estimate for the battery from a Process Instruments representative was approximately $200.

The sensors for each well would be analog output and of simplistic design. Process Instruments has actually recommended Endress+Hauser sensors for this application to use along with the Banner wireless components. The pressure sensors would be the Cerabar M PMP model of sensors by Endress+Hauser. These sensors can handle pressures up to 6000 psi and temperatures up to 750

degrees Fahrenheit. The temperature sensors would be the T13 XP RTD model of sensors by Endress+Hauser. These sensors can handle temperatures up to 1100 degrees Fahrenheit. Full details and tables on the sensors are provided in Appendix D. All of the sensors have analog outputs that would be connected to the node to send the data back to the gateway. The cost estimate for each sensor from a Process Instruments representative was approximately $500 to $750 or $1,000 to $1,500 for both the pressure and temperature sensors.

Summing up all of the components together, Santa Maria Pacific Holdings would be looking at $1,500 for the gateway along with $2,000 to $2,500 per well for the node, sensors, and battery. This is substantially less than the products for the wireless mesh network. A table summarizing the cost of each system is provided in Appendix C.

4.1.3 Safety Considerations

In an oil field, safety is of utmost importance. With high pressures and temperatures coming from the wells, all equipment must meet ANSI requirements. The Orcutt field will require equipment with the Class 1 Division 2 rating. Electrical equipment that is located in a hazardous location where ignitable concentrations of flammable gases, vapors, or liquids are present within the atmosphere is given the classification of Class I. Since the gases or liquids would only be present under abnormal operating conditions the equipment would fall under Division 2.

In order to meet these standards an exterior housing will have to be purchased for the sensor to be placed in. This is an additional cost but negligible compared to the cost of the rest of the equipment. This equipment meets the specified safety regulations and is fit to be in the field.

4.1.4 Maintenance and Repair Considerations

Minimizing the amount of time for maintenance on the wireless system is crucial. Time wasted by workers fixing problems with the network is money wasted. To prevent unnecessary network stoppages, the Banner Network comes with the self-healing network. Each node has site surveying capabilities to identify obstructions that may block the radio's line of sight. If such obstructions are found, the node will automatically redirect its data to another node at a different well. From there the data will be transmitted back to the field office without any downtime.

Another key component to this system is the multiple components utilized at each well. This will lower repair costs as well as expansion costs. If a sensor ever were to fail or break, money would be spent replacing just that sensor instead of other units that have the radio and sensor together and cost more money. Also, expanding the network is easy. If another sensor was to be added to a well, the additional analog inputs on the node would allow for easy connection to the existing network. For example, if a flow sensor was desired, the sensor would just have to be installed in the well pipe and then wired up to the node for data transmission to the gateway.

4.2 Power Supply for Motor

The best option for the power supply to the motor is the conversion to a DC motor. This system will have higher upfront costs compared to the diesel generator but as time goes on the economics for the system will be superior due to the reduced yearly costs. This eliminates the fuel costs and the daily maintenance associated with the generator. This system is also better than the AC motor because of the possibility of not being able to find the AeroVironment controller. This controller is what makes the AC motor system so beneficial. If the controller is being discontinued it severely affects the reliability and service of the system.

4.2.1 System Set-up

The DC motor system will have a very simple setup which is part of why it is so appealing. The only components necessary are the modules, racks, controllers, and the DC motor. The installation will be approximately $10,000 which could be less depending upon installer and the time to install. The setup for each well will be different because each well head has a different landscape. This means that the design and layout of each well head will be important with the space constraints around well heads.

4.2.2 Component Specifications and Pricing

A DC 3 horsepower motors price range is from $2,500-6,000. With the costs for new motors, this plan is the most economical and makes the most sense. To determine the exact cost of the motor there would need to be a further evaluation of the current pumping system and its requirements.

The solar system would be comprised of 20, 250 watt solar modules. This over design is to allow the system to power up earlier in the morning and run later into the evening. The system would also require a controller which would cost $5,000. This controller is less expensive than the AeroVironment controller because their piece is specialized and incorporates several components.

4.2.3 Safety Considerations

The safety considerations are heavily dependent upon proper installation. Having the solar system professionally installed will limit most safety risks. The safety considerations associated with the dc motor will have to abide by all requirements associated with an oilfield environment

4.2.4 Maintenance and Repair Considerations

The DC motor has relatively few maintenance and repair concerns associated with this system. The system has not daily maintenance like what the diesel generator would be dealing with. It also has no additional parts which need to be oiled and lubricated besides the motor. These lacks of repairs are due to system simplicity. Components of the system which could need repairs mostly have warranties. The solar panels come with an industry standard of 25 years and the controllers typically have 2-5 years. The only maintenance which is required of the system will be to clean off the solar panels occasionally. This is due to the dusty conditions in the oil field. As dust builds up the efficiency goes down. This is a task which depends upon the activity in the well area as well as weather conditions.

4.2.5 Abandonment of Solar

After looking over all of the options for solar and comparing costs and feasibility, Santa Maria Pacific Holdings decided to abandon this part of the project during the middle of Winter Quarter. Santa Maria Pacific Holdings believed time was better spent finding the best wireless network for their needs rather than on part of the project that had almost no chance of being implemented.

5. Design Verification Plan

5.1 Sensor Network

Since the sensors for the wireless network will be purchased from a product supplier there are no real physical tests that will be done to the sensors. It is safe to assume that these products will be able to survive in oil field conditions and send data back to the field office properly. All components are professionally built and have warranties that come with them. All components must be checked that they satisfy the necessary Class 1 Division 2 rating for oil field applications.

The main objective for CP Solar Wells is to insure that the system is installed and validate that all components work appropriately and communicate with each other properly. The professionals who install the equipment will be the ones to talk with to insure this objective is completed. Having a system that doesn't work is pointless, so CP Solar Wells must make sure that the entire network is functional and working before the project can be called complete.

6. Management Plan

Over the course of the year the roles of each team member were clear and remained consistent. Jonathan Hyland was in charge of researching different solar options available. When the solar option was abandoned, Jon's main responsibility became assisting in the set-up of meetings with product suppliers of the wireless sensor networks.

Matt Mastro was in charge in researching companies that could provide wireless sensors for Santa Maria Pacific Holdings. He was also the project lead and was responsible for the content and formatting of all reports submitted. He was also the primary contact with Santa Maria Pacific Holdings.

Kyle Moore was in charge of scheduling for CP Solar Wells and assisted in the set-up of meetings with the wireless sensor suppliers. He was also a contributor to reporting and assisted in research for all areas of the project.

A Gantt chart showing our projected schedule for winter and spring quarter is shown in Appendix E. Due to the large changes in the project scope at the start of winter quarter the Gantt Chart for Fall Quarter is not included because it is no longer applicable to the project.

7. Product Realization

7.1 Product Selection

Based on the research done by CP Solar Wells, it was recommended that Santa Maria Pacific choose the Banner network for use in the Orcutt oil field. This conclusion was based on the effectiveness and reliability of the Banner network and also the relatively inexpensive cost of the Banner components. The capability of connecting multiple sensors to one radio transmitter was also an attractive cost reducing feature of the Banner network. Despite this recommendation Santa Maria Pacific has chosen to purchase sensors from Rosemount and utilize the wireless mesh network. Santa Maria Pacific has a preexisting relationship with Rosemount as they already utilize many of their products in their field. While Rosemount products are more expensive than those produced by Banner, the quality of Rosemount products is unmatched by any other company and Rosemount has an extremely good reputation in both performance and customer service.

7.2 Components Ordered

Santa Maria Pacific has ordered Rosemount 3051S Wireless Series Pressure Transmitters (Model #: 3051S 2 T G 4A 2 A11 X 5A WA 3 WK 1 I5 M5) and Rosemount 648 Wireless Temperature Transmitters (Model #: 648 D X 1 D 1 I5 WA3 WK1 M5 XA) to install in their Orcutt oil field. The specification sheets for these products can be found in Appendix F. The ordering process was done independent of CP Solar Wells and the sensors will be installed by professional technicians employed by Santa Maria Pacific with the assistance of Rosemount technical support. Santa Maria Pacific has also ordered Rosemount Manifolds to assist in the installation process and allow for multiple sensors in one location.

Figure 13 - Rosemount 648 Wireless Temperature Transmitter

7.3 Performance Testing

Performance testing of the Rosemount sensors will be done by the technical staff of Santa Maria Pacific to ensure sensor communication and accuracy. CP Solar Wells will not assist in the testing process. Any necessary troubleshooting will be done by Santa Maria Pacific and Rosemount technical support. If the sensors perform well and meet the needs of Santa Maria Pacific they will be more widely implemented in the Orcutt oil field.

8. Conclusion

The research performed by CP Solar Wells greatly assisted Santa Maria Pacific in their decision to choose Rosemount sensors and transmitters to implement in the Orcutt oil field. While they did not choose the Banner network recommended by CP Solar Wells, the high quality products produced by Rosemount will meet all of Santa Maria Pacific's needs and Rosemount will provide them with outstanding customer support throughout the lifetime of the components. The successful purchasing and implementation of sensors in the Orcutt oil field reflects the quality of work that CP Solar Wells provided for Santa Maria Pacific.

Once again, the idea to power a three horsepower motor using solar panels was abandoned by Santa Maria Pacific. Our research showed that purchasing solar arrays to be used off of the electrical grid would not be cost effective for use in the Orcutt oil field.

Since Santa Maria Pacific has chosen, ordered, and installed Rosemount's wireless mesh network and pressure and temperature transmitters, the task designated to CP Solar Wells to design solar powered oil well sites is now complete.

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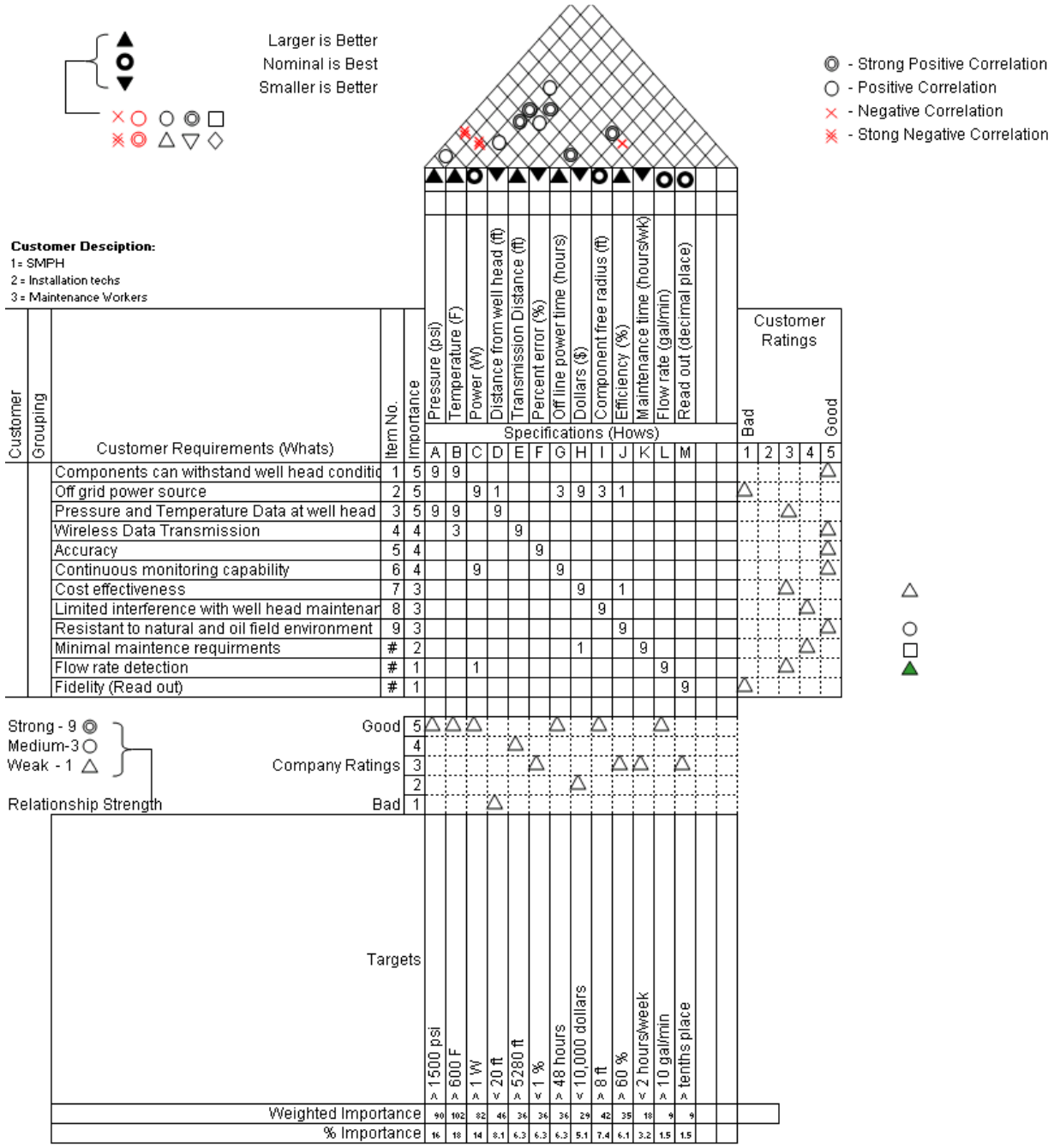
Appendix A - Quality Function Deployment Chart (QFD)



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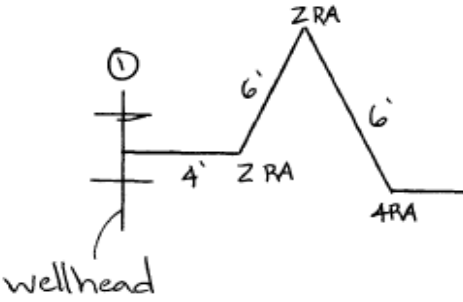
Appendix B – Pressure Drop from Well Head Calculations

12-1-10

Pressure Drop Calcs



Assumptions

- constant pipe area (2")
- constant velocity/flow

$\rho_w = 62.4\ lb/ft^3$ @ 3

$sg = 0.855$ } from
≈ 34 API } reynolds

$\nu = 4\ cp$ @ 50°C
$= 2.5\ cp$ @ 100°C
$= 1.5\ cp$ @ 200°C

$\nu = 8.354 \times 10^{-5}$ @ 50°C
$= 5.221 \times 10^{-5}$ @ 100°C
$= 3.133 \times 10^{-5}$ @ 200°C
} all units $lb \cdot s/ft^2$

$$Re = \frac{\rho \bar{V} D}{\nu}$$

Major Losses

$Q \approx 15\ bbl/day$

$$Q = 15\ \frac{bbl}{day}\left(\frac{42\ gal}{1\ bbl}\right)\left(\frac{0.13368\ ft^3}{1\ gal}\right)\left(\frac{1\ day}{86400\ s}\right)$$

$$Q \approx 9.7475 \times 10^{-4}\ ft^3/s$$

$$\bar{V} = \frac{Q}{A} = \frac{9.7475 \times 10^{-4}\ ft^3/s}{\frac{\pi}{4}(1/6\ ft)^2} = 0.0447\ ft/s$$

$$Re = \frac{(0.855)(62.4\ lb/ft^3)(0.0447\ ft/s)(1/6\ ft)}{5.221 \times 10^{-5}\ lb \cdot s/ft^2\ (32.2\ ft/s^2)} = 236.4 \leq 2300$$

laminar

$$h_l = \left(\frac{64}{Re}\right)\frac{L}{D}\frac{\bar{V}^2}{2} = \left(\frac{64}{236.4}\right)\left(\frac{50\ ft}{1/6\ ft}\right)\left(\frac{0.0447\ ft/s}{2}\right)^2 = ~~1.815~~\ 0.0811\ ft^2/s^2$$

Minor Losses

Inlets and Exits – assumed to be none

Enlargements/Contractions – assumed constant pipe area

Pipe Bends

From fig. 8.16 of Fox & McDonald

$r/D \approx 1$ so $L_e/D = 20$

$$h_{lm} = f\frac{L_e}{D}\frac{\bar{V}^2}{2} = 8\left(\frac{64}{236.4}\right)(20)\left(\frac{(0.0447\ ft/s)^2}{2}\right) = 0.0433\ ft^2/s^2$$

(24)

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Valves and Fittings

Assumed to have 2 gate valves

From Table 8.4 of Fox & McDonald

$L_e/D = 8$

$$h_{lm} = f\,L_e/D\,\frac{\bar{V}^2}{2} = 2\left(\frac{64}{236.4}\right)(8)\left(\frac{(0.0447\ ft/s)^2}{2}\right) = 0.00433\ ft^2/s^2$$

$$\left(\frac{P_1}{\rho} + \alpha_1\frac{\bar{V}_1^2}{2} + gz_1\right) - \left(\frac{P_2}{\rho} + \alpha_2\frac{\bar{V}_2^2}{2} + gz_2\right) = h_{lT}$$

$$\frac{P_1 - P_2}{\rho} + g(z_1 - z_2) = h_l + h_{lm}$$

$$\frac{P_1 - P_2}{\rho} = h_l + h_{lm} - g(z_1 - z_2)^{0}$$

$$P_1 - P_2 = \rho(h_l + h_{lm})$$

$$= 0.855\left(62.4\ lb/ft^3\right)\left(0.0811\ ft^2/s^2 + 0.0433\ ft^2/s^2 + 0.00433\ ft^2/s^2\right)\left(\frac{1}{32.2\ ft/s^2}\right)$$

$$= 0.213\ psf$$

$$\Delta p = 1.479 \times 10^{-3}\ psi$$

Turbulent Flow

* New set of parameters

water @ temp.: $\rho = 1.87\ slug/ft^3$, $\mu = 6.28 \times 10^{-6}\ lb\cdot s/ft^2$ @ 200°F

$Q = 800\ bbl/day$

$D = 2\ in$

$$Q = 800\ bbl/day\left(\frac{42\ gal}{1\ bbl}\right)\left(\frac{0.13368\ ft^3}{1\ gal}\right)\left(\frac{1\ day}{86400\ s}\right) = 0.05199\ ft^3/s$$

$$\bar{V} = \frac{Q}{A} = \frac{0.05199\ ft^3/s}{\frac{\pi}{4}(1/6\ ft)^2} = 2.3829\ ft/s$$

$$Re = \frac{(1.87\ slug/ft^3)(2.3829\ ft/s)(1/6\ ft)}{6.28 \times 10^{-6}\ lb\cdot s/ft^2} = 118260 \geq 2300$$

turbulent

(15)

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$$h_\ell = f\frac{L}{D}\frac{V}{2}$$

From table 8.1 of Fox & McDonald

Cast Iron	0.00085	feet
Commercial Steel or Wrought Iron	0.00015	ε, roughness

Commer. steel

$$\frac{\varepsilon}{D} = \frac{0.00015}{2/12} = 0.0009$$

$$Re = 1.18 \times 10^5$$

From Moody Diagram

$f = 0.0215$

$$h_\ell = 0.0215\left(\frac{50\ ft}{1/6\ ft}\right)\left(\frac{(2.3829\ ft/s)^2}{2}\right) = 18.31\ ft^2/s^2$$

Pipe Bends

$r/D \approx 1 \quad L_e/D \approx 20$

$$h_{\ell m} = 0.0215\left(20\right)(8)\left(\frac{(2.3829\ ft/s)^2}{2}\right) = 9.767\ ft^2/s^2$$

Valves & Fittings

$L_e/D = 8$

$$h_{\ell m} = 0.0215(8)(2)\left(\frac{(2.3829\ ft/s)^2}{2}\right) = .9767\ ft^2/s^2$$

$$P_1 - P_2 = \rho\left[h_\ell + h_{\ell m} - g(z_1 - z_2)\right] \quad (z_1 - z_2 \to 0)$$

$$= 1.87\ slug/ft^3\left[18.31 + 9.767 + 0.9767\right] ft^2/s^2$$

$$= 54.33\ psf$$

$$\Delta p = 0.377\ psi$$

Cast Iron

$$\frac{\varepsilon}{D} = \frac{0.00085}{2/12} = 0.0051$$

$$Re = 1.18 \times 10^5$$

From Moody Diagram

$f = 0.031$

Fluid Parameters				
Pipe Diameter	2	in	0.167	ft
Pipe Length	50	ft		
Flow Rate	2000	bbl/day	0.130	ft^3/s
Dynamic Viscosity	6.28E-06	lb.s/ft^2		
Density	1.87	slug/ft^3		

Intermediate Calculations		
Fluid Velocity	5.957233182	ft/s
Reynolds	2.96E+05	

Head Loss and Pressure Drop

				Major Loss	Minor Losses		
	Roughness, e (ft)	e/D	f	h_l (ft^2/s^2)	h_{bends} (ft^2/s^2)	h_{valves} (ft^2/s^2)	Δp (psi)
Commerical Steel	0.00015	0.0009	0.0215	114.451	61.040	6.104	2.358

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Appendix C – Vendor Contact Information and Pricing

Sensor Vendors

Rosemount, Inc.
Nationwide
Robert Long
Email: Robert.long@emerson.com
Phone: (800) 999-9307

Control Microsystems Inc.
Nationwide
Greg Ochs
Email: gochs@controlmicrosystems.com
Phone: (760) 466-7397

Process Instruments & Controls, LLC
Bakersfield, CA
Andy Shogren
Email: ashogran@process-instruments.com
Phone: (661) 617-6000

ABB Instrumentation
Irvine, CA
Chris Heidari
Email: chris@mcrt.com
Phone: (949) 830-3929

Omega Engineering
Nationwide
Ashish Desai
Email: desai@omega.com
Phone: (203) 359-1660 ext. 2326

Digi-Key
Nationwide
Glenda Chaplinski
Email: datacenter@digikey.com
Phone: (800) 344-4539 ext. 1324

Paine Electronics
East Wenatchee, WA
Dan Harper
Email: dan@paineelectronics.com
Phone: (509) 881-210 ext. 2122

Systemation Incorporated
Niskayuna, NY
Matt Gleason
Email: gleason@systemationinc.com
Phone: (518) 382-8594

Solar Panel Vendors

Pacific Energy LLC.
Web: Alteryourenergy.com
Phone: (805) 544-4700

Solarponics Inc.
Web: Solarponics.com
Phone: (805) 466-5595

REC Solar
Web: recsolar.com
Phone: (805) 528-9705

Sensor Cost

Table 2 - Transmitter Cost and Specifications

Transmitters							
Company	Network Type	HART Protocol	Wireless Transmission	Battery Life (years)	Cost ($)	Warranty (years)	Lead Time (weeks)
Rosemount	Mesh	Yes	Yes	10	2,500	1.5	3 to 5
Control Microsystems (Accutech)	Fixed	Yes	Yes	10	1,300	3	3 to 4
Process Instruments *	Banner	Yes	Yes	10	1,300	1	3 to 4

*Price shown includes cost of the separate radio

Table 3 - Receiver Cost and Specifications

Receivers				
Company	Network Type	Network Size	Cost ($)	Warranty (years)
Rosemount	Mesh	100	4,000	1.5
Control Microsystems (Accutech)	Fixed	100	3,600	3
Process Instruments	Banner	64 nodes*	1,500	1

*1 node can support up to 4 devices

Table 4 - Total Cost of System Components

Total Cost				
Company	One-Time Cost for Gateway ($)	Cost of Transmitters per Well* ($)	Total Cost for First Well ($)	Total Cost for Each Additional Well ($)
Rosemount	4,000	5,000	9,000	5,000
Control Microsystems (Accutech)	3,600	2,600	6,200	2,600
Process Instruments	1,500	2,600	4,100	2,600

*Cost of Sensors per Well assumes two transmitters for pressure and temperature

Appendix D – Vendor Provided Component Specifications

Banner Network Gateways and Nodes

SureCross™ DX80 MultiHop Wireless Network

- Selectable power levels up to 1 watt transmit power; license-free operation up to 4 watt EIRP, with a high-gain antenna, in the U.S. and Canada for 900 MHz
- *Flex*Power power input options allow for +10 to 30V dc, solar or battery power
- Serial communication style (RS-232 or RS-485) is user selectable
- Multiple hops allow for an extended range
- Message routing improves link performance
- SureCross architecture creates self-forming and self-healing wireless networks
- DIP switches select operational modes: master, repeater or slave
- Built-in site survey mode enables rapid assessment of a location's RF transmission properties by one person; hands-free operation and rapid display updates enable efficient antenna placement optimization
- FHSS radios operate and synchronize automatically; no user setup is required; Selectable network IDs reduce interference from collocated networks
- Banner is constantly working on new models with I/O variations, contact factory for the latest model information

DX85 Modbus RTU Remote I/O
Used to expand I/O capacity when connected to a Data Radio or Gateway
(see page 406)

DX80 Data Radios

Description	Frequency	Transmit Power	Models*
MultiHop Radio	900 MHz	DIP switch selectable up to 1 Watt	DX80DR9M-H
	2.4 GHz	150 mW EIRP	DX80DR2M-H

* Banner is constantly working on new models with I/O variations. Contact factory for the latest model information.

SureCross™ Ethernet Radio

Description	Frequency	Transmit Power	Models*
Ethernet Radio	900 MHz	150 mW	DXER9

DX80 Data Radio DX80 Specifications

Visit bannerengineering.com for more information.

More information online at bannerengineering.com

CP Solar Wells

SureCross™ DX80 Point-to-Multipoint Wireless I/O Network

- An industrial wireless I/O network that can operate in extreme environments while eliminating the need for costly wiring runs
- A basic network consists of a Gateway system controller and one or more Nodes that monitor and/or control I/O in remote locations
- Nodes are easily deployed throughout a facility for gathering data to be concentrated at the Gateway
- Bi-directional communication between the Gateway and Node(s), including fully acknowledged data transmission
- Frequency Hopping Spread Spectrum (FHSS) technology and Time Division Multiple Access (TDMA) control architecture combine to ensure reliable data delivery within the unlicensed Industrial, Scientific and Medical (ISM) bands
- *Flex*Power™ options allow for +10-30V dc, solar and battery power sources
- 900 MHz and 2.4 GHz models accommodate worldwide communication standards
- Rugged IP67/NEMA 6 design enabling simple plug-and-play installation
- Installation is fast and easy with flexible mounting and power options

DX85 Modbus RTU Remote I/O
Used to expand I/O capacity when connected to a Data Radio or Gateway
(see page 406)

DX80 Gateways

- Gateways are the master of Banner's SureCross Wireless Network
- Modbus 485 communication capability is integrated into every Gateway
- Gateway models are available with discrete, analog and a mix of both I/O types
- IP20 housing option is certified for Class I Div 2 areas

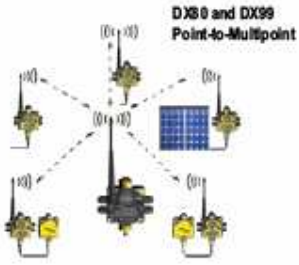
DX80 Nodes

- The Node collects the data and wirelessly transmits it to the Gateway
- Nodes may be powered by either 10 to 30V dc battery or solar power options
- Models are available in a variety of input/output options
- IP20 housing option is certified for Class I Div 2 areas

DX80 Gateways and Node

DX80 Node

DX80 Gateway



More information online at bannerengineering.com

DX80 EtherNet/IP and Modbus TCP Gateways

	Frequency	I/O	Models
	900 MHz	DX80 GatewayPro Modbus/TCP to EtherNet/IP protocol converter	DX80P9T6S
	2.4 GHz		DX80P2T6S
	900 MHz	DX80 GatewayPro (Modbus/TCP) with advanced web-based configuration capabilities	DX80P9A6S
	2.4 GHz		DX80P2A6S
	No Radio	Protocol Conversion: Modbus RTU to Modbus TCP/IP or EtherNet/IP	DX83T
		Advanced user configuration model	DX83A

DX80 Modbus RTU Gateways, 10–30V dc

	Frequency	Base	I/O	Models*
	900 MHz	IP67	Discrete: Six selectable inputs, six PNP outputs	DX80G9M6S6P6
		IP20		DX80G9M6S6P6C
	2.4 GHz	IP67		DX80G2M6S6P6
		IP20		DX80G2M6S6P6C
	900 MHz	IP67	Discrete: Six selectable inputs, six NPN outputs	DX80G9M6S6N6
		IP20		DX80G9M6S6N6C
	2.4 GHz	IP67		DX80G2M6S6N6
		IP20		DX80G2M6S6N6C
	900 MHz	IP67	Analog: Four inputs, four 0-20 mA outputs	DX80G9M6S0P0M4M4
		IP20		DX80G9M6S0P0M4M4C
	2.4 GHz	IP67		DX80G2M6S0P0M4M4
		IP20		DX80G2M6S0P0M4M4C
	900 MHz	IP67	Analog: Four inputs, four 0-10V outputs	DX80G9M6S0P0V4V4
		IP20		DX80G9M6S0P0V4V4C
	2.4 GHz	IP67		DX80G2M6S0P0V4V4
		IP20		DX80G2M6S0P0V4V4C
	900 MHz	IP67	Discrete: Four selectable inputs, four PNP outputs Analog: Two inputs, two 0-20 mA outputs	DX80G9M6S4P4M2M2
		IP20		DX80G9M6S4P4M2M2C
	2.4 GHz	IP67		DX80G2M6S4P4M2M2
		IP20		DX80G2M6S4P4M2M2C
	900 MHz	IP67	Discrete: Four selectable inputs, four PNP outputs Analog: Two inputs, two 0-10V outputs	DX80G9M6S4P4V2V2
		IP20		DX80G9M6S4P4V2V2C
	2.4 GHz	IP67		DX80G2M6S4P4V2V2
		IP20		DX80G2M6S4P4V2V2C
	900 MHz	IP67	Discrete: Eight selectable inputs, four PNP outputs (When your wireless network does not include a host system, eight input/four output Gateway must be mapped to the four input/eight output node.)	DX80G9M6S8P4
		IP20		DX80G9M6S8P4C
	2.4 GHz	IP67		DX80G2M6S8P4
		IP20		DX80G2M6S8P4C
	900 MHz	IP67	Discrete: Four selectable inputs, eight PNP outputs (When your wireless network does not include a host system, the four input/eight output Gateway must be mapped to the eight input/four output node.)	DX80G9M6S4P8
		IP20		DX80G9M6S4P8C
	2.4 GHz	IP67		DX80G2M6S4P8
		IP20		DX80G2M6S4P8C

* To order the internal antenna models, replace the S as the 9th digit with a W. Internal antennas require an additional week for manufacture and shipping. For example, DX80G9M6S0P0V4V4 is the external antenna model and DX80G9M6W0P0V4V4 is the internal antenna model.

More information online at bannerengineering.com

DX80 Nodes, 10-30V dc—Discrete

	Frequency	Base	I/O	Models*
 DX80 Node IP67  DX80..C IP20 External Terminal Strips CID2 certified	900 MHz	IP67	**Discrete:** Six selectable inputs, six PNP outputs	DX80N9X6S6P6
		IP20		DX80N9X6S6P6C
	2.4 GHz	IP67		DX80N2X6S6P6
		IP20		DX80N2X6S6P6C
	900 MHz	IP67	**Discrete:** Six selectable inputs, six NPN outputs	DX80N9X6S6N6
		IP20		DX80N9X6S6N6C
	2.4 GHz	IP67		DX80N2X6S6N6
		IP20		DX80N2X6S6N6C
	900 MHz	IP67	**Discrete:** Eight selectable inputs, four PNP outputs (When your wireless network does not include a host system, the eight input/four output node must be mapped to the four input/eight output Gateway.)	DX80N9X6S8P4
		IP20		DX80N9X6S8P4C
	2.4 GHz	IP67		DX80N2X6S8P4
		IP20		DX80N2X6S8P4C
	900 MHz	IP67	**Discrete:** Four selectable inputs, eight PNP outputs (When your wireless network does not include a host system, the four input/eight output node must be mapped to the eight input/four output Gateway.)	DX80N9X6S4P8
		IP20		DX80N9X6S4P8C
	2.4 GHz	IP67		DX80N2X6S4P8
		IP20		DX80N2X6S4P8C

* All Nodes on this page are available with internal antennas. To order the internal antenna models, replace the S as the 9th digit with a W. Internal antennas require an additional week for manufacture and shipping. For example, DX80N9X1S2N1M1 is the model number for the external antenna device and DX80N9X1W2N1M1 is the internal antenna device.

DX80 Nodes, 10-30V dc—Analog

	Frequency	Base	I/O	Models*
 DX80 Node IP67  DX80 Node IP20 (C1D2 certified)	900 MHz	IP67	**Analog:** Four 0-20 mA inputs, four 0-20 mA outputs	DX80N9X6S0P0M4M4
		IP20		DX80N9X6S0P0M4M4C
	2.4 GHz	IP67		DX80N2X6S0P0M4M4
		IP20		DX80N2X6S0P0M4M4C
	900 MHz	IP67	**Analog:** Four 0-10V inputs, four 0-10V outputs	DX80N9X6S0P0V4V4
		IP20		DX80N9X6S0P0V4V4C
	2.4 GHz	IP67		DX80N2X6S0P0V4V4
		IP20		DX80N2X6S0P0V4V4C

CP Solar Wells

SureCross™ DX80 Specifications	
Radio	
Range*	**900 MHz:** Up to 4.8 kilometers (3 miles); **2.4 GHz:** Up to 3.2 kilometers (2 miles)
Transmit Power (150 mW radios)	**900 MHz:** 21 dBm Conducted; **2.4 GHz:** 18 dBm Conducted, ≤ 20 dBm EIRP
Spread Spectrum Technology	FHSS (Frequency Hopping Spread Spectrum)
Antenna Connector	Ext. Reverse Polarity SMA, 50 Ohms
Antenna Max. Tightening Torque	0.45 N•m (4 in•lbf)
Link Timeout	**Gateway:** Configurable, up to 2 minutes **Node:** Defined by Gateway

* With the standard 2 dB antenna. High-gain antennas are available, but the range depends on the environment and line of sight. To determine the range of your wireless network, perform a Site Survey.

CP Solar Wells

SureCross™ DX80 Specifications (cont'd)	
General	
Power*	+10 to 30V dc (For European applications: +10 to 24V dc, ± 10%) *Flex*Power: +10 to 30V dc or 3.6 to 5.5V dc low power option (For European applications: +10 to 24V dc, ± 10% or 3.6 to 5.5V dc low power option) Integrated Battery models: 3.6V dc low power option from an internal battery
Power Consumption	Less than 1.4 W (60 mA) at 24V dc
Mounting	#10 or M5 (M5 hardware included)
M5 Fasteners Max. Tightening Torque	0.56 N•m (5 in•lbf)
Case Material	Polycarbonate
Weight	0.26 kg (0.57 lb.) Integrated battery models: 0.30 kg (0.65 lbs) IP20 models: 0.23 kg (0.50 lbs)
Indicators	Two LED, bi-color
Switches	Two Push Buttons
Display	Six Character LCD
Connection**	5-pin M12 Euro-style quick disconnect (QD cable is included with DX80 product)
External Cable Glands**	Four PG-7 type, One 1/2 NPT type
Cable Glands Max. Tightening Torque**	0.56 N•m (5 in•lbf)
Gateway Communications	
Interface	2-wire RS-485
Baud Rates	9.6k, 19.2k (default), or 38.4k
Data Format	8 data bits, no parity, 1 stop bit
Protocol	Modbus RTU
Environmental	
Environmental Rating	Internal wiring terminals: IEC IP67; NEMA 6 External wiring terminals: IEC IP20; NEMA 1
Environmental Rating (external wiring terminals, in suitable enclosure)	External wiring block models: Class I, Division 2, Group A, B, C, D T4 −40 to +80° C
Operating Temperature	Electronics: −40 to +85° C LCD: −20 to +80° C
Operating Humidity	95% max. relative (non-condensing)
Radiated Immunity	10 V/m, 80-2700 MHz (EN61000-6-2)
Shock and Vibration***	IEC 68-2-6 and IEC 68-2-7 Shock: 30g, 11 millisecond half sine wave, 18 shocks Vibration: 0.5 mm p-p, 10 to 60 Hz
Compliance, Radio	
900 MHz Models	FCC ID TGUDX80: This device complies with FCC Part 15, Subpart C, 15.247 IC: 7044A-DX8009
2.4 GHz Models	FCC ID UE300DX80-2400: This device complies with FCC Part 15, Subpart C, 15.247 ETSI/EN: In accordance with EN 300 328: V1.7.1 (2006-05) IC: 7044A-DX8024
Certification (DX8x..C External Wiring Terminals and IP20 Housings)	Class I, Division 2, Groups A, B, C, D. Certificate: 1921239 Ex/AEx nA II T4 LCIE/ATEX Zone 2 (Group IIC). Certificate: LCIE 09 ATEX 1035 U II 3G Ex nA IIC

* For European applications, power the DX80 from a Limited Power Source as defined in EN 60950-1.
** IP67 models only
*** Operating the devices at the maximum operating conditions for extended periods can shorten the life of the device.

CP Solar Wells

Banner Network Pressure Sensors by Endress+Hauser

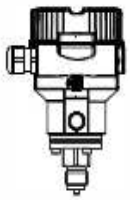
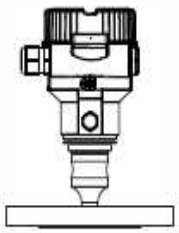
Application

The Cerabar M pressure transmitter is used for the following measuring tasks:

- Absolute pressure and gauge pressure measurement in gases, steams or liquids in all areas of process engineering and process measurement technology
- Level, volume or mass measurements in liquids
- High process temperature
  - without diaphragm seals up to 125°C (257°F)
  - with diaphragm seals up to 400°C (752°F)
- High pressure up to 400 bar (6000 psi)
- International usage thanks to a wide range of approvals

Your benefits

- Very good reproducibility and long-term stability
- High reference accuracy: up to ±0.15%, as PLATINUM version: ±0.075%
- Turn down up to 100:1
- End-to-end modularity for differential pressure, hydrostatics and pressure (Deltabar M – Deltapilot M – Cerabar M), e.g.
  - replaceable display
  - universal electronics
- Easy commissioning without the need for an operating tool
- Menu-guided operation
- Output signals: 4 to 20 mA, 4 to 20 mA with HART

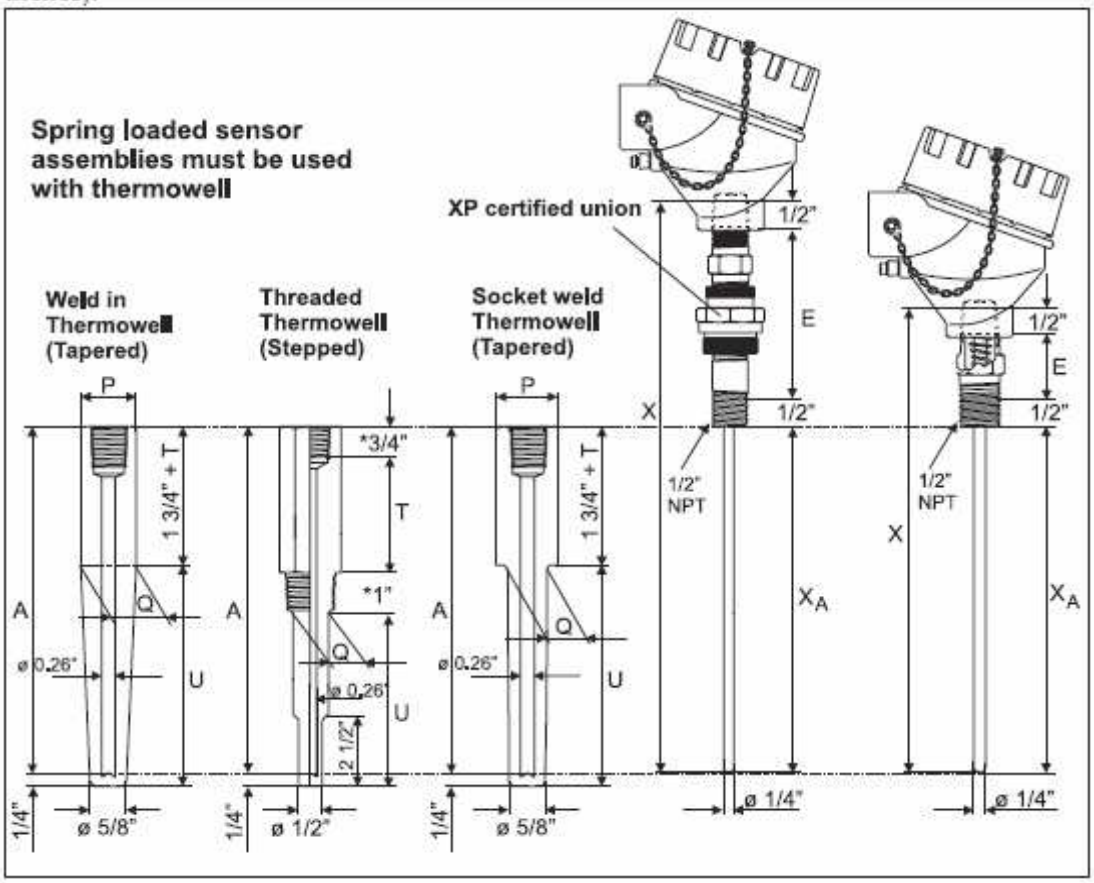
Cerabar M – Product family	PMC51  With capacitive measuring cell and ceramic process isolating diaphragm (Ceraphire®)	PMP51  With piezoresistive measuring cell and metal welded process isolating diaphragm	PMP55  With diaphragm seal
Field of application	– Gauge pressure and absolute pressure – Level		
Process connections	– Thread – EN flanges DN 25 – DN 80 – ANSI flanges 1" – 4" – JIS flanges 50 A – 100 A	– Thread – EN flanges DN 25 – DN 80 – ANSI flanges 1" – 4" – JIS flanges 25 A – 100 A – Prepared for diaphragm seal mount	– Wide range of diaphragm seals
Measuring ranges	From –100/0 to 100 mbar (–1.5/0 to 1.5 psi) to –1/0 to 40 bar (–15/0 to 600 psi)	From –400/0 to 400 mbar (–6/0 to 6 psi) to –1/0 to 400 bar (–15/0 to 6000 psi)	
OPL [1]	Max. 60 bar (900 psi)	Max. 600 bar (9000 psi)	
Process temperature range	–20 to +100 °C (–4 to +212°F)	–40 to +125°C (–40 to +257°F)	–70 to 400 °C (–94 to +752 °F) depending on the filling oil
Ambient temperature range	▪ Without LCD display: -40 to +85°C (–40 to +185 °F) ▪ With LCD display: –20 to +70°C (–4 to +158°F) (extended temperature application range (-40 to 85°C (-40 to 185°F)) with restrictions in optical properties such as display speed and contrast) ▪ Separate housing: –20 to +60°C (–4 to +140°F) ▪ Diaphragm seal systems depending on the version		
Reference accuracy	– Up to ±0.15% of the set span – PLATINUM version: up to ±0.075% of the set span		Up to ±0.15% of the set span
Supply voltage	– 11.5 to 45 V DC (versions with plug-in connection 35 V DC) – For intrinsically safe device versions: 11.5 to 30 V DC		
Output	4 to 20 mA, 4 to 20 mA with superimposed HART protocol		
Options	– PMP51, PMP55: NACE-compliant materials – PMC51, PMP51, PMP55: inspection certificate 2.2 or 3.1 or other certificates – Specific firmware versions – Initial device settings – Separate housing – Broad range of accessories		
Specialties	– Metal-free measurement with PVDF connection – Special cleaning of the transmitter to remove paint-wetting substances, for use in paint shops	– Process connections with minimum oil volume – Gas-tight, elastomer-free	– Wide range of diaphragm seals – For extreme medium temperatures – Process connections with minimum oil volume – Completely welded versions

1) OPL = over pressure limit; depends on the lowest-rated element, with regard to pressure, of the selected components

CP Solar Wells

Dimensions

for T13 assemblies with spring loaded insert and self contained nipple (dimensions in inches).



Note: *For thermowells with ½" NPT - 1" Process thread length and ¾" Hex length dimensions are reversed.

U = Thermowell Immersion length (see table)
E = Extension (see table)
Q = Thermowell diameter
T = Lag dimension (3" or specified length 1" to 6" in ½" increments)
X_A = A = Immersion length RTD sensor, thermowell drilled depth (A= U+1½"+T)
X = Insert overall length (X = A+E)
P = Pipe size (Nom. ¾"; Dia. = 1.050" - Nom. 1"; Dia. = 1.315")

Note: Spare part insert, TU111. For replacement with additional option code (XP spare part) need to be used to assure approved classification, please contact Endress+Hauser!

CP Solar Wells

U	E (nom. dimension)	Process connection	Shape of Thermowell	ø D
2½", 4½", 7½", 10½"; specified length 2" to 18" in ½" increments	Hex nipple = 1" or Nipple Union Nipple (NUN) = 4" or 7" Material: Steel or 316SS	½" NPT	Stepped (Standard duty) Tapered (Heavy duty)	5/8" 11/16"
		¾" NPT	Stepped (Standard duty) Tapered (Heavy duty)	¾" 7/8"
		1" NPT	Stepped (Standard duty) Tapered (Heavy duty)	7/8" 1 1/16"
		¾" Socket weld	Stepped (Standard duty) Tapered (Heavy duty)	¾" ¾"
		1" Socket weld	Stepped (Standard duty) Tapered (Heavy duty)	7/8" 1"
		¾" weld in	Tapered (Heavy duty)	1.050"
		1" weld in	Tapered (Heavy duty)	1.315"

Wire specifications 24AWG, 19 strand silver plated copper with 0.010" TFE extruded outer

Recommended minimum immersion for thermowell:

Stepped TW = 2½"	Tapered TW = 4½"	Weld in TW = 4½"

Technical data

Weight	From 1 to 10 lbs
Material	316SS (Wetted parts)
Shock and vibration resistance	4g/2 to 150 Hz as per IEC 60 068-2-6

Ambient temperature limits

Housing without head-mounted transmitter	
Aluminium pressure die-cast housing	-58 to 212 °F (-50 to 100 °C)
Stainless steel housing	-58 to 212 °F (-50 to 100 °C)
Housing with head-mounted transmitter	
All types of housing	-40 to 185 °F (-40 to 85 °C)
Field transmitter	
with display	-40 to 158 °F (-40 to 70 °C)
without display	-40 to 185 °F (-40 to 85 °C)

Performance Characteristics

Maximum measured error (Pt100 / IEC 60751)

Class	max. Tolerances (°C)
A	± (0.15 + 0.002 · |t*|), temperature range: -100 °C to 450 °C
B	± (0.3 + 0.005 · |t*|), temperature range: -200 °C to 600 °C

* |t| = absolute value °C. For measurement errors in °F, calculate using equation above in °C, then multiply the outcome by 1.8.

Dielectrical strength — The units are factory tested with 850 V_{DC} for one second between live parts (leads/terminals) and exposed non-current-carrying metal parts (e.g. insert sheath)

Supplementary documentation

All important Temperature Operating Instructions, particularly with regard to head and field transmitters are available on CD-ROM, find enclosed or order by order number: **SONDTT-AG.**

USA

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Fax 317-535-8498
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People for Process Automation

CP Solar Wells

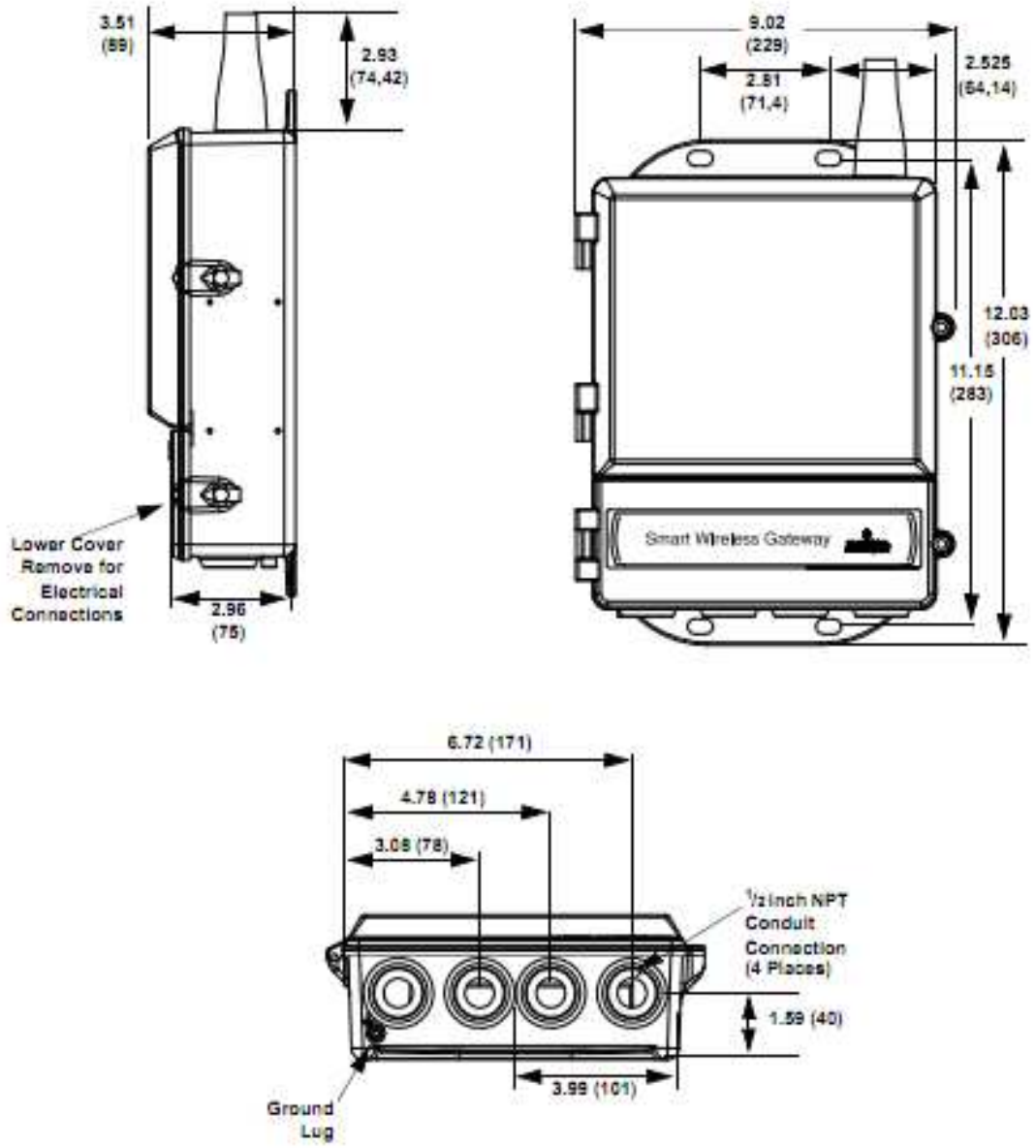
Rosemount Wireless Gateway

Product Data Sheet
00813-0200-4420, Rev DA
December 2010

Smart Wireless Gateway

Dimensional Drawings

Figure 1. Smart Wireless Gateway
(Dimensions are in inches (millimeters)



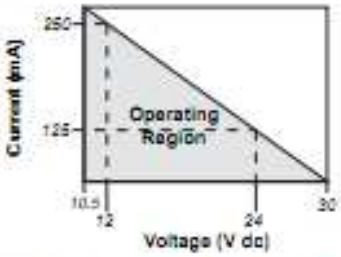
CP Solar Wells

Specifications

Functional Specifications

Input Power
10.5 - 30 Vdc

Current Draw
Operating Current Draw is based on 3 Watts average power consumption. Momentary startup Current Draw up to twice Operating Current Draw.



Radio Frequency Power Output from Antenna
Maximum of 10 mW (10 dBm) EIRP
Maximum of 40 mW (16 dBm) EIRP for WN2 High Gain option

Environmental
Operating Temperature Range:
-40 to 158 °F (-40 to 70 °C)
Operating Humidity Range:
10-90% relative humidity

EMC Performance
Complies with EN61326-1:2006.

Antenna Options
Integrated Omnidirectional Antenna
Optional remote mount Omnidirectional Antenna

Physical Specifications

Weight
10 lb (4.54 kg)

Material of Construction
Housing
Low-copper aluminum, NEMA 4X
Paint
Polyurethane
Cover Gasket
Silicone Rubber
Antenna
PBT/PC integrated Omnidirectional Antenna

Certifications
Class I Division 2 (U.S.)
Equivalent Worldwide

Communication Specifications

Isolated RS485
2-wire communication link for Modbus RTU multidrop connections
Baud rate: 57600, 38400, 19200, or 9600
Protocol: Modbus RTU
Wiring: Single twisted shielded pair, 18 AWG. Wiring distance up t
4,000 ft. (1,524 m)

Ethernet
10/100base-TX Ethernet communication port
Protocols: Modbus TCP, OPC, HART-IP, https (for Web Interface)
Wiring: Cat5E shielded cable. Wiring distance 328 ft. (100 m).

Fiber Optic Ethernet (optional)
100BaseFx optical Ethernet communication port
Wavelength: 1300 nm center
Multimode
SC connectors
Protocols: Modbus, TCP, OPC, HART-IP, https (for Web Interface
Wiring: 50/125 um or 62.5/125 um fiber, 2.48 miles (4.0 k.)
maximum distance.

Modbus
Supports Modbus RTU and Modbus TCP with 32-bit floating poin
values, integers, and scaled integers.
Modbus Registers are user-specified.

OPC
OPC server supports OPC DA v2, v3

Self-Organizing Network Specifications

Protocol
IEC 62591 (WirelessHART), 2.4 - 2.5 GHz DSSS

Maximum Network Size
100 wireless devices @ 8 sec.
50 wireless devices @ 4 sec.

Supported Device Update Rates
1 sec. to 60 min.

Network Size/Latency
100 Devices: less than 10 sec.
50 Devices: less than 5 sec.

Data Reliability
>99%

CP Solar Wells

Product Certifications

Approved Manufacturing Locations

Rosemount Inc. – Chanhassen, Minnesota, USA
Emerson Process Management GmbH & Co. • Karlstein, Germany
Emerson Process Management Asia Pacific Private Limited • Singapore
Beijing Rosemount Far East Instrument Co., Limited • Beijing, China

Telecommunication Compliance

All wireless devices require certification to ensure that they adhere to regulations regarding the use of the RF spectrum. Nearly every country requires this type of product certification. Emerson is working with governmental agencies around the world to supply fully compliant products and remove the risk of violating country directives or laws governing wireless device usage.

FCC and IC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions. This device may not cause harmful interference. This device must accept any interference received, including interference that may cause undesired operation. This device must be installed to ensure a minimum antenna separation distance of 20 cm from all persons.

Ordinary Location Certification for FM

As standard, the Gateway has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

North American Certifications

N5 FM Division 2, Non-Incendive
Certificate Number: 3028321
Nonincendive for Class I, Division 2, Groups A, B, C, and D.
Suitable for Class II, III, Division 1,
Groups E, F, and G; Indoors/outdoor locations;
Type 4X
Temperature Code: T4 (-40 °C < T_a < 60 °C)

Canadian Standards Association (CSA)

N8 CSA Division 2, Non-Incendive
Certificate Number: 1849337
Suitable for Class I, Division 2, Groups A, B, C, and D.
Dust Ignition-proof for Class II, Groups E, F, and G;
Suitable for Class III Hazardous Locations.;
Install per Rosemount drawing 01420-1011.
Temperature Code: T4 (-40 °C < T_a < 60 °C)
CSA Enclosure Type 4X

European Union Directive Information

The EC declaration of conformity for all applicable European directives for this product can be found on the Rosemount website at www.rosemount.com. A hard copy may be obtained by contacting your local sales representative.

ATEX Directive (94/9/EC)

Emerson Process Management complies with the ATEX Directive.

Electro Magnetic Compatibility (EMC) (2004/108/EC)

Emerson Process Management complies with the EMC Directive.

Radio and Telecommunications Terminal Equipment Directive (R&TTE)(1999/5/EC)

Emerson Process Management complies with the R&TTE Directive

CE

European Certification

N1 ATEX Type n
Certificate Number: Baseefa 07ATEX0056X
ATEX Marking: Ex II 3 G
Ex nA nL IIC T4 (-40 °C < T_a < 60 °C)
Special condition for safe use (X):
The surface resistivity of the antenna is greater than one gigaohm. To avoid electrostatic charge build-up, it must not be rubbed or cleaned with solvents or a dry cloth.
The Apparatus is not capable of withstanding the 500V insulation test required by Clause 9.4 of EN 60079-15: 2005. This must be taken into account when installing the apparatus.

ND ATEX Dust
Certificate Number: Baseefa 07ATEX0057
ATEX Marking: Ex II 3 G
Ex tD A 22 IP66 T135 (-40 °C < T_a < 60 °C)
Maximum working Voltage = 28 V

N7 IECEx Type n
Certificate Number: IECEx BAS 07.0012X
Ex nA nL IIC T4 (-40 °C =< T_a <=60 °C)
Maximum working voltage = 28 V
Special condition for safe use (X):
The surface resistivity of the antenna is greater than one gigaohm. To avoid electrostatic charge build-up, it must not be rubbed or cleaned with solvents or a dry cloth.
The Apparatus is not capable of withstanding the 500 V insulation test required by Clause 9.4 of EN 60079-15: 2005. This must be taken into account when installing the apparatus.

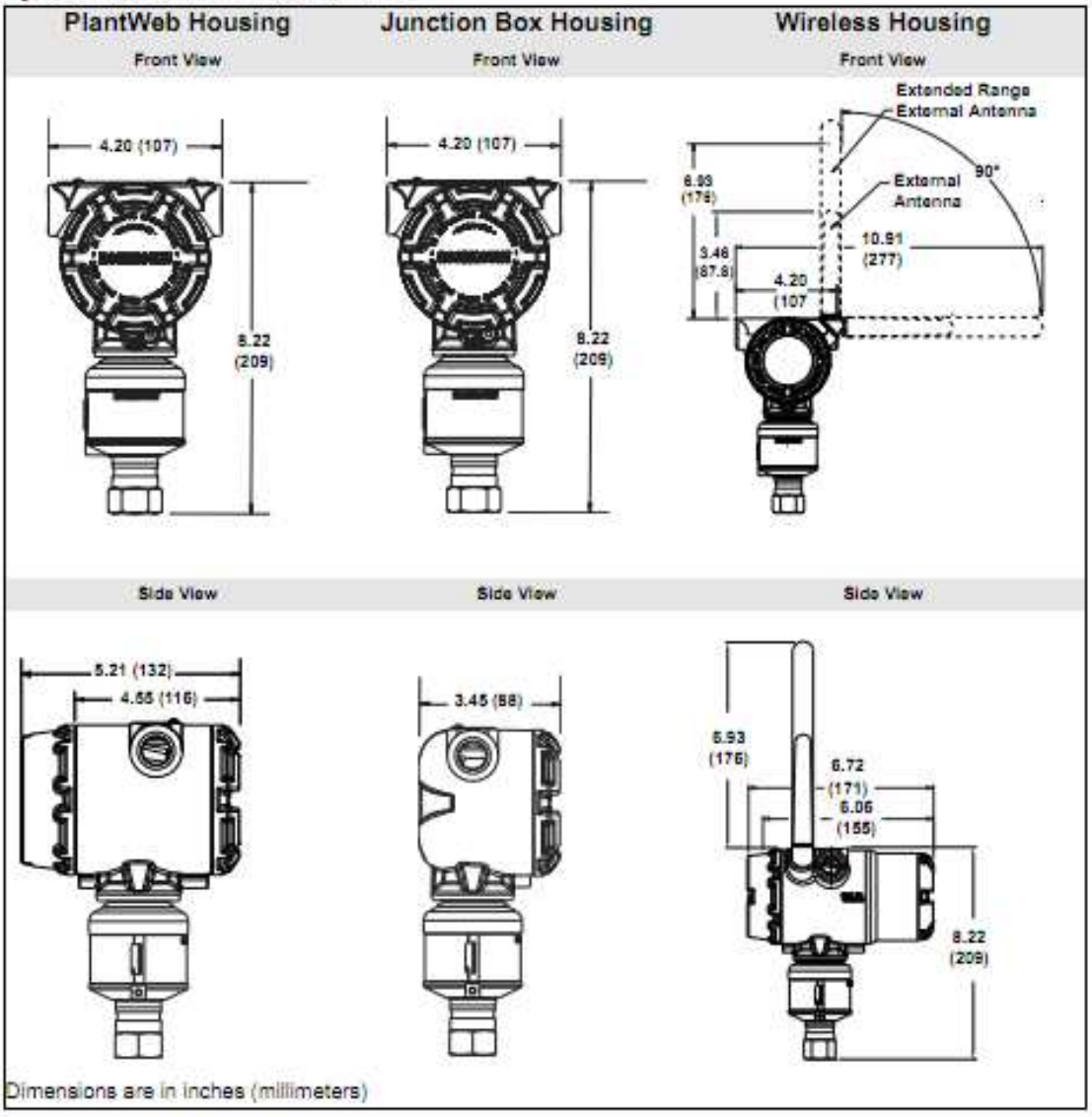
NF IECEx Dust
Certification Number: IECEx BAS 07.0013
Ex tD A22 IP66 T135 (-40 °C < T_a < 60 °C)
Maximum working voltage = 28 V

Combinations of Certifications

KD Combination of N5, N6, and N1.

Rosemount Wireless Pressure Transmitter

Figure 3. Transmitter with In-Line Sensor Module



CP Solar Wells

Rosemount 3051S Certifications

Approved Manufacturing Locations

Rosemount Inc. — Chanhassen, Minnesota USA
Emerson Process Management GmbH & Co. — Wessling, Germany
Emerson Process Management Asia Pacific Private Limited — Singapore
Beijing Rosemount Far East Instrument Co., LTD — Beijing, China
Emerson Process Management LTDA — Sorocaba, Brazil
Emerson Process Management (India) Pvt. Ltd. — Mumbai, India
Emerson Process Management, Emerson FZE — Dubai, United Arab Emirates

Ordinary Location Certification for FM

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

European Directive Information

The EC declaration of conformity for all applicable European directives for this product can be found at www.rosemount.com. A hard copy may be obtained by contacting an Emerson Process Management representative.

ATEX Directive (94/9/EC)

Emerson Process Management complies with the ATEX Directive.

European Pressure Equipment Directive (PED) (97/23/EC)

Models 3051S_CA4; 3051S_CD2, 3, 4, 5; (also with P8 option)

Pressure Transmitters — QS Certificate of Assessment - EC No. 59552-2009-CE-HOU-DNV, Module H Conformity Assessment

All other Model 3051S Pressure Transmitters — Sound Engineering Practice

Transmitter Attachments: Diaphragm Seal - Process Flange - Manifold — Sound Engineering Practice

Primary Elements, Flowmeter — See appropriate Primary Element D/G

Electro Magnetic Compatibility (EMC) (2004/108/EC)

EN 61326-1:2006
EN 61326-2-3:2006

HART & FOUNDATION Fieldbus Hazardous Locations Certifications

North American Certifications

FM Approvals

E5 Explosion-proof for Class I, Division 1, Groups B, C, and D; T5 (T_a = 85 °C); Dust Ignition-proof for Class II and Class III, Division 1, Groups E, F, and G; T5 (T_a = 85 °C); hazardous locations; enclosure Type 4X, conduit seal not required when installed according to Rosemount drawing 03151-1003.

I5/IE Intrinsically Safe for use in Class I, Division 1, Groups A, B, C, and D; T4 (T_a = 70 °C for output options A or X; T_a = 60 °C for output option F); Class II, Division 1, Groups E, F, and G; Class III, Division 1; Class I, Zone 0 AEx ia IIC T4 (T_a = 70 °C for output options A or X; T_a = 60 °C for output option F) when connected in accordance with Rosemount drawing 03151-1006; Non-Incendive for Class I, Division 2, Groups A, B, C, and D; T4 (T_a = 70 °C for output options A or X; T_a = 60 °C for output option F) Enclosure Type 4X.
For entity parameters see control drawing 03151-1006.

Canadian Standards Association (CSA)

All CSA hazardous approved transmitters are certified per ANSI/ISA 12.27.01-2003.

E6 Explosion-proof for Class I, Division 1, Groups B, C, and D; Dust Ignition-proof for Class II and Class III, Division 1, Groups E, F, and G; suitable for Class I, Division 2, Groups A, B, C, and D, when installed per Rosemount drawing 03151-1013, CSA Enclosure Type 4X; conduit seal not required; Dual Seal.

I6/IF Intrinsically Safe for Class I, Division 1, Groups A, B, C, and D when connected in accordance with Rosemount drawings 03151-1016; Dual Seal.
For entity parameters see control drawing 03151-1016.

Rosemount 3051S Wireless Certifications

Approved Manufacturing Locations

Rosemount Inc. — Chanhassen, Minnesota USA
Emerson Process Management GmbH & Co. — Wessling, Germany
Emerson Process Management Asia Pacific Private Limited — Singapore
Beijing Rosemount Far East Instrument Co., LTD — Beijing, China
Emerson Process Management LTDA — Sorocaba, Brazil
Emerson Process Management (India) Pvt. Ltd. — Mumbai, India

Telecommunication Compliance

All wireless devices require certification to ensure that they adhere to regulations regarding the use of the RF spectrum. Nearly every country requires this type of product certification. Emerson is working with governmental agencies around the world to supply fully compliant products and remove the risk of violating country directives or laws governing wireless device usage.

FCC and IC Approvals

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: This device may not cause harmful interference and must accept any interference received, including interference that may cause undesired operation.

This device must be installed to ensure a minimum antenna separation distance of 20 cm from all persons.

Ordinary Location Certification for FM

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

European Directive Information

The EC declaration of conformity for all applicable European directives for this product can be found at www.rosemount.com. A hard copy may be obtained by contacting an Emerson Process Management representative.

ATEX Directive (94/9/EC)

Emerson Process Management complies with the ATEX Directive.

European Pressure Equipment Directive (PED) (97/23/EC)

Models 3051S_CA4; 3051S_CD2, 3, 4, 5; *(also with P9 option)*
Pressure Transmitters — QS Certificate of Assessment • EC No. 59552-2009-CE-HOU-DNV,
Module H Conformity Assessment

All other Model 3051S Pressure Transmitters — Sound Engineering Practice

Transmitter Attachments: Diaphragm Seal • Process Flange • Manifold — Sound Engineering Practice

Primary Elements, Flowmeter — See appropriate Primary Element QIG

Electro Magnetic Compatibility (EMC) (2004/108/EC)

EN 61326-1:2006
EN 61326-2-3:2006

Radio and Telecommunications Terminal Equipment Directive (R&TTE)(1999/5/EC)

Emerson Process Management complies with the R&TTE Directive.

Hazardous Locations Certifications

North American Certifications

Factory Mutual (FM) Approvals

I5 FM Intrinsically Safe, Non-Incendive, and Dust Ignition-proof.
Intrinsically Safe for Class I/II/III, Division 1, Groups A, B, C, D, E, F, and G
Zone Marking: Class I, Zone 0, AEx ia IIC
Temperature Codes T4 (T_{amb} = -60 to 70 °C)
Non-Incendive for Class I, Division 2, Groups A, B, C, and D.
Dust Ignition-proof for Class II/III, Division 1, Groups E, F, and G
Ambient temperature limits: -60 to 65 °C
For use with Rosemount SmartPower options 00753-9220-0001 only.
Enclosure Type 4X / IP66

CSA - Canadian Standards Association

Process Sealing

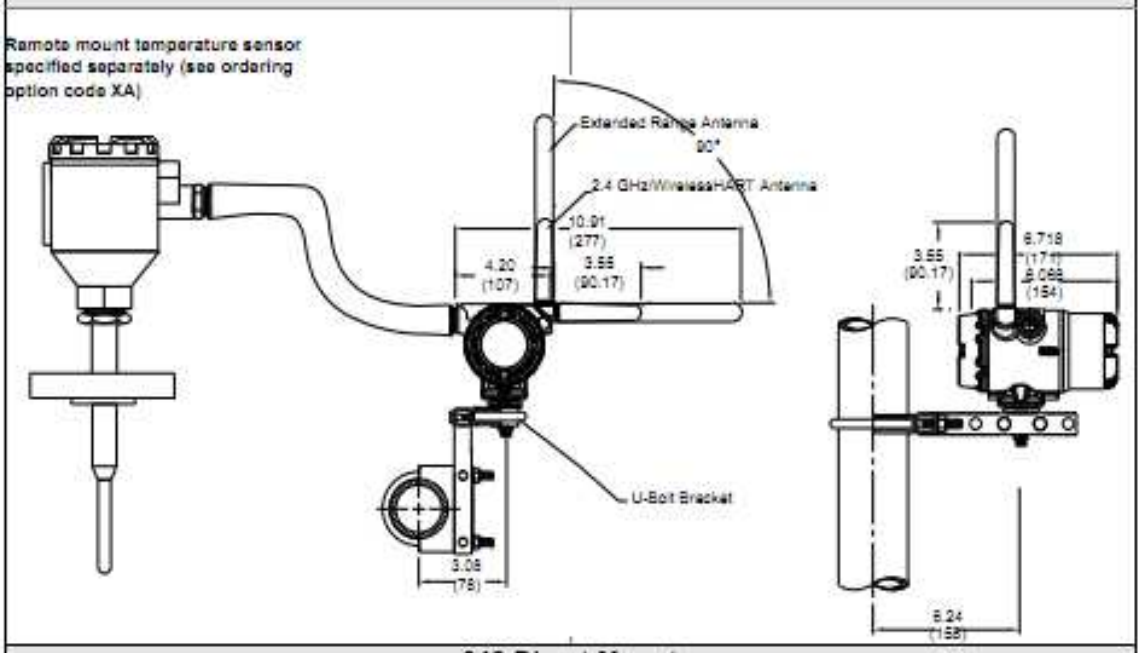
All CSA hazardous approved transmitters are certified per ANSI/ISA 12.27.01-2003.

I6 CSA Intrinsically Safe
Intrinsically Safe for Class I, Division 1, Groups A, B, C, and D.
Temp Code T3C
Enclosure Type 4X / IP66
For use with Rosemount SmartPower options 00753-9220-0001 only.

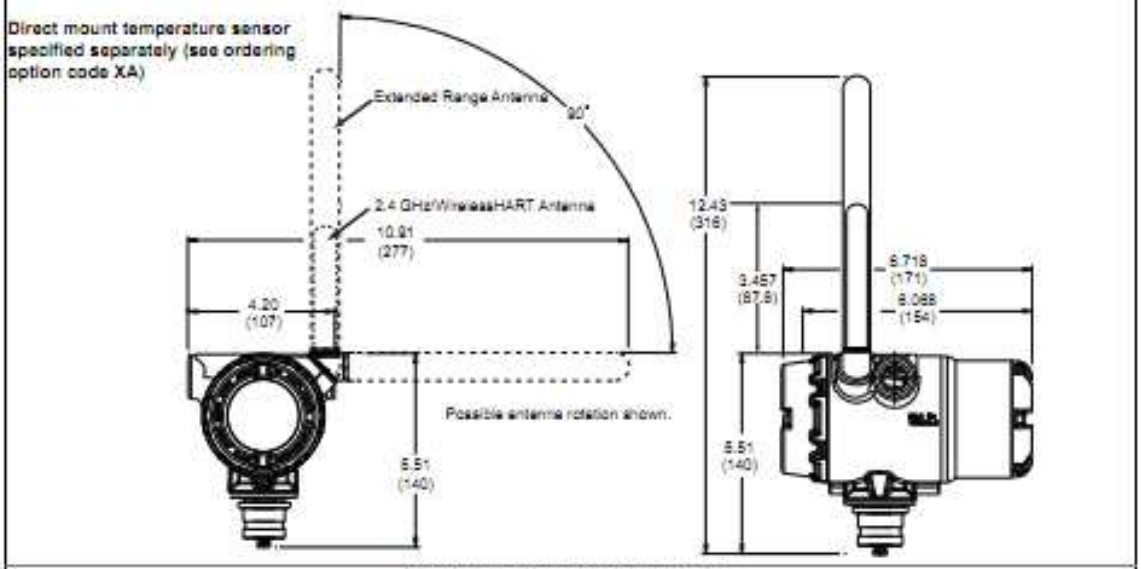
CP Solar Wells

Dimensional Drawings

648 Remote Mount



648 Direct Mount



Dimensions are in inches (millimeters)

CP Solar Wells

Transmitter Specifications

Functional Specifications

Input

Supports Thermocouple, RTD, millivolt, and ohm input types. See "Transmitter Accuracy" on page 8 for sensor options.

Output

WirelessHART 2.4 GHz DSSS

Local Display

The optional five-digit integral LCD Display can display engineering units (°F, °C, °R, K, Ω, and millivolts). Display update rate up to once per minute.

Humidity Limits

0–99% Non-condensing Relative Humidity

Update Rate

WirelessHART, user selectable 8 seconds to 60 minutes

Accuracy (Pt 100 @ reference condition: 20 °C)

±0.225 °C (±0.405 °F)

Radio Frequency Power Output from Antenna

Long Range (WK1 option) antenna: Maximum of 10 mW (10dBm) EIRP

Physical Specifications

Electrical Connections

Power Module

The Emerson SmartPower™ Long Life Power Module is field replaceable, featuring keyed connections that eliminate the risk of incorrect installation.

The Power Module is an intrinsically Safe solution, containing Lithium-thionyl chloride with a polybutadine terephthalate (PBT) enclosure.

The 648 Wireless has Power Module life time rating of 10 years with a one-minute update rate, at reference conditions.(1)

Sensor Terminals

Sensor terminals permanently fixed to terminal block

Field Communicator Connections

Communication Terminals

Clips permanently fixed to terminal block, designated by the text "COMM."

Materials of Construction

Enclosure

Housing - Low-copper aluminum or stainless steel

Paint - Polyurethane

Cover O-ring - Buna-N

Terminal Block and Power Module

PBT

Antenna

PBT/Polycarbonate (PC) integrated omnidirectional antenna

Mounting

Transmitters may be attached directly to the sensor. Mounting brackets also permit remote mounting. See "Dimensional Drawings" on page 12.

Weight

Low-copper Aluminum:
- 648 without LCD - 4.8 lbs. (2.0 kg)
- 648 with M5 LCD - 4.7 lbs (2.1 kg)

Stainless Steel:
- 648 without LCD - 9.0 lbs. (3.8 kg)
- 648 with M5 LCD - 8.1 lbs (3.7 kg)

Enclosure Ratings (648)

Housing Style option codes D and E are Type 4X and IP66/67 rated dual-compartment housings.

Performance Specifications

ElectroMagnetic Compatibility (EMC)

All Models:

Meets all relevant requirements of EN 61326-1; 2006; EN 61326-2-3; 2006

Transmitter Stability

The 648 has a stability of ±0.225% of output reading or 0.225 °C (whichever is greater) for 24 months

Self Calibration

The analog-to-digital measurement circuitry automatically self-calibrates for each temperature update by comparing the dynamic measurement to extremely stable and accurate internal reference elements.

Vibration Effect

No effect when tested per the requirements of IEC60770-1:

High Vibration Level - field or pipeline (10-60 Hz 0.21mm displacement peak amplitude / 60-2000 Hz 3g).

---

(1) Reference conditions are 70 °F (21 °C), and routing data for three additional network devices.
NOTE: Continuous exposure to ambient temperature limits (-40 °F or 195 °F; -40 °C or 85 °C) may reduce specified life by less than 20 percent.

Product Certifications

Approved Manufacturing Locations

Rosemount Inc. - Chanhassen, Minnesota, USA
Emerson Process Management GmbH & Co. - Karlstein, Germany
Emerson Process Management Asia Pacific Private Limited - Singapore

European Union Directive Information

The current Declaration of Conformity is located at the end of this document. The most recent revision of the European Union Declaration of Conformity can be found at www.emersonprocess.com.

ATEX Directive (94/9/EC)

Emerson Process Management complies with the ATEX Directive.

Electro Magnetic Compatibility (EMC) (2004/108/EC)

Emerson Process Management complies with EMC Directive.

Radio and Telecommunications Terminal Equipment Directive (R&TTE)(1999/5/EC)

Emerson Process Management complies with the R&TTE Directive.

Telecommunication Compliance

All wireless devices require certification to ensure that they adhere to regulations regarding the use of the RF spectrum. Nearly every country requires this type of product certification. Emerson is working with governmental agencies around the world to supply fully compliant products and remove the risk of violating country directives or laws governing wireless device usage.

FCC and IC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: This device may not cause harmful interference. This device must accept any interference received, including interference that may cause undesired operation.

This device must be installed to ensure a minimum antenna separation distance of 20 cm from all persons.

Ordinary Location Certification for FM

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

Hazardous Locations Certificates

North American Certifications

Factory Mutual (FM) Approvals

I5 FM Intrinsically Safe, Non-Incendive and Dust Ignition-proof
Certificate Number: 3027705
Intrinsically Safe for Class I/II/III, Division 1, Groups A, B, C, D, E, F, and G
Zone Marking: Class I, Zone 0, AEx ia IIC
Temperature Codes: T4 (T_{amb} = -50 to 70 °C)
T5 (T_{amb} = -50 to 40 °C)
Non-Incendive for Class I, Division 2, Groups A, B, C, and D
Temperature Codes: T4 (T_{amb} = -50 to 70 °C)
T5 (T_{amb} = -50 to 40 °C)
Dust Ignition-proof for Class II/III, Division 1, Groups E, F, and G
Ambient temperature limits: -50 to 85 °C

Enclosure: Type 4X/IP66/IP67
Intrinsically Safe and Non-Incendive when installed in accordance with Rosemount drawing 00648-1000.
For use with Rosemount Power Module P/N 753-9220-XXXX only.

N5 FM Non-Incendive and Dust Ignition-proof
Certificate Number: 3027705
Non-Incendive for Class I, Division 2, Groups A, B, C, and D
Temperature Codes: T4 (T_{amb} = -50 to 70 °C)
T5 (T_{amb} = -50 to 40 °C)
Dust Ignition-proof for Class II/III, Division 1, Groups E, F, and G
Ambient temperature limits: -50 to 85 °C

Enclosure: Type 4X/IP66/IP67
For use with Rosemount Power Module P/N 753-9220-XXXX only.

Canadian Standards Association (CSA)

I6 CSA Intrinsically Safe
Certificate Number: 1143113
Intrinsically Safe for Class I, Division 1, Groups A, B, C, and D
Temp Code T3C

Enclosure: Type 4X/IP66/IP67
Intrinsically Safe when installed per Rosemount drawing 00648-1020.
For use with Rosemount Power Module P/N 753-9220-XXXX only.

Control Microsystems (Accutech) Wireless Gateway

Accutech Base Radio — Product Data Sheet

Accutech Base Radio

Functional		
Location		Interfaced with RTU/PLC or PC
Radio Frequency Range		902-928MHz license-free band
RF Channel Data Rate		32,000, 64,000, 128,000 or 256,000 bps
Features		
Configuration Interface	Local: Remote:	LCD and Keypad Accutech Manager, Windows®-based GUI software, providing network-wide fault and performance-management features and field unit configuration capabilities
RF Characteristics		▪ 902MHz - 928MHz band (FCC/IC) ▪ 915MHz - 928MHz band (Australia) ▪ 915MHz - 921MHz band (New Zealand) ▪ Up to 5000ft (~1500m) typical range with obstructions ▪ The RF module in each radio is individually tested and calibrated over the full temperature range to ensure reliable wireless operation
Output Options		RS-485 digital communications with conversion to RS-232 or USB for interface with PC or server and Accutech Manager Serial Modbus RTU over RS-485 Modbus RTU in TCP or UDP (with optional third-party converter)
Self-Diagnostics		Contains extensive self-checking software and hardware that continuously monitors operation. Any sensor or device parameter that is out of spec is identified and reported.
Connections	Data: Diagnostics: Antenna Type: Antenna Connector:	RS-232 or RS-485, RJ45 RS-232 (DTE - RxD, TxD) RS-485 (2 wires, Termination DIP switch enabled) Tx, Rx LED RS-232 or RS-485, RJ45 RS-232 (DTE - RxD, TxD) RS-485 (2 wires, Termination DIP switch enabled) Tx, Rx LED 1/2 wave dipole, 6dB maximum gain allowable RPSMA
General	Input Voltage: Input Current: Input Power: Serial Data Rate: Dimensions: Packaging: Terminations: Environment: LED Power Enable:	11 to 30VDC, 30VDC maximum 13.8VDC, 24VDC nominal 30mA maximum (at 13.8VDC nominal) 0.5W maximum (11 to 30VDC) 4,800, 19,200 or 76,800 bps 4.25 inch (108mm) wide 4.625 inch (118mm) high 1.75 inch (44mm) deep Corrosion-resistant zinc plated steel with black enamel paint 5-pole removable terminal block, 12-22AWG, 15A contacts 8-pole RJ-45 style jacks 5% RH to 95% RH, non-condensing -40°C to 70°C (-40°F to 158°F) operation -40°C to 85°C (-40°F to 185°F) storage LEDs can be disabled with DIP switch
Approvals and Certifications	FCC: Hazardous Locations - North America: Safety: Digital Emissions:	FCC 15.247 cCSA$_{us}$ Class 2258 02 - Process Control Equipment - For Hazardous Locations, Class 2258 82 - Process Control Equipment - For Hazardous Locations - Certified to US Standards. Class I, Div 2, Groups A, B, C and D, Input rated 11-30VDC, 7.2W; temp code T4, ambient: 70C. Can/CSA Std. C22.2 No. 0-M91 (R2001) - General Requirements – Canadian Electrical Code, Part II CSA Std. C22.2 No. 213-M1987 – Non-Incendive Electrical Equipment for Use in Class I, Div 2 Hazardous Locations CSA Std. C22.2 No. 142-M1987 - Process Control Equipment UL Std. No. 1604 (3rd Ed.) - Electrical Equipment for Use in Class I and II, Div 2, Class III Hazardous (Classified) Locations UL Std. No. 508 (17th Ed.) - Standard for Industrial Control Equipment FCC 47 CFR Part 15, Subpart B, Class A Verification ICES-003 Issue 4 (Canada) AS/NZS CISPR 22: 2006 (Australia/New Zealand) C-Tick compliance, Registration number N15744.
Warranty		3-Year parts and labor

CP Solar Wells

Accutech BR20
DIN Rail Mounted Base Radio (with optional long haul radio)

Features:

- Accutech base radio
- Optional long-haul Trio K-Series radio
- DIN rail-mounted metal enclosure
- Support for max. 100 Accutech field units
- License-free 900MHz band communication
- Secure frequency-hopping, spread-spectrum transmission
- LCD for base radio configuration
- CSA Class I, Div 2 rating
- 3-Year Warranty [parts and labor]

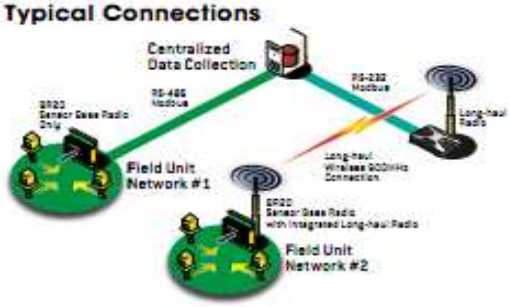
The Accutech BR20 base radio bridges the price and performance gap by providing both wireless data links to Accutech field units in its standard configuration and long-haul links to centralized data collection sites with an optional Trio K-Series data radio; all within a robust, DIN-rail mounted metal enclosure. Secure, license-free 900MHz, spread-spectrum technology is used throughout with a full suite of hardware options and configuration and diagnostics tools available to minimize maintenance costs and optimize operation.

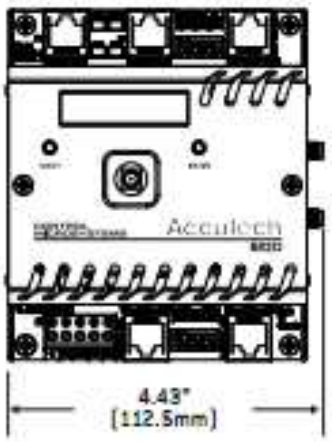
Expensive, hard-wired sensor installations are eliminated thanks to the easy-to-install-and-configure BR20 which provides process instrumentation data from field units through a wireless connection. The BR20 is configured locally via an LCD/keypad or remotely with Accutech Manager, which also acts as a user-friendly environment for wireless network diagnostics and management of the Accutech network. A wide range of field units are supported with a maximum of 100 possible per base radio network.

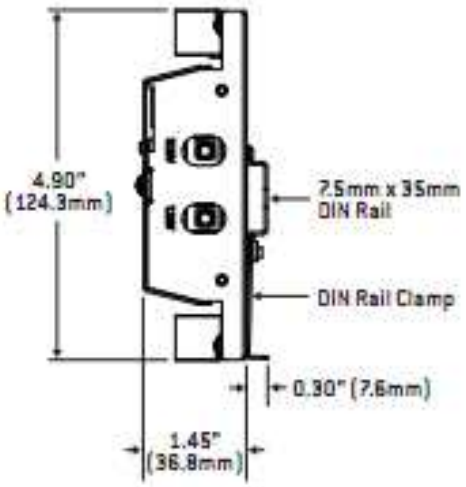
The optional integrated long-haul Trio radio shares all the features of Trio K-Series radios, including RS-232 and RS-485 user interfaces, channel-sharing, collision-avoidance and support for leading industrial communication protocols. A separate system port eliminates the need to interrupt critical data flow during configuration and diagnostics sessions which are handled by the Trio TView+ application.

The BR20 can be used to collect Accutech field unit data alone or as part of a larger system with the optional long-haul radio. The product is powered by readily-available 11-30VDC and is certified Class I, Div 2, Groups A, B, C and D for installation in hazardous locations.

Typical Connections







CP Solar Wells

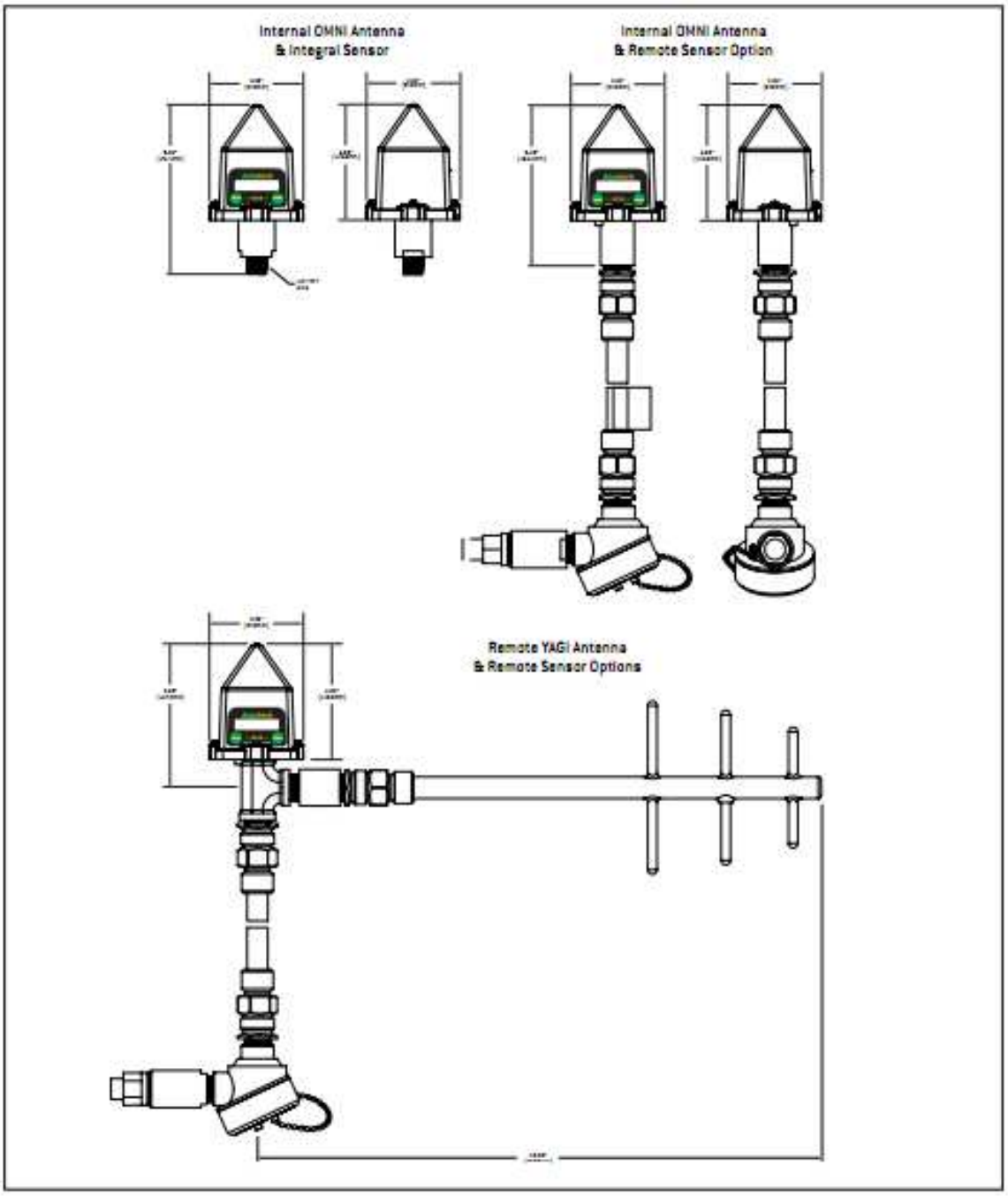
Control Microsystems (Accutech) Wireless Pressure Transmitter

Accutech Field Unit — Product Data Sheet

GP10 Specifications

Functional		
Sensor Type		Gauge Pressure
Location		Field Unit
Frequency Range		902-928MHz
Power		Integrated battery
Features		
Remote Configuration Interface		Accutech Manager, Windows™-based GUI software, providing network-wide fault and performance-management features and field unit configuration capabilities.
Local Configuration Interface		▪ Integrated LCD with membrane-switch buttons ▪ Display provides pressure reading and error messages, if applicable ▪ Configure sampling and RF parameters locally using membrane-switch buttons.
Sensor	Accuracy:	± 0.1 % of sensor URL including the combined effects of linearity, hysteresis, repeatability and temperature (applies to standard unit without isolating seals).
	Stability:	Combined zero and span stability: less than ± 0.1% of sensor URL per year at 70°F (21°C)
	Output Resolution:	24-bit Analog to Digital conversion
	Gauge Pressure Ranges:	250, 1000, 5000 PSIG (17, 70, 350 BAR)
RF Characteristics		▪ 902MHz - 928MHz band (FCC/IC) ▪ 915MHz - 928MHz band (Australia) ▪ 915MHz - 921MHz band (New Zealand) ▪ Up to 5000ft (~1500m) typical range with obstructions ▪ The RF module in each field unit is individually tested and calibrated over the full temperature range to ensure reliable wireless operation ▪ Transmit Power: +13dBm ▪ Receive Sensitivity: -113dBm ▪ Adjacent Channel Rejection: 48dBc ▪ Alternate Channel Rejection: 62dBc
Self-Diagnostics		▪ Low battery alarm – indicates the need to replace the battery (approximately one month warning). ▪ Contains extensive self-checking software and hardware that continuously monitors operation. Any sensor or device parameter that is out of spec is identified and reported.
General		
	Operating Ambient Environment:	▪ -40°F to +250°F (-40°C to +121°C), process temperature, steady-state ▪ -40°F to +230°F (-40°C to +110°C) ambient temperature sensor ▪ -40°F to +185°F (-40°C to +85°C) electronics ▪ -4°F to +158°F (-20°C to +70°C) display (full visibility) ▪ -40°F to +185°F (-40°C to +85°C) display (with reduced visibility) ▪ Humidity: to 95 %, non-condensing
	Materials of Construction:	▪ Base Plate: 304 Stainless Steel ▪ Cover: GE Lexan®, V-0 rating and UV stable ▪ Process Connection: 1/2" MNPT
	Power:	▪ Self-contained power ▪ One 'C' Cell ▪ Up to ten (10) year battery life (depends on sample rate and RF-update rate)
	Operating Shock and Vibration:	Certified per IEC EN60068 2-6 (vibration) and 2-27 (shock)
	Random Vibration Characteristics:	Certified to withstand 8 g's, 15 minutes per axis from 9 – 500Hz
	Electromagnetic Compatibility Safety Certifications:	Operates within specification in fields from 80 to 1,000MHz with field strengths to 30V/m. Meets EN 50082-1 General Immunity Standard and EN 55011 compatibility emissions standard. ▪ Intrinsically Safe: CSA - Exia IIC; AEx ia IIC; Class I, Div. 1, Groups A, B, C & D; Class II, Div. 1, Groups E, F & G; Class III, Div. 1

CP Solar Wells



CP Solar Wells

Control Microsystems (Accutech) Wireless Temperature Transmitter

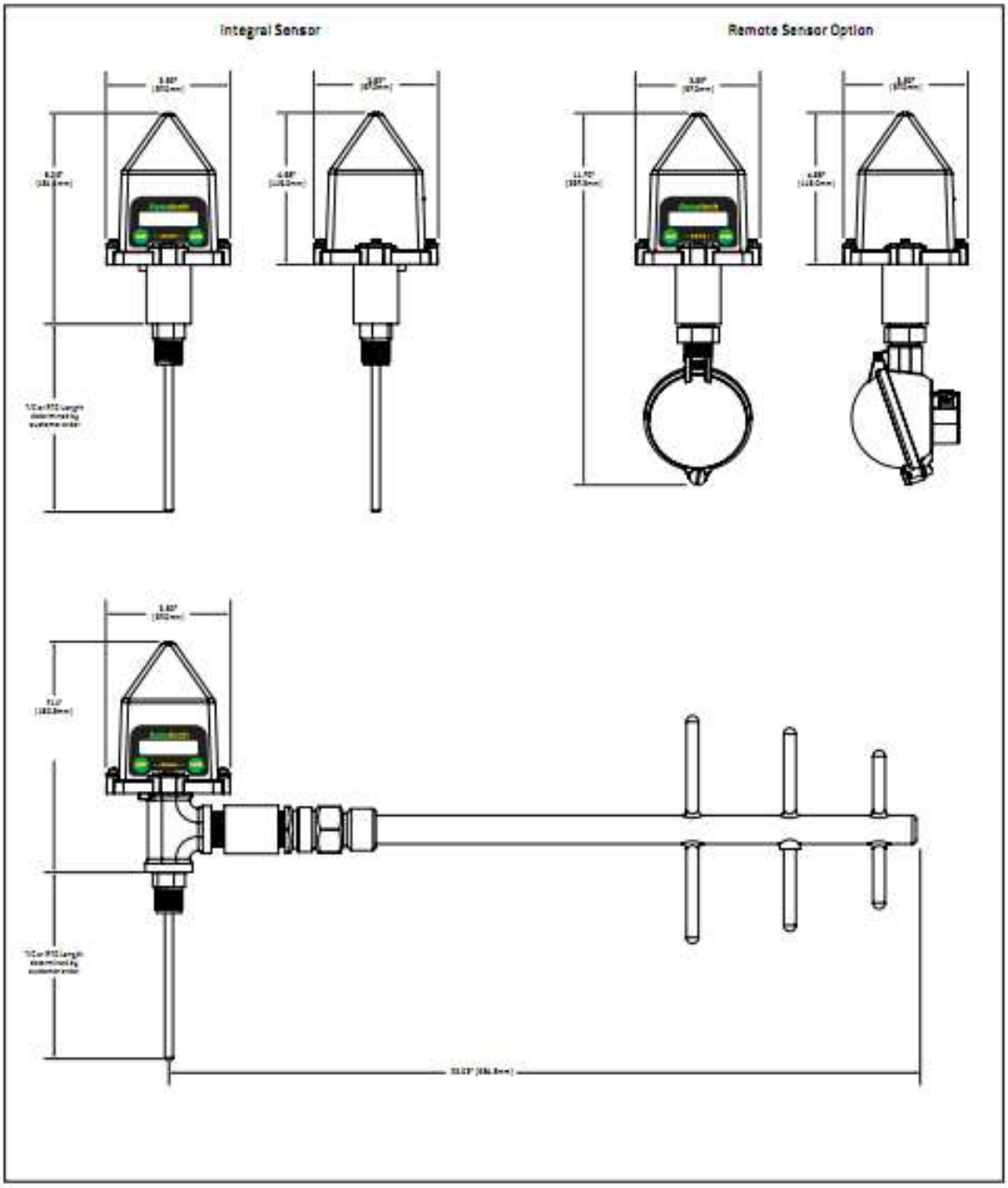
Accutech Field Unit — Product Data Sheet

RT1O Specifications

Functional	
Sensor Type	RTD Temperature High accuracy, high temperature: -200° to 800°C (-330° to 1470°F)
Location	Field Unit
Frequency Range	902-928MHz
Power	Integrated battery

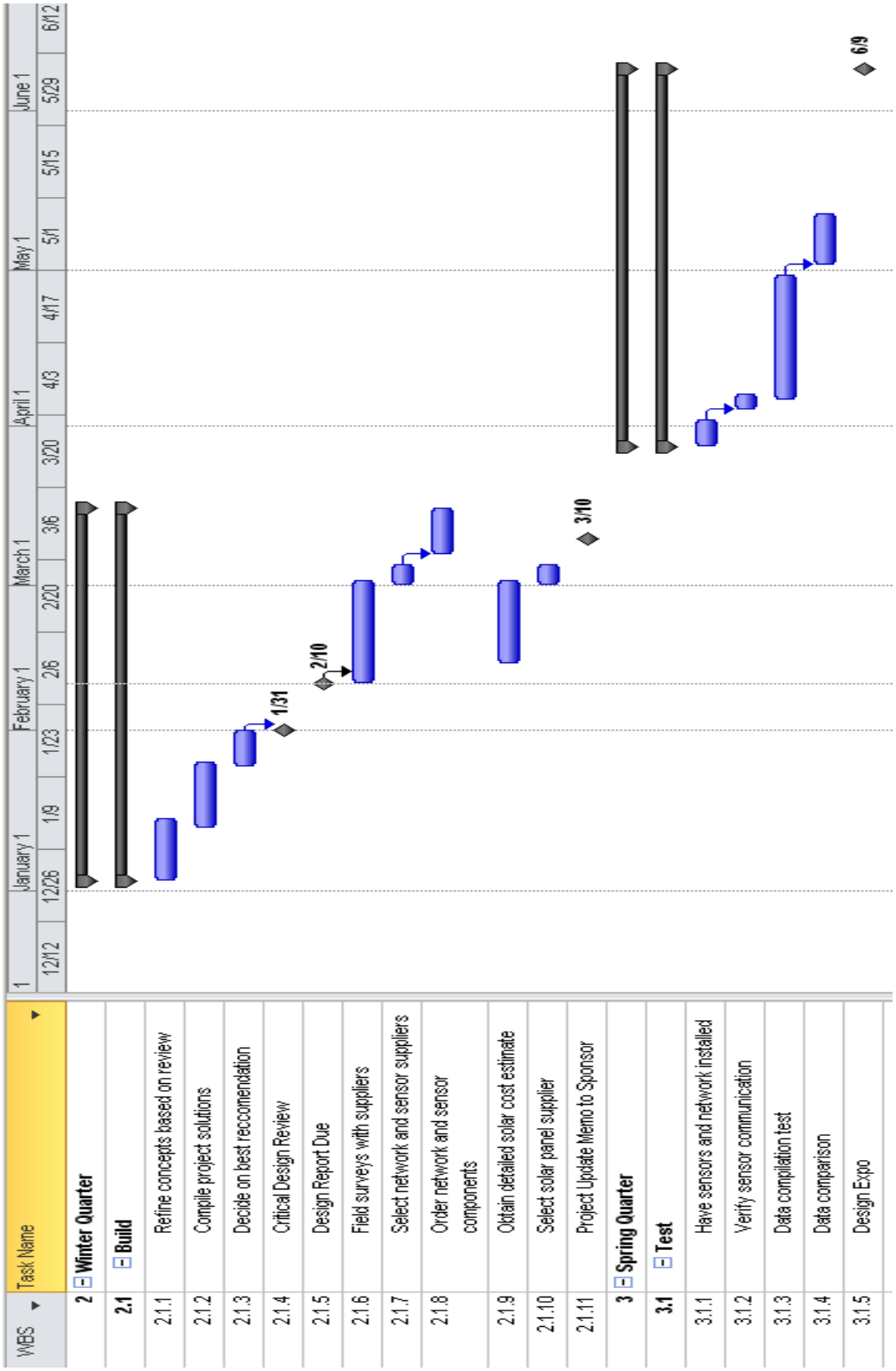
Features	
Linearization	RTD linearization to ± .09°F (.05°C), custom linearization with 22-point curve
Remote Configuration Interface	Accutech Manager, Windows™-based GUI software, providing network-wide fault and performance-management features and field unit configuration capabilities.
Local Configuration Interface	▪ Integrated LCD display with membrane-switch buttons provides pressure reading and error messages, if applicable ▪ Configure sampling and RF parameters locally using membrane-switch buttons
Sensor Accuracy:	± 0.1 % of full-scale reading, RTD: ± 0.002 % of reading per °C for ambient temperature effect
Stability:	Stability deviation per year is less than 0.025 %
RF Characteristics	▪ 902MHz - 928MHz band (FCC/IC) ▪ 915MHz - 928MHz band (Australia) ▪ 915MHz - 921MHz band (New Zealand) ▪ Up to 5000ft (~1500m) typical range with obstructions ▪ The RF module in each field unit is individually tested and calibrated over the full temperature range to ensure reliable wireless operation
Self-Diagnostics	▪ Low battery alarm – indicates the need to replace the battery (approximately one month warning). ▪ Contains extensive self-checking software and hardware that continuously monitors operation. Any sensor or device parameter that is out of spec is identified and reported.
General	
Operating Ambient Environment:	▪ -40 to +185°F (-40 to +85°C) electronics, -4 to +158°F (-20 to +70°C) display with full visibility, -40 to +185°F (-40 to +85°C) display with reduced visibility ▪ Humidity: 0 to 95 %, non-condensing
Power:	▪ One 'C' Cell ▪ Up to ten (10) year battery life (depends on sample rate and RF-update rate)
Materials of Construction:	▪ Base Plate: 304 Stainless Steel
Physical Characteristics:	▪ Cover: GE Lexan®, V-0 rating and UV stable ▪ Process Connection: 1/2" MNPT
Operating Shock and Vibration:	Certified per IEC EN00068 2-6 (vibration) and 2-27 (shock)
Random Vibration Characteristics:	Certified to withstand 6 g's, 15 minutes per axis from 9 – 500Hz
Electromagnetic Compatibility	
Safety Certification:	Operates within specification in fields from 80 to 1,000MHz with field strengths to 30V/m. Meets EN 50082-1 General Immunity Standard and EN 55011 compatibility emissions standard. ▪ Intrinsically Safe: CSA - Exia IIC; AEx ia IIC: Class I, Div. 1, Groups A, B, C & D; Class II, Div. 1, Groups E, F & G; Class III, Div. 1

CP Solar Wells



CP Solar Wells

Appendix E – Gantt Chart



CP Solar Wells

Appendix F – Purchased Transmitters Specification Sheets

Rosemount Pressure Transmitters

Rosemount 3051S WirelessHART

Rosemount 3051S In-Line Gage or Absolute Transmitter

Model	Transmitter Type		
3051S	In-Line Pressure Transmitter		
Code	**Performance Class**		
1[1]	Ultra: 0.025% span accuracy, 200:1 rangedown, 10-year stability, 12-year limited warranty		
2	Classic: 0.055% span accuracy, 100:1 rangedown, 5-year stability		
Code	**Device Type**		
T	In-Line		
Code	**Measurement Type**		
G	Gage		
A	Absolute		
Code	**Pressure Range**		
	TG	TA	
1A	-14.7 to 30 psi (-1,0 to 2,1 bar)	0 to 30 psia (2,1 bar)	
2A	-14.7 to 150 psi (-1,0 to 10,3 bar)	0 to 150 psia (10,3 bar)	
3A	-14.7 to 800 psi (-1,0 to 55 bar)	0 to 800 psia (55 bar)	
4A	-14.7 to 4000 psi (-1,0 to 276 bar)	0 to 4000 psia (276 bar)	
5A	-14.7 to 10000 psi (-1,0 to 689 bar)	0 to 10000 psia (689 bar)	
Code	**Isolating Diaphragm / Process Connection Material**		
2[2]	316L SST		
3[2]	Alloy C-276		
Code	**Process Connection Style**		
A11[3]	Assemble to Rosemount 306 integral manifold		
B11[3][4]	Assemble to one Rosemount 1199 diaphragm seal		
E11	1/2–14 NPT female		
F11	Non-threaded instrument-flange (I-flange) (Range 1-4 only)		
G11	G1/2 A DIN 16288 male (Range 1-4 only)		
H11	Coned and threaded, compatible with autoclave type F-250-C (Range 5A only)		
Code	**Output[5]**		
A	4–20 mA with digital signal based on HART protocol		
F[6]	FOUNDATION fieldbus protocol		
X[7]	Wireless (Requires wireless options and wireless housing 5A or 5J)		
Code	**Housing Style**	**Materials[8]**	**Conduit Entry Size**
00	None (SuperModule Platform only, no housing included)		
01[9]	Assemble to Rosemount 753R Web-Based Monitoring Indicator		
1A	PlantWeb housing	Aluminum	1/2–14 NPT
1B	PlantWeb housing	Aluminum	M20 x 1.5 (CM20)
1C	PlantWeb housing	Aluminum	G1/2
1J	PlantWeb housing	SST	1/2–14 NPT
1K	PlantWeb housing	SST	M20 x 1.5 (CM20)
1L	PlantWeb housing	SST	G 1/2
5A	Wireless PlantWeb housing	Aluminum	1/2–14 NPT
5J	Wireless PlantWeb housing	SST	1/2–14 NPT
2A	Junction Box housing	Aluminum	1/2–14 NPT
2B	Junction Box housing	Aluminum	M20 x 1.5 (CM20)
2C	Junction Box housing	Aluminum	G 1/ 2
2J	Junction Box housing	SST	1/2–14 NPT
2E	Junction Box housing with output for remote interface	Aluminum	1/2–14 NPT
2F	Junction Box housing with output for remote interface	Aluminum	M20 x 1.5 (CM20)
2G	Junction Box housing with output for remote interface	Aluminum	G1/2
2M	Junction Box housing with output for remote interface	SST	1/2–14 NPT
7J[10]	Quick Connect (A size Mini, 4-pin male termination)	SST	

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Code	Options
PlantWeb Control Functionality	
A01[11]	FOUNDATION fieldbus Advanced Control Function Block Suite
PlantWeb Diagnostic Functionality	
D01[11]	FOUNDATION fieldbus Diagnostics Suite
DA1[12]	HART Diagnostics Suite
Code	**Wireless Options - Select code from each wireless category (example: WA2WK1)**
Wireless Burst Rate	
WA	User Configurable Burst Rate
Operating Frequency and Protocol	
3	2.4 GHz DSSS, WirelessHART
Omnidirectional Wireless Antenna	
WK	Long Range, Integral Antenna
WM	Extended Range, Integral Antenna
SmartPower™	
1	Long-life Power Module Adapter, Intrinsically Safe NOTE: Long-life Power Module must be shipped separately, order Part No. 00753-9220-0001.
Code	**Options**
Mounting Bracket	
B4	Bracket, all SST, 2-in. pipe and panel
Special Configuration (Software)[13]	
C1[13][14]	Custom software configuration *Note: A Configuration Data Sheet must be completed, see document number 00806-0100-4801 for HART and 00806-0100-4802 for wireless.*
C4[13][14]	NAMUR alarm and saturation values, high alarm
C5[13][14]	NAMUR alarm and saturation values, low alarm
C6[13][14]	Custom alarm and saturation signal levels, high alarm *Note: Requires option code C1, custom software configuration. A Configuration Data Sheet must be completed.*
C7[13][14]	Custom alarm and saturation signal levels, low alarm *Note: Requires option code C1, custom software configuration. A Configuration Data Sheet must be completed.*
C8[13][14]	Low alarm (Standard Rosemount alarm and saturation signal levels)
Special Configuration (Hardware)	
D1[13][14]	Hardware adjustments (zero, span, alarm, security) *Note: Not available with Housing Style codes 00, 01, 2E, 2F, 2G, 2M, 5A, or 7J.*
D4	External ground screw assembly
Product Certifications[15]	
E1	ATEX Flameproof
I1	ATEX Intrinsic Safety
IA	ATEX FISCO Intrinsic Safety; for FOUNDATION fieldbus protocol only
N1	ATEX Type n
K1	ATEX Flameproof, Intrinsic Safety, Type n, Dust (combination of E1, I1, N1, and ND)
ND	ATEX Dust
E4	TIIS Flameproof
E5	FM Explosion-proof, Dust Ignition-proof
I5	FM Intrinsically Safe, Division 2
IE	FM FISCO Intrinsically Safe; for FOUNDATION fieldbus protocol only
K5	FM Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2 (combination of E5 and I5)
E6	CSA Explosion-proof, Dust Ignition-proof, Division 2
I6	CSA Intrinsically Safe
IF	CSA FISCO Intrinsically Safe; for FOUNDATION fieldbus protocol only
K6	CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2 (combination of E6 and I6)
D3[16]	Measurement Canada Accuracy Approval
E7	IECEx Flameproof, Dust Ignition-proof
I7	IECEx Intrinsic Safety
IG	IECEx FISCO Intrinsic Safety; for FOUNDATION fieldbus protocol only
N7	IECEx Type n
K7	IECEx Flameproof, Dust Ignition-proof, Intrinsic Safety, Type n (combination of E7, I7, and N7)
E2	INMETRO Flameproof
I2	INMETRO Intrinsic Safety
K2	INMETRO Flameproof, Intrinsic Safety

E3[17]	China Flameproof
I3[17]	China Intrinsic Safety
KA	ATEX and CSA Flameproof, Intrinsically Safe, Division 2 (combination of E1, E6, I1, and I6) *Note: Only available on Housing Style codes 00, IA, IJ, 2A, 2J, 2E, or 2M.*
KB	FM and CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2 (combination of E5, E6, I5, and I6) *Note: Only available on Housing Style codes 00, IA, IJ, 2A, 2J, 2E, or 2M.*
KC	FM and ATEX Explosion-proof, Intrinsically Safe, Division 2 (combination of E5, E1, I5, and I1) *Note: Only available on Housing Style codes 00, IA, IJ, 2A, 2J, 2E, or 2M.*
KD	FM, CSA, and ATEX Explosion-proof, Intrinsically Safe (combination of E5, E6, E1, I5, I6, and I1) *Note: Only available on Housing Style codes 00, IA, IJ, 2A, 2J, 2E, or 2M.*
DW[18]	NSF Drinking Water Approval
Alternate Materials of Construction	
L1	Inert sensor fill fluid *Note: Silicone fill fluid is standard.*
Digital Display[19]	
M5	PlantWeb LCD Display
M7[14][20]	Remote mount LCD display and interface, no cable; PlantWeb housing, SST bracket, requires 4-20 mA / HART output *Note: See the 3051S Reference Manual (document number 00809-0100-4801) for cable requirements.* *Contact an Emerson Process Management representative for additional information.*
M8[14][20][21]	Remote mount LCD display and interface, 50 ft. (15 m) cable; PlantWeb housing, SST bracket, requires 4-20 mA / HART output
M9[14][20][21]	Remote mount LCD display and interface, 100 ft. (31 m) cable; PlantWeb housing, SST bracket, requires 4-20 mA / HART output
Special Procedures	
P1	Hydrostatic testing with certificate
P2[22]	Cleaning for special services
P3[22]	Cleaning for less than 1 PPM chlorine/fluorine
Special Certifications	
Q4	Calibration certificate
QP	Calibration certificate and tamper evident seal
Q8	Material traceability certification per EN 10204 3.1.B
QS[13][14]	Prior-use certificate of FMEDA Data
QT[23]	Safety-certified to IEC 61508 with certificate of FMEDA data
Q16	Surface finish certification for sanitary remote seals
QZ	Remote Seal System Performance Calculation Report
Terminal Blocks	
T1[24]	Transient terminal block
T2[25]	Terminal block with WAGO® spring clamp terminals
T3[25]	Transient terminal block with WAGO spring clamp terminals
Conduit Electrical Connector	
GE[26]	M12, 4-pin, Male Connector (*eurofast®*)
GM[26]	A size Mini, 4-pin, Male Connector (*minifast®*)

Typical Model Number: 3051S1TG 2A 2 E11 A 1A DA1 B4 M5

(1) Not available with Wireless Operating Frequency and Protocol option codes 1 or 2.
(2) Materials of Construction comply with metallurgical requirements highlighted within NACE MR0175/ISO 15156 for sour oil field production environments. Environmental limits apply to certain materials. Consult latest standard for details. Selected materials also conform to NACE MR0103 for sour refining environments.
(3) "Assemble to" items are specified separately and require a completed model number.
(4) Contact an Emerson Process Management representative for performance specifications.
(5) For spare SuperModule Platforms, select output code A.
(6) Requires PlantWeb housing.
(7) Available approvals are FM Intrinsically Safe, Division 2 (option code I5), CSA Intrinsically Safe (option code I6), ATEX Intrinsic Safety (option code I1; only available with 2.4 GHz), and IECEx Intrinsic Safety (option code I7; only available with 2.4 GHz).
(8) Material specified is cast as follows: CF-3M is the cast version of 316L SST. For housing, material is aluminum with polyurethane paint.
(9) Available with output code A only. Not available with approvals. See Rosemount 753R Product Data Sheet, 00813-0100-4379, to specify Web-Based Monitoring Indicator. Does not integrate into plant host systems.
(10) Available with output code A only. Available approvals are FM Intrinsically Safe, Division 2 (option code I5), ATEX Intrinsic Safety (option code I1), or IECEx Intrinsic Safety (option code I7). Contact an Emerson Process Management representative for additional information.
(11) Requires PlantWeb housing and output code F.
(12) Requires PlantWeb housing and output code A. Includes Hardware Adjustments as standard. Not available with option code QT.
(13) Not available with output code F or Housing code 01.
(14) Not available with output code X.
(15) Valid when SuperModule Platform and housing have equivalent approvals.
(16) Requires PlantWeb housing and Hardware Adjustments option code D1. Limited availability depending on transmitter type and range. Contact an Emerson Process Management representative for additional information.
(17) Contact an Emerson Process Management representative for availability.
(18) Requires 316L SST diaphragm material and Process Connection code E11 or G11.
(19) Not available with Housing code 01 and 7J.

(20) Not available with output code F, Housing code 01, option code DA1, or option code QT.
(21) Cable supplied is Belden 3084A, rated for ambient temperatures up to 167°F (75°C).
(22) Not available with process connection option code A11.
(23) Not available with output code F or X. Not available with housing code 01 or 7J.
(24) Not available with Housing code 00, 01, 5A, or 7J.
(25) Available with output code A and PlantWeb housing only.
(26) Not available with Housing code 00, 01, 5A, or 7J. Available with Intrinsically Safe approvals only. For FM Intrinsically Safe, Division 2 (option code I5) or FM FISCO Intrinsically Safe (option code IE), install in accordance with Rosemount drawing 03151-1009 to maintain outdoor rating (NEMA 4X and IP66).

Rosemount Temperature Transmitter

Rosemount 648

Product Data Sheet
00813-0100-4648, Rev FA
April 2011

Rosemount 648 Temperature Transmitter

The Rosemount 648 Wireless Temperature transmitter delivers industry-leading temperature field reliability as a wireless process measurement with Best-in-Class specifications and capabilities.

Transmitter features include:

- IEC-approved *Wireless*HART protocol (Option Code WA3)
- External Antenna (Option Code WK1)
- Extended Range, External Antenna (Option Code WM1)
- Large LCD Display (Option Code M5)
- Transmitter-Sensor Matching (Option Code C2)
- 3-Point Calibration Certificate (Option Code Q4)
- Assemble to Sensor (Option Code XA)

Table 1. Rosemount 648 Temperature Transmitter Ordering Information

★ The Standard offering represents the most common options. The starred options (★) should be selected for best delivery. The Expanded offering is subject to additional delivery lead time.

Model	Product Description		
648	Temperature Transmitter		
Transmitter Type			
Standard			**Standard**
D	Wireless Field Mount		★
Transmitter Output			
Standard			**Standard**
X	Wireless		★
Measurement Configuration			
1	Single-Sensor Input		★
Housing Style		**Material**	
Standard			**Standard**
D	Dual Compartment Housing	Aluminum	★
E	Dual Compartment Housing	SST	★
Conduit Entry Size			
Standard			**Standard**
1	½-14 NPT		★
Product Certifications			
Standard			**Standard**
NA	No Approval		★
I5	FM Intrinsically Safe, Non-Incendive, and Dust Ignition-proof		★
N5	FM Non-Incendive and Dust Ignition-proof		★
I6	CSA Intrinsically Safe		★
I1	ATEX Intrinsic Safety		★
I7	IECEx Intrinsic Safety		★
I4	TIIS Intrinsic Safety		★
I3	China Intrinsic Safety		★

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Table 1. Rosemount 648 Temperature Transmitter Ordering Information

★ The Standard offering represents the most common options. The starred options (★) should be selected for best delivery. The Expanded offering is subject to additional delivery lead time.

Wireless Options (Include with selected model number)

Wireless Update Rate, Operating Frequency, and Protocol		
Standard		**Standard**
WA3	User Configurable Update Rate, 2.4 GHz DSSS, IEC 62591 (WirelessHART)	★
Omnidirectional Wireless Antenna and SmartPower™		
Standard		**Standard**
WK1	External Antenna, Adapter for Black Power Module (I.S. Power Module Sold Separately)	★
WM1	Extended Range, External Antenna, Adapter for Black Power Module (I.S. Power Module Sold Separately)	★
	NOTE: Black Power Module must be shipped separately, order Part #00753-9220-0001.	
Mounting Bracket		
Standard		**Standard**
B5(1)	"L" Mounting Bracket for 2-inch pipe and panel mounting - All SST	★
Display		
Standard		**Standard**
M5	LCD Display	★
Software Configuration		
Standard		**Standard**
C1	Custom Configuration of Date, Descriptor, Message and Wireless Parameters (Requires CDS with order)	★
Line Filter		
Standard		**Standard**
F5	50 Hz Line Voltage Filter	★
F6	60 Hz Line Voltage Filter	★
Sensor Trim		
Standard		**Standard**
C2	Transmitter-Sensor Matching - Trim to Specific Rosemount RTD Calibration Schedule (CVD Constants)	★
5-Point Calibration		
Standard		**Standard**
C4	5-Point Calibration (Requires Q4 option code to generate a Calibration Certificate)	★
Calibration Certificate		
Standard		**Standard**
Q4	Calibration Certificate (3-Point Calibration)	★
Cable Gland Option		
Standard		**Standard**
G2	Cable Gland (7.5 mm - 11.9 mm)	★
G4	Thin Wire Cable Gland (3 mm - 8 mm)	★
Assemble To Options		
Standard		**Standard**
XA(1)	Sensor Specified Separately and Assembled to Transmitter	★
Typical Model Number: 648 D X 1 D 1 NA WA 3 WK 1 M5 C1 F6		

(1) When ordering a Rosemount 648 with the XA option, a mounting bracket is not included. If a bracket is required, please order option code B5.

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