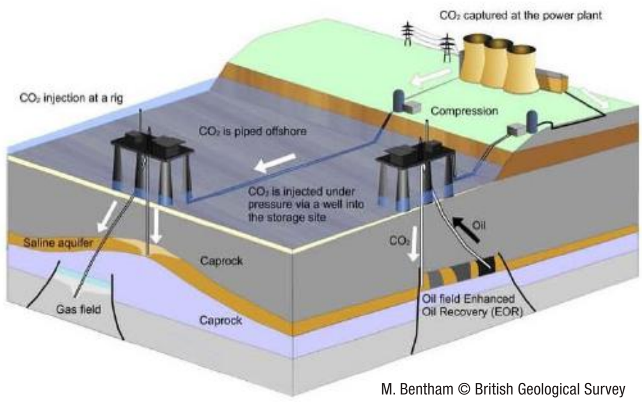
for the transport and storage of carbon dioxide (CO_2)

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Climate change due to global warming is a globally acknowledged concern. Global warming is in essence due, among other things, to carbon dioxide (CO_2), also known as a greenhouse gas. Climate policy at the international level is focused, among other things, on strategies and protective measures to reduce the production of the gas or even to prevent it altogether.

According to the International Energy Agency (IEA), Carbon Capture and Storage (CCS) is a key element of the climate protection strategy to achieve the ambitious climate protection target of reducing CO_2 by 80 to 95% in the industrialized nations by 2050. This also applies to the alternative approach of Carbon Capture and Utilization (CCU), with the use of CO_2 in chemical processes or material applications. However, it is rarely possible to store or reuse CO_2 where it arises.



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CO_2 produced in large quantities in industrial processes therefore has to be transported to large permanent storage facilities. Pipelines are the right choice for economically viable transport. And this is where our Mannesmann CO2ready® steel pipe comes into play – safely and dependably.

You can find further information on the industrial generation of CO_2 and on the technologies for its capture, storage and utilization on our website.

Product description

Our Mannesmann CO2ready® steel pipes are a high-quality product from one of the world's leading specialists in the manufacture of longitudinally HFI-welded steel pipes. In extensive trials, some of them conducted in the context of EU-funded multinational EU-wide projects, Mannesmann Line Pipe GmbH has successfully tested materials of longitudinally HFI-welded steel pipes for suitability under a wide variety of service conditions. Specifically for Mannesmann CO2ready® steel pipes, we have managed to demonstrate the safety and reliability of our product in the SARCO2 project sponsored by the European Commission – Research Fund for Coal and Steel – Requirements for safe and reliable CO2 transportation pipeline (SARCO2) – Publications Office of the EU (europa.eu).

In this project, Mannesmann Line Pipe GmbH teamed up with the renowned research institutes Salzgitter Mannesmann Forschung GmbH (Germany) and Centro Sviluppo Materiali S.p.A. (Italy, now RINA S.p.A.) to successfully test longitudinally HFI-welded steel pipes.

Corrosion tests investigated how impurities in the gas (e.g. hydrogen sulfide (H_2S), hydrogen (H_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and nitrogen (N_2)) and the parameters during transport of CO_2 mixtures affected the general and local corrosion behavior. Our pipes performed impressively across the board, provided that there was no excess water in the gas due to improper operating conditions.

Mannesmann CO2ready® pipes under scrutiny

Corrosion tests

Depending on the process involved, the quantities and types of the above-mentioned impurities in the gas can vary in the case of all CO_2 capture technologies. During the investigation, the corrosive properties under different conditions and with different gas compositions from different capture types such as oxyfuel, post-combustion or pre-combustion capture were tested for their general and local corrosion behavior. In addition to the different pressure, temperature and flow conditions, account was also taken of potential process disturbances with more critical conditions. For example, the CO_2 gas mixture may contain excessive amounts of water due to improper operating conditions. In this case, the NO_2 and SO_2 components present particularly in the oxyfuel process could shift the pH value to lower values through the formation of acid.

In the corrosion tests, Mannesmann CO2ready® pipes performed impressively across the board in terms of safety and reliability. Even the brief occurrence of free water is not a problem as long as only traces of acid-producing nitrogen dioxide and sulfur dioxide or hydrogen sulfide, which triggers hydrogen-induced corrosion mechanisms, are present in the gas.

Test setup for CO_2 corrosion tests (rotating cage) and autoclave laboratory at Salzgitter Mannesmann Forschung GmbH

Mechanical tests

When carbon dioxide is transported through a pipeline, the CO_2 is in a so-called "supercritical" state as a two-phase mixture (liquid and gas). If the pipeline cracks, this means that the pressure in the pipeline initially drops rapidly as a result of the medium escaping. The decompression rate is dramatically reduced by the conversion of the liquid CO_2 into a gas, but at the same time the internal pressure remains constant until the liquid phase is fully converted (plateau). Impurities in the CO_2 (e.g. from separation processes) further intensify this. In sum, this reduces the scope for preventing a crack from propagating along the pipe by reducing the internal pressure to below a critical threshold.

However, conventional calculation methods and models for pipeline design under internal pressure only take single-phase substances, such as natural gas, into account. Therefore, in addition to the corrosion tests, a burst test was performed on a 220 m long test pipeline in order to determine its mechanical/technological properties and behavior in the event of a CO_2 pipeline failure. This enabled the propagation of (long-running) cracks under internal pressure to be assessed for the future design of CO_2 transport lines. These mechanical/technological tests and the "full-scale" burst test successfully demonstrated the outstanding toughness and crack arrest behavior of Mannesmann CO2ready® pipes.

Burst test on a CO_2 test line. CO_2 mixture (94.0% CO_2) at 127 bar, material X65, measuring 610 x 13.7 mm, from the RFCS-funded SARCO2 project. Cracking in the steel pipe is arrested after a few meters.

Material properties

For Mannesmann CO2ready® steel pipes, it is possible to use normalized rolled N steels up to grade X52/L360 or thermomechanically rolled TM steels from grade X42M/L290M to X70M/L485M. Compared with standard-quality steel pipes, both material designs feature limited sulfur and phosphorus contents, among other things. This provides a higher degree of purity, so there are fewer points of attack for stress corrosion cracking (SCC) or hydrogen-induced corrosion (HIC, SCC) when a water-rich phase forms in the CO_2 gas (ISO27913 permits max. 200 ppm). Further details of the properties can be found in the German technical standard on HFI-welded pipes for the transport of carbon dioxide (CO_2), which we will be pleased to make available to you on request.

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