RPS Energy

ALASKA GAS HYDRATE TEST WELL DRILLING, COMPLETION, & PRODUCTION CONSIDERATIONS

NETL

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MORGANTOWN

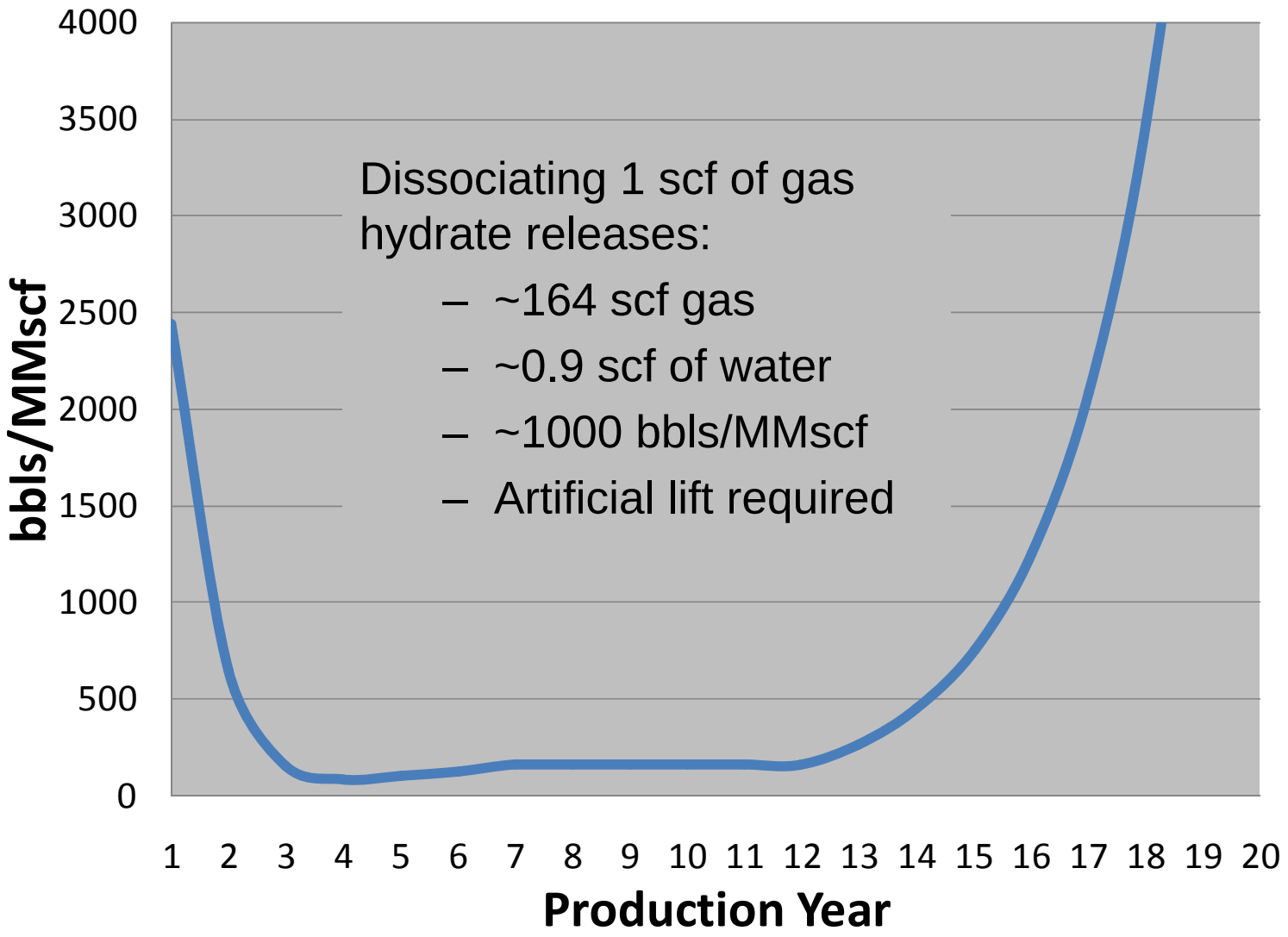
Well Objectives

- Meet required scientific objectives
  - Initiate gas and water production at rates that are measurable and sustainable
    - Primary: pressure depletion
    - Secondary: chemical, thermal, CO2, other
  - Collect pressure, temperature and other required data
- Optimize cost, reliability, operability
  - Flow assurance
  - Integrate into existing operations

Gas Hydrate Production Considerations

- Gas production rate
- Water production rate
- Operating pressure
- Flow assurance
  - Hydrate/freezing control
  - Sand control
  - Reservoir subsidence
  - Hydraulic isolation
- ***Applies to vertical and horizontal wells, regardless of location***

Water Production Considerations



Operating Pressure Considerations

- Gas hydrate fields will operate below the typical late-life reservoir pressure for a conventional gas reservoir
- Compression probably required unless access available to low pressure gathering system or going directly to flare

Flow Assurance Considerations

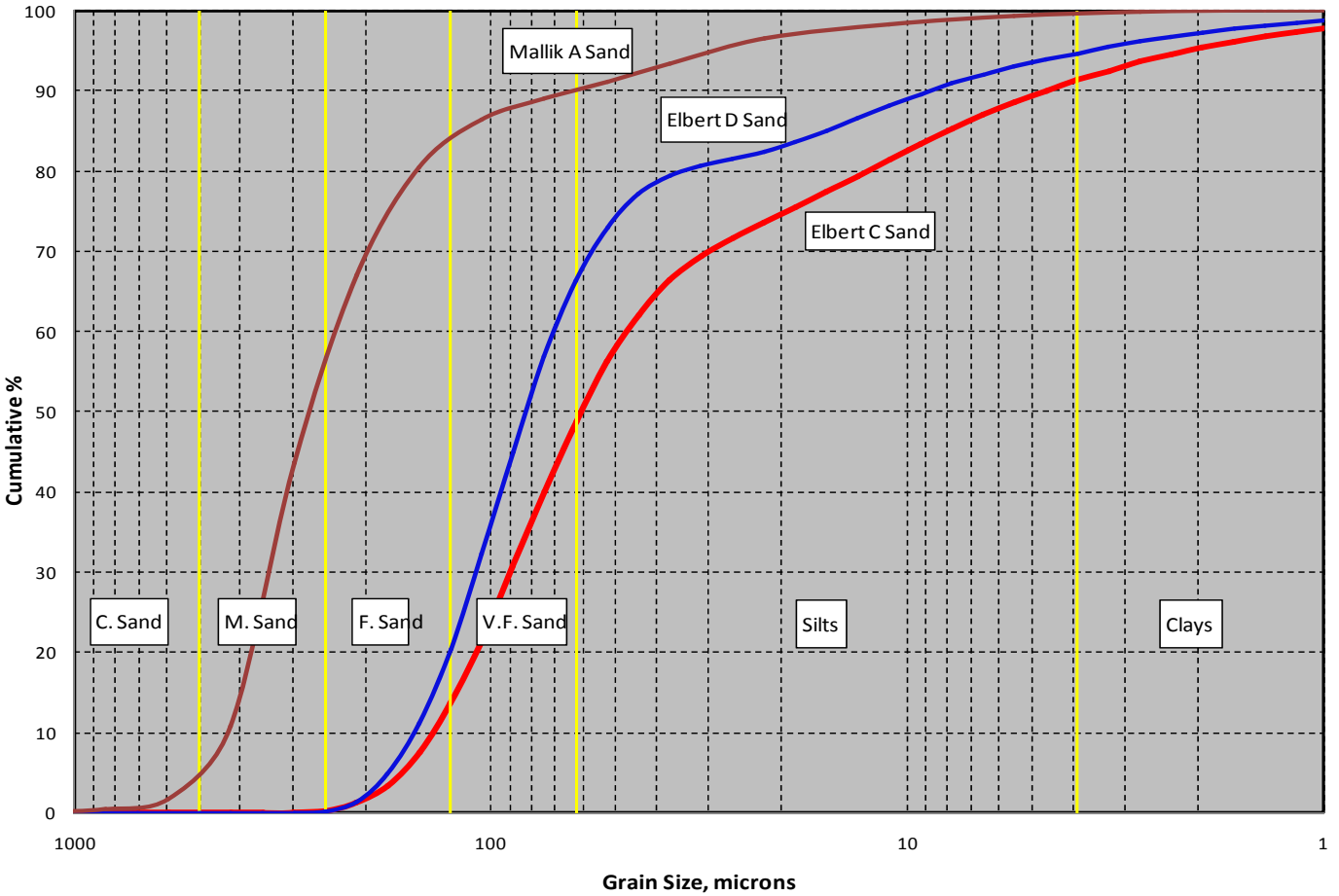
- Hydrate/freezing control
  - Inhibition (glycol/methanol)
  - Low dose hydrate inhibitors or cold flow technology
  - Near wellbore heating – at production zone and in permafrost zone
- Sand control
  - Premium screens or gravel packs
- Subsidence
  - Some design procedures to offset tensile failures
  - Shear failures require sidetrack or well replacement

Hydraulic Isolation Considerations

- Proximity to free water/gas contacts can prematurely end testing operations
  - Flow behind pipe
    - Free gas/water
    - Uphole gas hydrates
  - Fractures (natural, planned, accidental)
  - Breakthrough after dissociation

- ***Well placement critical to success of test***

Comparison Mallik & Elbert Sands

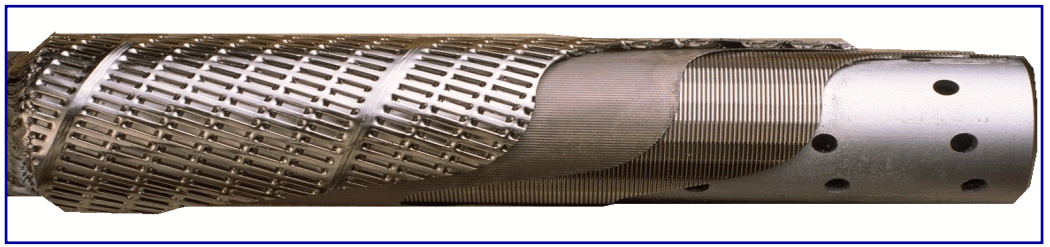


Sand Control Considerations

- Vertical well
  - 9.625” casing or 8.5” open hole
  - 5” premium screen (>20% open flow area) designed with appropriate mesh screen slot width
  - Circulate appropriate mesh gravel pack into place
- Horizontal Well
  - 8.5” open hole
  - Wire-wrapped screen required for horizontal since hole cleaning is uncertain and premium screens more prone to plugging with drill solids

Premium Screen Options

Baker: EXCLUDER 2000



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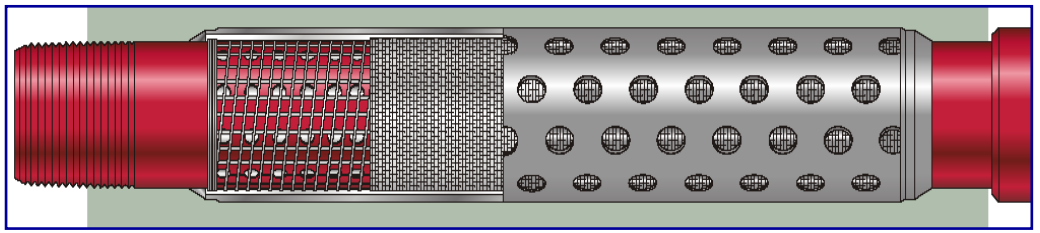
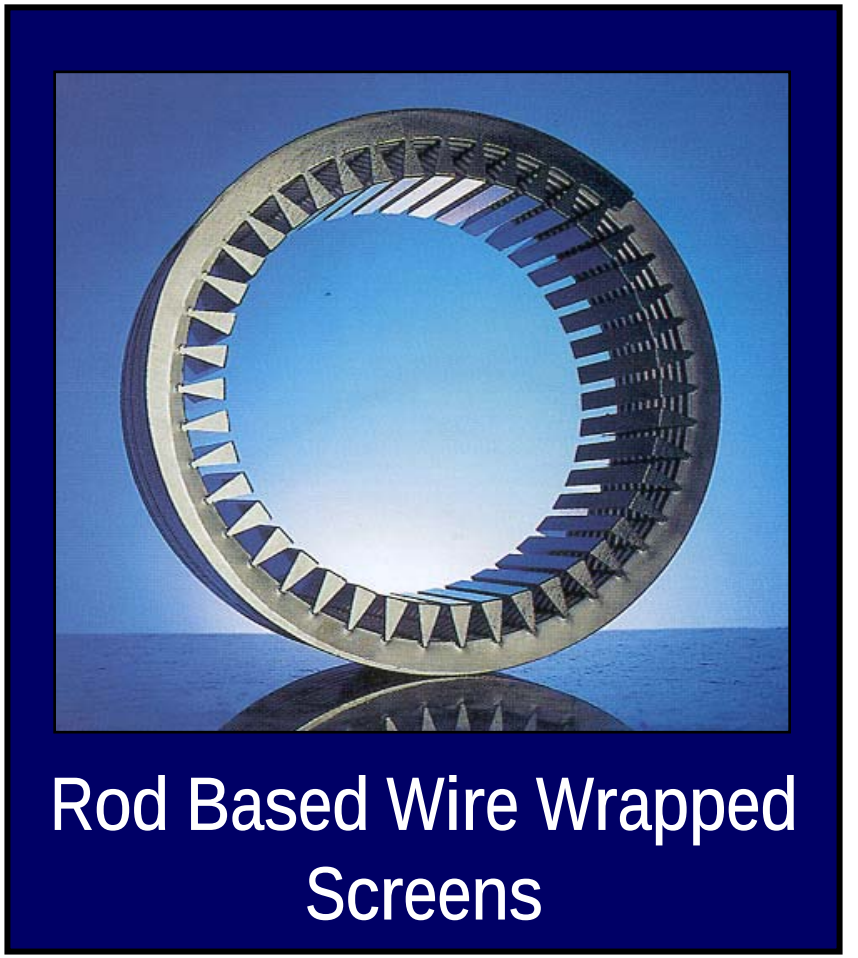
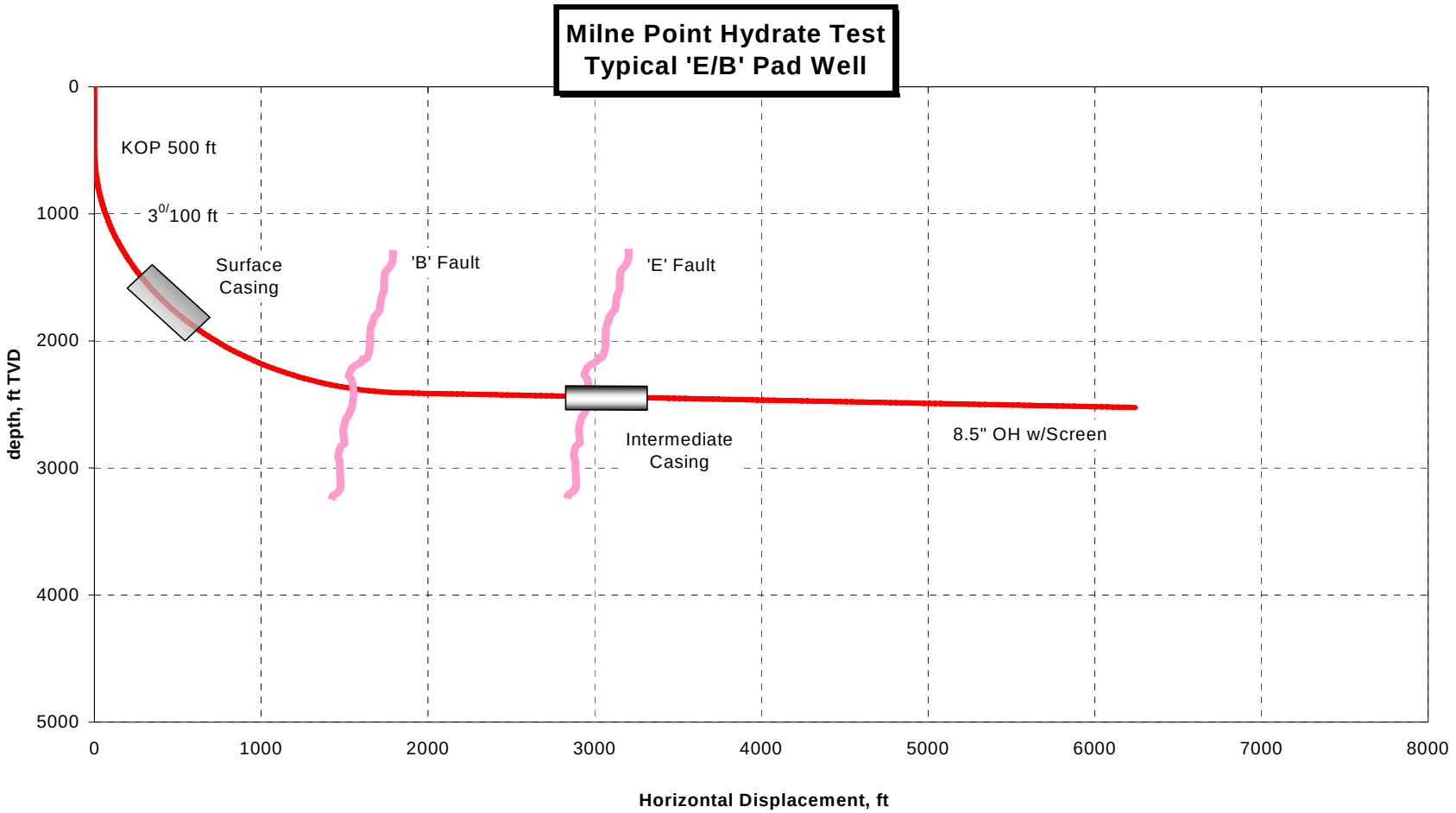


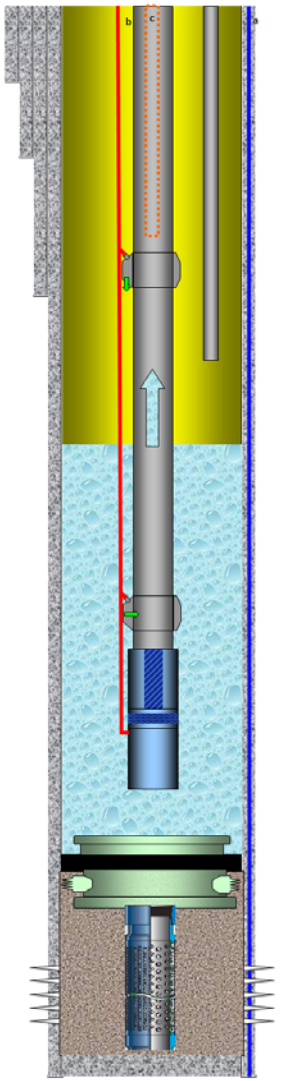


Hz Shallow Well



Typical Gas Hydrate Well Completion

- Mallik equivalent
- Sand control
- ESP
- Downhole instrumentation
  - Pressure, temperature
  - Distributed temperature (DTS)
- Flow assurance
  - Chemical injection
  - Heat trace
  - Downhole heater
- Other configurations depending upon specific well & reservoir situations



Conclusions

- Vertical and horizontal drilling technology, including extended reach drilling, is available for gas hydrate test wells
- There are no apparent barriers to production using existing well completion technology
- Well placement and proximity to free gas/water layers (hydraulic isolation) critical to test success