NORTEX
DATA SCIENCE CLUSTER | Offshore Data Analytics
Drilling & Well Technology

ONGOING P&A RESEARCH IN DRILLWELL

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- P&A challenges
- IRIS & Drillwell
- P&A Projects; TLIH, Barrier Reference Facility, Leakage Risk Assessment

Some P&A challenges (ref.: Sigrun Daireaux, Statoil)

http://www.slideshare.net/Statoil/plug-abandonment

1. Faster and cheaper casing removal
   - Less cuts, mutipurpose tools, logging tools
2. Alternative methods for creating an annulus barrier
   - Cement, expanding formation, other
3. Alternative materials for annulus barrier
   - Easily placed, seal for eternity, shorter
4. P&A without cutting + pulling the tubing and casing
   - Multiple annuli, barrier verification
5. Logging through multiple casings
   - Same or higher quality interpretation
6. Preventing leak paths from control cables
   - How do we prevent leak paths
7. Optimum well construction for future P&A

IRIS Energy
Efficient and safe energy production

Research areas

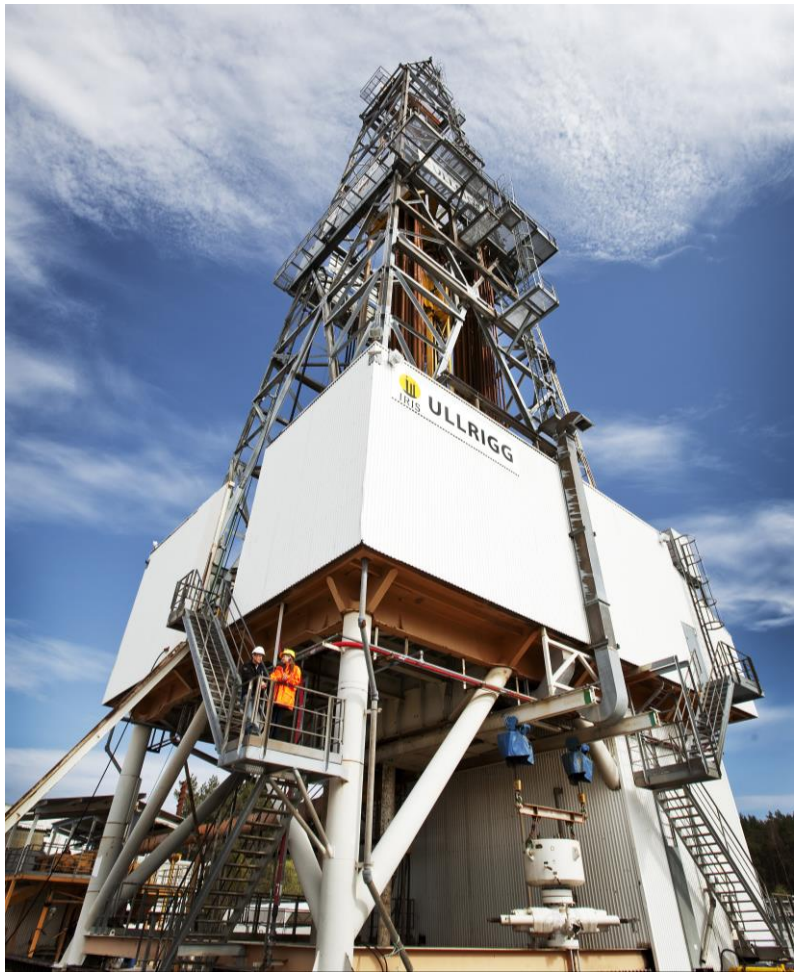
- Drilling & Well Technology
- Reservoir technology
- Improved Oil Recovery
- New energy

Resources

- 85 employees
- Drilling simulators (“Virtual rig”)
- Petroleum laboratory

› Two national research centers;
DrillWell and *National Center for Improved Oil Recovery*

Ullrigg Drilling & Well Center (UBBS)



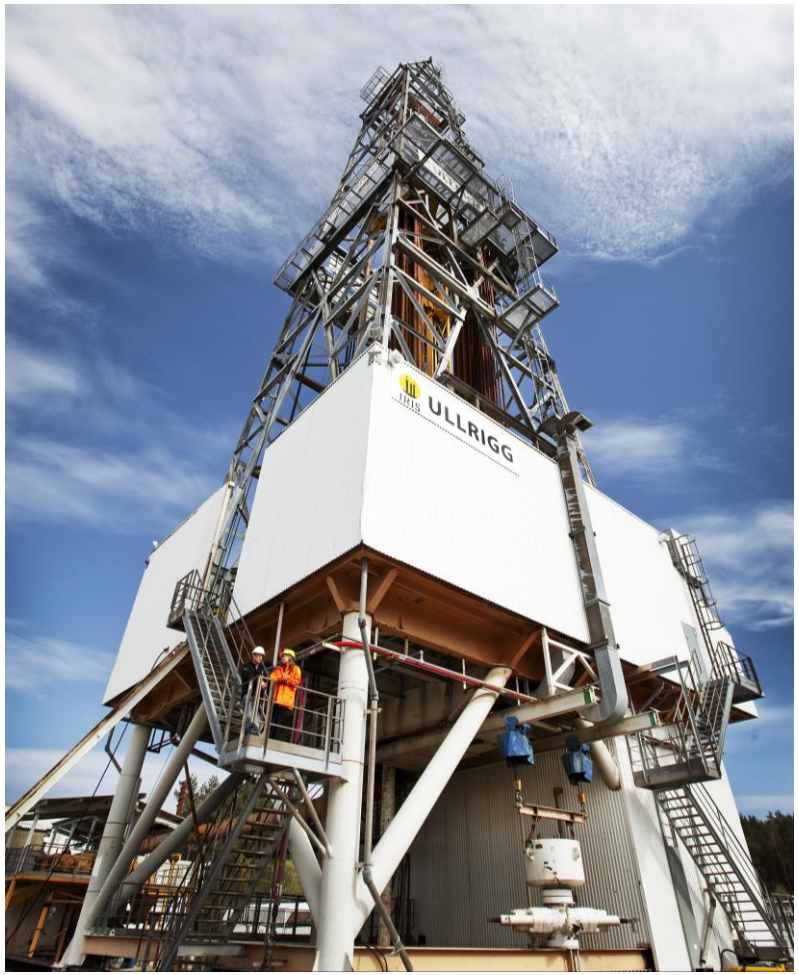
An internationally recognised facility used for:

- Research
- Technology qualification
- Training

Resources

- 25 employees
- Ullrigg + 7 wells
- Test cells for HP/HT
- Well intervention center
- Flow loops
- Jar bench

Ullrigg Drilling & Well Center (UBBS)



Drilling and Well Centre for Improved Recovery
2011 - 2019

Vision; Unlock petroleum resources through better drilling and well technology

Objective; Improve drilling & well technology; provide improved safety for people and the environment and value creation through better resource development, improved efficiency in operations and reduced cost

Goals:

- Cost reduction
- Improved recovery
- Efficient field development

R&D programmes

P1: Efficient drilling operations for cost reduction

P2: Drilling solutions for improved recovery

P3: Well solutions for improved recovery

Statoil ConocoPhillips DETNORSKE Lundin Norway wintershall BASF Gruppe

DrillWell Project - Improved plugging and abandonment (P&A)

- Long-term integrity of plugging material
- Tubing left in hole
- Optimized materials for P&A (PhD)
- Rig-less P&A (PhD study)

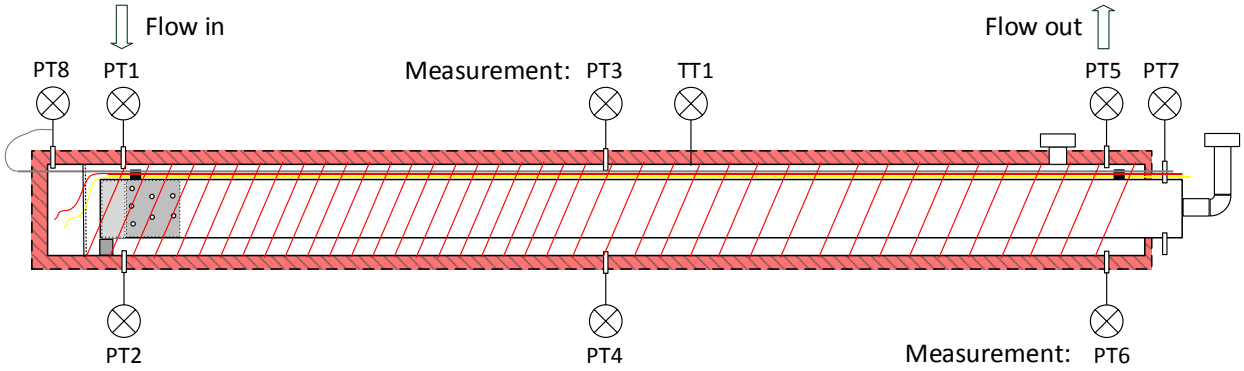
1. Barrier Evaluation Reference Facility
2. Leakage risk assessment for plugged & abandoned wells

+ Cementing Irregular Wellbore Geometries

Tubing left in hole (TLIH)

- 36 m of 7” tubing inside 9 5/8” casing - standard G-cement (2013)
- 12 m of 7 ” tubing inside 9 5/8” casing - expanding cement (2014)
- Test the barrier quality with and without control lines in the tubing
- Leakage tests to determine micro annuli between cement casing/tubing
- “Longer term leakage test” and oil after water (2015)

Leakage rate / pressure testing – annulus



Conventional G cement (2013):

- Visible cement shrinkage – not uniform
- Permanent “effective micro annulus” ca. 60 µm (equiv. permeability ≈ 3 D)

Expanding cement (2014 & 2015):

- Expanded cement presses against casing with 80 bar
- Residual “effective micro annulus” ca. 15 µm (equiv. permeability ≈ 10 mD)

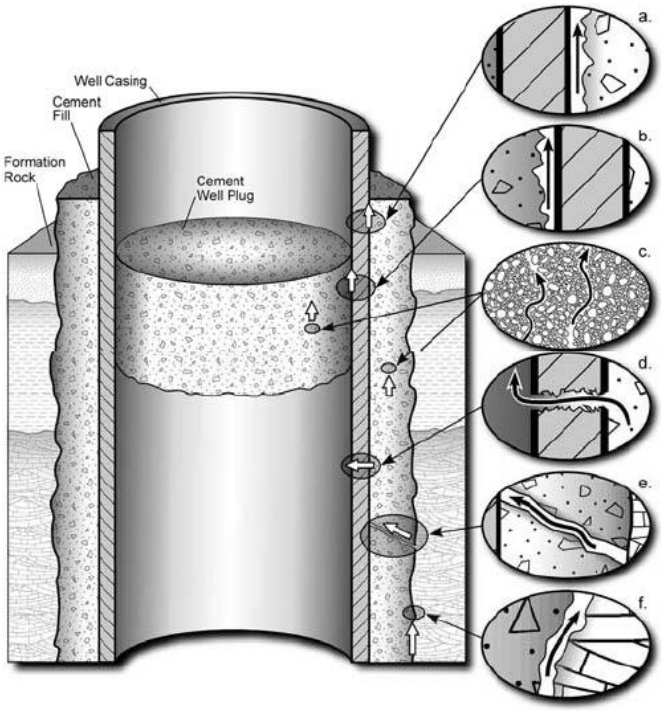
Perfect displacement, no channels, pockets or cracks

- Perfect cementing around control lines

Barrier evaluation reference facility

Challenge; Annular isolation must be assessed to select the most cost effective P&A solution

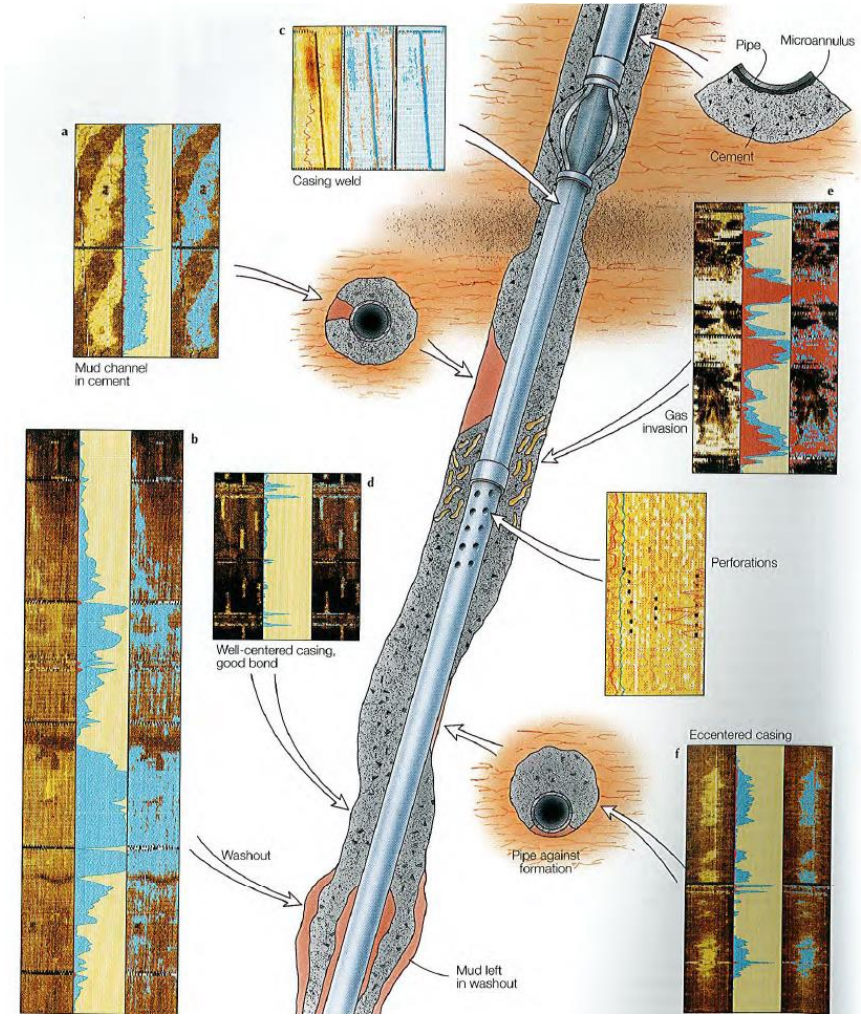
Objective; investigate the link between cement evaluation techniques and the quality of the hydraulic seal



Barrier evaluation reference facility

Goal; establish reference conditions for cement (barrier) logging:

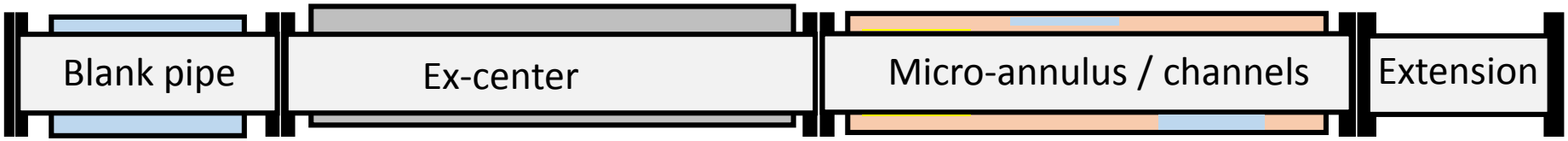
- Measure the performance of current and emerging technologies
- Investigate the relationship between the hydraulic seal and properties from logs
- Investigate technologies for logging through multiple tubulars
- Investigate other sealing materials and their log response



Pilot phase; Re-use of TLIH test sections

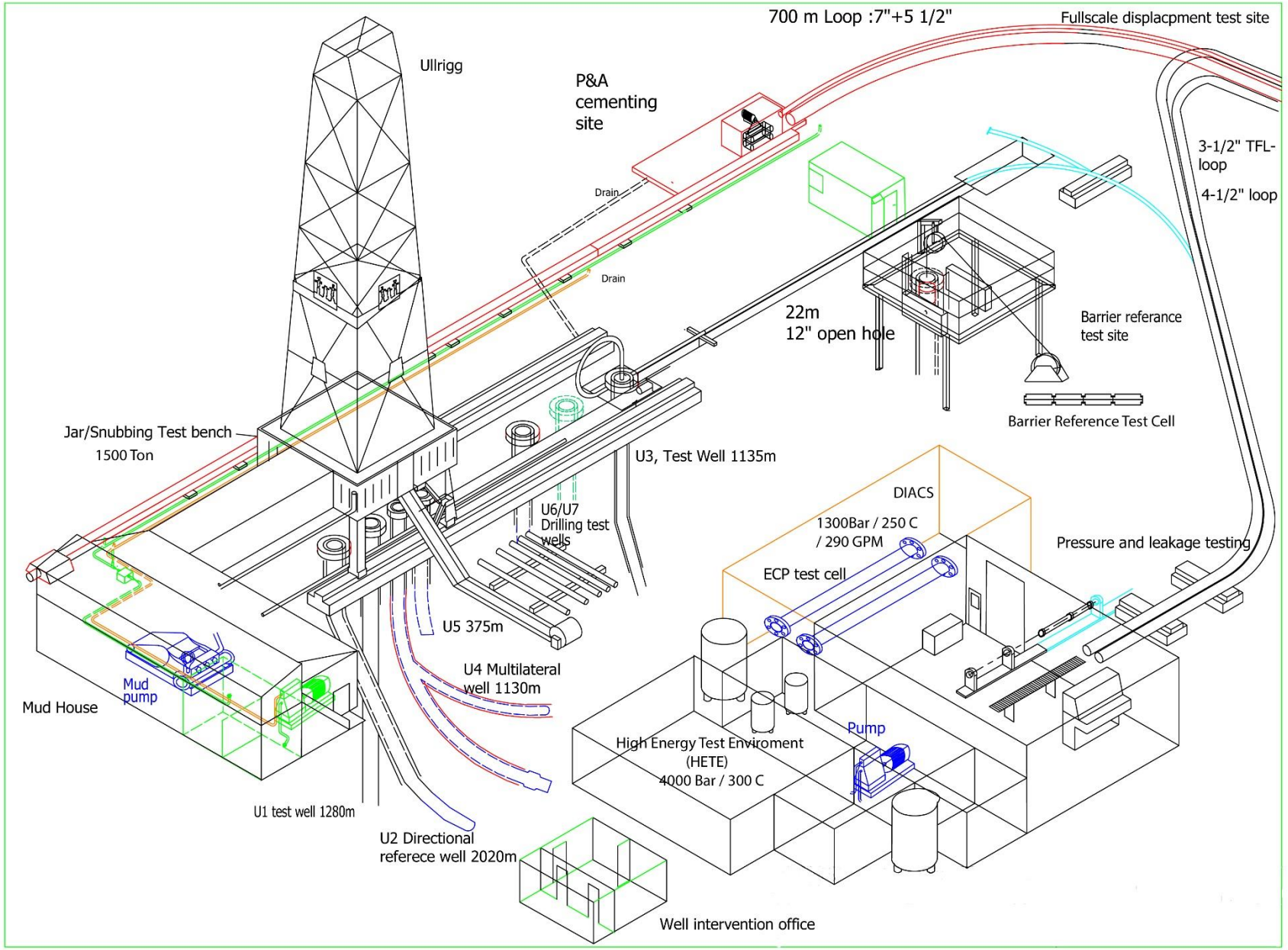
1. Hydro jetting used to remove cement from tubing
2. 4 sections with expanding G cement cleaned;
   - 1 x 3m + 2 x 3.5m + 1 x 5.4m
3. 1 section with a permanent µ-annulus (conventional G cement – 2013 experiments) under consideration

Reference cell concept



1. Test sections can be coupled, extensions as required for tool type
2. Internal and/or annular pressure up to 140 bar (2000 psi)
3. Annular fluid can be changed (water, oil, mud, gas)
4. Horizontal rig-up; use deployment bar + IRIS TFL Injector
5. Vertical rig-up; install test cells in IRIS test well (TD 22 m, openhole ID 12") + wireline winch

P&A innovation test centre, UBBS

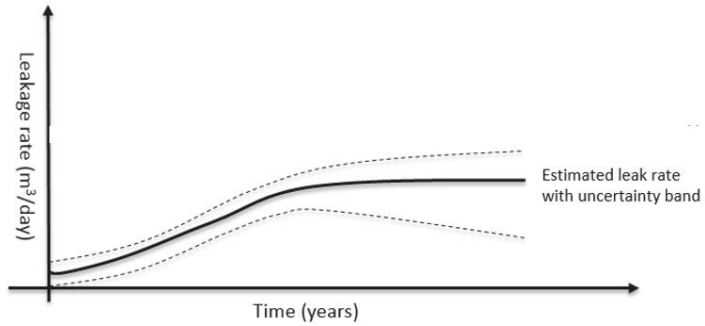


Leakage risk assessment for plugged & abandoned wells

The primary objective of this project is to develop a methodology for evaluating the quality of the barrier system of a permanently plugged and abandoned well by expressing the quality of the barrier system in terms of leakage probability and potential future leakage rates.

Leakage risk

Example: the probability that a given well will leak within 100 years is 3%.



Risk = probable frequency ✚ probable magnitude

Leakage risk assessment for plugged & abandoned wells

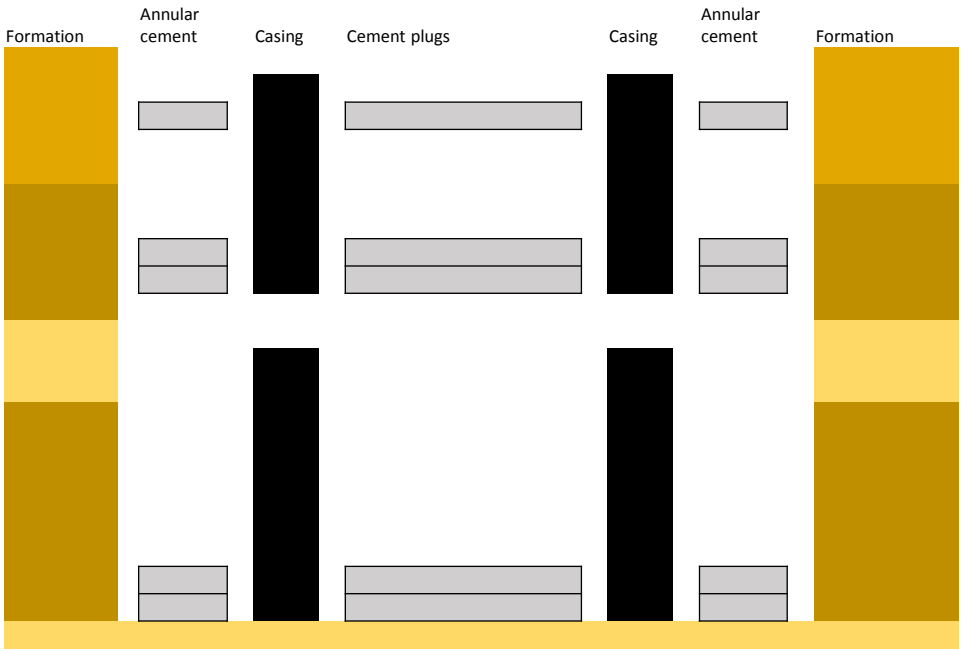
How will we do it?

Initialization

- Caprock/Formation
  - Strength
  - Permeability
- Cement properties
  - Strength
  - Permeability
- Microannulies
- Reservoir
  - Pressure, content and flow potential

Flow

- Pore space
  - Cement
  - Formation
- Microannuli
- Fractures
- Volume mixing

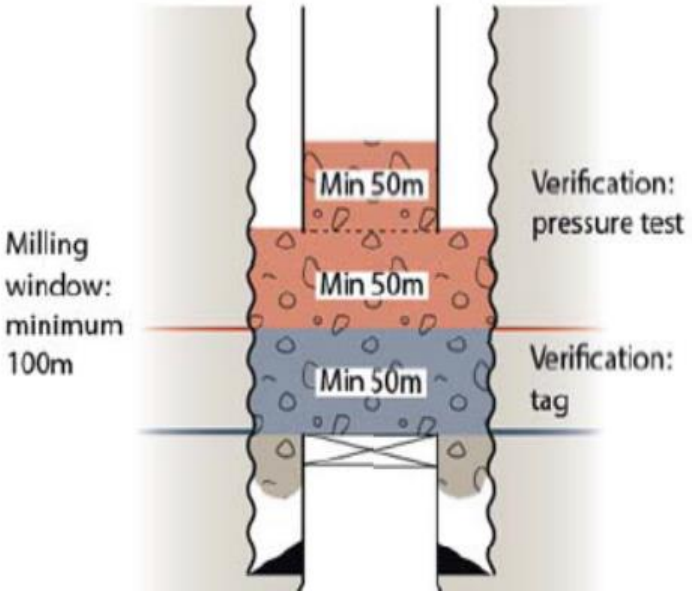


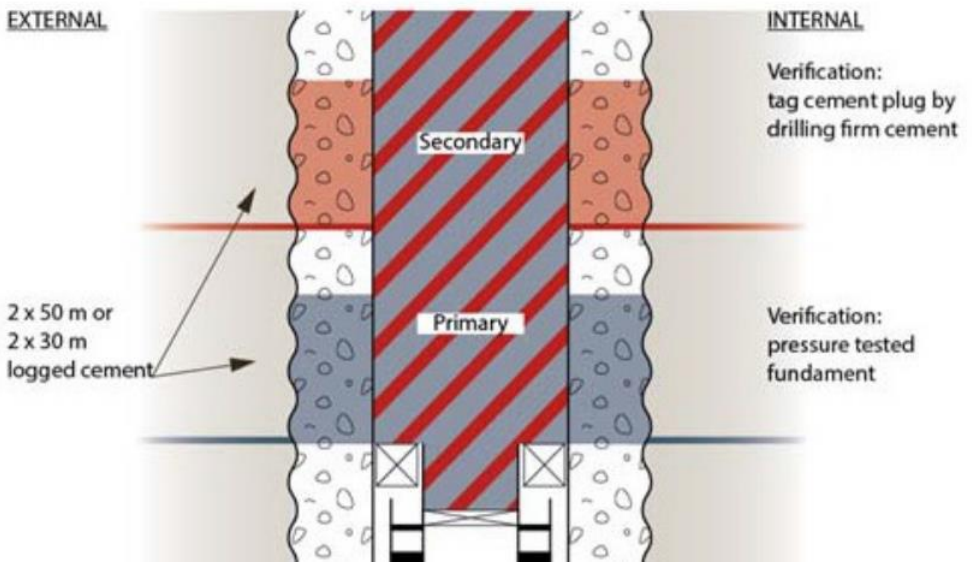
Degradation

- Cement degradation
  - Permeability
  - Strength
  - Microannuli
  - Erosion
- Casing corrosion
  - Microannuli
  - Erosion
- Formation reactions
  - Contamination
  - Erosion
  - Strength
  - Permeability
- Fractures/cracks
  - Cement strength / Formation strength vs. Fluid pressure / Geological stress changes

Leakage risk assessment for plugged & abandoned wells

- Application example; decision situation, should we mill 9 5/8” or not? (assuming tubing has been cut and pulled)





The decision should be risk-based.