

Decarbonization Process

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



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The global industrial sector is undergoing a fundamental transformation as it adopts the decarbonization process to meet net-zero emissions targets. This transition involves the integration of Carbon Capture, Utilization, and Storage (CCUS), the production of green hydrogen through electrolysis, and the optimization of energy-intensive chemical processes. In each of these stages, precise level measurement is not merely a monitoring requirement but a critical safety and efficiency parameter.

Reliable level instrumentation ensures that solvents in carbon scrubbers are maintained at optimal heights, prevents overfilling in high-pressure CO₂ storage tanks, and manages the delicate balance of fluids in hydrogen separators. This article provides a technical overview of how different level measurement technologies support the decarbonization process, the principles behind their operation, and the engineering considerations necessary for successful deployment.

Core Measurement Principles in Industrial Level Control

Before selecting a device for a decarbonization application, it is essential to understand the underlying physics of the primary measurement technologies. Each method interacts differently with the process media, temperature, and pressure.

Radar Level Measurement (Non-Contact and Guided Wave)

Radar technology relies on the emission of electromagnetic pulses (usually in the microwave spectrum). In non-contact radar, the sensor emits a signal that reflects off the surface of the liquid and returns to the sensor. The time-of-flight (ToF) or frequency shift is used to calculate the distance. Guided Wave Radar (GWR) utilizes a physical probe to direct the signal, making it highly effective in low-dielectric liquids or applications with heavy steam and turbulence.

| Ultrasonic Level Sensors

Ultrasonic sensors function similarly to radar but use sound waves instead of electromagnetic waves. The sensor emits high-frequency sound pulses that bounce off the material surface. Because sound requires a medium to travel, ultrasonic sensors are sensitive to air temperature, pressure changes, and the presence of heavy vapors or foam, which can attenuate the signal.

| Hydrostatic Level Transmitters

Hydrostatic measurement is based on the principle that the pressure at the bottom of a vessel is directly proportional to the height of the liquid column above it. 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. This method is highly reliable for atmospheric tanks but requires differential pressure (DP) setups for pressurized vessels.

| Magnetic Level Gauges

Magnetic level gauges utilize a float containing a permanent magnet that moves with the liquid level inside a bypass chamber. As the float rises or falls, it flips magnetic flags or activates a reed chain transmitter on the exterior of the chamber. This provides both a local visual indication and a remote electronic signal without the process media ever touching the electronic components.

| Role of Instrumentation in the Decarbonization Process

The decarbonization process typically involves several distinct stages where level control is vital for process stability.

| Carbon Capture and Solvent Management

In post-combustion carbon capture, flue gases are passed through an absorber column containing chemical solvents, such as amines. These solvents react with CO₂ to remove it from the gas stream. Level meters are required to manage the inventory of the lean and rich solvent tanks. Because amine solutions can foam and produce vapors, non-contact radar or GWR with specialized algorithms are often preferred to ensure the signal is not lost in the foam layer.

| CO₂ Liquefaction and Storage

Once captured, CO₂ must be compressed and liquefied for transport or sequestration. This happens at high pressures (often exceeding 50 bar) and low temperatures. Level measurement in these tanks is challenging due to the rapid phase changes of CO₂. Magnetic level gauges are frequently used here because they can withstand high-pressure ratings while providing a clear visual reference for operators in the field.

| Green Hydrogen Electrolysis

Green hydrogen is produced by splitting water into hydrogen and oxygen using renewable electricity. This process occurs in electrolyzers where the level of the electrolyte (often a potassium hydroxide solution) must be strictly controlled to prevent gas mixing, which could lead to explosive atmospheres. Small-form-factor radar sensors or hydrostatic transmitters with chemical-resistant diaphragms are standard in these compact, high-pressure environments.

| Technical Selection Criteria

When evaluating instrumentation for a decarbonization process project, engineers must consider several variables to ensure long-term reliability. For a comprehensive overview of available instrumentation, engineers can visit the [Main Page](#) to review product options and application support.

Criteria	Radar (FMCW)	Ultrasonic	Hydrostatic	Magnetic Gauge
Pressure Range	Up to 160 bar+	Up to 3 bar	Up to 400 bar	Up to 250 bar
Temperature Range	-196°C to +450°C	-40°C to +80°C	-40°C to +120°C	-196°C to +400°C
Accuracy	±1 mm to ±5 mm	±0.25% of range	±0.1% to ±0.5%	±5 mm to ±10 mm
Media Type	Liquids/Solids	Liquids	Liquids	Liquids
Foam Resistance	Excellent (GWR)	Poor	Good	Excellent
Corrosive Media	Excellent (PTFE)	Good (Plastic)	Depends on Diaphragm	Excellent (Alloy)

Installation Considerations and Best Practices

Proper installation is as critical as device selection in the decarbonization process. Failure to account for vessel geometry or internal obstructions can lead to false readings and process downtime.

- Nozzle Positioning:** For radar and ultrasonic sensors, the device should be mounted away from the tank wall to avoid side-wall reflections. Typically, a distance of 1/6th of the tank diameter is recommended.
- Stilling Wells:** In tanks with heavy agitation, turbulence, or foaming (common in carbon capture scrubbers), installing the sensor inside a stilling well or bypass pipe can provide a calm surface for more accurate measurement.
- Vapor Compensation:** In high-pressure CO2 or hydrogen applications, the gas phase density can change significantly. For ultrasonic sensors, this can alter the speed of sound, requiring temperature and pressure compensation. Radar is generally unaffected by gas density changes unless the pressure is extremely high.
- Material Compatibility:** Decarbonization often involves aggressive chemicals like amines or concentrated electrolytes. Wetted parts should be constructed from 316L stainless steel, Hastelloy, or coated with PTFE/PFA to prevent corrosion.

| Limitations and Common Risks

While modern level meters are highly advanced, they are not universal solutions. Engineers should be aware of the following limitations:

Dielectric Constant (ϵ_r): Radar relies on the dielectric constant of the liquid. Very low ϵ_r fluids (like some liquefied gases) reflect less energy, which may require the use of a GWR or a stilling well to concentrate the signal.

Scaling and Build-up: In carbon capture processes, solvents can sometimes crystallize or leave deposits on probes. Non-contact radar is advantageous here as it does not touch the media, reducing maintenance requirements.

Hydrogen Permeation: Hydrogen molecules are small enough to permeate through standard metal diaphragms in hydrostatic sensors. For hydrogen service, gold-plated diaphragms are often required to prevent hydrogen embrittlement and sensor drift.

| Frequently Asked Questions (FAQ)

Q: Why is radar preferred over ultrasonic for carbon capture tanks?

A: Carbon capture often involves amine solvents that produce vapors and foam. Radar (especially FMCW or GWR) can penetrate these vapors and ignore light foam, whereas ultrasonic signals are often scattered or absorbed, leading to "lost echo" errors.

Q: Can hydrostatic sensors be used in pressurized CO₂ tanks?

A: Yes, but a single-ended pressure sensor will only measure the head pressure plus the liquid weight. For pressurized tanks, a differential pressure (DP) transmitter or two synchronized hydrostatic sensors are required to cancel out the overhead gas pressure.

Q: What is the maintenance cycle for a magnetic level gauge in a decarbonization plant?

A: Magnetic gauges are low-maintenance because the electronics are isolated. However, the bypass chamber should be flushed periodically to prevent the accumulation of sediment or magnetic particles that could trap the float.

Q: How does the decarbonization process impact sensor life?

A: The primary impact is through chemical exposure and extreme temperatures. Using high-grade alloys and non-contact measurement methods can extend the service life of instruments to 10-15 years, even in harsh CCUS environments.

| Conclusion

Successfully implementing a decarbonization process requires a granular understanding of fluid dynamics and chemical interactions within the system. Level measurement serves as the eyes of the operation, providing the data necessary to optimize carbon uptake and ensure the safe storage of gases. By selecting the appropriate technology—whether it be the versatility of radar, the robustness of magnetic gauges, or the simplicity of hydrostatic transmitters—industrial operators can ensure their path to net-zero is both safe and efficient.