Annulus Leak Detection and Well Repair in a Class I Well

GWPC 2020 UIC Conference - San Antonio, TX
February 17, 2020
Safety Moment
—Allergies
—Airborne – Weather Events and Seasonal
—General awareness
—Pollen count
—Antihistamines
Introduction

—Lead Engineer and Project Manager at WSP for 10 years

—Worked on 30+ Class I wells in permitting, MIT, well repair, drilling, and completions.
Presentation Agenda

—Annulus leak detection
—Leak Determination
—Well Repair
  —Removing and replacing Tubing/Packer
  —Determining casing leak
  —Installing Liner
  —Sidetrack
Annulus Leak Detection
Well Annulus Monitoring System (WAMS)

- Annulus Pressure Exceeds Injection Pressure
- Fluid Level Changes with Pressure and Temperature
- Any Fluid Lost is Nonhazardous Brine

Recorded Parameters:
- Injection Pressure
- Fluid Level
- Annulus Pressure
- Differential Pressure
Well Annulus Monitoring System (WAMS)

Recorded Parameters:
- Injection Pressure
- Fluid Level
- Annulus Pressure
- Differential Pressure

Wellhead
Injection Tubing
Casing
Packer
Nitrogen
Annulus Fluid

Recorded Parameters:
- Injection Pressure
- Fluid Level
- Annulus Pressure
- Differential Pressure
Annulus Volume

— Temperature effects
  — Only a few gallons of water cooling down can cause a significant decrease in annulus pressure due to compressibility.

— Compressibility of fluid example:
  — 7” X 4-1/2” casing-tubing annulus with packer set at 5000 ft. Volume = 140 bbls
  — Reduction in annulus pressure of 50 psig caused by reduction of 1.03 gallons in the annulus.

— $C_w = 3.5 \times 10^{-6} \text{ psi}^{-1}$
Leak Determination

— Tubing leak
   — Tubing pressure and casing pressure will typically equalize

— Casing leak:
   — Annulus pressure will drop to 0 psig
   — WAMS unit not able to maintain pressure due to fluid loss -- dependent on size of casing leak
Tubing Leak
Remove Injection Tubing
Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Surface Casing and Cement

Long-String Casing

Packer

Changing Tubing String and Packer

• Un-sting from packer

Perforations
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work

Surface Casing and Cement

Long-String Casing

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval
Changing Tubing String and Packer

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Changing Tubing String and Packer

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- Retrieve old packer
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Surface Casing and Cement

Long-String Casing

Perforations
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer
- Remove setting tool

Long-String Casing

Packer

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer
- Remove setting tool
- Stab into packer with new tubing
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Veritilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string

• Cement Liner in place, monitor pressure
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools
- Drill out cement and plug
Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools
- Drill out cement and plug.

Trip out of the hole
Install new packer and tubing

- Run in new packer
Install new packer and tubing

- Run in new packer
- Set new packer
Install new packer and tubing

- Run in new packer
- Set new packer
- Remove setting tool
Install new packer and tubing

- Run in new packer
- Set new packer
- Remove setting tool
- Stab into packer with new tubing
Casing Leak
Sidetrack
Setting Whipstock /Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
**Setting Whipstock/Sidetrack**

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing
- Allow 12 - 24 hours to set and trip out of hole
Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and allow 12 - 24 hours to set
- Release from cement retainer and trip out of hole
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing
- Allow 12 - 24 hours to set and trip out of hole
- Trip in with work string and locate top of cement, ensure a hard tag.
- Run in with whipstock
Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
- Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)
• Run in with whipstock
• Orient whipstock and set whipstock
• Trip out with whipstock setting tool
• Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
• Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)
• Trip out of hole with milling assembly and trip in with bit. Drill sidetrack
Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
- Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)
- Trip out of hole with milling assembly and trip in with bit. Drill sidetrack
- Proceed with completing sidetrack
QUESTIONS AND COMMENTS
Thank you!