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Well engineering design in Laslau Mare based on lessons learned

Morched Guettat
SPM Schlumberger

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Introduction

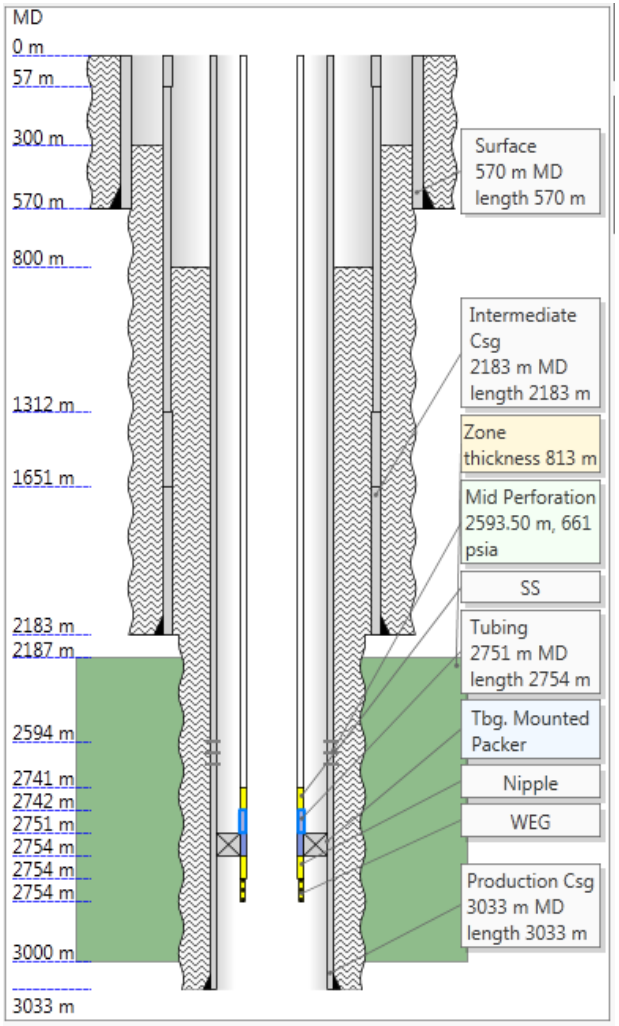
- Well engineering is the discipline which should deliver the main five :
  1. Safe drilling operations
  2. Safe to operate wells
  3. Wells capable to achieve their production/injection/observation/data acquisition targets
  4. Wells capable of being re-completed, when necessary at a reasonable cost
  5. Wells designed for their life cycle (fit-for-purpose)

Introduction

- Production engineering is the discipline which addresses:
  1. Well completion selection (natural flow, ALS, injection, multi-completion etc.)
  2. Flow assurance
  3. Well performance
  4. Production/injection systems analysis
  5. Wells stimulation opportunities

Classical LM well design

- Conductor pipe is the structural pipe
- 13 3/8” is the Surface casing sat at around 570 m and which will hold the BOP for the next phase
- 9 5/8” is the intermediate casing which is set above the depleted gas reservoirs
- 5 ½” is the production casing which will be set at TD (8 ½” openhole)



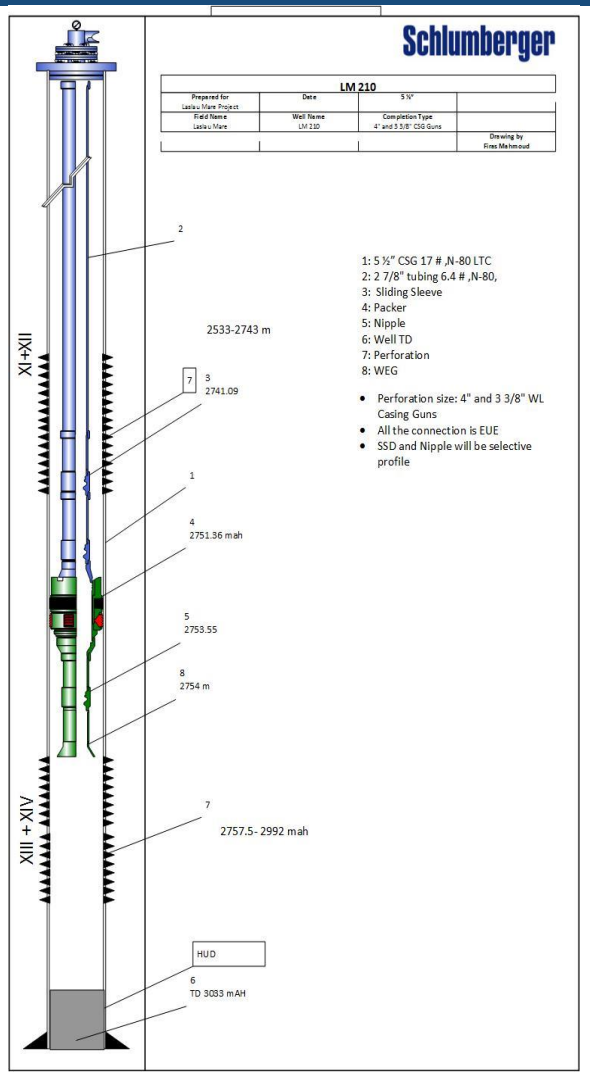
Well production target

- The well's expected production performance were as follows:
  - 50 Kscm/d up the casing from the upper permeable package
  - 30 Kscm/d through the tubing from the lower package

For an average field pressure of 8 bara.

Well design for fracturing operation

- Production casing 5 ½” 17ppf
- Tubing string 2 7/8” 6.4 ppf EUE
- Production packer
- Sliding Sleeve Door (SSD)
- Landing nipple



Completion limitation for frack job

- Long open reservoir intervals
- Depleted reservoir pressures
- Small production casing size to accommodate a suitable frack string
- The biggest size of the frack string cannot handle the injection pressures

Main fracturing job events

- Used a snubbing unit
- A 3 ½” frack string was used
- A Frack packer was set above the planned interval to be stimulated
- CO2 foam frack was executed
- Pumping rates: 20 BPM (3 m3 per minute)
- 60 to 80 bars back pressure were kept in the annulus

Main findings from the infill well

- The mud weights and bits type were suitable for the proposed drilling
- The casing design can be down-sized (smaller holes)
- Production rates are not as high as forecasted
- Low angle deviated well has no impact on the productivity
- Long open intervals limit the future stimulation operation performance
- Use of snubbing unit had a merit

Consideration for new infill wells

- Reduce the casing size to minimize the annulus cross section
- This will imply a down sizing of the well casing sizes
- Drill the reservoir at a higher angle
- Open the planned stimulated zone only
- Extend the perforation for other zones using underbalance technique
- Use a snubbing unit to avoid water based fluid negative effect
- Optimize the completion equipment use

Consideration for new infill wells

(Continued)

- Include all future operations as part of the well design
- Use of snubbing unit instead of WO rig
- Use of snubbing unit only when necessary

Future well general overview

- Dual completion well
- Lower package will access probable reserves
- Lower package is very tight
- Need to frack the lower package immediately following the well drilling completion
- Extend the perforation of the lower package in under-balance conditions
- Need to test the stimulated zone for a period of one year

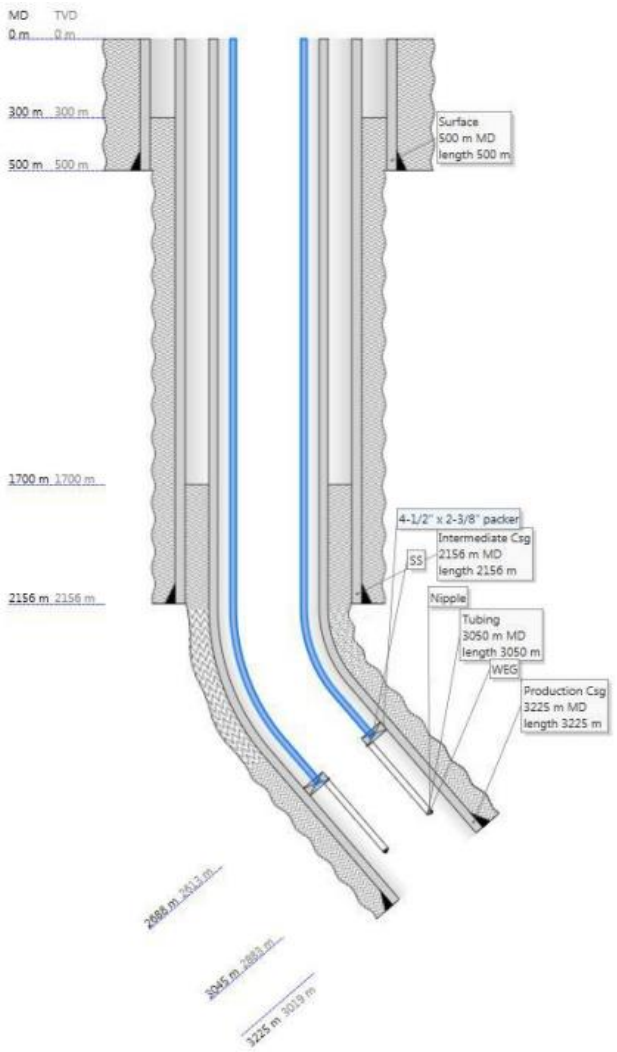
Proposed drilling & completion program

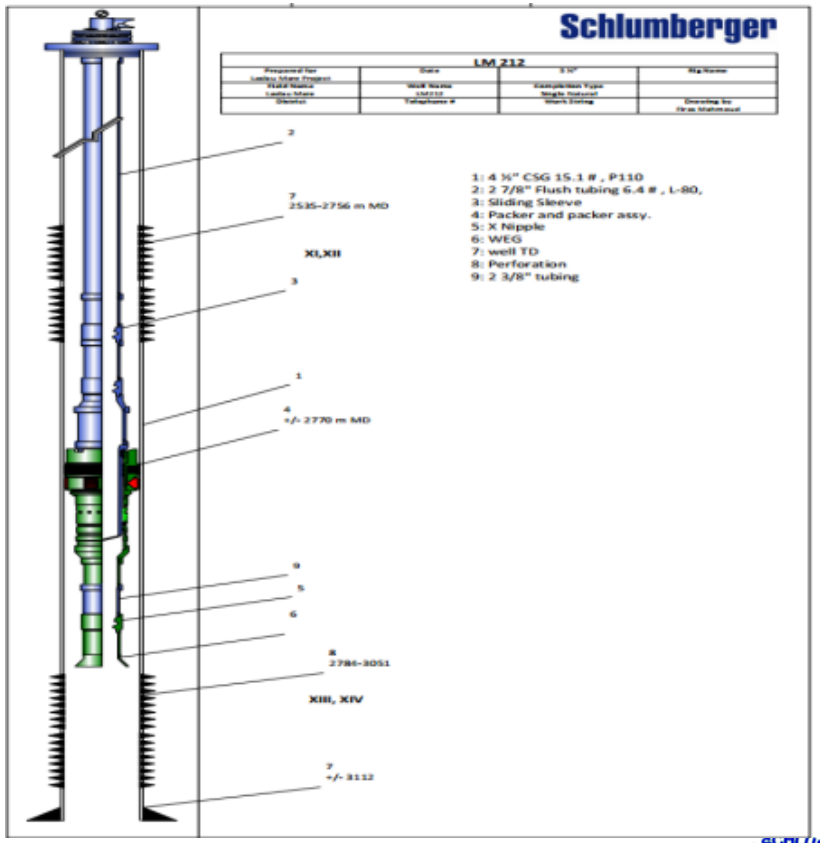
- Run a conductor pipe
- Drill 12 ¼” hole and run, set and cement a 9 5/8” surface casing
- Drill 8 ½” hole, run, set and cement a 7” intermediate casing
- The well will be deviated to 40º below the 7” shoe
- Drill 6” hole, run set and cement the 4 ½” production casing
- Run scrapper run then Cement log
- Release the drilling rig
- Perforation of the planned frack interval under-balance

Proposed drilling & completion program
(Continued)

- Fracture operation will be performed down the 4 ½” casing
- Flow back the well
- Perforate under-balance the rest of the lower package
- Rig up the snubbing unit and snub-in the completion
- Release the snubbing unit
- Test the well for one year
- Mobilize the snubbing unit
- Snub-out the completion
- Perforate the upper package under-balance
- Run 2 7/8” selective completion with a 2 3/8” tubing tail

Proposed future well schematic in Laslau Mare





Effect of completion size on Flow Assurance

Calculated Criticals	Turner's	Coleman's
Critical Velocity for Gas (ft/s)	29	24
Critical Velocity for Gas (m/s)	8.70	7.20
Critical Flowrate (MScf/d)	1376	1139
Critical Flowrate (Kscm/d)	39	32

Standard design 5 ½" X 2 7/8"

Calculated Criticals	Turner's	Coleman's
Critical Velocity for Gas (ft/s)	29	24
Critical Velocity for Gas (m/s)	9	7
Critical Flowrate (MScf/d)	562	465
Critical Flowrate (Kscm/d)	16	13

Slimhole design 4 ½" X 2 7/8"

Thank you