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Articles How do different types of level measurement devices work? Click here for more information on the technologies behind level measurement and the Time of Flight principle.Radar level transmittersHow do radar level transmitters work?Radar level transmitters work with high-frequency radar pulses which are emitted by an antenna and reflected from the product surface. The time of flight of the reflected radar pulse is directly proportionate to the distance traveled. If the tank geometry is known, the level can be calculated from this variable.Advantages of radar level transmittersVery accurate - 0.5 mm (0.02 inches)Installation at topNon-contactAccuracy independent of dielectric constant, density and conductivityNo re-setup required when changing liquidsThings to take into account:Must take into account tank designFoam can be an issueBlocking distanceTurbulent surfacesMinimum dielectric constantGuided Radar level transmittersHow do Guided Radar level transmitters work?Guided Radar level transmitters work with high-frequency radar pulses which are guided along a probe. As the pluses impact the medium surface, the characteristic impedance changes and part of the emitted pulse is reflected. The time between pulse launching and receiving is measured and analysed by the instrument and constitutes a direct measure for the distance between the process connection and the product surface.Advantages of Guided Radar level transmittersVery accurate - 0.2 mm (0.04 inches)Works with some foamInstallation at topAccuracy independent of dielectric constant, density and conductivityNo re-setup requiredThings to take into account:Must take into account tank designHeavy foam can be an issueBlocking DistanceTurbulent surfacesMinimum dielectric constantUltrasonic level transmittersHow do Ultrasonic level transmitters work?Ultrasonic measurement is based on the time-of-flight principle. A sensor emits ultrasonic pulses which the surface of the medium reflects and the sensor detects again. The required time of flight is a measure for the distance travelled in the empty part of the tank. This value is deducted from the overall height of the tank to yield the level.Advantages of Ultrasonic level transmittersNon-contact (lowest cost)Installation at topAccuracy independent of density changes, dielectric or conductivityNo calibration with medium requiredThings to take into account:Minimum density requiredFoam is an issueBlocking DistanceTurbulent surfacesVapours/gas above the liquidTemperature difference between liquid and sensorNo vacuum (10 psia), no high pressures (44 psia)Capacitance level transmittersHow do Capacitance level transmitters work?The principle of capacitive level measurement is based on the change in capacitance of the capacitor due to the change in the level formed by the probe and the container wall. When the probe is in the air, a low capacitance is measured. When the container is filled, the capacitance of the capacitor increases the more the probe is covered. A capacitance probe may be compared to an electric condenser. As the tank is filled, the probe capacity increases. This change is electrically analysed.Advantages of Capacitance level transmittersVery cost effectiveEstablished principleFast speed of responseInterface measurement possibleHigh temperatures and pressures possibleThings to take into account:Many versionsConductive/insulatorProbe coating - chemical compatibilityGround reference tubeNon-metallicRe-calibration with different media10 pF minimum spanFoam can be an issueOther resources...If you would still like to learn more about the principles or technolgoies behind level measurement, follow the links below:Non contact level measurementLevel measurement for hygienic applicationsResources for this article:Material from experts in level measurement, Endress & Hauser, were utilised in compiling this article. The leading online technical resource centre for the Process Industry. Interested in receiving even more industry-leading news from Process Industry Forum delivered directly to your inbox? Then sign up to our free newsletter. Bringing you the latest news, trends, innovations and opinion from across the process industry, our exclusive newsletter gives you all the industry insights of the moment in one, easy-to-digest bulletin. Stay ahead of the competition with regular process industry news instalments from PIF. As already discussed in operating principle of non-contact radar level sensors/gauges, radar level measurement can be done using: guided and unguarded radar waves. We have already covered unguided or non-contacting radar level measurement. Here the focus is on the operating principle of guided wave radar level measurement applications. Guided wave radar (GWR) is also called time domain reflectometry (TDR) or micro-impulse radar (MIR). In guided wave radar installations, the guided wave radar sensor/gauge is mounted on the top of a tank or chamber, and the probe usually extends to the full depth of the vessel where level measurement is required. A typical guided wave radar installation in a vessel is shown below:Guided Wave Radar Level Measurement Probe Low energy pulses of microwaves, traveling at the speed of light, are sent down the probe. At the point of the liquid level (air / liquid interface) on the probe, a significant proportion of the microwave energy is reflected back up the probe to the transmitter (The GWR installation always comprise the sensor and transmitter as a composite unit).The transmitter measures the time delay between the transmitted and received echo signal and the on-board microprocessor in the transmitter calculates the distance to the liquid surface using the formula: Distance = [Speed of light x time delay] / 2 Once the transmitter is programmed with the reference gauge height (Ho shown above) of the application usually the bottom of the tank or chamber the liquid level(H - Ho) is calculated by the microprocessor. At the interface of air and liquid within the vessel, a proportion of the pulses will continue down the probe through low dielectric fluids and a second echo can be detected from an interface between two liquids at a point below the initial liquid level. This characteristic makes guided wave radar a good technique for measuring liquid/liquid interfaces such as oil and water and measuring through some types of foams. Guided wave radar can be used in vessels with tight geometry, in chambers, and in tanks of all sizes. AdvantagesThey can be used in low dielectric process fluidsThey can be applied to liquids in turbulent applicationsBecause reflection of waves is dependent on a flat surface, they can be used with many powders and grains as well as liquids with slanted surfaces caused by vorticesThey provide accurate and reliable measurement for both level and interface applicationsThey are used with liquids, sludges, slurries and some solidsNo compensation is necessary for changes in density, dielectric or conductivity of fluids under measurement.Changes in pressure, temperature and vapour space conditions have no impact whatsoever on the accuracy of radar level measurementsMaintenance of Guided Wave Radar probes/sensors is minimal since there are no moving partsGuided Wave Radar probes/sensors are easy to install and can be used in place of other level measurement technologies such as displacer and capacitance.Application LimitationsGuided Wave Radar probes should not be in direct contact with metallic object (vessel wall) as this will impact the signal. An exception is the use of a coax-style probe.Material build up on probe tends to affect measurement accuracy. This can be remedied by purchasing probes with advanced diagnostics capabilities.Application of guided wave radar probes in chambers less than 3 inches creates a lot of problems there tend to material build up and the metallic contact between probe and vessel wall cannot be guaranteed most times Verifying that you are not a robot... Guided wave radar (GWR) liquid level measurement sensors have been on the market since the mid to late 1990s, though it is still considered by many as a new technology. GWR can be used in a wide range of applications and media including solids and liquids. Guided wave radar transmitters are very commonly used in liquid interface level measurement.Radar Level Transmitter Operating PrincipleRadar level transmitters measure the distance from the transmitter to the fluid surface by measuring the time of flight of a high frequency electromagnetic radio wave, typically in the microwave frequency range - GHz. The distance from the transmitter to fluid surface is subtracted from the tank depth to give the liquid level. Difference between Guided Wave Radar and Radar Level MeasurementGuided wave radar level measuring instruments use a probe to guide the electromagnetic waves to and from the process liquid, as shown in the diagram below:Advantages of GWR Level Transmitters over Pulse Radar Level TransmittersNon-contact radar devices experience more signal loss than guided-wave radar devices, due to dispersion of the electromagnetic waves. Radar waveguides combat this signal loss by channeling the radio energy along a straight-line path.Guided Wave Radar Waveguide TypesThere are various types of wave guide available commercially, including single metal rods, parallel pairs of metal rods - also known as twin element probes, and coaxial metal rod and tube structure. For all types of probe it is recommended that PTFE probes are used for liquid level measurement of viscous fluids.Single Element Rod ProbesThe single element rod probe is the least efficient and exhibits the greatest energy losses. However, single rod probes are more tolerant of process fouling than two-rod or coaxial probes, where viscous liquid or solid matter may cling to the wave guide. Clinging liquid or solids can cause electromagnetic wave reflections that fool the transmitter into thinkinging it is seeing a reflection from a liquid level or liquid interface surface.Coaxial ProbesCoaxial probes are the most efficient waveguides and suffer the least energy loss. For this reason guided wave radar transmitters with coaxial probes are used in the more difficult low dielectric hydrocarbon applications.Twin Elelment Waveguide ProbesTwin elelment waveguide probes are less efficient than coaxial probes, but more efficient than single element probes. These are good general purpose probes that are typically used in longer range applications, or where flexible probes are required. Guided Wave Radar and Liquid Dielectric PermittivityWith all radar level instruments, including GWR transmitters, the necessary condition for electromagnetic wave reflection is a sudden change in dielectric permittivity. When an electromagnetic wave encounters a sudden change in dielectric permittivity, some of that waves energy will be reflected resulting in another wave traveling in the opposite direction, while the remainder of the waves energy continues forward to propagate into the new material. The strength of the reflected signal depends on how greatly the two materialsdielectric permittivity differs, i.e. their relative permattivity, or as it is sometimes called - dielectric constant. A strong reflected wave is required for good operation of the guided-wave radar measuring sensor, therefore radar level instruments function best when there is a large difference in relative permittivity between the two substances at the interface.With air as the gas medium above the liquid we have relaative permativities of approximately 2 for gasoline, 42 for glycerin, and 80 for water.Compensating for Changes in Dielectric ConstantChanges in dielectric constant can alter the accuracy of radar level measurement. Factors that can alter the dielectric constant of gases include pressure and temperature, therefore the accuracy of a radar level instrument will vary as the pressure and/or temperature of the gas above the liquid vary. Often, the variation is insufficient to cause concern.In high accuracy applications it is common to compensate for the error by either- Pressure and Temperature compensation The compensation calculation can be performed within the plant control system, or some manufacturers offer this capability within their guided wave radar transmitter.- Use of a Reference Signal In this case the radar level instrument is furnished with a reference probe of fixed length who's entire length is always above the liquid level (i.e. it only senses gas).Guided Wave Radar Transmitters - Typical FeaturesGuided wave radar accuracy: expect to achieve 2.5mm or 0.1% of distance for measurements up to 5 metresTransmitter mounting: Head mounted and remote mounted options are widely availableExplosion protection: sensors and transmitters are widely available for use in hazardous areas, either as explosion proof, or intrinsically safe (IS)Transmitter power supply: 2 wire, loop powered universally availableOutput signal: 4-20mA superimposed with a digital HART, FOUNDATION Fieldbus, or Modbus widely availableOperating temperature and pressure ranges: can cope with wide temperature range (-170C to 450C), and from full vacuum to 400 barMeasurement range: guided wave radar is a contact level measurement technique, that requires the radar waveguide length to be at least as long as the required measurement range (span). Using flexible cable probes as the waveguide allows level measurements up to 50m. Guided Wave Radar InstallationGuided wave radar level measurement requires a relatively flat fluid surface. If the surface is turbulent then the use of a Stilling Well or chamber should be considered.For low dielectric liquids consider using a level chamber - a metal chamber acts as a shield and amplifier to the radar signal, giving more reliable reflections.Position the insertion probe such that it is subject to a minimum of lateral force.For long probes, the lower end of the probe should be be fixed to the bottom of the vessel.Ensure adequate headroom, i.e. clearance above the vessel is required for insertion and removal of the probe.Nozzles used for guided wave radar instruemnts should be a minimum of 4 inch - note that mounting flange sizes vary by GWR supplier, so be sure to check.Technical LibraryThe following pages on Control and Instrumentation.com give more detail on various other liquid level measurement methods:Radar level transmitter basically employs electromagnetic waves to determine the fluid level in a tank. It converts level information into a 4-20 mA signal and transmits it to the controller; this signal may then be used in a measurement and control loop to control a process. The level is also displayed by an inbuilt display in the transmitter. Having worked with some of these particular level transmitters in the field (particular the guided wave radar level instruments), I can attest that this is one of the most robust level measurement technologies that can handle difficult liquid conditions like those exhibiting heavy vapors, turbulence, bubbling and form formation however different manufacturers of these instruments offer a variety of options that suit different application specifications. There are two types of radar level transmitters: Non-contact radar level transmitters. Guided wave radar level transmitters. Short bursts of electromagnetic energy are emitted to a liquid surface. An ultra-high speed timing circuitry measures the time of the signal reflected off the liquid surface-transit time (i.e. the total time taken by the initial pulse to liquid surface plus the time taken by reflected pulse from the liquid surface). Complex signal processing filters out false reflections and other background noises. The precise level is then calculated by factoring in the tank height and sensor offset information. Distance (D) = C(Speed of Light) x T (Transit Time)/2 Figure 1.0 Principle of operation (non-contact radar level transmitter) Generally non-contact radar is used in media that involve liquids or slurries, hydrocarbons to water-based media. Examples of applications where this technology is used include: Pulp and paper process industries (chemical storage, piping vessels etc.). Chemical processing (feedstock vessels, catalyst tanks, corrosives and caustics, mixing and blending tanks, waste sumps, day and batch tanks). This instrument operates by using pulses of electromagnetic energy, which are transmitted down a probe. When a pulse reaches a liquid surface that has a higher dielectric than the air/vapor in which it is traveling, the pulse is reflected. An ultra-high speed timing circuit accurately measures the transit time and provides a precise measurement of the liquid level or the liquid-liquid interface as shown in the diagram below: Figure 1.1 Guided wave radar level transmitter operating principle Generally guided wave radar is used in media that involve liquids or slurries, hydrocarbons to water-based media. Typical applications include: These instruments find use in applications that involve hydrocarbons (low dielectric media subject to variation such as hexane, butane, LPG, etc.). Separators. Propane storage and chillers. Steam drums. Ammonia tanks. Molten sulfur. Knock out drums (compressor, flare knock out drums, and so on). You may also read: Please follow us & share: Please enable JavaScript to use this website. Guided wave radar (GWR) technology is based on the Time Domain Reflectometry (TDR) principle. Low power nanosecondpulses are guided along with a probe submerged in the process media. When a pulse reaches the surface of the material it is measuring, part of the energy is reflected back to the transmitter, and the time difference between the generated and reflected pulse is converted into a distance from which the total level or interface level is calculated. The speed of travel of the pulse is impacted by the dielectric of the medium. This change in travel time is predictable and allows compensation for the measurement to be accomplished. The reflectivity of the product is a key parameter for measurement performance. A high dielectric constant (DC) of the media gives a better reflection and a longer measuring range.Figure 1: GWR Typical interface level reflection When an interface level of two immiscible layers should be measured, the first fluid should have a lower dielectric. The reflection from this first low dielectric fluid is weak. This permits the rest of the signal to detect the interface between these two fluids. Less than 5% of the signal is reflected back to the transmitter for a fluid with a dielectric of 2 (e.g. oil).Interface measurement accuracy depends on the upper product dielectric and a distinct interface (low emulsion layer of few mm) between the two fluids. While guided wave radar works in many conditions, some precautions need to be taken with respect to probe choice. Several probe styles are available and the application, length, and mounting restrictions influence their choice. Unless a coaxstyle probe is used, probes should not be in direct contact with a metallic object, as that will impact the signal.If the application tends to be sticky or coat, then only single lead probes should be used. Single lead probes are preferred when there is a risk of contamination (because the coating can result in the product bridging across the two leads for twin versions or between the inner lead and outer pipe for the coaxial probes, and may cause erroneous level readings). For viscous or sticky applications, PTFE probes are recommended to facilitate product flow. Periodic cleaning may also be required. Maximum error due to coating is 110% depending on probe type, dielectric constant, coating thickness and coating height above the product surface. The presence of oilfilm on the single probe will not have any effect.Some advanced GWRs on the market have advanced diagnostics, with the ability to detect buildup on the probe. This gives an indication of how good the surface signal is compared to the noise, and when to clean the probe (predictive maintenance).GWR can be used on cryogenic applications (e.g. 196C) with the recommendation of the coaxial probe. Proper insulation may be required to reduce ice formation on the upper part (e.g. insulate the nozzle).GWR measurement in foamy applications depends on the foam properties: light and airy or dense and heavy, high or low dielectrics, etc. If the foam is conductive and dense, the transmitter may measure the surface of the foam. If the foam is less conductive, the microwaves may penetrate the foam and measure the liquid surface. This type of application should be considered on a case by case basis. Depending on foam properties, GWR may detect the foam/liquid interface or the top of the foam or the top of the liquid. GWR is not suitable for the watersand interface. Since the sand is embedded in water, which is a high dielectric media (DC = 80), the transmitter can only see the water. The same is true for all media that are dissolved in water.Differentparameters(factors)affecttheechoandthereforethemaximummeasuringrangediffers dependingonapplicationaccordingto:disturbing objects close to the probemedia with higher dielectric constant gives a better reflection and allows a longer measuring rangesurface foam and particles in the tank atmosphere may affect measuring performanceheavy coating or contamination on the probe should be avoided since it can reduce the measuring range and might cause erroneous level readings.Figure 2: GWR interface level measurementWhen the interface will be measured, the criteria according to Figure 3 should be fulfilled:Figure 3: GWR Interface measurement dielectric criteriaFigure 4: GWR Maximum dielectric constant vs technology.The maximum allowable upper product thickness/measuring range is primarily determined by the dielectric constants of the two liquids.An example of the maximum upper product thickness for the flexible single probe is presented in Figure 5. However, characteristics can vary between the different applications.Figure 5: GWR Maximum upper product thickness Emulsions/foam above a few centimeters disrupt the interface measurement. The results vary with the fluid mix. In many cases, the interface is measured at the top of the emulsion layer.Emulsion layers above a few centimeters cannot be measured with the GWR principle. This is due to the emulsion dielectric stochastic repartition and the emulsion bubble composition. If the emulsion layer is greater than a few centimeters only the top of the upper layer can be detected.Sometimes emulsion can be formed of a mixture of fine solids combined with emulsified oil and water, sometimes including multiple components. Stable liquid emulsion and solid particles trigger rapid emulsion layer growth.The more particles are present, the larger such an emulsion is. Although applications with emulsions are difficult for GWR measurement, the usage of a stilling well can help to achieve better product separation and therefore more accurate measurements.Figure 6: GWR interface measurement in the vessel with emulsion GWR provides accurate and reliable interface measurements and can be used in a wide variety of applications. It is a topdown, direct measurement as it measures the distance to the product surface.GWR should be considered for clean liquidliquid interface and/or clean liquidgas interface.GWR interface measurement with emulsion, foam, fluid buildup or crystallization is not possible (deposit causes false reading).GWR level instrument accuracy is a function of the liquid dielectric constant. Care should be taken to determine the dielectric constants of the fluids being measured over their full range of possible compositions and operating conditions.The vessel internals e.g. supports and reinforcement should not be at the vicinity of the level measurement device or in the radar path.GWR requires a relatively flat fluid surface. If surface is turbulent then a Stilling Well should be considered.For long probes, the lower probe end should be fitted with an additional stainless steel cylinder with fixing eye to ensure an adequate fixing to the bottom of the vessel.GWR installed in a sensor cage or standpipe should never be in contact with the cage/standpipe internals. Centring disk may be used. The centring disk should provide isolation between the probe and the cage/standpipe internals.GWR sensor cage/stand pipe measuring range should be carefully studied. For a sideside sensor cage/stand pipe the maximum measuring range should be between the middle (axe) of the upper and the lower tapping connection.A key advantage of radar is that changes in pressure, temperature, and most vapour space conditions have no impact on the accuracy of its level measurements. Moreover, no compensation is necessary for changes in dielectric, conductivity, or density of the fluid.Changing density is one of the major issue is when measuring level or interface using older technologies, such as displacers; they are more likely to happen due to changes in process or ambient conditions, and thus have more influence on the reliability and accuracy of density based technologies..n addition, radar devices have no moving parts, so maintenance is minimal. GWR is easy to install and enables simple replacement of older technologies, even while there is liquid in the tank. Direct measurements on the top of the tank (flanges connection)Below are recommendations for the nozzle configuration and dimensions for flanged installations on top of the tank/vessel.Table 1: GWRnozzlediameterChambers with a diameter of less than 7.62 cm can cause problems with buildup and might make it difficult to avoid contact between the chamber wall and probe.Chambers provide a fixed view of the level in a vessel. Thus, when the level drops below or rises above the chamber, it will not be seen in the chamber. The effective measurement range of a chamber is the area between the taps.Figure 7: GWRpossibleerrorchambersmeasurementChamber installation and sizingThe location of the chamber should be as close to area of measurement as possible. If the chamber is further away, the fluid inside it is less like the fluid in the vessel. More distance gives more time for the fluid to cool (or heat up in cryogenic applications). Cooler fluid will be more viscous and dense.More viscous fluid will not respond as quickly and in extreme cases, can completely plug the chamber. Larger connections between the vessel and the chamber will enhance flowthrough of the fluid and allow fresh fluid to move through the chamber more easily and more closely resemble the material in the vessel.If the density in the chamber is lower than the density of the fluid in the vessel, it may actually appear to shrink and cause the level measurement to be lower in the vessel than it actually is, especially if fluid movement is stagnant.Figure 8: GWR chamber installation and sizingMatch product level in tank and chamberBelow are examples of cases that might occur in field conditions.Figure 9: GWR Case 1 Difference in product-specific gravity (SG)Figure 10: GWR Case 2 Lack of circulation in the chamberLevel and interface applicationsMeasurement of level and interface in a chamber should be avoided as the lack of fluid flow will not provide representative measurements.However, chambers are often used for interface measurements between oil and water. In cases where it is the only way to get a measurement, multiple connections to chamber will help to enhance fluid flow. The additional crossover connections should be located near the more critical measurement areas.In these applications, there should be good flowthrough of both the top and bottom fluid for the interface measurement to be tracked. Care should be taken to avoid having a layer of fluid trapped in the chamber.Interface measurements should assess the dielectric constant of both layers to properly configure the device for the intended level application. Specific configuration parameters might require adjustment once the device has been commissioned.Figure 11: GWR chamber with multiple connectionsFully submerged interface applicationsA submerged interface application is one where the upper portion of the probe is in oil or a similar fluid and the interface between the upper fluid and lower fluid is the desired measurement. Often this measurement is done with the GWR mounted in a chamber/cage. This is called a flooded chamber.A single lead probe should always be used for this application as this provides the most distinct reference pulse. Ideally, there should be no air gap present at the top of the probe.However, air is often trapped in the chamber. If there is an air pocket, then it creates an offset in the measurement reading due to the difference in the speed of travel of the microwaves in the air space compared to the upper fluid.For example, if the device is configured with oil as the upper fluid with dielectric constant of 2, the offset error will be 30% of the size of the air pocket (that is, a 15.7 in. (40 cm) air pocket creates a 4.7 in. (12 cm) offset error to the reading).There are several options available to overcome the error introduced due to the air pocket:If process safety allows it, a vent can be included in the top of the chamber that allows the air to be removed. This vent can be piped back to process. A flushing ring can be installed between the GWR flange and the chamber flange to accommodate this.Figure 12: GWR fully submerge air pocketIf the air pocket is small and is within the upper blind zone of the device, the Upper Null Zone can be configured to block any potential incorrect reading of the surface.Figure 13: GWR fully submerge air pocket echoInterface measurements in vesselsThe most common interface application in vessels implies measurements of both upper product level and interface level.Figure 14: GWR interface measurement in vesselThough not very common, fully submerged vessel interface applications can be possible too. A good example of such application are desalters and inverted interface measurements.Inverted interface measurementsThe previous examples cover situations when the upper product has a lower DC than the lower one. However, sometimes there are applications where product disposition is inverted: the high dielectric product lies on top of the low dielectric one, which makes topdown measurement impossible for GWR.In this case, the GWR mounting position is inverted so that it is installed at the bottom of the tank. For applications where there may be some solids or slushy deposits at the bottom of the vessel, it is advisable to put a flushing connection in the mounting nozzle to allow occasional cleaning.Figure 15: GWR interface measurement in the vessel with lower DC upperConfiguration routine is the same as for standard interface measurements using interface with submerged probe mode.Dielectric constants have to be set according to product separation. Upper product means the one that is closer to the tank bottom.When installing GWR on the tank bottom, there is no limit of probe types to be used. Flexible probes need to be attached to the tank roof. This can be done by following the same guidelines, provided for standard installations. The actual upper media DC value is known. The configuration needs to include the actual DC value (at the factory or at the site). If the actual upper DC is not known in a range of 20% around the actual measure, the accuracy will be impacted.Above this 20% value, it is recommended to perform a site/field calibration to improve the measurement accuracy.Source: International Association of Oil & Gas ProducersAcknowledgments: IOGP Instrumentation and Automaton Standards Subcommittee (IASSC), BG Group, BP, Endress + Hauser, Emerson, Honeywell, Krohne, Petrobras, PETRONAS Carigali Sdn Bhd, Repsol, Siemens, Statoil, Total, Vega, Yokogawa.Read Next: Guided wave radar (GWR) technology is based on the Time Domain Reflectometry (TDR) principle. Low power nanosecondpulses are guided along with a probe submerged in the process media. 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This vent can be piped back to process. A flushing ring can be installed between the GWR flange and the chamber flange to accommodate this.Figure 12: GWR fully submerge air pocketIf the air pocket is small and is within the upper blind zone of the device, the Upper Null Zone can be configured to block any potential incorrect reading of the surface.Figure 13: GWR fully submerge air pocket echoInterface measurements in vesselsThe most common interface application in vessels implies measurements of both upper product level and interface level.Figure 14: GWR interface measurement in vesselThough not very common, fully submerged vessel interface applications can be possible too. A good example of such application are desalters and inverted interface measurements.Inverted interface measurementsThe previous examples cover situations when the upper product has a lower DC than the lower one. 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This can be done by following the same guidelines, provided for standard installations. The actual upper media DC value is known. The configuration needs to include the actual DC value (at the factory or at the site). If the actual upper DC is not known in a range of 20% around the actual measure, the accuracy will be impacted.Above this 20% value, it is recommended to perform a site/field calibration to improve the measurement accuracy.Source: International Association of Oil & Gas ProducersAcknowledgments: IOGP Instrumentation and Automaton Standards Subcommittee (IASSC), BG Group, BP, Endress + Hauser, Emerson, Honeywell, Krohne, Petrobras, PETRONAS Carigali Sdn Bhd, Repsol, Siemens, Statoil, Total, Vega, Yokogawa.Read Next: Radar level transmitters electronic devices that are used for fluid level measurement. As the name suggests, these level transmitters use radar technology for fluid level detection. These transmitters function on the basis of electromagnetic waves at a range of 10GHz under microwave X-band bandwidth. Due to non-contact level measurement, these level transmitters have found their place in industries like mining, boiler technologies, paper and pulp industries, etc. How do these transmitters work? Why they have gained prominence in various industries? This is a two-part blog answer everything that you would like to know about these transmitters. Radar Level Transmitter Setup Instead of directly jumping to the working principle of radar level transmitters, it is important to understand the set up first. Let us discuss the components and assembly setup of a radar level transmitter. The setup of radar lever transmitters is not complex rather easy to understand. It only features three fundamental components, which are as discussed below. Solid-state Oscillator: A solid-state oscillator functions as an electromagnetic signal transmitter. The solid-state oscillator sends out electromagnetic waves in the direction of fluid surface in order to measure the depth or level of fluid without any physical contact. A radar Antenna: The radar antenna in this system works as a transducer between the empty space in the fluid container and the electromagnetic signal sources or receivers. The antenna receives the process signals and transfers them to the receiver. Receiver and Signal Processor System: The receiver is a hardware microprocessor that converts the received signal into a reading. The signal processor performs the computer data conversion to digital readings. Along with these three fundamental setup components of the radar level transmitters, the setup wizard is offered with advanced systems. This setup wizard support acts as a software interface to the transmitter operation. It makes the remote operation possible. The working of radar level transmitters is based on these three setup components. Working Principle of Radar Level Transmitters The working principle of radar fluid lever transmitters is a function of Time Domain Reflectometry (TDR). It is also known as the Time of Flight (TOF) radar measuring principle. However, the step-by-step description of the radar level detectors working principle is as follows. Since these transmitters are used as level sensors itself, it can be said that the electromagnetic signals are sent from the sensor. The solid-state oscillator that is installed in radar level sensor setup oscillates electromagnetic waves to the fluid surface. The distance can be measured considering oscillator as a reference point and fluid surface as the destination. Once electromagnetic waves hit a fluid surface, the surface itself reflects a pulsating signal to the radar antenna. The antenna transmits the signal to the receiver. As the receiver collects the signal returning pulse reflection, the time taken for reflection is calculated. The time to level calculation is performed by the signal processor. Once the signal processor translates reflection time into distance traveled that is considered as the depth of the fluid according to Time Domain Reflectometry. This is the overall working principle of radar level detector sensors but the factors like Dielectric Constant (DC) of the fluid impact on the working efficiency of the sensor. The pulse reflection is highly impacted by dialectic constant as high DC pulsates strong reflections where low DC fluid absorbs most signals. Factors Affecting Accuracy: While radar level transmitters are highly accurate, several factors influence their performance: Dielectric Constant (DC): Fluids with high DC produce strong signal reflections, while low DC media absorb more energy, weakening the return signal. Surface Turbulence: Excessive agitation or foam can scatter the radar waves. Obstructions or Vessels Geometry: Internal fittings or narrow tanks can lead to signal deflections, which may require tuning or use of guided wave radar level sensors. Modern radar devices like the VEGA radar level transmitter are equipped to handle such complexities with adaptive signal processing and advanced diagnostics. Benefits of Using Radar Level Sensors: Non-contact measurement eliminates wear and tear. High accuracy and repeatability. Suitable for extreme temperatures and pressures. Resistant to steam, dust, and vapors. Flexible options including guided wave radar, open-air radar, and VEGA radar level transmitters for specific needs. Radar level transmitters, including guided wave radar level sensors, offer a powerful solution for non-contact and highly accurate level measurement. With models tailored for every environmentfrom basic tanks to aggressive chemical applicationsradar technology remains a cornerstone in modern industrial instrumentation. For reliable, industry-standard instrumentation including VEGA radar level transmitters and other top brands, explore our inventory at The Transmitter Shop (TTS)where precision meets performance. Frequently Asked Questions (FAQ): What is a radar level sensor? A radar level sensor is a device that uses microwave radar signals to determine the distance to a fluid or solid surface inside a container or tank, helping calculate its level. How does a radar sensor work? It works by transmitting microwave signals toward the measured surface and receiving the reflected signals. The time taken for the signals to travel to the surface and back is used to compute the level. How accurate is the radar level transmitter? Most radar level transmitters provide millimeter-level accuracy. Advanced models like the guided wave radar level transmitter or VEGA radar level transmitter offer even better precision under complex conditions. How accurate is radar when the cop is moving? This question relates to radar speed guns used by law enforcement, not industrial level sensors. Moving radar guns adjust readings using Doppler shift but may require calibration to ensure accuracy. How often do cops have to calibrate the radar gun? Radar guns used by police departments are typically calibrated every 612 months, depending on state regulations and usage, to ensure legal accuracy. Industrial radar level sensors also require periodic validation but not as frequently. Related Posts Guided wave radar (GWR) technology is based on the Time Domain Reflectometry (TDR) principle. Low power nanosecondpulses are guided along with a probe submerged in the process media. When a pulse reaches the surface of the material it is measuring, part of the energy is reflected back to the transmitter, and the time difference between the generated and reflected pulse is converted into a distance from which the total level or interface level is calculated. The speed of travel of the pulse is impacted by the dielectric of the medium. This change in travel time is predictable and allows compensation for the measurement to be accomplished. The reflectivity of the product is a key parameter for measurement performance. A high dielectric constant (DC) of the media gives a better reflection and a longer measuring range.Figure 1: GWR Typical interface level reflection When an interface level of two immiscible layers should be measured, the first fluid should have a lower dielectric. The reflection from this first low dielectric fluid is weak. This permits the rest of the signal to detect the interface between these two fluids. Less than 5% of the signal is reflected back to the transmitter for a fluid with a dielectric of 2 (e.g. oil).Interface measurement accuracy depends on the upper product dielectric and a distinct interface (low emulsion layer of few mm) between the two fluids. While guided wave radar works in many conditions, some precautions need to be taken with respect to probe choice. Several probe styles are available and the application, length, and mounting restrictions influence their choice. Unless a coaxstyle probe is used, probes should not be in direct contact with a metallic object, as that will impact the signal.If the application tends to be sticky or coat, then only single lead probes should be used. Single lead probes are preferred when there is a risk of contamination (because the coating can result in the product bridging across the two leads for twin versions or between the inner lead and outer pipe for the coaxial probes, and may cause erroneous level readings). For viscous or sticky applications, PTFE probes are recommended to facilitate product flow. Periodic cleaning may also be required. Maximum error due to coating is 110% depending on probe type, dielectric constant, coating thickness and coating height above the product surface. The presence of oilfilm on the single probe will not have any effect.Some advanced GWRs on the market have advanced diagnostics, with the ability to detect buildup on the probe. This gives an indication of how good the surface signal is compared to the noise, and when to clean the probe (predictive maintenance).GWR can be used on cryogenic applications (e.g. 196C) with the recommendation of the coaxial probe. Proper insulation may be required to reduce ice formation on the upper part (e.g. insulate the nozzle).GWR measurement in foamy applications depends on the foam properties: light and airy or dense and heavy, high or low dielectrics, etc. If the foam is conductive and dense, the transmitter may measure the surface of the foam. If the foam is less conductive, the microwaves may penetrate the foam and measure the liquid surface. This type of application should be considered on a case by case basis. Depending on foam properties, GWR may detect the foam/liquid interface or the top of the foam or the top of the liquid. GWR is not suitable for the watersand interface. Since the sand is embedded in water, which is a high dielectric media (DC = 80), the transmitter can only see the water. The same is true for all media that are dissolved in water.Differentparameters(factors)affecttheechoandthereforethemaximummeasuringrangediffers dependingonapplicationaccordingto:disturbing objects close to the probemedia with higher dielectric constant gives a better reflection and allows a longer measuring rangesurface foam and particles in the tank atmosphere may affect measuring performanceheavy coating or contamination on the probe should be avoided since it can reduce the measuring range and might cause erroneous level readings.Figure 2: GWR interface level measurementWhen the interface will be measured, the criteria according to Figure 3 should be fulfilled:Figure 3: GWR Interface measurement dielectric criteriaFigure 4: GWR Maximum dielectric constant vs technology.The maximum allowable upper product thickness/measuring range is primarily determined by the dielectric constants of the two liquids.An example of the maximum upper product thickness for the flexible single probe is presented in Figure 5. 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Care should be taken to determine the dielectric constants of the fluids being measured over their full range of possible compositions and operating conditions.The vessel internals e.g. supports and reinforcement should not be at the vicinity of the level measurement device or in the radar path.GWR requires a relatively flat fluid surface. If surface is turbulent then a Stilling Well should be considered.For long probes, the lower probe end should be fitted with an additional stainless steel cylinder with fixing eye to ensure an adequate fixing to the bottom of the vessel.GWR installed in a sensor cage or standpipe should never be in contact with the cage/standpipe internals. Centring disk may be used. The centring disk should provide isolation between the probe and the cage/standpipe internals.GWR sensor cage/stand pipe measuring range should be carefully studied. 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Radar level transmitters are a popular choice for liquid level measurement due to their high accuracy and reliability. Radar is a technology that utilizes electromagnetic waves for measurement and detection. Radar level transmitters measure the distance between the surface of a liquid and the sensor by transmitting and receiving microwave signals to determine the level of the liquid. Signal emission: the transmitter of the radar level transmitter emits microwave signals to the surface of the liquid. Signal reflection: a part of the microwave signal is reflected back by the liquid surface, the formation of the return signal. Signal reception and calculation: the receiver receives the echo signal, and calculates the time required to transmit the signal to return to the echo signal, i.e., time of flight. Level measurement: the flight time is multiplied by the speed of signal propagation (usually the speed of light) to calculate the distance between the surface of the liquid and the sensor. Level conversion: The calculated distance is converted to a level measurement and transmitted to a display or control system. Lets take an example:First, the transmitter of the radar level transmitter emits a high-frequency microwave signal. The emitted microwave signal passes through the water in the settling tank and reaches the surface of the water, part of the signal is reflected by the surface of the water and returns, and the receiver receives the signal reflected back from the surface of the water. By measuring the time between transmitting the signal and receiving the reflected signal (time of flight), the radar level transmitter calculates the distance between the water surface and the sensor. The calculated distance value is converted into a level measurement and transmitted to a display or monitoring system. Schematic diagram of the operating principle of guided wave radar level transmitter Key points in the operational process: Continuous monitoring: The radar level transmitter continuously sends and receives signals to ensure real-time monitoring of the liquid level in the settling tank. Level change analysis: By monitoring changes in liquid level, it is possible to understand the progress of the settling process and wastewater treatment, so that appropriate measures can be taken to adjust the treatment process. Reflection and interference problems: It is necessary to pay attention to the reflection of the signal on the surface of the liquid, while avoiding the interference of the signal by factors such as air bubbles, foam or turbidity of the sewage. Advantages and Cautions: High accuracy measurement: Radar technology can provide high accuracy level measurement and maintain accuracy even in harsh environments. Environmental adaptability: Able to cope with different effluent characteristics, but need to pay attention to possible reflection and interference problems during signal propagation to ensure the accuracy of measurement. There are different types of radar level transmitters, each of which may have a slightly different principle of operation. Below are a few common types of radar level transmitters and their main working principles: Pulse radar: Transmits a microwave signal in short pulses and measures the time of flight of the signal to determine the liquid level. It is suitable for a wide range of media and industrial environments because of its short operating time. Continuous wave radar: continuously emits microwave signals to identify liquid levels by frequency or phase changes. Suitable for high-precision measurements and interference-prone environments. Non-contact radar: the use of FM continuous wave technology, can be in the liquid surface of different dielectric constant to provide more accurate measurement, suitable for a variety of media and harsh environments. Leaky wave radar(guided wave radar level transmitter): Measures liquid level by introducing a microwave signal into a waveguide tube and allowing it to interact with the medium. Suitable for applications with small level variations. Each type of radar level transmitter differs slightly in principle and application, but all are based on radar technology, which utilizes the reflection of a microwave signal against the surface of a liquid to measure the level. Selection of the right type for a particular application depends on factors such as media properties, measurement requirements and environmental conditions. Radar level transmitters are commonly used in a variety of industrial scenarios where accurate measurement of liquid levels is required, including but not limited to the following areas: Chemical plants and process installations: Used to monitor the level of chemicals in storage tanks, reactors, tanks or pipelines. Oil and gas industry: Used for level monitoring in tanks, storage tanks, pipelines, etc., to help control the storage, transportation and handling of oil and liquid gases. Water and wastewater treatment: In wastewater treatment plants, it is used to monitor the level of sewage tanks, sedimentation tanks, water tanks and so on. Food and beverage industry: for monitoring the level of tanks or troughs in food production, such as the storage of raw materials in brewing, dairy or beverage production. Energy production and power plants: for monitoring the level of fuel storage tanks, cooling pools, etc.. Pharmaceutical industry: for pharmaceutical equipment in the liquid storage tanks or reactor level monitoring. Radar level transmitters utilize microwave signals to accurately measure liquid levels and determine the distance between the liquid and the sensor by calculating the signals time of flight. Although reliable, attention should be paid to the effects of signal reflection and external interference on accuracy. Overall, it provides a reliable technical solution for industrial monitoring and control with high accuracy and stability. Apure offers level transmitters in addition to water quality analyzers, flow measurement, pressure measurement, temperature measurement and ozone generators. Guided wave radar (GWR) technology is based on the Time Domain Reflectometry (TDR) principle. Low power nanosecondpulses are guided along with a probe submerged in the process media. When a pulse reaches the surface of the material it is measuring, part of the energy is reflected back to the transmitter, and the time difference between the generated and reflected pulse is converted into a distance from which the total level or interface level is calculated. The speed of travel of the pulse is impacted by the dielectric of the medium. This change in travel time is predictable and allows compensation for the measurement to be accomplished. The reflectivity of the product is a key parameter for measurement performance. A high dielectric constant (DC) of the media gives a better reflection and a longer measuring range.Figure 1: GWR Typical interface level reflection When an interface level of two immiscible layers should be measured, the first fluid should have a lower dielectric. The reflection from this first low dielectric fluid is weak. This permits the rest of the signal to detect the interface between these two fluids. 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When a pulse reaches the surface of the material it is measuring, part of the energy is reflected back to the transmitter, and the time difference between the generated and reflected pulse is converted into a distance from which the total level or interface level is calculated. The speed of travel of the pulse is impacted by the dielectric of the medium. This change in travel time is predictable and allows compensation for the measurement to be accomplished. The reflectivity of the product is a key parameter for measurement performance. A high dielectric constant (DC) of the media gives a better reflection and a longer measuring range.Figure 1: GWR Typical interface level reflection When an interface level of two immiscible layers should be measured, the first fluid should have a lower dielectric. The reflection from this first low dielectric fluid is weak. This permits the rest of the signal to detect the interface between these two fluids. Less than 5% of the signal is reflected back to the transmitter for a fluid with a dielectric of 2 (e.g. oil).Interface measurement accuracy depends on the upper product dielectric and a distinct interface (low emulsion layer of few mm) between the two fluids. While guided wave radar works in many conditions, some precautions need to be taken with respect to probe choice. Several probe styles are available and the application, length, and mounting restrictions influence their choice. Unless a coaxstyle probe is used, probes should not be in direct contact with a metallic object, as that will impact the signal.If the application tends to be sticky or coat, then only single lead probes should be used. Single lead probes are preferred when there is a risk of contamination (because the coating can result in the product bridging across the two leads for twin versions or between the inner lead and outer pipe for the coaxial probes, and may cause erroneous level readings). For viscous or sticky applications, PTFE probes are recommended to facilitate product flow. Periodic cleaning may also be required. Maximum error due to coating is 110% depending on probe type, dielectric constant, coating thickness and coating height above the product surface. The presence of oilfilm on the single probe will not have any effect.Some advanced GWRs on the market have advanced diagnostics, with the ability to detect buildup on the probe. This gives an indication of how good the surface signal is compared to the noise, and when to clean the probe (predictive maintenance).GWR can be used on cryogenic applications (e.g. 196C) with the recommendation of the coaxial probe. Proper insulation may be required to reduce ice formation on the upper part (e.g. insulate the nozzle).GWR measurement in foamy applications depends on the foam properties: light and airy or dense and heavy, high or low dielectrics, etc. If the foam is conductive and dense, the transmitter may measure the surface of the foam. If the foam is less conductive, the microwaves may penetrate the foam and measure the liquid surface. This type of application should be considered on a case by case basis. Depending on foam properties, GWR may detect the foam/liquid interface or the top of the foam or the top of the liquid. GWR is not suitable for the watersand interface. Since the sand is embedded in water, which is a high dielectric media (DC = 80), the transmitter can only see the water. The same is true for all media that are dissolved in water.Differentparameters(factors)affecttheechoandthereforethemaximummeasuringrangediffers dependingonapplicationaccordingto:disturbing objects close to the probemedia with higher dielectric constant gives a better reflection and allows a longer measuring rangesurface foam and particles in the tank atmosphere may affect measuring performanceheavy coating or contamination on the probe should be avoided since it can reduce the measuring range and might cause erroneous level readings.Figure 2: GWR interface level measurementWhen the interface will be measured, the criteria according to Figure 3 should be fulfilled:Figure 3: GWR Interface measurement dielectric criteriaFigure 4: GWR Maximum dielectric constant vs technology.The maximum allowable upper product thickness/measuring range is primarily determined by the dielectric constants of the two liquids.An example of the maximum upper product thickness for the flexible single probe is presented in Figure 5. However, characteristics can vary between the different applications.Figure 5: GWR Maximum upper product thickness Emulsions/foam above a few centimeters disrupt the interface measurement. The results vary with the fluid mix. In many cases, the interface is measured at the top of the emulsion layer.Emulsion layers above a few centimeters cannot be measured with the GWR principle. This is due to the emulsion dielectric stochastic repartition and the emulsion bubble composition. If the emulsion layer is greater than a few centimeters only the top of the upper layer can be detected.Sometimes emulsion can be formed of a mixture of fine solids combined with emulsified oil and water, sometimes including multiple components. Stable liquid emulsion and solid particles trigger rapid emulsion layer growth.The more particles are present, the larger such an emulsion is. Although applications with emulsions are difficult for GWR measurement, the usage of a stilling well can help to achieve better product separation and therefore more accurate measurements.Figure 6: GWR interface measurement in the vessel with emulsion GWR provides accurate and reliable interface measurements and can be used in a wide variety of applications. It is a topdown, direct measurement as it measures the distance to the product surface.GWR should be considered for clean liquidliquid interface and/or clean liquidgas interface.GWR interface measurement with emulsion, foam, fluid buildup or crystallization is not possible (deposit causes false reading).GWR level instrument accuracy is a function of the liquid dielectric constant. 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