Natural Gas Process Control

A practical guide to natural gas process control, covering the reader intent, the relationship to natural gas process control, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next step.

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In the upstream, midstream, and downstream sectors of the energy industry, natural gas process control is a fundamental requirement for ensuring operational safety, environmental compliance, and economic efficiency. The processing of natural gas involves the removal of impurities such as water, hydrogen sulfide, and carbon dioxide, as well as the separation of heavier hydrocarbons. Throughout these stages, precise level measurement of liquids—including condensates, glycol, amine, and produced water—is critical.

Welk provides a comprehensive suite of industrial level measurement instruments designed to withstand the high pressures and hazardous environments typical of natural gas facilities. By understanding the underlying physics of measurement and the specific demands of the process, engineers can select the most reliable instrumentation for their control loops.

Measurement Principles and Technologies

Effective natural gas process control relies on various physical principles to determine fluid levels within pressurized vessels and storage tanks. The following technologies are standard in the industry.

Radar Level Measurement (Non-Contact and Guided Wave)

Radar technology is widely considered the gold standard for natural gas applications due to its high accuracy and lack of moving parts.

Non-Contact Radar: These instruments emit high-frequency microwave pulses (typically 26 GHz or 80 GHz). The sensor measures the Time of Flight (ToF) between the emission of the pulse and the receipt of the reflection from the liquid surface. Because microwaves travel at the speed of light and are largely unaffected by the gas composition, pressure, or temperature in the vapor space, they are ideal for volatile natural gas liquids.

Guided Wave Radar (GWR): GWR uses a physical probe (rod or cable) to guide the microwave pulse to the liquid surface. This is particularly effective for fluids with low dielectric constants, such as liquefied petroleum gas (LPG) or light condensates, as the probe concentrates the energy, ensuring a stronger return signal. GWR is also the preferred method for interface measurement, such as detecting the boundary between oil and water in a separator.

Ultrasonic Level Sensors

Ultrasonic sensors function similarly to radar but use sound waves instead of electromagnetic waves. The transducer emits an ultrasonic pulse that reflects off the surface of the medium. The distance is calculated based on the speed of sound. However, in natural gas process control, ultrasonic sensors are generally limited to low-pressure storage or water treatment applications, as changes in gas density and high pressure significantly alter the speed of sound, leading to measurement errors.

Hydrostatic Level Transmitters

Hydrostatic measurement determines the level by measuring the pressure exerted by the liquid column at the bottom of the tank. The formula used is $P = \rho \cdot g \cdot h$, where P is pressure, ρ is the density of the fluid, g is gravity, and h is the height of the liquid. In pressurized natural gas vessels, a differential pressure (DP) transmitter is required to compensate for the gas pressure above the liquid. This method is highly reliable but requires accurate knowledge of the fluid's density.

Magnetic Level Gauges (MLG)

An MLG consists of a bypass chamber mounted to the side of the vessel. A float containing a permanent magnet moves with the liquid level, flipping magnetized flaps on an external scale to provide a visual indication. For automation, a magnetostrictive transmitter can be attached to the chamber to provide a 4-20mA or digital signal. MLGs are favored for their robustness and the fact that they provide a mechanical backup to electronic systems.

Selecting Instruments for Natural Gas Applications

Choosing the right instrument for natural gas process control requires an evaluation of the process conditions, including pressure, temperature, and the chemical properties of the media. The following table provides a general selection guide for common gas processing tasks.

Application	Recommended Technology	Pressure Range	Key Advantage
High-Pressure Separators	Guided Wave Radar	Up to 40 MPa	Excellent interface measurement (Oil/Water)
Condensate Storage	Non-Contact Radar (80 GHz)	0 - 2 MPa	High precision, no contact with media
Glycol/Amine Tanks	Hydrostatic / GWR	0 - 5 MPa	Reliable in foaming conditions
LPG/LNG Storage	Guided Wave Radar	Up to 10 MPa	Works with low dielectric constant fluids
Scrubber Boots	Magnetic Level Gauges	Up to 25 MPa	Visual confirmation + remote transmission
Overfill Protection	Vibrating Level Switches	N/A	Independent safety redundant system

For more detailed specifications on these technologies, engineers can Review product options and application support on our main page to find the exact configuration for their specific site requirements.

Key Application Points in the Process Chain

Natural gas process control is not a monolithic task; it involves several distinct units, each with unique level measurement challenges.

1. Inlet Separators and Scrubbers

At the entrance of a processing plant, inlet separators remove bulk liquids (water and hydrocarbons) from the gas stream. Maintaining the liquid level in the "boot" of the separator is critical to prevent liquid carryover into compressors or downstream units. Guided Wave Radar is often used here because it can distinguish between the aqueous and organic phases (interface measurement) even under high pressure.

2. Dehydration Units (Glycol Contactor)

Natural gas must be dehydrated to prevent hydrate formation and corrosion. This is typically done using Triethylene Glycol (TEG). Level control in the contactor tower and the flash tank is essential for the glycol regeneration process. Because glycol can foam, non-contact radar or GWR with foam-handling algorithms is preferred over ultrasonic or buoyancy-based methods.

3. Gas Sweetening (Amine Units)

Amine units remove $H2S$ and $CO2$. Like glycol units, amine systems are prone to foaming and involve corrosive fluids. Level transmitters must be constructed from compatible materials (e.g., 316L Stainless Steel or Hastelloy) and provide stable readings despite the presence of vapors.

4. Fractionation Columns

In the NGL (Natural Gas Liquids) recovery stage, fractionation columns separate ethane, propane, and butane. These processes operate at cryogenic temperatures or high pressures. Level instruments must be rated for these extremes, often requiring specialized insulation or remote seals for hydrostatic transmitters.

Installation and Engineering Best Practices

Correct installation is as important as technology selection in natural gas process control. Poorly installed sensors can lead to signal loss or mechanical failure.

Nozzle Geometry: For non-contact radar, the nozzle height and diameter must be considered to avoid internal reflections. 80 GHz radars are more forgiving due to their narrow beam angle, but standard engineering practices still apply.

Stilling Wells: In vessels with heavy turbulence or internal obstructions (like heating coils), installing a radar or float-based instrument inside a stilling well or bypass pipe can stabilize the measurement.

Hazardous Area Certification: Natural gas facilities are classified as hazardous zones. All level instruments must carry appropriate certifications, such as ATEX, IECEx, or UL/CSA (Explosion-proof or Intrinsically Safe), depending on the region.

Grounding and Lightning Protection: Since many natural gas storage tanks are located outdoors in remote areas, proper electrical grounding is essential to protect the electronics from static discharge and lightning strikes.

Venting and Equalization: For hydrostatic and magnetic level gauges, ensuring that the vapor space is properly equalized to the transmitter or gauge chamber is vital for accuracy in pressurized systems.

Technical Challenges and Limitations

While modern instrumentation is highly advanced, certain factors can still limit the effectiveness of natural gas process control systems.

1. Low Dielectric Constants: Natural gas liquids (NGLs) often have low dielectric constants ($\varepsilon r < 2.0$). This reduces the amount of energy reflected back to a radar sensor. In these cases, GWR or high-sensitivity non-contact radar is mandatory.

2. Heavy Foaming: In amine and glycol units, foam can absorb radar signals or create false levels for ultrasonic sensors. Using GWR with specialized software or magnetic gauges can mitigate this.

3. High-Pressure Vapor Phases: At very high pressures, the density of the gas phase can increase significantly, potentially slowing down the speed of radar pulses (the "gas phase effect"). High-end radar units include compensation features for this phenomenon.

4. Paraffin and Scale Buildup: In upstream applications, crude oil and gas condensates can leave paraffin deposits on probes. Magnetic level gauges with oversized chambers or non-contact radar are less susceptible to these issues than displacement-based floats.

Frequently Asked Questions (FAQs)

Q: Why is 80 GHz radar preferred over 26 GHz for natural gas tanks?

A: 80 GHz radar has a much narrower beam angle (typically 3 to 4 degrees), which allows it to avoid reflections from internal tank structures like ladders or agitators. It also offers better resolution, which is helpful when measuring through narrow nozzles.

Q: Can I use a single GWR probe to measure both total level and interface?

A: Yes, Guided Wave Radar is capable of detecting both the upper liquid surface and the interface between two liquids (e.g., oil and water), provided the upper liquid has a lower dielectric constant than the lower liquid and the layer is thick enough for the instrument to resolve.

Q: How do I handle level measurement in cryogenic LNG storage?

A: LNG storage requires specialized materials that can withstand temperatures as low as -162°C. Non-contact radar is often used because the electronics can be isolated from the extreme cold, or GWR with specialized cryogenic seals and extensions.

Q: What maintenance is required for Magnetic Level Gauges?

A: MLGs are relatively low-maintenance. Periodic checks include ensuring the float moves freely and cleaning the chamber if the process media is prone to scaling or solids deposition. If a transmitter is attached, its calibration should be verified annually.

Q: Are hydrostatic transmitters suitable for tanks with changing gas composition?

A: If the gas pressure is high and the composition changes frequently, the density of the gas phase might change, affecting a standard DP (Differential Pressure) setup. In such cases, radar is often a more stable choice as it is less dependent on fluid and gas density.

For engineers designing or upgrading natural gas process control systems, the selection of level instrumentation must be based on a rigorous assessment of the physical environment. Welk continues to innovate in this field, providing the accuracy and reliability required for the modern energy landscape. For further technical data and selection tools, visit our Main Page to explore our full range of industrial level measurement solutions.