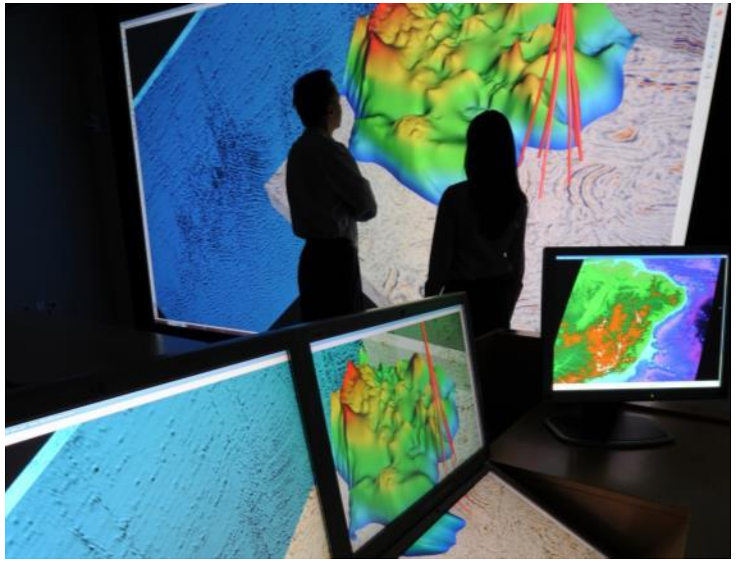

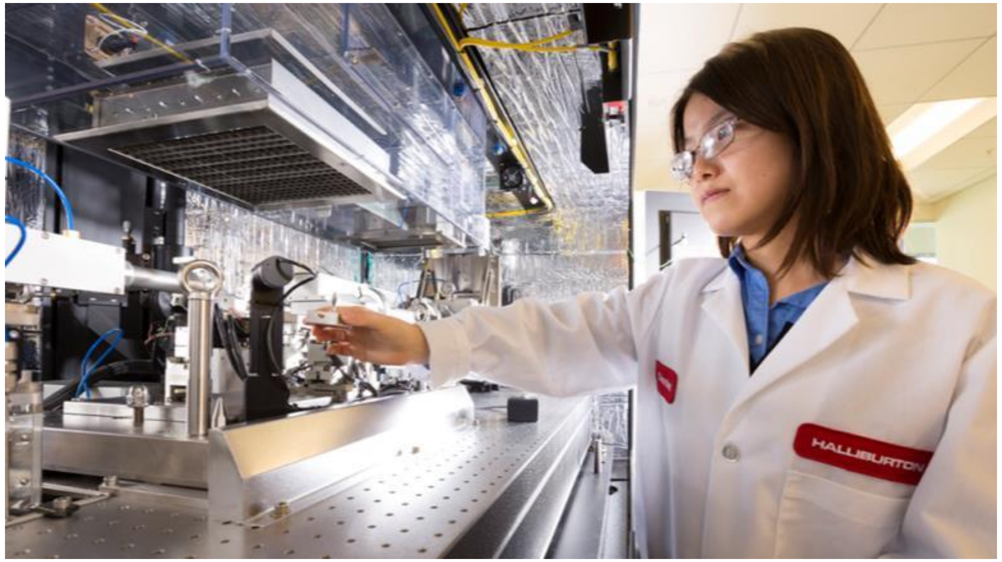

PAF 2018

Tailored P&A fluid for PW&C operations

Gunnar Lende & Duncan Clinch

Technical Managers

Halliburton Cementing & Baroid Norway

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Incentive for new integrated P&A mud and spacer for PW&C operations

Large volume of spacer consumed due to nature of operation

- Mixing
- Handling
- Pumping
- Waste, etc.

Spacer contains surfactants

Massive mud contamination due to pump & pull operation

Spacer contaminates mud ➔ surfactants in mud ➔Mud foaming problems

➔ mud soon becomes useless and has to be disposed of

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Idea for new integrated P&A mud and spacer for PW&C operations

Instead of concentrated surfactants in spacer with short exposure time:

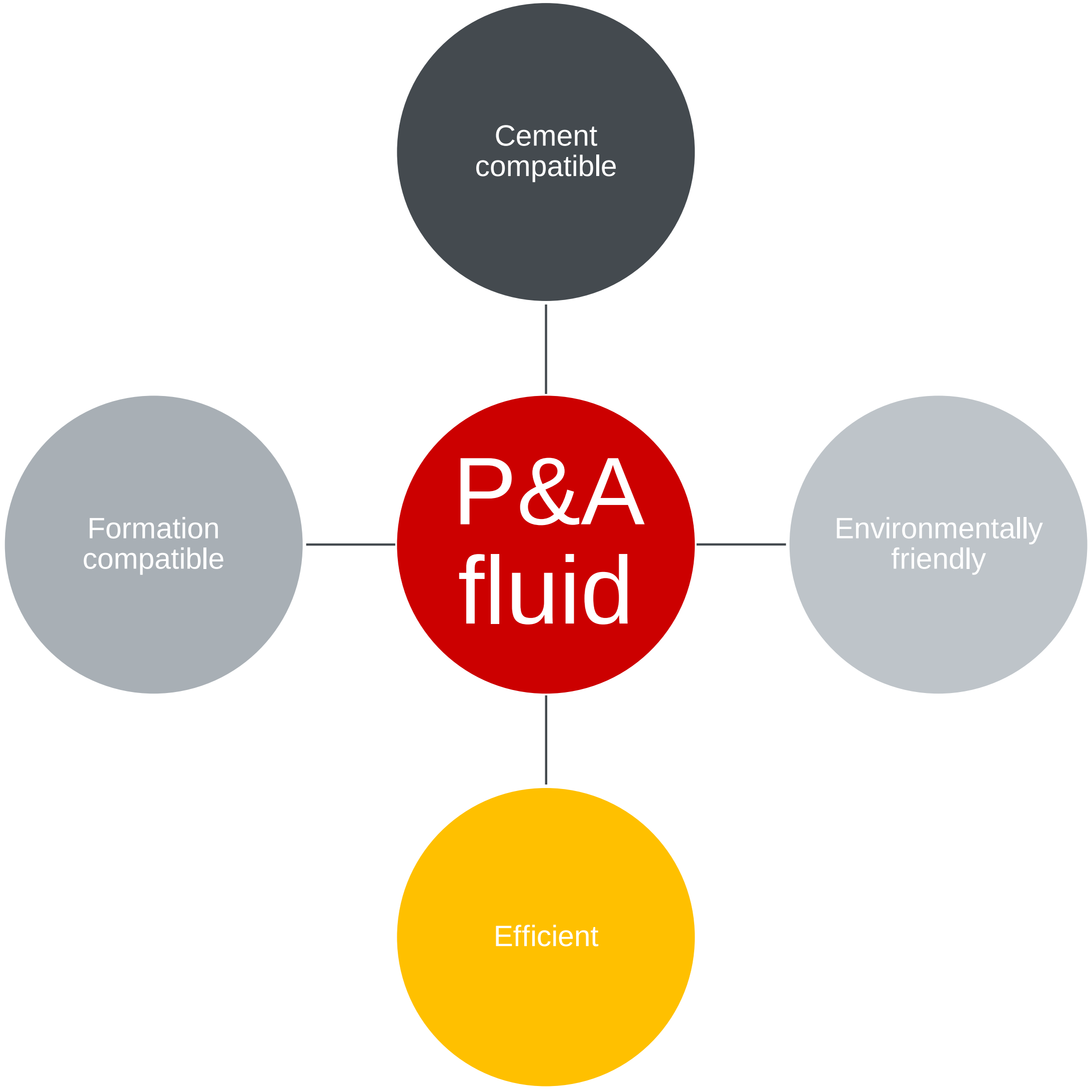
- Low concentration in P&A fluid with long exposure time

Save time by integrating spacer and P&A mud into one fluid

Make environmentally friendly so can discharge

May trigger formation swelling to finish the job

- Expanding cement + formation creep
- ➔ best possible sealing potential



<u>Challenges</u> for new integrated P&A mud and spacer for PW&C operations

Can a standard drilling fluid act as spacer for cement?

Answer is NO!

Many chemicals used in drilling fluid are generally not OK to get into the cement

- Excessive retardation, or
- Excessive acceleration
- Unacceptable strength development
- Excessive viscosity and gelation
- Unmanageable placement complications
- Practical problems on rig

Cement incompatible

Formation compatible

Std drilling fluid

Environmentally friendly

Efficient

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<u>Challenges</u> for new integrated P&A mud and spacer for PW&C operations

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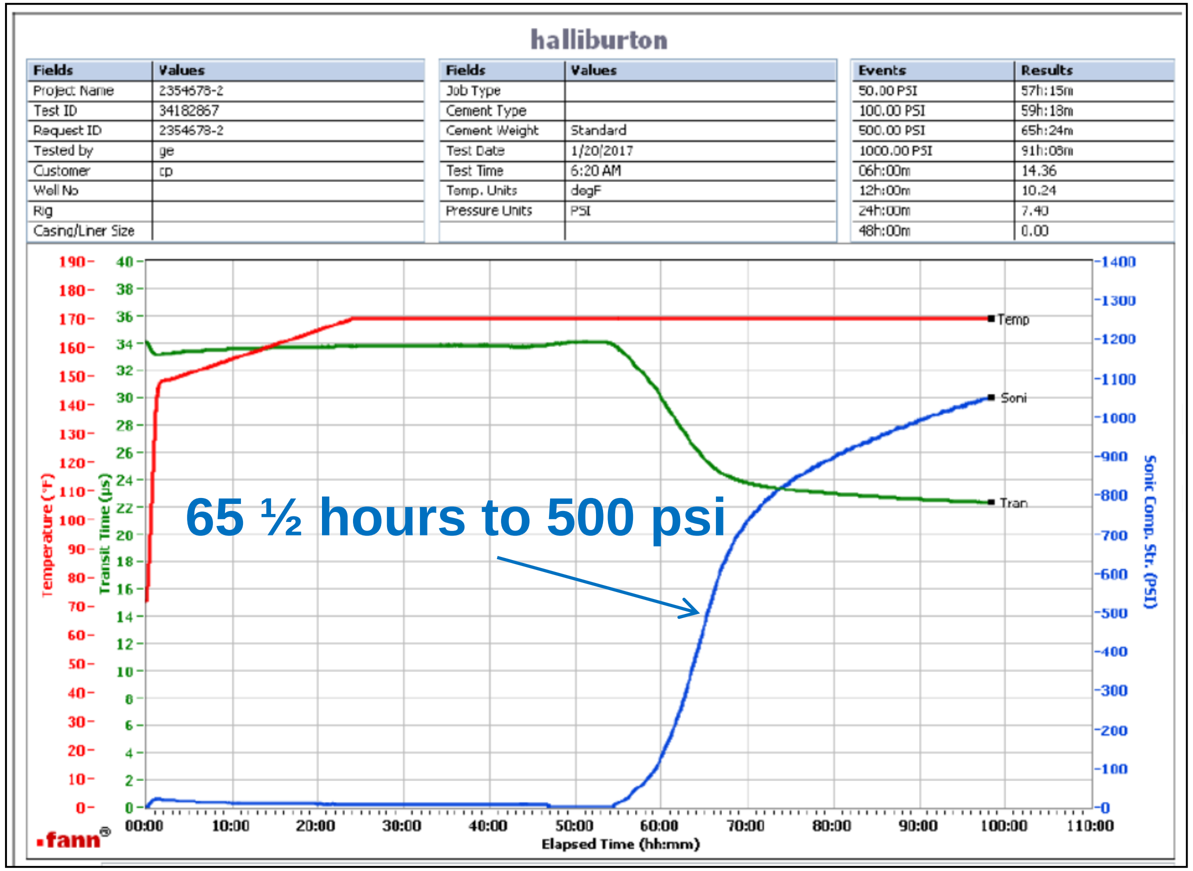

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Fields	Values
Project Name	2354678-2
Test ID	34182867
Request ID	2354678-2
Tested by	ge
Customer	cp
Well No	
Rig	
Casing/Liner Size	

Fields	Values
Job Type	
Cement Type	
Cement Weight	Standard
Test Date	1/20/2017
Test Time	6:20 AM
Temp. Units	degF
Pressure Units	PSI

Events	Results
50.00 PSI	57h:15m
100.00 PSI	59h:18m
500.00 PSI	65h:24m
1000.00 PSI	91h:08m
06h:00m	14.36
12h:00m	10.24
24h:00m	7.40
48h:00m	0.00

20:80 mud:cement example

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<u>Solution</u> for new integrated P&A mud and spacer for PW&C operations

Can we make a P&A fluid that can act as spacer for cement?

Answer is YES

Select/develop chemicals compatible with cement,

but still do the job in mud,

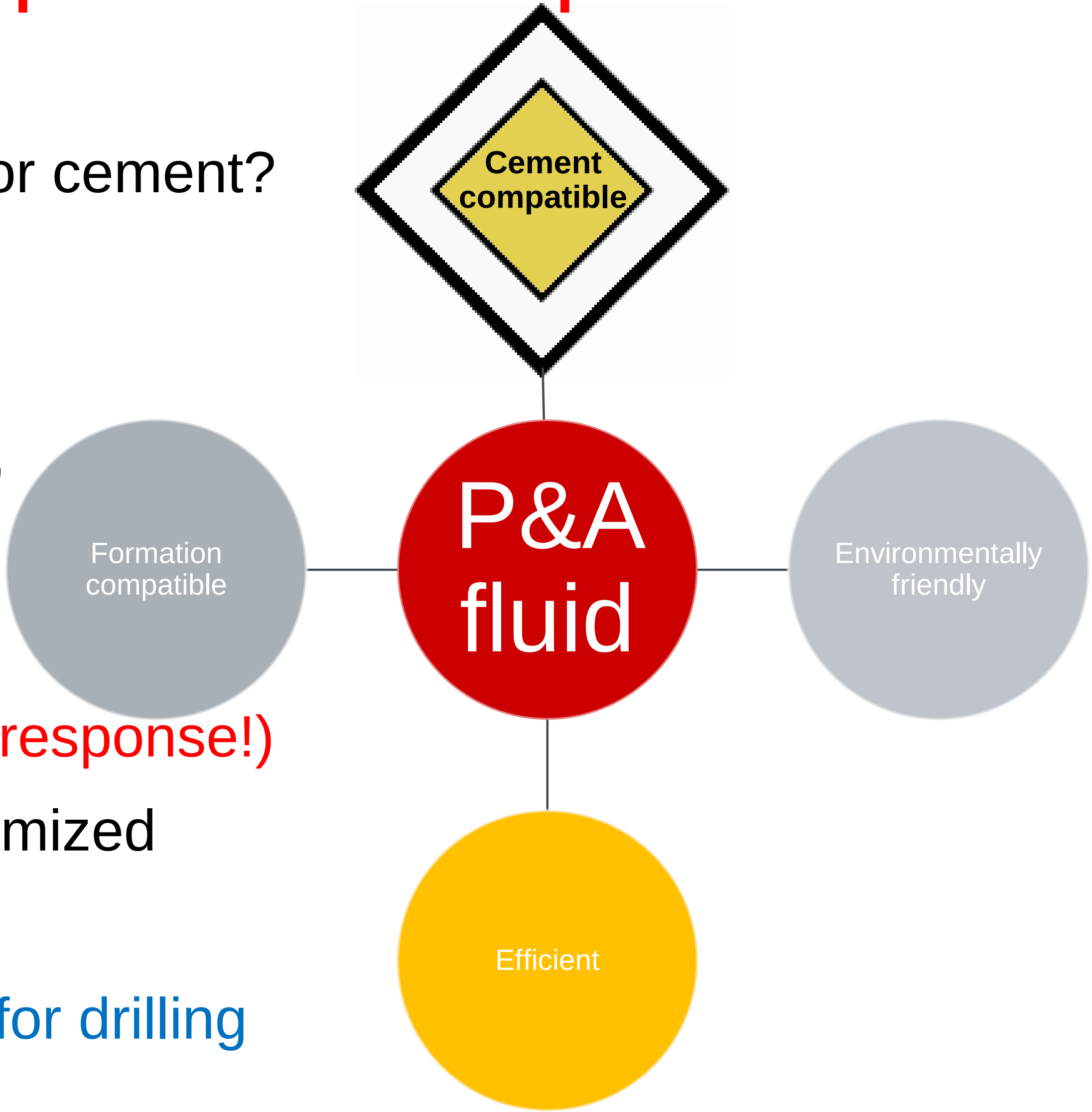
and be environmentally acceptable for discharge

Tailor design to application (understand formation response!)

Careful testing and iterative development until optimized

Application window may be very narrow

Short term life span and quite possibly unsuitable for drilling



Design criteria for new integrated P&A mud and spacer for PW&C operations

- Compatible with the cement design
- Sea water based (may trigger slow formation swelling)
- Suitable for the Perf, Wash & Cement operation
  - High velocity nozzle exposure, high ΔP;
  - PLUS low shear cmt plug placement inside pipe
  - Intermixing with behind the casing material (barite, cuttings, old mud, etc.)
  - Cuttings lifting capacity
- Environmentally acceptable materials only (OSPAR/SKIM Y1 or better)
- Non-foaming surfactants
- Topside work environment friendly
- Easy to mix
- Reasonable cost

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Working the problem

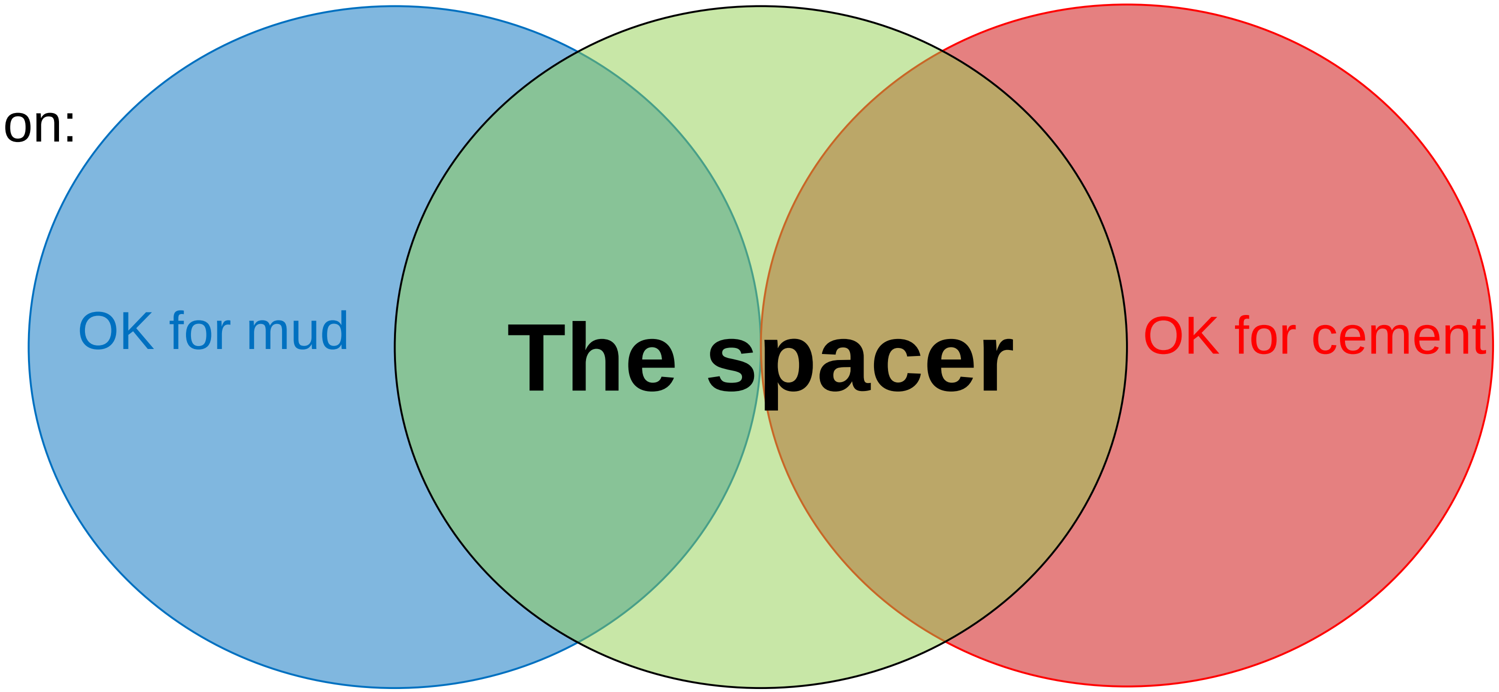
Cumbersome lab work on both cement and mud side

Multiple iterations

Essential collaboration between mud design engineer and cementing design engineer

Most mud chemicals have negative impact on cement ➔useless in a spacer

Typical situation:



The traditional way

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So how did it go?

After a lot of work:

Halliburton Cement Norway worked with both A/MI and Baroid to develop solution

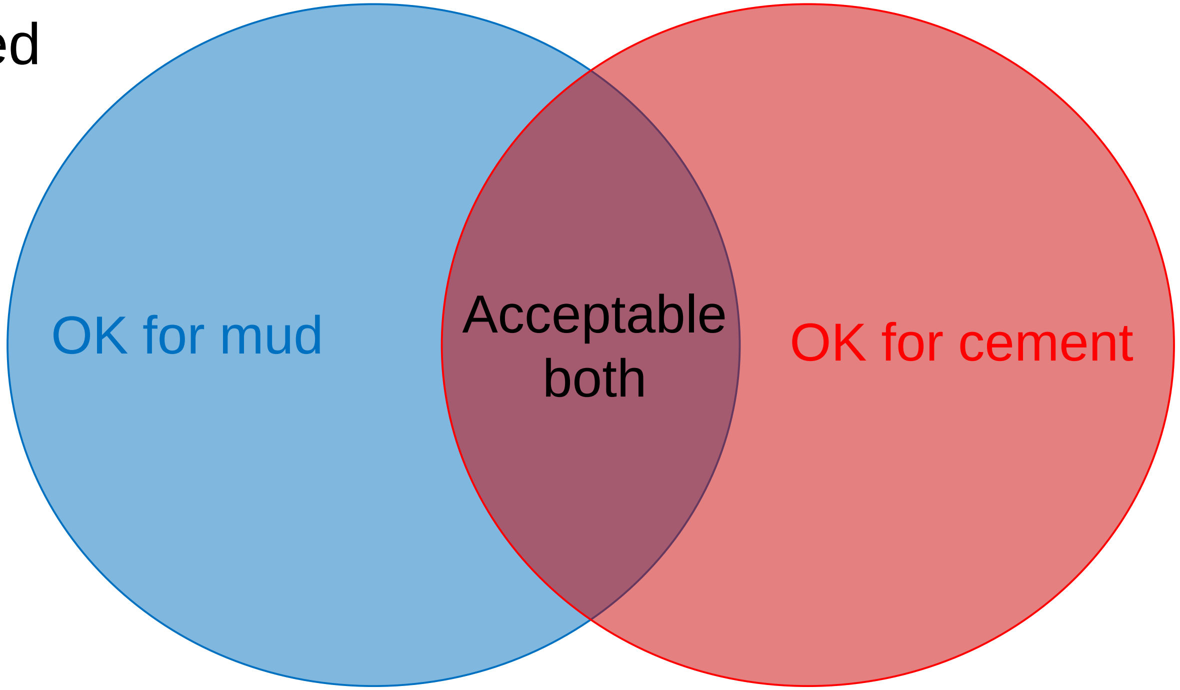
Not perfect but an acceptable compromise

Highly tailored to application

Several new mud additives introduced

Modified AbandaCem slurry design

Successful field implementation



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Fluid test results (last job)

Fluid compatibility tests:

100% criteria

(Limit = 2 x highest; ½ x lowest)

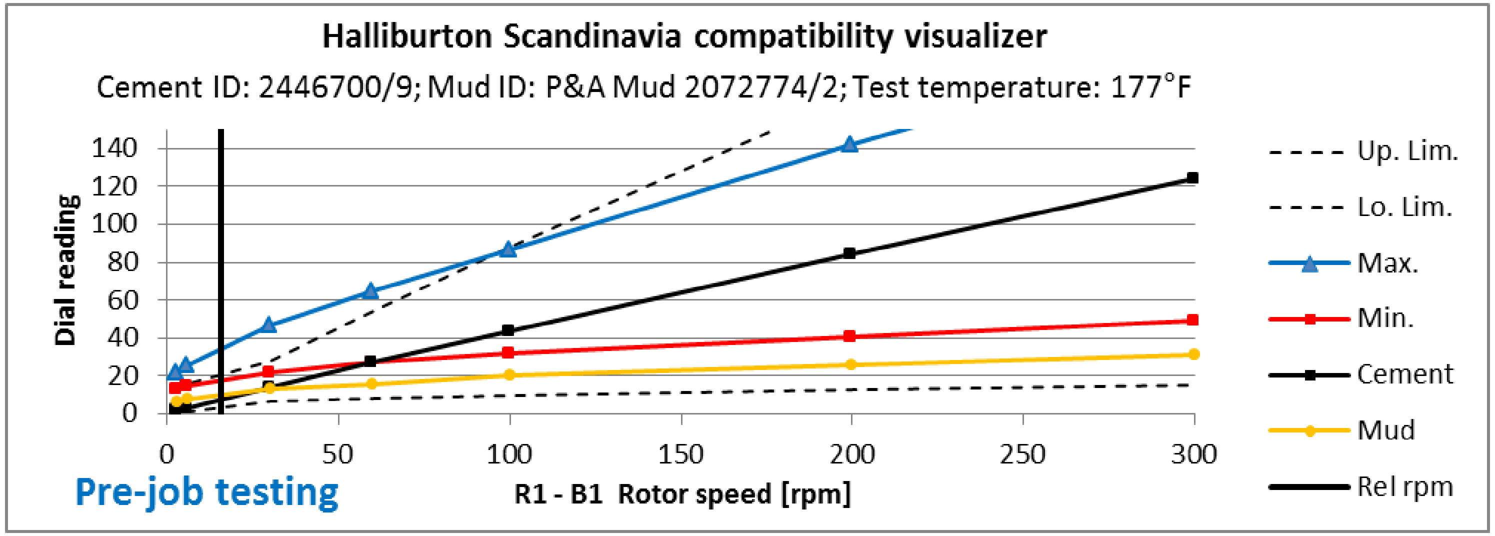
vs

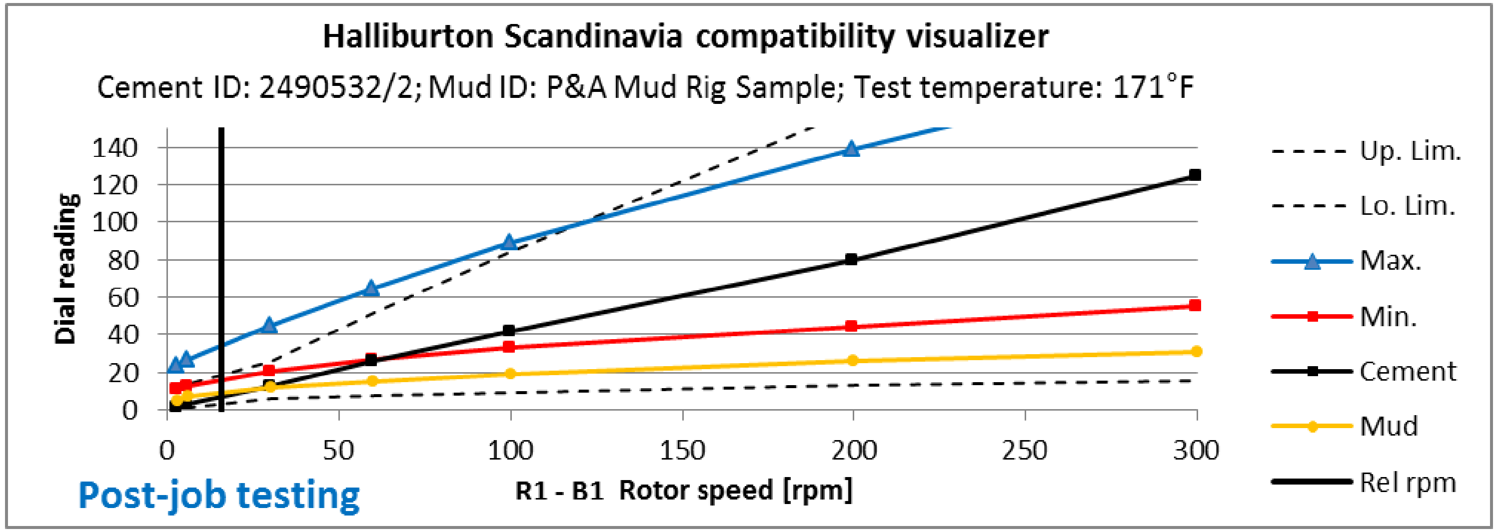
Max & Min reading recorded

Post job test results

confirmed

Pre-job test results





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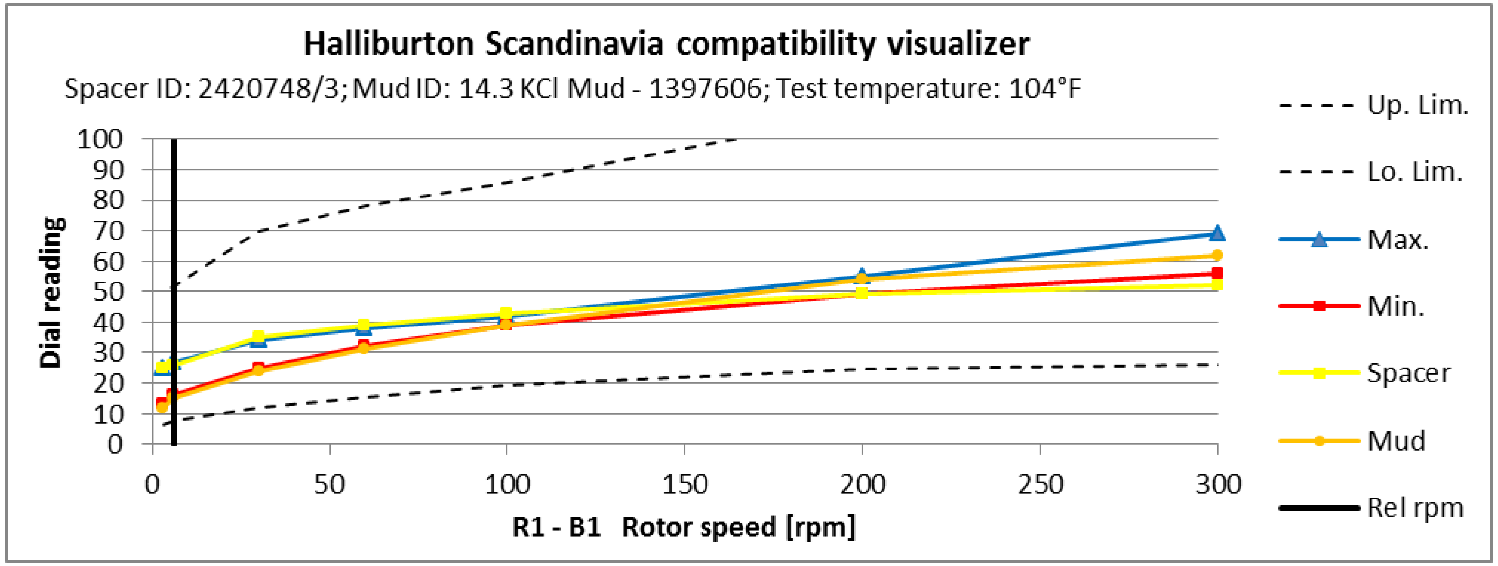
Spacer reference

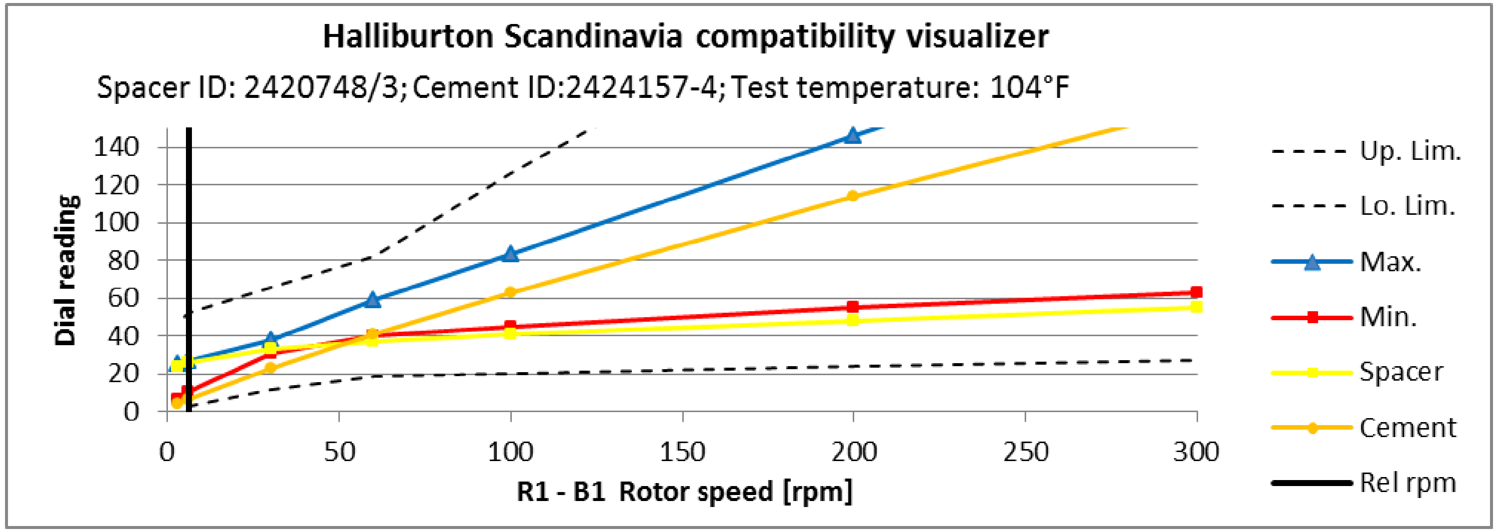
Fluid compatibility tests:

Purpose made spacer example

(EcoSpacer II)

100% criteria





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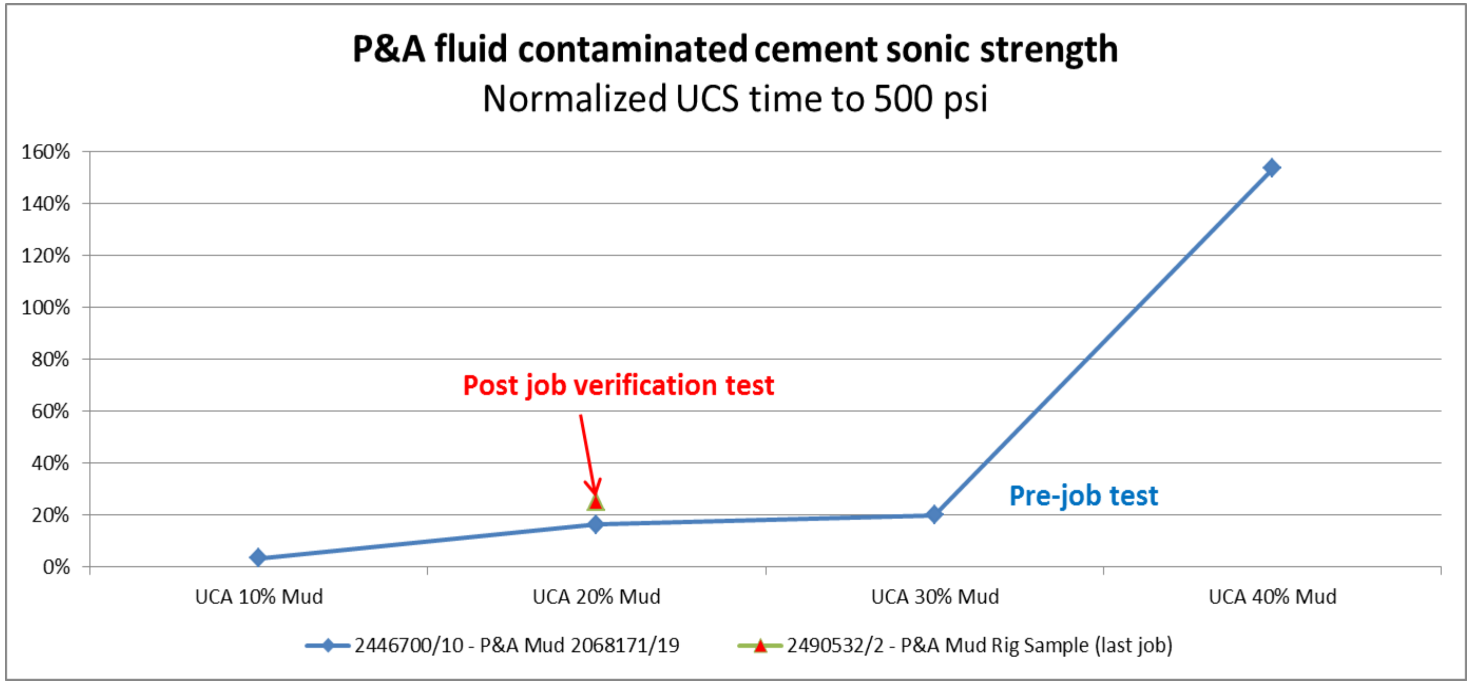
Fluid test results (last job)



Impact on strength development

Minimal impact from chemicals at moderate dilution

Then retardation at 40/60

A heavily diluted cement will not have the necessary low permeability to be a barrier

Or it is so contaminated it is not a continuous plug

➔Contamination greater than 20 – 30 % not really of interest

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Spacer reference:

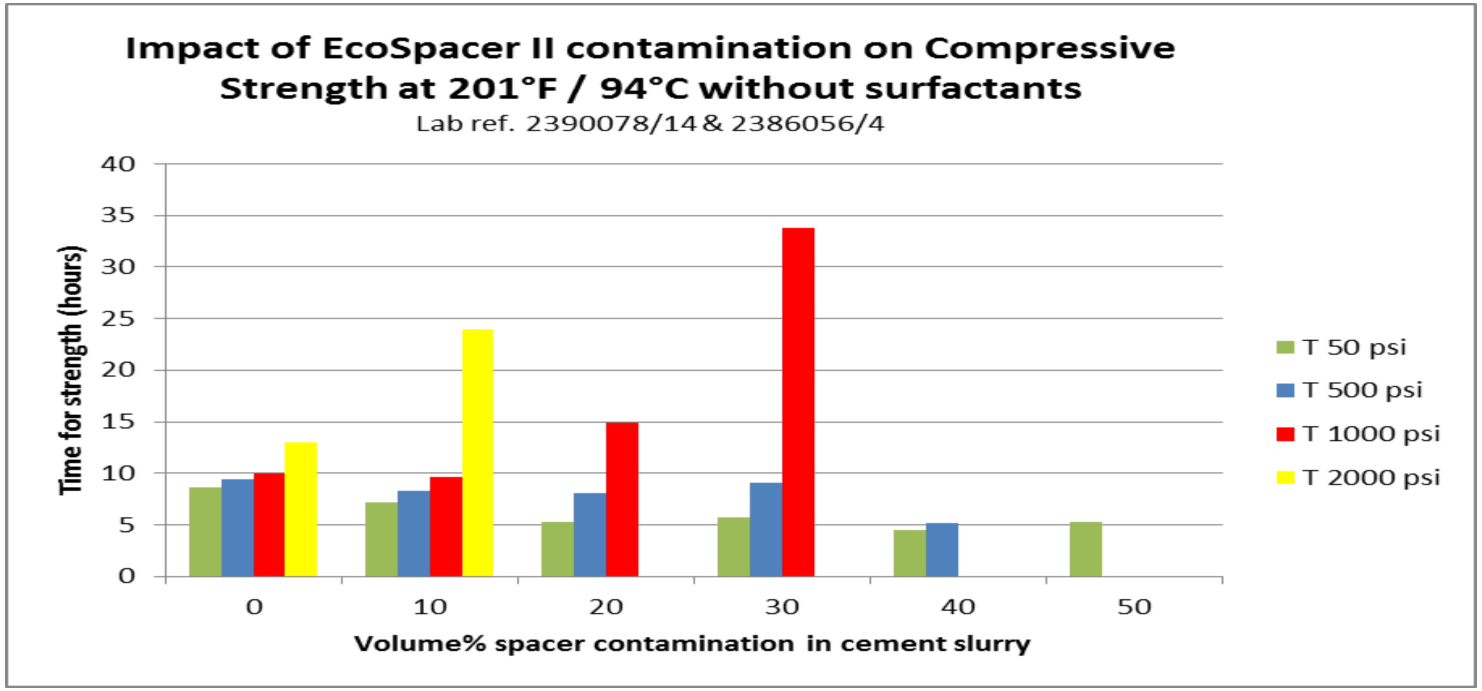
Impact on strength development

Purpose made spacer example

(EcoSpacer II)

No retarding chemicals

Dilution only effect seen



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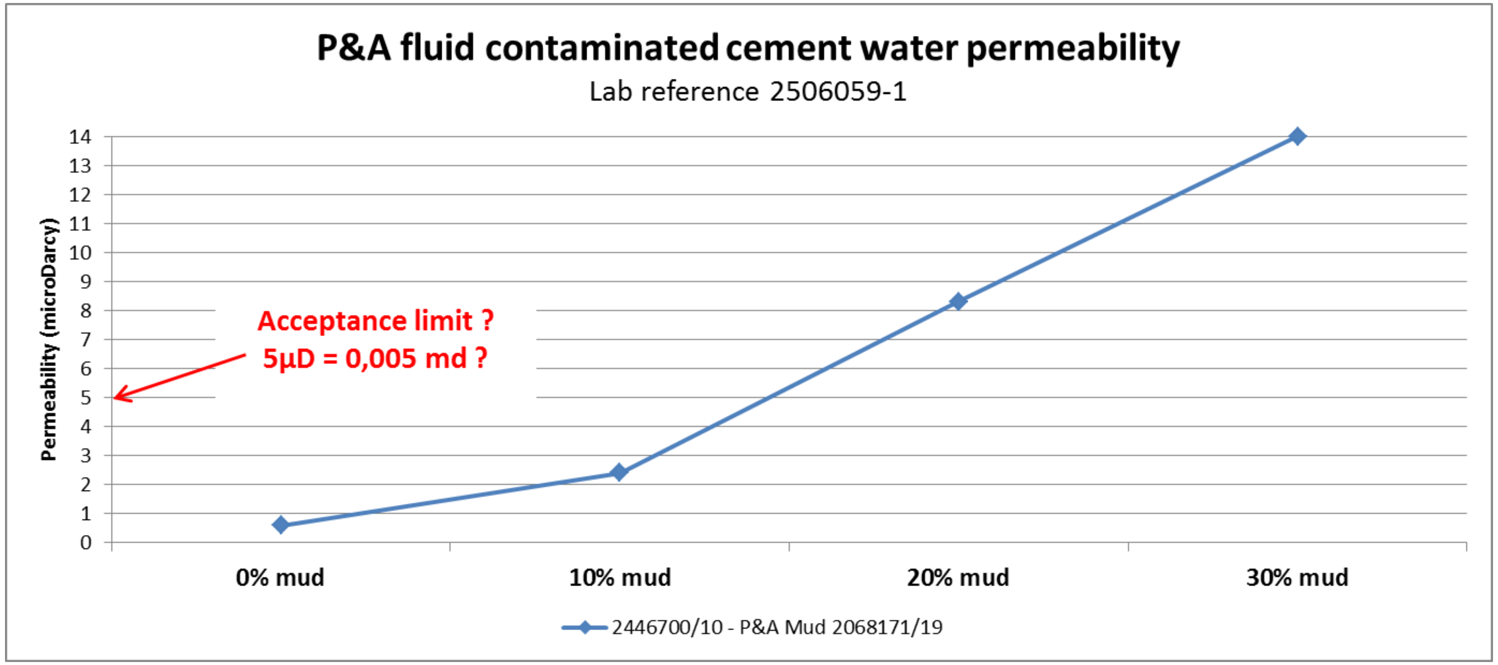
Contamination impact on Kw

Cement permeability tests:

Kw = H_2O permeability

- 5 days curing
- Increasing mud dilution
- Otherwise identical conditions



Who can say what is an acceptable permeability?

The acceptance limit depends on several parameters

At the end of the day the operator has to decide on acceptable leakage rate

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Leakage rate comparison

$$K = 14\,700 \frac{q \cdot \mu \cdot L}{A \cdot \Delta p}$$

K is the permeability, expressed in millidarcies;

q is the flow rate, expressed in millilitres per second;

μ is the liquid viscosity, expressed in centipoise;

L is the sample length, expressed in centimetres;

A is the cross-sectional area, expressed in centimetres squared;

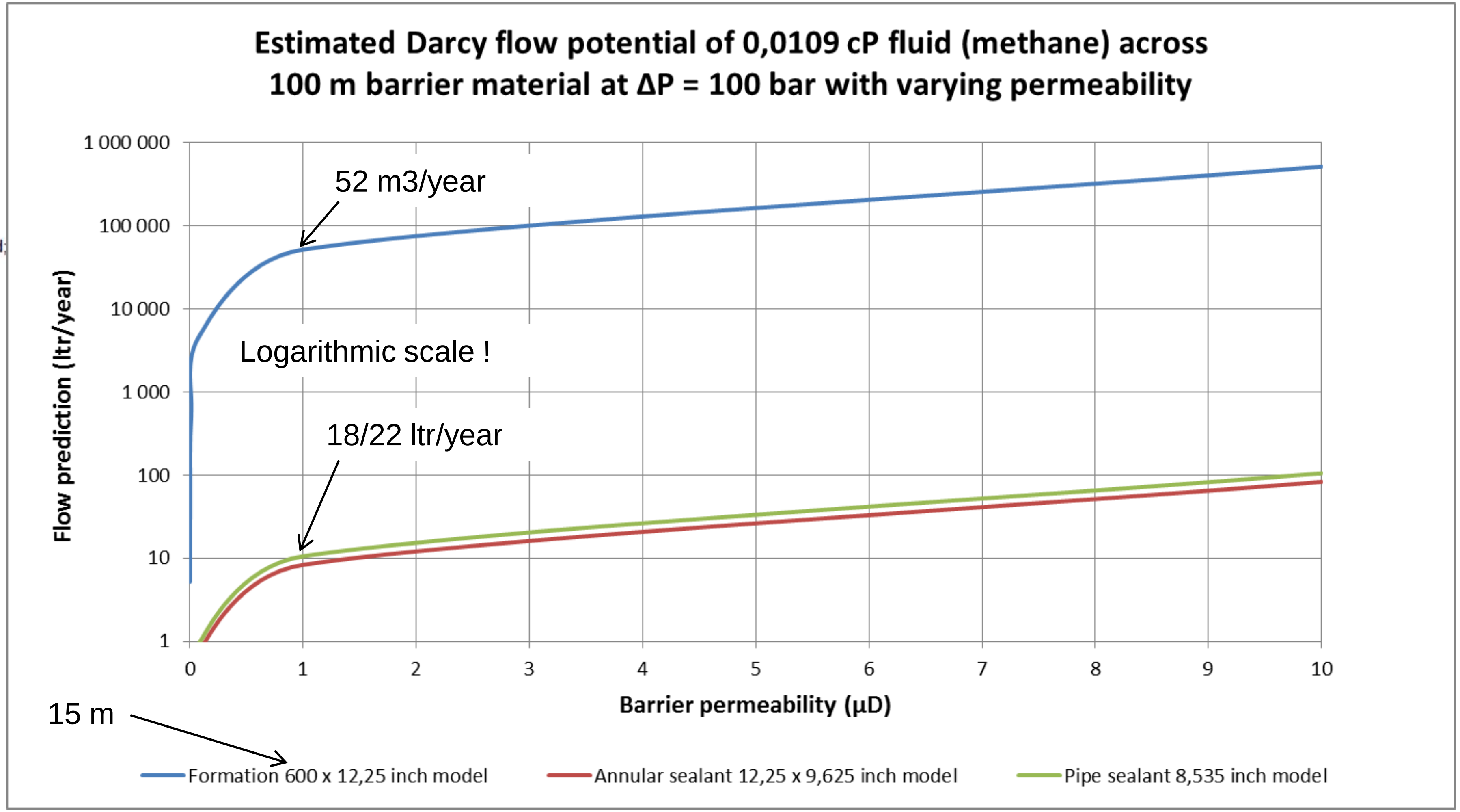
p_i is the inlet pressure, expressed in pounds per square inch;

p_o is the outlet pressure, expressed in pounds per square inch;

Δp is $(p_i - p_o)$, expressed in pounds per square inch.

$$Q = \frac{K*A*\Delta P}{\mu*L*14700}$$

Where $A = \pi/4*(D^2-d^2)$



<u>Diameter</u> is most dominating factor for Darcy flow calculations

Any fracture or micro annulus will throw leak rate off scale

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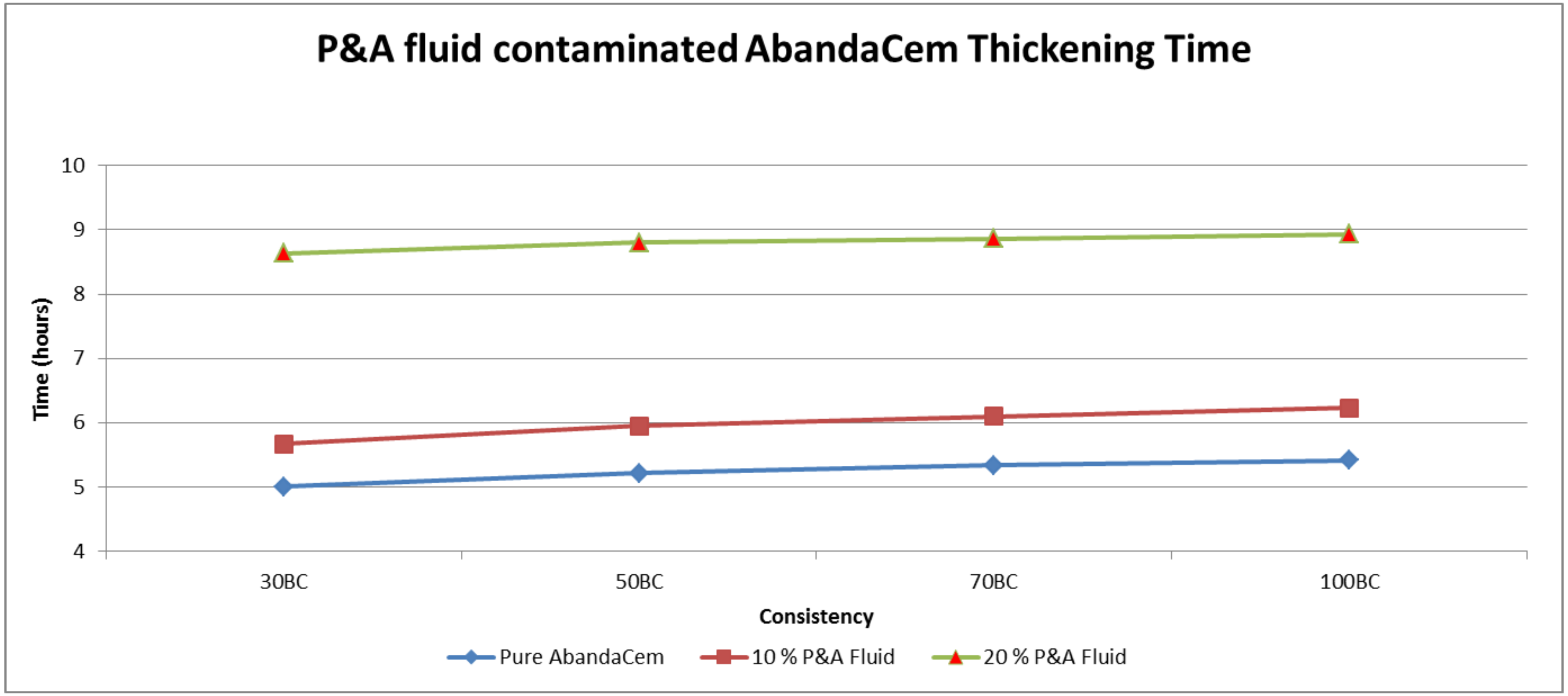
Fluid test results (last job)

Impact on Thickening Time

Key issue is to avoid reduction of pumpable time

No issues seen



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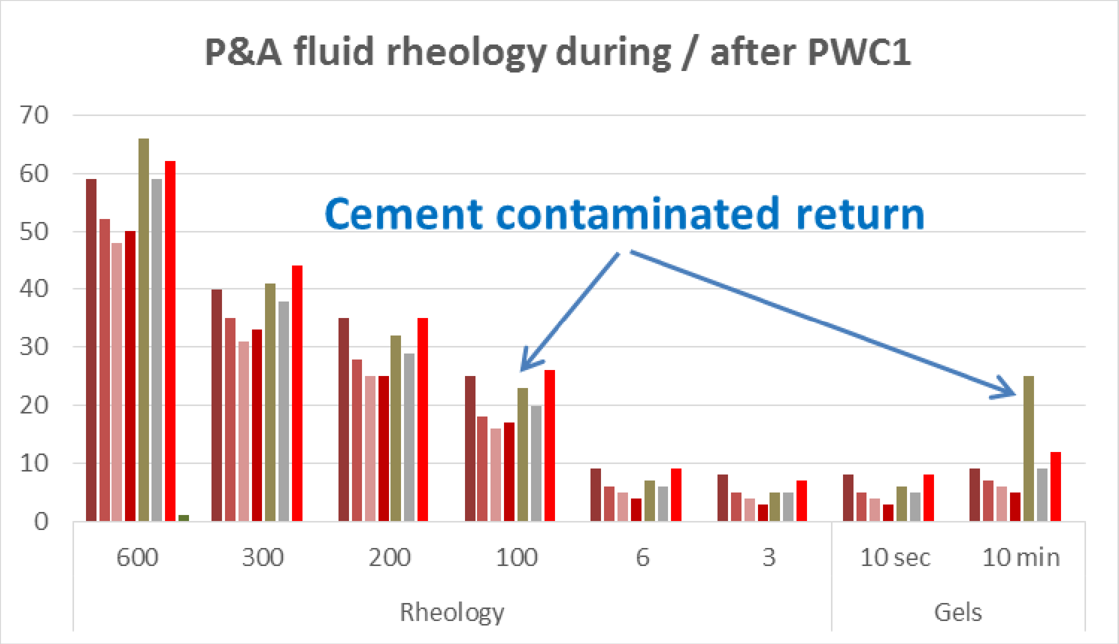
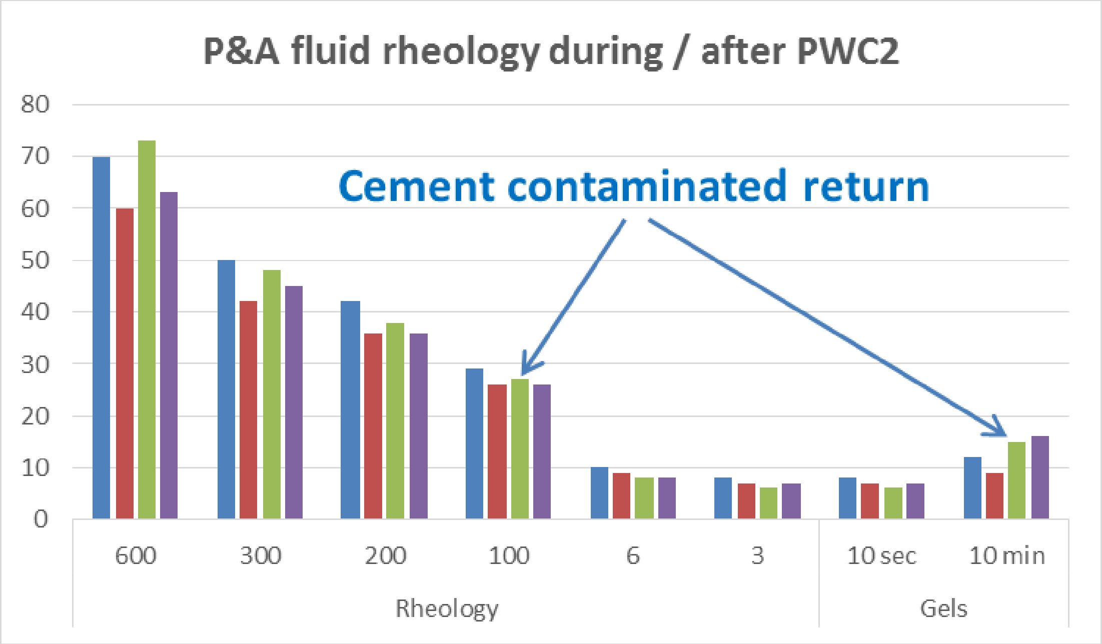
P&A fluid field results (last job)

Excellent results for mud field performance





OWR ➔ 1- 3% when washing due to OBM behind casing, no negative response

No foaming observed during entire plugging operation

No treatment with Sodium Bicarbonate or Citric Acid necessary

The PWC WBM was extremely stable and well suited for the PWC operations and only minor treatment was required for maintenance

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So how did it go?

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Last jobs have been successful

- No operational issues
- Fluid performed as intended
- Objective was met
- Time effective

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THANK YOU