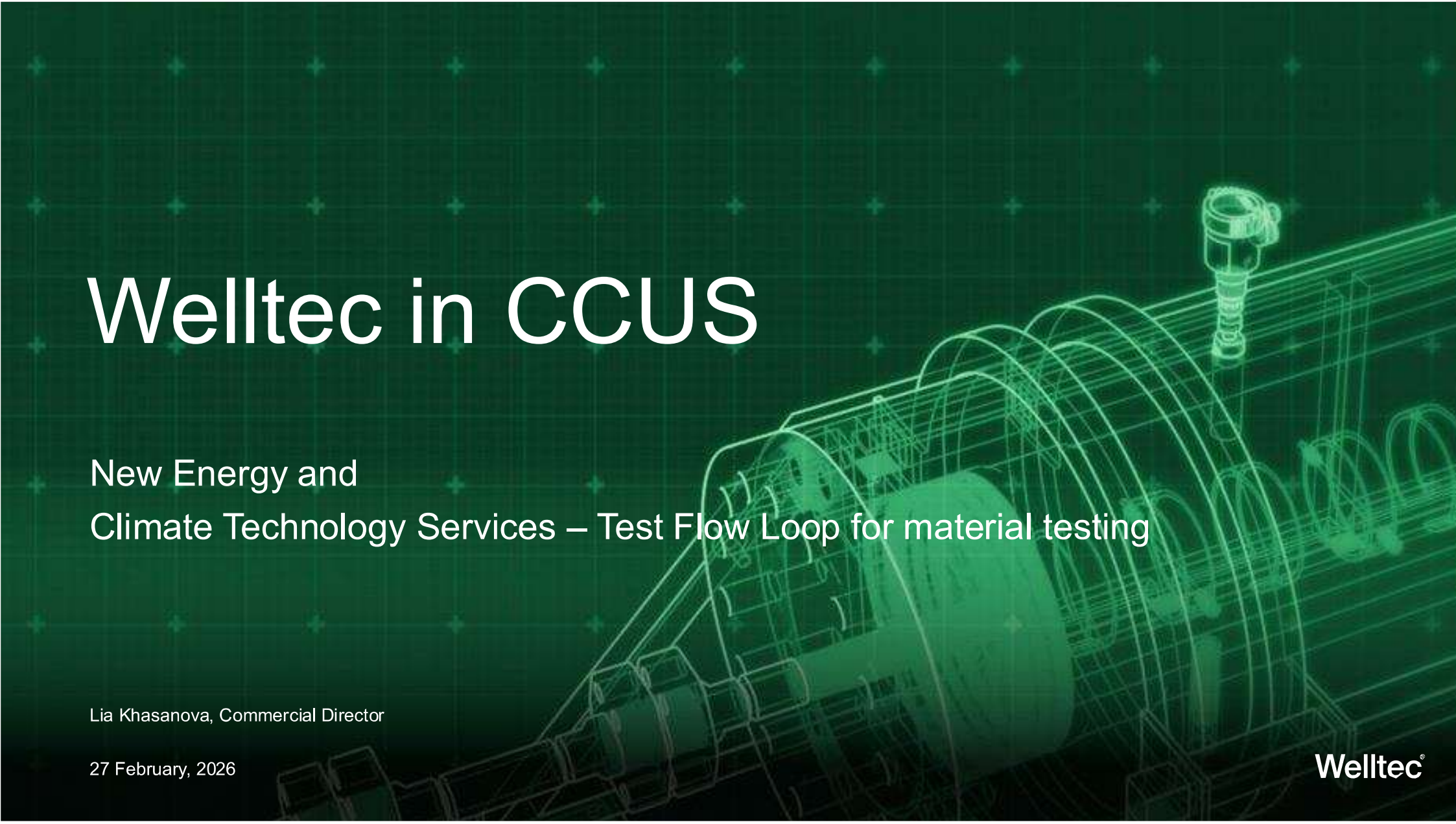
Welltec in CCUS

New Energy and
Climate Technology Services – Test Flow Loop for material testing



Lia Khasanova, Commercial Director

27 February, 2026

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Welltec overview

A truly global company servicing the energy industry with market leading technologies.

- 31 years of innovative technology development within the energy sector (164 patent families)
- HQ, Development & Engineering and in-house manufacturing at 2 locations in Denmark (Copenhagen & Esbjerg)
- 43 global offices and service facilities located in 25 countries
- >900 employees worldwide

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Welltec's current portfolio of solutions for Green Energy/CCUS

Field Engineer preparing metal expandable packer for deployment, USA land operations.

Field Engineer preparing well conveyance and fishing tools for deployments, ME land operations.

***Small-scale carbon capture** for post-combustion point-sources. Welltec's Prototype at Greenfarm's biogas plant. Gråsten Landbrugskole, Denmark*
*(**Focus: DK, NO, PL, FR, DE**)*

CCS ⟷ CCU

Welltec's testing facility for CO2 environment – Test Flow Loop. Established to start collaboration with Project Greensand, Esbjerg, DK

EUDP
SINTEF DTU
GREENFARM
AALBORG UNIVERSITET
ESBJERG HAVN
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How it started…

Welltec became partner in Project Greensand, DK and established its clear presence in the CCS market by becoming a recognised service provider within testing services

- Welltec is a partner in Project Greensand consortium since 2021 with focus on **material testing, selection** and **qualification** for subsequent phases of the project.
- The consortium is led by Nini JV (Ineos E&P and Wintershall Dea AG) with 22 other international and Danish partners
- More details on Project Greensand can be found on the website:

  Project Greensand | CO2 Lagring

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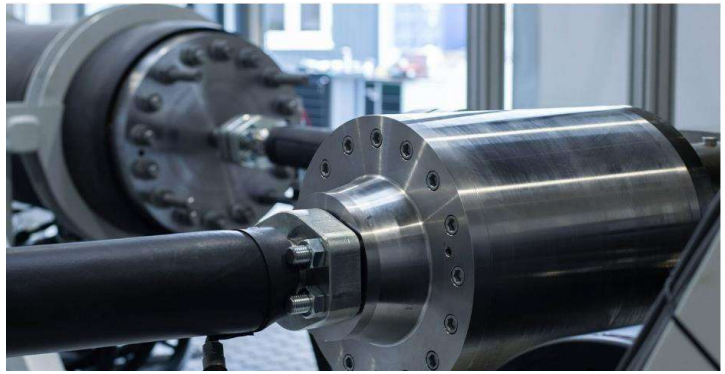
Test Flow Loop features and capabilities

Welltec has established new testing facility located in Esbjerg, DK.

- Possibility to run extended **corrosion tests**
- Possibility to perform **immersion corrosion tests in variety of modes with liquid, dense or supercritical CO_2**
- Possibility to perform variety of **stress corrosion tests**
- Possibility to add **8 impurities** at high precision and constant concentration
- Possibility to accommodate up to 40 material coupons
- Horizontal, tilted and vertical positioning of test chamber.
- Sampling and post exposure analysis with **experienced partner**.



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Test Flow Loop specifications

- Made of Hastelloy C22 / C276.
- Temperature range: -40 - +150 °C.
- Pressure: Up to 350 bar
- Flow velocity of 15 m/s with density of water.
- Impurities: H_2S, NO_x, NO, SO_x, O_2, N_2, and CO, with possibility to extend.
- Impurity system: Impurities can be added frequently to maintain concentration.
- The media will be in either gas, liquid or super critical state
- The impurities added as gas phase into the CO2.
- Samples can be extracted if a third-party analysis is required.

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Test Flow Loop applications

Designed with flexibility in mind, it is a full-scale test loop that can be adapted to a multitude of different testing applications. The loop can be transformed and adopted to integrated large pieces of equipment or even assemblies.

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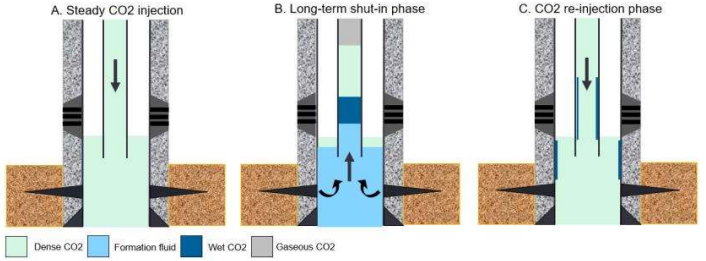
Material (coupon) test for CCS projects in Denmark

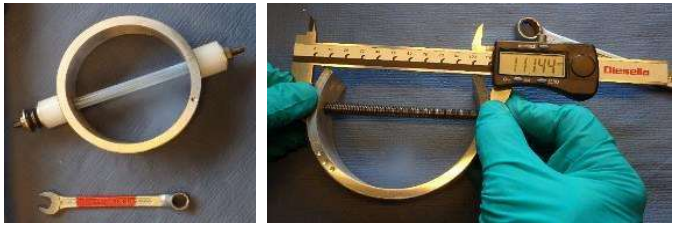
In this example, simulation of the flow back of formation water during **long term shut-in scenario** was performed. Relevant for the projects with expected shut-in periods or cyclic injection

- Set up with 50/50 vol% **brine/liquid CO2**
- Brine saturated **with chlorides** (prepared at facility, on the basis of compositional analysis of formation fluid)
- Impurities: NO_2, SO_2, H2S, O_2 and H_2O
- **Replenishment** of impurities every 48 hours
- P and T were equivalent to **downhole conditions**
- **Crevice** corrosion and **Stress Corrosion Cracking** testing
- 720 hours, semi-stagnant condition

- Significant mass loss caused by crevice corrosion has been seen on low-grade material (anything below Cr22+)
- Impurities and replenishment impact was quite drastic



Overview of operational scenarios in CO2 injection wells



Examples of a ring with crevice corrosion formers (left) prior to testing and C-ring for SCC (right)

Placement of the material coupons inside the test chamber (30 coupons in total)

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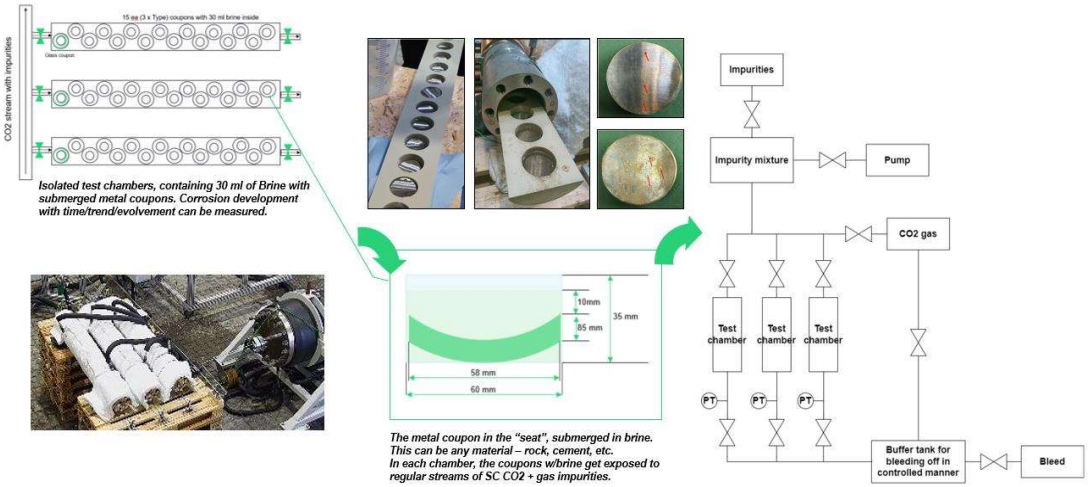
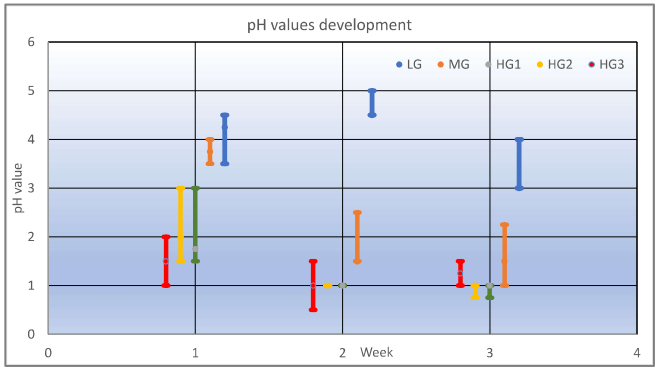
Material (coupon) test for CCS projects in Denmark

Simulation of one the **worst-case situations** when the well material is in contact with **minimal amount** of chlorides-saturated fluid/**brine** (less than 5%) and mixed with 95% **impure CO2**. For re-injection cases or check valve leakage

- Brine saturated with chlorides (prepared at facility based on compositional analysis of formation fluid)
- Each coupon submerged in **30 ml of brine**
- Impurities: NO_2, SO_2, H2S, O_2 and H_2O
- **Replenishment** of impurities every 48 hours
- P and T were equivalent to downhole conditions
- Each chamber was removed in 1-week intervals to simulate the corrosion trend and its influence on pH



Test set up to simulate the environment with extremely small amount of brine saturated with CO2 + impurities



Development of pH levels during the test. Higher levels measured around lower grade material.
pH test strips were used to measure ex-situ pH levels

Impurity	Concentration [ppm]
O_2	10
NO_2	50
SO_2	40
H_2S	5

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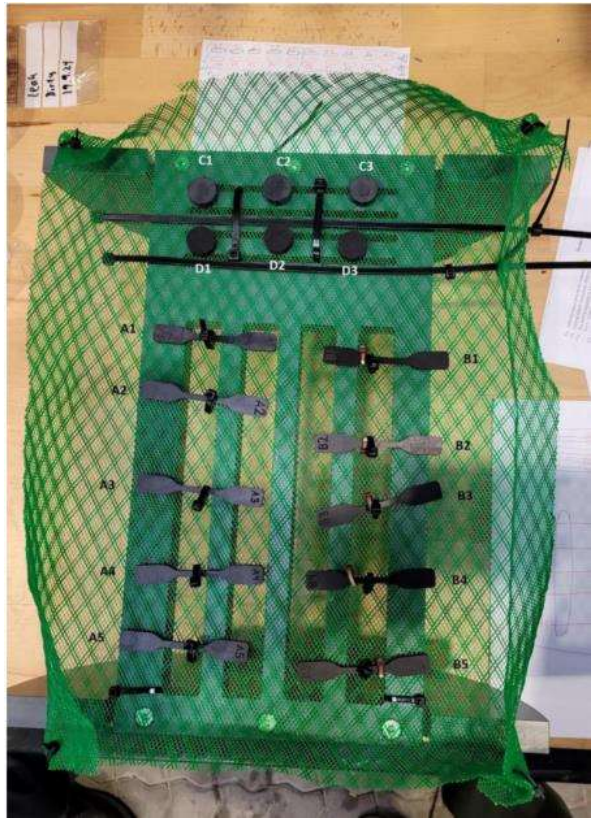
Elastomer test for CCS project in the Netherlands

The elastomers are planned to be part of surface pumping equipment, which will be used for injecting liquid CO2 into the well. Two types of material was shaped to perform tensile testing, where one type has failed to withstand test conditions.



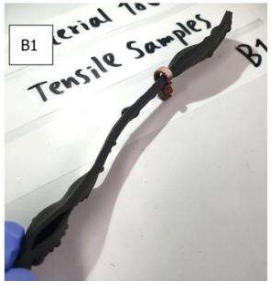


Figure 17 D1 sample. Cross section view. After flow loop testing.

- No brine, only liquid CO2
- Impurities: NO_2, SO_2, H2S, O_2 and H_2O
- No replenishments of impurities
- P – 140 bar
- T – 4 C
- Bleed off rate 0.6 bar/min

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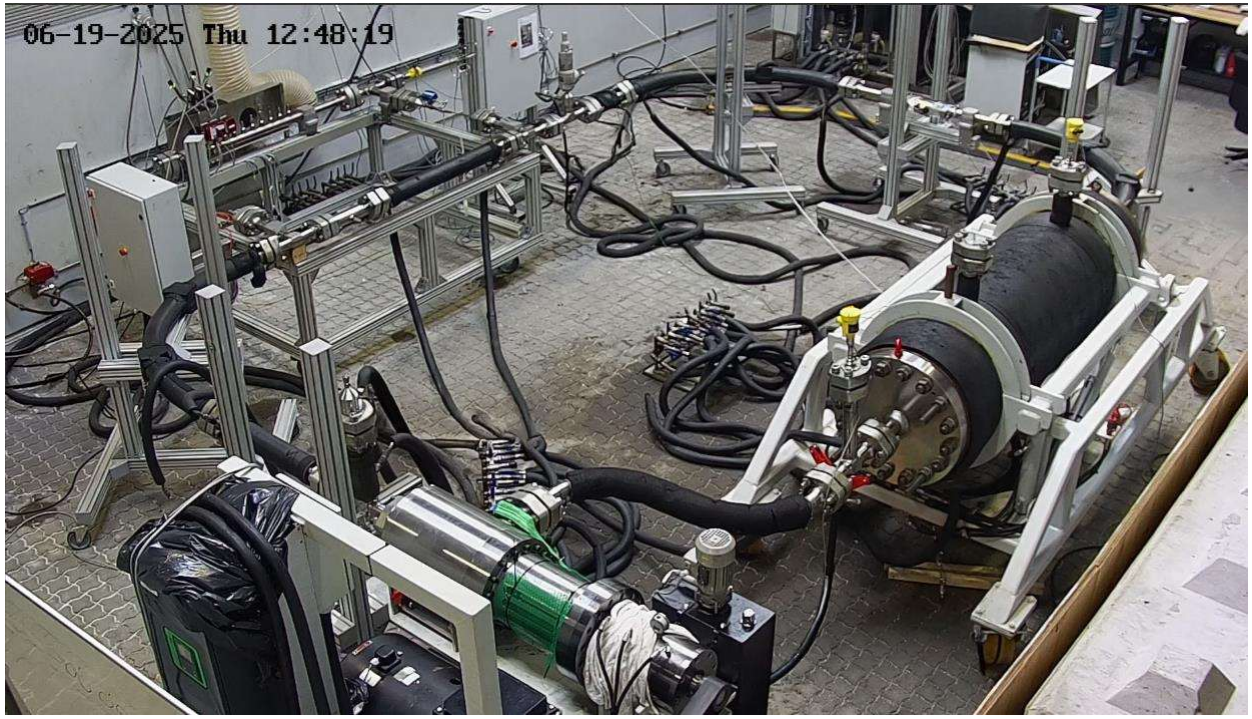
“Corrosion impact on Sand Screen” test for Greensand

Ineos Energy, the leading partner for Project Greensand has ordered the dynamic/static testing (4th test on Flow Loop) of their perforated joint with sand-screen on, to assess **possible corrosion impact** (plugging) of the screens due to CO2/Brine exposure



Test is performed with:

- Liquid CO2
- Impurity gases
- Brine (formation fluid)
- At 60 DegC and 225 Bar
- Duration ca 1 month

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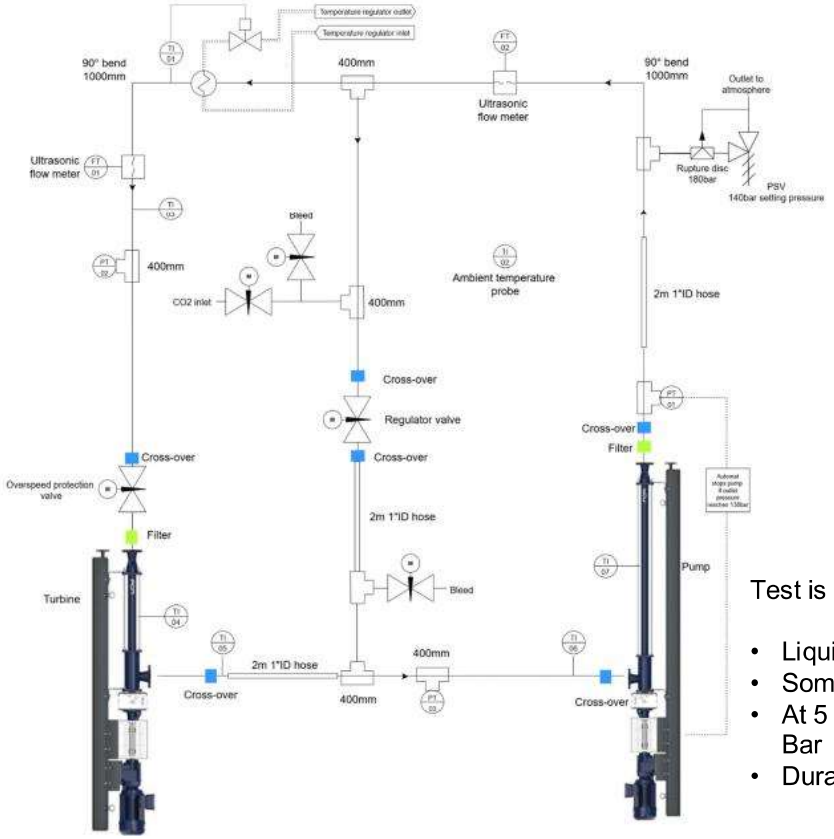
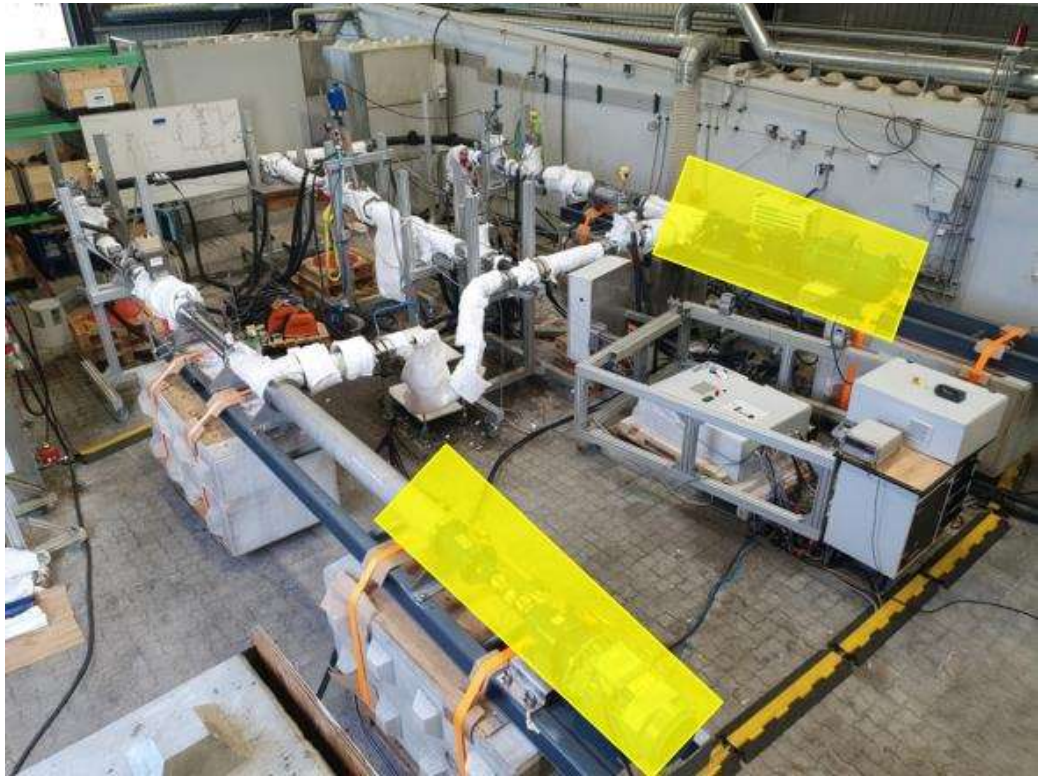
Pump and Turbine qualification for CO2 pumping applications

Currently our Flow Loop is being utilized to test and qualify pumping equipment for one of the suppliers for CCS project in the Netherlands. The equipment needs to be able to pump liquid CO2 into an injector well. The test is successful.



Test is performed with:

- Liquid CO2
- Some impurity gases
- At 5 – 20C and 140 Bar
- Duration ca 2 weeks



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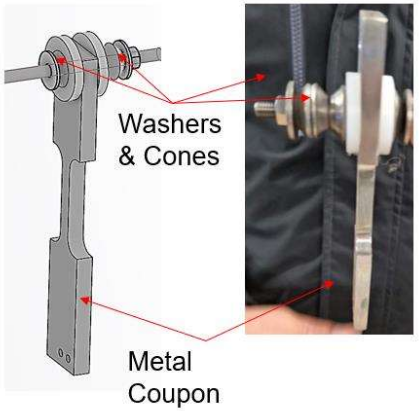
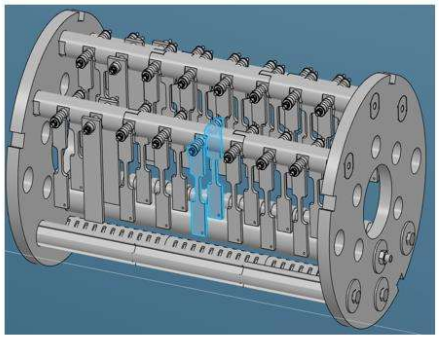
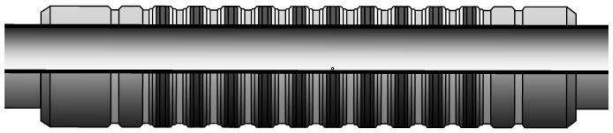
Testing Metal Expandable Packers for CCS applications

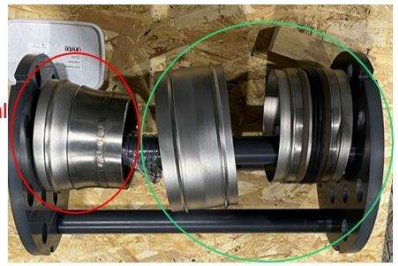
The scenario of periodic injections or frequent shut-ins. Longer shut-ins may cause the reservoir fluid to flow back into the well resulting in multiphase content inside the wellbore

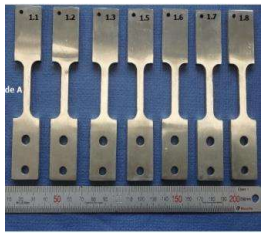




MEP expands by applied pressure through bore



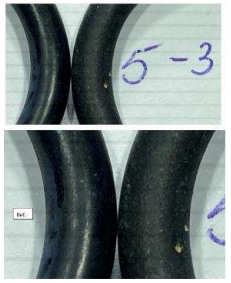




High- and low-grade alloy material's corrosion.

Crevice and general corrosion mechanisms are observed

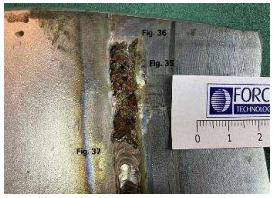
Reference and tested elastomeric samples. HNBR type 2.



HNBR Type 2. Changes in surface roughness of test sample compared to reference, i.e. some decomposition of the material.

Magnified area Piece 1: 8.5" component. After the test. Only light orange corrosion products.

Magnified area with corroded weld.



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Industry Standards Applied

- Visual inspection of test samples
- Mass loss for crevice corrosion testing (as per ISO 18070:2015)
- Yield strength (as per ASTM E8/E8M 16a)
- Tensile strength (as per ASTM E8/E8M 16a)
- Hardness (as per ISO 6507-1:2018 & ISO 6508-1:2016)

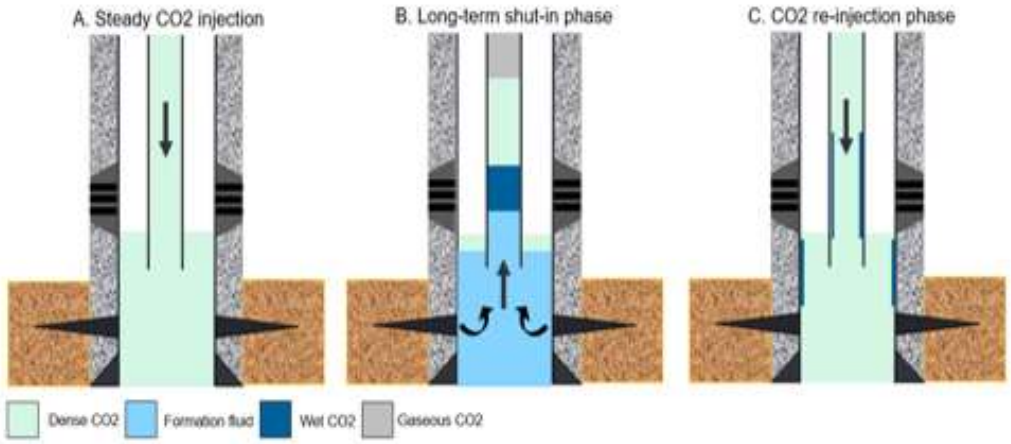
Tested in 3 different loads (compression, tension, free hanging):

- Visual inspection of test samples
- Density (as per ASTM D792 or ISO 1183)
- Hardness (as per DIN 53505 or ISO R868)
- Compression testing (as per ISO 815)
- Tensile strength (as per ASTM 1414)

- Visual inspection after testing
- Stress corrosion cracking
- Corrosion assessment by:
  - ✓ Stereo Microscope
  - ✓ Energy Dispersive X-ray (EDX)
  - ✓ Light Optical Microscope

Test Conditions Matching Long-term Shut In (Scenario B)

The scenario of periodic injections or frequent shut-ins. Longer shut-ins may cause the reservoir fluid to flow back into the well resulting in multiphase content inside the wellbore



Brine	Impurities	Pressure	Temperature	Flow rate
Yes	Yes	280 bar	60°C	Stagnant conditions

CO2 impurities content:

CO2	Base fluid
NO2	25 ppm
O2	10 ppm
SO2	25 ppm
H2S	5 ppm
Brine	90% (loop volume)

Chemical composition of artificially produced water:

	Composition [mg/L]
Na^{+}	29300
Ca^{2+}	4800
Mg^{2+}	1027
K^{+}	211
Ba^{2+}	123
Fe^{2+}	0.9
SR^{2+}	602
Cl^{-}	57900
SO_4^{2-}	6.3
ALK (HCO_3^{-})	100

- Set up with 90/10 vol% brine/liquid CO2
- Brine with high Cl- content
- Replenishment of impurities every 72 hours
- 720 hours
- pH and O2 level were monitored daily

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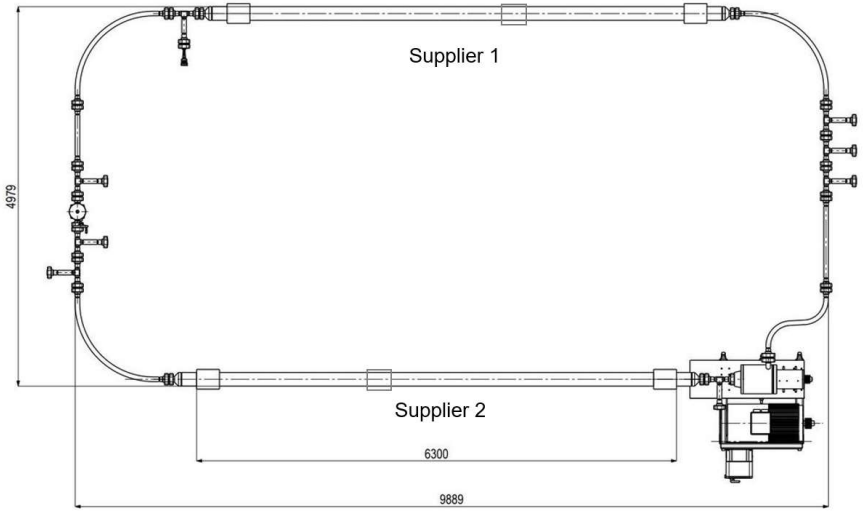
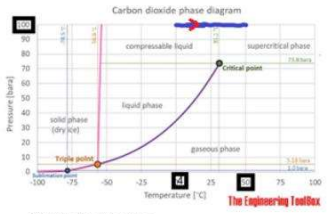
Equipment qualification for CO2 environment

- Qualification of alternative technologies containing metallic and elastomeric material which may be affected by CO2 environment
- The principle of testing equipment is based on exposing it to different states of CO2 (e.g. liquid, SC or gaseous), pending on the expected scenarios during equipment lifecycle.

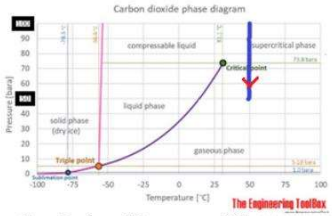
Example of the candidate alternative technology - GRE-Lined Tubular
Can be any well intervention or other tool that need to be exposed to CO2 environment.



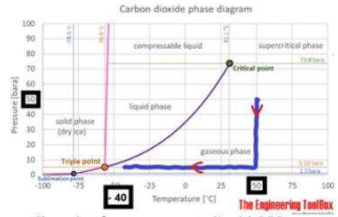
Example with tubing assemblies test planned in Q3 2024



CO2 in liquid state



Changing from SC to gaseous CO2 state



Changing from gaseous to liquid CO2

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Thank you for your time

For further details regarding Test Flow Loop please contact:

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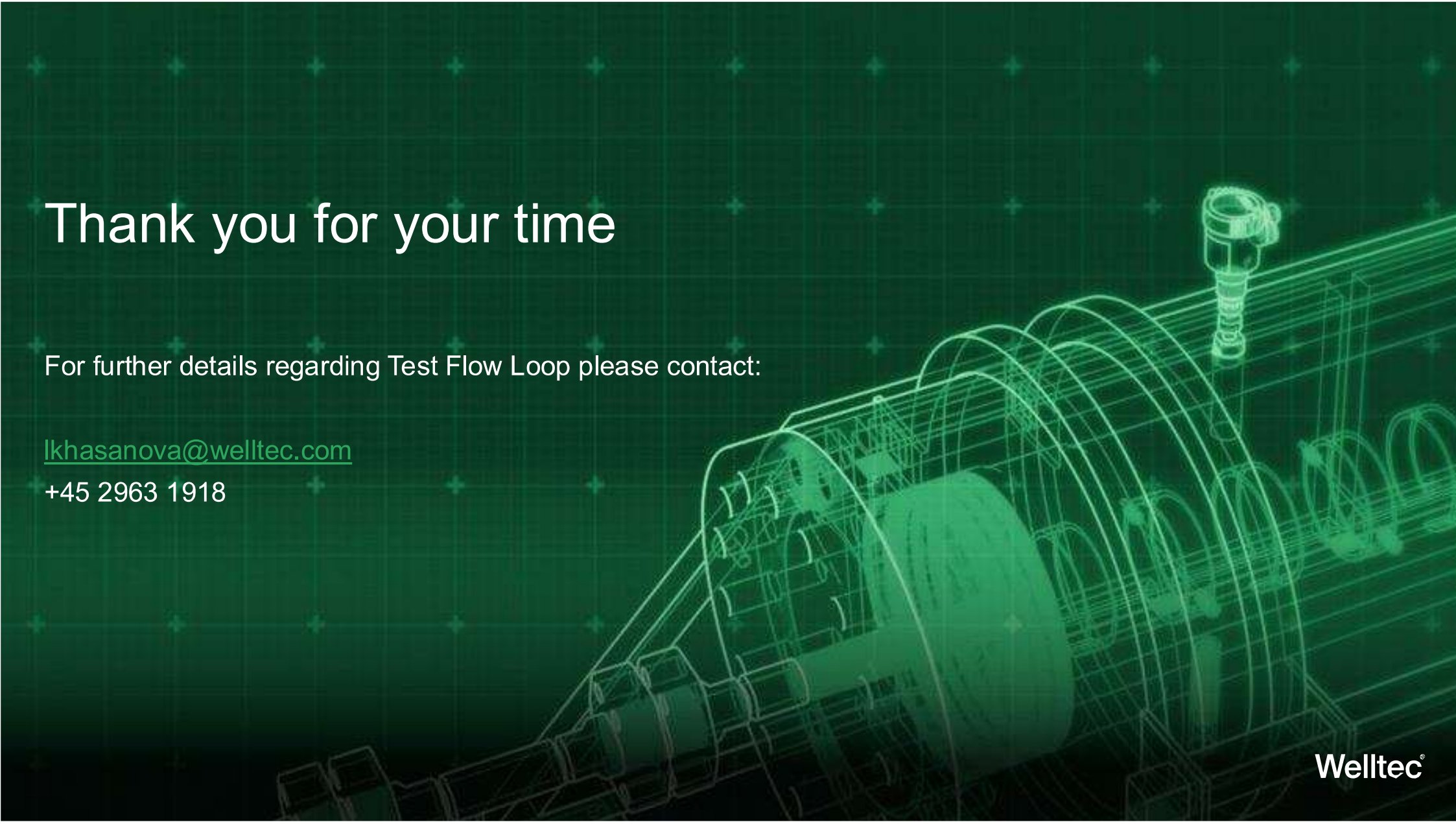
+45 2963 1918



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