

# Coiled Tubing Bias Welds Recent Failures Trend

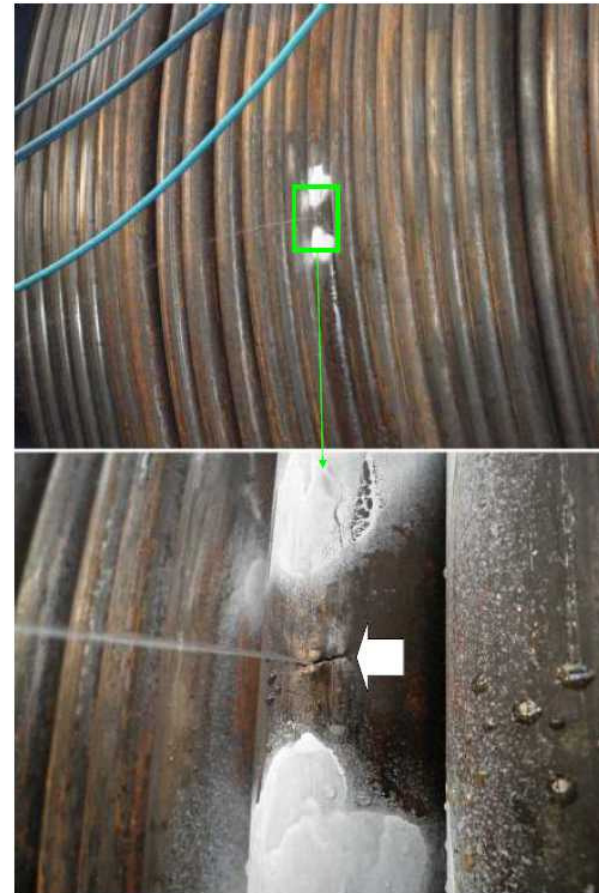


Tomas Padron, Coiled Tubing Research and Engineering (CTRE)

October 29<sup>th</sup>, 2014  
ICoTA Roundtable, Calgary, Canada

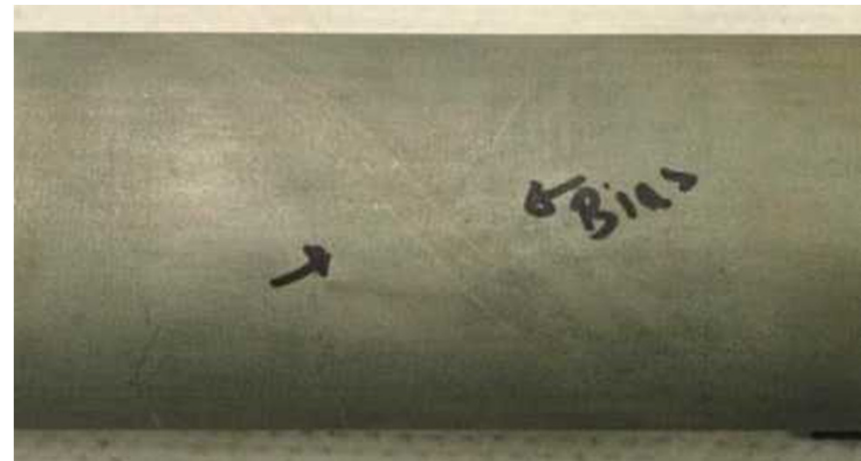
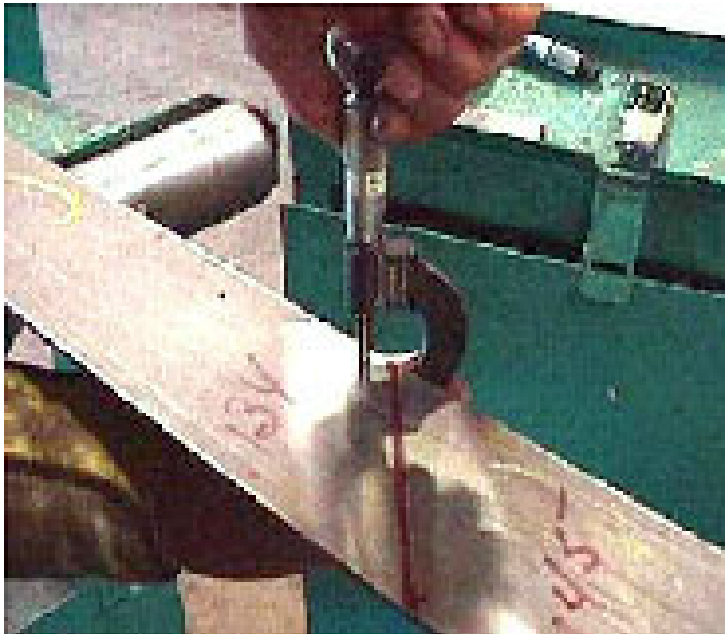
# Bias Weld Failures - Outline

- Background Information
- Bias Weld Failures Causes
- Main Ideas



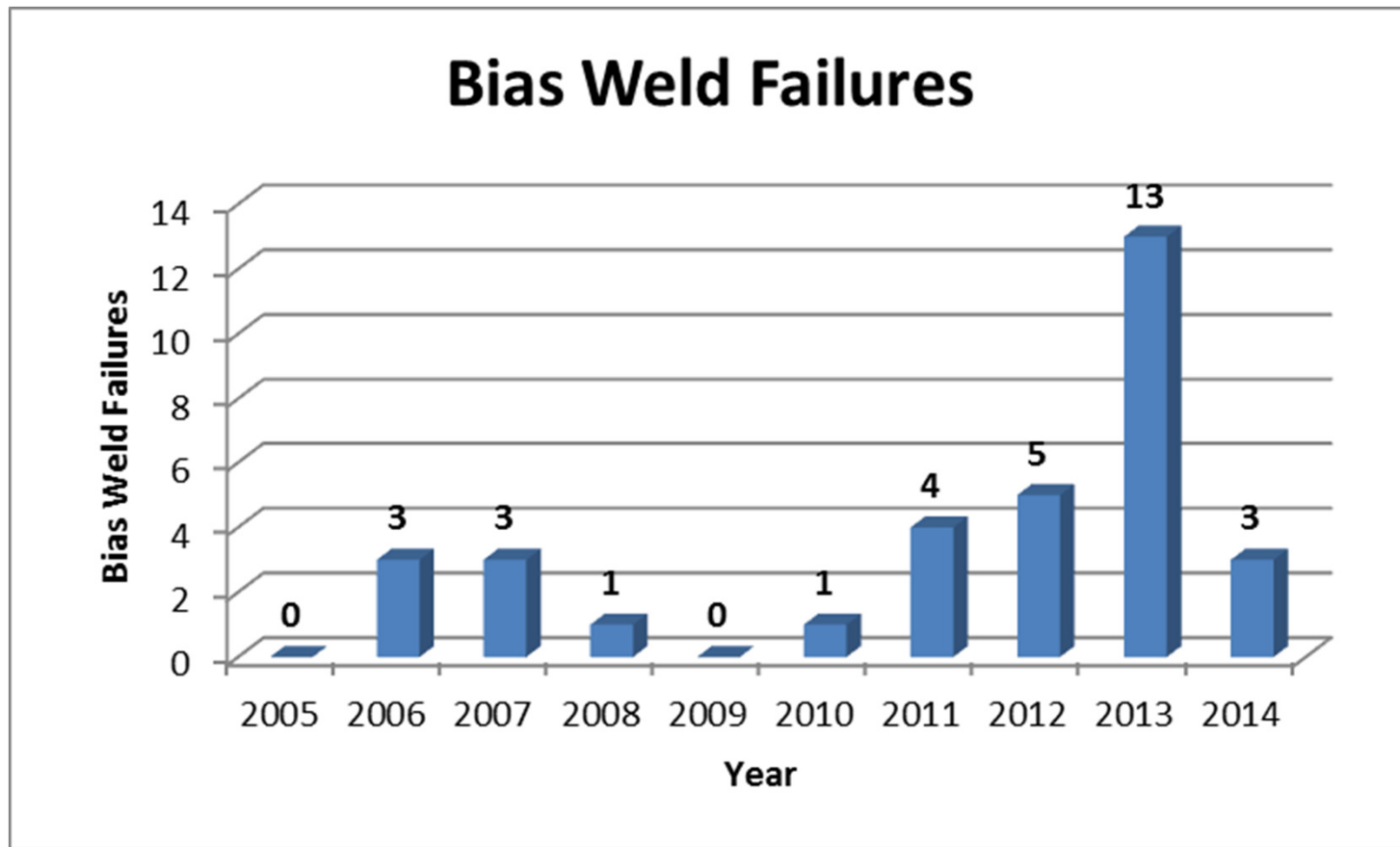
# Bias Weld Failures - Background

Bias weld: plasma arc weld at 45° to joint steel strips ...After conforming the pipe it forms a helical weld

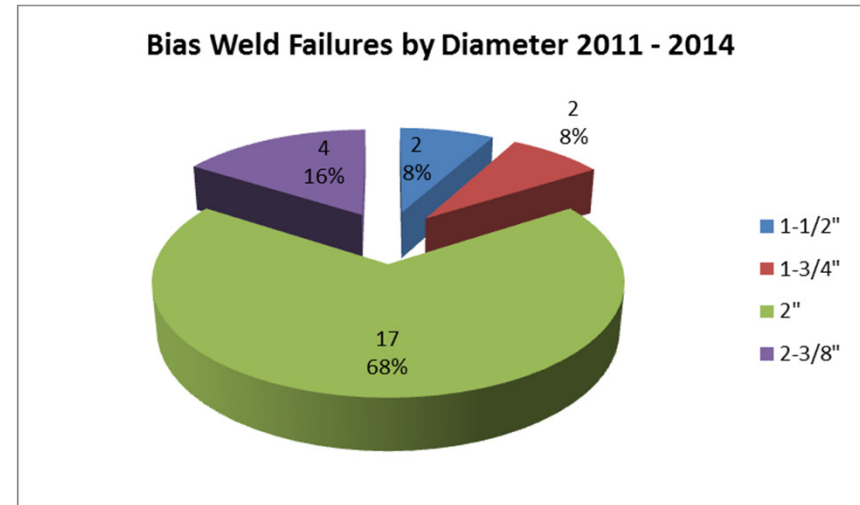
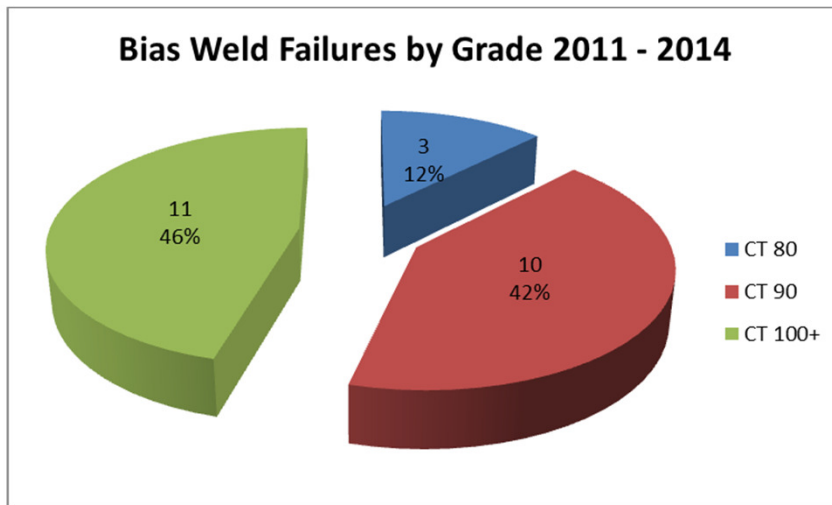


# Bias Weld Failures - Background

Bias weld failures trend in BHI:

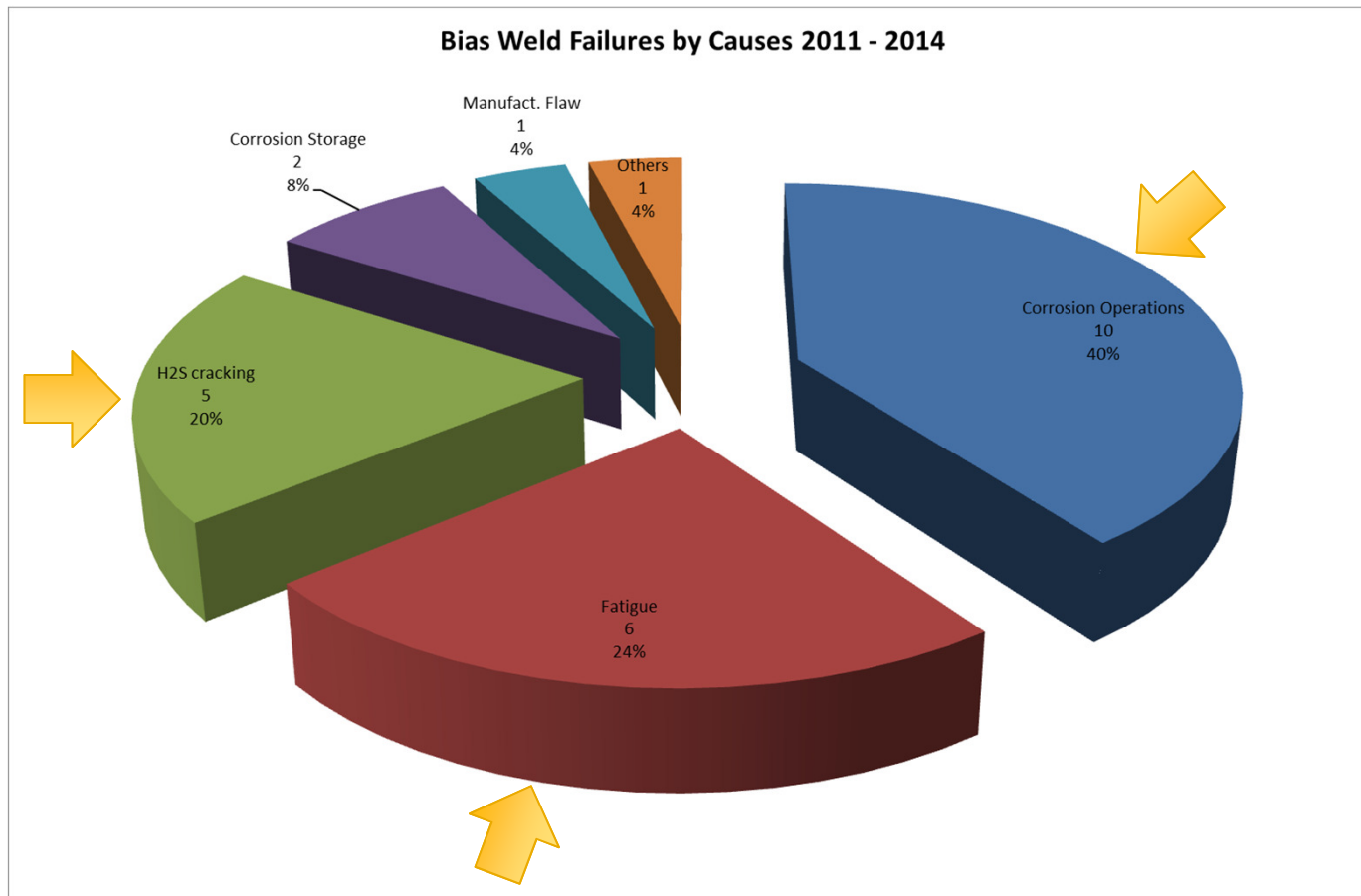


# Bias Weld Failures - Background



- CT90 and CT100+: 88% of bias weld failures
- 68% of the failures associated with 2" pipe
- Strings from the 3 CT manufacturers

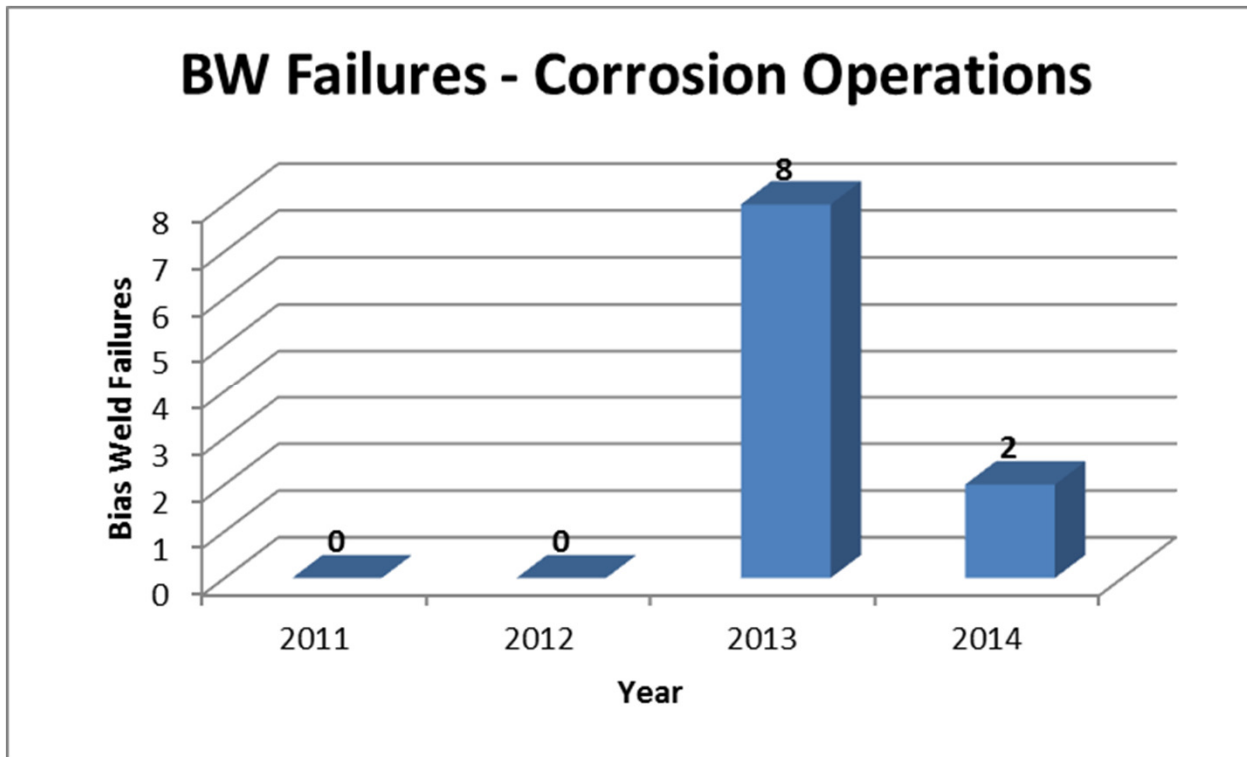
# Bias Weld Failures - Causes



Corrosion Operations, Fatigue, and H2S Cracking represent 84% of the bias weld failures

# Bias Weld Failures – Corrosion Operations

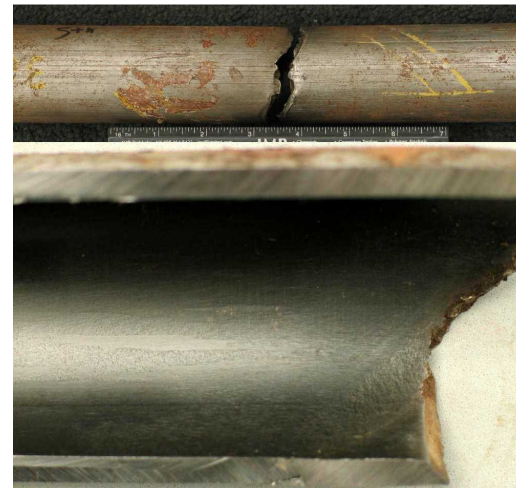
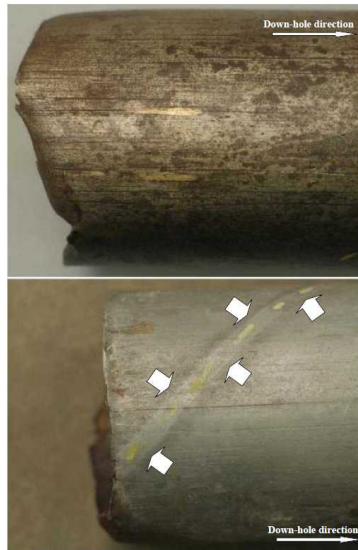
Corrosion Operations: failures associated with corrosion damage caused by fluids used during operations.





# Bias Weld Failures – Corrosion Operations

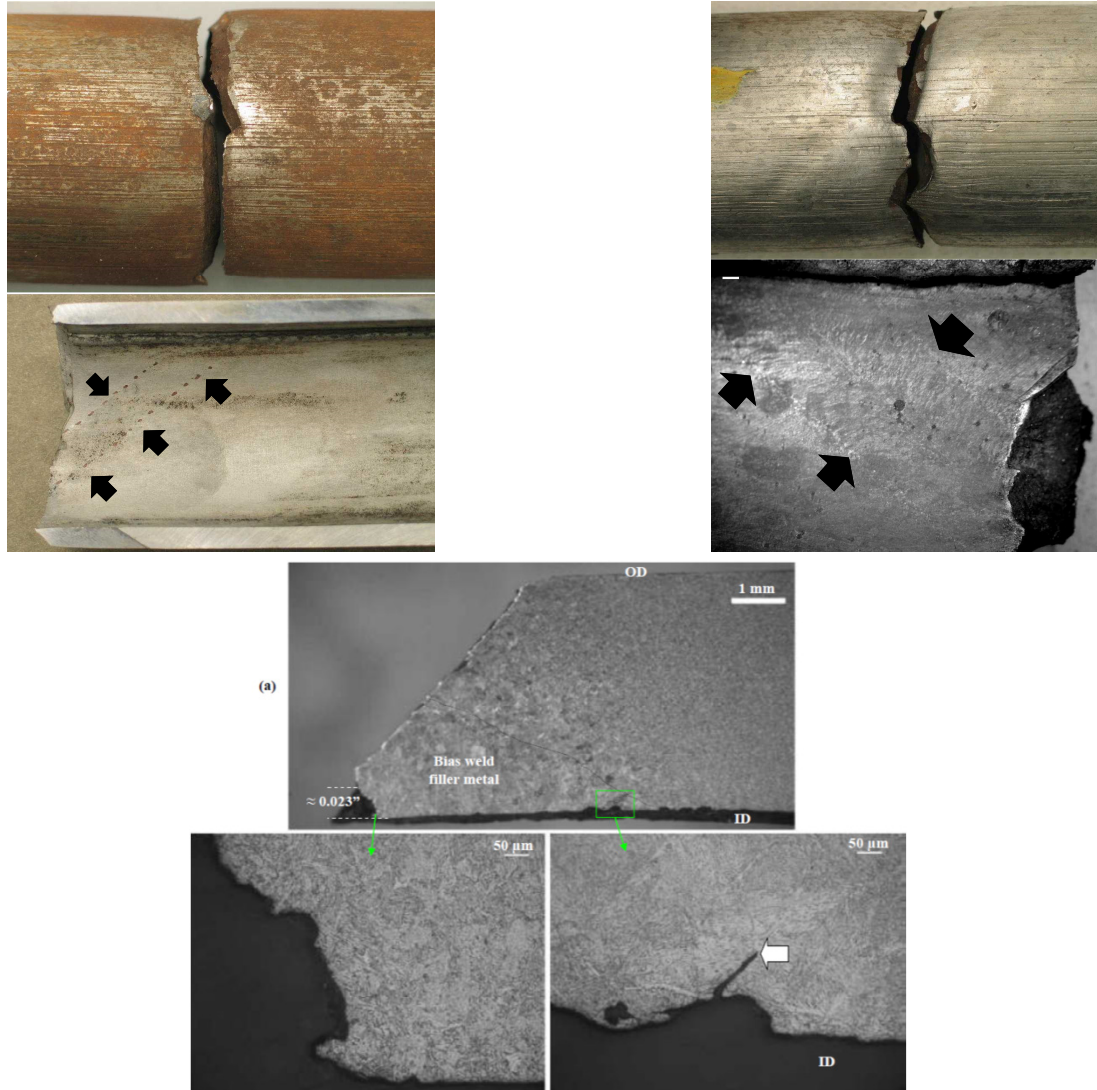
- Six (6) CT failures occurred while milling plugs in Alice – USA.
- String characteristics:
  - 2" OD x tapered
  - 90 Grade
  - Basically new strings
- All the failures occurred on bias welds.



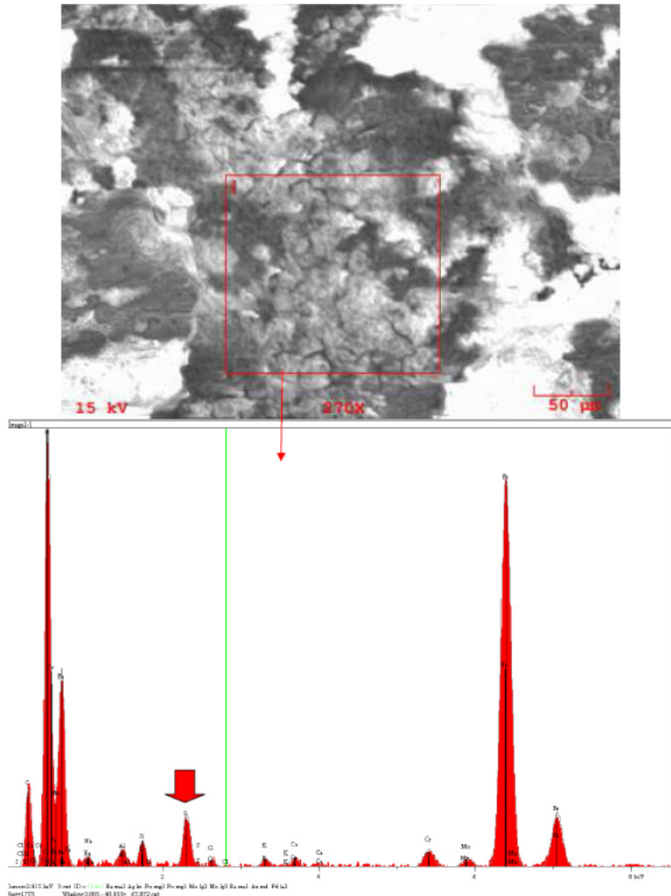


# Bias Weld Failures – Corrosion Operations

- On 3 failures: internal pitting corrosion on the bias weld region.
- Fatigue cracks starting at these pits
- High pressure regime (around 7,000 psi).
- Fluid: recycled fluid “treated” with biocide.

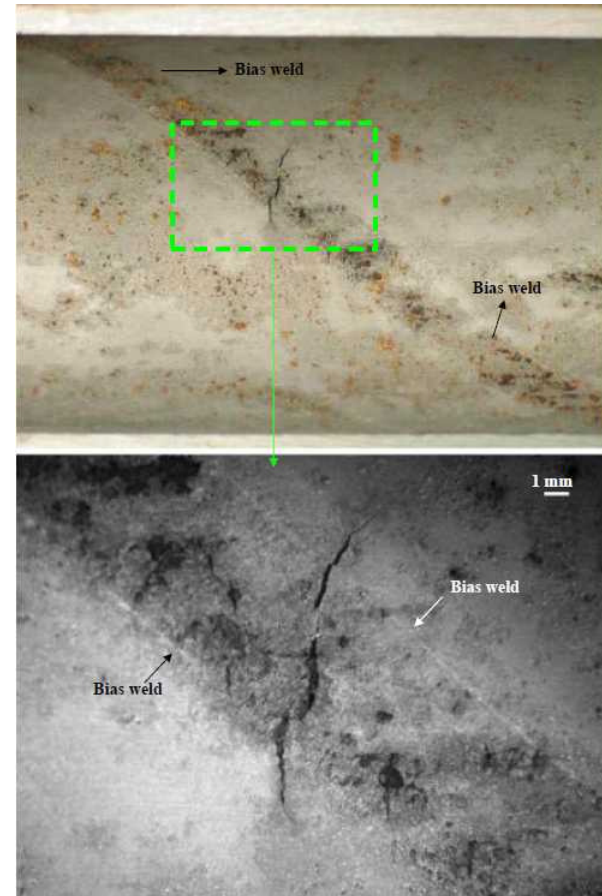
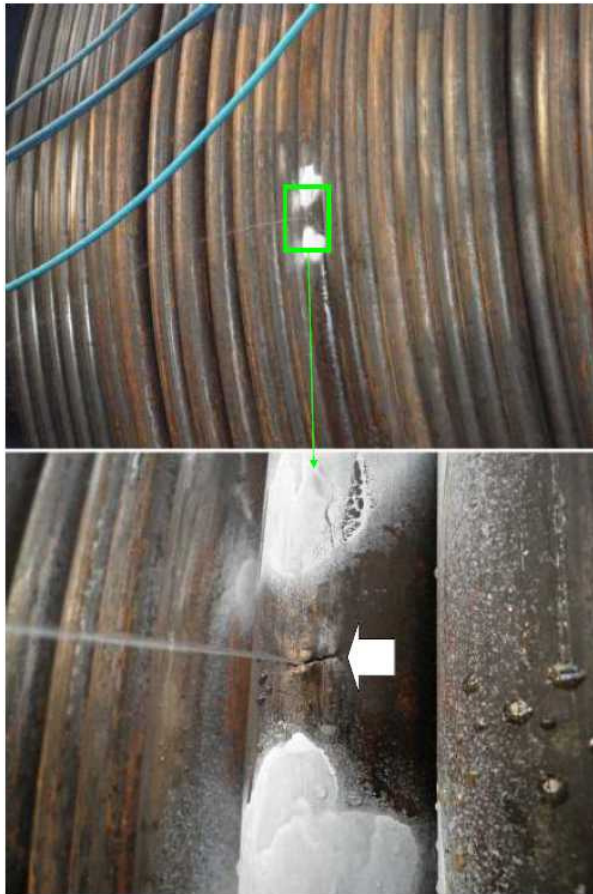


# Bias Weld Failures – Corrosion Operations



- Sulfur (S) was found within the internal pits
- Recycled fluid analyses revealed:
  - Sulfur, pungent odors of rotten eggs, and sulfide in the form of black precipitates
  - 4.2 – 5.2 million bacteria per ml
  - APBs and SRBs

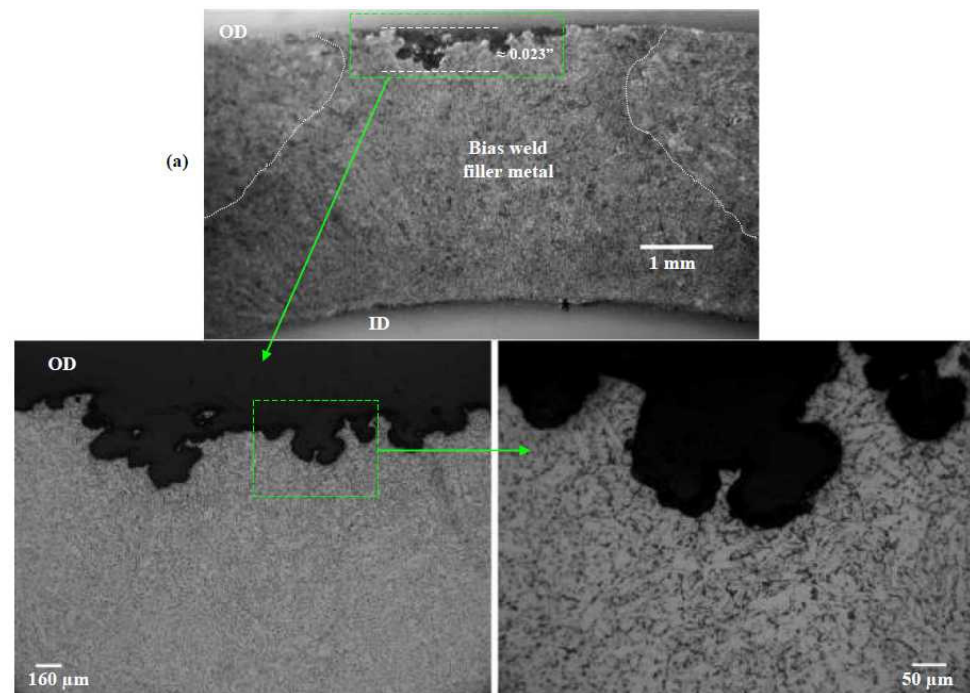
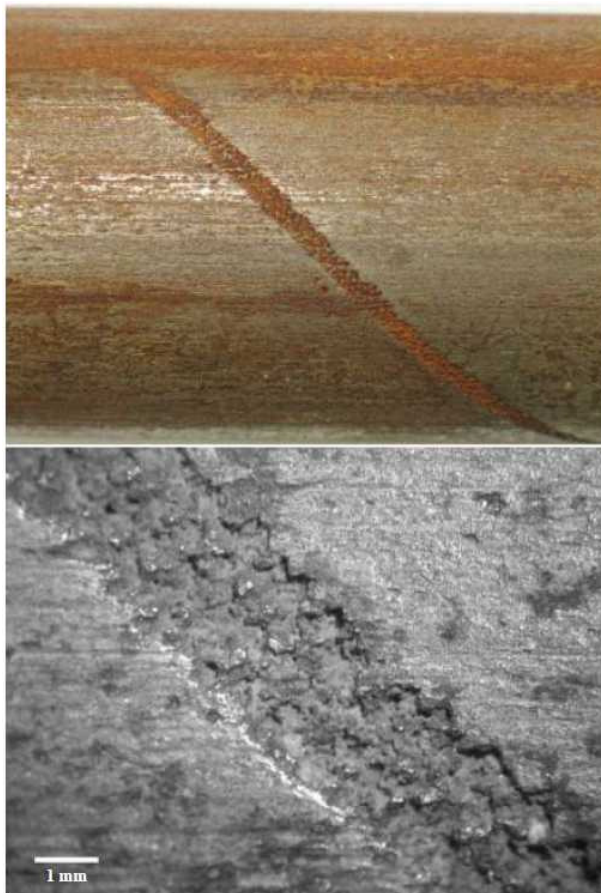
# Bias Weld Failures – Corrosion Operations



Failure: Pinhole; Date: November 2013; String: 2-3/8" x 0.156" – CT100+  
Fluid: Customer supplied "treated" sea water (oxygen scavenger + biocide)



# Bias Weld Failures – Corrosion Operations

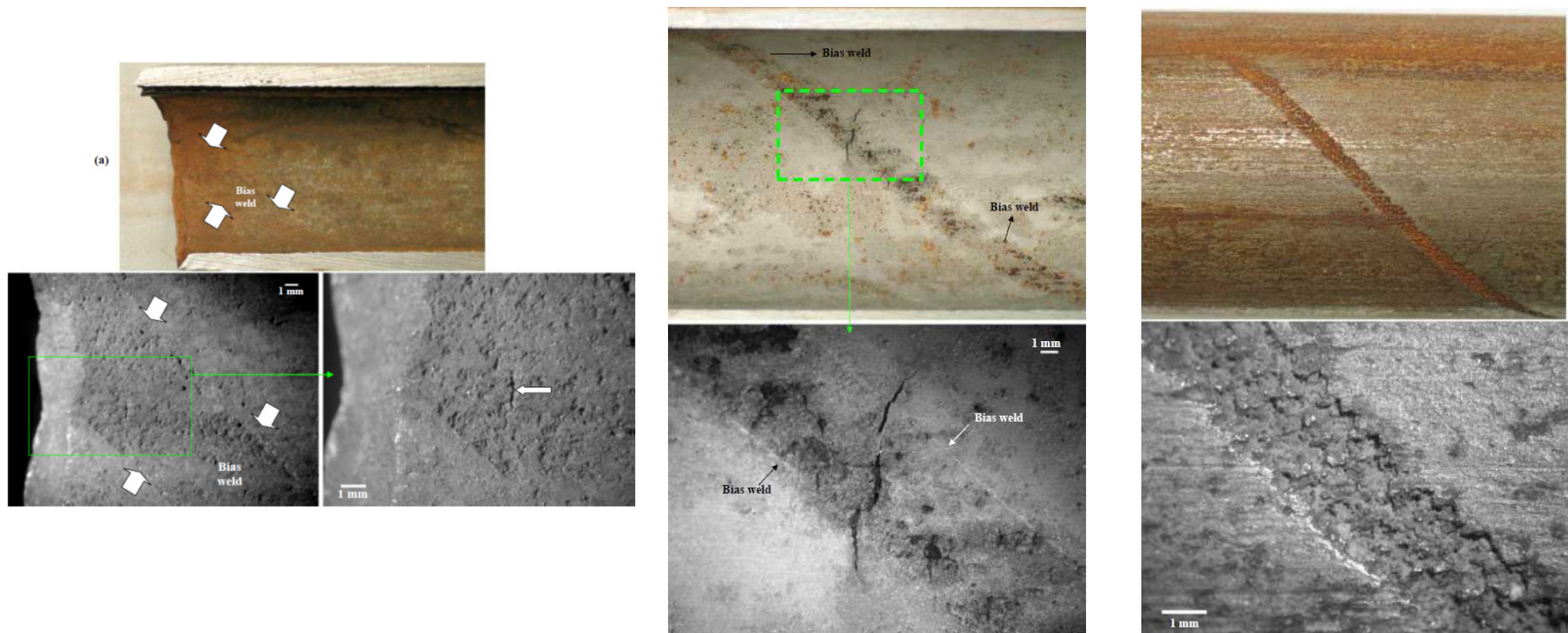


Failure: Ext. corrosion on bias weld; Date: October 2013; String: 2" x Tapered – CT90  
Fluids: fracturing fluid + acid mix with inhibitor

# Bias Weld Failures – Corrosion Operations

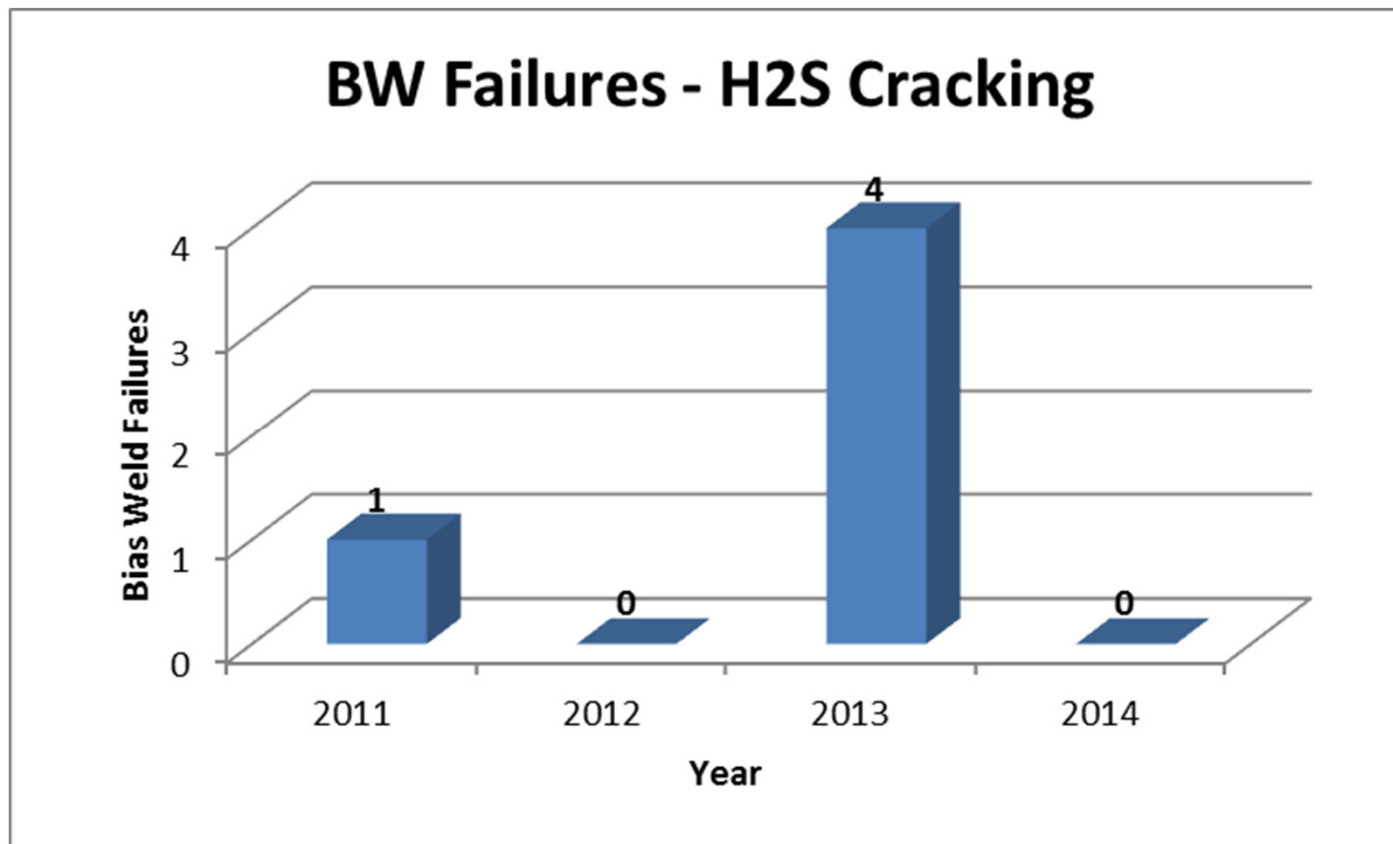
- Corrosion Operations:

- The examples showed a greater susceptibility to corrosion damage on the bias weld region – this is considered as “expected” but....Could this be a topic for investigation and improvement?



# Bias Weld Failures – H2S Cracking

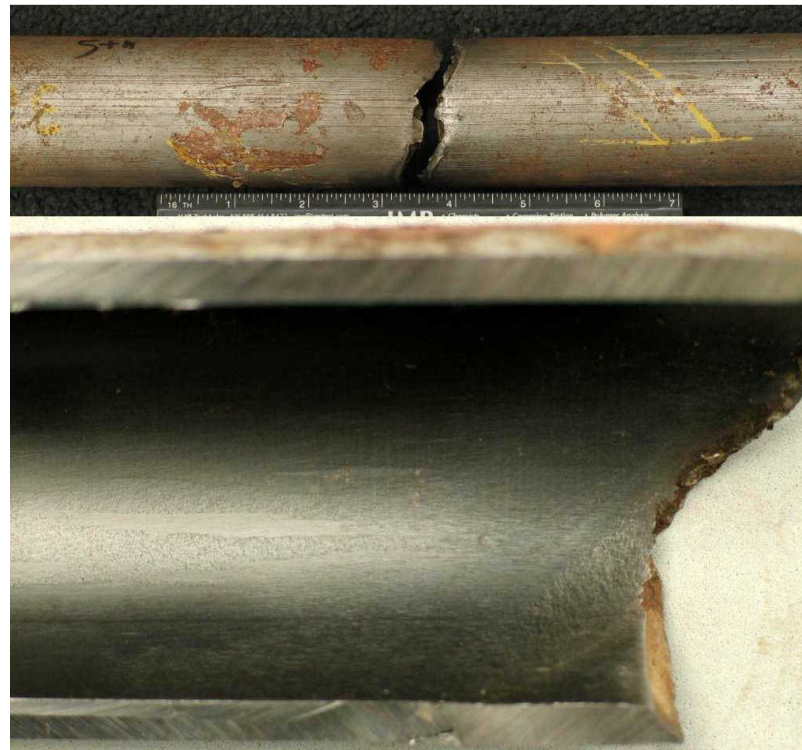
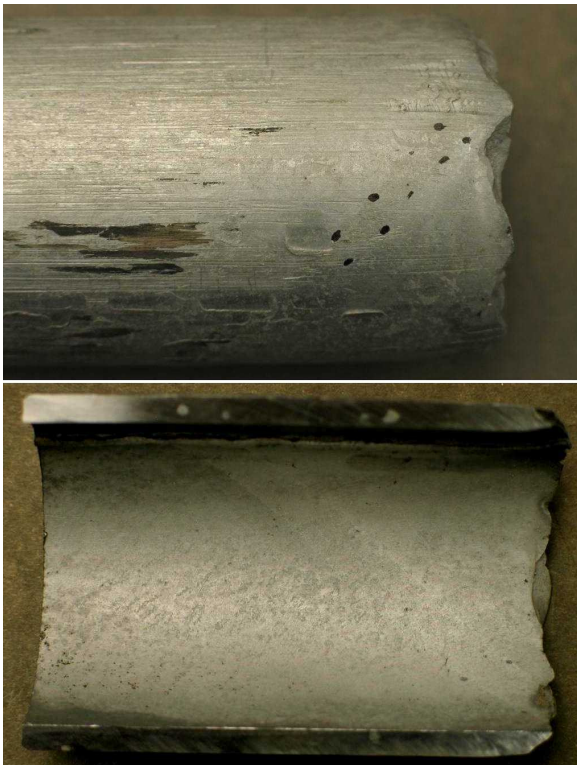
H2S cracking: failure by internal cracking due to the exposure to a sour environment. H2S sources could be different, i.e. well, contaminated fluid, etc.





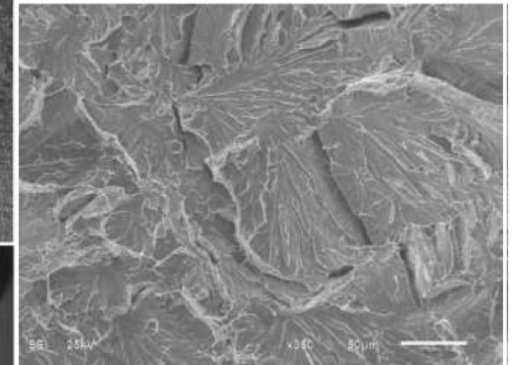
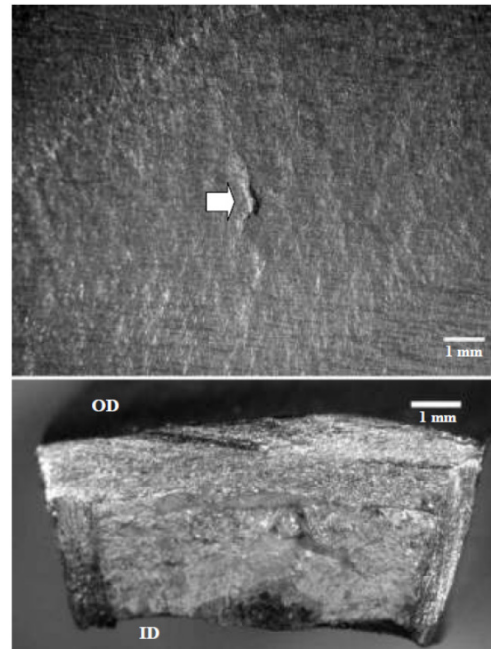
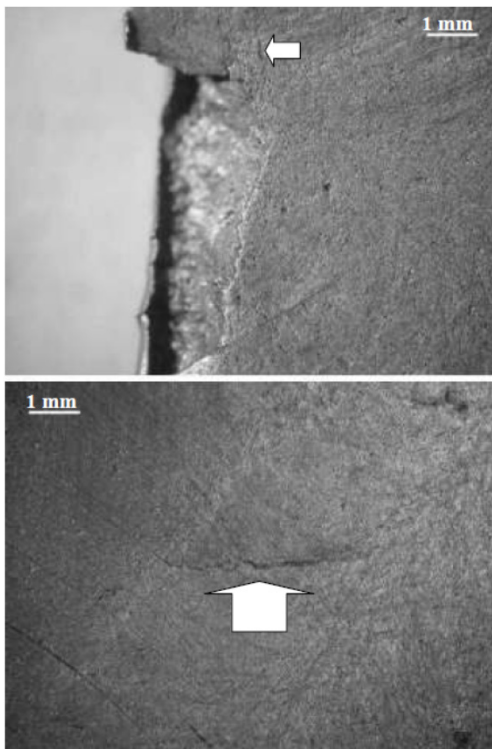
# Bias Weld Failures – H2S Cracking

- Three (3) CT failures occurred while milling plugs in Alice – USA.
- String characteristics: 2" OD x tapered - 90 Grade / Basically new strings
- Failures occurred as fractures at bias welds



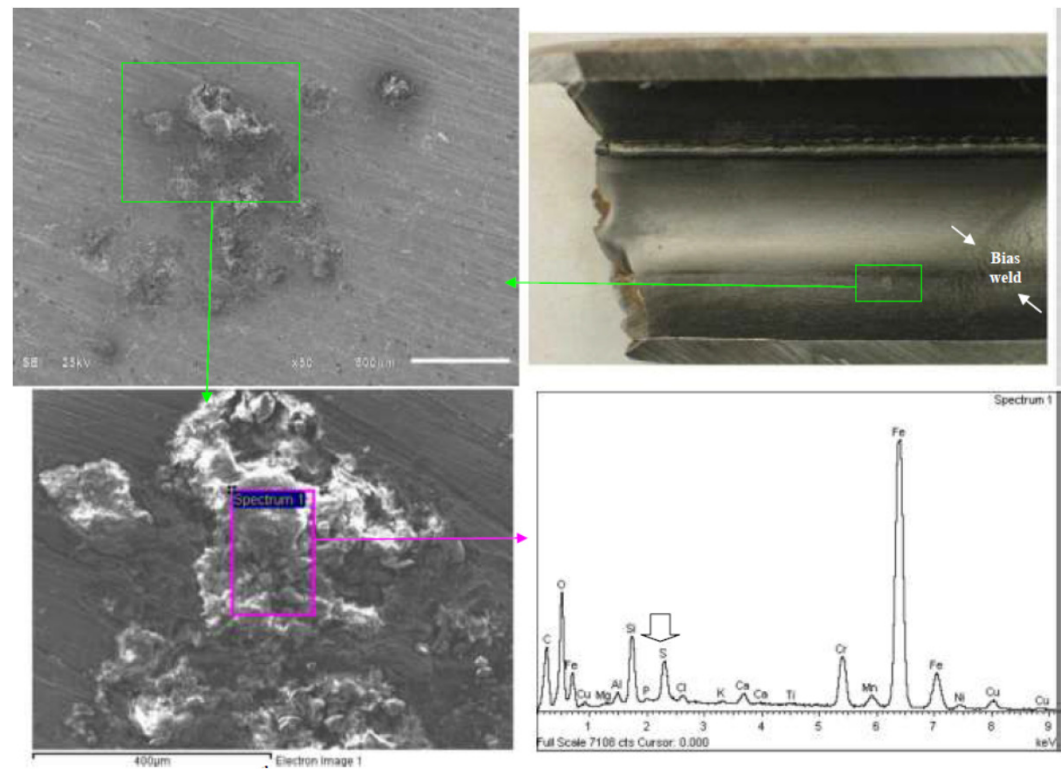
# Bias Weld Failures – H<sub>2</sub>S Cracking

- Internal corrosion damage very mild or absent – no fatigue cracking associated with isolated pits
- Internal cracking on the bias welds – “cleavage” features - similar to cracking due to exposure to H<sub>2</sub>S



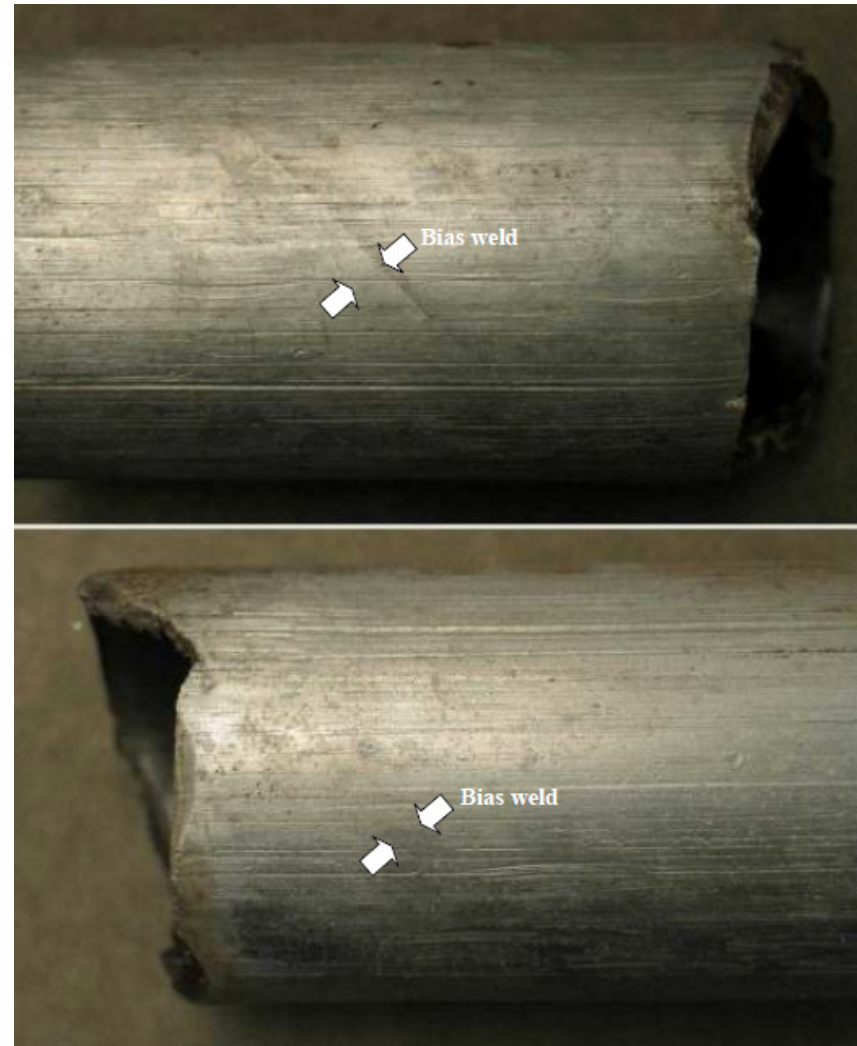
# Bias Weld Failures – H2S Cracking

- Fluid: recycled fluid “treated” with biocide
- Sulfur was observed on some shallow pits
- Fluid analyses revealed the presence of SRBs
- “Localized sour environments” – Bias weld weakest point



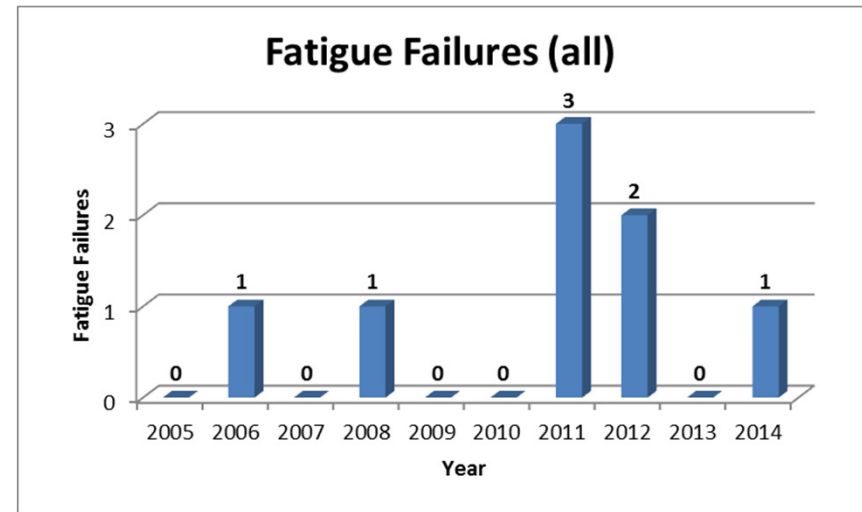
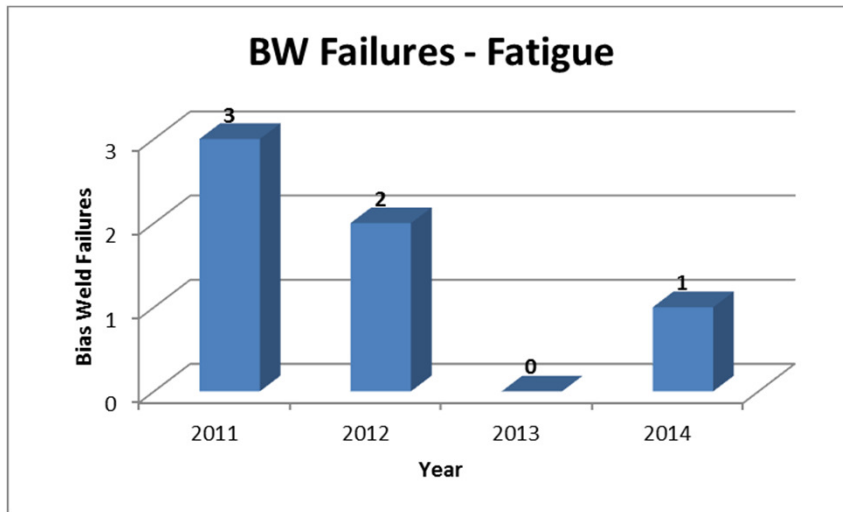
## Bias Weld Failures – Contaminated Recycled Fluid

- Corrective actions:
  - Treating for bacteria in the system (including tanks)
  - Treating circulating fluid
  - Treating stagnant fluid





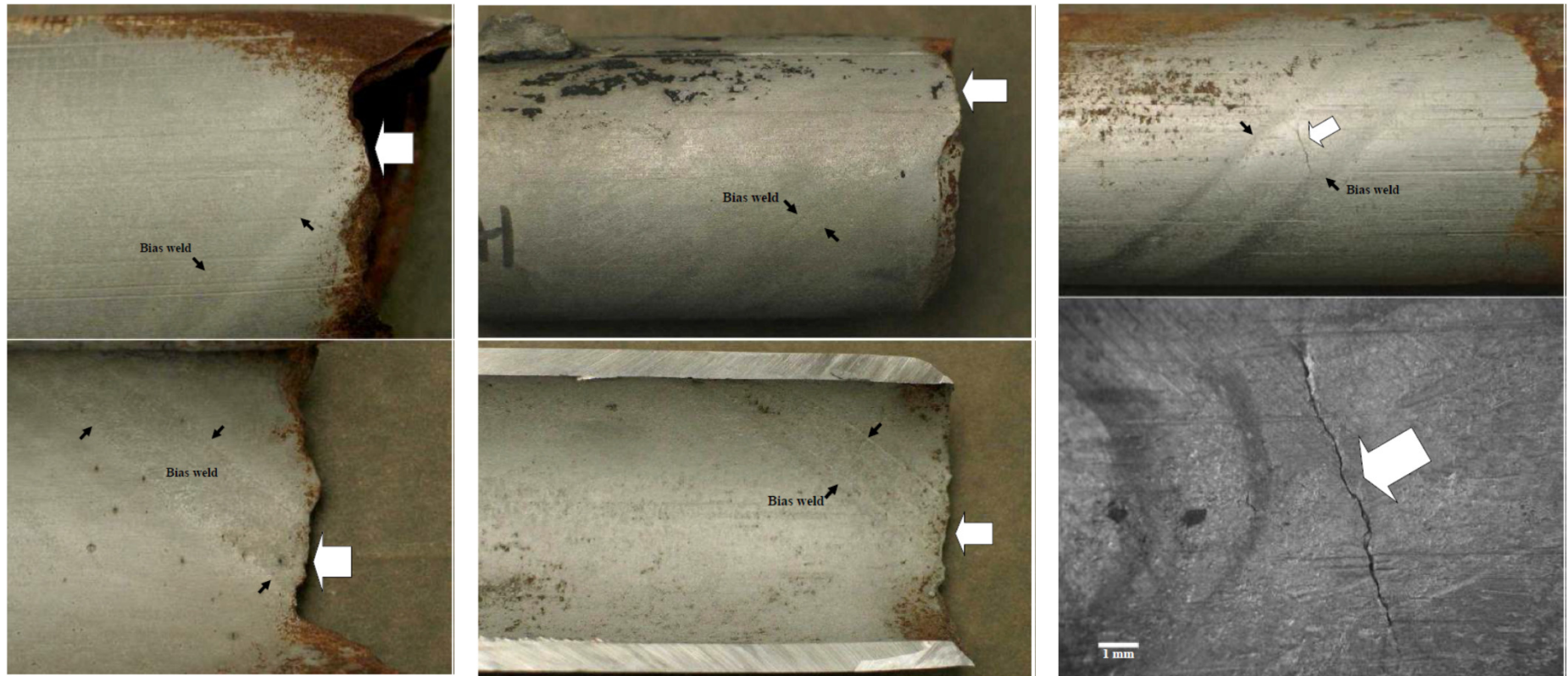
# Bias Weld Failures – Fatigue



Not common to have “pure” fatigue failures

# Bias Weld Failures – Fatigue

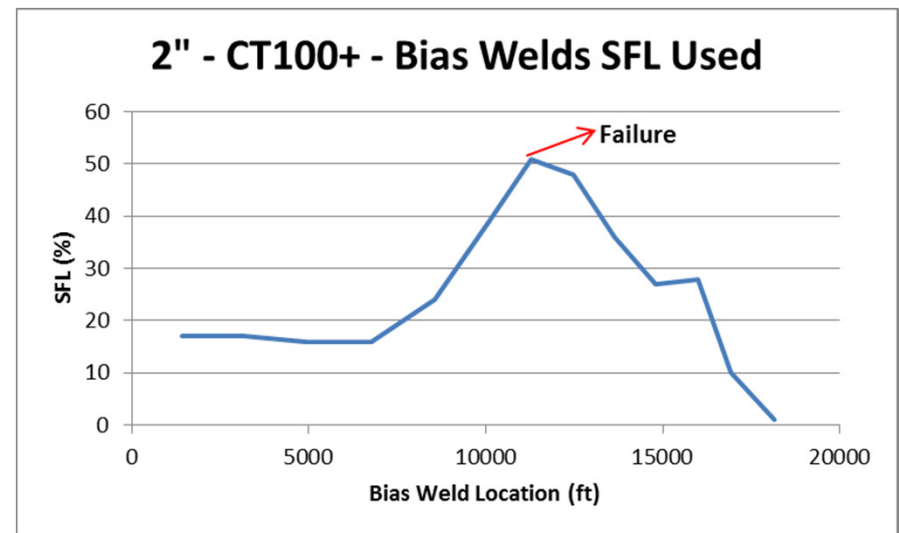
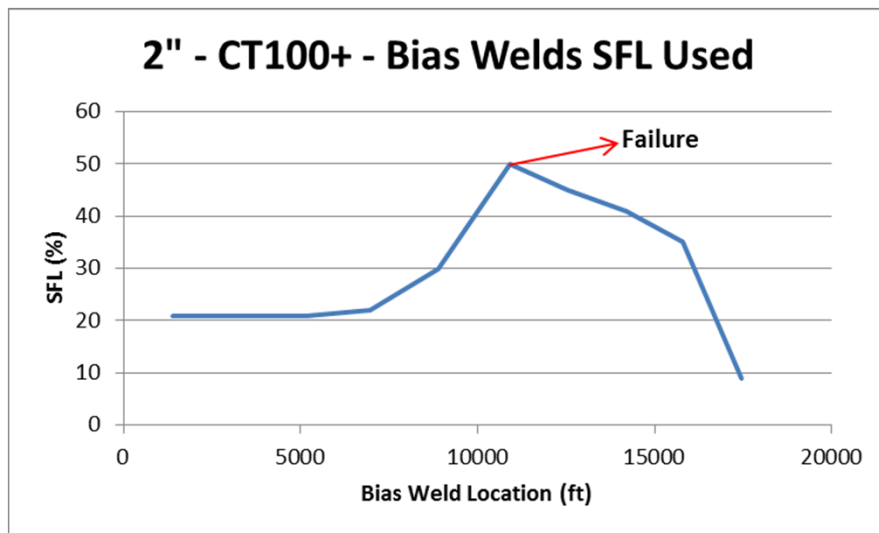
- Strings: 2" x tapered – CT100+
- Operating Pressure: 6,000 – 7,000 psi
- **Strains at bias weld locations: 1.8% - 2.3%**
- SFL used at bias weld locations: around 50%



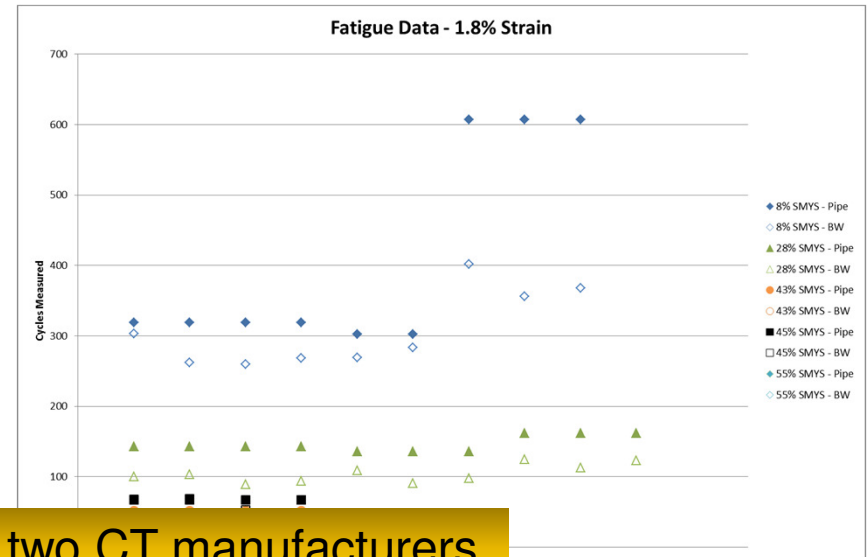
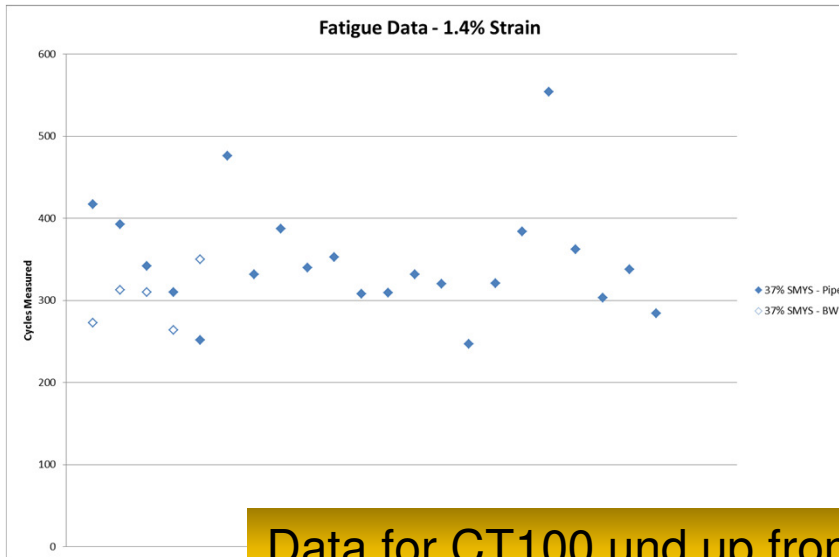


# Bias Weld Failures – Fatigue - Main Ideas

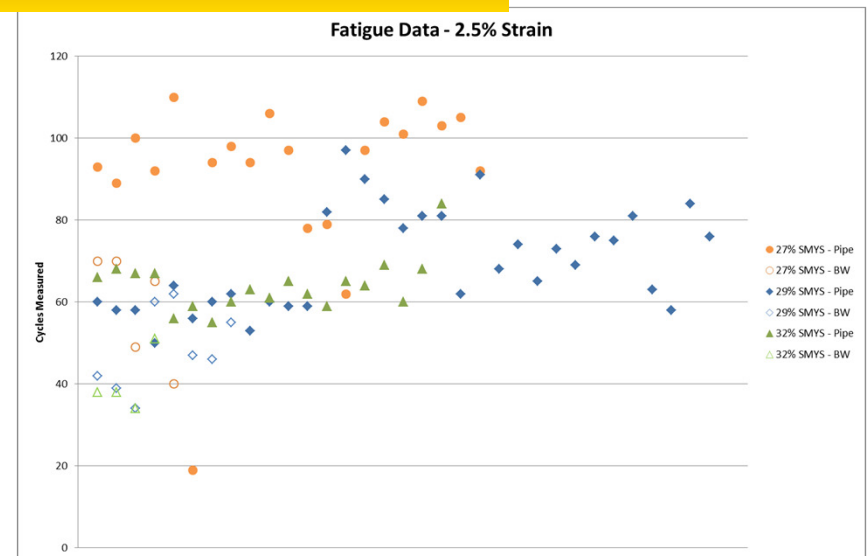
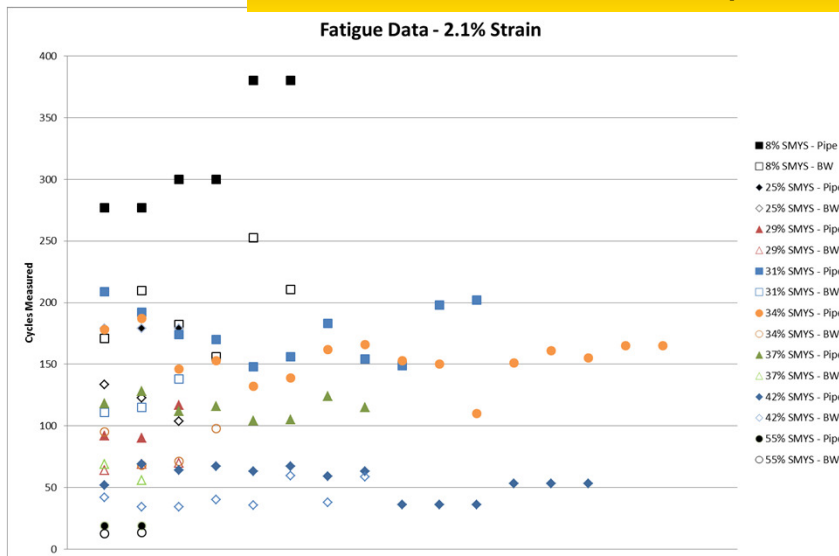
- Analysis of strings records showed:
  - Most of the retired strings without failures – SFL at bias welds < 50%
  - Failures at bias welds – SFL  $\geq$  50%



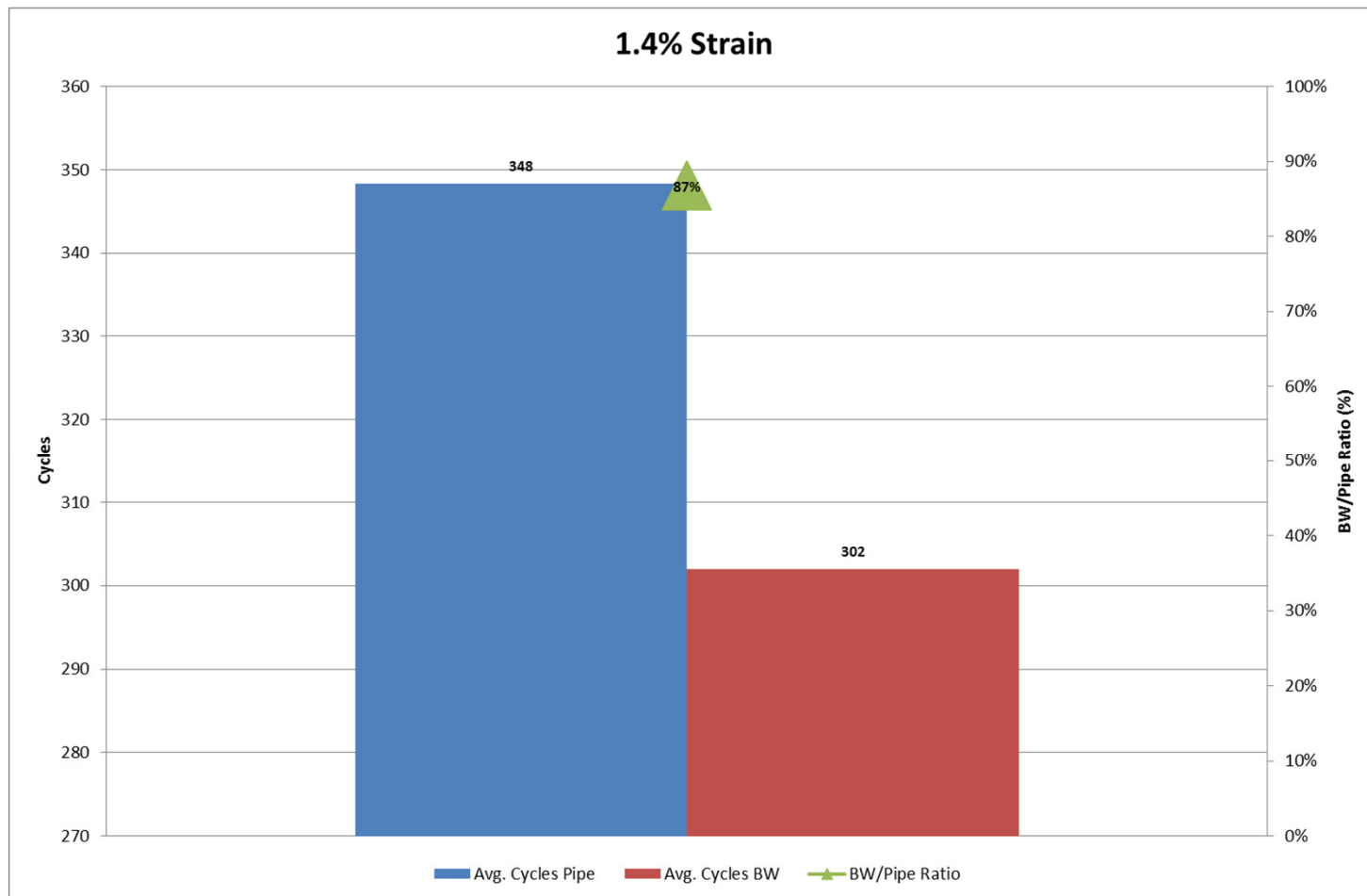
# Bias Weld Failures – Fatigue



Data for CT100 und up from two CT manufacturers

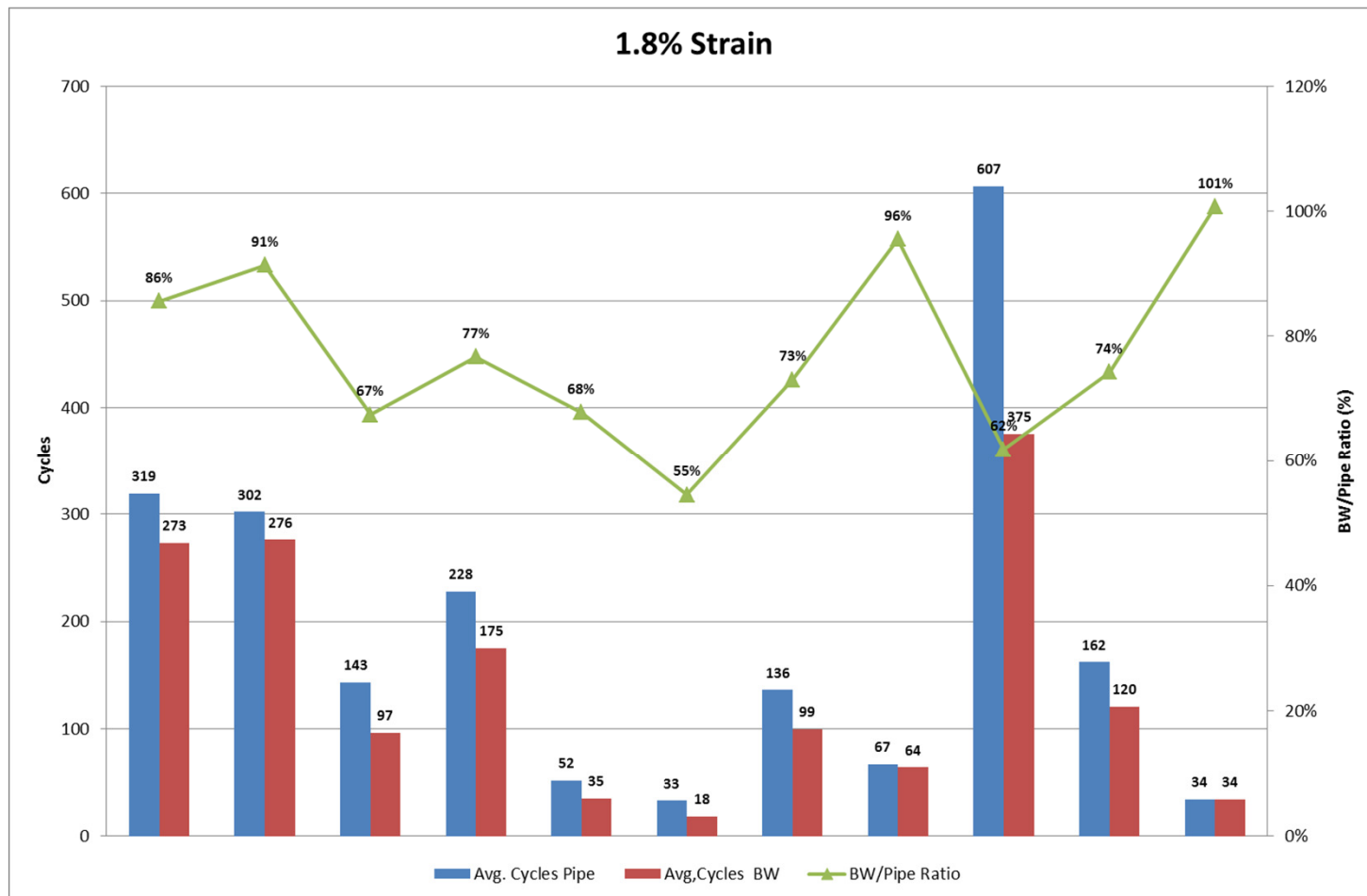


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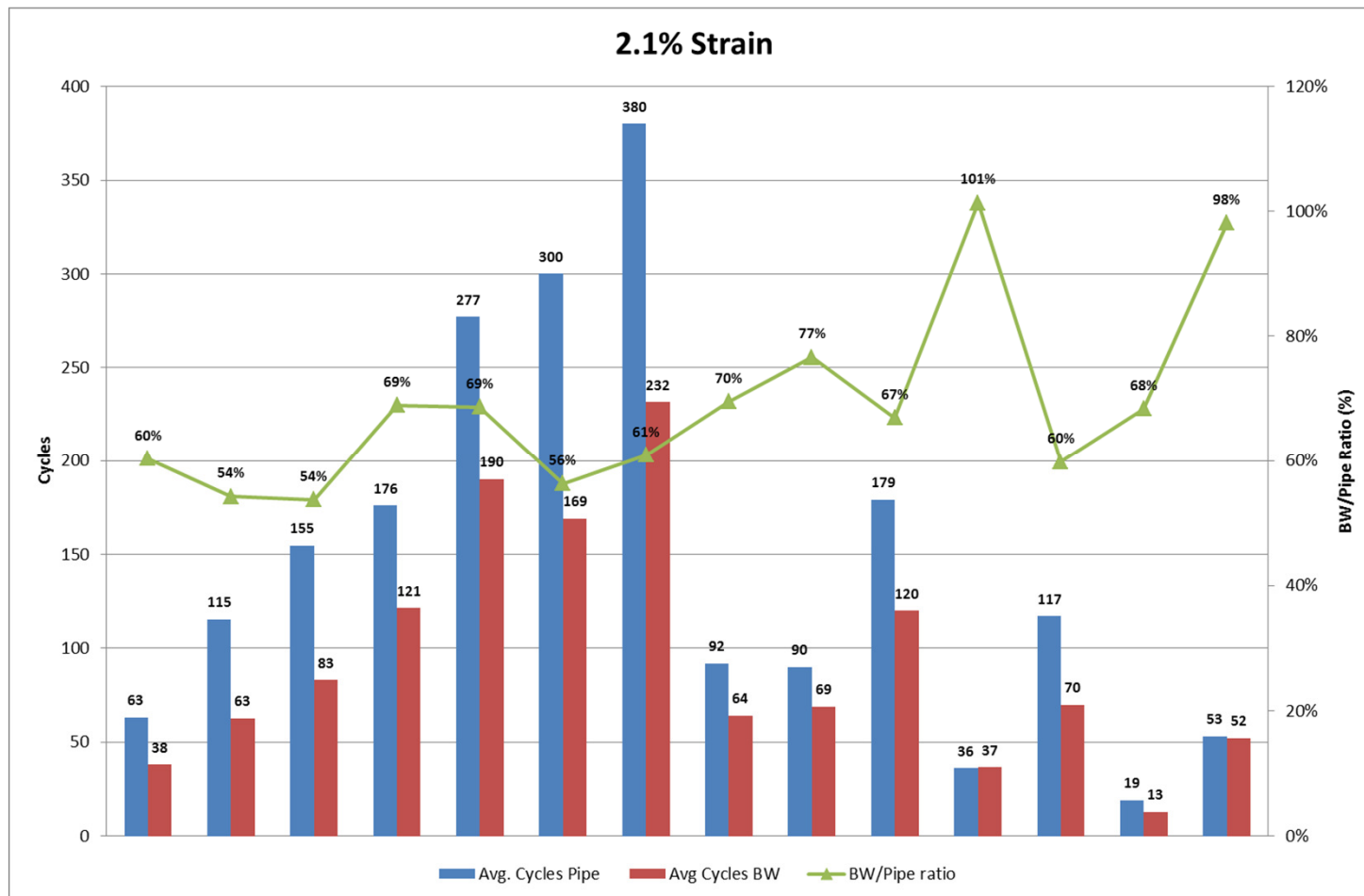
At low strain (1.4%) the measured bias weld fatigue life was 87% of the pipe base material

# Bias Weld Failures – Fatigue



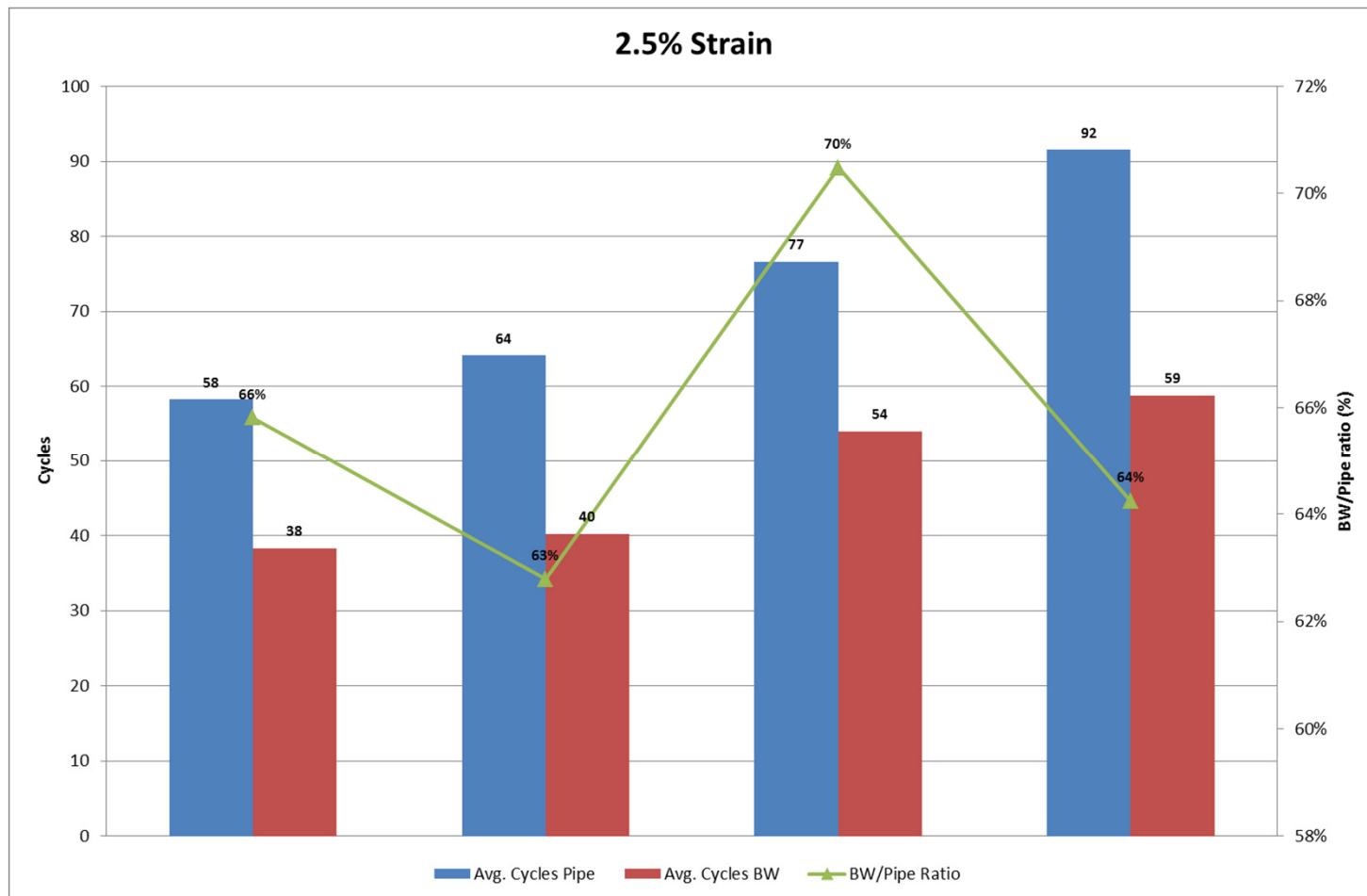
At 1.8% strain most of the values were lower than 80% (55% - 77%)

# Bias Weld Failures – Fatigue



At 2.1% strain the reduction of fatigue life at the bias weld is more significant (below 70%)

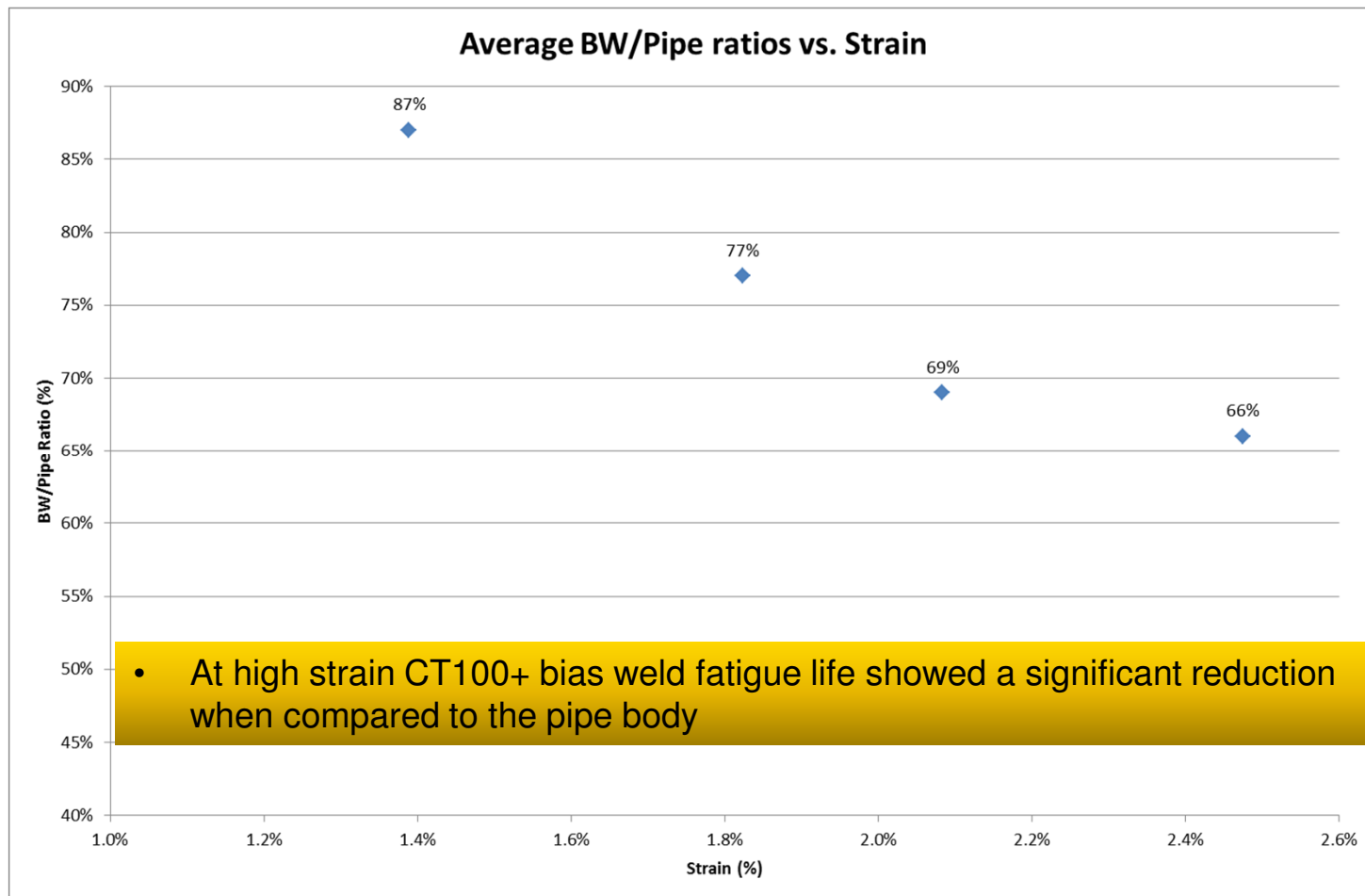
# Bias Weld Failures – Fatigue



Similar to 2.1% strain (bias weld fatigue life around 60s% of the pipe)



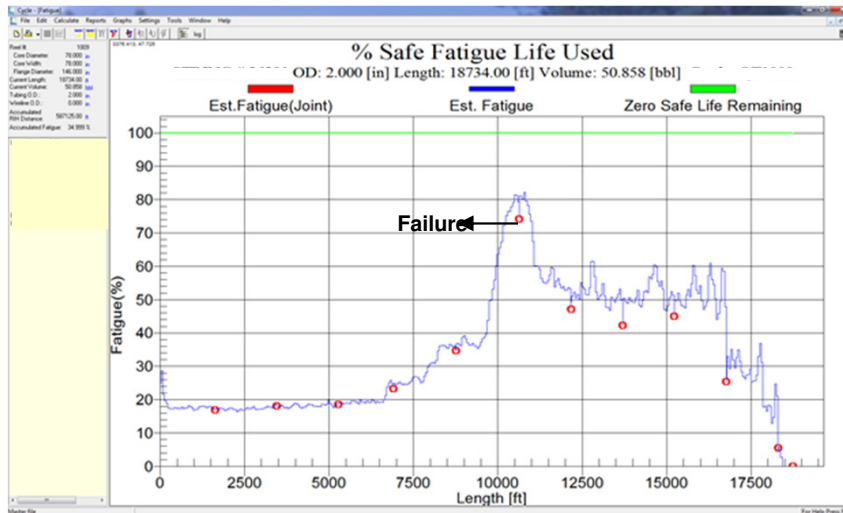
# Bias Weld Failures – Fatigue



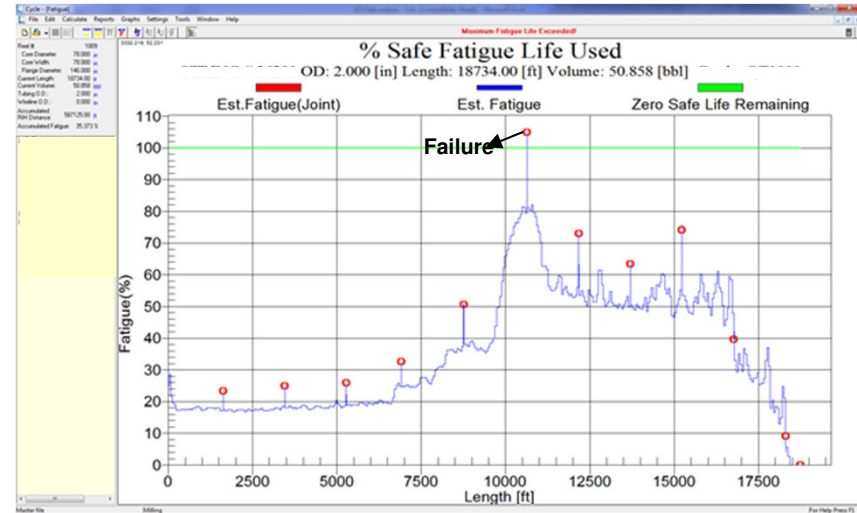
# Bias Weld Failures – Fatigue

From the failures and the fatigue data it can be inferred that a bias weld de-rating is required for strings CT100 and up

De-rating should consider strain (reel and gooseneck):



Original – no de-rating



De-rating

Further fatigue testing on used bias welds (from strings retired from service) confirmed that the de-rating was required.

# Bias Weld Failures – Main Ideas

- Between 2011 and 2013 and abnormal increase of failures associated with bias welds was observed.
- Strings involved: CT90 and 100+; mainly 2” OD; from the 3 CT manufacturers
- Causes of failures:
  - Corrosion operations
  - H<sub>2</sub>S cracking
  - Fatigue

# Bias Weld Failures – Main Ideas

- Corrosion operations and H<sub>2</sub>S cracking:
  - Bias weld more susceptible to corrosion damage – Improvement?
  - Mainly associated with recycled fluid contaminated with bacteria
  - Corrective actions: treatment of system, fluid, and stagnant conditions
  
- Fatigue failures:
  - Associated with high strained CT100+ bias welds (1.8% to 2.3%)
  - Fatigue data confirmed need of de-rating factor for CT100+ bias welds
  - De-rating depending on level of strain

# Coiled Tubing Bias Welds Recent Failures Trend

## THANK YOU

## QUESTIONS?



October 29<sup>th</sup>, 2014  
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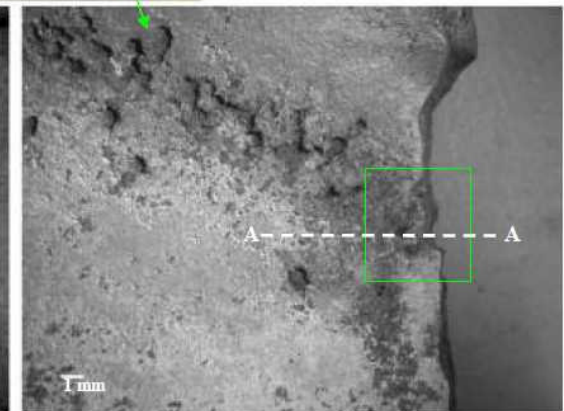
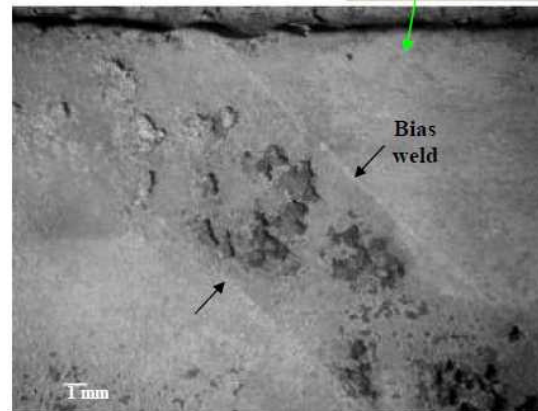


# Acknowledgments

- CTRE
- Steven Craig and BHI USA land staff

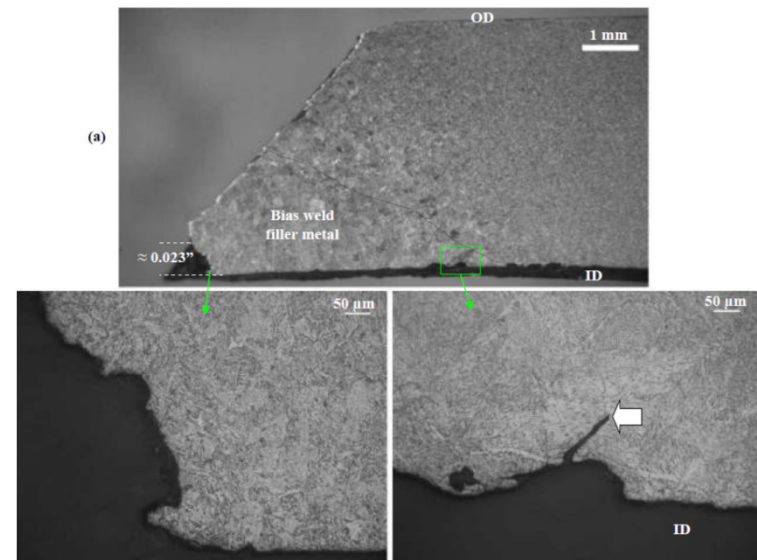
# Backup

# Bias Weld Failures – Corrosion Operations



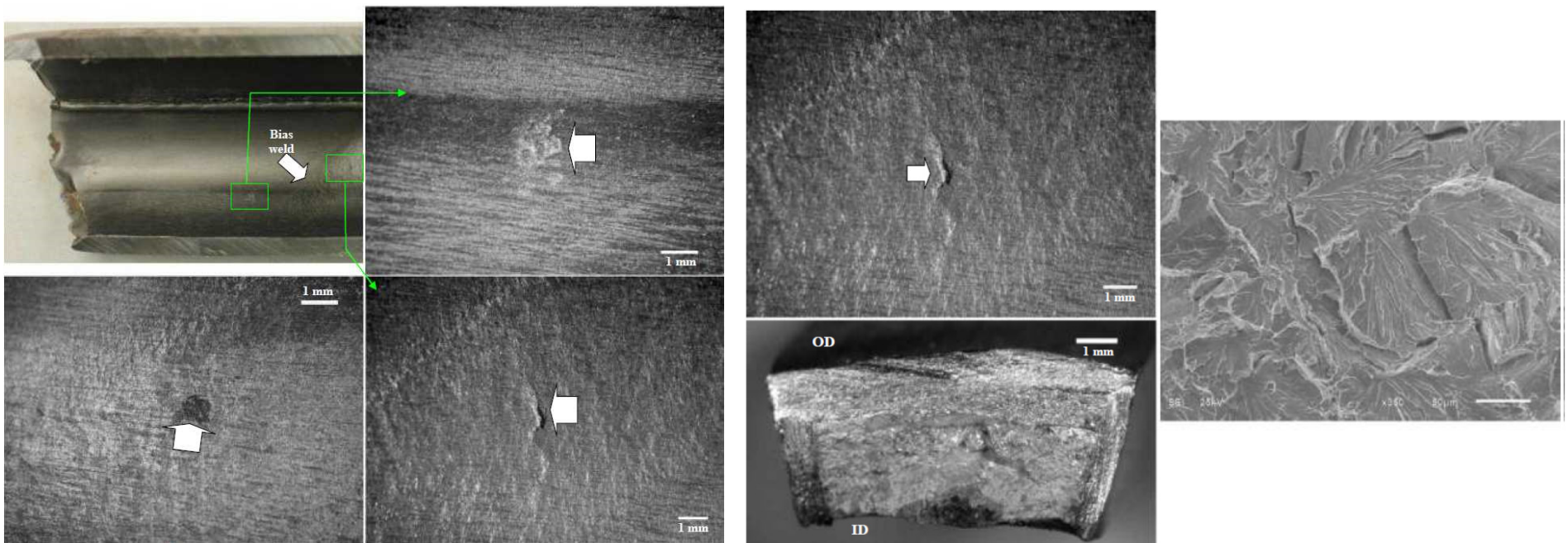
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# Bias Weld Failures – Corrosion Operations



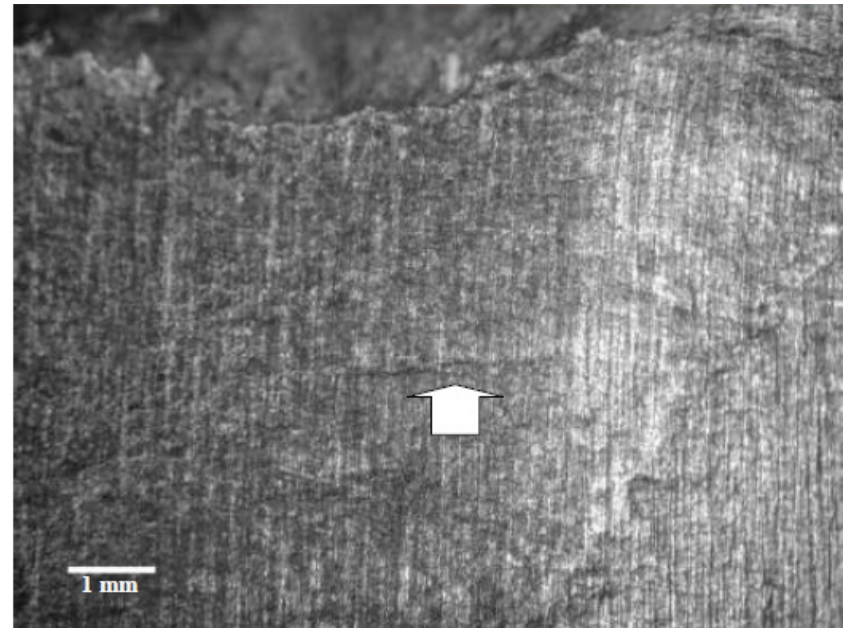
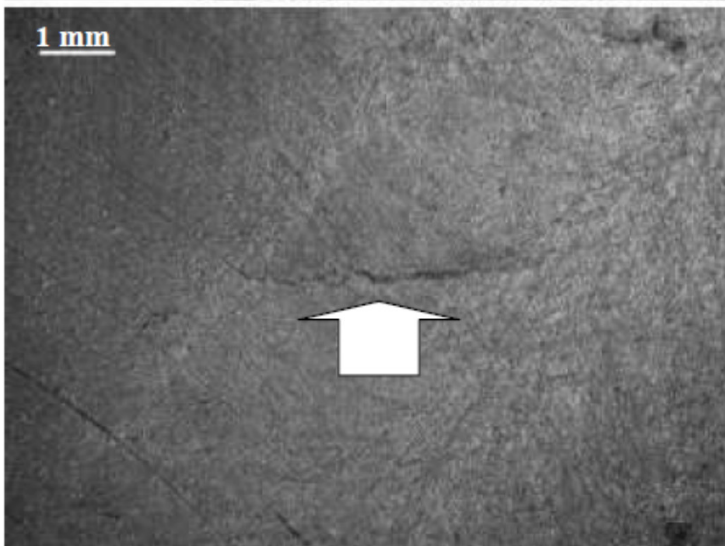
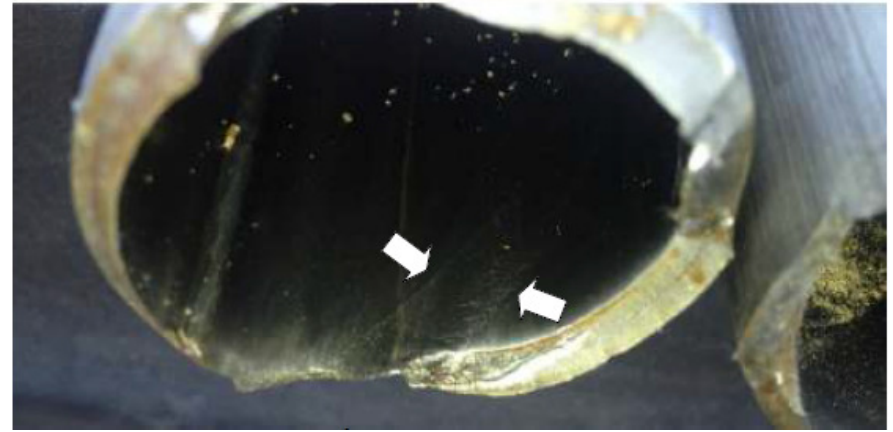
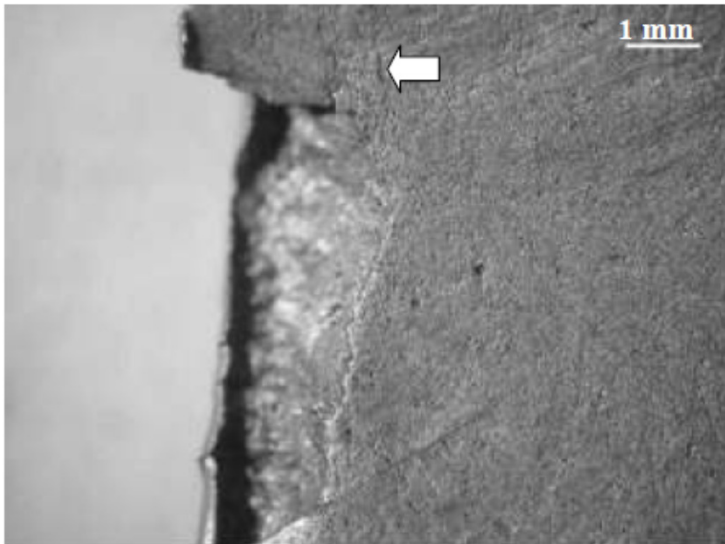
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- Internal corrosion damage very mild or absent – no fatigue cracking associated with isolated pits
- Internal cracking on the bias welds – “cleavage” features - similar to cracking due to exposure to H<sub>2</sub>S



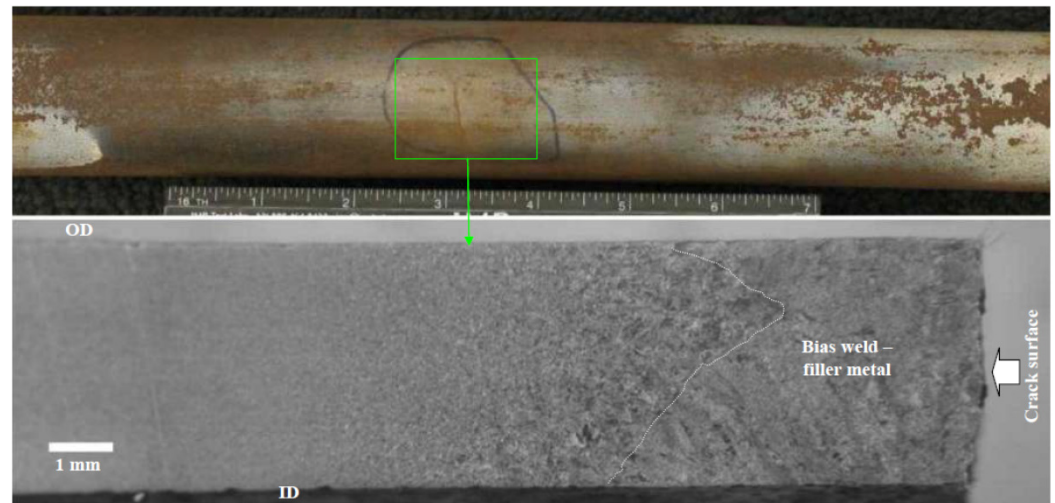


# Bias Weld Failures – H<sub>2</sub>S Cracking

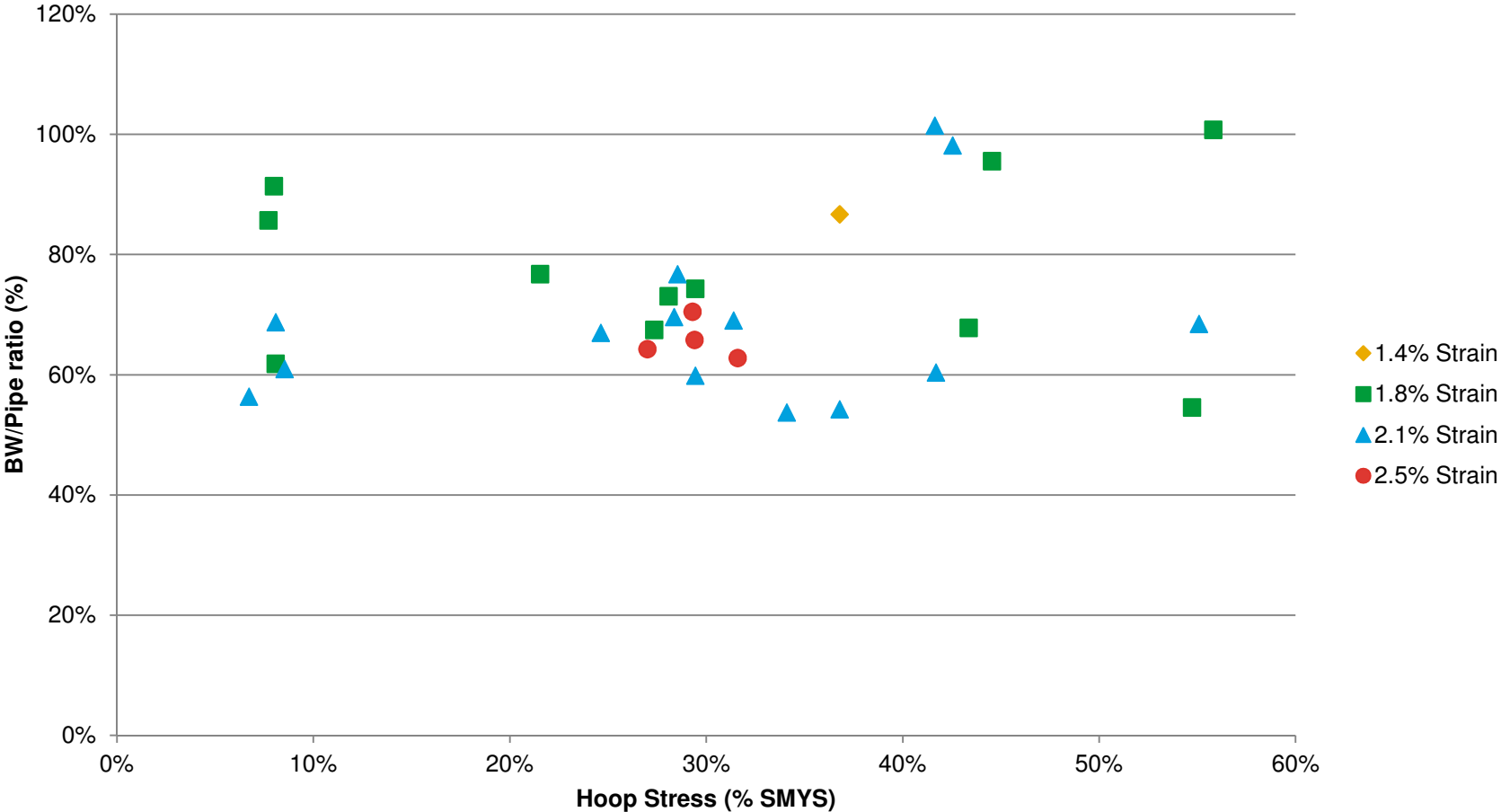


# Bias Weld Failures – H2S Cracking

- Date: January 2013
- String: 1-3/4" x tapered – CT80
- Failure: two cracks on bias welds
- Well: 37 psi H2S partial pressure
- Use of only H2S scavenger – not anti-cracking inhibitor
- Cracking on bias welds due to Sulfide Stress Corrosion Cracking (SSCC).



# BW/Pipe ratios vs Hoop Stress



# Bias Weld Failures – Fatigue

- Bias weld Charpy energy at room temp. lower than base metal (16% to 35%)..mode of fracture: cleavage

Notch Location	Impact Values (ft-lbf)	Average Impact Values (ft-lbf)
Bias Weld	6.6	4.5 (brittle – cleavage)
	4.8	
	7.2	
	4.2	
	1.6	
	2.8	
Parent Metal	27.0	27.3 (ductile - dimples)
	28.0	
	27.4	
	26.8	
Bias Weld	4.6	8.9 (brittle – cleavage)
	10.0	
	10.2	
Parent Metal	26.0	27.7 (ductile – dimples)
	29.2	
	28.0	

