Charge testing for well concept selection

November 2012

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EWAPS 12 - 6

Presented at 1st European & W African Perforating Symposium, Amsterdam 7 – 9 November 2012

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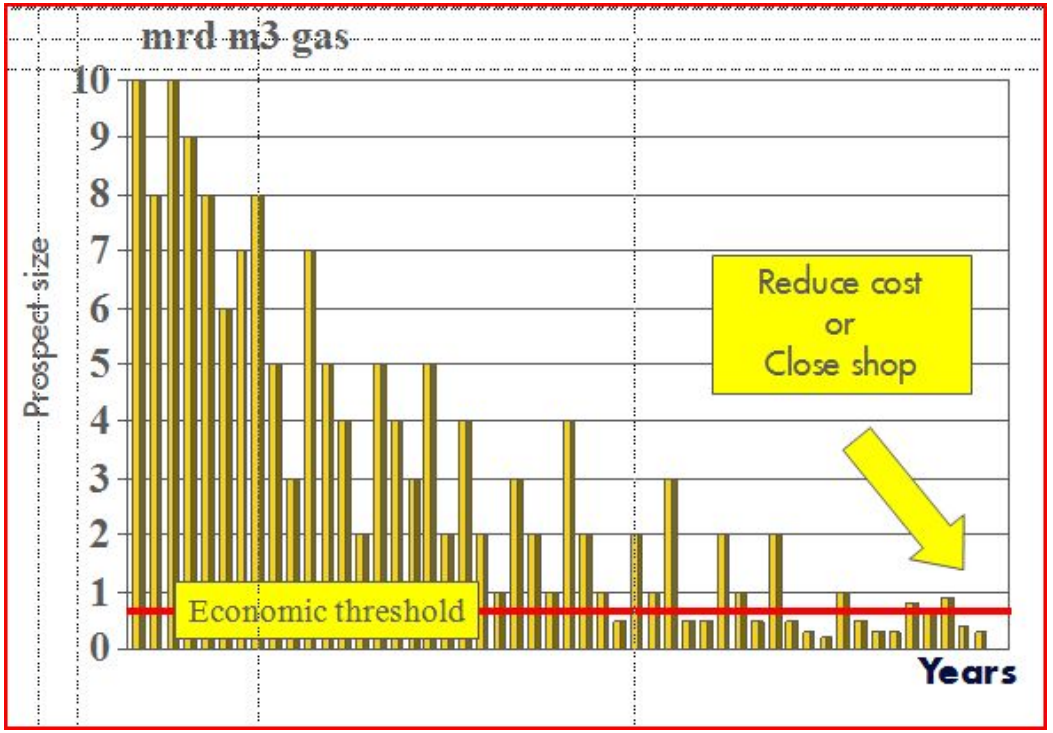
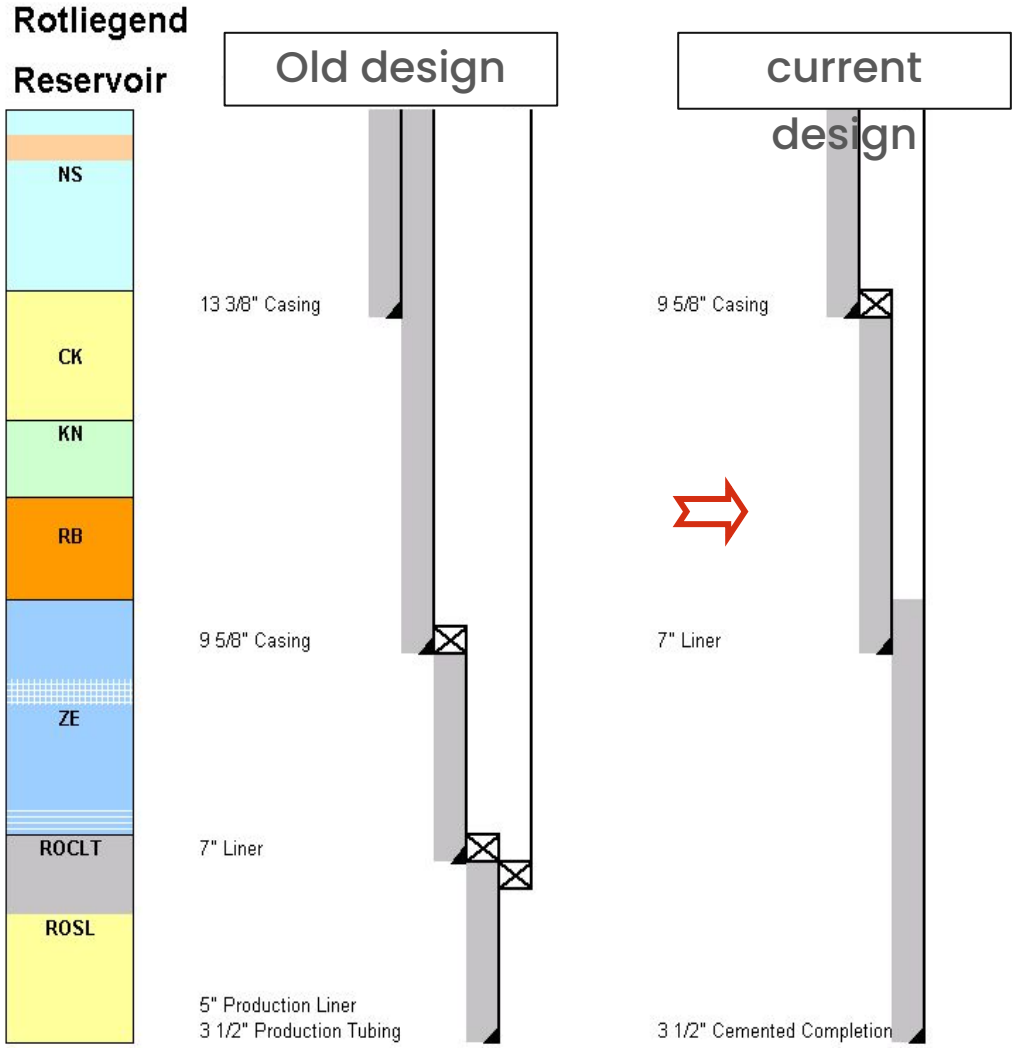
Well concept evolution

- Netherlands / Southern UK sector scene setting
  - Mature area, remaining gas/oil accumulations small size (0.2 – 1 BCM)
  - Early 2000's: "step change" in costs required
- Significant changes (down sizing) required in well design, rig selection, well functionality and surface lay-out in order to meet



Well concept evolution – 1st step

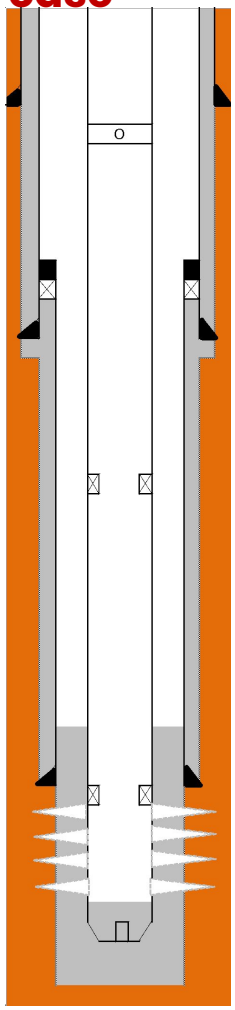


- Typical well data
  - Reservoir depths: 2800- 4600 mAH (1800 – 3500 m TVD)
  - Reservoir pressure 250 – 360 bar (undepleted)
  - Reservoir temperature 100 - 125 deg C
  - permeability : <1 - 50 mD, porosity 8 - 20 %
- typical features:
  - reduced csg sizes
  - simple wellhead
  - 3½" cemented completion
  - 2" perf guns, static balanced / slight underbalance for trigger interval

☐ Concept worked for no. of years BUT next step ?

Well concept evolution – the next step ?

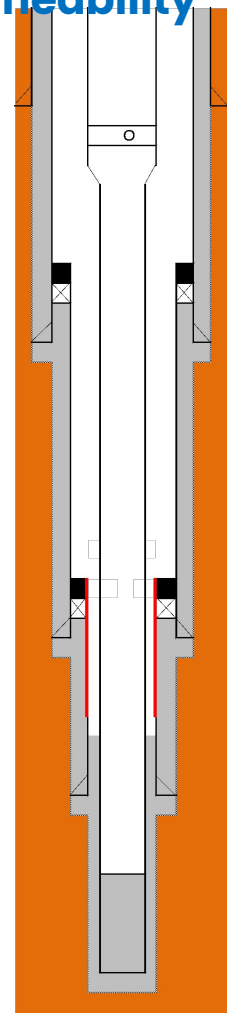
Current base case



3 ½" tbg, cemented in 6" – or 4 7/8" OH

2" guns

Proposed "slim" case, low permeability



2 7/8" tbg, cemented in 4 7/8"- or 3 15/16" OH

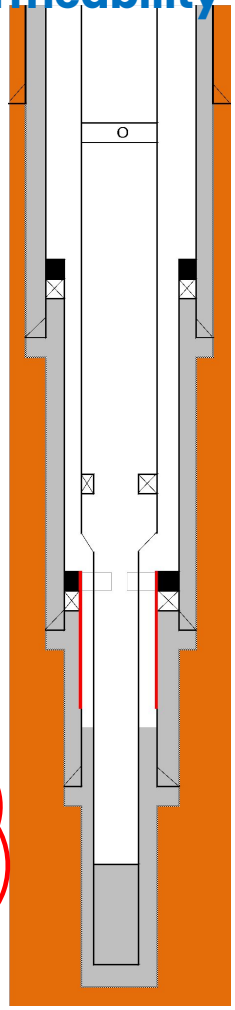
small guns:

1 9/16" or

1 11/16"

Driven by swell data assumptions

Proposed "slim" case, high permeability



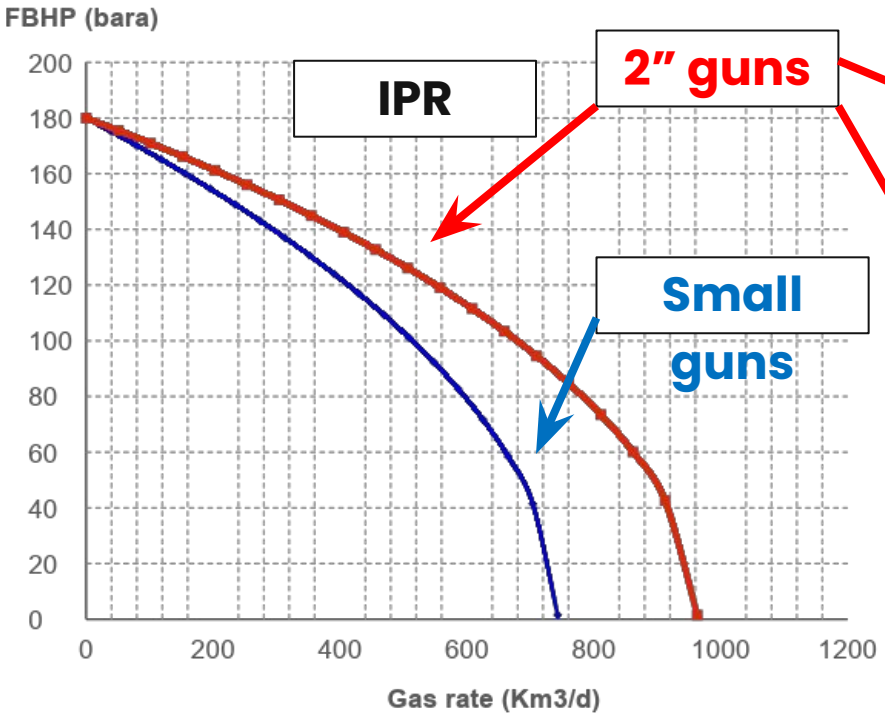
3 ½" * 2 7/8" tbg, cemented in 4 7/8"- or 3 15/16" OH

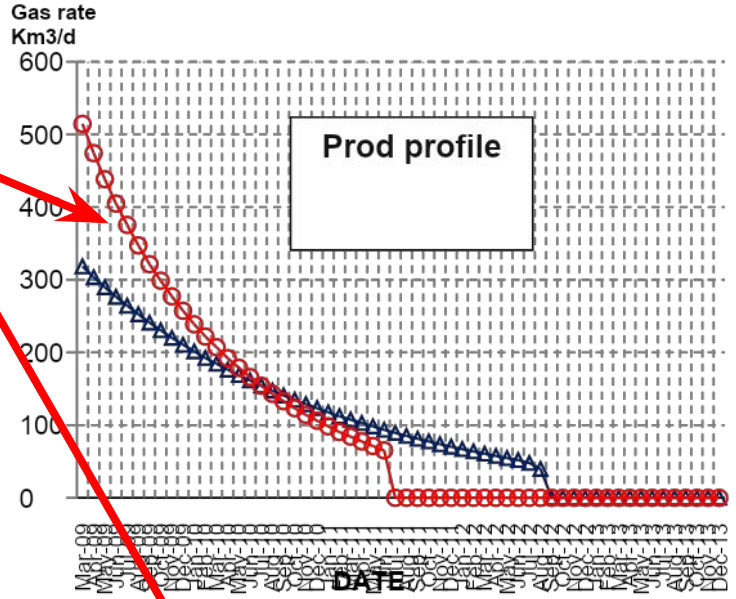
small guns:

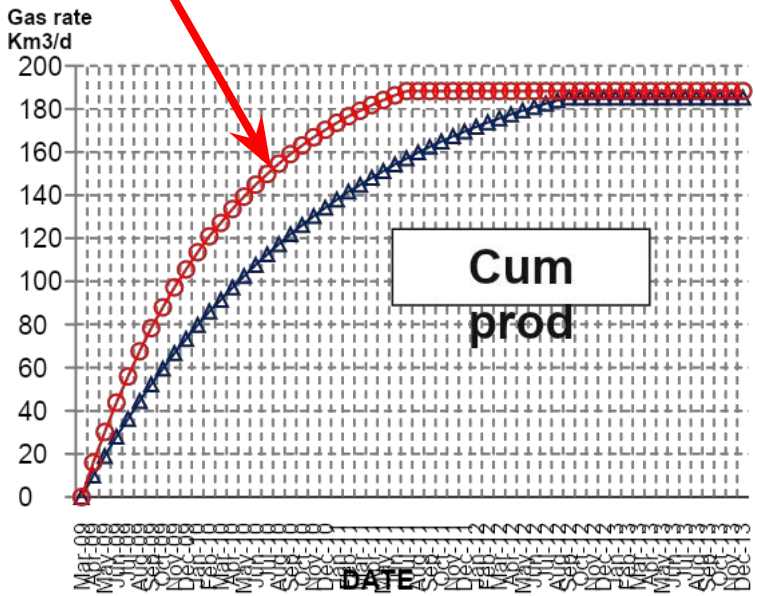
1 9/16" or

1 11/16"

Slim well concept – impact gun size (base modelling)







Case for charge testing:

based on initial modeling, impact (Q / NPV) of changing to slim completion could be significant needs further clarification

Test set-up / test conditions

Field conditions → Charge testing conditions in lab

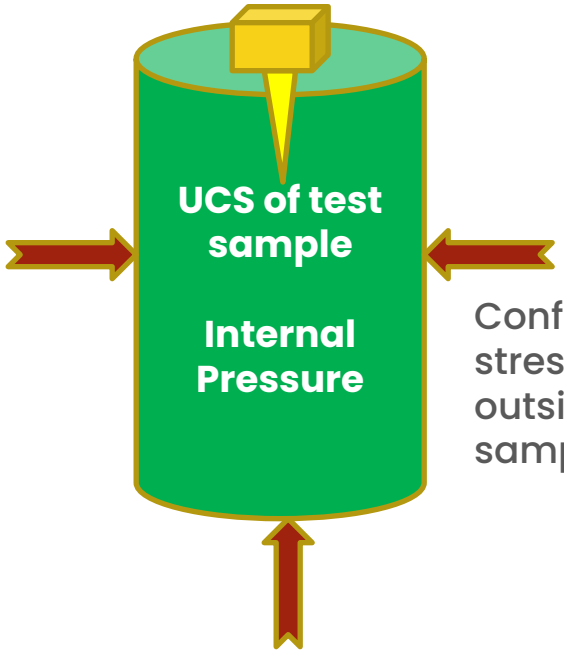
Overburden = approx 9200 psi (634 bar)

reservoir
UCS = 1000 – 2000 psi (70 – 140 bar)

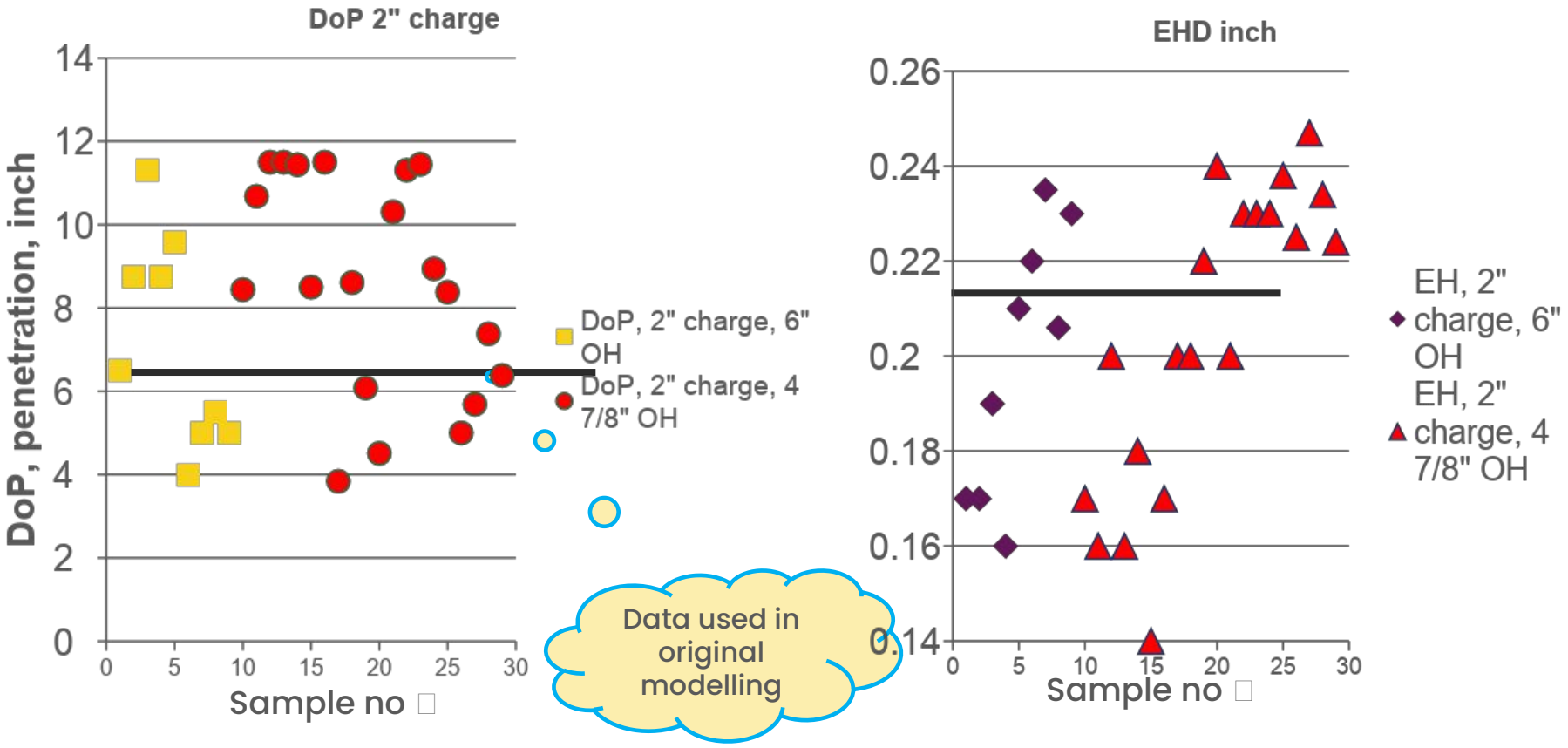
Res Pressure = 4350 – 5000 psi (180 - 350 bar)

In order to mimic field conditions as good as possible selected the following parameters:

- Carbon Tan material (sandstone)
- internal / confining stress
- Section 2 only, no flow conditions
- Various combinations OH

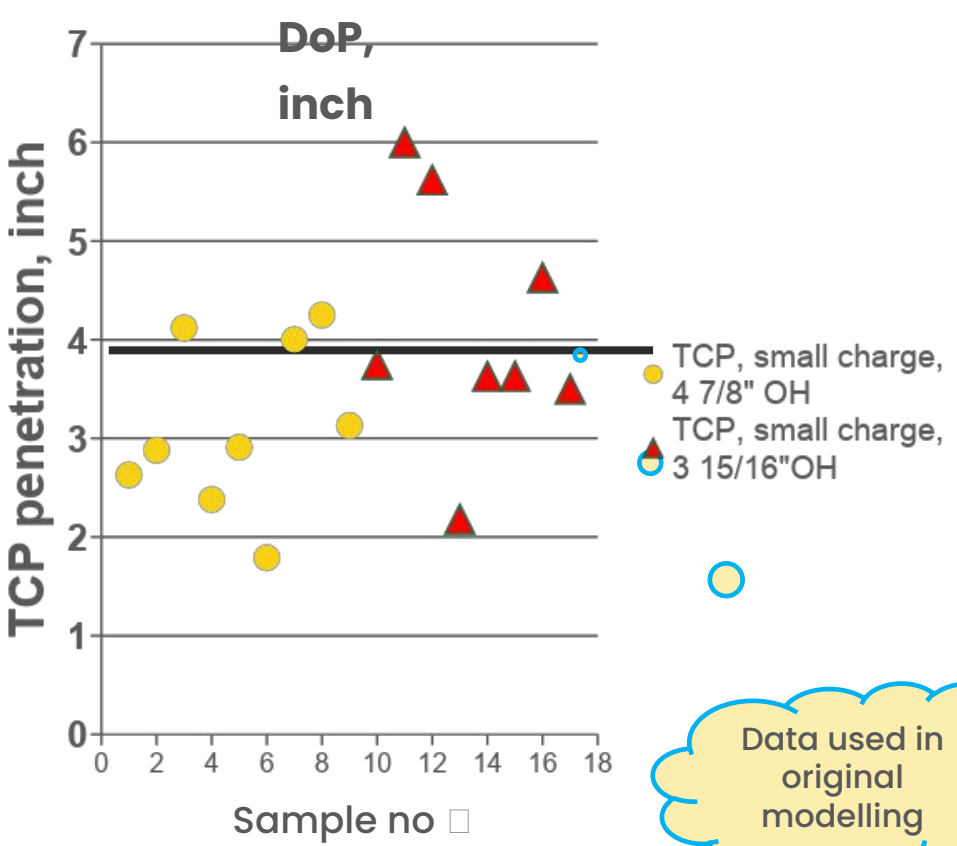


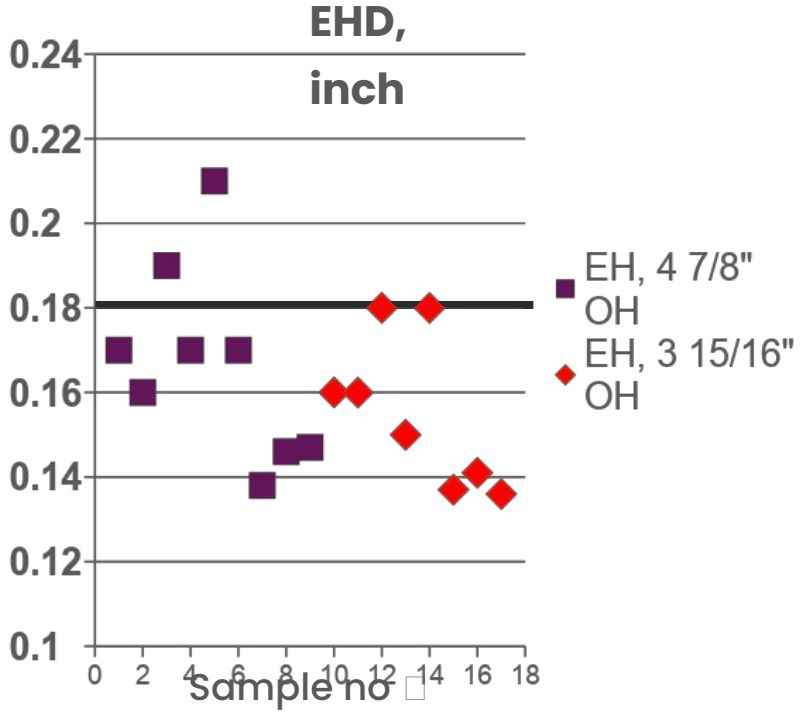
Charge test results 2” charge



- Carried out some 33 tests (3 labs, test data randomly plotted !!)
- Tests in 7” and 4” Carbon Tan cores, both centralised / excentralised.
- In some tests free gun volume (FGV) reduced to minimise effect DUB (dyn underbalance)

Charge test results small charge



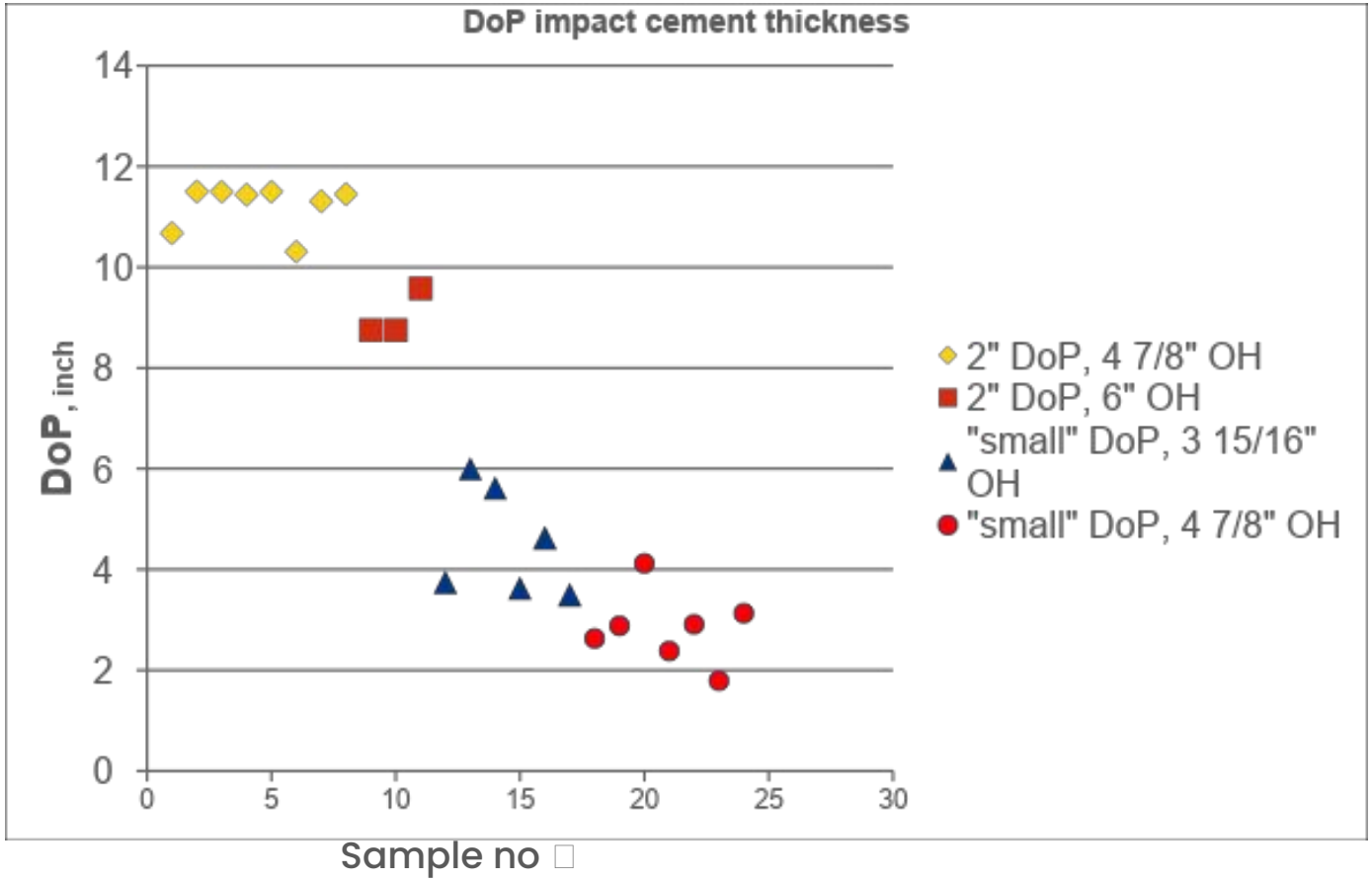


Data used in original modelling

- Carried out some 17 tests (3 labs, test data randomly plotted !!)
- Tests in 7” and 4” Carbon Tan cores, both centralised / excentralised.
- In some tests FGV reduced to minimise effect DUB

Findings charge testing (1)

- Futher analysis of results
  - Impact cement thickness clearly seen in majority of tests (6” vs 4 7/8” OH, 4 7/8” vs 3 15/16” OH)



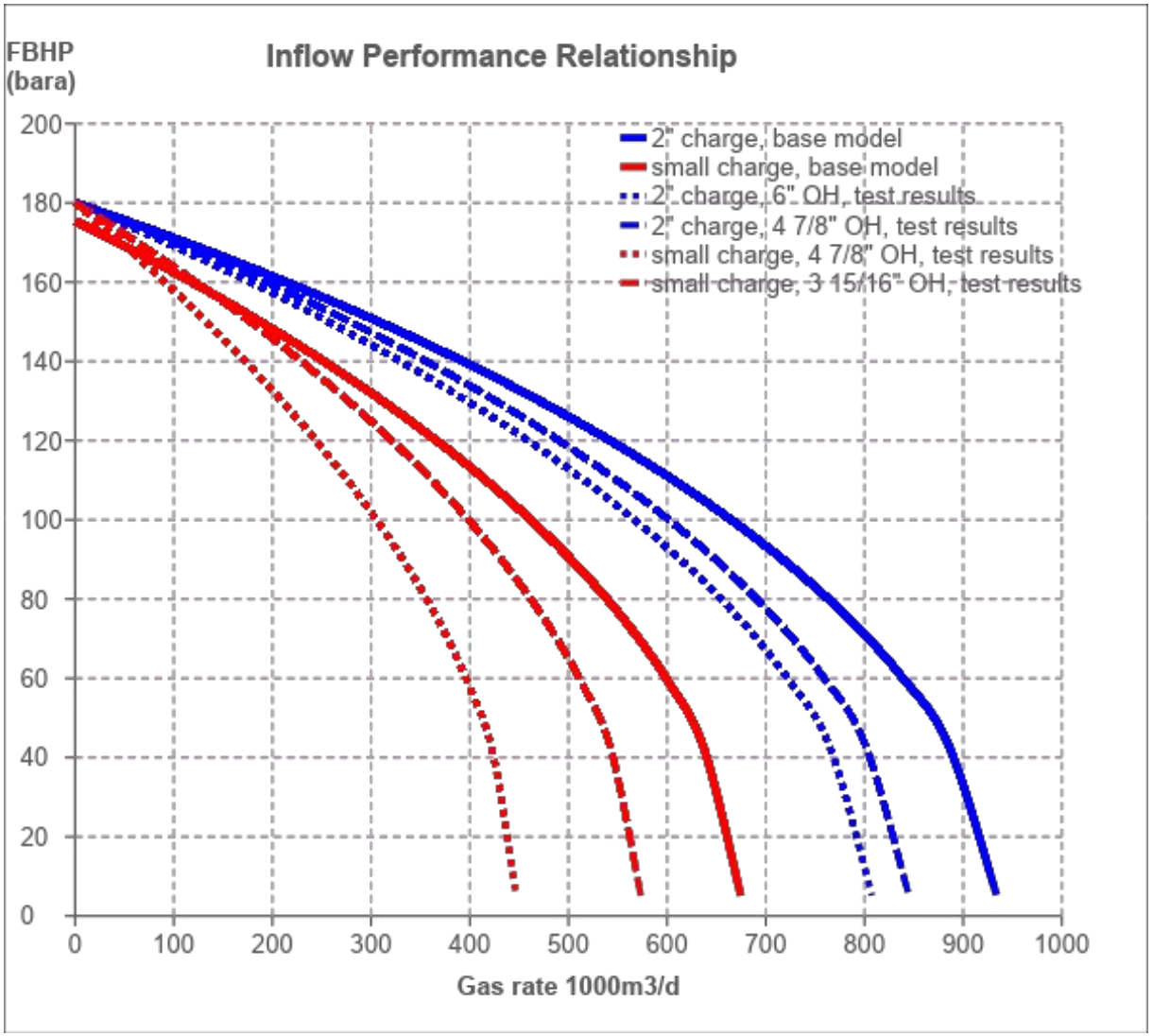
Findings charge testing (2)

- Futher analysis of results
  - Centralisation / stand-off impact: significant and hence to be included, not directly included in original modeling
  - Overall "perforation efficiency" (OH tunnel length/TCP tunnel length) from tests some 80%, hence efficiency for actual field conditions lower (less optimal conditions for dyn UB) □ tentatively set @ 50%

DoP 2" charge			
	vertical	deviated	Used for original modeling
6" OH	9"	7.7"	7"
4 7/8" OH	11"	9.6"	
EH	0.19"	0.17"	0.22"
Eff, %	50	50	80

Small charge			
	vertical	deviated	Used for original modeling
4 7/8" OH	2.9"	2.4"	4"
3 15/16" OH	5.1"	4.3"	
EH	0.17"	0.17"	0.17"
Eff, %	50	50	80

Impact charge testing on well concept selection



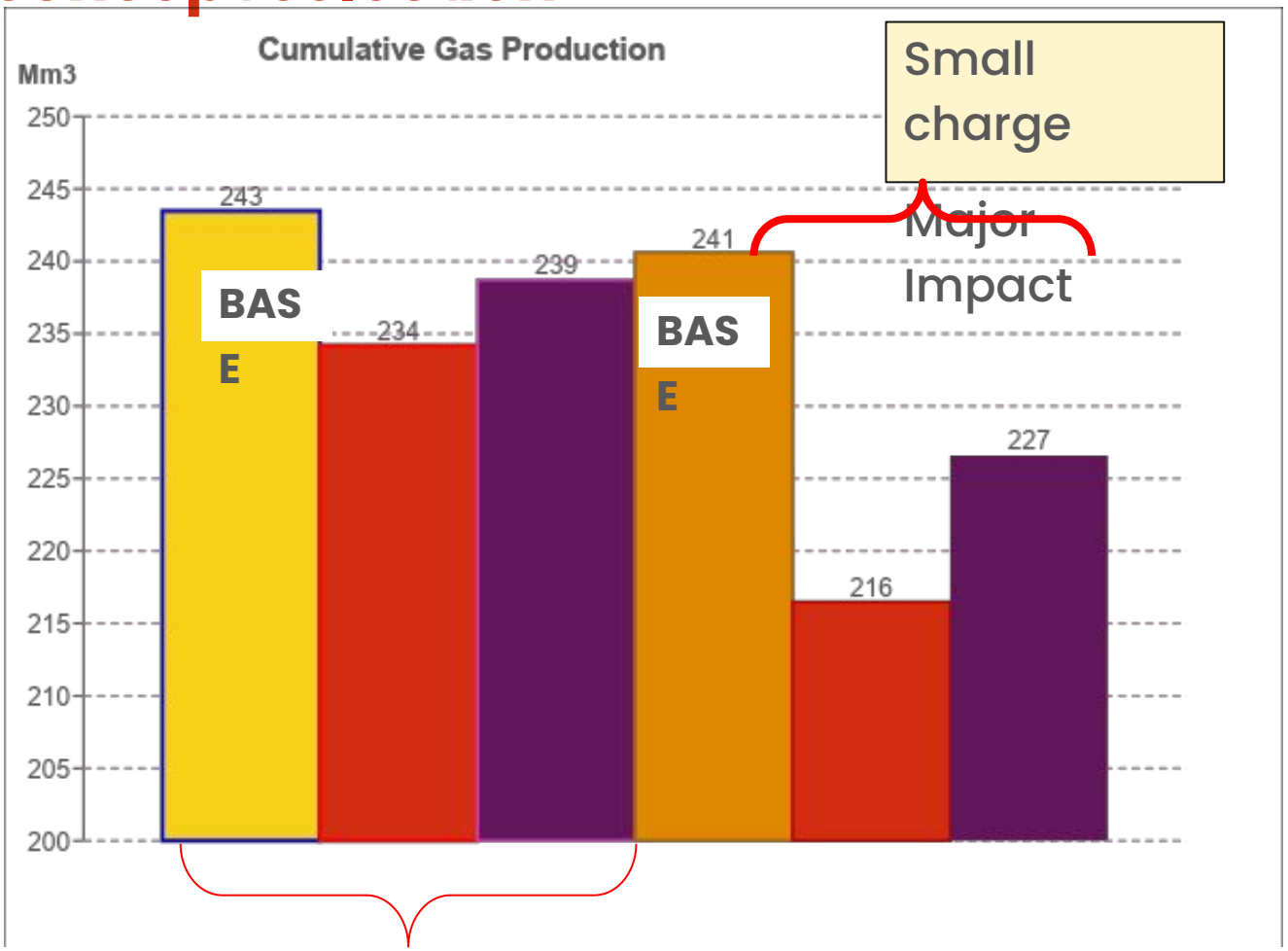
Impact 2" charge:

- test results impact rel. minor
- Higher DoP offset by lower assumed perforation eff.

Impact small charge:

- impact clear
- Lower DoP + lower assumed perforation eff.

“Economics” : Impact charge testing on well concept selection



Conclusions

- Charge testing results
  - Reducing tubing size to 2 7/8" and using smaller charges not attractive given loss of inflow / recovery *this concept no longer pursued !!*
    - Impact perf tunnel efficiency significant
  - Impact cement thickness for smaller charges potentially under-estimated
    - potential impact on selected drilling practices (OH drilling diameter)
  - Perforation tunnel efficiency possibly overestimated in original modelling
    - "ideal" lab tests gave results of approx 80%, field conditions (small clearance, low static UB) far from ideal.
- Way forward
  - Carry out gun survival tests for 2" guns ins[illegible]g