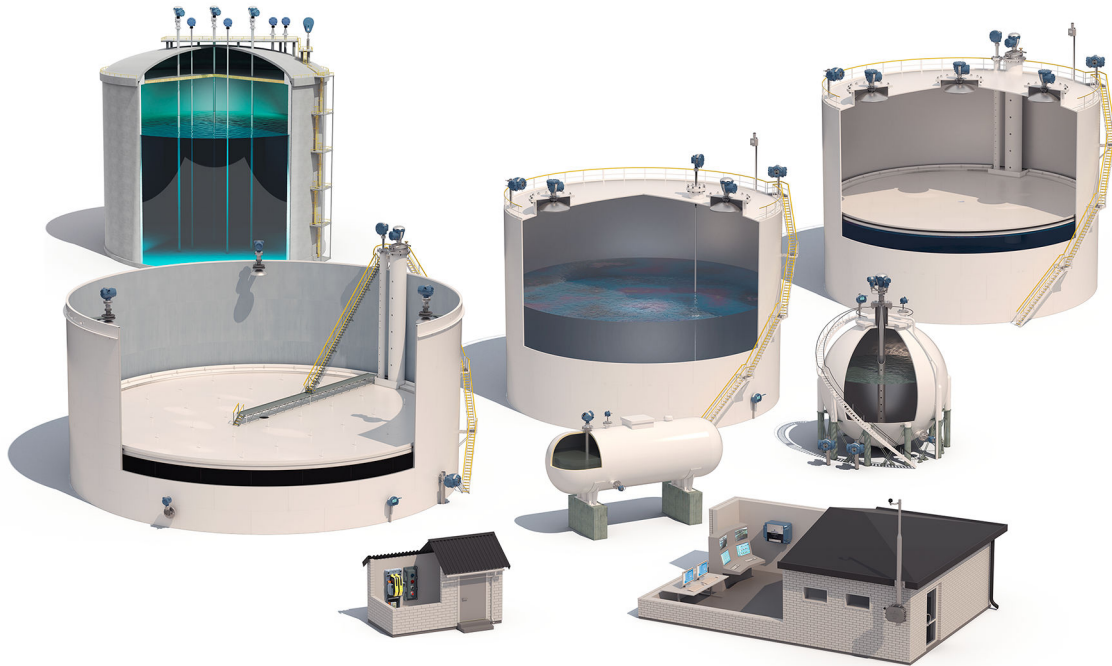


Rosemount™ Tank Gauging System

High-performance bulk liquid measurement and overflow prevention



Secure efficient operations and reduce risk with scalable and open architecture tank gauging technology

- Get certified custody transfer accuracy based on innovative radar technology
- Comply with safety and overflow prevention standards such as API 2350 and IEC 61511
- Simplify automation and expansion with Emerson wireless solutions
- Improve inventory management and oil movement operations
- Use emulation to easily replace old gauges from other vendors

What if you could meet every challenge today and tomorrow?

There are always new challenges to face in a tank storage facility. Expansion or refurbishing projects mean you have to connect new equipment to your installation. This is also the case when you replace damaged or outdated technology. Emerson’s Rosemount Tank Gauging System lets you meet your challenges so you can increase plant efficiency and protect the value of your assets.



Works everywhere

The Rosemount Tank Gauging System is suitable for all applications and tank types: pressurized or non-pressurized, with fixed or floating roofs. Applications include bulk liquid storage tanks in:

- Tank storage terminals
- Refineries
- Aviation fuel depots
- Lube oil depots
- Full containment storage tanks storing LNG and other liquefied gases
- Petrochemical industries
- Power plants
- Distilleries
- Biofuel plants
- Vegetable oil depots

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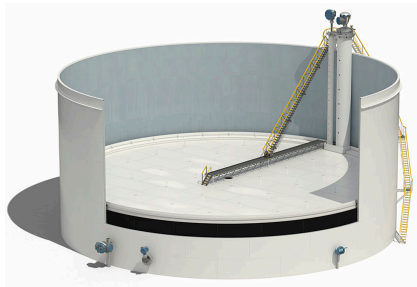
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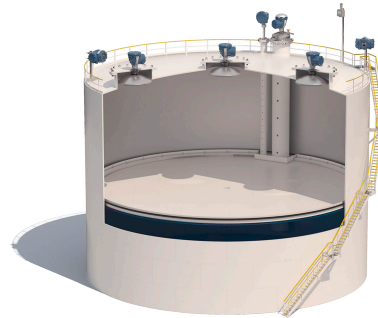
Tank applications

Tank gauging is used on large storage tanks in refineries, fuel depots, pipelines, airports, and storage terminals. Storage tanks usually come in four basic designs: Cylindrical fixed roof tanks, cylindrical floating roof tanks and pressurized tanks of either spherical or horizontal cylinder design. There are tank gauges available for all these tank types.

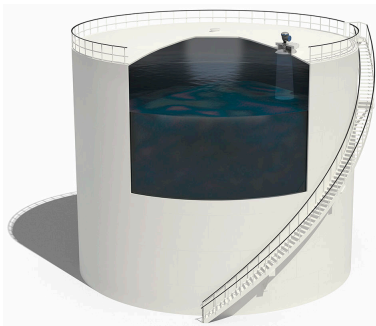
Figure 1: Available Tank Types



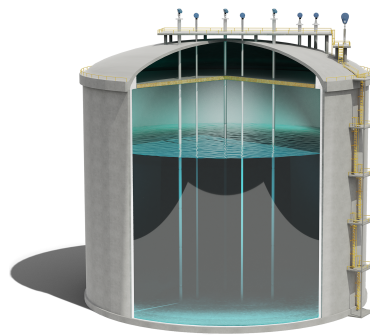
Floating roof tank



Internal floating roof tank



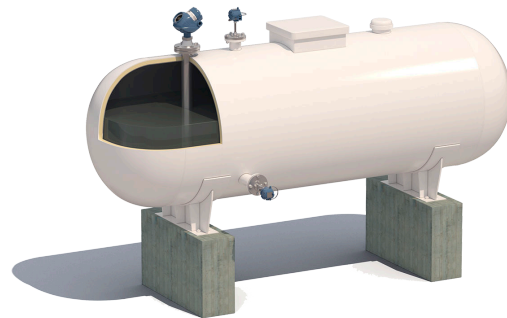
Fixed roof tank



Full containment storage tank



Pressurized LPG tank



Bullet tank

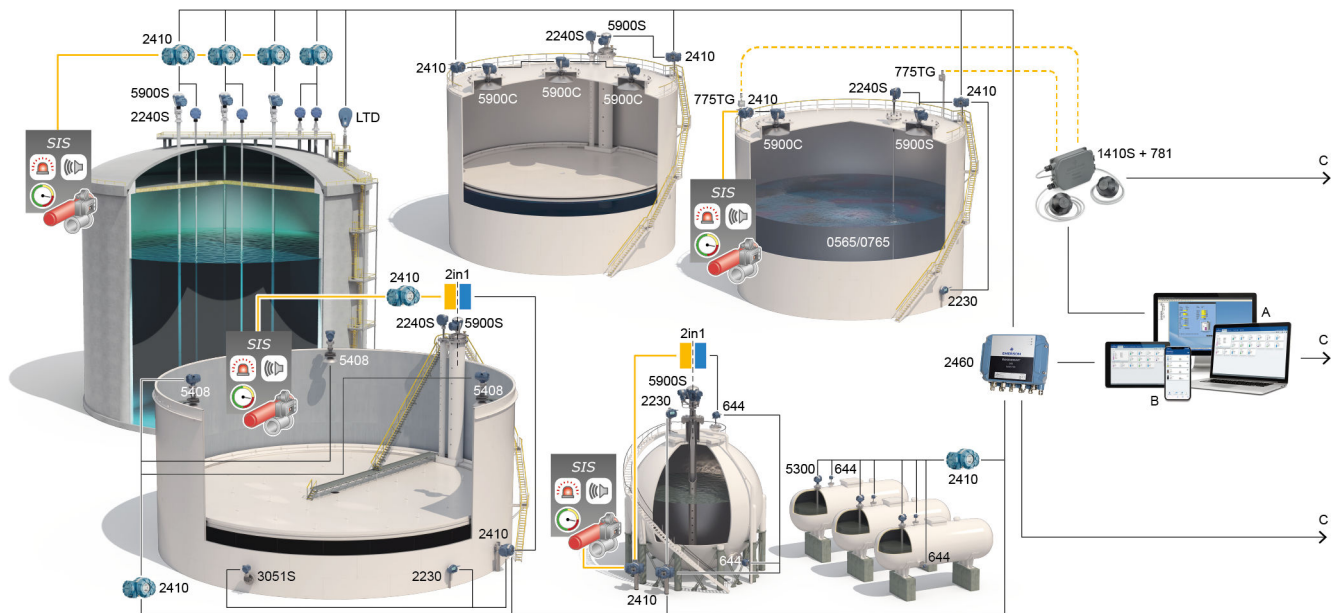
System overview

The Rosemount Tank Gauging System measures and calculates tank data for custody transfer, inventory management, product movement, mass balance, and loss control — as well as leak detection and overfill prevention.

Functions include:

- Complete inventory management and custody transfer functions as per OIML and API standards
- Multiple spot temperature measurement
- Free water interface level measurement
- Vapor pressure and hydrostatic pressure measurement giving online density
- IEC 61508 certified SIL2/SIL3 independent overfill prevention
- Interoperability with all major DCS and host systems
- Automatic proof-testing without affecting tank operations
- Floating roof monitoring
- Support for full containment storage tanks, including features for roll-over prediction and stratification

Figure 2: Rosemount Tank Gauging System Overview



- A. Rosemount TankMaster
- B. Rosemount TankMaster Mobile
- C. Alternative connection to DCS/PLC/SCADA/Host

Make the most of your tank farm

Boost plant efficiency

Having access to reliable and accurate real-time tank inventory data is key to high plant productivity. Operators can handle more tanks, and safely fill them higher to better utilize the storage capacity. Rosemount Tank Gauging System is based on a scalable technology with open architecture, allowing you to improve efficiency step by step.

- Possible to combine devices freely including devices from previous systems
- Automatic configuration of devices speeds up commissioning
- Wired and wireless networks can co-exist within the same system
- Installation can be done with tanks in operation (except for pressurized tanks)
- Rosemount TankMaster Mobile gives you access to live inventory data, whenever and wherever you need it

Raise the safety level

Lawmakers, corporate management, insurance companies, members of the community – demands for increased safety come from just about everywhere. Rosemount Tank Gauging System allows you to meet existing and future requirements at the same time as you protect plant assets, the environment, and human lives.

- Continuous surveillance – radar level gauges are always in operation
- Two-wire intrinsically safe cabling on tanks
- IEC 61508 certified SIL 2 and SIL 3 capable level and alarm output devices
- 2-in-1 gauging allowing simultaneous level measurement and independent alarm functionality
- API 2350 overfill prevention guidelines and expertise available whenever you need it
- Remote proof-testing without affecting the process
- Continuous automatic monitoring of floating roofs
- Cool-down control, leak and stratification detection for liquefied gas



Unique 2-in-1 solution with full separation



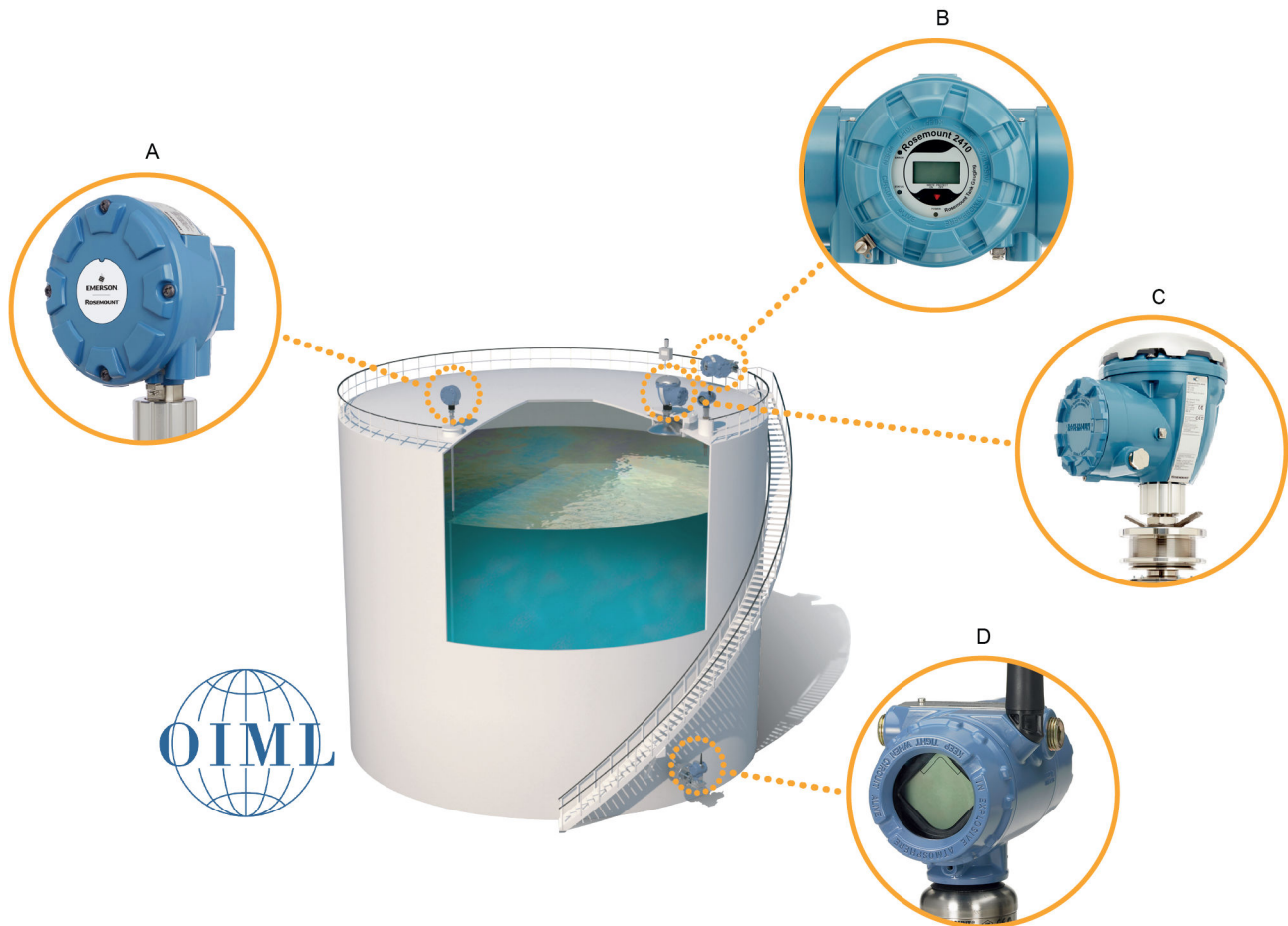
Certified SIL 2 or SIL 3 capable overfill safety

Ensure precise measurements

The Rosemount Tank Gauging System gives you precise data for certified custody transfer, inventory management, and loss control. The level measurement accuracy of ± 0.5 mm (0.02 in.), together with the highest precision average temperature measurement, ensures exact net volume calculations. In cases where medium accuracy is sufficient, we offer a number of cost-effective gauging instruments.

- Level gauges with no moving parts and only the antenna inside the tank
- Custody transfer certification by OIML as well as many national institutes
- Precise measurement lets you stay in control of the inventory and custody transfer
- Keep accurate track of leaks and overfills

Figure 3: The Rosemount Tank Gauging System Provides Precise Tank Measurements



- A. *Transmitter for three- or four-wire calibrated average temperature sensors*
- B. *Display and communication hub for wired and wireless data*
- C. *Ultra-precise radar level*
- D. *Pressure measurement for online mass and density*

Go further with modern technology

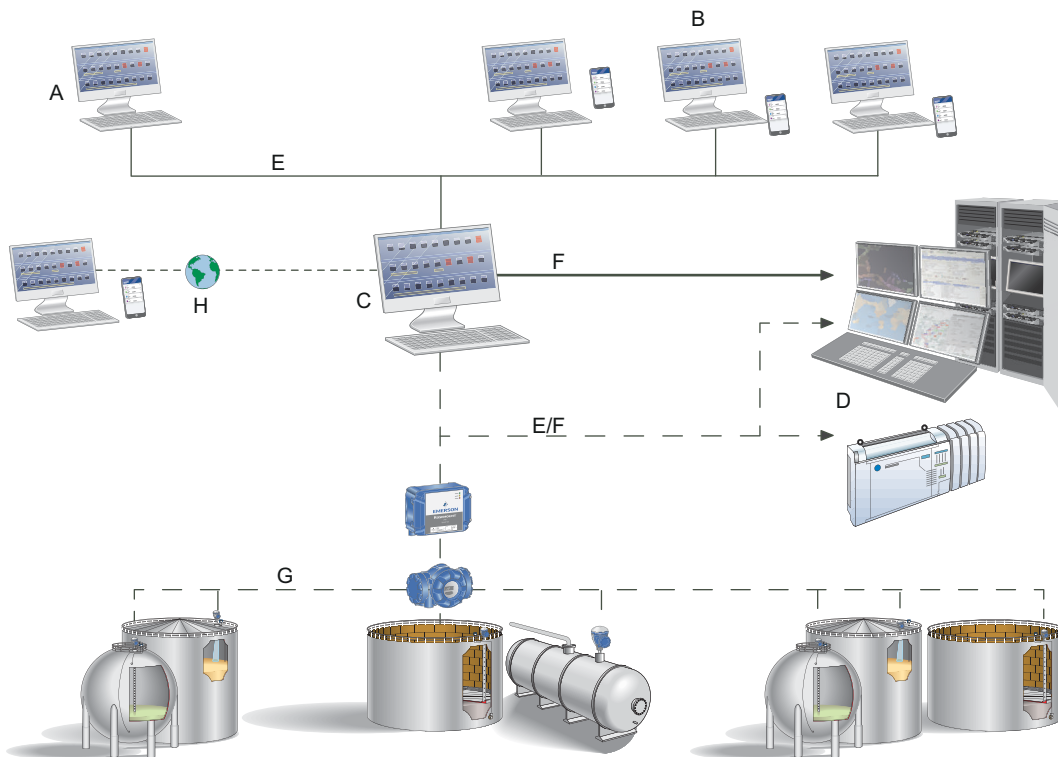
Stay in control with Rosemount TankMaster

TankMaster is a powerful, easy-to-use Windows™-based inventory management software package. It is easy to configure with no software engineering time required. Data can be shared with users on all levels and information can be accessed wherever you are.

Graphic plant layout with customized views for efficient operations:

- Gives the operator a complete tank content overview
- Collects all tank gauging data from the measurement devices on the tanks
- Offers alarm handling and reporting
- Allows proof-testing from the control room
- Provides system configuration and service

Figure 4: TankMaster Distributes Essential Inventory Tank Gauging Data



- A. SCADA / Ethernet (OPC Client)
- B. TankMaster Client: Engineering, Management, Operation etc.
- C. Rosemount TankMaster Server
- D. DCS/PLC
- E. Ethernet
- F. Modbus®
- G. FOUNDATION™ Fieldbus Tankbus
- H. Secure connection from external network

Rosemount TankMaster Mobile provides immediate access to inventory data

Rosemount TankMaster Mobile is an application for remote monitoring of tank farms. It is an add-on to the Rosemount TankMaster Inventory Management software, adding mobility, sharing, and networking. TankMaster Mobile provides operational information available whenever and wherever you need it.

Figure 5: Greater Access to Up-To-Date Tank Inventory Data

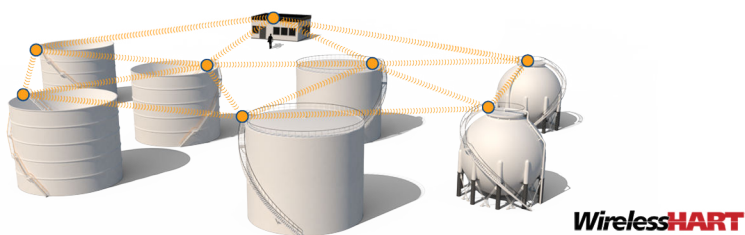


- Easy-to-use web application optimized for computer, tablet, and smartphone
- Instant overview of your tank farm and fast drill down to details
- Cyber secure solution

Reach more tanks at less cost

Wireless tank gauging allows for installation cost savings by up to 70 percent. The Rosemount Tank Gauging System supports Emerson's wireless technology based on the wireless field network industry standard IEC 62591 (*WirelessHART*[®]). The wireless network is self-organizing and automatically finds the best way around any obstacle.

Figure 6: Self-Organizing Wireless Network



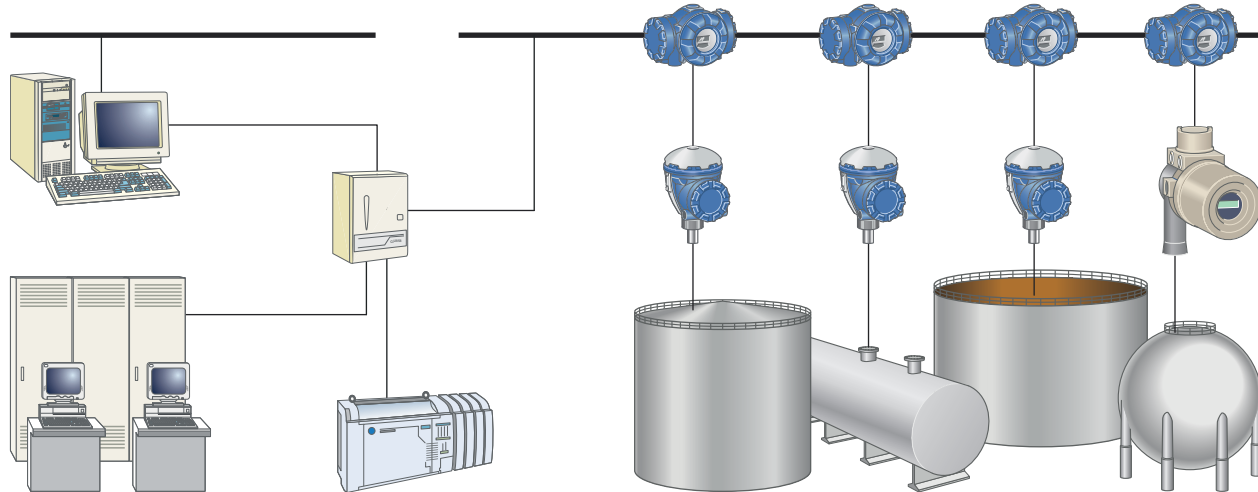
Wireless data transmission gives you a lot of benefits and opportunities:

- No need for digging and trenching in a potentially complicated and dangerous tank environment
- Possible to connect tanks located far away and divided by water or roads
- Easy to automate all bulk liquid storage measurement
- Redundant communication can be created without time-consuming cabling work
- Downtime for expansion, upgrading, and maintenance is kept to a minimum

Meet the future with emulation

Emulation technology lets you replace old level gauges from all major vendors with modern radar-based tank gauging, using your existing field wiring and host system.

Figure 7: Replace Old Level Gauges with Modern Radar-Based Tank Gauging



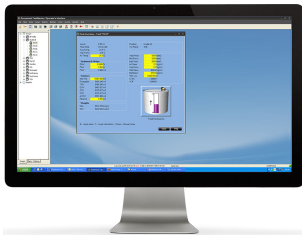
- Easy way to upgrade your tank gauging system at a pace that suits you
- New and accurate devices make it possible to improve efficiency and safety
- Precise data strengthens tank inventory control allowing increased throughput

Key devices for tank gauging

For decades, Rosemount radar level gauges have been the obvious choice when precision is critical. The Rosemount 5900S gauge builds upon this legacy by offering level measurement accuracy of ± 0.5 mm (0.02 in.). Even if accuracy is important, the need can vary. This is why we include gauging solutions for both demanding custody transfer with full inventory management functionality as well as applications where accuracy is less critical.

Inventory Management Software

TankMaster Inventory Management Software



Rosemount TankMaster is a powerful, easy-to-use Windows™-based inventory management software package, collecting real-time tank gauging data such as level, temperature, water interface level and pressure.

It automatically calculates volume and mass for inventory and custody transfer for bulk liquid storage tanks. It also provides operator overview, configuration, setup and service for Rosemount tank gauging systems.

TankMaster Mobile Inventory Management Software



Rosemount TankMaster Mobile provides instant inventory overview as well as quick access to tank details such as level, volume, temperature, level rate, and more. It is device responsive and works seamlessly across smartphones, tablets, and computers.

Inventory data can easily be shared within the organization as well as externally, ensuring personnel and partners have the information they require right when and where they need it.

Radar level gauges

Rosemount 5900S Radar Level Gauge



The Rosemount 5900S Radar Level Gauge delivers ± 0.5 mm (0.020 in.) instrument accuracy, reducing level measurement uncertainty to a minimum. It enhances your storage operation by providing certified custody transfer accuracy, better inventory management and reliable loss control data. It is SIL 2 and SIL 3 certified according to IEC 61508 and enables API 2350 compliant solutions.

Rosemount 5900C Radar Level Gauge



The Rosemount 5900C Radar Level Gauge provides ± 1 mm (0.04 in.) instrument accuracy. It is normally combined with high precision multiple spot temperature sensors for net volume calculations. It is SIL 2 certified according to IEC 61508.

Rosemount 5300 and 5408 Radar Level Transmitters



Guided wave radar and non-contacting radar level transmitters for medium accuracy, non-inventory grade applications.

Temperature and free water level

Rosemount 2240S Multi-input Temperature Transmitter



Ultra-stable temperature measurement. Connects up to 16 spot temperature sensors for average liquid temperature measurement and online temperature stratification monitoring.

For measuring shell temperature in cryogenic applications, the flange connection is designed to allow connection of separate individual spot sensors.

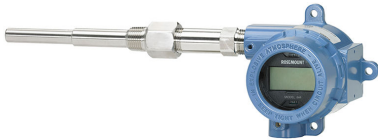
Rosemount 565, 566, 765, and 614 Sensors



Three- and four-wire calibrated temperature sensors and free water level measurement. Up to 16 Pt-100 spot elements per sensor/transmitter. Only fully immersed elements are used to determine product temperature. Each sensor is connected to a Rosemount 2240S transmitter.

Rosemount 614 is specifically designed for temperature measurements in cryogenic and refrigerated tanks.

Rosemount 644 Temperature Transmitter



For single-point temperature measurement.

Rosemount 214C Single Point Temperature Sensors



For single-point Pt-100 temperature measurement. Covers a wide range of temperatures, from -321 to 1112°F (-196 to 600°C).

Pressure

Rosemount 3051S Pressure Transmitter



A best-in-class solution that offers enhanced capabilities for pressurized and vented tank level measurements. Enables online density, mass, and vapor pressure measurement. Designed to allow direct mounting, remote mounting, balanced systems and Tuned-System™ assemblies.

Communication and accessories

Rosemount 2410 Tank Hub



The Rosemount 2410 handles data communication between field devices and the control room for one or several tanks. It enables emulation of other vendor's protocols, wireless communication and SIL certified overfill prevention. The Rosemount 2410 also feeds power to Rosemount field devices on the FISCO compliant intrinsically safe Tankbus.

Rosemount 2460 System Hub



The Rosemount 2460 System Hub transfers real time tank gauging data from field devices to the Rosemount TankMaster Inventory Management Software and/or a Host/DCS system. It has eight configurable ports for host or field device communication. The Rosemount 2460 supports system redundancy and emulation of other vendor devices.

Rosemount 2230 Graphical Field Display



The Rosemount 2230 Graphical Field Display presents tank gauging data such as level, temperature, pressure and total observed volume. It provides all tank data directly in the field, and offers different view options. This back-lit user-friendly display is designed for tough environments and can be installed in hazardous (Ex) areas, on the tank roof or at the foot of the tank. It is approved for legal custody transfer.

Rosemount 2100 Series Liquid Level Switch



Alternative option with point level switch when gauge in constant operation is not used for overfill prevention.

Rosemount 2180 Fieldbus Modem



The Rosemount 2180 Field Bus Modem is used for connecting the TRL2 field bus from Rosemount Tank Gauging field devices or the Rosemount 2460 System Hub, to the Rosemount TankMaster PC in the control room. It is connected to the PC using either the RS232 or the USB interface.

The modem has LEDs to indicate power-on and communication, and if required front panel switches to set gain and termination. The mounting kit enables fitting to a standard DIN rail.

Emerson Wireless Gateway



Network manager providing an interface between field devices and the Rosemount TankMaster software or DCS/Host system in the control room.

Engineered with industry-leading security, scalability and data reliability. Designed to easily connect to legacy host systems, additional devices can be added quickly without the need for configuration of the communication paths.

Emerson Wireless 775 THUM Adapter



The Emerson Wireless 775 THUM™ Adapter is integrated in a connection box that can be installed away from the Rosemount 2410 Tank Hub.

Connection cabinets



The Rosemount Control Cabinet is designed for Rosemount Tank Gauging products. It is used to simplify installations and protect tank gauging equipment and computers from heat, dust and unauthorized access.

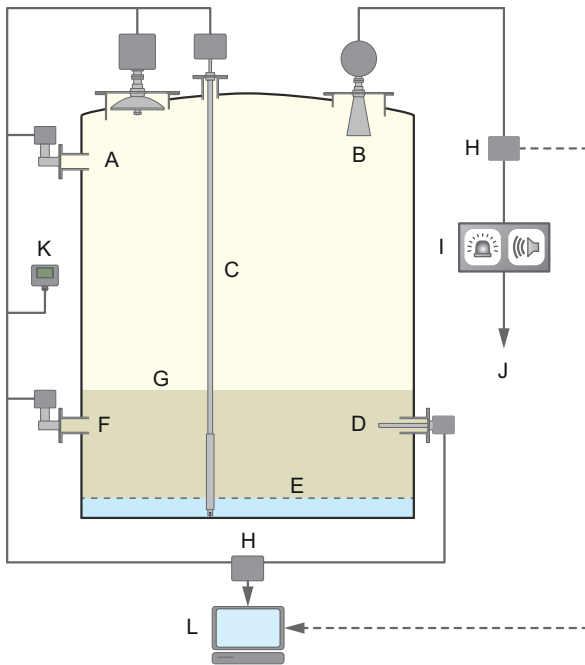
The cabinet is usually customized for specific project requirements. It can be pre-configured with already tested connections.

System functions

The Rosemount Tank Gauging System performs a number of important tank storage facility functions. The exact scope can vary according to specific user requirements. (For a more detailed list of inventory management functions, see Rosemount TankMaster Inventory Management Software [Product Data Sheet](#).)

Measurements

Figure 8: Multiple Instrument Measurements Connected into a Multi-Purpose System



- A. Vapor pressure
- B. Overfill prevention (SIS)
- C. Multiple spot average temperature
- D. Spot temperature
- E. Free water level
- F. Liquid pressure
- G. Level
- H. Communication hub
- I. Alarm
- J. Emergency shutdown system
- K. Field display
- L. Inventory Management, custody transfer, net volume, gross volume, density, mass, etc.

Data communication functions

- Communication with other systems, DCS, SCADA, PLC, Enterprise system etc. (Ethernet, RS485/232, Modbus[®] TCP/RTU etc.)
- Emulation of other vendor's fieldbus/gauges
- Emulation of other vendor's control room HMI
- Modbus or FOUNDATION Fieldbus wired transmission of data
- *WirelessHART*[®] transmission of data

Other functions

- Operator graphics and Human Machine Interface
- Web application for computer, tablet, and smartphone
- Alarm handling
- Relay outputs for overflow prevention alarms (SIL)
- 4-20 mA SIL output
- Relay outputs for overflow prevention and other alarms (non-SIL)
- Remote proof-testing
- Leak alarms
- Batch reporting
- Log reports
- Mass balance reports
- Historical data sampling
- Floating roof monitoring
- System configuration and setup
- Product temperature profile including product stratification monitoring and alarming
- Roll-over prediction

Technology

Radar level gauging

Rosemount radar level gauges provide outstanding reliability with no moving parts and only the antenna inside the tank.

For radar level measurement, there are mainly two modulation techniques:

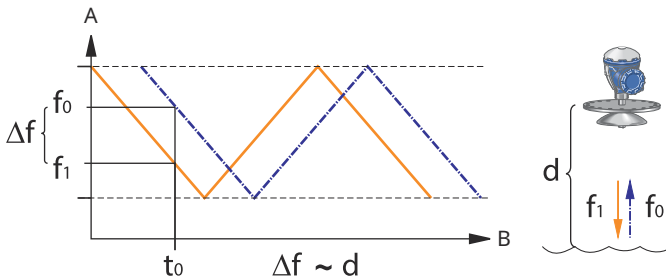
- Frequency Modulated Continuous Wave, FMCW: Used by high-performance radar level gauges. Rosemount 5900S uses FMCW, together with digital reference and filter technology, which enables custody transfer accuracy.
- Pulse method: Measures the time it takes for a pulse to travel to the surface and back. The time difference is converted to a distance, from which the level is calculated. One special case of the pulse method is the Time Domain Reflectometry (TDR) technology, as used in Rosemount 5300, where a low-power nano-second pulse is guided down a probe towards the process media surface, where it is reflected back.

The radar gauge/transmitter consists of a transmitter head and an antenna. The transmitter head can be combined with any antenna type in the same gauge series, minimizing spare parts requirements. No matching of transmitter head and antenna is required, which means the transmitter head can easily be replaced without opening the tank.

The FMCW method

The FMCW-method (Frequency Modulated Continuous Wave) means that the transmitted radar signal has a linear frequency variation around 10 GHz. The reflection from the liquid surface has a slightly different frequency compared with the signal transmitted from the antenna when the reflection is received. The difference in frequency is directly proportional to the distance between the antenna and the liquid surface, and thereby also the liquid level. This technology enables a very accurate and stable measured value.

Figure 9: Principle of FMCW Technology



- A. Frequency, f (GHz)
- B. Time, t (s)

Technology for real-world tank applications

Rosemount 5900 antennas are designed with no horizontal surfaces according to the American Petroleum Institute Standard (API ch. 3.1B ed.1). The antennas have an inclined polished surface where microwaves are emitted, which make the antennas less susceptible to condensed water or product. The drops of condensation do not cover the active part of the antenna, and the radar signal is not attenuated. This results in higher accuracy and better reliability.

Figure 10: Radar Antennas Designed to Make Any Condensation Quickly Drip Off



The Rosemount 5900 Series radar level gauges with parabolic antennas are designed also for harsh environments like bitumen tanks. [Figure 11](#) shows an antenna in operation after being exposed to blown bitumen at 220 °C (430 °F) for several months.

Figure 11: Antenna Exposed to Blown Bitumen for Several Months



The Rosemount 5900 Series with still-pipe array antenna uses the Low Loss Mode technology transmitting radar waves close to the pipe centerline. This technology virtually eliminates signal and accuracy degradation due to rust and product deposits on the inside of the pipe wall.

Figure 12: The Low Loss Mode Enables Full Accuracy also in Old and Worn Still-Pipes



For best measurement performance in LPG applications, an integrated pressure sensor enables corrections for vapor influence. Measurements in closed tanks with liquefied gases including LNG can be verified using a permanently installed verification pin with a known distance to the antenna.

The still-pipe used for LNG and LPG ensures adequate signal strength from the surface, also when the liquid is boiling.

Figure 13: Radar Gauges for Pressurized Gas Tanks

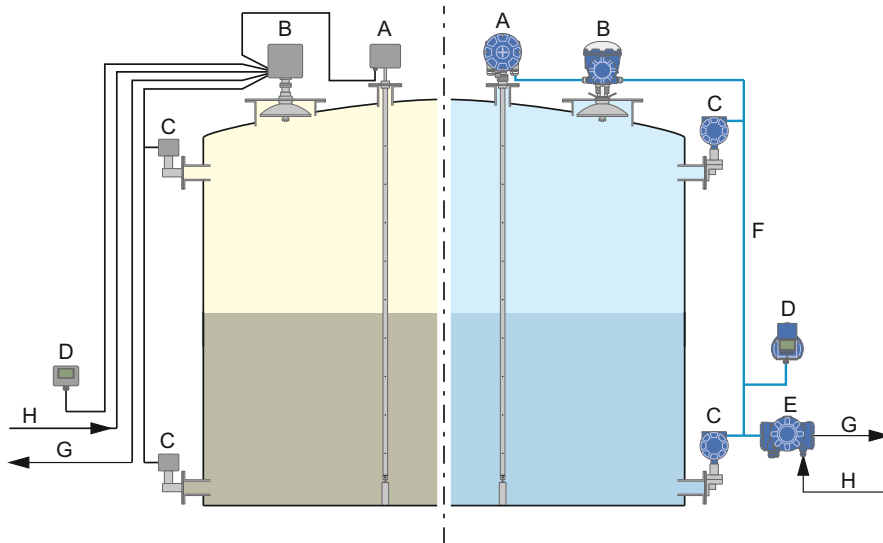


Open and scalable system architecture

The system can include a wide range of devices making it easy to build a large or small customized tank gauging system. Thanks to the modular design, a system can easily be expanded or upgraded.

All field devices are connected on the Tankbus, which is based on the open FOUNDATION™ Fieldbus industry standard.

Figure 14: Previous System (Left) - Rosemount Tank Gauging System (Right)



- A. Temperature and freewater level
- B. Level
- C. Pressure
- D. Field display
- E. Tank hub
- F. Tankbus
- G. Fieldbus
- H. Power

Lower cost and easier commissioning

The Rosemount Tank Gauging System supports plug-and-play technology for trouble-free installation.

All fieldbus segments in a system are autoconfigured minimizing the need for specific FOUNDATION™ Fieldbus knowledge. The existing field cabling can normally be used. No special tools are required, and all parts can easily be carried to the tank roof.

Installation can be done with tanks in operation, except for cryogenic storage and pressurized tanks such as Liquefied Petroleum Gas (LPG) tanks.

Intrinsically safe cabling on tank

The system is designed to minimize power consumption, which enables the use of two-wire intrinsically safe technology. The field devices are powered by the Tankbus via the Rosemount 2410 Tank Hub using FISCO (FOUNDATION Fieldbus Intrinsically Safe Concept). This solution has several advantages:

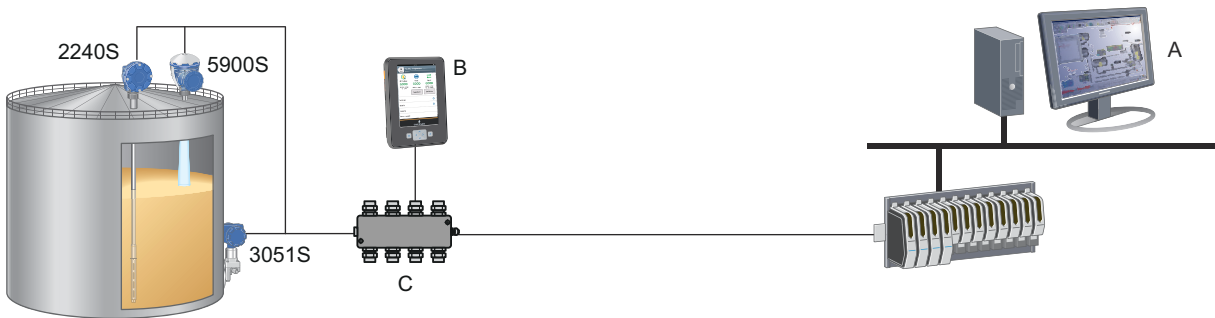
- Increased safety at system start-up and operation
- Quicker and easier installation due to less cabling
- Cable usage without conduits

Integration with other systems

The Rosemount system can be connected to all major suppliers of DCS, SCADA systems, plant host computers, or terminal automation systems. Integration can be made in several ways via:

- Rosemount TankMaster PC
- Rosemount 2460 System Hub
- Rosemount 2410 Tank Hub
- Direct connection to the tank devices if the host system is based on FOUNDATION Fieldbus (no Rosemount 2410 or Rosemount 2460 hub included in this case)

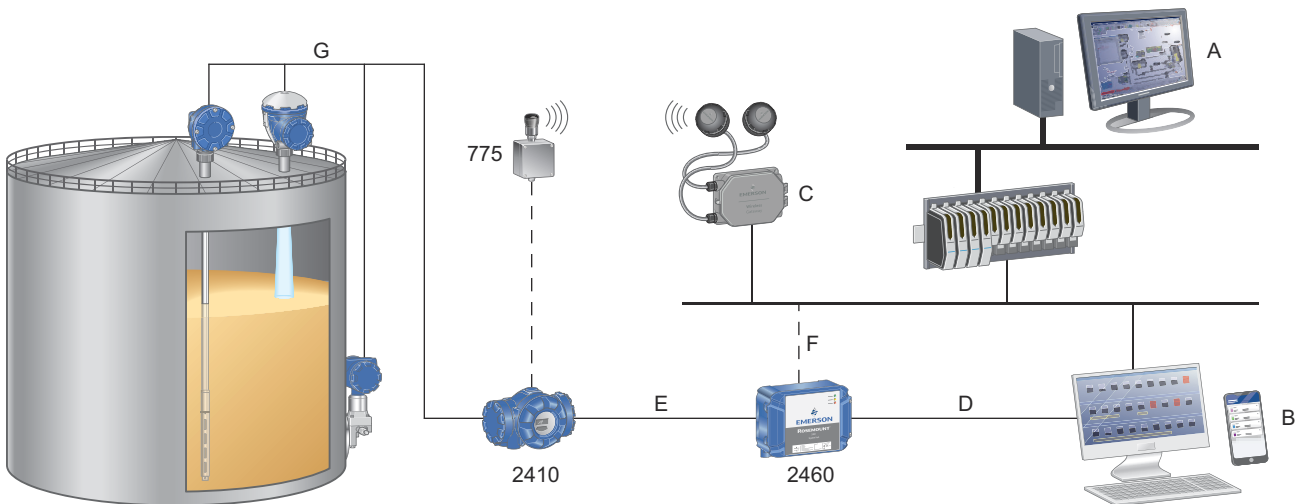
Figure 15: Tank Gauging Devices Connected Directly to a FOUNDATION Fieldbus Host System



- A. DeltaV™ host system
- B. Handheld communicator
- C. Segment coupler

Using a connection to TankMaster gives the advantage of communicating both measured values and comprehensive inventory data. The Rosemount 2460 system hub can also provide inventory data.

Figure 16: Connection to a host system can be made via Rosemount 2410, Rosemount 2460, a TankMaster PC, or directly



- A. DCS/Host
- B. Rosemount TankMaster
- C. Emerson Wireless Gateway
- D. Ethernet
- E. RS485 or TRL2 Modbus
- F. RS485 or RS232 Modbus
- G. Tankbus⁽¹⁾

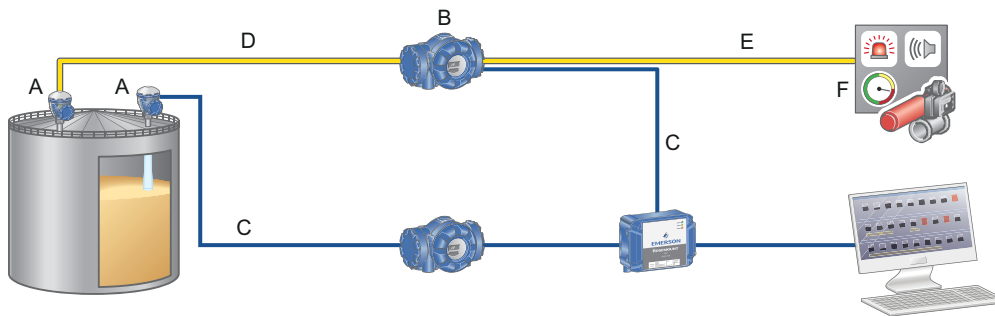
Reduce the risk of tank overfills

The Rosemount Tank Gauging System can be used as part of a highly reliable automatic or manual overfill prevention system. In such Safety Instrumented System (SIS) applications, level measurement is duplicated in one Basic Process Control System (BPCS) layer and one independent Functional Safety layer.

The Rosemount 5900 Series gauges and tank hubs are IEC 61508 certified SIL 2 or SIL 3 capable. They include separate certified alarm loop relays or analog output functionality.

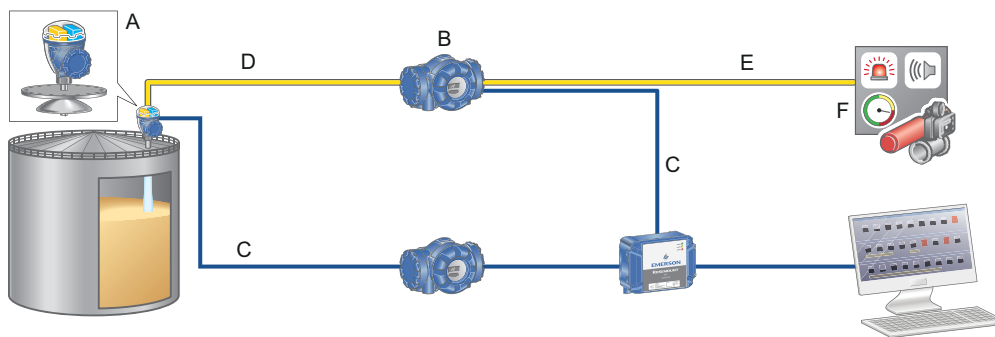
The innovative 2-in-1 technology saves installation cost and reduces complexity by enabling the Rosemount 5900S gauge to provide dual level data in two independent layers of protection using only one housing and a single tank nozzle. The level output from the safety layer sensor is available as redundant level measurement data.

Figure 17: SIL 2-Certified System with Dual Gauges



- A. Rosemount 5900S Radar Level Gauge
- B. SIL 2 relay or analog output
- C. Level
- D. Level/Safety
- E. Alarm
- F. Emergency shut-down system (ESD)

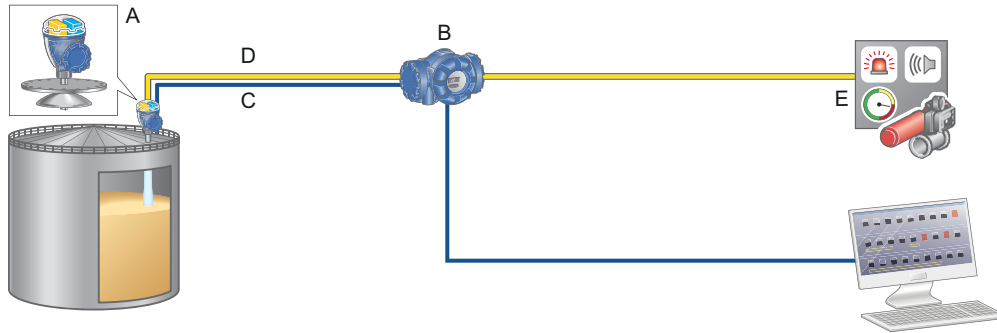
Figure 18: SIL 2-Certified System with 2-in-1 Gauge



- A. Rosemount 5900S Radar Level Gauge 2-in-1
- B. SIL 2 relay or analog output
- C. Level
- D. Level/Safety
- E. Alarm
- F. Emergency shut-down system (ESD)

(1) The intrinsically safe Tankbus complies with the FISCO standard.

Figure 19: SIL 3-Certified System with 2-in-1 Gauge



- A. Rosemount 5900S Radar Level Gauge 2-in-1
- B. SIL 3 relay output
- C. Level x 2
- D. Alarm
- E. Emergency shut-down system (ESD)

One important advantage is that the Rosemount 5900 Series gauge is in constant operation. Unlike a conventional switch, it provides continuous information about its status and performance, since it is being used in everyday tank farm operations. In addition, the alarm level can easily be set to any chosen value.

The level value from the radar level gauge is transferred on the digital bus to a TankMaster PC or other host system, whereas the alarm signal uses the separate relay or analog output in the Tank Hub. Follow the recommendations in the Rosemount 5900 Radar Level Gauge and Rosemount 2410 Tank Hub [Safety Manual](#).

The Rosemount gauging system supports all categories covered by the API 2350 revision 4, which is the first internationally recognized tank gauging standard for overfill prevention. It covers not only instrumentation but also procedures and processes for the whole plant/terminal life cycle, including the requirements for establishing a detailed risk assessment. See [The Complete Guide to API 2350](#) and [The Engineer’s Guide to Overfill Prevention](#).

Automatic remote proof test

TankMaster includes a proof-test manager, which allows operators to safely perform proof-testing of overfill alarm functionality remotely from the control room. The proof-testing made at regular intervals can be combined with the continuous product level monitoring.

The proof-test manager performs a number of tests:

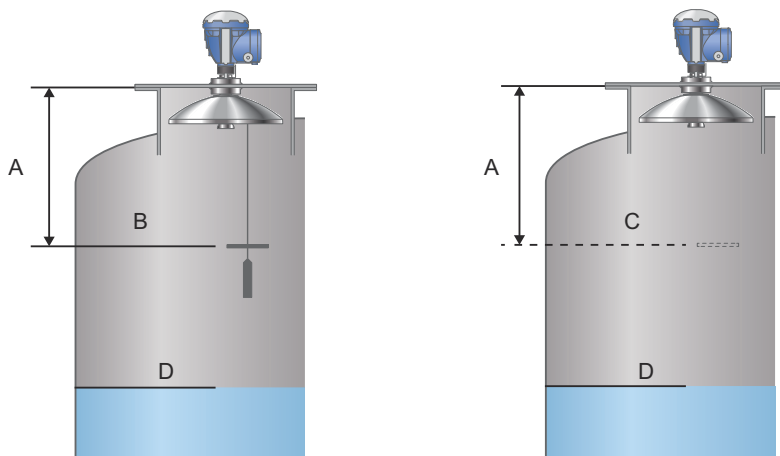
- High-level alarm verification using a reference reflector
- High-level alarm verification with simulated reference reflector
- One-point level verification by hand-dipping to verify automatic level measurements
- Analog output verification
- Relay output verification

A step-by-step proof-test wizard guides the user through the selected tests. Once the selected proof-tests are done, a summary will show a list of the performed tests with the results.

The proof-test functionality supports wired systems with Rosemount 2410 tank hubs and Rosemount 5900 gauges, both non-SIL and SIL. The Rosemount 2230 Graphical Field Display can be used to initiate a pre-configured proof test of a Rosemount 5900 gauge.

The high-level alarm verification proof test can be based on either a simulated reference reflector or a physical reference reflector, see [Figure 20](#).

Figure 20: Proof Test Using Physical Reflector (Left) or Simulated Reflector (Right)



- A. Reference reflector distance
- B. Physical reflector
- C. Simulated reflector
- D. Maximum product level

Proof-test report

When the proof test is finalized and approved, a test report is automatically created. The test report includes field device-specific information, detailed test results, when the test was performed, who performed the test, and who approved it.

Proof-test history

All proof-test reports can easily be displayed on a later occasion using the proof-test history option.

Proof-test scheduling

The proof-test scheduling lets the user specify when the next proof-test should be performed. The test frequency and the desired type of reminder may also be set (pop-up message and/or e-mail).

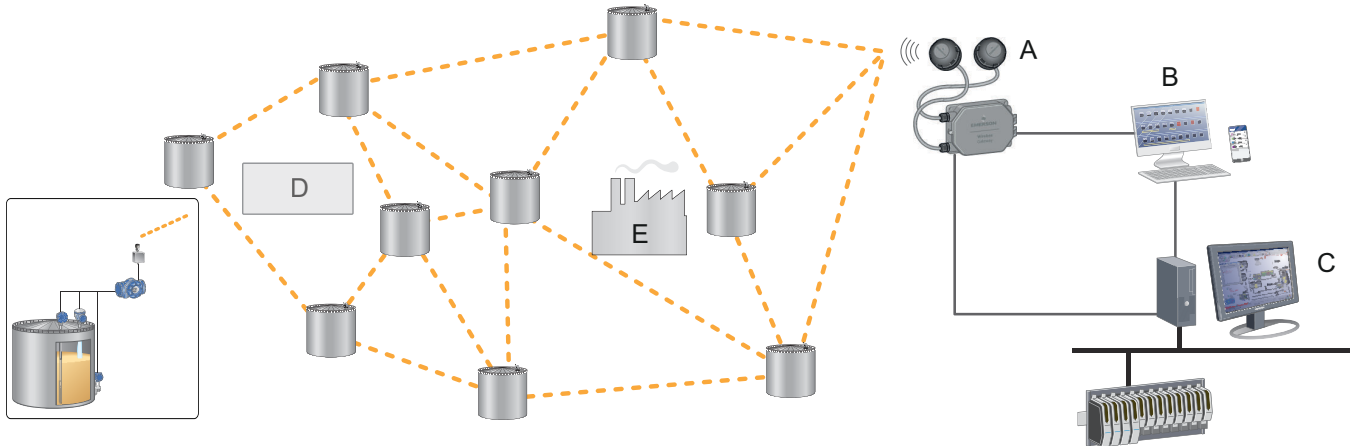
Use wireless technology to reach more tanks at less cost

The Rosemount Tank Gauging System supports Emerson's wireless technology, based on IEC 62591 (*WirelessHART®*), the industry standard for wireless field networks. Reducing field wiring leads to substantial savings in infrastructure, design, and labor required for installation and commissioning.

In addition, the time between project start-up and an up-and-running wireless system is drastically reduced. Wireless tank gauging allows for cost savings up to 70 percent, and gives other benefits as well.

All wireless devices communicate with the host system through the Wireless Gateway. A Rosemount Tank Gauging System can consist of both wired and wireless networks.

Figure 21: Wireless Devices Communicating with the Host System through the Wireless Gateway



- A. Emerson Wireless Gateway
- B. Rosemount TankMaster
- C. DCS/Host
- D. Temporary obstacle
- E. Permanent obstacle

Better utilization of tank capacity

Wireless functionality allows tank gauging data from remotely located tanks, previously collected manually or not at all, to be integrated into the system. This results in a more efficient tank capacity utilization, as well as better inventory and loss control functionality.

Self-organizing field network increases reliability

A wireless device can transmit its own data as well as relay information from other devices in the network. The self-organizing field network automatically finds the best way around any fixed or temporary obstacle. Nodes can identify a network, join it, and self-organize into dynamic communication paths. Reliability increases when the network expands - the more devices, the more communication paths. For fastest update rate, direct hops to the gateway are required.

Secure data transmission

Emerson's wireless field network is designed for best-in-class security. Data is protected by 128-bit encryption, authentication, verification, anti-jamming, and key management.

Wireless connection of tank gauging equipment

The Wireless Gateway is the network manager that provides an interface between field devices and the TankMaster inventory software or host/DCS systems.

Each wireless node in the Rosemount Tank Gauging System consists of a Rosemount 2410 Tank Hub and either a Rosemount 5900 Series gauge or one or several Rosemount 5300/5408 transmitters plus the other tank devices. Rosemount 2410 is connected to the mains power, and a THUM Adapter. The tank gauging system can be complemented with other wireless devices such as pressure and temperature transmitters.

The wireless transmission supports measurement data handled by the tank devices such as level, temperature, free water level, and pressure.

Easy step-by-step installation using emulation

The Rosemount gauging system is compatible with all other major tank gauge vendors. Step-by-step modernization of an existing tank gauging system is possible using available field and control room solutions.

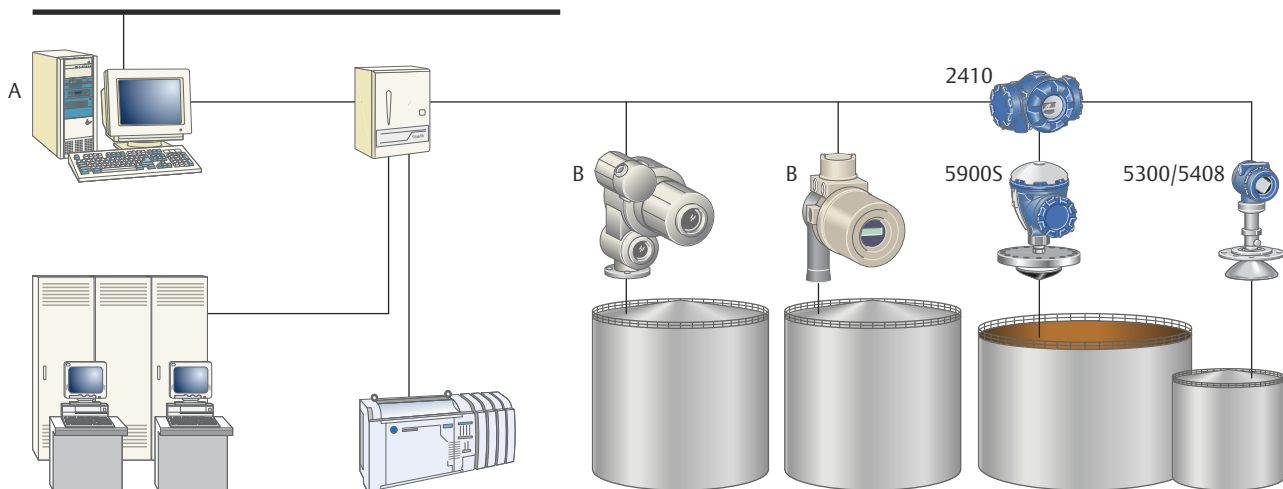
Gauge emulation

Many old mechanical float or servo gauges from other vendors can be upgraded with modern Rosemount level and temperature devices and a Rosemount 2410 Tank Hub, using the existing tank openings, field cabling, and control system. By replacing mechanical gauges, it is possible to avoid re-calibration work, the expenses associated with spare parts and maintenance.

The new radar gauge is normally installed with the tank in operation. No hot work is required. The Rosemount 2410 has an open design, covering everything from electrical interface and communication protocol to utilization of different power sources.

A Rosemount gauge seamlessly replaces another device, independent of measurement technology. Data from the tank is displayed as before on the existing inventory management system.

Figure 22: Gauge Emulation

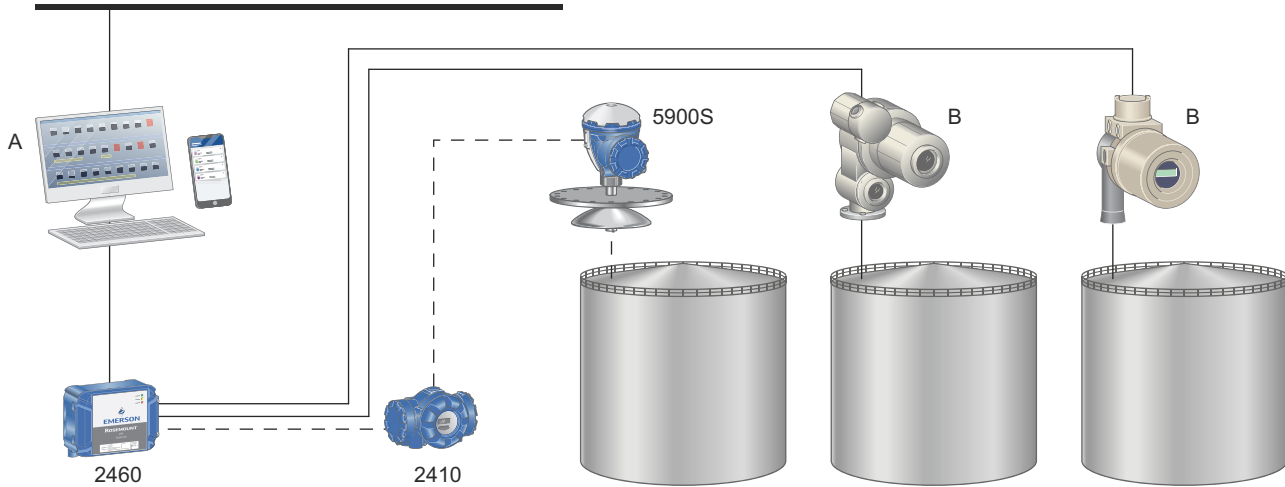


- A. Existing host system from other vendor
- B. Float/servo gauges in an existing system from other vendor

Seamless control room connectivity

In addition, other tank management systems can be seamlessly replaced with the Rosemount TankMaster software. Since the Rosemount 2460 System Hub supports emulation of other vendors' control room devices, Rosemount TankMaster can replace an existing inventory management system and still be able to communicate with the field devices in use. This solution provides interoperability, and problem-free communication with existing field devices, often with a better update rate than before.

Figure 23: Replacing Old Tank Monitoring Software with Rosemount TankMaster



A. Rosemount TankMaster

B. Float/servo gauges from other vendor in an existing system

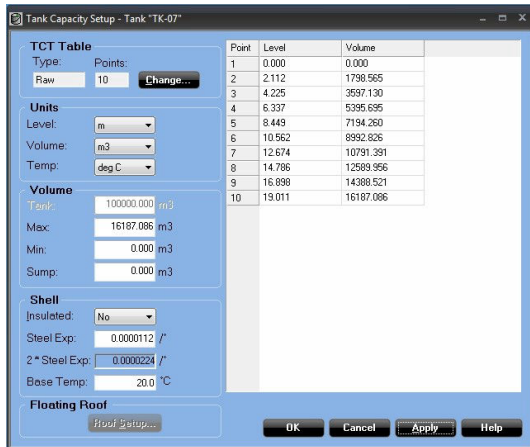
Tank gauging as a system application

Tank gauging is an integrated system application, which has specific requirements on the measuring devices in the system. These requirements vary depending on how the system is used. A Rosemount gauging system can be configured with highest accuracy for custody transfer/inventory control, or with medium accuracy required for less critical applications.

High performance inventory and custody transfer applications

A Rosemount gauging system used for custody transfer gives accurate measurement values for volume calculations. These calculations require a selection of suitable devices to obtain high performance for measurement of level, free water level, average temperature, and in some cases reference density. If any of these sensors is poorly matched, the result of the standard volume calculation may suffer. Similar conditions apply for inventory measurements, for which the net standard volume is important. For mass balance and loss estimation, the calculated mass is in focus.

Figure 24: Tank Capacity Setup Window



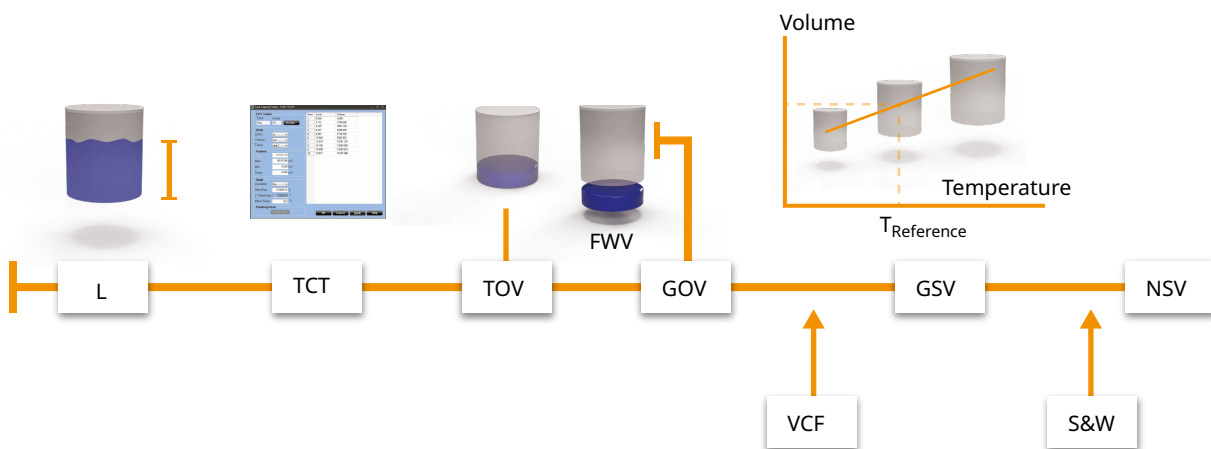
The Rosemount Tank Gauging System includes equipment for high-accuracy measurement and calculations such as:

- Level: Rosemount 5900S
- Temperature and Free Water Level: Rosemount 2240S with Rosemount 565/566/614 or 765 sensors (four-wire sensor with up to 16 spot elements)
- Pressure: Rosemount 3051S
- Volume calculations as per API standards: TankMaster WinOpi software and Rosemount 2460 System Hub

System devices exchange measured data between units to optimize functionality. For instance, product temperature measurement functions use level information for calculating average product liquid temperature. Data from pressure transmitters is used to calculate density, etc.

Inventory parameters are calculated based on input data available for the current tank. Figure 25 shows an example of how the measured product level is converted to a standardized volume.

Figure 25: Inventory Calculations and Custody Transfer



L	Level	VCF	Volume Correction Factor
TCT	Tank Capacity Table	GSV	Gross Standard Volume
TOV	Total Observed Volume	S&W	Sediment & Water
FWV	Free Water Volume	NSV	Net Standard Volume
GOV	Gross Observed Volume		

Tank monitoring applications

In a system primarily intended for oil/product movement only, level and observed volume (TOV) are important parameters, but do not necessarily require the highest accuracy. The Rosemount gauging system includes the following equipment for non-inventory grade measurement and calculations:

- Level: Rosemount 5408 or Rosemount 5300
- Temperature: Rosemount 644 Transmitter with Rosemount 214C Sensor
- Volume calculations: TankMaster WinView software or Rosemount 2460 System Hub

Operation and configuration

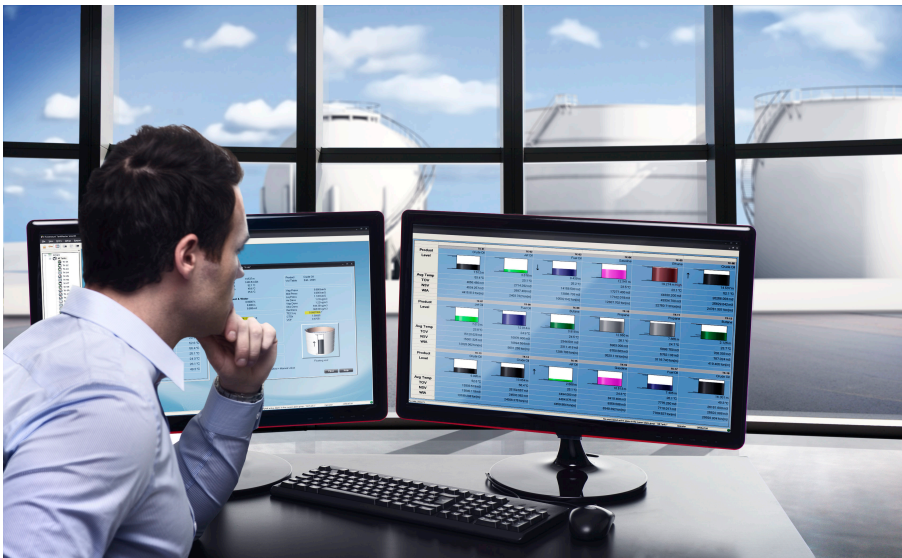
The TankMaster software is the operator's interface to the system. This user-friendly software is easy to configure and start up. No specialized software engineering is required. It gives the operator a good overview and quick access to any measured values.

This software provides a wide range of inventory and custody transfer functions such as net volumes according to API/ISO standards, reporting, alarms, graphics, trends, batch handling, etc. It also supports floating roof monitoring and proof-testing.

In addition, the TankMaster software is the primary configuration tool. Basic configuration can also be done with a handheld communicator, AMS Device Manager, or DeltaV™.

Protocols for communication with major suppliers of plant host computers, such as DCS or SCADA systems, have been developed and certified. In many cases the plant's DCS/SCADA system works as the operator's interface for tank management data from the Rosemount gauging system.

Figure 26: Rosemount TankMaster is the Operator's Interface to the System

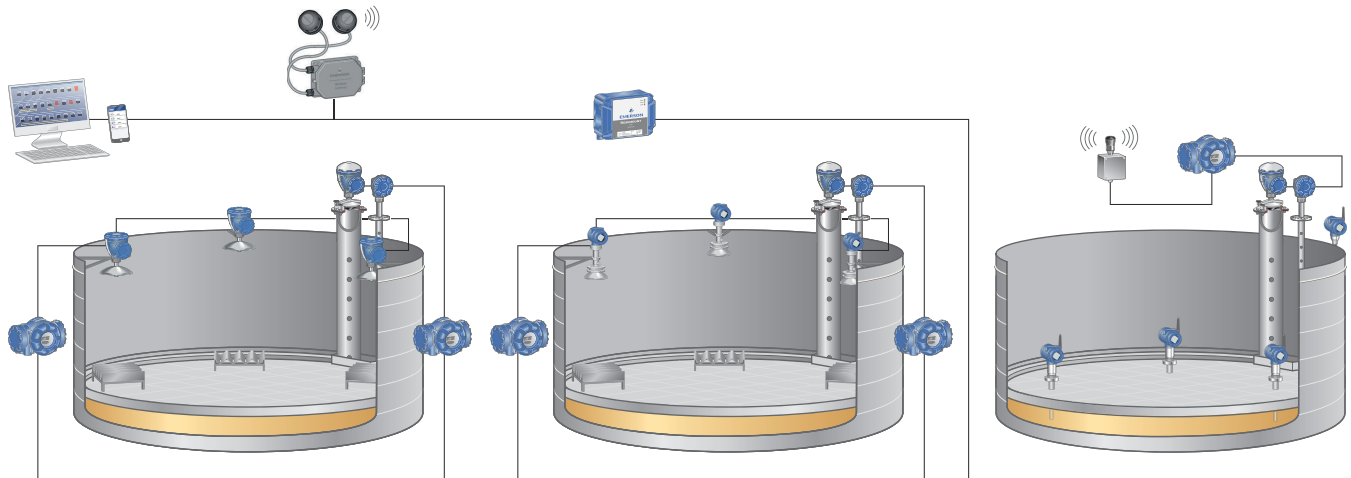


Floating roof monitoring

Floating roofs on storage tanks offer advantages in terms of reduced need for vapor recovery but can also create operational and safety issues. A sinking, tilting, leaking, or collapsing roof can cause significant mechanical damage, create overfills and the release of explosive hydrocarbon vapor. The cause of the tank malfunctioning may be that the roof is stuck due to damaged or wrongly mounted rim seals.

Leaking pontoons, overfills, strong winds, and inadequate draining during heavy rain or snowfall can also dangerously affect buoyancy and roof position.

Figure 27: Floating Roof System with Shell Mounted and Roof Mounted Radar Devices



By measuring the floating roof position, the Rosemount Tank Gauging System can continuously monitor the roof and give alarms for roof tilting and other hazardous tank conditions. Normally the roof monitoring is combined with liquid level measurement in a still-pipe for complete tank overview in the control room operator's interface.

Figure 28: The Operator can Check Tank Conditions in Real Time



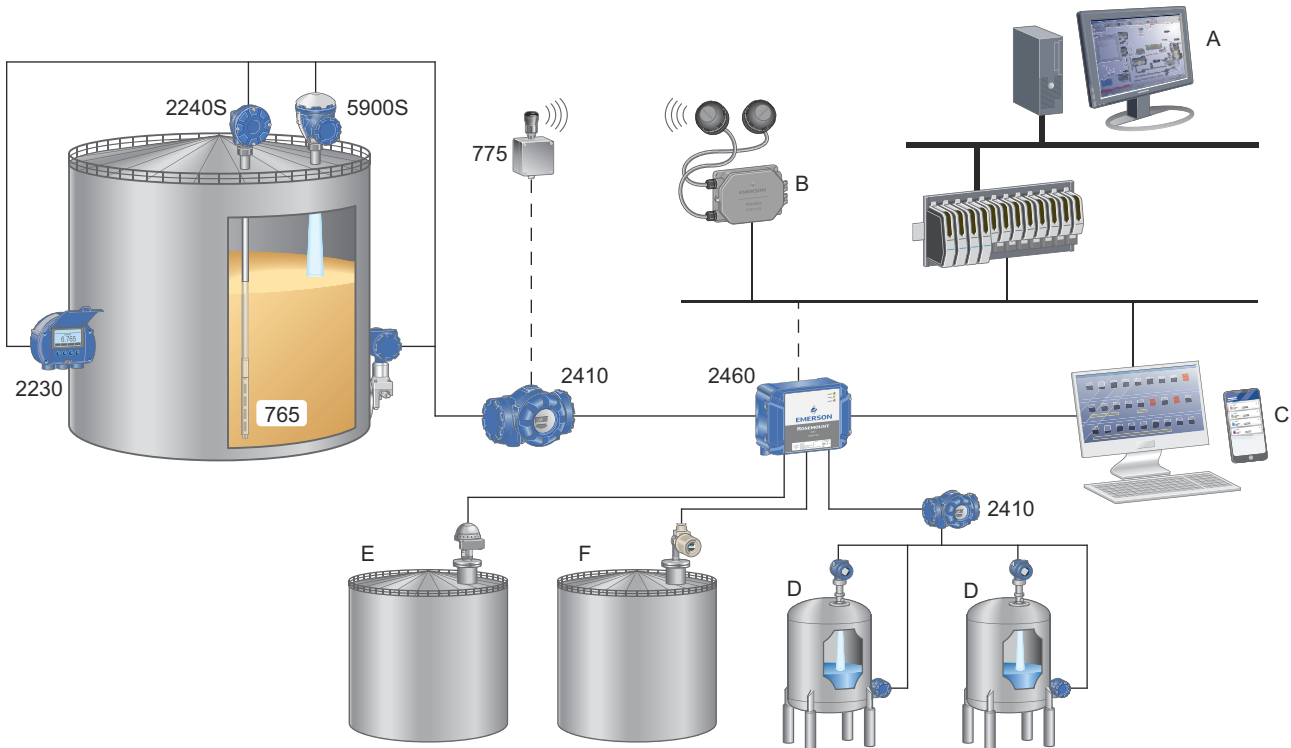
System layout configurations

Open architecture enables the most cost-effective layout

The Rosemount Tank Gauging System supports a large number of configuration combinations. It can incorporate both Rosemount 5900S-, 5900C-, 5300-, or 5408-based configurations, networks with previous generations of Rosemount radar gauges (TRL2, Rex, Pro), and even gauges from other vendors.

Wired and wireless networks can co-exist within the same system. This flexibility enables a step-by-step upgrade.

Figure 29: Rosemount Tank Gauging System with Multiple Configuration Combinations



- A. DCS/Host
- B. Wireless Gateway
- C. Rosemount TankMaster Inventory Management
- D. Rosemount 5408 or 5300 system configuration
- E. TankRadar Rex or Pro Tank Gauging System
- F. Tank Gauging System from other vendor (e.g. servo or float based)⁽²⁾

(2) Requires Rosemount 2460 System Hub.

Custody transfer and inventory tank gauging – 5900S system configuration

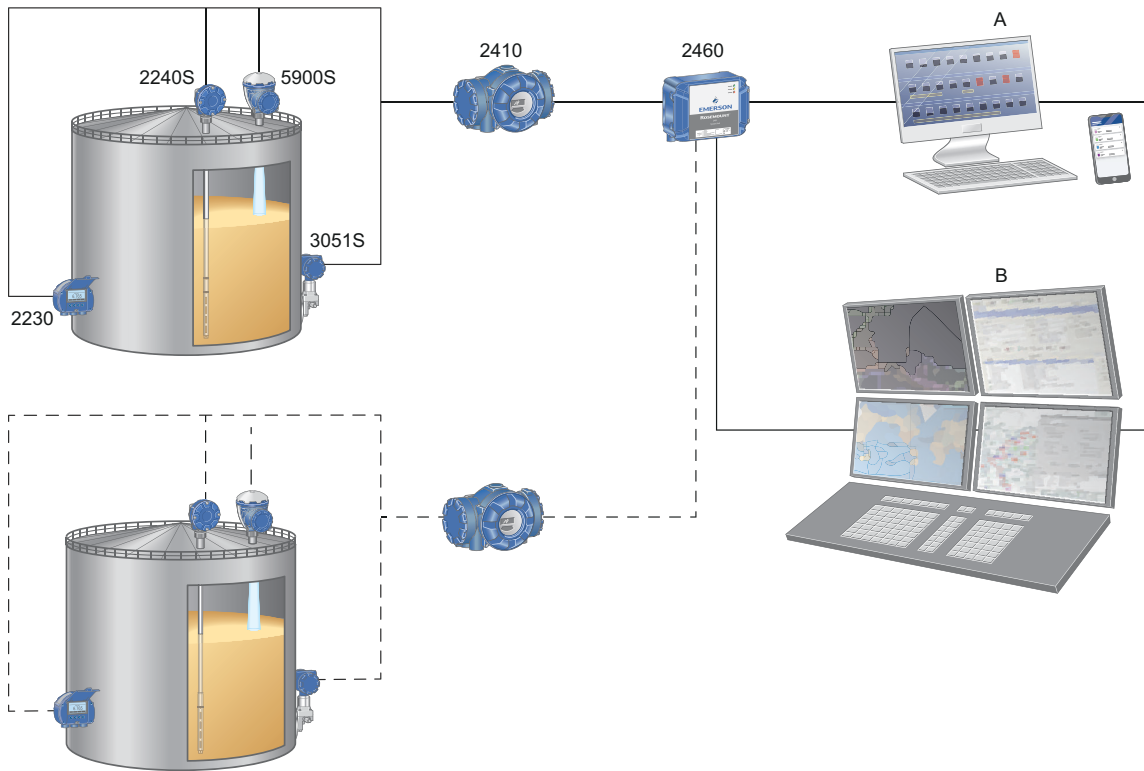
The Rosemount 5900S-based tank gauging configuration is used for the highest demands on accurate measurements for inventory management and custody transfer. Precise net volumes are calculated using tank strapping tables and compensation for temperature and tank characteristics.

For temperature measurements, the Rosemount 2240S Temperature Transmitter is combined with the Rosemount 565, 566 or 765 Multiple Spot Temperature Sensors. The Rosemount 3051S transmitter is used for pressure measurements. Each tank has a designated Rosemount 2410 Tank Hub.

All values are transferred to the TankMaster software, which has a complete set of inventory and custody transfer functions. TankMaster includes an API/ISO calculator for volume and density. Alternatively, inventory data can be transferred directly from the Rosemount 2460 System Hub to the DCS/Host without going via TankMaster.

When highest transfer precision is not required, the Rosemount 5900S can be replaced by the Rosemount 5900C Radar Level Gauge.

Figure 30: High-Precision System



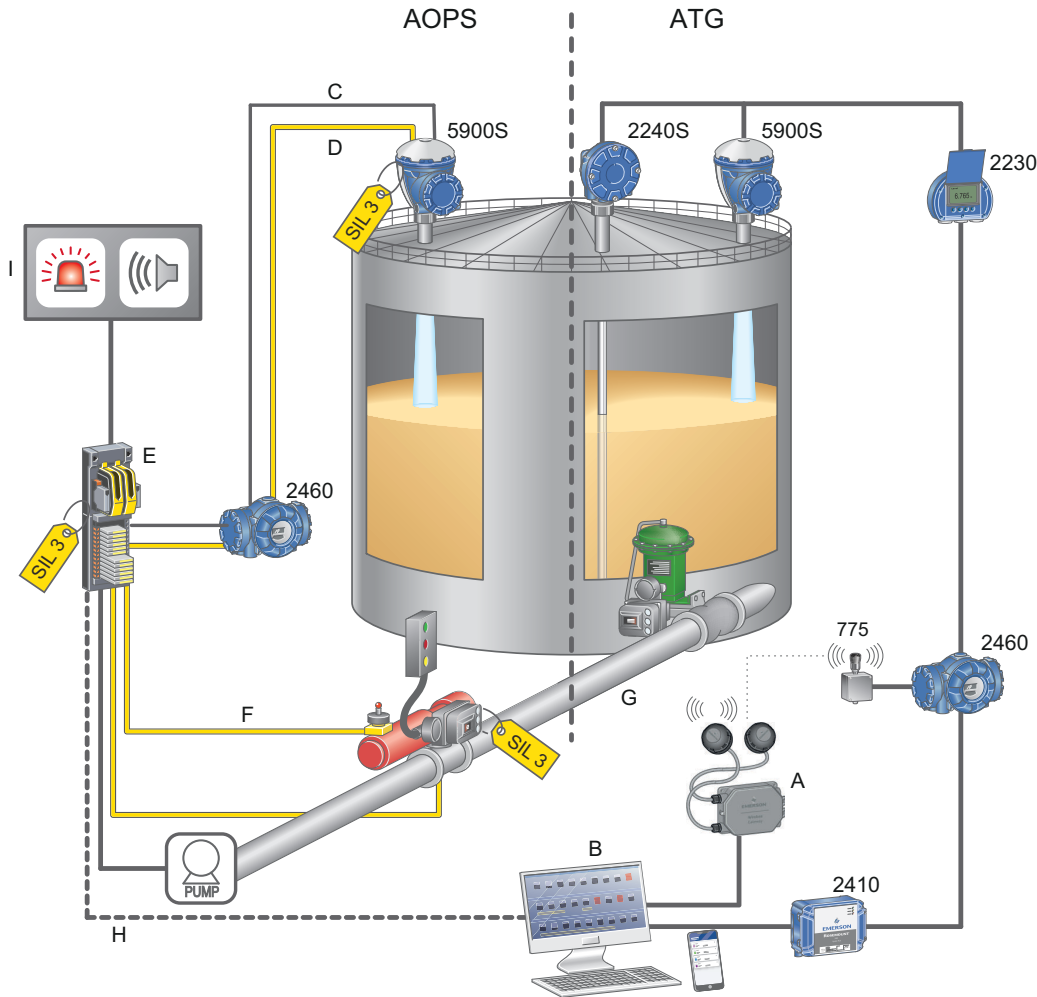
- A. Rosemount TankMaster Inventory Management
- B. DCS/ Host

Functional safety configurations for overfill prevention

The process and terminal industries apply independent protection layers (IPLs) to minimize the risk of a potential hazard such as tank overfills.

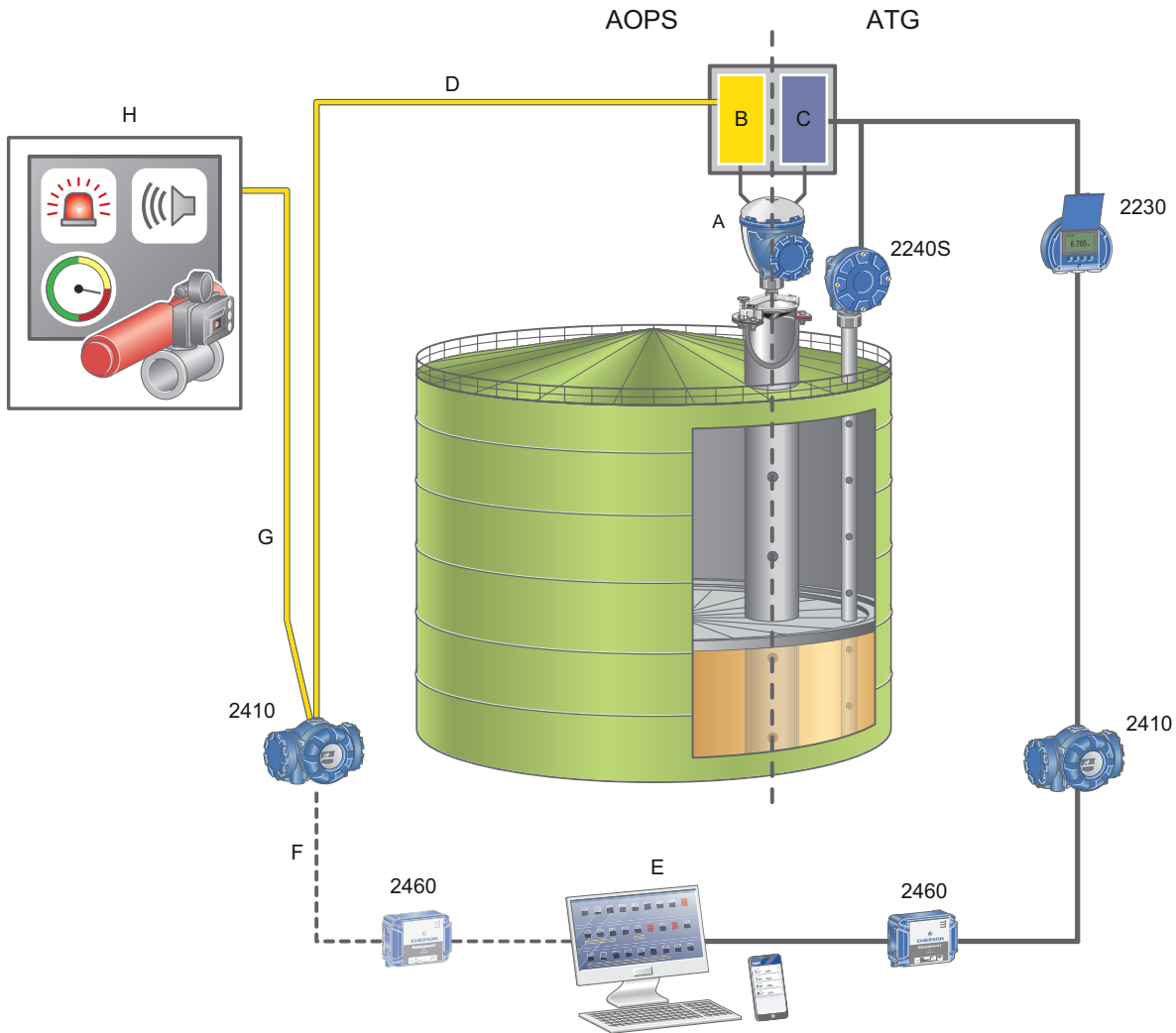
The Rosemount Tank Gauging System supports a number of SIS (Safety Instrumented Systems) configurations designed for overfill prevention. Which configuration is most suitable depends on a number of factors such as the type of storage tank, existing instrumentation, Safety Integrity Level, etc.

Figure 31: Integrated Emerson Solution for Automatic Overfill Prevention System (AOPS) and Automatic Tank Gauging (ATG)



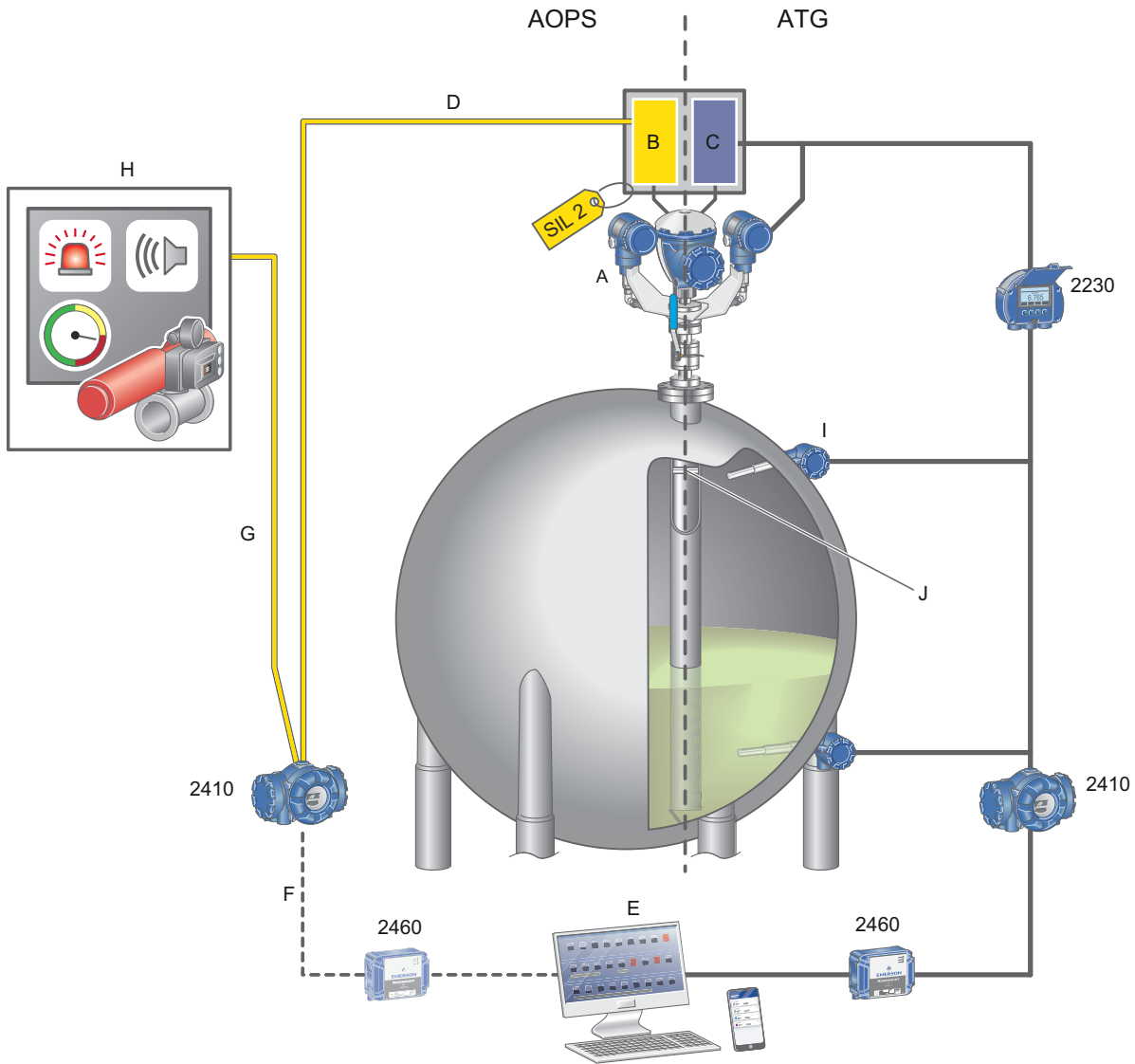
- A. Emerson Wireless Gateway
- B. TankMaster Inventory Management
- C. Level
- D. Safety
- E. DeltaV SIS
- F. SIL-PAC (Fisher™ DVC + Bettis™ Actuator)
- G. Fisher valve
- H. Connection to TankMaster (optional)
- I. Independent alarm panel, high-high alarm

Figure 32: Floating Roof AOPS 2-in-1



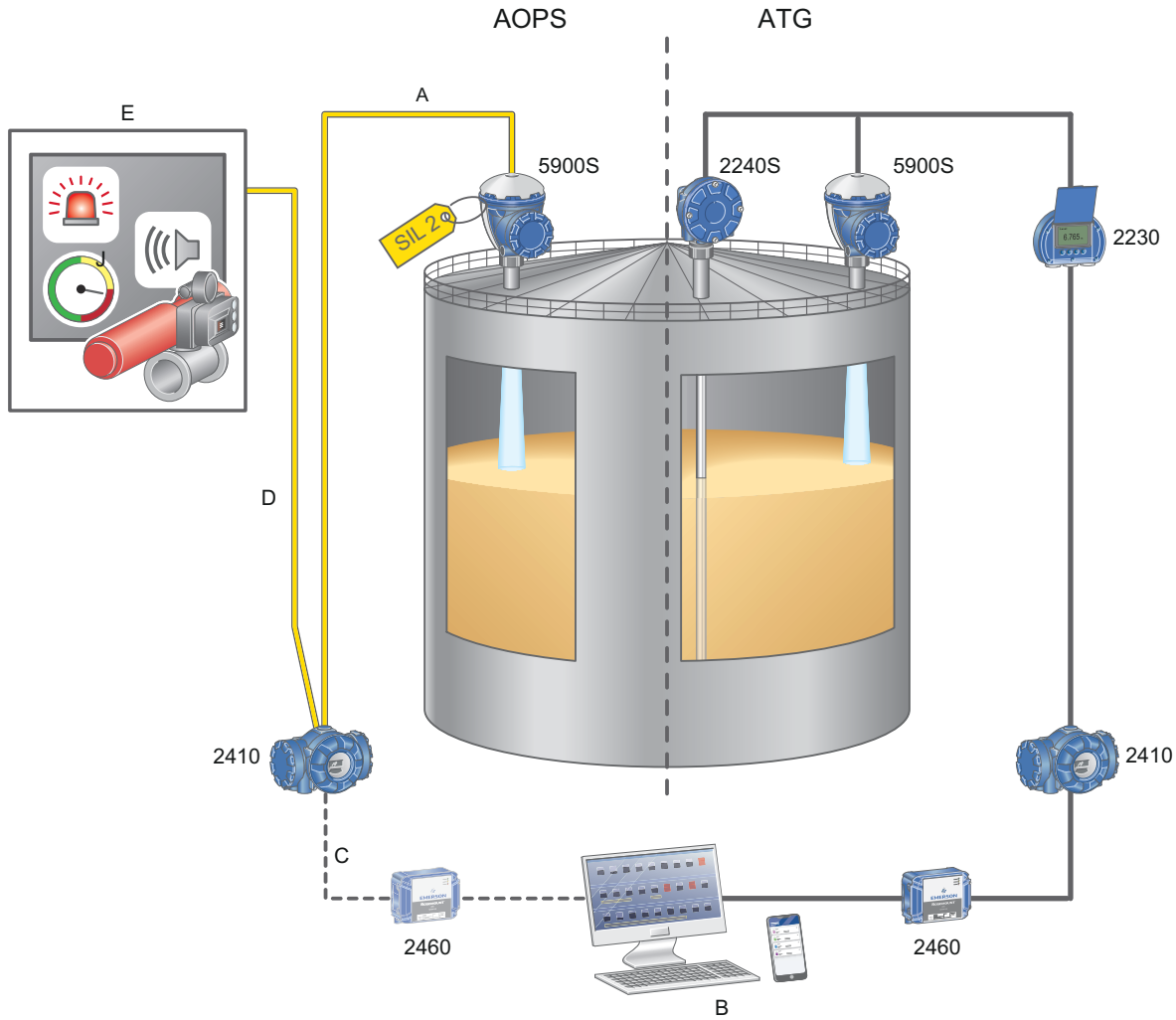
- A. Rosemount 5900S 2-in-1 Radar Level Gauge
- B. Overfill
- C. Level
- D. Level/Safety
- E. TankMaster Inventory Management
- F. Connection to TankMaster (optional)
- G. SIL 2 relay or 4-20 mA analog signal
- H. Safety Instrumented System (SIS)

Figure 33: Sphere AOPS 2-in-1



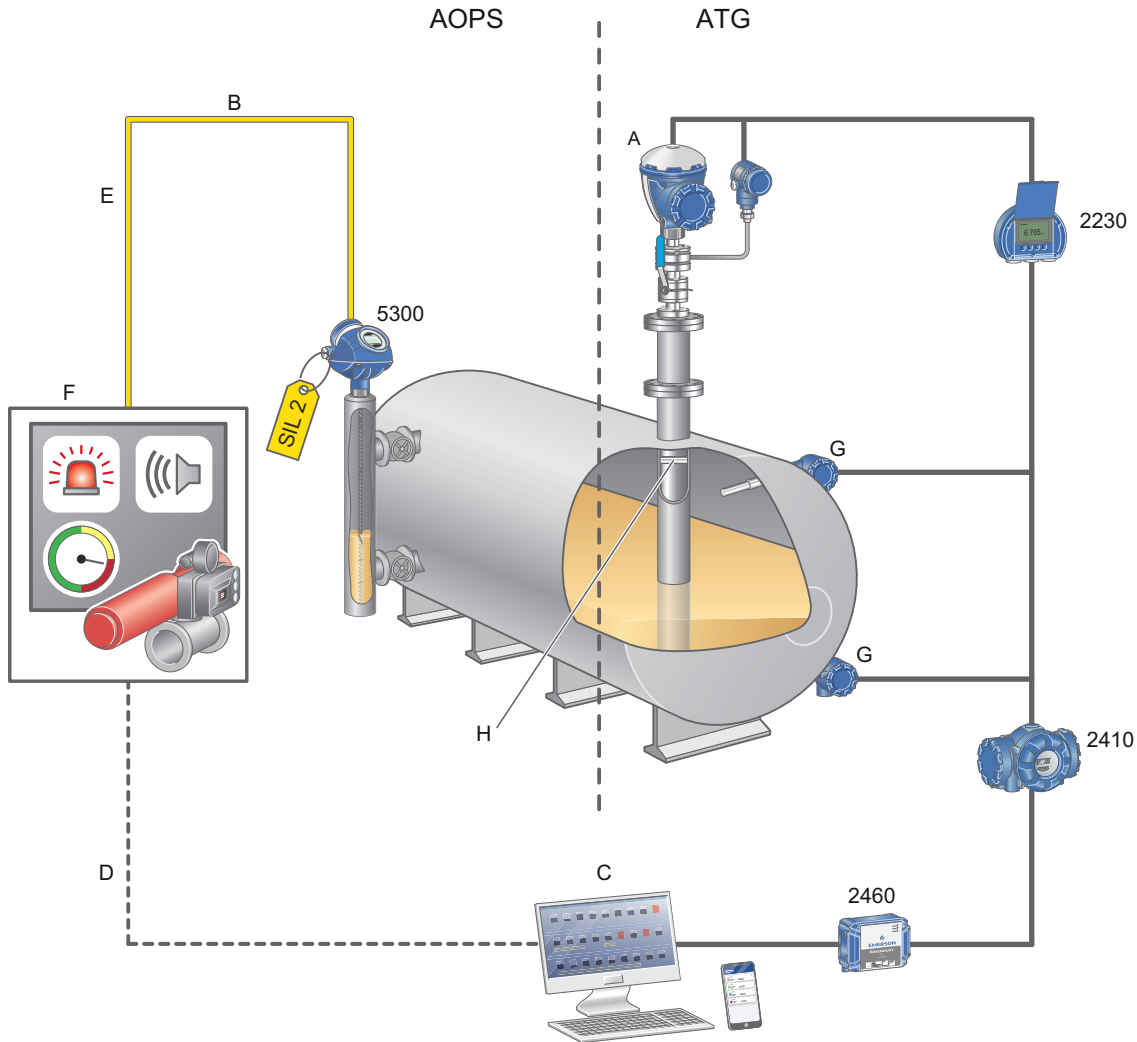
- A. Rosemount 5900S 2-in-1 Radar Gauge with Pressure Transmitter
- B. Overfill
- C. Level
- D. Level/Safety
- E. TankMaster Inventory Management
- F. Connection to TankMaster (optional)
- G. SIL 2 relay or 4-20 mA analog signal
- H. Safety Instrumented System (SIS)
- I. Rosemount 644 with Single Point Temperature Sensor
- J. Verification pin

Figure 34: Fixed Roof AOPS



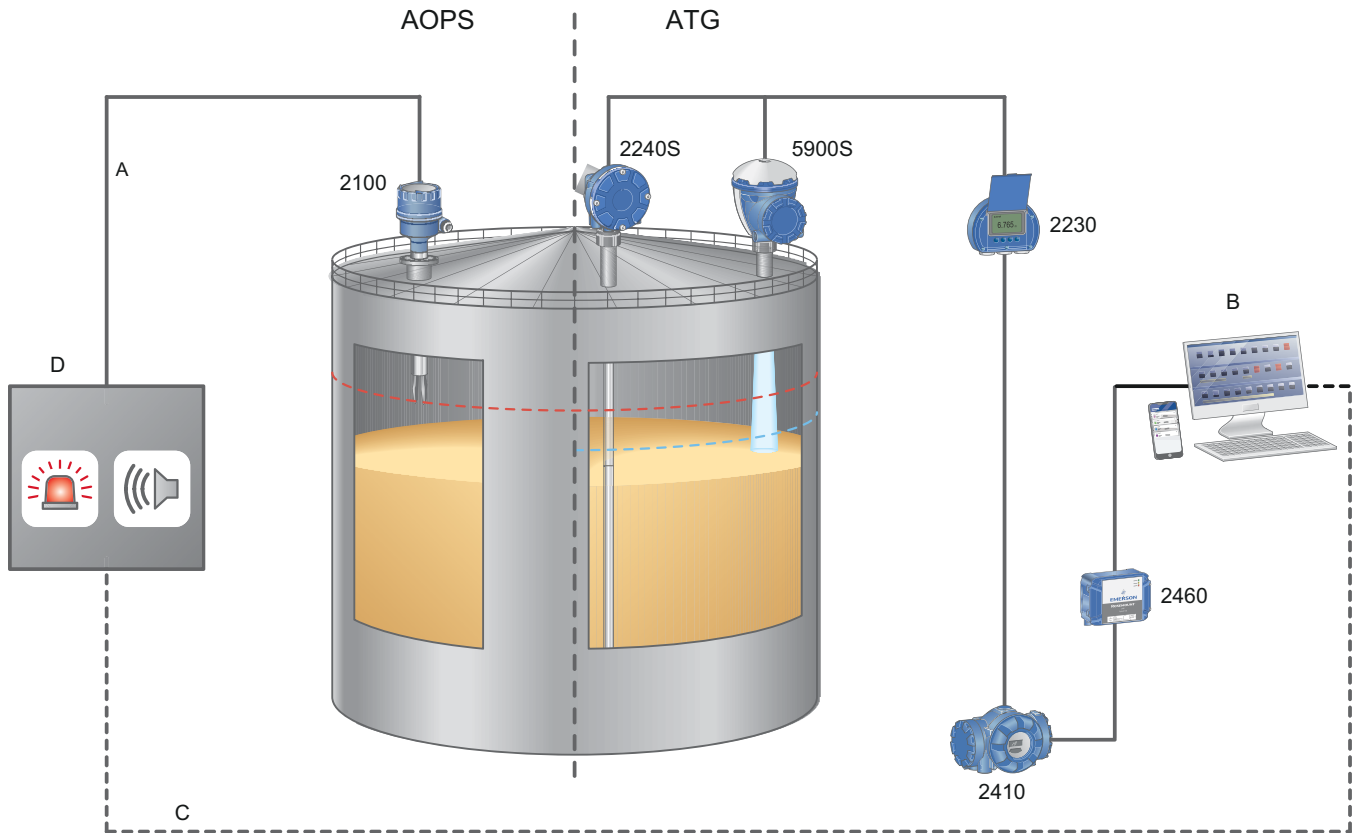
- A. Level/Safety
- B. TankMaster Inventory Management
- C. Connection to TankMaster (optional)
- D. SIL 2 relay or 4-20 mA analog signal
- E. Safety Instrumented System (SIS)

Figure 35: Pressure Vessel AOPS



- A. Rosemount 5900S Radar Level Gauge with Pressure Transmitter
- B. Level/Safety
- C. TankMaster Inventory Management
- D. Connection to TankMaster (optional)
- E. SIL 2 4-20 mA analog signal
- F. Safety Instrumented System (SIS)
- G. Rosemount 644 with Single Point Temperature Sensor
- H. Verification pin

Figure 36: Fixed MOPS 5900S Including Level Switch

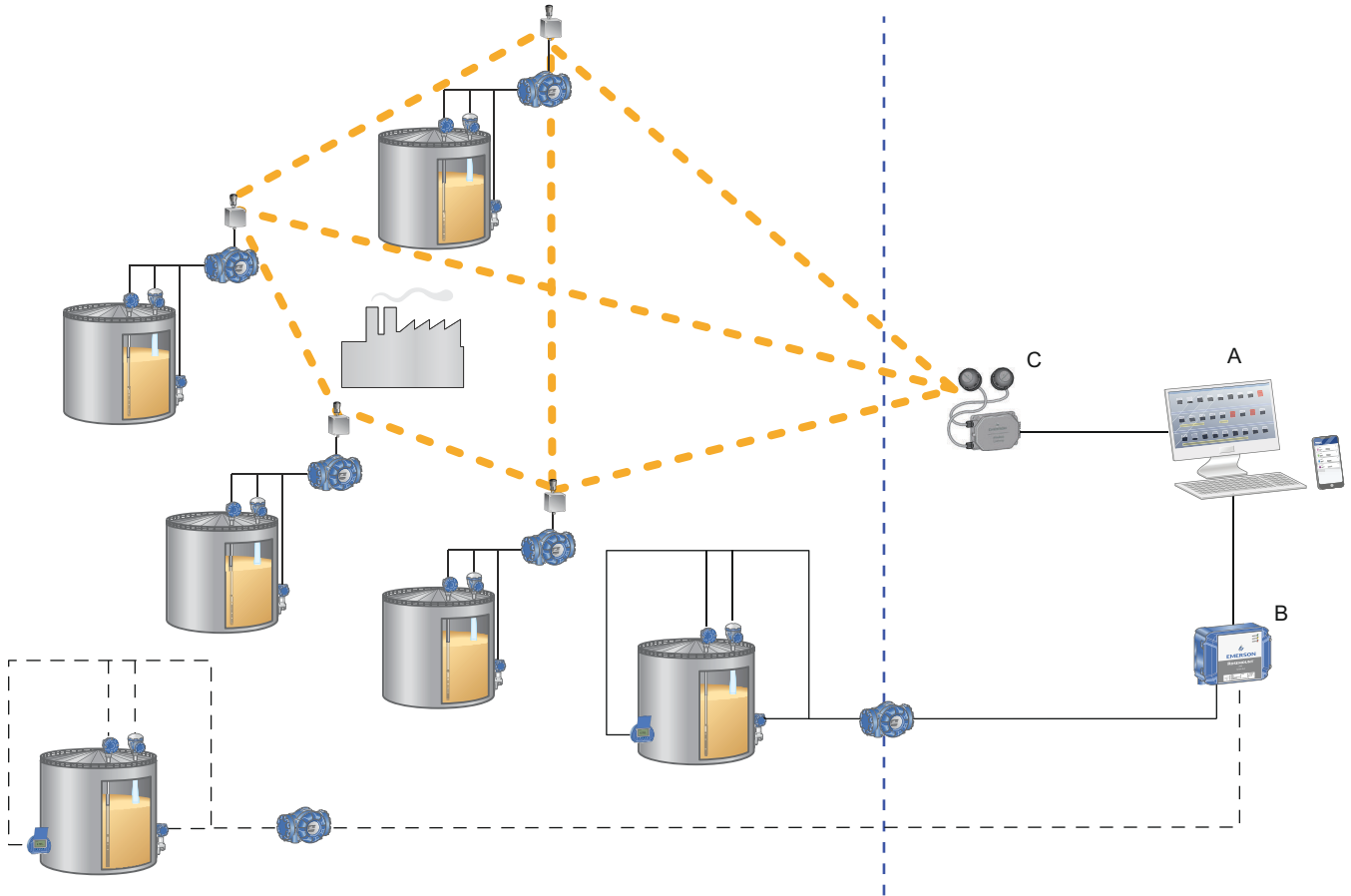


- A. Relay signal
- B. TankMaster Inventory Management
- C. Connection to TankMaster (optional)
- D. Independent alarm panel
High-High alarm

Wired and wireless combination

Wired and wireless communication may be combined within the Rosemount Tank Gauging System for most cost-effective access to data. It is possible to connect a wireless Rosemount gauging system to any existing wired tank gauging system.

Figure 37: Field, Hazardous Area (Left) - Control Room, Safe Area (Right)



- A. Rosemount TankMaster Inventory Management
- B. Emerson Wireless Gateway
- C. Rosemount 2460 System Hub

It is also possible to add a wireless connection to a tank with wired communication to achieve system redundancy.

Improve system reliability with redundancy

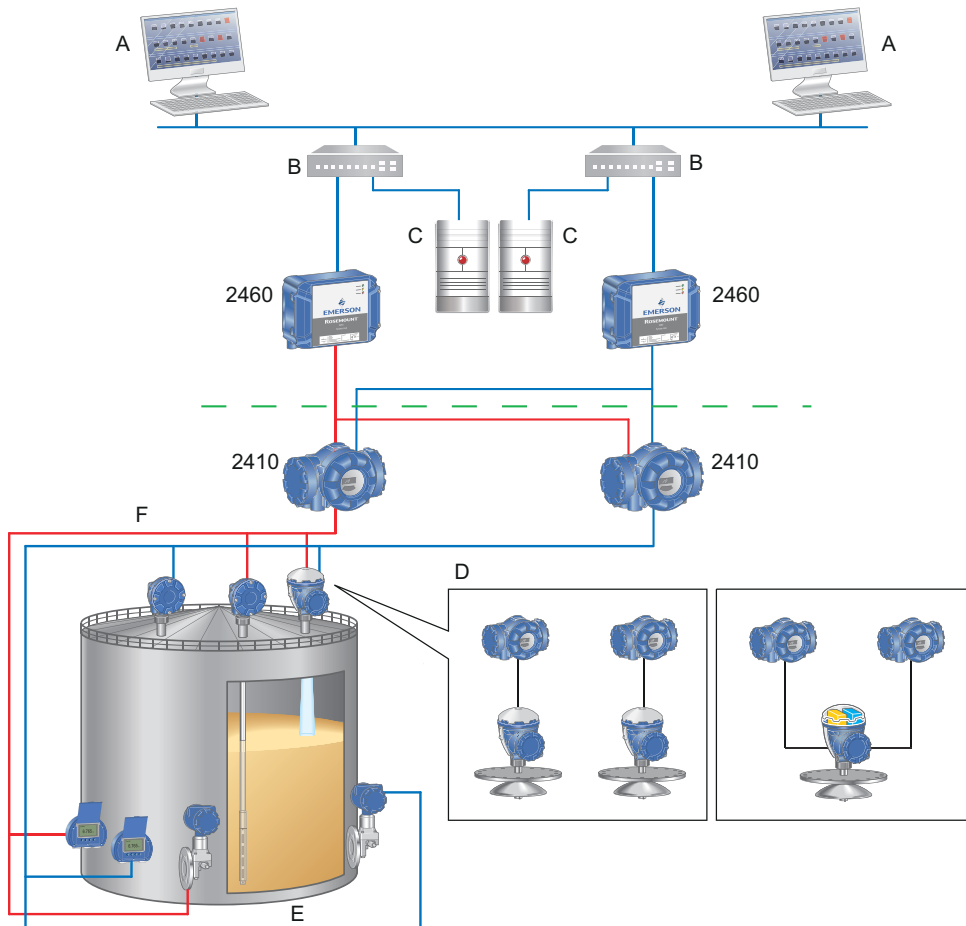
The Rosemount Tank Gauging System supports several redundancy designs, allowing two identical devices for critical operations. Redundancy can be used for some or all equipment, from the control room to the field devices:

- Two TankMaster PCs — both active and separately asking for data, or one primary active and the secondary in hot standby backup mode.
- Two System Hubs — the primary unit is active, the other is in backup mode. A control signal is sent between the two units.

If the backup unit is not receiving it, or if the primary unit is not working properly, a failure message is sent to TankMaster (or a DCS system), and the backup unit is activated.

- Two Tank Hubs — enables two separate Tankbuses on the same tank.
- Tank Device Redundancy — dual-level measurement devices (e.g., two Rosemount 5900 Series gauges or a Rosemount 5900S 2-in-1), dual temperature transmitters with associated sensors, etc.

Figure 38: Fully Redundant System



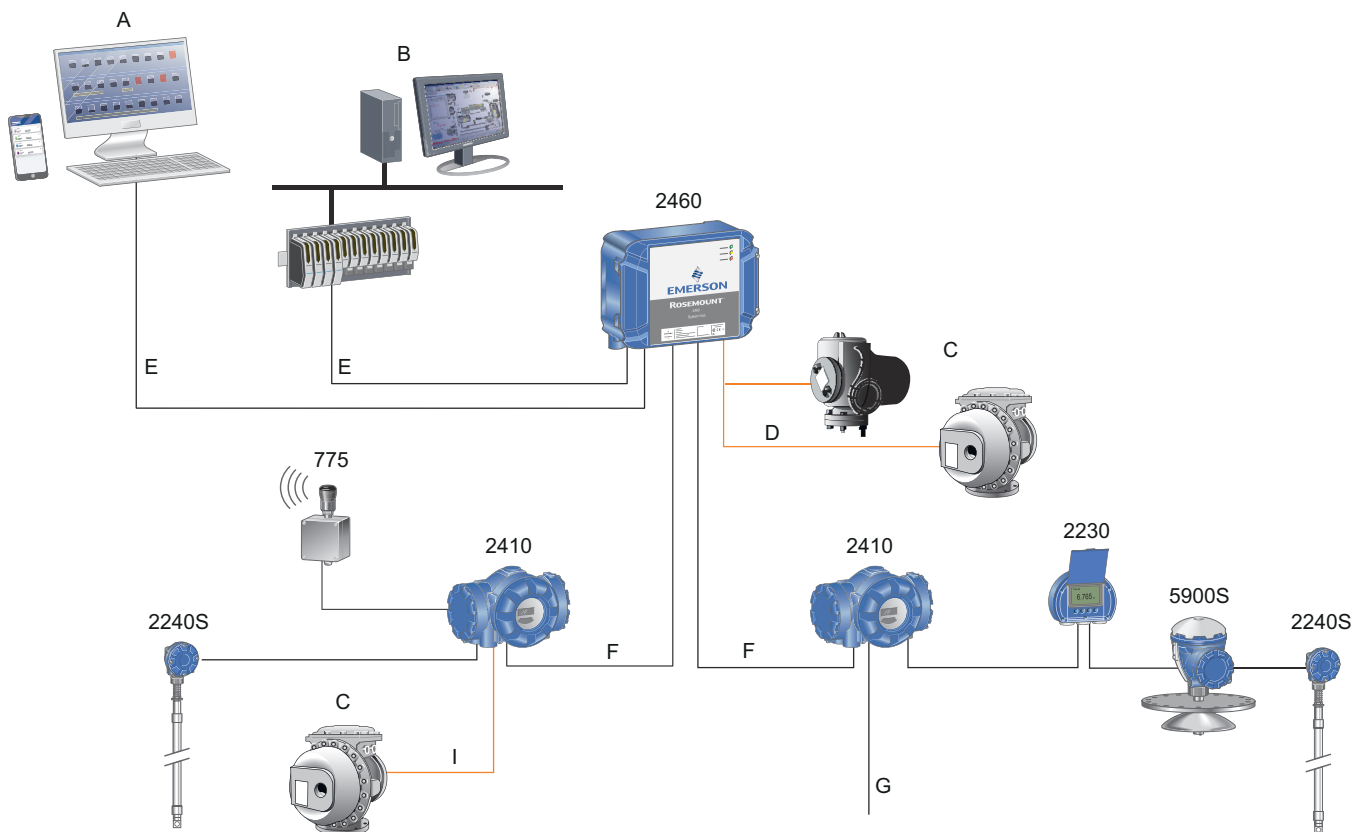
- A. TankMaster client PCs
- B. Network switches
- C. TankMaster servers
- D. Alternatives for level redundancy:
Two tank hubs and two Rosemount 5900S/5300/5408 Level Gauges
Two tank hubs and one Rosemount 5900S, 2-in-1 Level Gauges
- E. Pressure x 2
- F. Temperature x 2

Emulation enables flexible system configuration

The Rosemount 2410 Tank Hub and the Rosemount 2460 System Hub support emulation of field devices from other vendors. In addition, the Rosemount 2460 hub enables exchange of an existing control room operator system to Rosemount TankMaster Inventory Management Software. The TankMaster software allows the configuration of the emulated field devices. TankMaster can also send commands to the connected servo gauges.

By using the Rosemount 2410 for tanks equipped with other vendor's level devices, you can add a Rosemount 2240S with multiple spot temperature sensors and benefit from getting more measurement data integrated in the system. The Rosemount 2410 Tank Hub also adds wireless capability to the emulated devices, either for primary communication or to achieve redundant communication. Wireless communication enables previously stranded data and diagnostics to be included in the automated tank gauging system.

Figure 39: Flexible System Configuration



- A. Rosemount TankMaster Inventory Management
- B. DCS/ Host
- C. Emerson Wireless 775 THUM™ Adapter
- D. Rosemount field devices
- E. Mechanical/servo/radar gauges from other vendor
- F. Enraf® BPM
- G. Modbus® TCP (Ethernet)
Modbus RTU (RS485/232)
- H. Primary bus: Enraf BPM TRL2, RS485, Analog output/input (passive, non-IS)
- I. Secondary bus: Enraf BPM, Varec®, Whessoe, L&&J, GPE⁽³⁾, TRL2, HART® 4-20 mA, WirelessHART®, Analog output/input (active/passive, IS/non-IS)

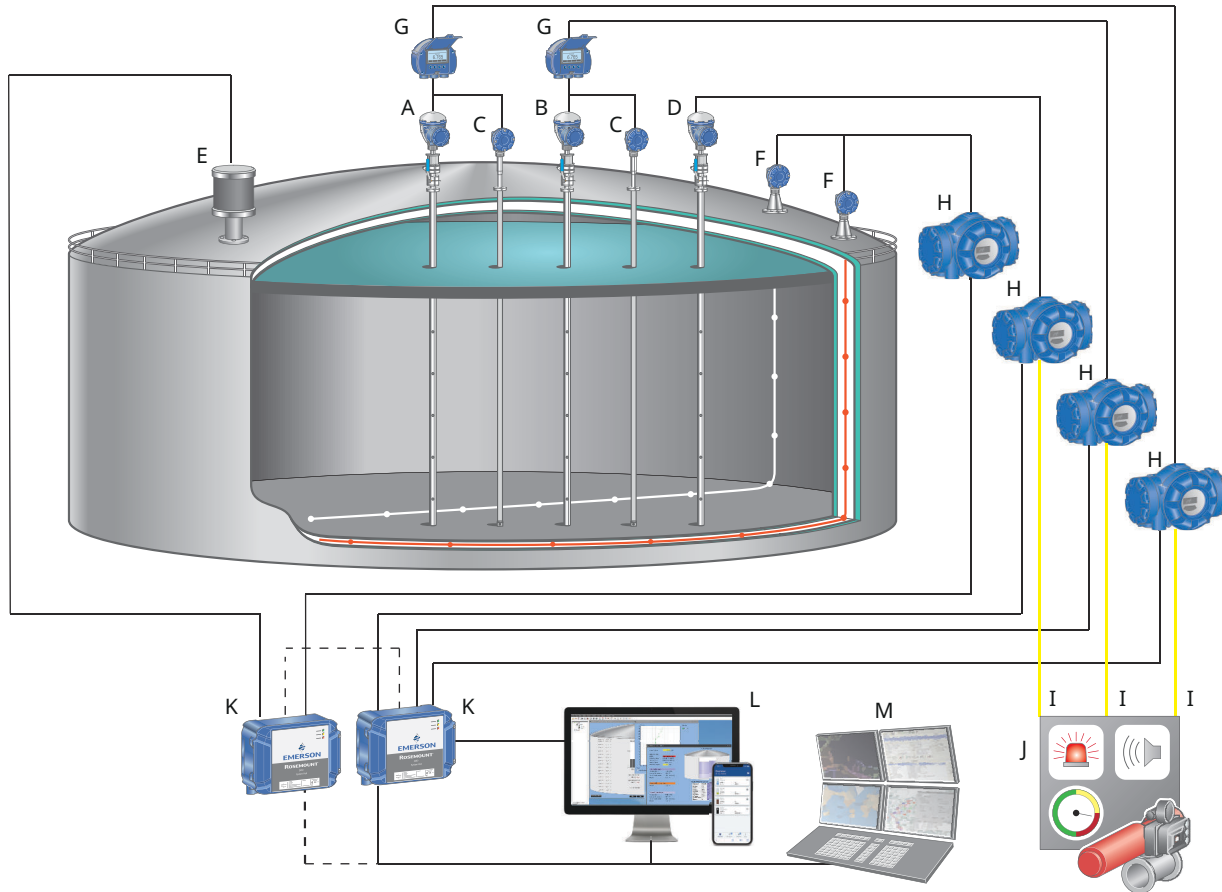
(3) See Rosemount 2410 model code for complete emulation possibilities.

Storage of liquefied gas in full containment tanks

A full containment tank gauging system combines high reliability with high measuring performance and safety functions. The Rosemount Tank Gauging System provides support for full containment storage tanks, including: cool-down, leak detection and product profile temperature measurements, stratification monitoring and alarm handling as well as optional roll-over prediction.

A full overview of all tank parameters is available in the Rosemount TankMaster Inventory Management. Temperature and density profile views for both current and historical profile values allows operators to detect signs of product stratification.

Figure 40: Typical System Configuration for Cryogenic and Refrigerated Storage



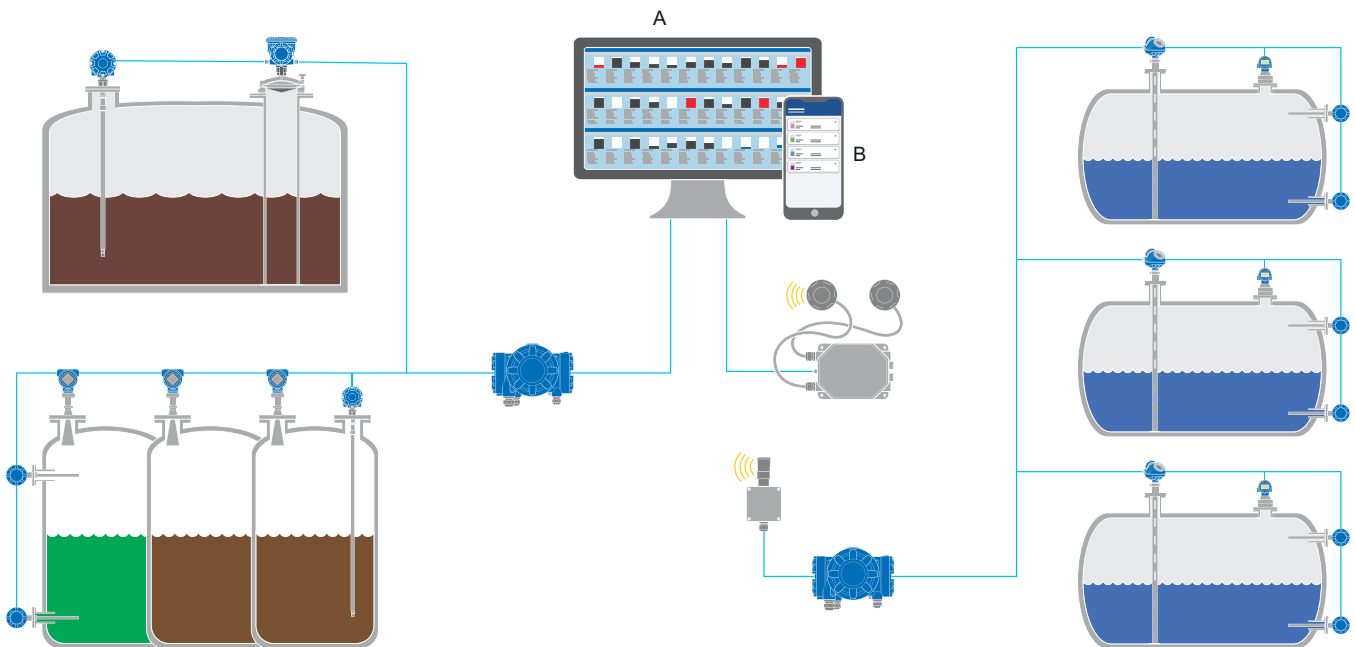
- A. Rosemount 5900S (primary level gauge)
- B. Rosemount 5900S (secondary level gauge)
- C. Rosemount 2240S temperature transmitter with Rosemount 566 cryogenic multiple spot temperature sensor
- D. Rosemount 5900S (independent continuous level alarm)
- E. Level, Temperature, and Density (LTD) Gauge for stratification detection
- F. Rosemount 2240S temperature transmitter with Rosemount 614 cryogenic spot sensor for cool-down and leak detection
- G. Rosemount 2230 Graphical Field Display
- H. Rosemount 2410 Tank Hub
- I. SIL 2/SIL 3 relay or 4-20 mA alarm signal
- J. Independent alarm panel
- K. Rosemount 2460 System Hub
- L. Rosemount TankMaster Software
- M. DCS/Host system

Tank monitoring with Rosemount 5408 or Rosemount 5300 system configuration

A Rosemount 5408 or Rosemount 5300 system configuration is a cost-efficient alternative for non-inventory grade tank monitoring at tank terminals, as well as applications in the biofuels industry, chemical plants, etc. This configuration is a good choice for medium accuracy applications. For level measurements, Rosemount 5408 (non-contacting radar) or Rosemount 5300 (guided wave radar) is used.

For temperature measurements, the Rosemount 644 Temperature Transmitter with a Rosemount 214C Single Point Temperature Sensor is used. The Rosemount 2240S Temperature Transmitter is an even better alternative if more than one temperature element is required. All values are transferred to the Rosemount TankMaster WinView tank management software. Rosemount TankMaster Mobile is used to monitor live inventory data, internally and/or externally.

Figure 41: Non-Inventory Grade Tank Monitoring System



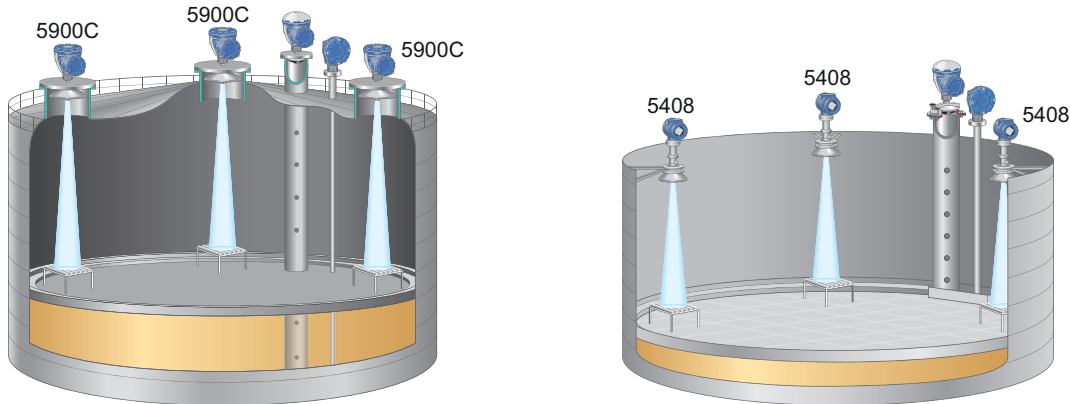
- A. Rosemount TankMaster WinView
- B. Rosemount TankMaster Mobile Inventory Management

Floating roof monitoring

Shell-mounted installation with non-contacting radar

Up to six non-contacting radar transmitters are placed on top of the tank at equal distances. Reflector plates on the floating roof enable measurements without any object protruding from the roof surface. Roof tilt is tracked by comparing the distance between each radar gauge and the floating roof. This non-contacting solution can be retrofitted to existing tank gauging systems without taking the tank out of operation. Adding the tank level measurement as a reference means that roof buoyancy can also be monitored.

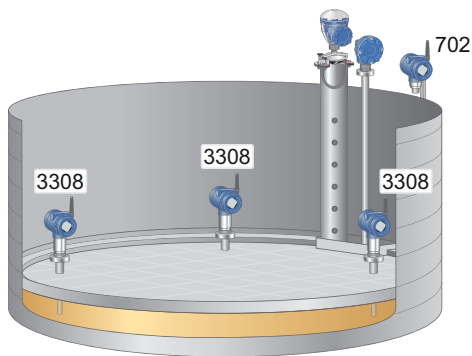
Figure 42: Shell-Mounted Installations Using Non-Contacting Radar



Roof-mounted installation with guided wave radar

An alternative solution is to use up to six guided wave radar level transmitters directly on the floating roof, with rigid probes penetrating through the roof and into the liquid below. Roof tilt is tracked by comparing the distance from the floating roof down to the product surface. The roof buoyancy is also monitored automatically. An advantage of the on-roof configuration is that it uses wireless transmission, battery power and existing nozzles.

Figure 43: Roof-Mounted Installation Using Guided Wave Radar and *WirelessHART*® Transmission of Data



Fully automatic solution

Measurement data is transmitted via wired or wireless communication to the control room, where an operator can monitor the roof status and make configurations using the Rosemount TankMaster software. Drain sump monitoring and liquid hydrocarbon detection can be added to the TankMaster roof monitoring function by installing a Rosemount 2160 Wireless Vibrating Fork Detector and a Rosemount 702 Wireless Discrete Transmitter with Liquid Hydrocarbon Detection. Automatic alarms are given for out-of-limit roof tilt, buoyancy, roof sticking, as well as drain sump blocking and hydrocarbon detection.

Specifications

System key performance specifications

Rosemount Tank Gauging System meets or exceeds requirements specified in industry-relevant standards, e.g., API MPMS Ch 7.3, Ch 3.1B and Ch 12.1.1, ISO 4266 and OIML R85.

Level measurement

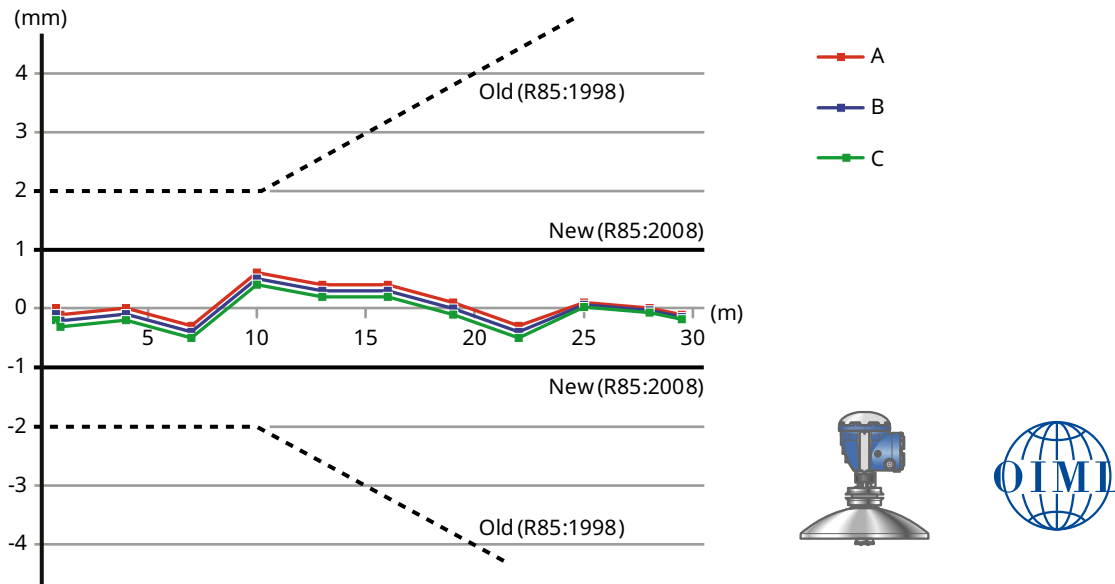
Instrument accuracy Rosemount 5900S

±0.5 mm (0.02 in.)

Instrument accuracy Rosemount 5900C

±1 mm (0.04 in.)

Figure 44: 5900S Fulfills OIML R85:2008 Custody Transfer Requirements



- A. Downwards manual log/Upwards manual log
- B. Downwards autolog
- C. Upwards autolog

Temperature stability of gauge

Typically $\pm 0.5\text{ mm}$ (0.02 in.) in -40 to +70 °C (-40 to +158 °F)

Update time of gauge

New measurement every 0.3 s

Update time for wireless systems

Depends on the number of hops to the gateway. Fastest update rate <math>< 8\text{ s}</math> requires devices with direct communication to the gateway.

Repeatability

0.2 mm (0.008 in.)



Maximum level rate

Up to 200 mm/s

Temperature measurement — Rosemount 2240S Multi-input Temperature Transmitter

Temperature conversion accuracy

±0.05 °C (±0.09 °F)

Over measuring range and ambient temperature 20 °C (68 °F)

Ambient temperature effect

±0.05 °C (±0.09 °F) within the total range; -40 to 70 °C (-40 to 158 °F)

Temperature measuring range

Supports -200 to 250 °C (-328 to 482 °F) for Pt-100

Resolution

± 0.1 °C (± 0.1 °F) according to API chapter 7 and 12

Update time

4 seconds

Temperature sensor calibration

Deviations deriving from the Pt-100 elements are repeatable and can be eliminated with a unique manufacturing calibration procedure, where the Callendar – Van Dusen equation is used. The whole process is computer-controlled and up to 16 elements in each sensor are automatically calibrated at the same time.

Sensor element type

Four-wire Pt-100 spot elements according to IEC/EN 60751

Number of elements per sensor

1-16

Temperature accuracy for Rosemount 565 or 765 temperature sensor

Table 1: Temperature Accuracy for Rosemount 565 or 765 Temperature Sensor

	Cable 20 m	PT-100 -40 °C (-40 °F)	PT-100 70 °C (158 °F)	Total sensor accuracy 0-70 °C (32 - 158 °F) ⁽¹⁾
Four-wire connection, 1/6 DIN B	± 0.001 °C (± 0.002 °F)	± 0.13 °C (± 0.234 °F)	± 0.19 °C (± 0.342 °F)	± 0.19 °C (± 0.342 °F)
Four-wire connection, calibrated	± 0.001 °C (± 0.002 °F)	± 0.045 °C ⁽²⁾ (± 0.081 °F)	± 0.025 °C (± 0.045 °F)	± 0.025 °C (± 0.045 °F)

(1) Root Mean Square values for wiring error and the largest platinum element error for the given range.

(2) X8 calibration extrapolated under use of standard Callendar-Van Dusen C constant from EN 60751.

Net Standard Volume uncertainty

Table 2: Net Standard Volume (NSV) Uncertainty in a Tank with a Radius of 20 m (66 ft) and a Level of 18.5 m (60.7 ft)

	Total accuracy 0 to +70 °C (32 to +158 °F)	NSV uncertainty in a 20 m (66 ft) tank and a level at 18.5 m (60.7 ft)
Four-wire connection, 1/6 DIN B	± 0.19 °C (± 0.342 °F)	3.8 m ³ (23.9 bbl)
Four-wire connection, calibrated	± 0.025 °C (± 0.081 °F)	0.5 m ³ (3.1 bbl)

Volume uncertainty comparison

The uncertainty of the calculated net volume depends not only on the accuracy of the devices, but also on the application. Below is an example to compare the difference between typical Rosemount 5900S, 5900C, 5408, and 5300 configurations.

- Crude oil, 887 kg/m³ density at 20 °C (68 °F) product temperature
- Tank height: 10 m (33 ft)
- Tank diameter: 15 m (49 ft)
- Number of inventories per year: 12
- Number of batch transfers per year: 24
- Ambient temperature: 5 to 35 °C (41 to 95 °F)

Under these conditions, the typical measurement accuracy is:

- 5900S: ±1 mm (0.04 in.), 0.17 °C (0.30 °F)
- 5900C: ±2 mm (0.08 in.), 0.17 °C (0.30 °F)
- 5408: ±6 mm (0.24 in.), 1.2 °C (2.2 °F)⁽⁴⁾
- 5300: ±10 mm (0.4 in.), 1.2 °C (2.2 °F)⁽⁴⁾
- A traditional mechanical tape and float system: ± 25 mm (1 in.), 1.5 °C (2.7 °F)⁽⁴⁾

According to *API Manual of Petroleum Measurement Standards, chapter 11*: considering both level and temperature uncertainty, the total volume uncertainty in liters is shown in [Table 3](#) and [Table 4](#).

Consequently, the Rosemount 5900S configuration reduces volume uncertainty in this example with approximately 90% compared to the Rosemount 5300/5408 system configuration.

Moreover, a Rosemount 5300/5408 system configuration reduces the volume uncertainty with approximately 50% compared to a mechanical tape and float system.

Although calculated for a specific application, this is a representative value for any hydrocarbon storage tank, independent of size.

Table 3: Volume Uncertainty Comparison in Liters (Barrels), Rosemount 565 with Thermometer Tolerance Class 1/6 DIN Class B

	5900S	5900C (1 mm)	5900C (2 mm)	5300	5408	Tape and float
Per inventory ⁽¹⁾	276.5 (2.4)	412.5 (3.6)	571.3 (4.9)	2129.2 (18.4)	1960.8 (17)	4725.9 (40.9)
Per batch ⁽¹⁾	314 (2.7)	534.9 (4.6)	773.6 (6.7)	2714.9 (23.5)	2338.9 (20.2)	6425.1 (55.6)
Per year ⁽¹⁾⁽²⁾	2496.2 (21.6)	4049.5 (35.0)	5769.1 (49.9)	20676.1 (178.8)	18250.6 (157.8)	47847.3 (413.8)

- (1) Statistical error, root mean square value (RMS).
- (2) 12 inventories and 24 batches.

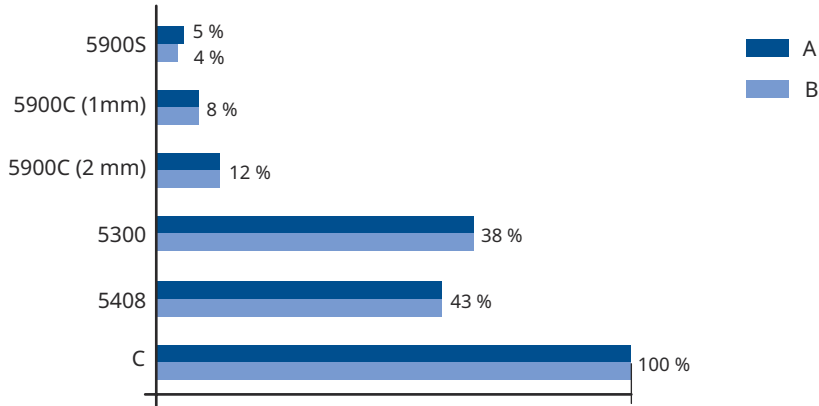
Table 4: Volume Uncertainty Comparison in Liters (Barrels), Rosemount 565 Callendar-Van Dusen Calibrated

	5900S	5900C (1mm)	5900C (2mm)	5300	5408	Tape and float
Per inventory ⁽¹⁾	178.3 (1.5)	354.3 (3.1)	530.8 (4.6)	2129.2 (18.4)	1960.8 (17)	4725.9 (40.9)
Per batch ⁽¹⁾	251 (2.2)	500.5 (4.3)	750.3 (6.5)	2714.9 (23.5)	2338.9 (20.2)	6425.1 (55.6)
Per year ⁽¹⁾⁽²⁾	1847.1 (16.0)	3679.2 (31.8)	5514.2 (47.7)	20676.1 (178.8)	18250.6 (157.8)	47847.3 (413.8)

- (1) Statistical error, root mean square value (RMS).
- (2) 12 inventories and 24 batches.

(4) Low estimate. According to API chapter 7: In large tanks not thoroughly mixed, vertical temperature differences of as much as 3 °C (5.4 °F) are normal, and differences of 5 °C (9.0 °F) are common.

Figure 45: Reduced Uncertainty with 5900 Series Gauges



- A. *Reduced Uncertainty, Rosemount 565 with Thermometer Tolerance Class 1/6 DIN Class B*
- B. *Reduced Uncertainty, Rosemount 565 Calibrated with Callendar-Van Dusen Constant*
- C. *Tape and float*

Pressure measurement — reference accuracy Rosemount 3051S

Coplanar pressure transmitter

Up to ±0.025% of span for ultra version, up to ±0.035% of span for classic version.

Liquid level pressure transmitter

Up to ±0.055% of span for ultra version, up to ±0.065% of span for classic version.

System design specifications

System layout

Communication on the self-configuring Tankbus connected to the Rosemount 2410 Tank Hub is based on the FOUNDATION Fieldbus. It is also possible to connect previous Rosemount tank gauging devices to the system via Modbus, integrate a wireless system and a system from another vendor.

Use the following information when customizing the system:

- The Rosemount 2410 Tank Hub delivers 250 mA to the Tankbus.
The number of tanks and units connected to the Tank Hub depends on which field devices are connected, and their power consumption. Current requirement per field device is listed in [Table 5](#).
- One Rosemount 2410 Tank Hub per tank is recommended for a Rosemount 5900 Series system configuration.
- Rosemount 2410 Tank Hub supports up to 10 tanks for a Rosemount 5408 system configuration, and up to 5 tanks for a Rosemount 5300 system configuration.
- Minimum voltage supply to the devices is 9 V.

Table 5: Power Budget

Field device	Current consumption (9 V)
Rosemount 5900 Series Radar Level Gauge	50 mA
Rosemount 5900S Radar Level Gauge, 2-in-1	100 mA
Rosemount 5300 or Rosemount 5408 Series Radar Level Transmitter	21 mA
Rosemount 2230 Graphical Field Display	30 mA
Rosemount 2240S Multi-input Temperature Transmitter	30 mA including temperature sensors
Rosemount 644 Temperature Transmitter	11 mA
Rosemount 3051S or Rosemount 2051 Pressure Transmitter	18 mA

Examples

250 mA from the Rosemount 2410 Tank Hub supplies power to:

One tank with:

- One Rosemount 5900S 2-in-1 Radar Level Gauge
- One Rosemount 2240S Multi-input Temperature Transmitter with sensor
- Two Rosemount 2230 Displays
- Two Rosemount 3051S Pressure Transmitters

Five tanks with:

- Five Rosemount 5300 or 5408 Radar Level Transmitters
- Five Rosemount 644 Temperature Transmitters with sensors
- One Rosemount 2230 Display

Six tanks with:

- Six Rosemount 5408 Level Transmitters
- Six Rosemount 644 Temperature Transmitters with sensors
- One Rosemount 2230 Display

Ten tanks with ten Rosemount 5408 Level Transmitters

Tankbus cable requirements

Recommended cabling is shielded twisted pairs, 0.75 mm² (AWG 18). Other possibilities are shielded twisted pairs, 0.5-1.5 mm² (AWG 22-16). Tankbus cabling must fulfill FISCO cable and installation requirements and be approved for use at minimum 85 °C (185 °F).

FISCO (Fieldbus Intrinsically Safe Concept)

The following cable characteristics are specified for FISCO according to IEC 60079-27.

Table 6: FISCO cable characteristics

Parameter	Value
Loop resistance	15 to 150 Ω/km
Loop inductance	0.4 to 1 mH/km
Capacitance	45 to 200 nF/km
Maximum length of each spur ⁽¹⁾ cable	60 m (197 ft) in gas Group IIC
Maximum length of each trunk ⁽²⁾ cable	1000 m (0.60 miles) in gas Group IIC, and 1900 m (1.18 miles) in gas Group IIB

- (1) *The spur is an unterminated part of the network. It is allowed to have an up to 60 m (197 ft) long spur. For longer distances, an alternative network configuration should be considered.*
- (2) *The trunk is the part of the network which has terminators at both ends. In the system, a trunk can be the part of the network between the Tank Hub and a segment coupler or the last device in a daisy-chain configuration.*

Reuse of existing cabling

It is recommended to install new Tankbus cabling according to the specifications previously described. However, in most cases it is possible to re-use the existing cabling if compliant with FISCO requirements.

Examples of allowed cabling distances

Typical characteristics for such a cable is:

- 0.75 mm² (AWG 18)
- 42 Ω/km (loop resistance)
- 115 nF/km
- 0.65 mH/km

The following examples show the allowed cabling distances for different system configurations. It is assumed that the devices are installed at the end of the cabling for a full load scenario. In reality that is not the case, which is why the allowed distances might be longer.

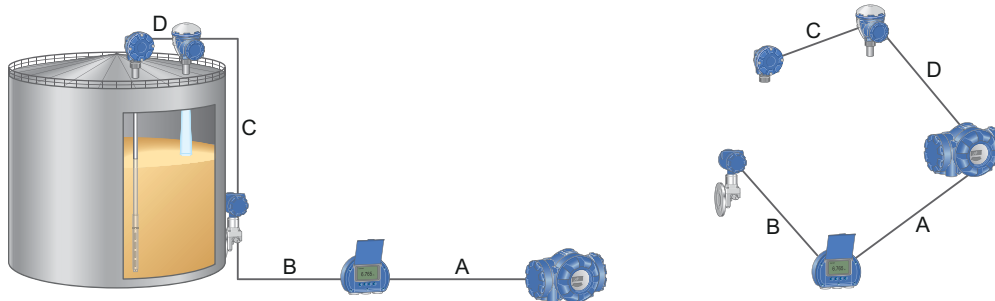
Maximum distance with maximum power usage for a Rosemount 5900S configuration

The Rosemount 2410 Tank Hub can deliver 250 mA (12.5 VDC) to the devices on the tank. A voltage drop of 3.5 V is allowed. This means that the total worst-case cable resistance can be up to 14 Ω (3.5/0.250). The maximum cable length is 333 m (1092 ft).

Maximum distance with typical power usage for a Rosemount 5900S configuration

A more typical current value is 128 mA for a tank equipped with one Rosemount 5900S gauge, one Rosemount 2230 display, one Rosemount 2240S temperature transmitter, and one Rosemount 3051S pressure transmitter. In this case a cable with a length of 650 m (2130 ft) can be used.

Figure 46: Total Cable Length



Total cable distance in Figure 46 (A+B+C+D) must not exceed the values in Table 7.

Table 7: Maximum Cabling Distance for a Rosemount 5900 Series Configuration

Cable diameter	Loop resistance	Maximum cabling distance from power source (2410) to all devices on the tank Distance in m (ft)		
		With maximum power usage of 250 mA	With typical power usage of 128 mA for 5900 Series, 2240S, 2230, 3051S	With typical power usage of 178 mA for 5900S 2-in-1, 2240S, 2230, 3051S
20 AWG (0.5 mm ²)	66 Ω/km	212 (695)	414 (1358)	298 (978)
18 AWG (0.75 mm ²)	42 Ω/km	333 (1092)	651 (2136)	468 (1535)
17 AWG (1.0 mm ²)	33 Ω/km	424 (1391)	829 (2720)	596 (1955)
16 AWG (1.5 mm ²)	26 Ω/km	538 (1765)	1000 (3281)	756 (2480)

Maximum distance with typical power usage for a 5900S 2-in-1 configuration

If the tank instrumentation is the same as in the previous example, but instead is equipped with a Rosemount 5900S 2-in-1 gauge, the typical current value is 178 mA. The cable can then be 468 m (1535 ft).

Table 7 is a guide to how long cables are allowed for a Rosemount 5900 Series system configuration with some common cable types.

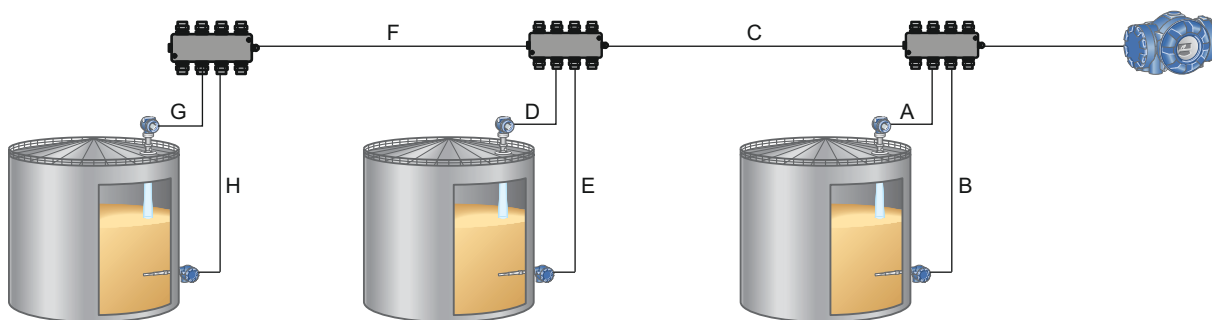
Maximum distance with typical power usage for a Rosemount 5300/5408 configuration

For a tank equipped with one Rosemount 5300 or Rosemount 5408 Transmitter, and one Rosemount 644 Temperature Transmitter, the typical current value is 31-32 mA. This means the cable can be up to 2604 m (8543 ft).

It is possible to have five such Rosemount 5300-based tanks or up to ten Rosemount 5408-based tanks, connected to one Rosemount 2410 Tank Hub if the total cable length is not exceeded.

Table 8 is a guide to how long cables are allowed for a Rosemount 5300 or Rosemount 5408 system configuration with some common cable types.

Figure 47: Total Cable Length



Total cable length in Figure 47 (A+B+C+D+E+F+G+H) must not exceed the values given in Table 8.

Table 8: Maximum Cabling Distance for a Rosemount 5300/5408 Configuration

Cable diameter	Loop resistance	Maximum cabling distance from power source (2410) to all devices on the tank, m (ft) with typical power usage of 32 mA per tank with 5300/5408 and 644				
		Five tanks	Four tanks	Three tanks	Two tanks	One tank
20 AWG (0.5 mm ²)	66 Ω/km	331 (1085)	414 (1358)	552 (1811)	828 (2716)	1000 (3281)
18 AWG (0.75 mm ²)	42 Ω/km	520 (1706)	651 (2136)	868 (2847)	1000 (3281)	1000 (3281)
17 AWG (1.0 mm ²)	33 Ω/km	662 (2171)	828 (2716)	1000 (3281)	1000 (3281)	1000 (3281)
16 AWG (1.5 mm ²)	26 Ω/km	841 (2759)	1000 (3281)	1000 (3281)	1000 (3281)	1000 (3281)

TRL2 fieldbus cable recommendations

In a Rosemount Tank Gauging System, the Rosemount 2410 Tank Hub communicates with a Rosemount 2460 System Hub using the TRL2 Modbus protocol.

The TRL2 field bus requires twisted and shielded pair wiring with a minimum area of 0.50 mm² (AWG 20 or similar).

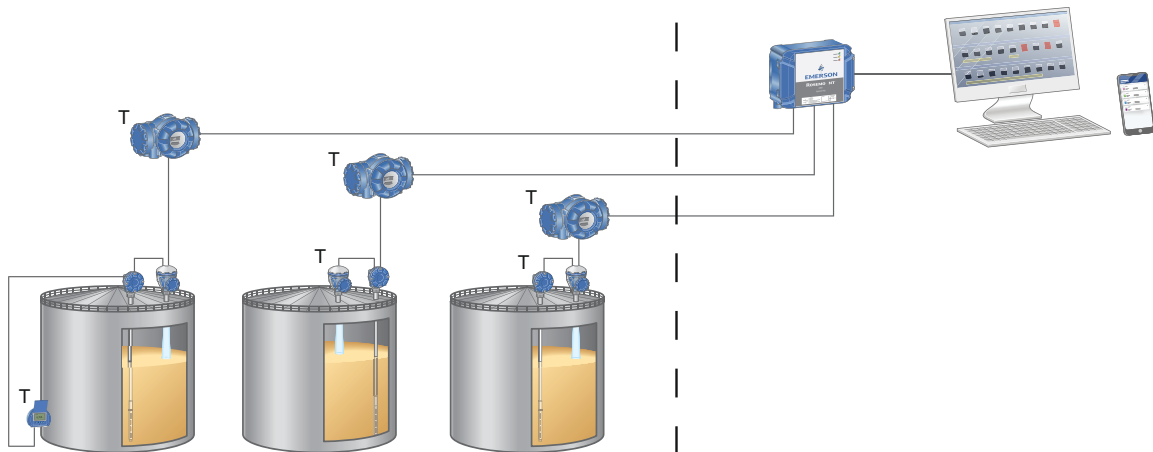
The maximum length of the TRL2 field bus is approximately 4 km (2.5 miles). The TRL2 field bus can normally use existing cables in the tank area.

Typical Tankbus wiring in a Rosemount 5900 Series system configuration

Available installation configurations enable easy and cost-efficient cabling. The Rosemount Tank Gauging System has a daisy chain feature for convenient wiring of the Tankbus.

The devices in a Rosemount 5900 Series system configuration have an on/off selectable built-in bus terminator (the last device on the bus must be terminated). No external segment couplers or bus terminators are needed when the last device on the bus is a Rosemount 5900 Series gauge, a Rosemount 2240S, or a Rosemount 2230.

Figure 48: Last Device on the Bus Terminated in a Rosemount 5900 Series System Configuration



T Built in terminator ON

System certifications

Refer to each device PDS/Reference manual for details.

Accuracy/legal metrological approvals

- OIML R 85 edition 2021
- Australia, NMI
- Belgium, BMS
- Bulgaria, Type Approval
- China, CPA
- Croatia, Custody Transfer Certificate
- Czech Republic, CMI
- Estonia, TJA
- France, LNE
- Germany, PTB Eich
- India, W&M
- Indonesia, MIGAS
- Italy, Ministero dello Sviluppo Economico
- Kazakhstan, GOST
- Malaysia, SIRIM
- Norway, Justervesenet
- Poland, GUM
- Portugal, IPQ
- Russia, GOST
- Serbia, Custody Transfer Certificate
- Switzerland, METAS
- The Netherlands, NMI
- Tunisia, ANM

Hazardous location certifications

- ATEX/UKEX
- IECEX
- FM-US
- FM-Canada
- INMETRO (Brazil)
- KCCs (South Korea)
- EAC/GOST (Russia, Belarus, Kazakhstan)
- NEPSI (China)
- PESO (India)
- CML (Japan)
- UAE (United Arab Emirates)

Safety/overfill protection approvals

- IEC 61508 certified SIL 2 and SIL 3 capable (depending on device)
- TÜV/DIBt WHG for overfill protection (Germany)
- SVTI for overfill protection (Switzerland)
- Vlare II for overfill protection (Belgium)

Appendix

Technical documentation for the Rosemount Tank Gauging System

Product Data Sheets

Rosemount 5900S Radar Level Gauge [Product Data Sheet](#)
Rosemount 5900C Radar Level Gauge [Product Data Sheet](#)
Rosemount 5408 Level Transmitter [Product Data Sheet](#)
Rosemount 5300 Level Transmitter [Product Data Sheet](#)
Rosemount 2240S Multi-input Temperature Transmitter [Product Data Sheet](#)
Rosemount 565/566/765/614 Temperature and Water Level Sensors [Product Data Sheet](#)
Rosemount 2230 Graphical Field Display [Product Data Sheet](#)
Rosemount 2410 Tank Hub [Product Data Sheet](#)
Rosemount 2460 System Hub [Product Data Sheet](#)
Rosemount TankMaster Inventory Management Software [Product Data Sheet](#)
Rosemount TankMaster Mobile Inventory Management Software [Product Data Sheet](#)
Single Point Temperature Measurement [Product Data Sheet](#)
Rosemount 214C Temperature Sensors [Product Data Sheet](#)
Rosemount 3051S Pressure Transmitter [Product Data Sheet](#)
Rosemount 2140 and 2140:SIS Level Detectors [Product Data Sheet](#)
Rosemount 2160 Wireless Level Detector [Product Data Sheet](#)
Rosemount Tank Gauging Accessories [Product Data Sheet](#)
Rosemount Control Cabinets [Product Data Sheet](#)
Emerson Wireless Gateway [Product Data Sheet](#)
Emerson Wireless 775 THUM Adapter [Product Data Sheet](#)

Reference Manuals

Rosemount 5900S Radar Level Gauge [Reference Manual](#)
Rosemount 5900C Radar Level Gauge [Reference Manual](#)
Rosemount 5300 Level Transmitter [Reference Manual](#)
Rosemount 5408 Level Transmitter with FOUNDATION Fieldbus Protocol [Reference Manual](#)
Rosemount 2240S Multi-input Temperature Transmitter [Reference Manual](#)
Rosemount 644 Temperature Transmitter with FOUNDATION Fieldbus Protocol [Reference Manual](#)
Rosemount 3051S Series Pressure Transmitter with FOUNDATION Fieldbus Protocol [Reference Manual](#)
Rosemount 2230 Graphical Field Display [Reference Manual](#)
Rosemount 2140 Level Detector Vibrating Fork [Reference Manual](#)
Rosemount 2160 Wireless Level Detector [Reference Manual](#)
Rosemount 2410 Tank Hub [Reference Manual](#)
Rosemount 2460 System Hub [Reference Manual](#)
Emerson Wireless Gateway [Reference Manual](#)
Emerson Wireless 775 THUM Adapter [Reference Manual](#)
Rosemount Tank Gauging System Configuration [Reference Manual](#)
Rosemount TankMaster WinOpi Inventory Management Software [Reference Manual](#)
Rosemount TankMaster WinView Tank Management Software [Reference Manual](#)
Rosemount Floating Roof Monitoring [Reference Manual](#)
Rosemount Tank Gauging Wireless System [Reference Manual](#)
Rosemount TankMaster Mobile Inventory Management Software [User Guide](#)
Rosemount TankMaster Mobile Inventory Management [Installation Manual](#)

When to use Rosemount 5900S or Rosemount 5900C in a Tank Gauging system

The Rosemount 5900S or 5900C gauge is recommended for high performance solutions for custody transfer, inventory control, oil/product movement and operations, and overfill prevention and leak detection.

Table 9: Accuracy

Features	Rosemount 5900S	Rosemount 5900C
Instrument accuracy	± 0.5 mm (0.02 in.) ⁽¹⁾	± 1 mm (0.04 in.) ⁽¹⁾
Typical system performance	± 1.0 mm (0.04 in.) or less	± 3 mm (0.12 in.)

(1) At reference conditions.

Table 10: Safety

Features	Rosemount 5900S	Rosemount 5900C
SIL 3	Yes, certified	No
SIL 2	Yes, certified	Yes, certified
Overfill prevention approvals	Yes, TÜV/DIBt WHG and other national approvals ⁽¹⁾	Yes, TÜV/DIBt WHG and other national approvals ⁽¹⁾
Proof-testing	Yes, extended and certified	Yes, extended and certified
Relay outputs for direct control	Yes	Yes

(1) Requires a Rosemount 2410 Tank Hub with applicable safety output.

Table 11: System Output

Features	Rosemount 5900S	Rosemount 5900C
Spot temperature	Yes	Yes
Average temperature	Yes	Yes
Free water level	Yes	Yes
Pressure	Yes	Yes
Total observed volume (TOV)	Yes	Yes
Gross observed volume (GOV)	Yes	Yes
Gross standard volume (GSV) ⁽¹⁾	Yes	Yes
Net standard volume (NSV) ⁽¹⁾	Yes	Yes
Density	Yes	Yes
Mass	Yes	Yes
Alarm handling	Yes	Yes
Batch handling feature	Yes	Yes
On-line density	Yes	Yes
Scheduled on-line reports	Yes	Yes

(1) According to API/ISO.

Table 12: Legal Metrological Approvals

Features	Rosemount 5900S	Rosemount 5900C
OIML R85	Yes	No
NMI, PTB	Yes	No

Table 13: Redundancy

Features	Rosemount 5900S	Rosemount 5900C
2-in-1 radar gauge	Yes	No

Table 14: Communication

Features	Rosemount 5900S	Rosemount 5900C
Emulation	Yes	Yes
Wireless field network	Yes	Yes

When to use Rosemount 5900C or Rosemount 5408 in a Tank Monitoring system

The Rosemount 5900C gauge or the Rosemount 5408 transmitter is recommended for oil/product movement and operations and overfill prevention.

Table 15: Accuracy

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
Instrument accuracy	± 1 mm (0.04 in.) ⁽¹⁾	± 2 mm (0.08 in.) ⁽¹⁾
Typical system performance	± 3 mm (0.12 in.)	± 6 mm (0.24 in.)

(1) At reference conditions.

Table 16: Safety

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
SIL 3	No	No ⁽¹⁾
SIL 2	Yes	No ⁽¹⁾
Overfill prevention approvals	Yes, TÜV/DIBt WHG and other national approvals ⁽²⁾	Yes, national approvals
Proof-testing	Yes, extended and certified (TankMaster WinSetup)	No ⁽¹⁾
Relay outputs for direct control	Yes	No

(1) Only available for Rosemount 5408 with Signal output code H.

(2) Requires a Rosemount 2410 Tank Hub with applicable safety output.

Table 17: System output

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
Spot temperature	Yes	Yes
Average temperature	Yes	No
Free water level	Yes	No
Pressure	Yes	No
Total observed volume (TOV)	Yes	Yes
Gross observed volume (GOV)	Yes	No
Gross standard volume (GSV) ⁽¹⁾	Yes	No

Table 17: System output (continued)

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
Net standard volume (NSV) ⁽¹⁾	Yes	No
Density	Yes	No
Mass	Yes	No
Alarm handling	Yes	Yes
Batch handling feature	Yes	No
On-line density	Yes	No
Scheduled on-line reports	Yes	No

(1) According to API/ISO.

Table 18: Legal metrological approvals

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
OIML R85	No	No
NMI, PTB	No	No

Table 19: Redundancy

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
2-in-1 radar gauge	No	No

Table 20: Communication

Features	Rosemount 5900C	Rosemount 5408 with signal output code U
Emulation	Yes	Yes
Wireless field network	Yes	Yes

Radar level device selection

This section provides a guideline on which radar level device and antenna/probe to use for various tanks and applications. In general, use Rosemount 5900S for custody transfer and inventory control, which requires highest accuracy and reliability.

Table 21: Fixed Roof Tanks

Tank and application	Recommended	Second choice	Alternative choice
18 in. or larger nozzle, no disturbing objects in tank	5900S with parabolic antenna	5900C with parabolic antenna	5408 with parabolic antenna or 5301 with flexible twin ⁽¹⁾ /single lead probe
8 in. to 17 in. nozzle, no disturbing objects in tank	5900S with horn antenna	5900C with cone antenna	5408 with parabolic or 5301 with flexible twin ⁽¹⁾ /single lead ⁽²⁾ probe
4-6 in. nozzle, no disturbing objects in tank	5900C with cone antenna	5408 with 4-in cone antenna	5301 with flexible single lead probe
2-3 in. nozzle, no disturbing objects in tank	5900C with 1-in or 2-in still-pipe antenna	5301 with flexible single lead probe	5408 with 2-in. or 3-in cone antenna

Table 21: Fixed Roof Tanks (continued)

Tank and application	Recommended	Second choice	Alternative choice
Objects in tank	5900S with parabolic antenna	5900C with parabolic antenna	5301 with coaxial ⁽¹⁾⁽³⁾ , flexible twin ⁽¹⁾ or single lead probe or 5408 with parabolic
5-12 in. still-pipe	5900S with still-pipe array antenna	5900C with still-pipe array antenna	5301 with flexible single lead probe and a centering disk
2-4 in. still-pipe measurement	5900C with 1-in or 2-in still-pipe antenna	5900C with cone antenna	5301 with flexible single lead probe and centering disks ⁽⁴⁾

- (1) For clean products with no risk for build-up.
- (2) Special considerations for 10 in. or larger nozzles. Consult the factory.
- (3) Best alternative choice for measuring distance up to 6 m (20 ft).
- (4) Maximum 20 m (66 ft). Centering disks required to be placed along the probe, with a separation distance of 5 m (16 ft).

Table 22: Floating Roof Tanks

Tank and application	Recommended	Second choice	Alternative choice
5-12 in. still-pipe	5900S with still-pipe array antenna	5900C with still-pipe array antenna	5301 with flexible single lead probe and a centering disk
Measurement towards tank roof	5900S with parabolic antenna	5900C with parabolic antenna	5408 with parabolic antenna

Table 23: Bullet/Sphere-Shaped Tanks

Tank and application	Recommended	Second choice	Alternative choice
Pressurized LPG sphere, > 6 m (20 ft)	5900S with LPG/LNG antenna	5900C with LPG/LNG antenna or 2-in still-pipe antenna	5301 with flexible twin lead probe ⁽¹⁾ and centering disks
Pressurized LPG bullet, < 6 m (20 ft)	5900S with LPG/LNG antenna	5900C with LPG/LNG antenna or 1-in ⁽²⁾ or 2-in still-pipe antenna	5301 with coaxial probe ⁽¹⁾ or flexible twin lead probe
Other bullet tanks (e.g., additive tanks) < 6 m (20 ft)	5900S with LPG/LNG antenna	5900C with 1-in or 2-in still-pipe antenna	5301 with coaxial probe ⁽¹⁾

- (1) For clean products with no risk for build-up.
- (2) Maximum 3 m (10 ft).

Table 24: Water Interface Measurement

Tank and application	Recommended	Second choice	Alternative choice
Upper Liquid Level + Free Water Interface Level	5900S and a 765 water level sensor ⁽¹⁾	5900C and a 765 water level sensor ⁽¹⁾	5302 with flexible twin lead ^{(2) (3)} or coaxial ⁽²⁾⁽⁴⁾ probe or 5302 with flexible single lead probe ⁽⁵⁾

- (1) When the free water interface level is < 1000 mm (3.3 ft).
- (2) For clean products with no risk for build-up.
- (3) Upper liquid thickness typically up to 25 m (82 ft) for oil/water interface.
- (4) Best alternative choice for measuring distance up to 6 m (20 ft).
- (5) Upper liquid thickness typically up to 15 m (49 ft) for oil/water interface.

For more information: [Emerson.com](https://www.emerson.com)

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