Low CO_2e P&A materials Do we have any ready?

Norway PAF 2023

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Reducing CO_2e - what matters?

Main contributors to CO2e:

1. Rig fuel consumption
2. Stand-by vessel fuel consumption
3. Supply vessel fuel consumption
4. Materials - manufacturing
5. Material – logistics fuel consumption
6. Chemicals
7. Other rig non-well material consumption
8. Time use

- Which one is most significant?
- Which one is easiest to reduce?
- Can one affect any of the others?

Examples:

If reduced material CO_2e increases use of rig time, overall CO_2e may go up, not down; or benefit reduced

For remote locations (example Hammerfest) logistics can be >60% of material CO2e

Reducing CO_2e - what matters?

Norway plug job statistics per August 2023:

- All plugs except lost circulation, dump bailer and KOP since 1997
- 7280 hits, 101603 m^3, average volume 14 m^3

➔saving potential could be up to ±78800 MT

➔Long term accumulated volume of small jobs makes a difference

Reducing CO_2e - what matters – example calculation

Rig emission:	3,4	MT/hour	35	m3 diesel per day	**1**	
Stand-by boat emission:	0,7	MT/hour	7	m3 diesel per day	**1**	
Supply boat emission:	0,7	MT/hour	7,5	m3 diesel per day	**1/2**	vessel per rig day
Sum diesel	4,8	MT/hour	49,5	m3 diesel per day		
Cement CO2e:	1,260	MT/m3		Class G cement (Tananger)		

Main contributors to CO_2e:

1. Rig fuel consumption
2. Stand-by vessel fuel consumption
3. Supply vessel fuel consumption
4. Materials - manufacturing
5. Material – logistics fuel consumption
6. Chemicals – low contribution
7. Other rig non-well material consumption ?
8. Time use – indirects ?

? Highly variable !

Class G cement (Tananger)	**0,909**	MT/MT
+ logistics to rig (typical)	**0,050**	MT/MT
Sum CO2 per MT	0,959	MT/MT
CO2 per m3 (1,90 sg)	1,260	MT/m3

1 hour rig$^+$ time corresponds to ±3,8 m^3 "G" cement

61% CO_2e saving on cement design

1 hour rig$^+$ time corresponds to ±9,8 m^3 low CO2e cement

Average 14 m3 per job

Saving potential ±10,8 MT per job

4,8 MT/hour

CO_2e saving corresponds to ±2 hours rig$^+$ time

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Rig time vs plugging material impact on CO_2 emissions

What matters – example calculation

- Rig diesel consumption based on annual average for semi-sub rig operating in Norwegian waters
- No extra allowance for stand-by and supply vessel contributions
- No extra allowance for chemicals, spacers, mud, etc.
- NeoCem E+ NS LT-50 blend at 1,70 sg replaces class G cement at 1,90 sg, **14 m^3 job volume**
- Typical job times assumed for placing plug in cased hole

Same assumptions as previous slide

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EXAMPLE JOB CALCULATION		Base case:			With 61% saving:			Break-even WOC	2,2
Activity	Time (hours)	CO2e (MT)	CO2e (%)		CO2e (MT)	CO2e (%)		CO2e (MT)	CO2e(%)
RIH with DP	6	29,0	17 %	25 %	29,0	18 %	28 %	29,0	25 %
Set mechnical plug	1	4,8	3 %	4 %	4,8	3 %	5 %	4,8	4 %
Circulate, set cement plug, POOH to top cement	5	24,1	14 %	21 %	24,1	15 %	23 %	24,1	21 %
Circulate B/U, cut cement	2	9,7	6 %	8 %	9,7	6 %	9 %	9,7	8 %
WOC, tag	12	57,9	34 %	-	57,9	36 %	-	10,8	9 %
POOH	5	24,1	14 %	21 %	24,1	15 %	23 %	24,1	21 %
Pressure test	1	4,8	3 %	4 %	4,8	3 %	5 %	4,8	4 %
Contribution, 14 m3 cement (MT)	14	17,6	10 %	15 %	6,9	4 %	7 %	6,9	6 %
SUM CO2e	32	172	100 %	100 %	161	100 %	100 %	114	100 %
SUM CO2e - no WOC	20	114	WOC	No WOC	103	WOC	No WOC	103	2,2 WOC

Can low CO2e solutions be used for P&A?

NORSOK D-010:2021+AC2:2021

Technically – what does it provide?

- ✓ Lower CO2 footprint
- ✓ NORSOK D010 r2021 compliant
- ✓ No need for use of silica flour for high temperature
- ✓ No need for expansion agent (inherent expansion)
- ✓ Eliminate need for Microsilica Liquid or Gascon
- ✓ Control with ordinary additives
- ✓ RCS = 0,57% as per EN-481 → ~~H373~~ (Norway)
- ➢ Good CO2 resistance seen so far

"It" for Norway now:

NeoCem E+ NS LT-50

- ✓ We have it in stock!
- ✓ We know how to use it!

Table 26 — Well barrier material requirements

Item	Property	Requirement
a.	Long term integrity **12 months 150°C**	Key integrity indicators like compressive and tensile strength, permeability and Young's Modulus should when measured over longer period, not indicate a deteriorating long-term trend. If such a trend is observed the test should continue to determine the final stable value.
b.	Permeability **< 5 µD**	Water permeability smaller or equal to 5 µD, or smaller or equal to 1000 times the formation permeability whichever is greatest. Alternatively, the zonal isolation material shall as a minimum have a combined permeability and length such that its ability to prevent fluid migration is as good or better than the cap rock it replaces.
c.	Radial shrinkage **> 0,25 % expansion**	For OH plugs / OH annular WBEs: low shrinkage. For internal, cased hole WBEs: long-term positive linear expansion.
d.	Mechanical loads **Competitive properties**	For WBEs exposed to loads outside relevant knowledge /experience envelopes (examples: geothermal, injection, high depletion, high pressure tests etc.), FEA (Finite Element Analysis) analysis should be performed and a 40 % safety factor in each individual load case should be achieved.
e.	Chemical stability **Good**	Withstand exposure to chemicals or substances that can exist without substantially affecting required integrity. Examples: H_2S, CO_2, H_2O, brines, hydrocarbons
f.	Bonding to tubulars **Good**	Shall bond properly to uncoated and de-greased steel or other tubulars in contact with it where bonding is required. If bonding cannot be achieved, the material shall be proven to have a compensating mechanism, such as expansion, that provides a hydraulic seal to casing and any exposed formation in contact with it.
g.	Effect on tubular integrity **None**	Shall not detrimentally affect properties of tubulars in contact with barrier material.

Approved by SWIPA

Can low CO_2e solutions be used for P&A?

SWIPA plug leak test comparison **NOTE: unpublished & temporary data**

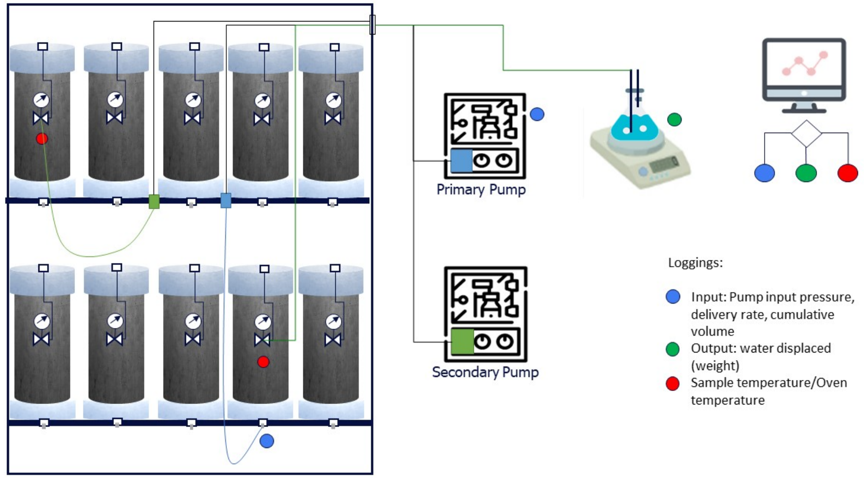
Leak test of 400 mm long plug in 5” pipe

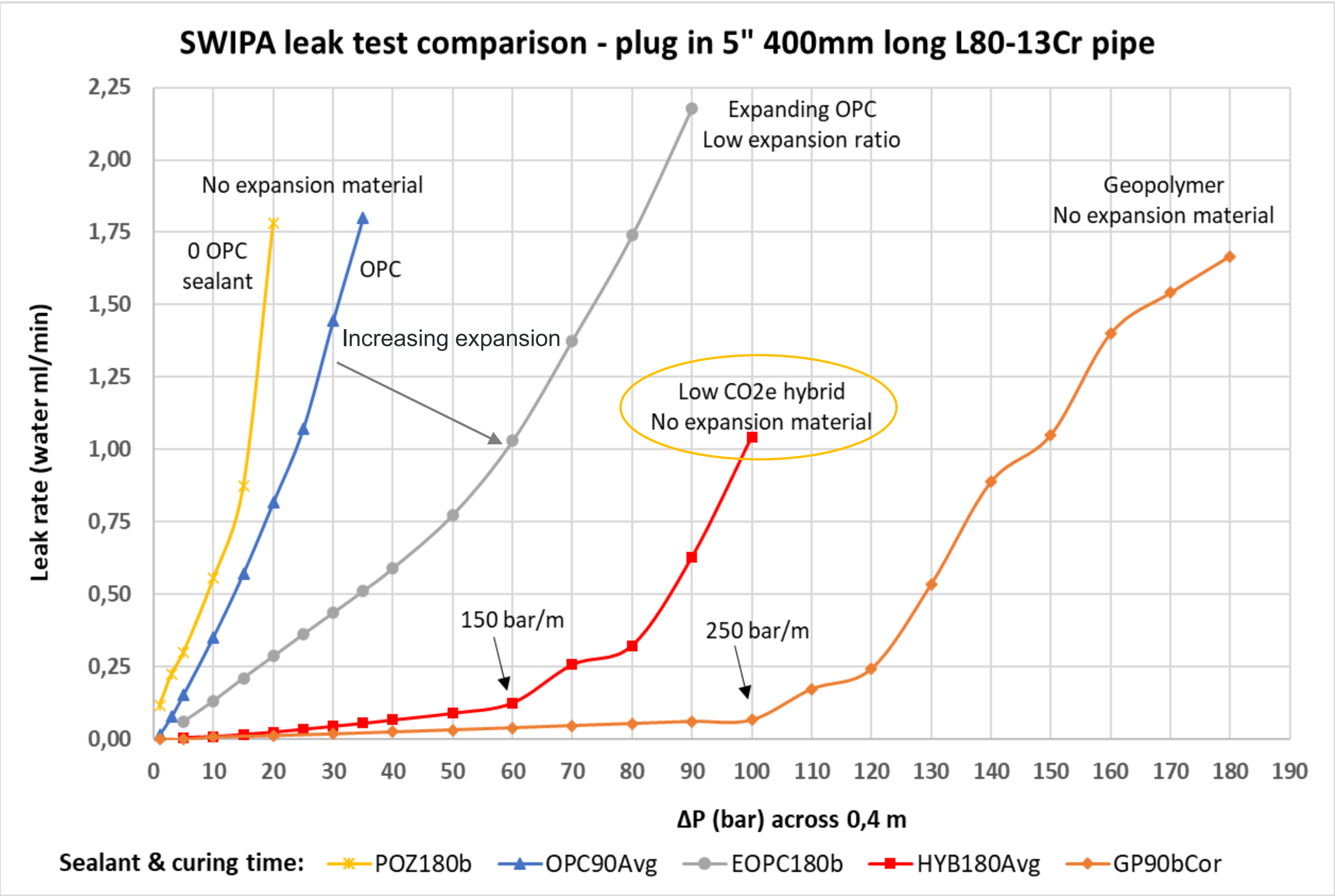
NeoCem E+ NS outperforms OPC

NeoCem E+ NS outperforms expanding OPC (low expansion ratio), <u>without</u> using any expansion additive

Geopolymer also outperforms expanding OPC

Note: expansion can be tuned in any of these





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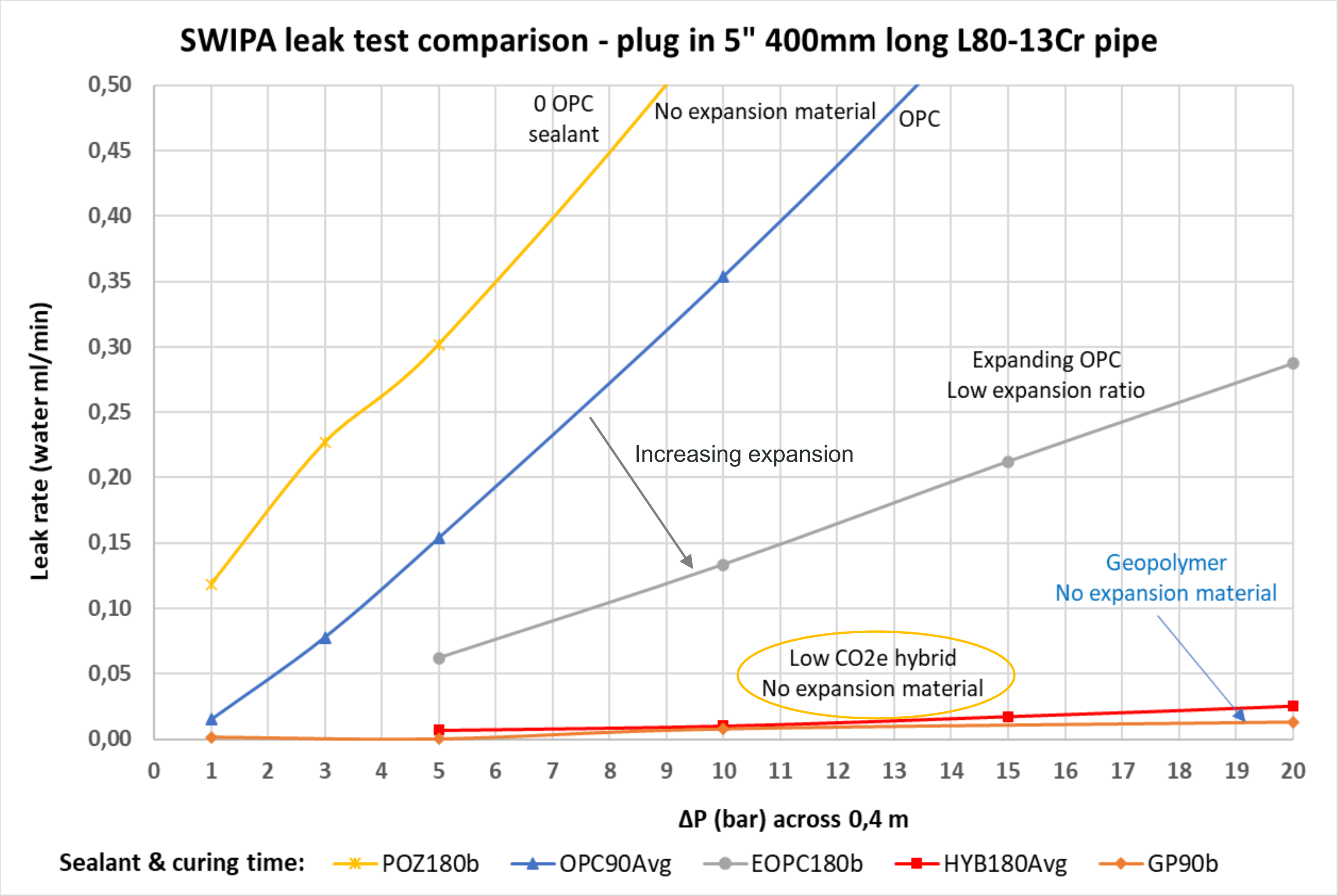

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Can low CO2e solutions be used for P&A?

Performance experience

So far (August 2023) we have done 26 plug jobs with the Halliburton low CO2e blend, with 384 m^3 pumped

No operational problems encountered

10 jobs tagged, average WOCT 12 hours, shortest 6 hours

5 jobs pressure tested, average WOCT 13 hours

Lowest UBHST 10°C, highest 145°C

Job category	Job category count	Job category volume (m3)	Average UBHST (°C)	Average BHCT (°C)
Pilot hole plug	9	103	36	21
Surface Plug	6	72	19	17
CH plug	1	16	21	18
OH plug	9	145	82	62
BHKA OH plug	1	48	125	90

Totally ±3700 m^3 / 3700 MT pumped (all job types)

Conclusion: Yes they can be used and can match performance of OPC when temperature is sufficient

THANK YOU

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We acknowledge our customers for making this possible:

ConocoPhillips Norway

Aker BP