4

Liquid level applications and technology selection

Topic **Page**

4. Liquid level applications and technology selection

Understanding the different needs a user has makes the selection between a point/continuous level measurement and a tank gauging system easier.

This chapter lists a number of different applications, gives recommendations on suitable technologies, and will provide key installation information and best practices. Since it is not practical to cover all possible applications, the applications chosen for this chapter are intended to give a broad overview of some very common types of applications that are found in many industries, as well as a few applications that may have specific challenges. It will also provide examples of where the various technologies are used. However, the final decision of the technology choice will include the application conditions, the installation constraints, and the capabilities of the technology.

4.1 Slop oil tanks

Primary function of application

Vessels used for waste recovery of hydrocarbons fluids.

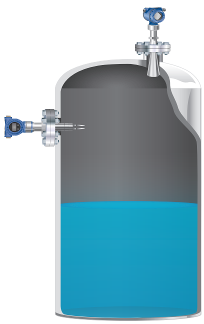

Figure 4.1.1: Slop oil level with non-contacting radar

Application characteristics and challenges

- Slop oil vessels contain a mixture of dirty hydrocarbons and water.
- Deposits and sticky materials are likely to be present.
- Density and other fluid properties can vary.

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with single lead probe	Ch. 6
Non-contacting radar	Ch. 7
Vibrating fork switch	Ch. 10

4.2 Plastic and fiberglass tanks

Primary function of application

Plastic tanks are typically used for storage of corrosive chemicals. They often do not have openings at the top for instrumentation.

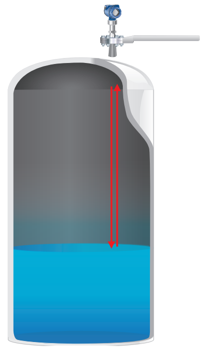

Figure 4.2.1: Level measurement in a plastic tank using non-contacting radar shooting through the roof

Suitable technologies

Technology	Installation guidelines
Non-contacting radar, 5408 with a bracket mount, 6 in. or 8 in. antenna.	Ch. 7
GWR may be used for solids or oil/water production tanks. Use 5300 with single lead probe	Ch. 6

Best practice

A curved roof surface will allow condensation on the inside of the roof to drain away and prevent interference of the radar signal. It will also allow rain or snow to drain away from the radar path. Flat roof tanks are not recommended for the above reasons.

Mount a non-contacting radar with as large an antenna as possible (6 in. or 8 in.) over the tank roof. The transmitter can be mounted with a bracket attached to a pipe. No flange is required which reduces overall weight. The end of the antenna should be horizontal so that it is parallel to the level surface, not the roof surface.

4.3 Ammonia

4.3.1 Ammonia, anhydrous (NH_3)

Primary function of application

Ammonia is widely used in many processes in the chemical industry. It is the raw material for the production of fertilizers and is used in many chemical processes. It is used industrially as a cleaning agent, disinfectant, and as a refrigerant. Ammonia, as used commercially, is often called anhydrous ammonia emphasizing the absence of water in the material. Anhydrous ammonia is stored under pressure or at a low temperature.

Application characteristics and challenges

- Anhydrous ammonia has heavy vapors which can be corrosive to some elastomers
- Density variations are common due to ammonia phase changes with temperature
- Stilling wells and /or valves sometimes present

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8
Guided wave radar with HP seal	Ch.6
Non-contacting radar	Ch. 7
Vibrating fork switch	Ch. 10

Best practice

- If guided wave radar is used, the HP process seal should be chosen. This seal uses no o-rings and has multiple barriers to contain any vapor leaks.
- If non-contacting radar is used choose a low frequency 5401. A stilling well is recommended.

4.3.2 Ammonia, aqueous (ammonium hydroxide, NH_4OH)

Primary function of application

Aqueous ammonia is a solution of ammonia in water and is used in diluted quantities for products like disinfectants or household cleaners and many industrial applications. It is commercially available in concentrations of up to 30% ammonia in water.

Application characteristics and challenges

- Aqueous ammonia is stabilized by the presence of water so phase changes are not as common as with anhydrous ammonia. Density is more stable.
- Vapors are present
- Valves are sometimes used

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7
Differential pressure	Ch. 9
Vibrating fork switch	Ch. 10

4.4 Cryogenic applications

Liquefied gases include materials such as LNG, LPG, ethylene, propylene, R22 and other refrigerants, carbon dioxide, nitrogen, argon, and xenon. These have uses as fuels, refrigerants, raw material components and other.

Application characteristics and challenges

These fluids tend to be very clean fluids with low viscosities and low dielectric values. In the processing industries, the vessel size and shapes vary but horizontal bullet cylinders are the most common. The biggest challenge is the temperature and its impact on the fluid properties and thus, the level measurement. As the fluid moves into impulse piping or bypass chambers, the warmer temperature can cause it to expand or vaporize.

In addition, transmitter electronics have ambient temperature limits of -50 or warmer. If too close to the process, the temperature of the electronics may impact the performance of the device.

Dielectric constants of common liquefied gases and refrigerants

Product	DC	F	C
Ammonia (R 717)	25	-103	-75
Argon, Liquefied	1.5	-376.0	-226.7
Boroethane	2.0	-198	-128
Butane	1.4	30.2	-1.0
Carbon dioxide (R 744)	1.6	32.0	0.0
Ethane	1.9	-288.4	-178.0
Ethane (R170)	1.9	-288.4	-178.0
Ethylene	1.5	26.6	-3.0
Fluorine (Liquefied)	1.5	-332.0	-202.2
Freon (various)	1.7 to 1.9	68	20
Hexane	2.0	-130.0	-90.0
Methane (Liquid Natural Gas)	1.7	-295.6	-182.0
Nitrogen (liquefied)	1.3	-310	-190
Propane (R290)	1.6	32.0	0.0
Propylene (R 1270)	11.9		
Trifluromethane (R-23)	6.3	-22	-30
Xenon	1.9	-169.6	-112.0

Suitable technologies

Technology	Installation guidelines
GWR with cryogenic probe	Ch. 6
DP with cold-temperature fill fluid	Ch. 9

Guided wave radar

Use a probe with the cryogenic seal (option C on the 5300 model). Both single and coaxial versions are available and are suitable for temperatures as low as -320 °F (-195 °C). For the very lowest dielectric fluids and for applications where internal obstacles are in the vessel, use the coaxial probe. The single probe can be used in the higher dielectric compounds or in bypass chambers. The probes may be mounted directly in the vessel or in a bypass chamber.
The chamber and connections to it should be well insulated to minimize temperature changes. In the case of the GWR, the insulation should not cover the top of the probe above the flange area. This transition distance is needed to meet the ambient condition limits for the electronics.

Differential Pressure

Use a DP transmitter with a low temperature fill fluid such as Syltherm XLT. This fluid can handle temperatures as low as -105 °C (-157 °F). The high pressure side of the transmitter should be connected with impulse piping. The transmitter should be raised above the high side tap by about 2 ft (0.6 m). This will allow some warming of the fluid especially if the application temperature exceeds the fill fluid temperature limit.

The low pressure side should use a dry leg connection. This will also allow the electronics temperature to meet ambient temperature specifications.

Electronic Remote Sensor technology can also be used on taller cryogenic vessels with smaller static pressures.

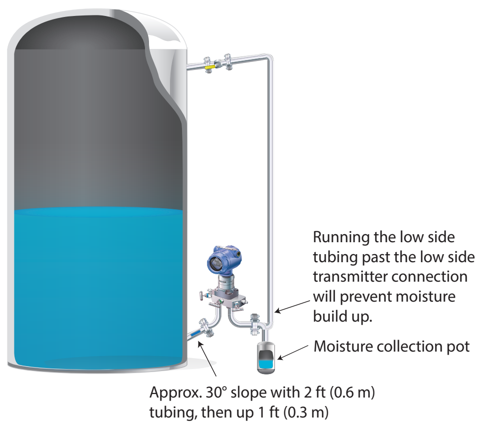

Figure 4.4.1: DP transmitter, wet/dry leg, with cold temperature fill fluid

4.5 Liquid Petroleum Gas (LPG) tanks

Primary function of application

LPG is compressed liquid petroleum gas and is composed primarily of propane (up to 95%) and small quantities of butane. It is a by-product of the refining industry and is a fuel source for industrial and domestic use.

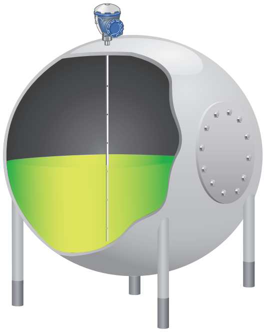

Figure 4.5.1: An LPG tank with an inventory tank gauging system

Application characteristics and challenges

May be spherical tanks containing products such as propane, butane, isobutane. LPG is stored in a variety of tanks shapes and sizes with horizontal cylinders being very common. Valves are often installed. Stilling wells and chambers are commonly used. It is a very low dielectric and low density fluid and as such offers challenges to many level measurements. Phase changes and thus density changes are common as the fluid vaporizes and condenses if the storage pressure and temperature change.

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7

Best practice

- Guided wave radar for smaller, horizontal vessels. If installed directly in the vessel, a coaxial probe should be used. If installed in a chamber, a single lead probe may be used.
- Non-contacting radar with stilling well for larger vessels and those with valves.
- Tank gauging systems for large vessels

4.6 Separators

4.6.1 2-phase separator

Primary function of application

A vessel where hydrocarbon fluids are allowed to separate into a gas phase and a liquid phase. Two phase separators may be horizontal or vertical vessels.

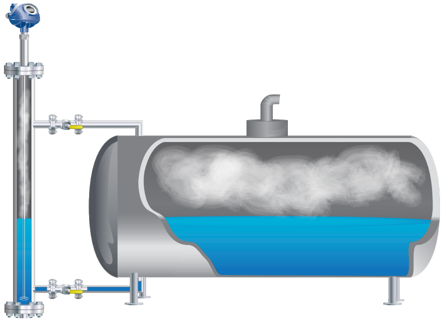

Figure 4.6.1: Two-phase separator

Application characteristics and challenges

Crude hydrocarbons can contain paraffins and other sticky materials. Density of the material can vary with supply. Pressure and temperature will vary widely depending on fluid source and its location in the process.

Depending on well pad geology, some crude hydrocarbons also contain sand and sediment. Over time this can build up in the base of the separator to reduce capacity. Extreme build up may lead to blocked inlets or sediment being drawn down lines and in to pumps.

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with single lead probe	Ch. 6
Differential pressure	Ch. 9
Vibrating fork switch, Rosemount 2140 (sand switch function)	Ch. 10

4.6.2 3-phase separator

Primary function of application

A 3-phase separator is used to separate hydrocarbon fluids into 3 components: gas, oil, and water. This is sometimes also called a Free Water Knock Out (FWKO) where the free water is removed from the oil prior to next processing stage.

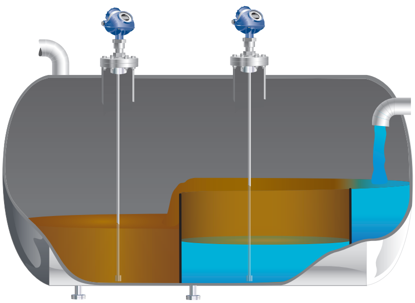

Figure 4.6.2: Three-phase separator

Application characteristics and challenges

Crude hydrocarbons can contain paraffins and other sticky materials. Density of the material can vary with supply. Pressure and temperature will vary widely depending on fluid source and its location in the process.

Some FWKO systems used with heavy crude may be heated.

Depending on well pad geology, some crude hydrocarbons also contain sand and sediment. Over time this can build up in the base of the separator to reduce capacity. Extreme build up may lead to blocked inlets or sediment being drawn down lines and in to pumps.

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with single lead probe , direct mount or in chamber	Ch. 6
Differential pressure	Ch. 9
Vibrating fork switch, Rosemount 2140 (sand switch function)	Ch. 10

4.6.3 Boot separator

Primary function of application

A boot separator includes a smaller section where water is allowed to accumulate for efficient removal.

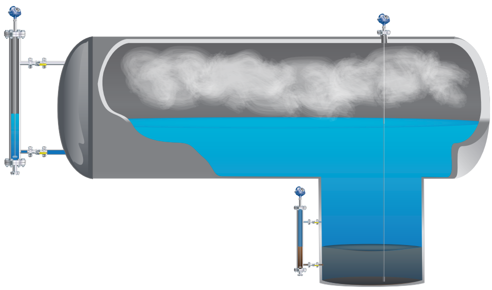

Figure 4.6.3: Two-phase separator with boot

Application characteristics and challenges

- This is an oil and water application. Depending on the fluid separation, an emulsion layer could be present
- Dirty or paraffin laden hydrocarbons could cause some coating so a single lead probe is recommended
- Usually a small measurement span (<1 m/3 ft) unless mounted from top of vessel and extending into the boot.

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with single lead rigid probe	Ch. 6
Vibrating fork switch	Ch. 10

NOTE!

Switches or floats may be used to detect when an interface reaches a predetermined point.

4.6.4 Flare knockout

Primary function of application

Serves as a recovery vessel in case of process upsets and allows vapors to flare off.

Application characteristics and challenges

- Since fluid may be from different sources, the density and other product properties may vary
- Pressure and temperature conditions will vary with location in process.

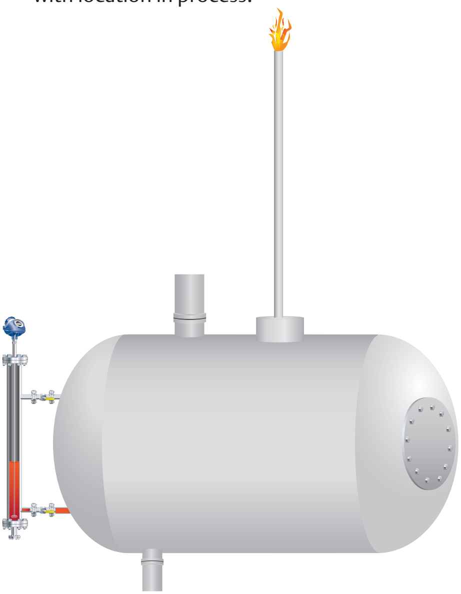

Figure 4.6.4: Flare knockout with guided wave radar

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with single lead probe, chamber or direct mount	Ch. 6
Differential pressure	Ch. 9
Non-contacting radar for taller vessels	Ch. 7

Best practice

GWR with single lead probe will minimize issues with product coating. For very tall vessels where fast level changes are expected, such as blowdown drums, consider non-contacting radar.

4.6.5 Settled Sand and Sediment Detection

Primary function of application

Serves to detect when clean out is necessary to ensure vessel operating at maximum capacity and prevent sand being drawn in to lines.

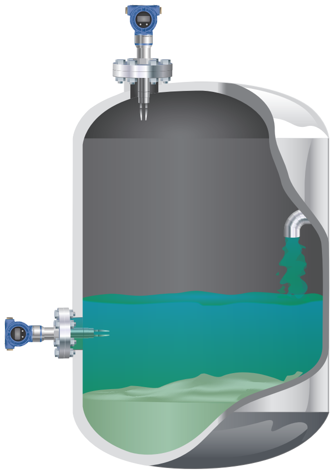

Figure 4.6.5: Vibration forks with sand detection functionality

Application characteristics and challenges

- Dirty/coating media inside separator that may build up on instrumentation
- Limited available process inlets in to separator vessel
- Geological differences at different separator locations means characteristics of the sediment may vary

Suitable technologies

Technology	Installation guidelines
Vibrating fork switch with sand detection function	Ch. 10

Best practice

- Consider Rosemount 2140 configured for sand detection function
- Select appropriate setting according to sediment type - most to least compact
- Device may be mounted in top or side of separator depending on location of available process inlets

4.7 Distillation towers

Primary function of application

Distillation columns allow separation of fluid mixtures based upon their boiling points. As vapors rise through the column, different components will condense at different temperatures and accumulate for withdrawal.

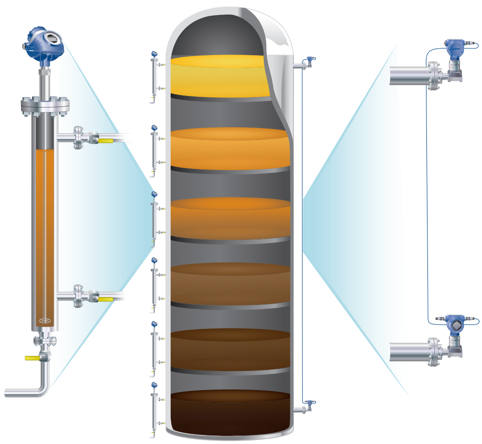

Figure 4.7.1: Level measurement at distillation tower; left hand side showing guided wave radar and right hand side showing differential pressure

Application characteristics and challenges

- Distillation columns will have a wide temperature ranges over its height. The lower end can be as high as 750 °F (400 °C).
- Fluids, especially at the lower end can be dirty and cause coating and plugging of equipment.
- It is important to insulate chambers and piping to minimize the risk of plugging and to maintain lower viscosity.

Suitable technologies

Technology	Installation guidelines
Guided wave radar with single lead probe	Ch. 6
Tray level: DP tuned system	Ch. 9
Column Differential: ERS	Ch. 9

Best practice for tray level measurements

- Guided wave radar; use standard pressure seal for upper portion of tower where the temperature is less than 302 °F (150 °C). Use the HTHP pressure seal for lower sections where temperature exceeds 150 °C
- Differential pressure, tuned system. Use high temperature fill fluids with Thermal Range Expander for lower portions of tower

Best practice for column differential

- Differential pressure; 3051S ERS
- Maximum tap-to-tap span = 500 ft. (152.4 m).
- Multiple ERS systems may be required to cover spans beyond 500 ft.
- Ratio of static pressure to differential pressure should be less than 100:1 (consult Emerson for applications greater than 100:1).

4.8 Blending tanks

Primary function of application

Blending tanks are used for mixing fluids or solids into fluids, usually at ambient conditions.
Level measurements are needed to monitor fluid additions.

Application characteristics and challenges

- May be corrosive, vapors, turbulence, foam
- Usually has an agitator for mixing

Figure 4.8.1: Level measurement in a tank with agitation

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7
Differential pressure	Ch. 9

4.8.1 Slurries

Application characteristics and challenges

Slurries are mixtures of a liquid and suspended particulates. Agitation is usually required to keep the solids in suspension.

Figure 4.8.2: Slurry level with non-contacting radar and differential pressure

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7
Differential pressure (ERS or Tuned-System) with extended diaphragm seal	Ch. 9

4.9 Reactor vessel

Primary function of application

Reactor vessels are similar to blending tanks except that a chemical reaction is required to produce the final product. While the components themselves can create an exothermic or endothermic reaction, sometimes external heat is required.

Application characteristics and challenges

- Vapors, foam, turbulence are often present
- Density can change as part of the reaction
- Pressure can vary from vacuum to positive pressure

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7
Differential pressure, ERS or tuned system	Ch. 9

Figure 4.9.1: Reactor vessel level with non-contacting radar

Best practice

- DP, tuned system, for smaller, higher pressure vessels
- DP, ERS, for taller vessels with lower static pressures (ratio of static pressure to DP span should be less than 100:1)

4.10 Sulfur pits

Primary function of application

Elemental molten sulfur is removed as a by product of desulfurization process in refineries. The collection tanks must be kept hot in order the keep the sulfur fluid.

Application characteristics and challenges

Semi-molten solid is kept hot and well insulated. The sulfur vapors can be heavy and will condense in cooler areas. The challenge is to minimize the condensation.

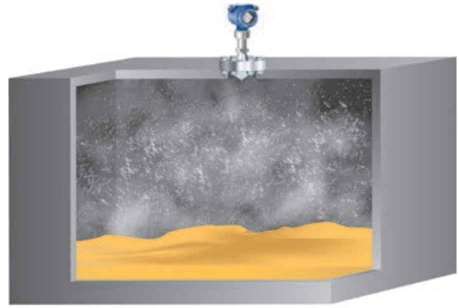

Figure 4.10.1: Rosemount 5408 process seal with nozzle installation

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7
Guided wave radar, with single flexible probe	Ch. 6

Best practice

Use Rosemount 5408 with cone antenna or process seal antenna. If mounted on a nozzle, the nozzle should be well insulated and heat traced to reduce sulfur condensation. Insulate and heat-trace the nozzle to reduce the amount of build-up.
If possible aviod tall nozzles.

A Rosemount 5408 with parabolic antenna may also be used. The antenna should be inside the vessel. This will minimize potential crystallization or build-up.

Siqnal quality metrics may be used to monitor signal strength to determine if cleaning of antenna or probe is needed.

4.11 Measuring on metal plates

Primary function of application

Metal plates are sometimes used as a target for a level device. The plate may be attached to a damper or other moving object and is used to indicate position.

Application characteristics and challenges

Clean application. Depending on location, ambient conditions may be harsh, with high temperatures from a nearby process or may have wide weather related temperature changes.

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7

Best practice:

Mount level unit on bracket centered above the plate. The level device should be positioned perpendicular to the metal surface. The size of the surface should be large enough to accommodate the beam width of the level device at the maximum expected distance.

4.12 Steam generation

4.12.1 Boiler drum level control

Primary function of application

Inaccurate drum level control can cause damage to the steam drum, the boiler, and even the turbine. If the drum level falls below set-point, the boiler may run dry and explode. If the level is higher than the set-point wet steam may be carried over to the turbine which damages the turbine blades. Redundant measurements are required for safety.

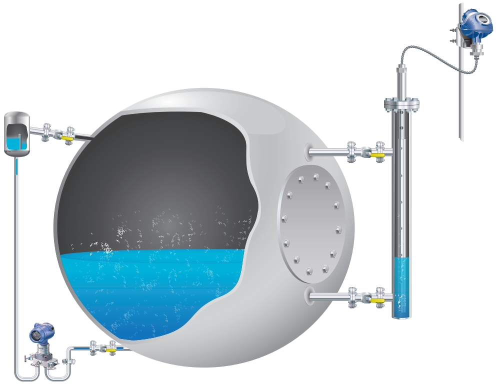

Figure 4.12.1: Boiler drum level control with differential pressure and guided wave radar

Application characteristics and challenges

- High pressure and temperature equipment required
- Density and dielectric of steam increases as pressure and temperature increases
- Density and dielectric of liquid decreases as pressure and temperature increases
- Both steam and liquid density changes require compensation in the DCS for the pressure transmitter level measurement
- Dielectric changes in the steam require compensation for the guided wave radar measurement
- Control range is over small span

Suitable technologies

Technology	Installation guidelines
Guided wave radar with Dynamic Vapor Compensation	Ch. 6
Differential pressure , wet leg, balanced	Ch. 9

Best practice

- Guided wave radar; with Dynamic Vapor Compensation for systems over 400 psi (27 bar)
- Differential pressure; for boiler drum systems with pressure over 600 psi (42 bar), wet legs are recommended. For systems where the pressure is <600 psi (42 bar), balanced systems are recommended

4.12.3 Boiler feedwater

Primary function of application

Feedwater heaters are staged to gradually increase pressure and temperature of the water prior to the boiler. Control of feedwater heater level can impact overall plant efficiency. Redundant measurements are required for safety.

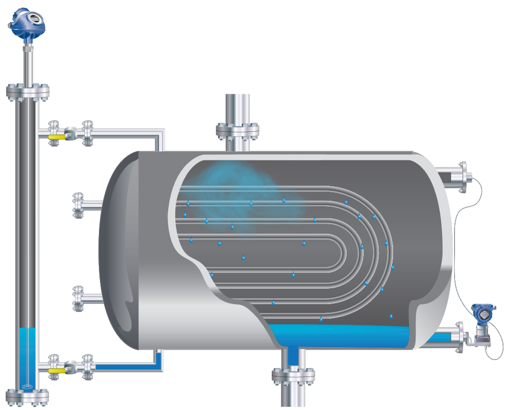

Figure 4.12.3: Feedwater heater level with long and short range installation of external chamber

Application characteristics and challenges

- HP feedwater heaters will have density changes of the liquid and dielectric changes of the vapor as pressure and temperature increase
- Magnetite build-up is common

Suitable technologies

Technology	Installation guidelines
Guided wave radar, with Dynamic Vapor Compensation for systems over 400 psi (27 bar) *	Ch. 6
Differential pressure	Ch. 9

* *Use standard GWR probes for lower pressure applications*

4.12.4 Deaerator

Primary function of application

Dearators remove non-condensible dissolved gases from makeup water. Steam is used to scrub the feedwater and is recaptured as condensate. Accurate deaerator level control ensures continuous feedwater to boiler feed pump.

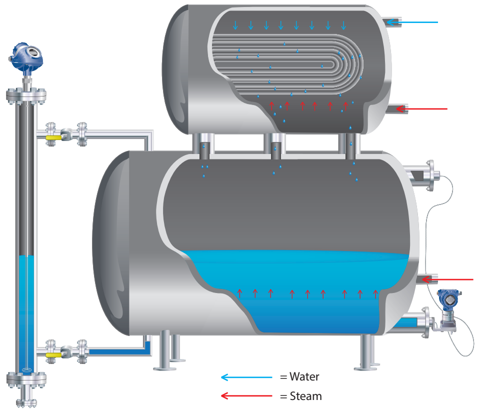

Figure 4.12.4: Deaerator level with guided wave radar and differential pressure

Application characteristics and challenges

- Usually operates at low pressure (< 50 psi) and sometimes at a slight vacuum
- Water is very clean and density is stable

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Differential pressure	Ch. 9

Best practice

- Use standard pressure seal for guided wave radar

4.13 Cooling tower

Primary function of application

Circulating water from the cooling tower is used to provide cooling to the condensing steam from the turbines. After absorbing heat in the condenser, it is cooled by evaporation as it falls through the cooling tower. A continuous water level is maintained in the cooling tower basin for circulation back to the condensor.

Application characteristics and challenges

- While the water being cooled may be clean, windblown debris may collect in the basin
- Foam is sometimes present depending upon water treatment chemical usage
- Depending on the style of the tower and installation locations, the trickling water may be like rain on the level device

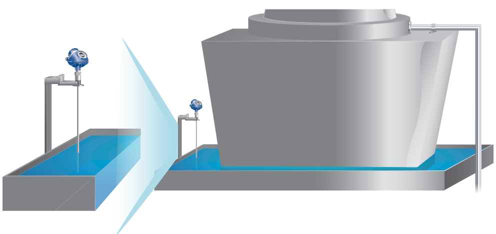

Figure 4.13.1: Cooling tower basin level with guided wave radar; overview and close-up

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7

NOTE!

Often, all of these technologies can be mounted with a bracket mount holding the device over the cooling tower basin.

4.14 Open lake or pond level

Primary function of application

Lake or pond levels are monitored to endure adequate supply of make-up water.

Application characteristics and challenges

- Water
- Top- down measurement

Stilling wells are sometimes used. In cold climates, ice may form on the surface. Non-contacting devices will measure the surface of the ice. Often used in power generation applications, or water and waste water applications.

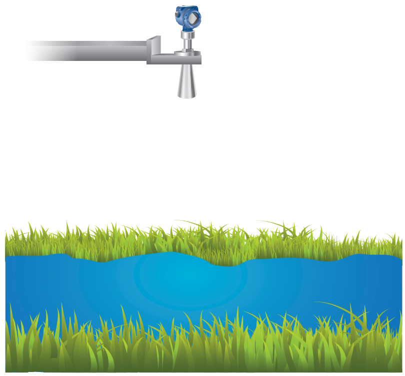

Figure 4.14.1: Measuring level in a pond

Suitable technologies

Technology	Installation guidelines
Guided wave radar if no ice is expected	Ch. 6
Non-contacting radar	Ch. 7

4.15 Sump applications

4.15.1 Sumps (drain pit for waste oil, condensate)

Primary function of application

A sump is a vessel located in a low place or below key equipment that collects waste or overflow liquids Waste oil, waste condensate, chemicals, or water could be collected for reprocessing or disposal.

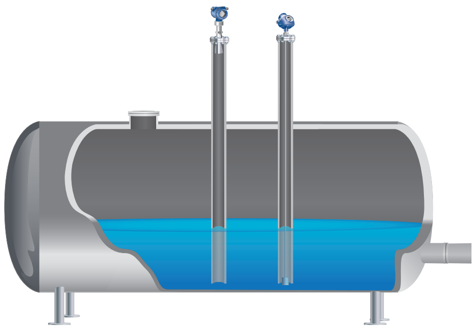

Figure 4.15.1: Condensate sump level with non-contacting radar in a stilling well or guided wave radar

Application characteristics and challenges

- Sumps may contain dirty, oily water
- This is often accessible only with top-down measurements
- It is sometimes desirable to measure interface

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7
Vibrating fork switch	Ch. 10

4.15.2 Open atmosphere sumps

Primary function of application

Treated waste water or rain collection water is stored in open atmosphere sumps.

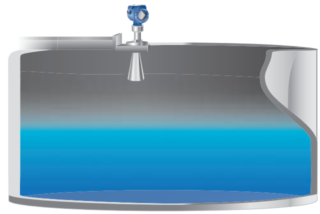

Figure 4.15.2: Open sump measurement with non-contacting radar transmitter

Application characteristics and challenges

- Water
- Top- down measurement

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7

4.15.3 Underground sumps

Primary function of application

Underground sumps are used to collect waste product streams. They are often underground for ease of filling and insulation in extreme temperature climates.

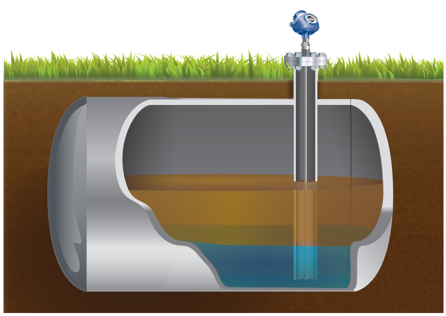

Figure 4.15.3: Underground tank with guided wave radar

Application characteristics and challenges

- Sumps may contain dirty, oily water
- This is often accessible only with top-down measurements
- It is sometimes desirable to measure interface

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7

4.16 Open channel flow

Primary function of application

Open channel flow applications allow the flow of a fluid, usually water, to be measured as it flows through a defined, but open, area. Often there is a restriction of the channel or a weir that will cause a rise in the water level as the flow increases. At this level changes, the flow can be calculated. Established formulas are used for the different types of channels.

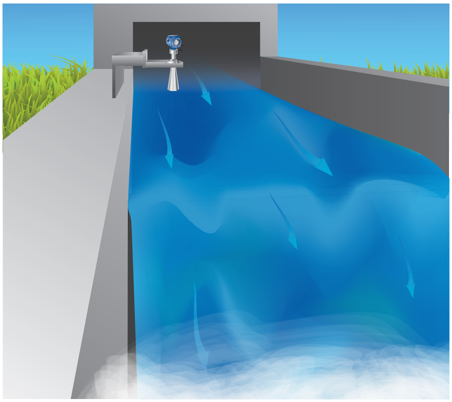

Figure 4.16.1: Measuring open channel flow

Application characteristics and challenges

Flowing fluid, usually water, rises as it passes through the restriction. The amount of rise can be used to determine flow rate. Measurement is usually made at ambient temperature conditions. In cold weather, warm streams may give off a condensing fog. In some waste streams, foam may be present.

Suitable technologies

Technology	Installation guidelines
Non-contacting radar	Ch. 7

4.17 Inlet screen condition monitoring

Primary function of application

Raw water is taken from a reservoir or river. Water intake requires removal of biological impurities and debris and so the water is passed through screens or filter to remove debris. Measurements are taken on both sides of these screens to monitor any clogging.

Application characteristics and challenges

- Raw water application which may be turbulent
- Upstream side may have floating debris
- Top-down measurement

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6

Best practice

For long range applications, for example where access is limited, radar transmitters are most suitable.

4.18 Point level detection

Primary function of application

The primary purpose of point level detection is to determine whether process media has reached a certain point within a vessel. In the case of a liquid detection application a point level sensor detects if it is dry or wet at a specific point in the vessel.

Point level sensors such as vibrating fork switches or mechanical float switches can be used alone as the primary means of level detection or as a backup to a continuous level measurement device to add redundancy to a system.

Point level sensors have many uses in both process and inventory tank gauging applications. Shown here are some typical uses:

- Overfill prevention

Figure 4.18.1: Overfill prevention

Manual Overfill Prevention Systems (MOPS)

Usually dependent upon human actions ie. alarm notifies an operator to take appropriate action to prevent an overfill.
Application characteristics and challenges :

- May be long periods of time between overfill prevention device being activated
- May be exposed site / harsh ambient conditions
- Some fluids may be viscous / coating
- Corrosive materials may be present
- May be hazardous location
- Liquid level may change rapidly
- Need ability to perform functional test
- Need local and remote warning /alarm message

Automatic overfill prevention system (AOPS)

Safety instrumented function (SIF) automatically shuts down plant assets in the event of an overfill.

Application characteristics and challenges:

- May be exposed site / harsh ambient conditions
- Some hydrocarbons (LNG / LPG) may be lightweight materials (low SG)
- Corrosive materials may be present
- May be hazardous location
- May be long periods of time between overfill prevention device being activated
- Need ability to perform functional test (proof test)
- System and equipment design compliance with IEC61508 / 61511 standards

Vibrating fork switches are a popular modern choice because not only are they a simple and cost effective means of installing reliable overfill prevention, they can be side-mounted on to a vessel if it is not possible to install a top-down solution such as a guided wave or non-contacting radar level transmitter.

Best practice

- Select sensor safety certified to IEC61508 with SFF>90%
- Select sensor with high diagnostics coverage and minimum dangerous undetected failures
- Recommend device with ability to perform proof test remotely ie. from control room

For point level overfill prevention, Rosemount 2140:SIS is recommended

- High and low level alarm

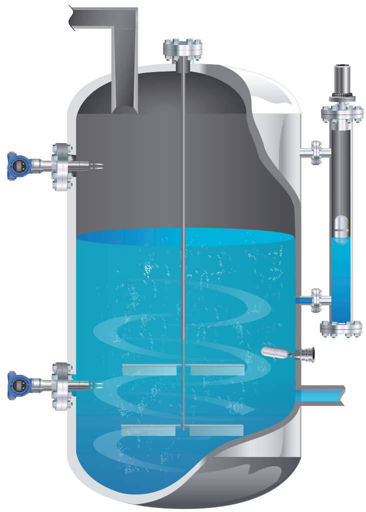

Figure 4.18.2: High and low alarm using vibrating fork and mechanical float technology. Refer to best practice recommendations for technology selection.

Maximum and minimum level detection in tanks containing many different types of liquids are ideal applications for vibrating forks and float switches.

High level alarms send an audio, visual or electronic alert to identify that the process fluid has reached the high limit, typically this is set around the upper 25% of the tank level.

A low level alarm alerts operators to a low condition, which may if left unchecked lead to a run-dry situation or may point to a leak.

It is common practice to fit an independent high level alarm switch as a backup device to the installed level device in case of primary device failure.

Application characteristics and challenges:

- May be exposed site / harsh ambient conditions
- Some fluids may be viscous / coating
- Corrosive materials may be present
- May be hazardous location
- Liquid level may change rapidly
- May need local and remote warning /alarm message
- May be limited access to top of tank / no available inlets
- May be limited power to the installation or installation in remote area

Best practice

- Consider application conditions- where process is corrosive or harsh, vibrating fork switches are recommended for their diagnostics and functional test capabilities
- If access to tank top is limited, vibrating forks may be side-mounted. Mechanical float switches may be chamber mounted, or select submersible version for mounting internally
- If process has coating characteristics, select vibrating fork technology with no moving parts. If application characteristics call for mechanical float technology (eg. high pressure/ temperature), routine inspection and cleaning should be performed
- In remote installations install wireless Rosemount 2160 to extend automation reach without need to install additional infrastructure
- Where power is limited, install Rosemount 2120 with low power relay output option- which is compatible with solar or battery-powered systems or install Rosemount 2160 with integrated power module.

Pump applications

- Pump control

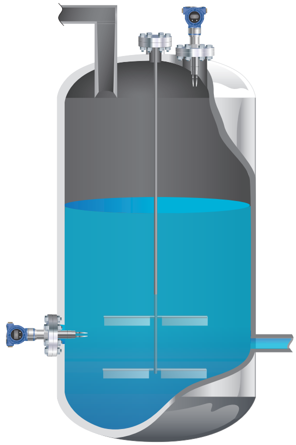

Figure 4.18.3: Pump control

Sometimes a vessel will be fitted with both a high and low level alarm switch to automate filling and emptying cycles to keep liquid contained within the desired limits.

- Pump and dry-run protection

Figure 4.18.4: Pump protection

This application is a subset of low-level alarm whereby a switch at low level either sends an alarm to alert that the process fluid has reached a critical low level. This prevents operation without liquid present which can cause damage to bearings and / or seals or

in extreme circumstances a dangerous overheating situation.
Alternatively, the alarm can be used as an alert to start a secondary process such as Clean In Place (CIP).

Point level switches may also be used as a means of monitoring pump lube oil level to ensure that the reservoir does no run dry.

- Empty pipe detection

Figure 4.18.5: A wireless with detecting wether there is liquid or not in the pipe

An alarm switch is fitted through the wall of a pipe to detect presence or absence of liquid. This may be as a method to protect a pump or to switch another instrument such as a flow meter on or off.

Suitable technologies

Application	Vibrating fork switch	Float switch
Overfill prevention	x	
High level alarm	x	x
Low level alarm	x	x
Pump control	x	x
Pump protection	x	

Table 4.19.1: Showing the technology suitable for different point level detection applications. See also: installation guidelines, chapter 10

4.19 Tank gauging applications

4.19.1 Fixed roof tanks

Primary function of application

These are large storage tanks that contain finished products such as refined oil products. These may also contain feedstock for processing. In both cases very accurate measurements are required for accounting and custody transfer purposes.

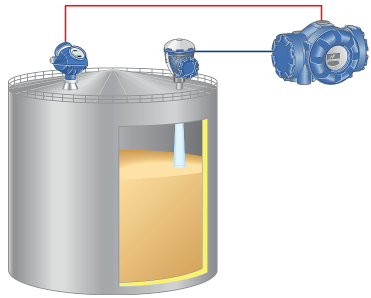

Figure 4.19.1: Storage tank with an inventory tank gauging system

Application characteristics and challenges

Large upright tanks containing crude oil or refined products. Can also be blending tanks, such as at load-out facilities where special additives are mixed in.

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8

4.19.2 Floating roof tanks

Primary function of application

Floating roof storage tanks are used for volatile, vaporous fluids such as gasoline. The roof rides the surface of the fluid and minimizes vapor.

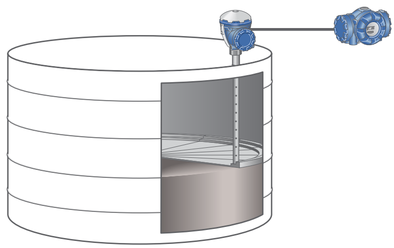

Figure 4.19.2: A floating roof tank with an inventory tank gauging system

Application characteristics and challenges

Large upright tanks with external/internal floating roofs containing oil. Stilling wells are often available for the level measurement. The roof moves up and down outside the stilling well.

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8
Non-contacting radar	Ch. 7

Best practice

The level measurement should be taken from the stilling well access point to provide best accuracy and to avoid any errors due to the roof tilting. Alternatively, the roof position can be measured with a non-contact device mounted from a bracket at the top. However if the roof tilts, the accuracy is compromised. In such cases, more than one unit could be used and the outputs compared.

4.19.3 Liquefied Natural Gas (LNG) tanks

Primary function of application

LNG is primarily methane – it also contains some propane and ethane – and cannot be liquefied solely by pressurization. The gas is cooled to -161°C and becomes a liquid in a process known as "liquefication". This reduces its volume by 600 times and makes it economical to transport.

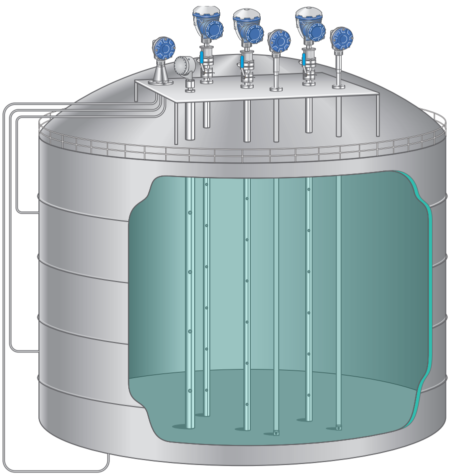

Figure 4.19.3: LNG tank with inventory tank gauging system

Application characteristics and challenges

Large upright cryogenic tanks with refrigerated liquefied natural gas. Because of the size, cryogenic conditions, safety valves, vapors, and low dielectric values, specialized instruments are required.

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8

4.19.4 Emulation

Primary function of application

Emulation provides a cost-efficient alternative to upgrade a tank gauging system, both regarding level measurement and control room devices, including the inventory management software. A system upgrade can be done step-by-step, or in one go.

Rosemount 5900 supports emulation of level devices based on both float, servo and radar technology. The same wiring and host system can be used.

Application characteristics and challenges

Many tank gauging systems still rely on old mechanical devices using float or servo technology, which can provide unreliable measurements and have unreasonably high maintenance costs because of their susceptibility to failure. Despite this, plant managers can be reluctant to replace them with modern and more reliable alternatives.

Replacing a complete tank gauging system is deemed too costly and partial upgrades are difficult due to communication compatibility issues. Plant managers are therefor often accepting the high maintenance costs, simply because they are not aware of any other options.

However, emulation provides a simple and cost-effective solution for tank gauging upgrade projects, enabling existing equipment to be replaced with devices from alternative vendors without the need for new wiring or communication networks. Emulation also solves the problem with non-performing radar level gauges in challenging applications.

Suitable technologies

Technology	Installation guidelines
High precision tank gauging system	Ch. 8

Best practice

Use guided wave radar or non-contacting radar depending on application characterizes in the tank farm. If necessary wireless can be used for remote tank locations.

4.20 Tank monitoring applications

Primary function of application

The tank monitoring system is designed to fit all small tank farms. Given the wide application coverage for Rosemount 5300 and Rosemount 5408 the system is suitable for many different industries, such as chemical and oil and gas. Typical applications could be batch tanks or clarifiers.

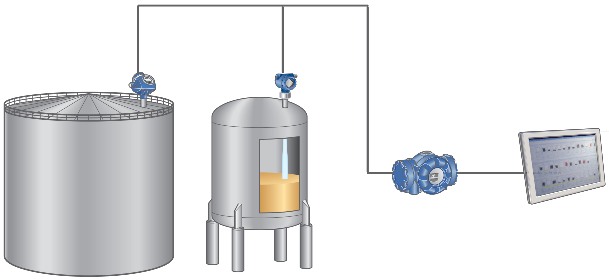

Figure 4.20.1: Tank monitoring system

Application characteristics and challenges

Depending on the industry and the type of media being measured there are many different challenges. Typically, there will be a group of small tanks with no existing automation or tanks with level control devices, but no overfill prevention system and need the additional safety system. In some cases, there are automated system, but visibility is missing to their tanks to monitor capacity.

Suitable technologies

Technology	Installation guidelines
Guided wave radar	Ch. 6
Non-contacting radar	Ch. 7