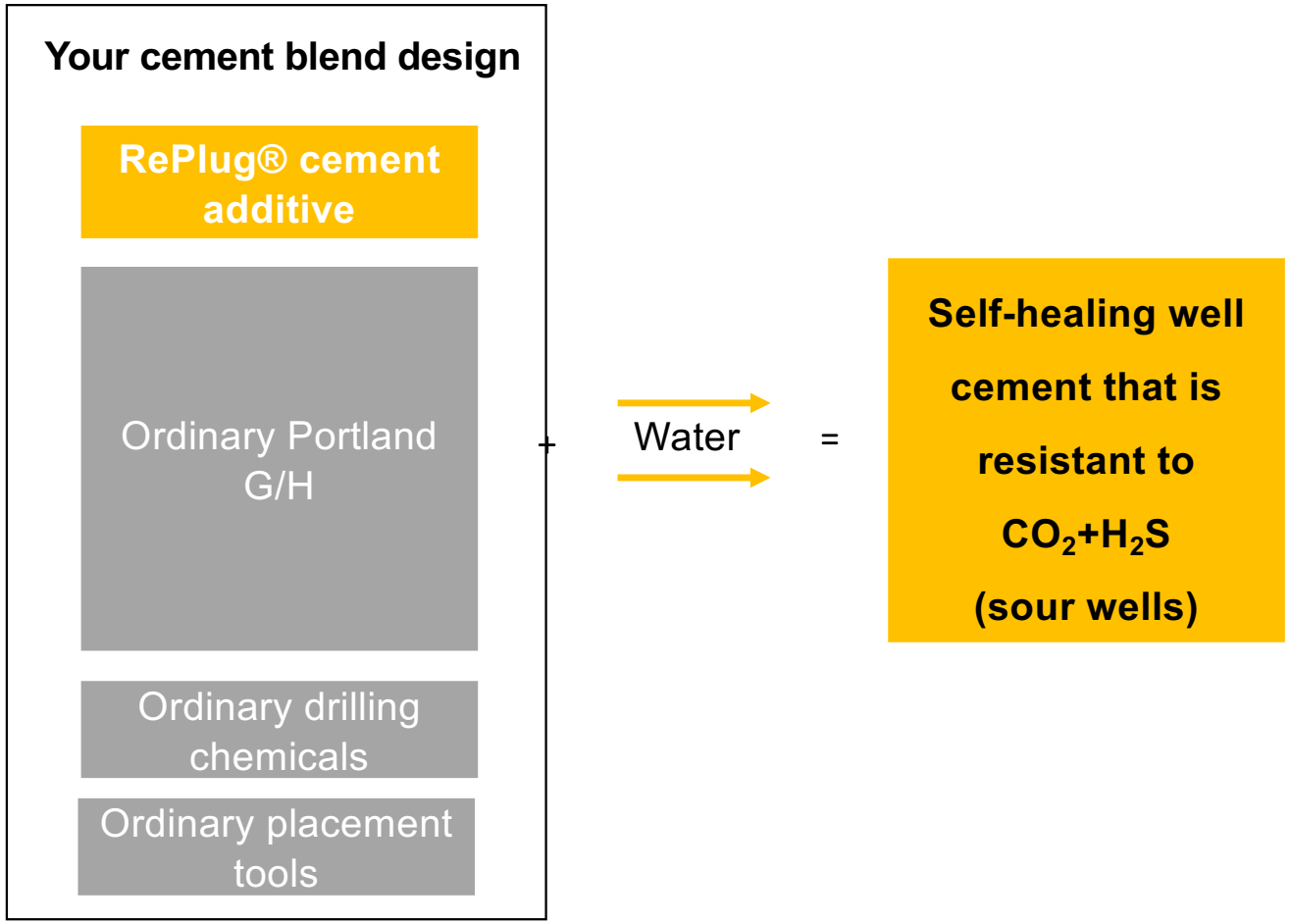
A NOVEL CEMENT ADDITIVE MATERIAL THAT MAKES ORDINARY CEMENT BLENDS SELF-HEALING AND MORE RESISTANT TO CO_2 AND H_2S

February 2022

Virtual Meeting hosted by the American Association of Drilling Engineers

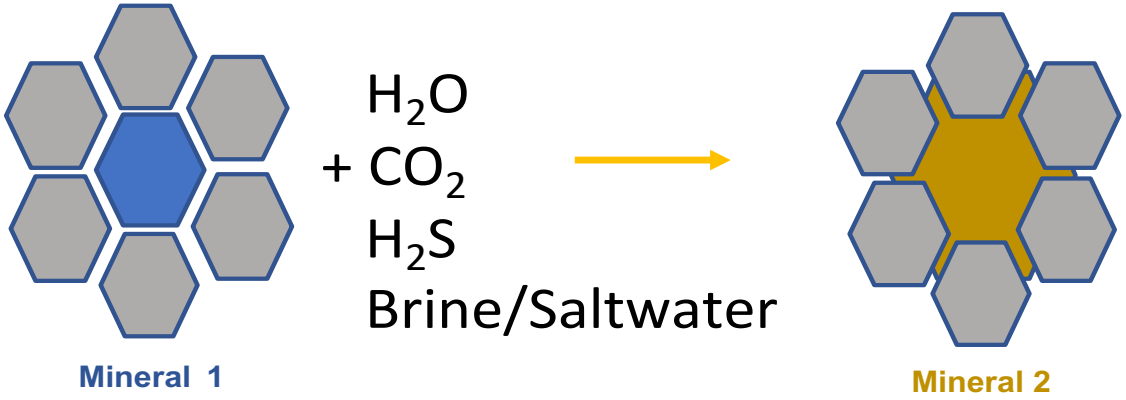
What is RePlug® and how does it work?



RePlug® - turning existing cement blend into a self-healing, CO_2 and H_2S gas-tight well cement

What is RePlug® and how does it work?

- RePlug® reacts minerals with water-based fluids to metamorphose them into cements with pores and cracks that would otherwise be pathways for leaks and decay
- After the blend is set, the self-healing process remains active with an “eternal” perspective or until the reactive materials are depleted
- Tests have validated that RePlug® persists, seals and protects against fluid and supercritical CO_2 in fluids as seen in CCS wells
- The presence of CO_2, H_2S and salts in the fluids do not adversely affect the reactions in the cement matrix, they may even benefit from it
- RePlug® seals the flow path & contributes to extremely low permeability

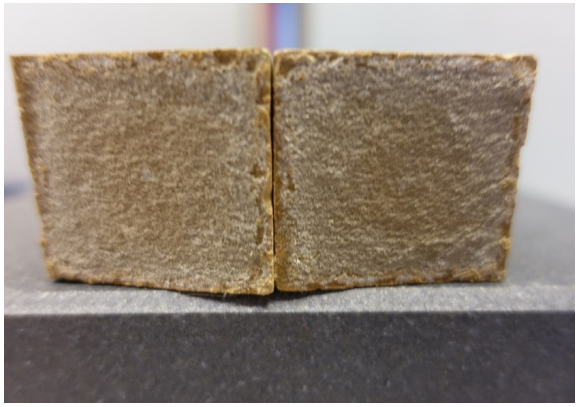


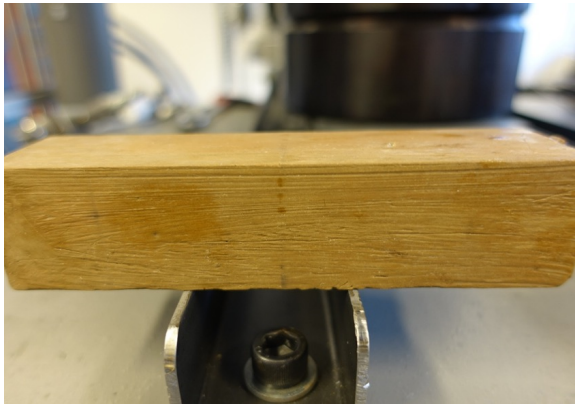
Self-healing effect: Testing w/ Halliburton Norway

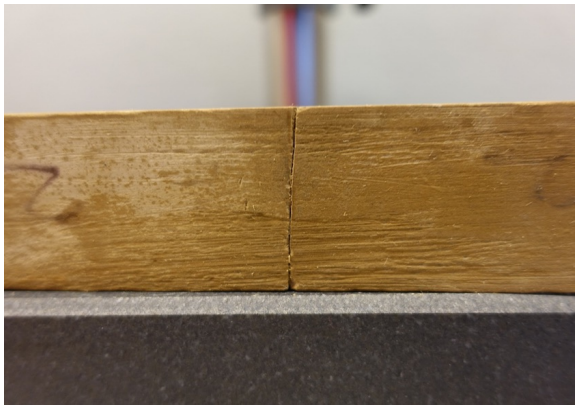
Flexural tensile strength tests (bent beam method)

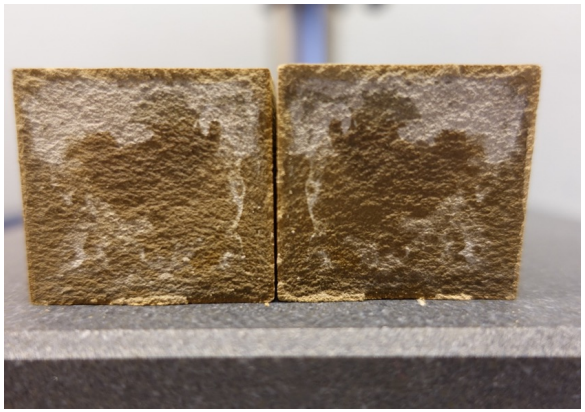
Validate claim for self-healing properties – will new compounds precipitated bond matrix together?

1. Cure 100ºC/212F & 310 bar 28 days
2. Test flexural tensile strength (929 & 1163, avg. 1046 psi)
3. Assemble parts, tie together
4. Cure 100ºC/212F & 310 bar, 9 days in CO_2 saturated fresh water
5. Observe – partly bonded
6. Test flexural strength (191 & 195, avg. 193 psi)
7. ➔ 18,5% of original strength in **9 days**



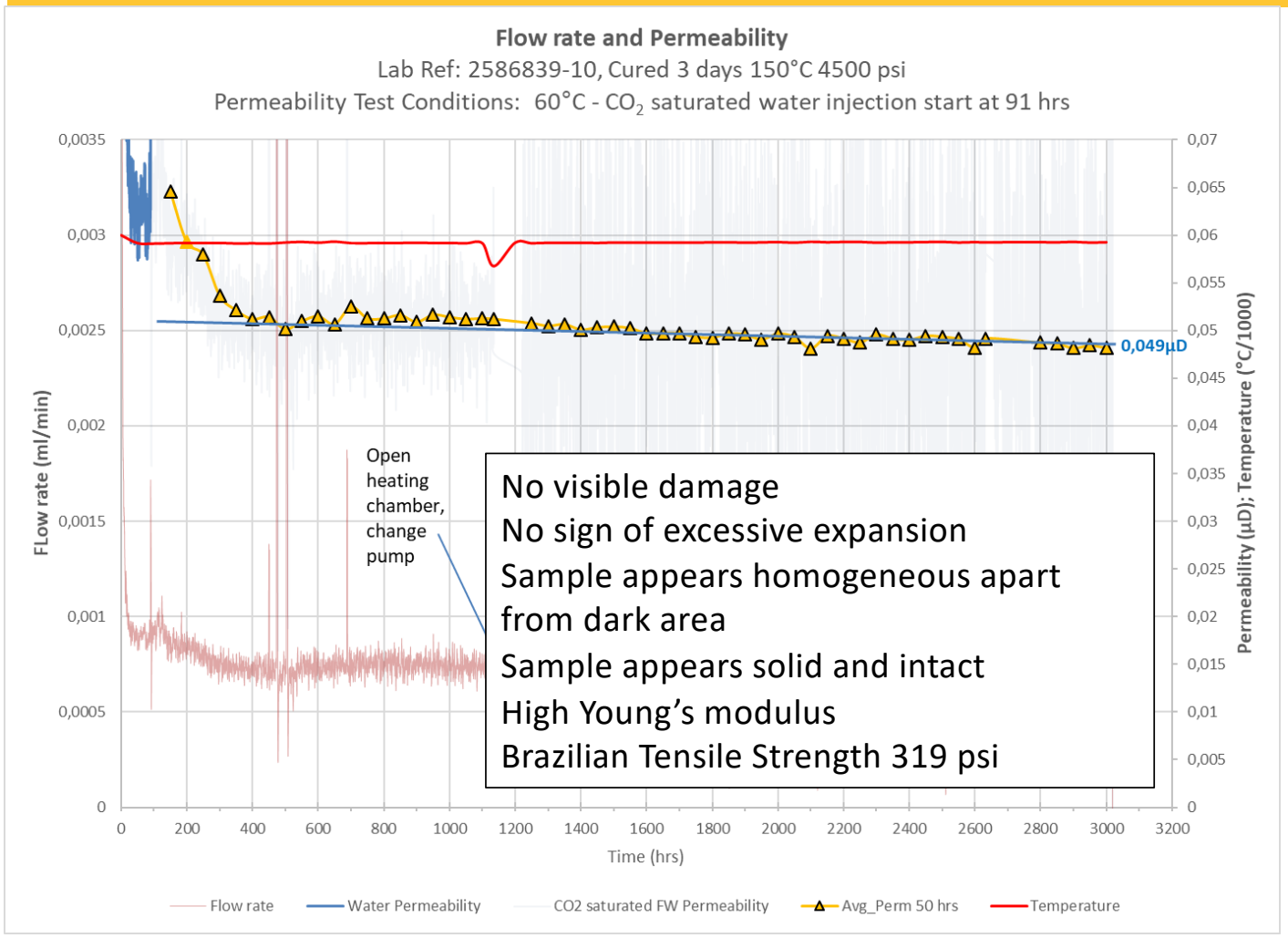


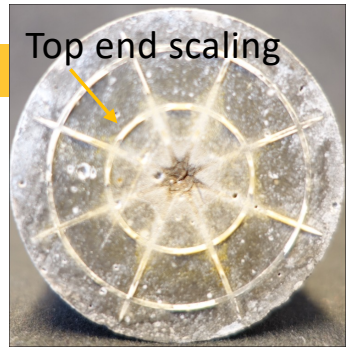


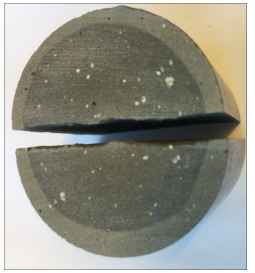


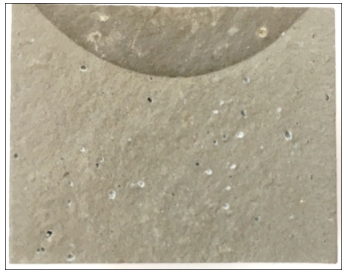
See SPE-204103 for more information

Halliburton 9-5/8” casing design – permeability response to CO_2









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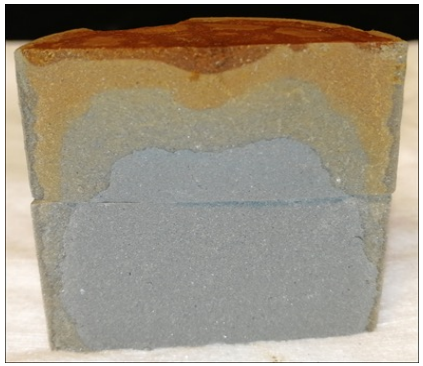
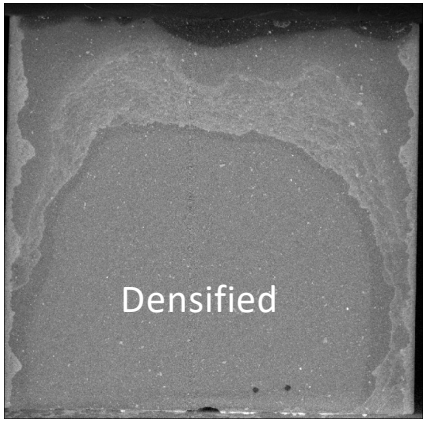
Halliburton 9-5/8” casing design – permeability response to CO_2

Cement with FDP-C1392-20



Increasing concentration of Hematite due to α-FeOOH reaction with carbonic acid (post C_4AF reaction) Plus RePlug® CO_2 reaction

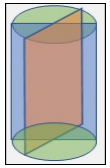


CT scan YZ-plane 1

CO_2 affected skin from autoclave exposure

CO_2 affected matrix from flow exposure

White precipitate



Reference cement

Increasing concentration of Hematite due to α-FeOOH reaction with carbonic acid (post C_4AF reaction)

CT scan YZ-plane 1

CO_2 affected matrix from flow exposure

No precipitate

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RePlug® - Testing by the research institute SINTEF

AGING OF REPLUG® BLEND IN SEAWATER AND SUPERCRITICAL CO_2

Aging of RePlug® blend in seawater and supercritical CO_2, plug is 4 cm tall

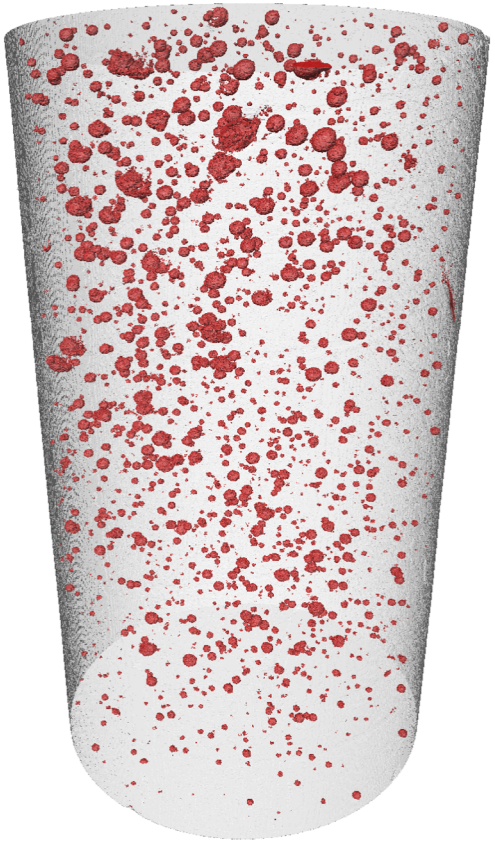
CT scans before exposure and after 4 weeks of aging

Red is porosity, blue is crystals outside the plug

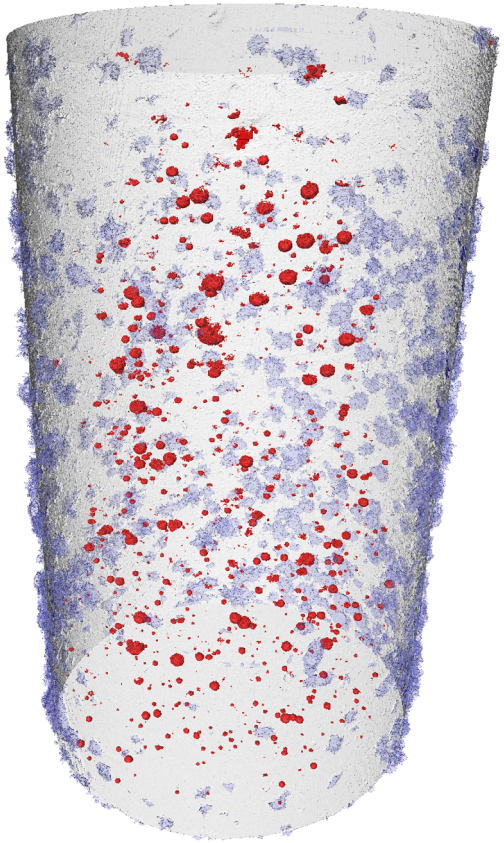
Tested in collaboration with the leading research institute SINTEF

SINTEF

BEFORE



AFTER 4 WEEKS



Source: ReStone, SINTEF

See SPE-200753

RePlug® - Testing by SINTEF

PICTURE OF CT SCAN SHOWING INCUBATION WITH SEAWATER AND SUPERCRITICAL CO2

Aging of RePlug® blend in seawater and supercritical CO_2, plug is 4 cm tall

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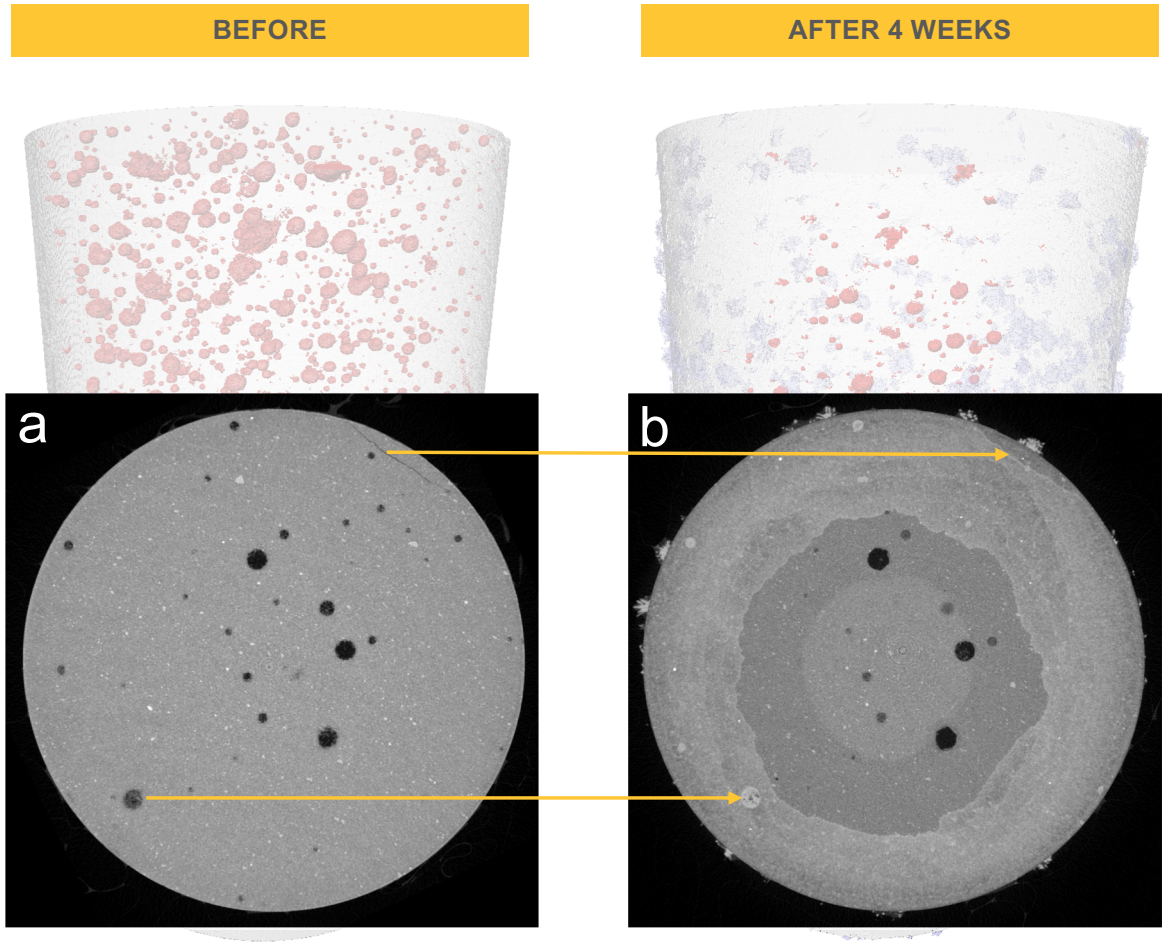

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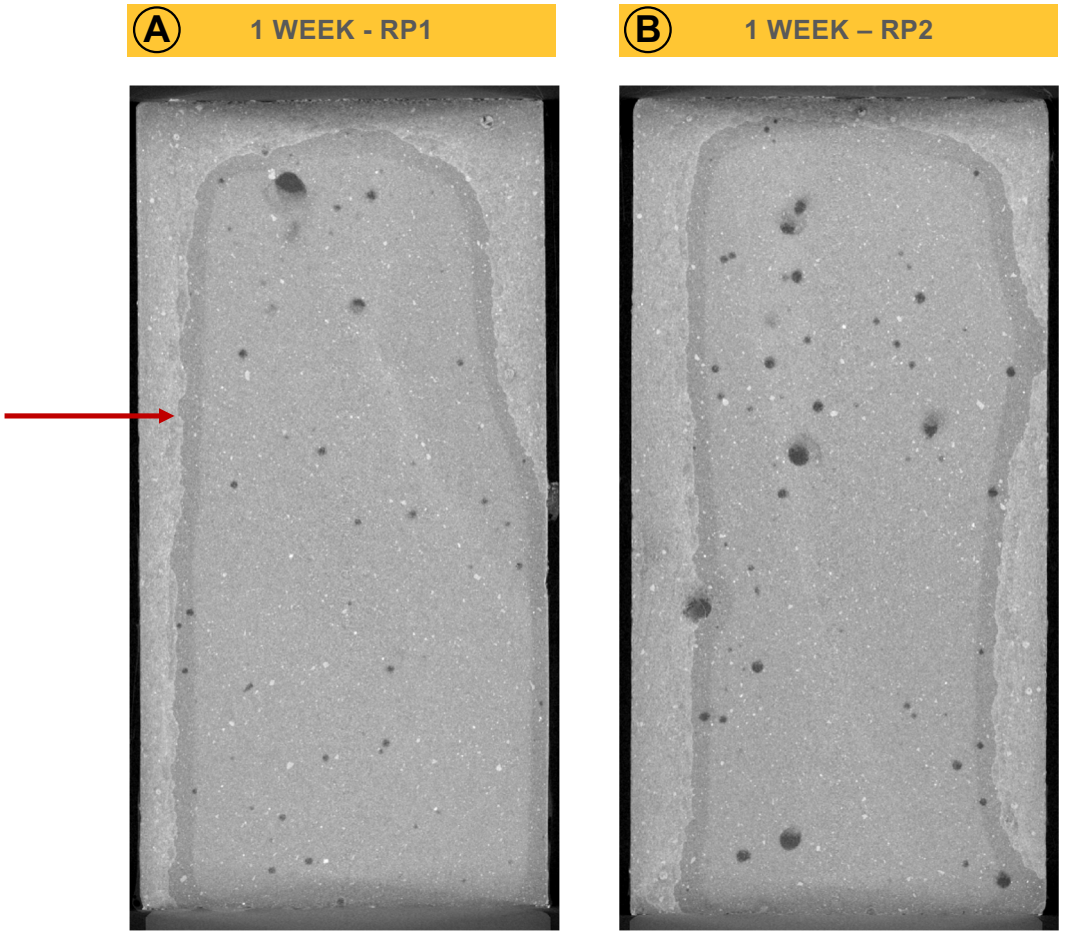
RePlug® - Testing by SINTEF

PICTURE OF CT SCAN SHOWING INCUBATION WITH SEAWATER AND SUPERCRITICAL CO2

Replicates after one week of exposure to 80 ºC, 200 bars

Mantle of sealed RePlug® protects core of unchanged cement



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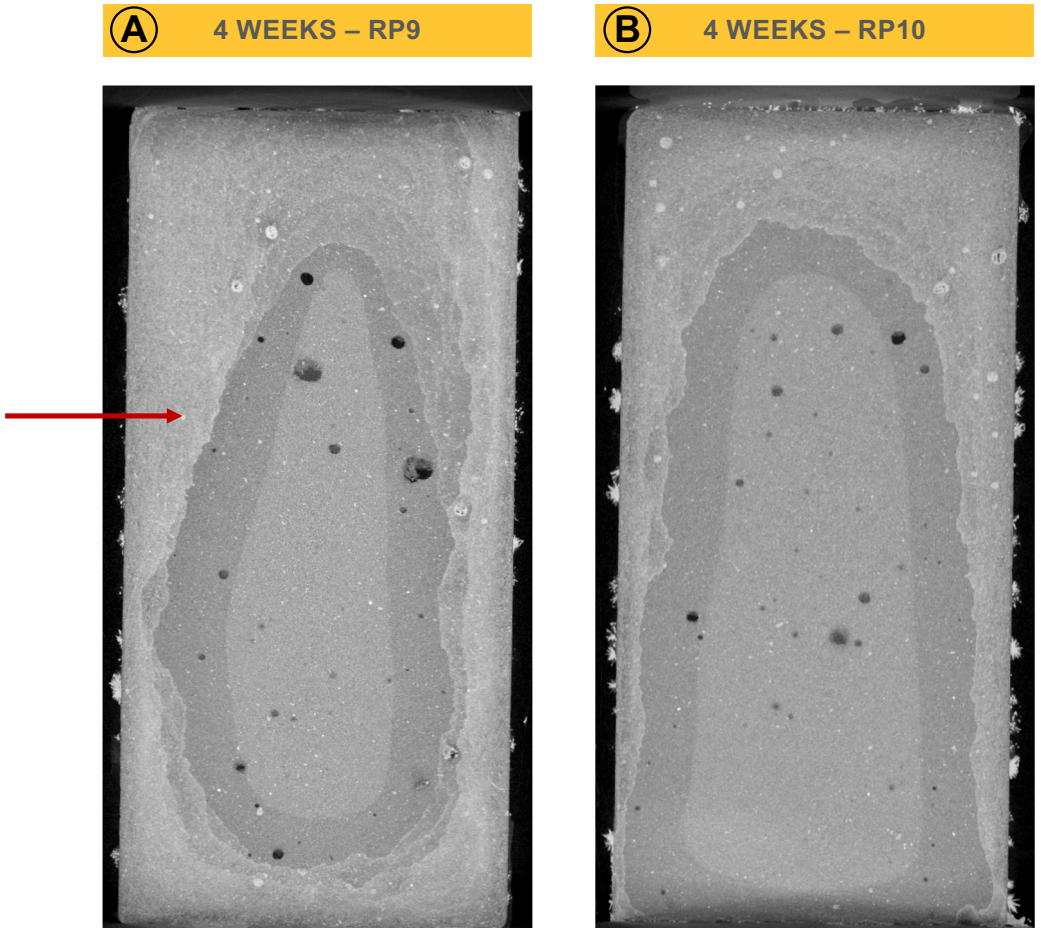

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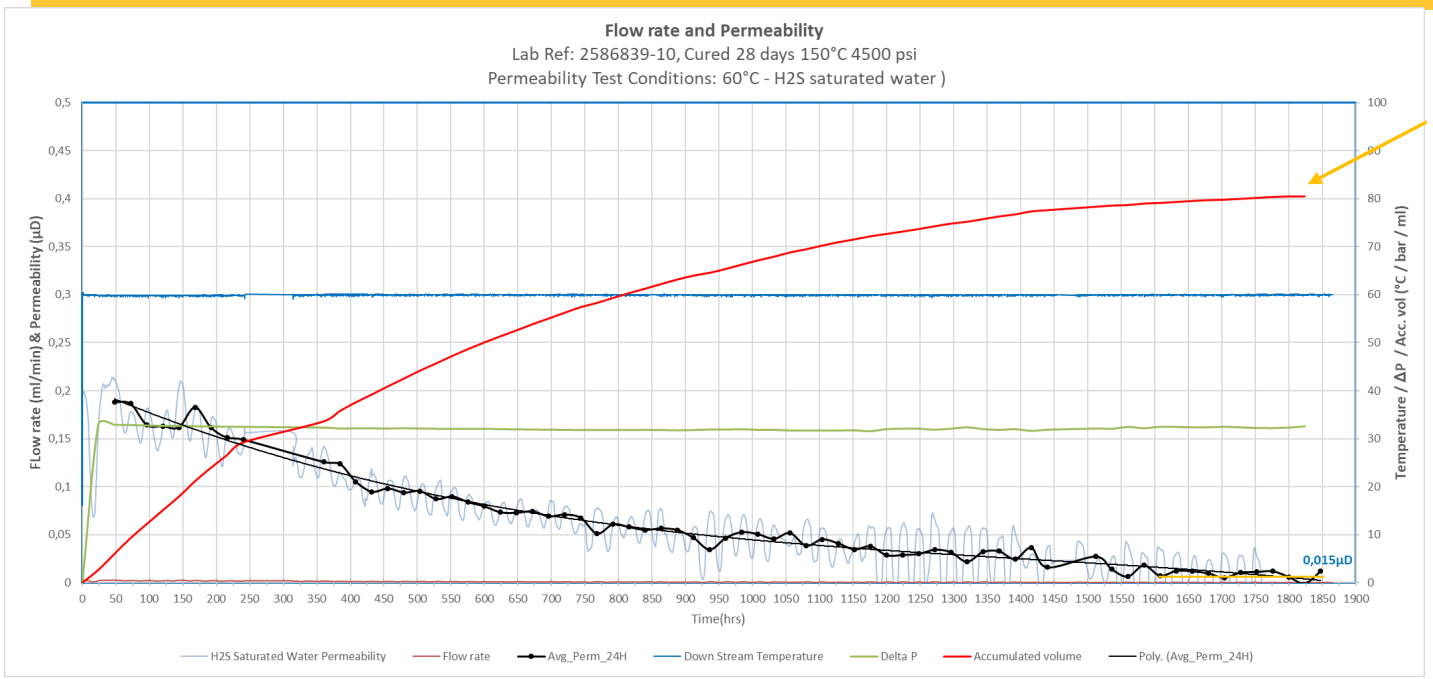
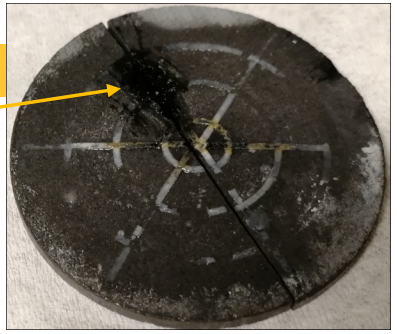
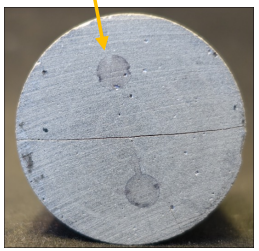
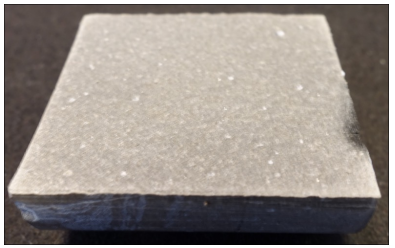
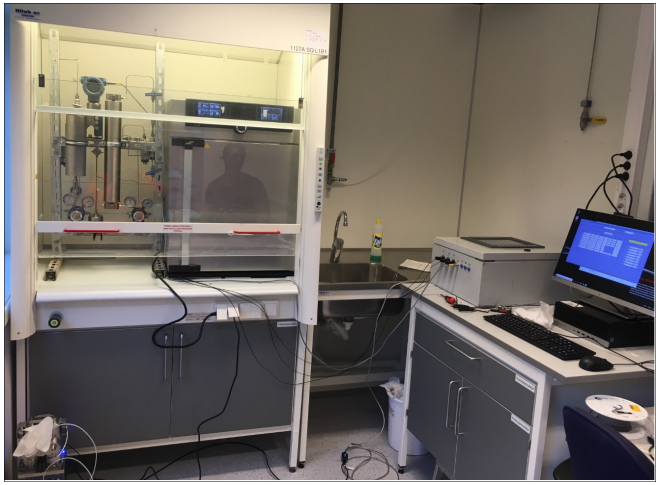
Halliburton 9-5/8” casing design – permeability response to H_2S:



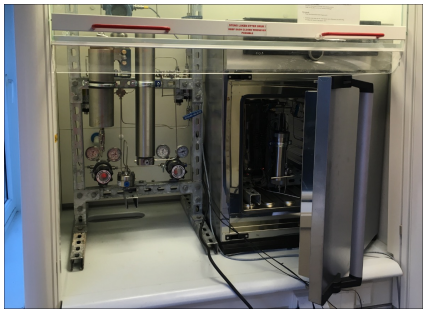








No visible damage
No sign of excessive expansion
Sample appears homogeneous
Sample appears solid and intact
High Young’s modulus
Brazilian Tensile Strength 443 psi



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RePlug® - Meeting Well Barrier Critera Standards

	Well barrier criteria	RePlug® technology
A	Provide long term (eternal) integrity	√ Well known
B	Impermeable	√ Self heals
C	Non shrinking	√ Expands to fill the available space
D	Able to withstand mechanical loads/impact/ flexible	√ Flexible and self-healing
E	Resistant to H_2S, CO_2, hydrocarbons	√ CO_2, H_2S, hydrocarbons
F	Bonding to tubulars	√ Tests show excellent wetting
G	Not harmful to the steel tubulars integrity	√ High buffer capacity

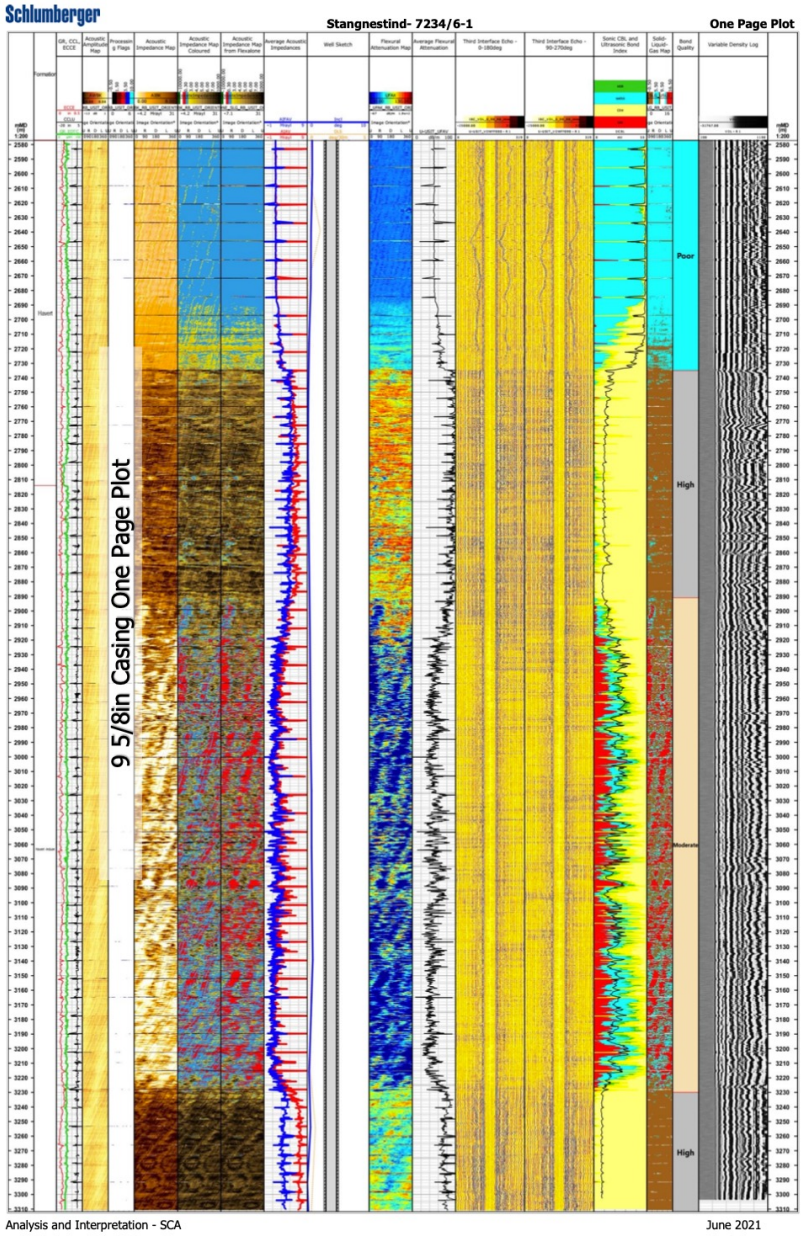
RePlug® - Operational

NO NEED FOR INVESTMENTS IN NEW TOOLS OR CEMENT INFRASTRUCTURE

- **RePlug® is designed to be used without changing the existing cement infrastructure, methods and procedures as exists for well cements today, and hence, without the need for investments in new and expensive equipment, reducing risks and maintaining HSE requirements for both oil service companies and operators**

- **Used with existing cement equipment & infrastructure for major O&G operators in wells, behind 7” expandable liner, behind 9 5/8” casing and for P&A plugs**

- **Technology proven by DNVGL-RP-A203/API-RP-17N standards**



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RePlug® - MAKES WELL SAFER

CHALLENGES THAT REPLUG SOLVES

- ✓ **No Micro Annuli due to self-healing**
- ✓ **High resistance and absorption of CO_2 & H_2S**
- ✓ **RePlug®– optimalised blend according to required characteristics (strength and/or ductile self-healing)**
- ✓ **RePlug® reacts and self-heals with fresh- and salt-water and/or CO_2**
- ✓ **Works in any well – not only for CCS wells**

RePlug® - Testing

- **Tests performed on RePlug**

FUNCTIONAL PILOT - RESEARCH PERFORMED

- Permeability
- Ring mould expansion test
- Ultrasonic compressive test
- Particle size distribution
- UCS
- UCA
- Triax cell test
- Brazilian tensile strength
- CT
- XRD
- Electronic formation of gel
- Bonding test
- Exposure to water, and CO_2
- Flowing with water, CO_2, salt water and H_2S
- Young's Modulus
- Tensile strength
- Compressive strength
- Thickening time
- Mix rheology
- API rheology
- API static gel strength
- Free fluid
- API fluid loss
- Mixability
- Slurry density
- Rheology results
- Results when exposed to water, seawater, brine, CO_2 and H_2S

ReStone at a glance

POSITIONED TO DISRUPT THE GLOBAL CEMENT AND CONCRETE INDUSTRIES

ABOUT RESTONE

- ReStone was established in 2016
- The company headquartered in Stavanger,
- ReStone is a material technology company that invents and patents technologies and products that exploit the chemical and physical properties of rock materials
- The company is aiming to create market opportunities from its innovations that use waste rock or under-utilised material-streams from excavations to reduce environmental impact, so prevalent today

- Selected research collaboration partners

HERIOT WATT UNIVERSITY

SINTEF

UNIVERSITY OF MARYLAND 18 56

HALLIBURTON

TECHNOLOGY AND PRODUCT LINES

- RePlug® - Cement additive with unique properties
  - A patented technology developed for use in CCS- & Petroleum wells
  - Unique set of properties and applicable for all parts of a well - and in the full well life cycle from drilling to P&A
- ReZem® - SCM product line under development
  - Developed on the backbone of RePlug®, the technology is designed to address key challenges in the land-based cement- and concrete industry on a global scale
  - ReZem® will be an environmentally friendly low-CO_2 supplementary cementitious material (“SCM”)

The ReStone Team

HIGHLY SKILLED AND MOTIVATED MANAGEMENT TEAM WITH COMPLIMENTARY COMPETENCES

Ingvar Grannes

Chief Executive Officer

Introduction
Mr. Grannes is the CEO of ReStone

Experience
He has more than 30 years of experience from the Petroleum industry, both from service companies and for major field operators.

Education
Drilling engineer

Astri Kvassnes

CTO / Research Manager

Introduction
Dr Kvassnes is the Research Manager and co-founder of ReStone

Experience
She has more than 20 years of work experience from environmental geology and research. Inventor of RePlug®.

Education
PhD in Marine Geology from Massachusetts Institute of Technology and Woods Hole Oceanographic Institute Joint Program.

Jill Clausen

COO/ Business Development Manager

Introduction
Dr Clausen is the Business Dev. Manager and co-founder of ReStone

Experience
She has more than 20 years of experience from research and petroleum industry.
Inventor of RePlug®.

Experience as Chair of Board, Board Member, Technical Advisory Board,
CTO, CBDO, COO and CEO

Education
Dr Scient in Structural / Petroleum Geology from University of Bergen

Øyvind Aasmyr

Chief Financial Officer

Introduction
Mr. Aasmyr is the CFO of ReStone

Experience
He has more than 14 years of experience from different positions within investment banking/corporate finance from leading independent investment banks to larger commercial banks in Norway

Education
MSc Finance and Business Administration from Norwegian School of Economics (NHH)

Philip Cederholm

Logistics & Supply Chain Manager

Introduction
Mr. Cederholm is the Logistics and Supply Chain Manager of ReStone

Experience
He has 10+ years of experience in logistics management, serving major international Oil & Gas companies. He has particularly focused on Drilling & Well operations.

Education
ACE 5S Lean Certificate, Leadership & social studies

Eyvind Time

Production and Quality Manager

Introduction
Mr. Time is the Production and Quality Manager of ReStone

Experience
He has 18 years industrial experience form the R&D, Production & Concrete industry.

Education
Master of Management BI Norwegian Business School, Grad Certificate Virtual Design & Construction (VDC) Stanford University

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+47 498294126 / +44 7554340193