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PEACE RIVER

2017 WELL INTEGRITY PERFORMANCE

Scheme Approval #8143

April 18, 2018

PREMIUM VALUE. DEFINED GROWTH. INDEPENDENT.

Agenda

1. 2017 Casing Integrity Summary
2. Pad 32 October Event
3. Pad 32 / 33 Follow-up Casing Inspections
4. Casing Integrity Initiatives

2017 Casing Integrity Summary

- No casing failures or well integrity issues on any thermal or utility wells (excluding Pad 32)
- All disposal wells in use passed packer isolation tests
  - 102/14-25-085-19W5M [well 322] on Aug. 11
  - 102/16-23-085-19W5M [well 323] on Aug. 11
  - 100/16-27-085-19W5M on Aug. 11
- One casing inspection log run on well 32-14 (October) to assess downhole corrosion – none noted
- One caliper log run on well 32-13 (October) to confirm casing deformation – no deformation found
- One metal thickness log run on well 32-13 (October) – no casing break detected, though indication of casing wall loss at surface was noted.
- Numerous, external casing, corrosion checks after October Pad 32 well event…

Pad 32 Well Event

- On October 15, a well experienced a hole in the casing during a routine pressure test, ~15cm below the wellhead (below ground).
- On October 17, a well experienced a hole in the casing during steam injection, ~50cm below the wellhead.
- Root cause of both events subsequently found to be significant external, shallow, corrosion on the production casing, not previously known to be present.
- Neither well had been constructed with surface casing.

Hole from p-test

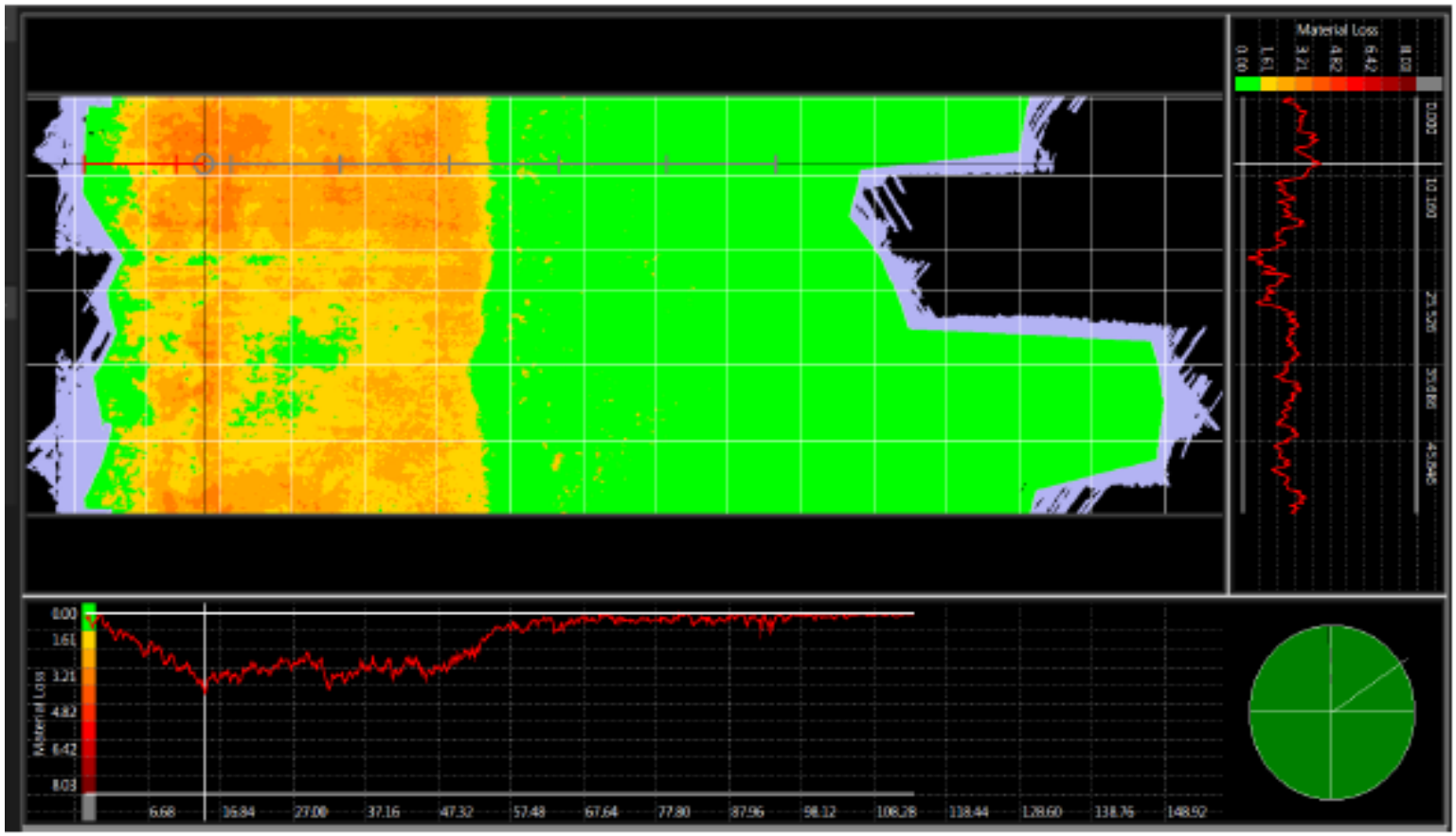
Hole from steam injection

Pad 32 Event Follow-up

- All wells on Pads 32 and 33 were excavated and external side of casing inspected (pads had been constructed and started at same time)
- Inspections consisted of laser mapping of the external casing surface and confirmation of wall loss with a pit gauge and UT measurements.
  - UT measurements later dropped due to difficulty obtaining meaningful values
- No evidence of internal casing corrosion found on any wells tested.
- Most wells required replacement of top ~1 – 1.8m of casing due to external corrosion.
- All new casing sections were externally coated with a protective material to prevent future corrosion; all wells not requiring repair also coated.
- Several wells on each other operating thermal pad were excavated and casing externally inspected to determine extent of corrosion problem on these pads.
- No wells were found to require casing cut-out and replacement, and in general corrosion levels did not require protective measures.

External Casing Inspections - methodology

- Laser and ultrasonic inspection used to assess amount of wall loss and indication of any internal corrosion:



External Casing Inspections - methodology

- Confirmation of laser results through a pit gauge and UT measurements:

- Data limited by overall surface wall loss and roughness; for UT by size of pits and surrounding surface area.

External Casing Inspections - Findings

- External surface corrosion variable by pad and not driven by well age
- Pads 32 and 33 showed highest wall losses:
  - up to 90% on ~12-year old wells (not counting 2 wells with holes)
  - up to ~8.6% annual corrosion rate
  - all wells affected to some degree
- Inspections on wells on other pads showed corrosion rates up to 3.3% wall loss/year (but most were <1.5%/yr):
  - pads 19, 20, 21, 30, and 31 checked
  - total of 16 wells checked
  - where installed, both surface and production casing were checked
- Mitigation options were:
  - application of a high temperature, corrosion-protective, coating, or
  - cut-out and replacement of casing sections not meeting minimum wall thickness requirements for required service
- No explanation found to explain the corrosion difference on Pads 32 and 33, vs. rest of operating pads.

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WELL INTEGRITY INITIATIVES

2017 Initiatives

- Understand the extent of external corrosion on thermal wells; take appropriate action where found to be a concern.
- Future risk mitigation

Future Risk Mitigation

- Updated internal Thermal Well Casing Integrity Protocol document to ensure:
  - preventative casing inspection checks are carried out as appropriate,
  - pressure testing is done to highest operating pressure anticipated,
  - inspection tools are identified and criteria for use set, and
  - repair criteria are established and applied as appropriate.
- Issued new internal Thermal Well External Casing Corrosion Management Protocol document to address preventative inspections and corrective measures for surface-based corrosion risk to establish:
  - inspection frequency of wells,
  - inspection process and methodology,
  - corrosion criteria for mitigation measures to be applied,
  - how mitigation (coating) / repairs are to be done, and
  - future inspection obligations based on prior corrosion history.
- Implemented staff training on new requirements in head office and at field operations.

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