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Managing well integrity on Erskine Normally Unattended Installation

The first HPHT development in the UKCS

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27th June 2018

Presentation Overview

- Erskine field development
- Well design
- Well integrity experiences
  - Tubing condition and liner deformation
  - Scale
  - Annulus Management
  - Subsurface Safety Valves
  - Christmas tree and wellhead
- Closing thoughts

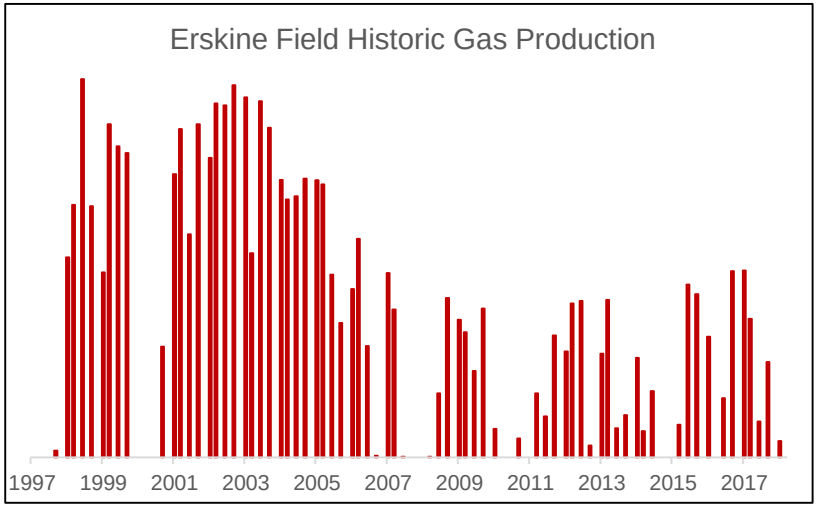
Erskine Normally Unattended Installation - Well Bay

Field Overview

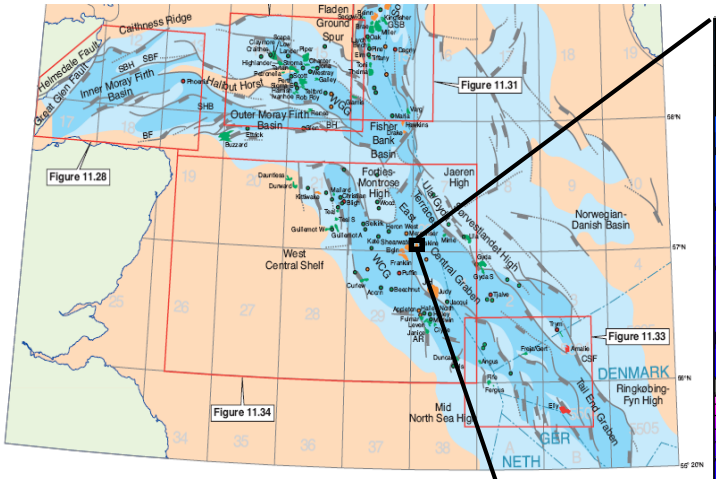
- Gas condensate field discovered in 1981
- First gas in 1997 via 5 production wells
  - Still the same 5 wells producing
- Chevron (50% operator)

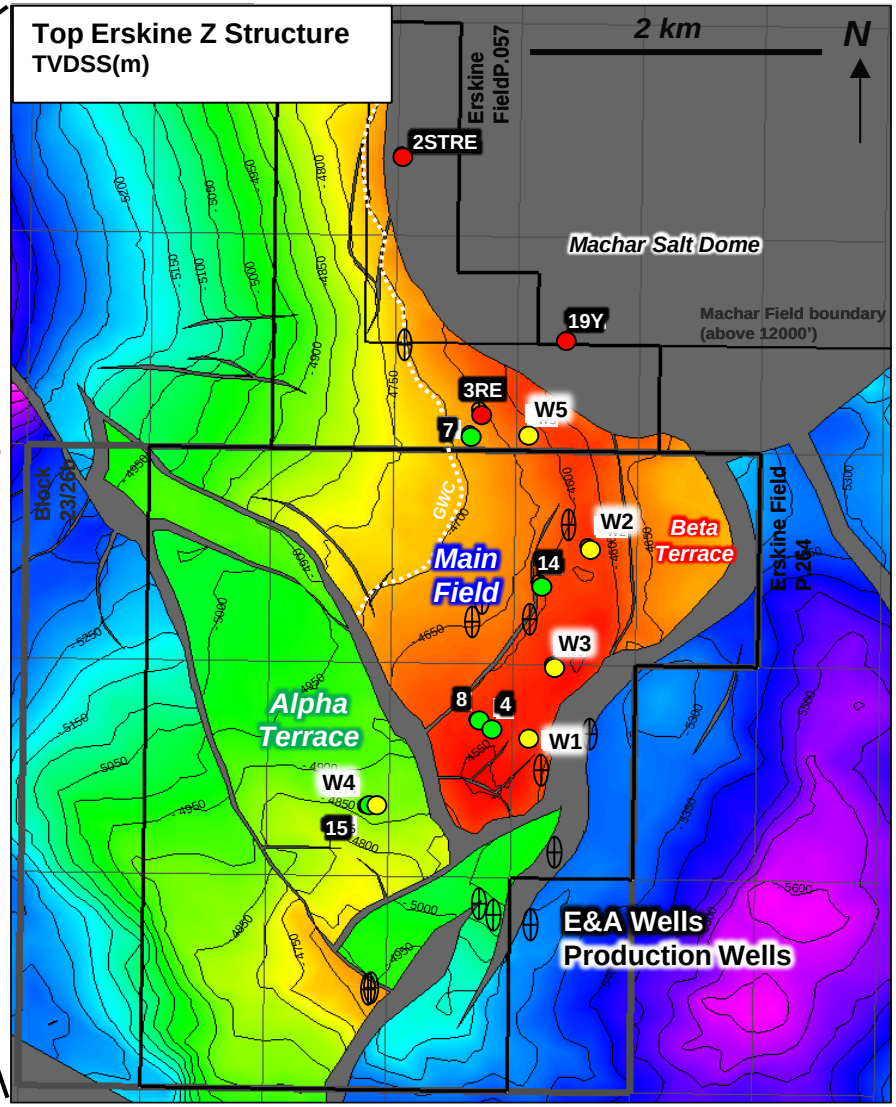
  Chrysaor (32%)

  Serica Energy (18%)
- Tied-back to the Chrysaor operated *Lomond* platform via 30km multiphase pipeline
  - Condensate exported to the Forties Pipeline System
  - Gas exported to CATS
- High pressure (960 bar) and high temperature (175^{o}C)
  - Currently depleted by ~600 bar
- Water depth 100m
- Field developed using an innovative NUI
  - Normal POB of 12
  - Maximum of 134 days attended per year
  - Minimal facilities design



Erskine Field Map





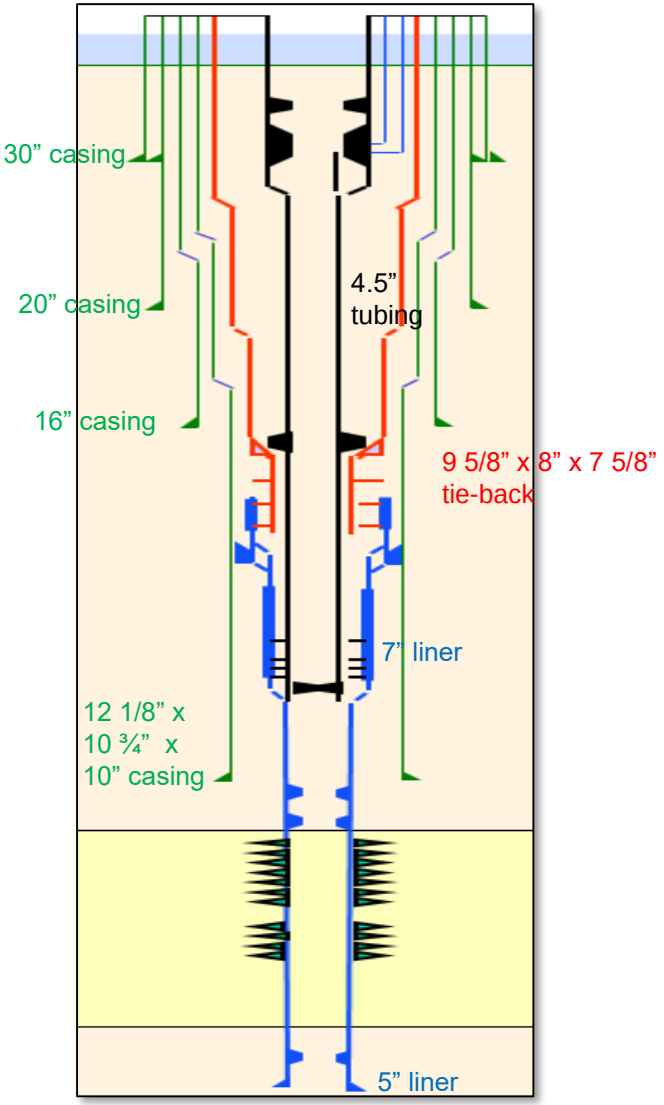
Reservoir and Fluid Properties

- Jurassic sandstone
  - Heather Tubidite
  - Erskine (Puffin)
  - Pentland
- CGR 180-210 bbl/scf
- Condensate gravity 40º API
- Column height: 500ft
- Reservoir depth: 15,500ft
- Porosity 20%
- Permeability 80mD

SPE 56899
Erskine Field: Early Operating Experience

Erskine Well Design

- Design Considerations
  - High pressure and high temperature
  - Flow rates up to 60MMscf/d
  - Ability to perform rig-less interventions (i.e. plug back wells and perforate in upper sands)
  - High reliability
- Design Features
  - Monobore completion for through tubing plug backs
  - PBR instead of production packers
  - Corrosion resistant alloys
  - Tubing Retrievable Subsurface Safety Valve (TR-SSSV) with the option for Wireline Retrievable Subsurface Safety Valves (WR-SSSV) in case of TR-SSSV failure
  - Designed for a 20 year life (now at 21 years) with several years to COP date
- W4 was successfully worked over in 1999 following failure of the tubing



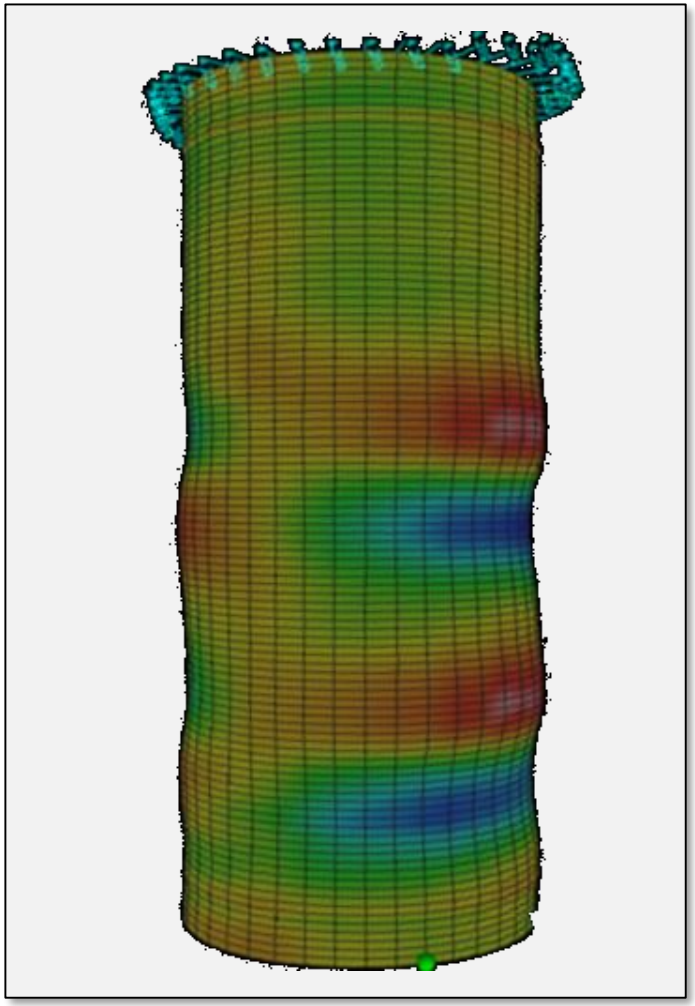
Example Erskine well schematic

SPE 30364: HPHT Drilling and Completion Design for the Erskine Field

SPE 67779: Erskine Field HPHT Workover and Tubing Corrosion Failure Investigation

Well Integrity Experiences
1. Tubing condition & liner deformation

- In order to assess the condition of the liner and tubing, calliper logs are routinely run on all Erskine wells
- Tubing condition is good throughout
- All wells have experienced some form of liner deformation
  - Shear Deformation
  - Axial Buckling
- Following initial deformation, subsequent surveys show that limited further deformation has occurred
  - Risk of well failure due to liner deformation is therefore presumed to be low
- Deformation can restrict access to the perforations putting limits on data-gathering and well interventions

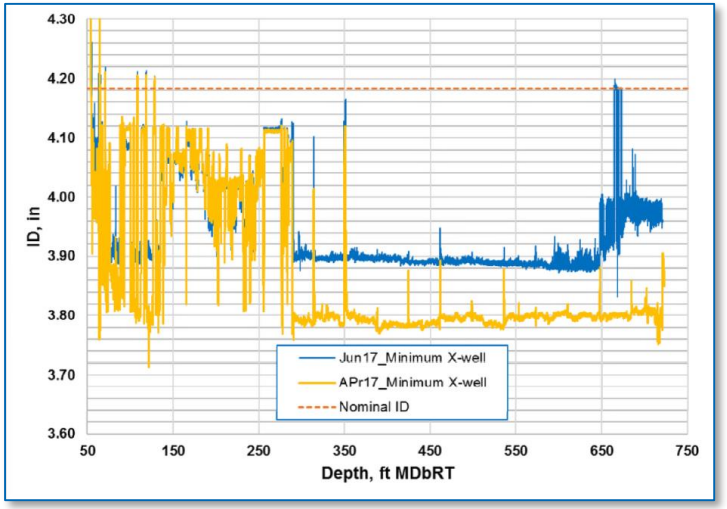


Example of a typical deformation features in the 5” liner

Well Integrity Experiences
2. Scale

- Severe scale deposition has occurred on some wells where we have experienced significant water production
  - W5 lost production due to scale in 2005 . A coiled tubing intervention was required to restore production
- Moderate scale deposition has been observed on all wells
  - Recent impact of scale has been on deposition across the SSSV which has required wireline milling operations to mitigate
- Calliper logs have shown scale deposition across the perforations on several wells
  - Scale can restrict access to the perforations
  - May be limiting production
- Most common scales are barium sulphate, zinc sulphide, lead sulphide and calcium carbonate
- No downhole inhibition or scale squeezes have been performed
- Scale inhibition is used for protection of the platform pipework

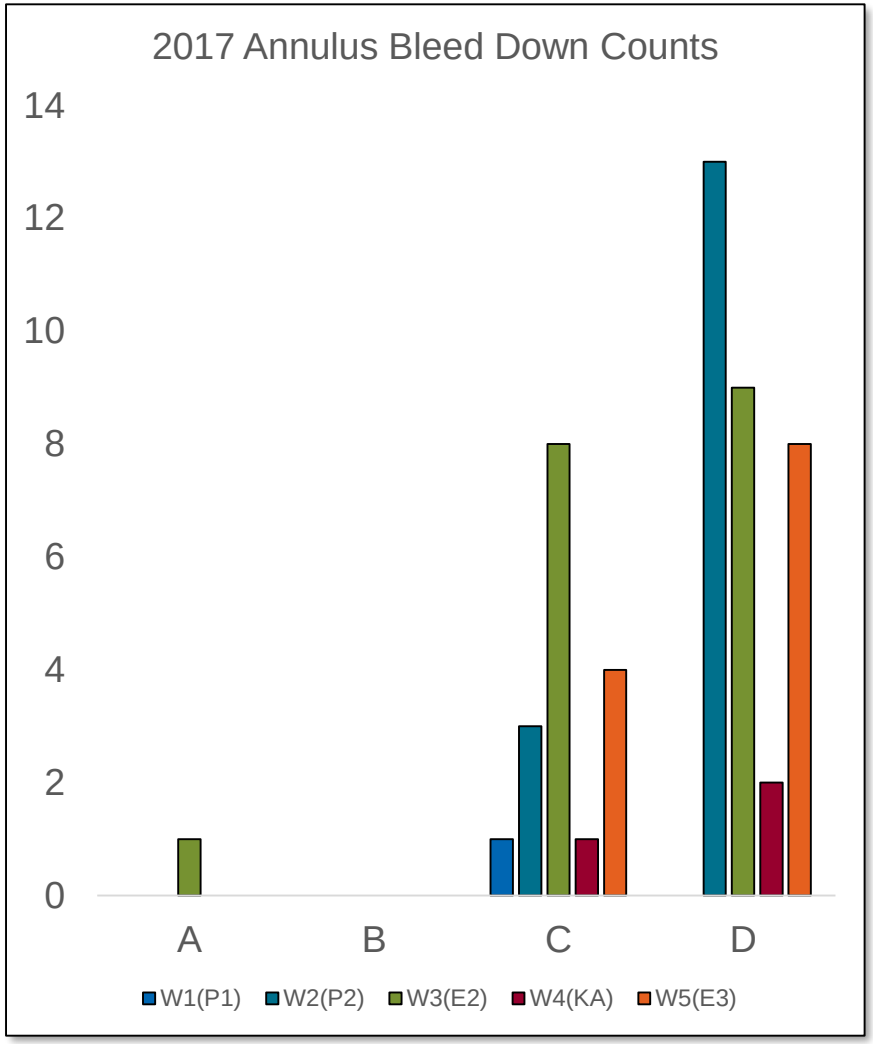
Coiled Tubing on W5 in 2005



Scale deposition profile above the SSSV pre and post wireline milling operations

Well Integrity Experiences
3. Annulus Management

- Annuli are monitored constantly using real-time pressure transducers linked to PI
  - Alarm and trip levels defined to prevent exceeding safe limits
  - Monitored at Lomond and by Chevron onshore team
- Periodic bleed-downs of annulus pressure required to maintain well integrity
  - Can require rapid intervention when Erskine is unattended
  - Bleed-down fluids are analysed onshore as required
- Majority of bleed-offs for the C and D annuli
  - A and B annulus bleed downs are very infrequent



Well Integrity Experience
4. Subsurface Safety Valves

- All wells were initially fitted with TR-SSSVs
- Over time some TR-SSSVs have been replaced with WR-SSSVs
- Two wells have suffered from SSSV control line failures so have had storm chokes fitted
  - Removes the need for a workover
  - Storm chokes cannot be tested in-situ
  - Requirement for annual changeout
  - Inspections after each replacement have found no significant issues
- Alternatives to storm chokes that don't require a workover would be beneficial to the asset
  - Could be tested in-situ
  - Remove the annual changeout requirement
  - Save on the cost of replacement and a workover


Fig. 2 – Piston prior to cleaning

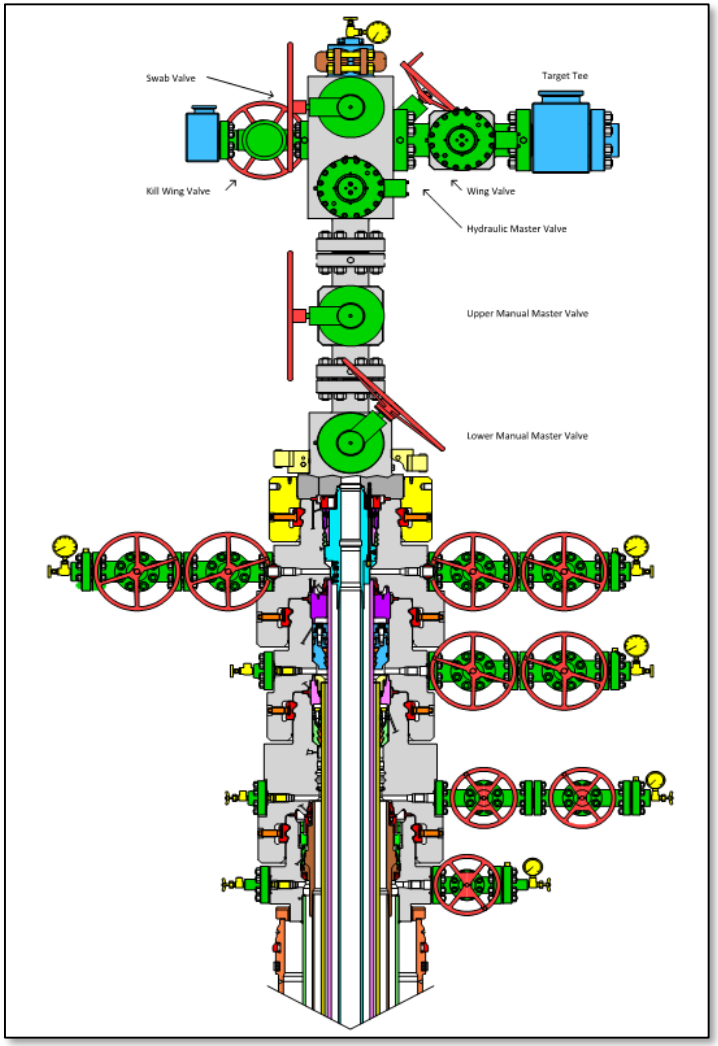

Fig. 3 – Piston after cleaning

Storm choke valve before and after cleaning

Well Integrity Experiences
5. Christmas Tree and Wellhead

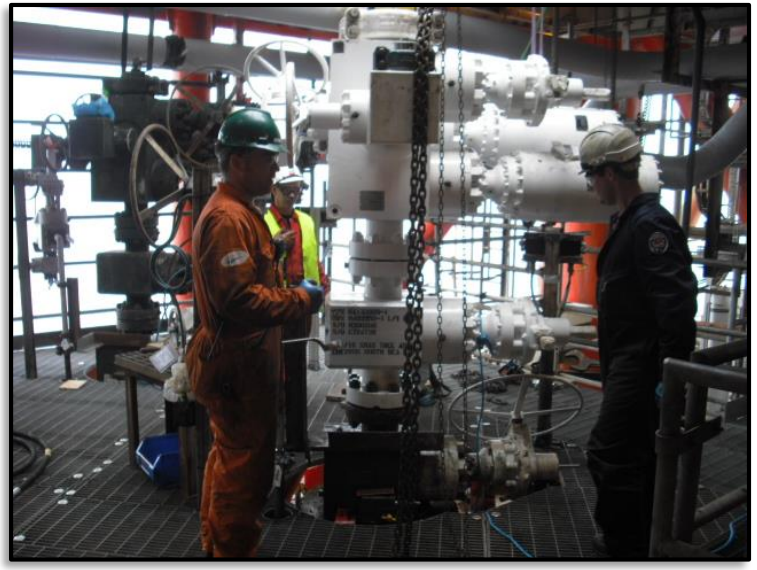
- Tree and wellhead are rated to 15,000psi
- Tree valves and wellhead are subject to annual testing and inspection (PMR)
- If a pressure test cannot be achieved, either maintenance is performed or a risk assessment is done to ensure sufficient barriers are in place to safely operate the well
- All wells have had a tree change in the past
- The main issue experienced is the wellhead test-port elastomeric seals failing. This prevents adequate testing of the metal to metal seals
  - More prevalent when testing cold
  - This needs to be monitored as the wellhead ages

OTC 8742 :HPHT Platform Wellheads &Christmas Trees- Performance Testing to Installation



Erskine wellhead and Christmas tree

Example Tree Change Photos - 2010



Closing Thoughts

- Erskine wells are still operating safely after 21 years and need to keep going to maximise economic recovery
- The well design has facilitated low cost interventions to maintain well integrity
- Liner deformation has been observed in all wells but does not appear to be dramatically worsening with time
- Wireline offshore days have typically been used for well integrity related activities rather than production enhancement opportunities
- Scale management has been reactive. Options are being looked at for proactive scale management
- Alternatives to storm chokes that don’t require a workover would be beneficial for the asset

Acknowledgements

- Yusif Zeynalzade (Chevron) and Paul Ness (Chevron) for providing technical review
- Chrysaor and Serica Energy for kindly agreeing to this presentation