BEYOND CAPTURE AND STORAGE

Garry Hanmer, Principal Simulation Consultant, Atmos International, UK, considers why ISO 27913 makes pipelines the critical link in CCUS.

Carbon capture and storage (CCS) is widely recognised as a key technology for reducing CO_2 emissions to the atmosphere. Yet while capture and storage often dominate the conversation, the latest version of ISO 27913 (second edition, corrected version September 2025) makes something clear. Pipelines are likely to be the primary means of transporting CO_2 from capture sites to storage or utilisation points.

Transport is not simply a connecting step; it allows carbon capture, utilisation, and storage (CCUS) to function as an integrated value chain. Without reliable, compliant pipeline transportation, captured CO_2 cannot reach its destination safely or at scale.

ISO 27913 exists because transporting CO_2 at scale is not the same as transporting hydrocarbons. There is significantly less industry experience in CO_2 service than in natural gas service, and CO_2 presents specific technical issues that must be managed to ensure safe and reliable operation.

A standard that supplements, not replaces

ISO 27913 is not a standalone pipeline code. It supplements existing standards such as ISO 13623, ASME B31.4, ASME B31.8, and EN 1594. Its purpose is to address CO_2-specific issues that are not adequately covered elsewhere, including fracture arrest and internal corrosion protection.

The scope of the standard is broad. It applies to rigid metallic pipelines, onshore and offshore systems, conversion of existing pipelines to CO_2 service, and transportation in both gaseous and dense phases. It also includes CO_2 stream quality assurance, converging streams from multiple sources, and health, safety and environmental aspects specific to CO_2 transport and monitoring.

The system boundary is clearly defined. Transportation begins at the pipeline inlet valve where composition, temperature, and pressure meet the specified requirements, and ends where the CO_2 leaves the transportation infrastructure and enters storage or utilisation facilities.

This clarity reinforces the role of transport as a distinct and accountable segment of the CCUS value chain.

CO_2 is not just another fluid

Pure CO_2 does not cause internal corrosion. However, transported CO_2 is rarely pure.

Impurities can alter thermodynamic behaviour and bubble point pressure. They can also react to form acidic aqueous phases, leading to corrosion or solid deposition.

The standard requires a clear CO_2 stream specification agreed between producer, transport entity and storage or utilisation operator. Industry practice is recognised as greater than 95 mol% CO_2, with combined non-condensables less than 5 mol%.

The process design must ensure that hydrates or aqueous phases are never present during any operational scenario, including transient operations such as depressurisation or restart. For dense phase transport, minimum operating pressure must remain above the bubble point pressure within the operating envelope.

These requirements elevate transport from a mechanical exercise to a fluid behaviour management challenge.

Managing corrosion and hydrates

Dehydration is identified as the primary control against internal corrosion. The maximum water content must be selected so that aqueous phase formation, hydrate formation and corrosion do not occur within design margins.

Continuous monitoring is required. Pressure, temperature, and water content should be measured continuously, with valid calibration certificates and calibration that reflects the specific CO_2 composition.

Measurement goes further. CO_2 mass flow and composition must be measured in single phase conditions to avoid significant uncertainty. Monitoring data should be available to both producer and pipeline operator, with records retained for trend analysis and auditing.

Transport integrity is therefore inseparable from measurement integrity.

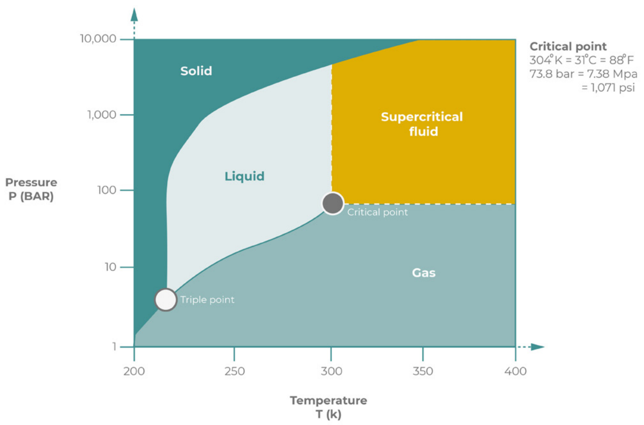

Figure 1. The phase diagram illustrates how the state of CO_2 changes with variations in temperature and pressure.

Reliability, safety, and integrity

ISO 27913 requires that reliability and availability be considered across the entire process from production to storage. Components are interdependent, and redundancy or diversity may be needed to maximise operational availability and avoid deferred injection.

Safety philosophy may be risk-based or deterministic depending on jurisdiction, but designers are directed to existing pipeline standards for risk assessment and hazard identification. Incident data from hydrocarbon pipelines may not accurately reflect CO_2 service and should be used with caution.

For internal failure mechanisms such as corrosion, failure statistics should only be applied where adequate control prevents the formation of aqueous phases.

The message is consistent. CO_2 transport demands its own integrity framework.

Converting existing pipelines

The standard also addresses re-qualification of existing pipelines for CO_2 service. Conversion is permitted only if the pipeline is re-qualified in accordance with the document or other recognised standards.

Re-qualification should include safety reassessment, management of change, verification of materials suitability, wall thickness and fracture arrest considerations, venting and block valve arrangements, and pressure safeguarding systems.

Repurposing infrastructure can accelerate deployment. ISO 27913 ensures it is done with technical rigor and a clear understanding of CO_2-specific risks.

Transport as the enabling link

The latest version of ISO 27913 was developed to ensure safe and reliable design, construction and operation of CO_2 pipelines at large scale. It recognises that future CCUS deployment will require larger pipeline systems, potentially in densely populated areas and offshore environments.

Capture technology attracts attention and geological storage anchors long-term climate goals. Between them lies a transport system that must manage phase behaviour, impurities, corrosion, fracture control, depressurisation, measurement accuracy and system reliability.

ISO 27913 makes it clear that pipelines are not a passive conduit. They are a technically demanding, safety-critical link in the CCUS chain.

Without compliant, reliable transport, capture, and storage cannot function as an integrated system. As deployment scales, that enabling link becomes decisive.

Turning standards into operational assurance

The latest version of ISO 27913 defines what safe and reliable CO_2 pipeline transportation should look like. It sets expectations around stream specification, dehydration, impurity control, fracture management, depressurisation, monitoring and integrity management. However, compliance does not happen on paper.

Operating above bubble point pressure in dense phase transport requires continuous awareness of pressure and temperature behaviour across the network. Avoiding hydrate formation depends on verified dehydration and real-time monitoring. Managing impurities requires accurate measurement and shared visibility between stakeholders. Controlling depressurisation requires understanding transient thermal effects over time.

As CCUS networks scale, particularly where multiple sources converge into shared infrastructure, operational complexity increases. Phase behaviour, compositional variation, and interdependent equipment performance must all be managed dynamically.

This is where advanced monitoring, transient simulation and leak detection systems become part of the integrity framework.

Real-time pipeline monitoring supports early detection of anomalies. Hydraulic simulation enables operators to test operating envelopes before implementation. Transient modelling helps assess depressurisation strategies and phase stability. Data validation strengthens measurement confidence and regulatory reporting.

A real-time pipeline simulation system such as Atmos SIM helps operate a CO_2 pipeline safely by continuously modelling pressure, temperature, flow rate, and fluid phase along the entire line and comparing predicted behaviour with live field data. Because CO_2 is often transported in a dense or supercritical phase (see Figure 1), small deviations in pressure or temperature can trigger phase change, rapid decompression, or fracture propagation. A real-time model can detect these conditions early and alert operators before safety limits are breached. The system supports real-time leak detection by identifying subtle hydraulic imbalances, predicts the consequences of operational actions such as start-ups, shutdowns, or rate changes, and ensures the pipeline remains within its defined operating envelope. By providing early warning, real-time simulation reduces the risk of loss of containment and enables safer, more controlled operation of CO_2 pipelines.

In this context, ISO 27913 does more than define technical requirements. It elevates transport to a performance discipline that must be continuously managed.

Capture enables decarbonisation. Storage delivers permanence. But it is transport, supported by robust monitoring and integrity systems, that ensures captured CO_2 moves safely, reliably and at scale.