

Chris Horkoff, C.E.T.

- 5+ years experience in corrosion field (pipeline, pressure vessel, tank integrity) - 2 years-Suffield, 3 years-Brooks
- Currently Facilities Integrity Coordinator – EnCana (Brooks)
- Chemical Engineering Technology discipline
- ABSA In-service pressure vessel inspector
- NACE - CP Tester, 5 year member

Dale Toews

- 5+ years experience in corrosion field (Contract with EnCana Corp.)
- Currently Facilities Integrity Coordinator – EnCana (Suffield)
- ABSA In-service pressure vessel inspector
- CGSB Level II NDE (U.T., M.P.I.)

Brooks/Suffield Shallow Gas
Gathering Pipeline System
Corrosion Mitigation and
Monitoring

Chris Horkoff, Dale Toews
EnCana Corporation
NACE 1-day Seminar
Medicine Hat, AB
11/22/05

Agenda

- Brooks shallow gas gathering
 - History
 - Corrosion mitigation & monitoring
- Suffield shallow gas gathering
 - History
 - Corrosion mitigation & monitoring

Brooks Shallow Gas Internal Corrosion History

- Implementation of siphon-strings during 1998-1999
- Initial sweet gas pipeline leaks occurred in 2000
- Areas with siphon-string installations included:
 - Alderson SYS 1, Alderson SYS 3-4, Alderson South, Alderson Gas Unit 3, Monogram
- Failures due to under-deposit attack and/or MIC
- Difficulties in providing effective mitigation due to:
 - no pigging facilities originally installed
 - L-lateral (90 degree) tie-ins
 - low pipeline pressure

Brooks Gas Internal Corrosion Mitigation Results

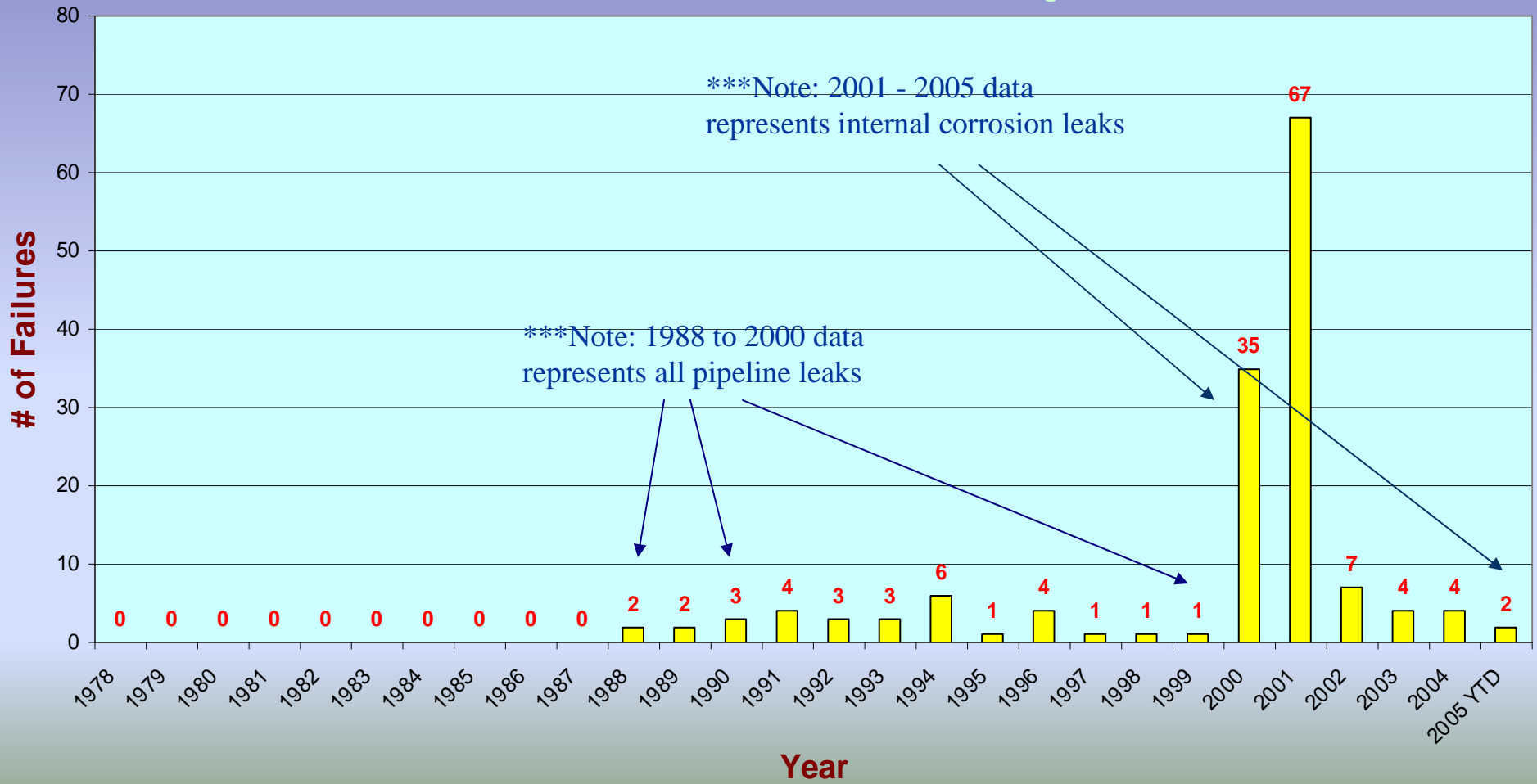
- Flow-drips initially utilized at wellheads to eliminate water ingress into the pipeline system
- Flow-drips removed due to excessive maintenance
- All previous siphon-string wells converted to swab operation (eliminated water ingress and solid deposition into the system)
- Gel pigging/inhibitor applications utilized in Alderson Gas Unit 3 in 2000

Brooks Gas Internal Corrosion Mitigation Results continued...

- Leaks in Alderson Gas Unit 3 were reduced from 25 in 2001 to 0 in 2002
- EnCana “Shallow Gas Pipeline Corrosion Mitigation Plan” generated

Brooks Shallow Gas Leak Summary

Brooks Shallow Gas Pipeline Leak Summary -
Alderson SYS 1, SYS 3-4, SYS South, GU #3, Monogram



Brooks Gas Internal Corrosion Mitigation Plan

- Pipeline systems will adhere to the options for internal corrosion control outlined in the EnCana “Shallow Gas Pipeline Corrosion Mitigation Plan” document as per system-specific requirements
- Batch inhibited methanol may act as a corrosion control tool in the previous siphon-string well areas where methanol is injected
- Swab well operation will continue in areas accessible for swabbing to eliminate water/solids ingress

Brooks Gas Internal Corrosion Mitigation Plan continued...

- 1 new gathering system currently has active siphon-string wells due to land access issues/irrigation throughout the year
- Program similar to Suffield biocide/inhibitor program implemented
- Corrosion coupon installations in field and inlet header
- Inhibitor residuals from batch treatments taken at the inlet header of the compressor station

Brooks Gas Internal Corrosion Mitigation Plan continued...

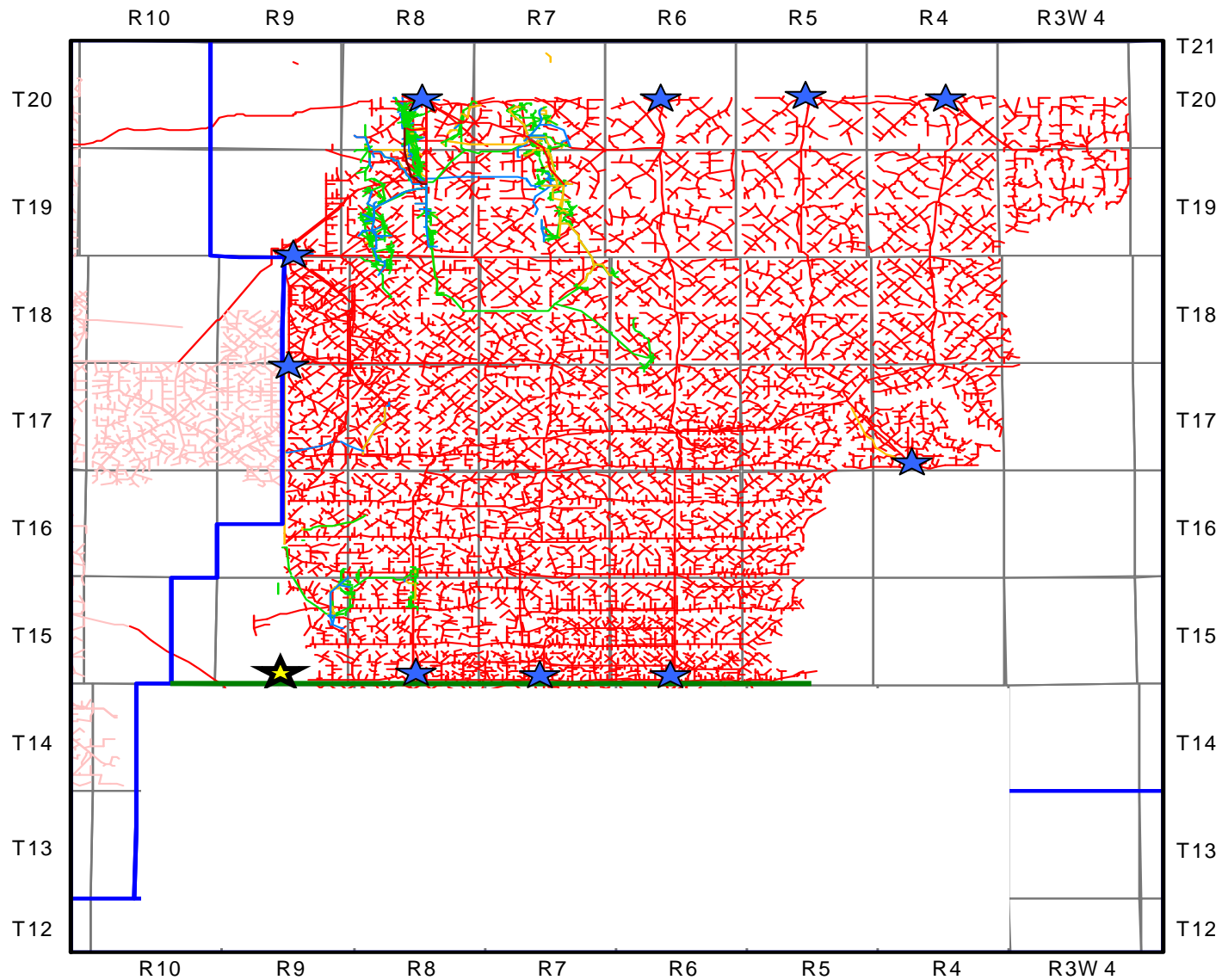
- HDPE pipeline installations occurring in fields where system pressure is tolerable
- Leak detection surveys will continue semi-annually for all previous siphon-string systems and have intervals dependant on failure frequency for the remainder of the Brooks gas systems
- Integrity assessments of shallow gas gathering systems are underway based on:
 - High impact areas
 - Probability of failure
 - Potential system corrosivity

Suffield Shallow Gas

- In military training area, all structures must be underground.
- Military exercises: 60% of wells may be inaccessible for 3 weeks

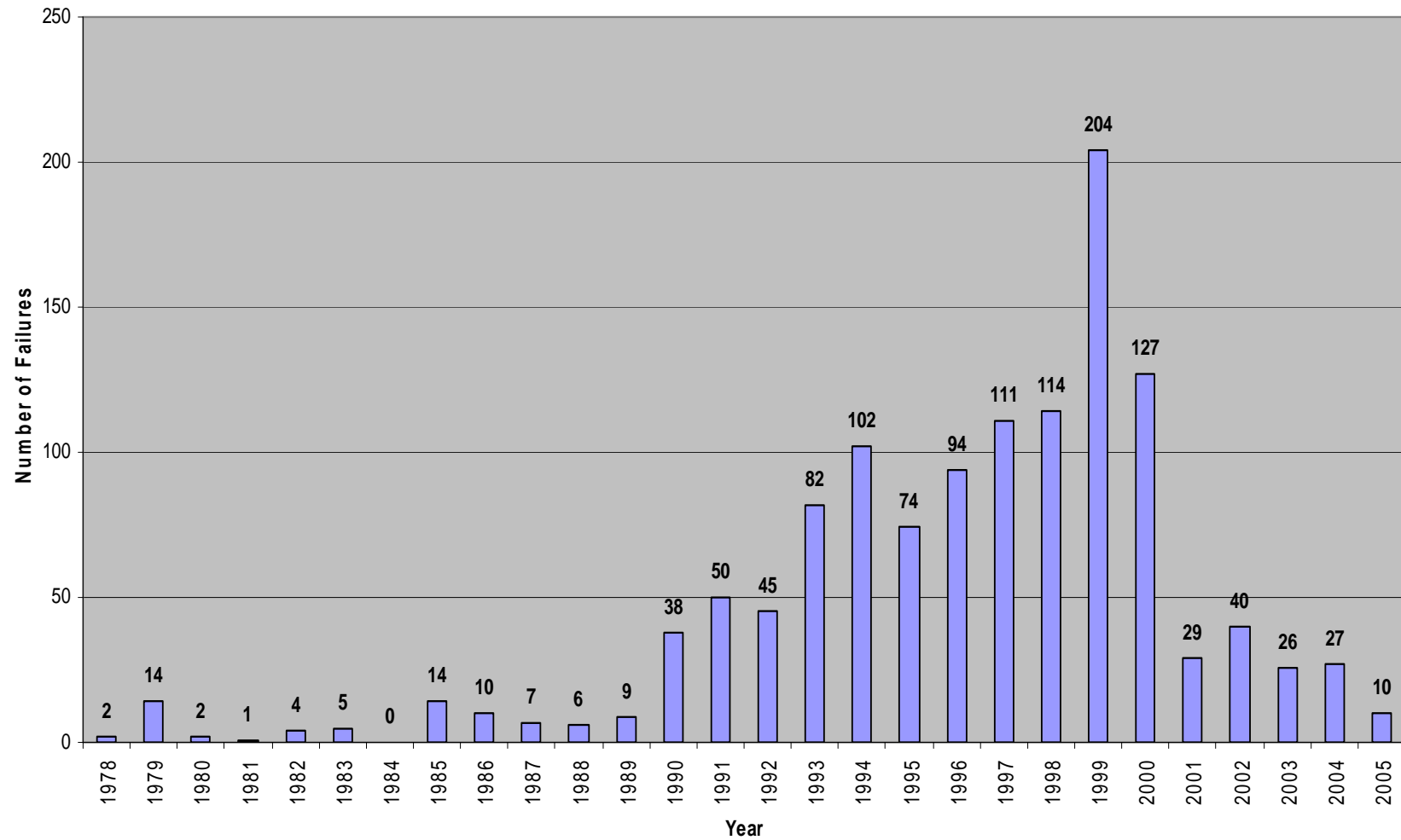


Suffield Shallow Gas



Suffield Shallow Gas

Suffield Shallow Gas Pipeline Failures



Suffield Shallow Gas

➤ History

- January 2000, almost all steel gathering system, mostly 2" (0.083" wall) with average operating pressures about 70 psi
- Typical gas composition of 0.2 mole % CO₂ (Milk River, SWS, Medicine Hat)
- Chloride levels <5,000 mg/L
- 1980 SRB identified as potential source of corrosion
- Early 1980's, isolated failures, various biocides tried.
- Late 1980's, some siphon string wells, biocide killed planktonic bacteria, failures continued.

SRB-Related Internal Corrosion Failure – 3" (6 o'clock Position)



SRB-Related Internal Corrosion Failure – 3" (6 o'clock Position)



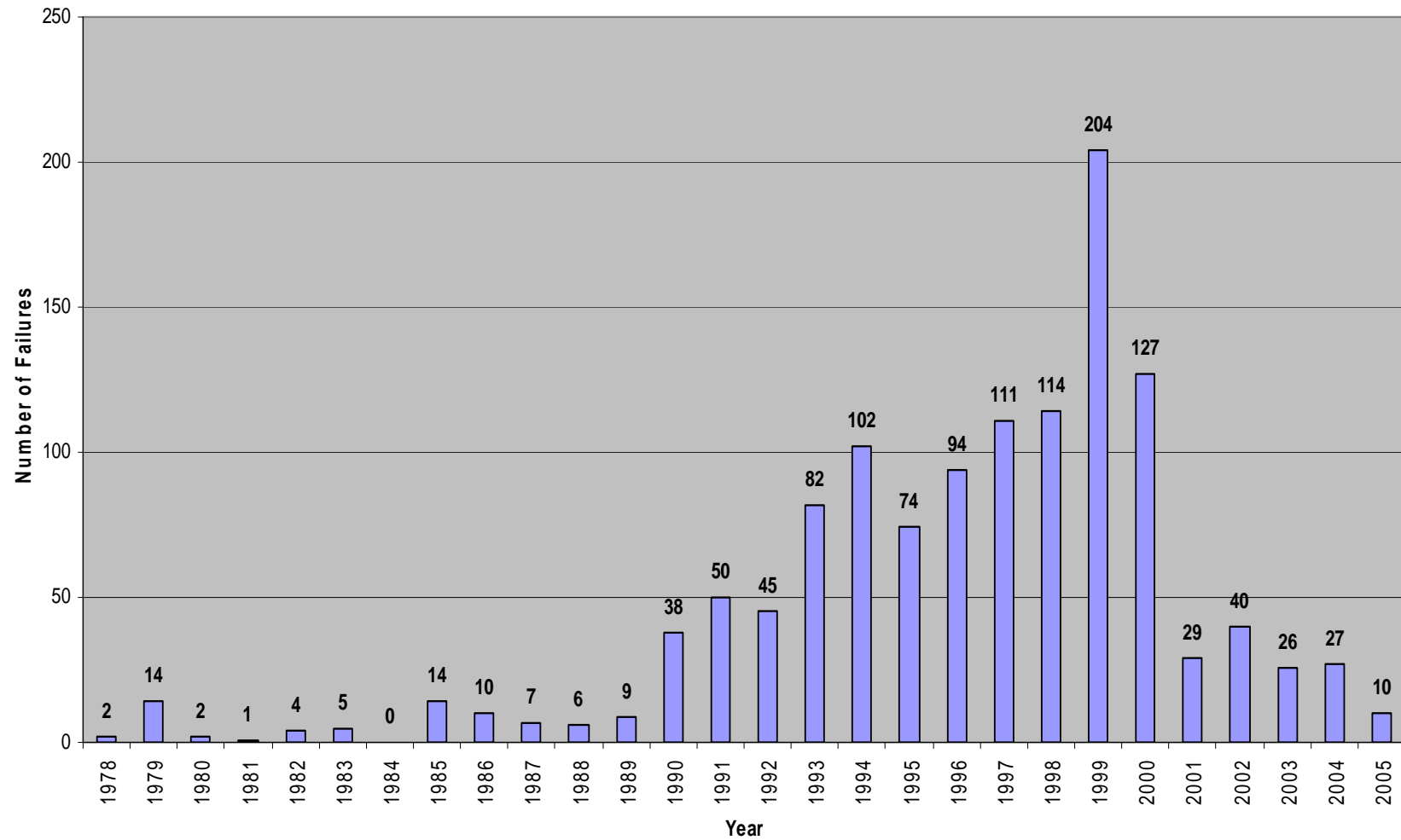
Suffield Shallow Gas

History

- Through 1990's, more siphon string wells
- 1992 – 1995 analysis and comparison of various biocides to control sessile bacteria using bio-film spools. Penetration of biofilm necessary.
- 1997 – 1999 field experimenting with various biocides, effects seen within 6 months.
- 1999 - Increased manpower dedicated to chemical application
- 2002 - Increased pigging to handle foam and clean pipe
- 2003 - corrosion inhibition on all failure repairs
- 2000 – 2005 935 km of HDPE pipe installed

Suffield Shallow Gas

Suffield Shallow Gas Pipeline Failures



3" Suffield Pipeline Pig Launcher



Suffield Shallow Gas

➤ Some obstacles

➤ Over-treatment with biocide led to foaming and production losses

- Biocide treatments staggered between different areas.
- Biocide treatments down well annulus, not pipeline.
- Diesel fuel injected at the extremities of the gathering system
- 2 post pigs after biocide application

➤ Military exercises and access

- Automatic pig launchers
- Careful planning with chemical applicators and piggers

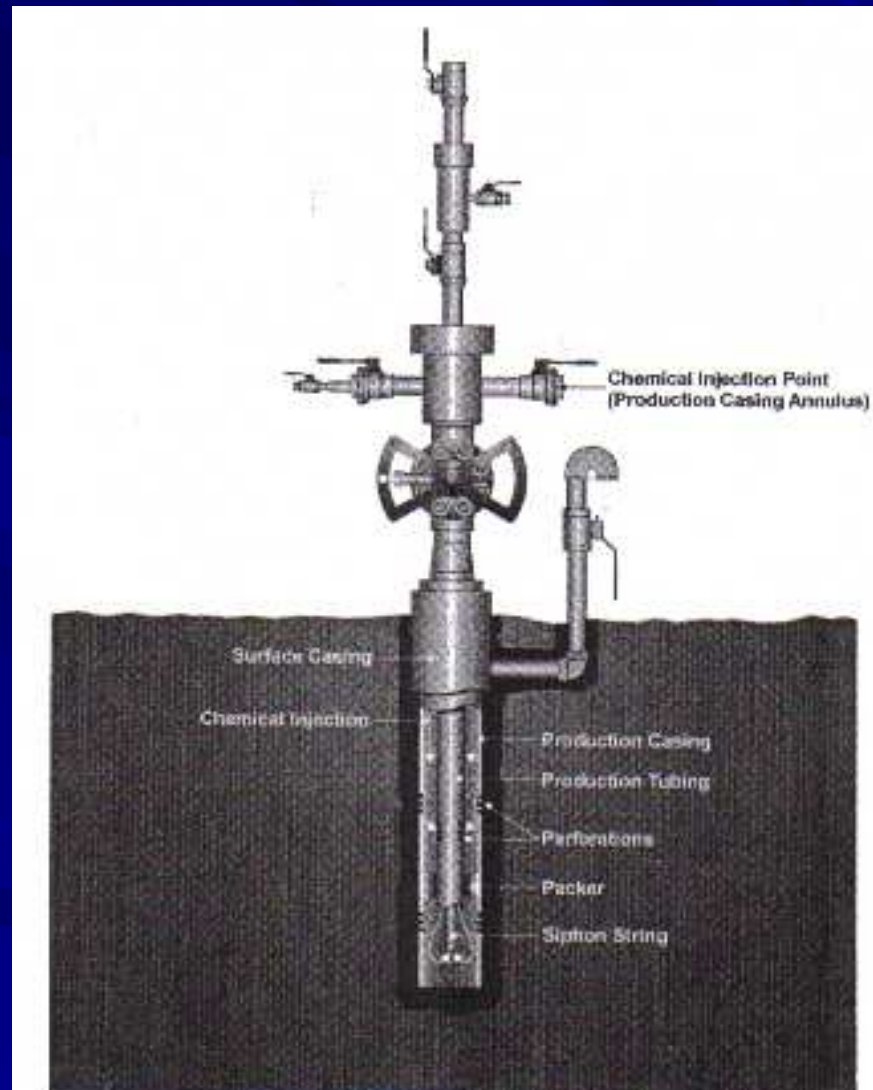
➤ Gathering system restrictions

- Foam pigs used.

➤ Pig launchers small, no pill treatments.

- Water soluble corrosion inhibitor.

Biocide Injection



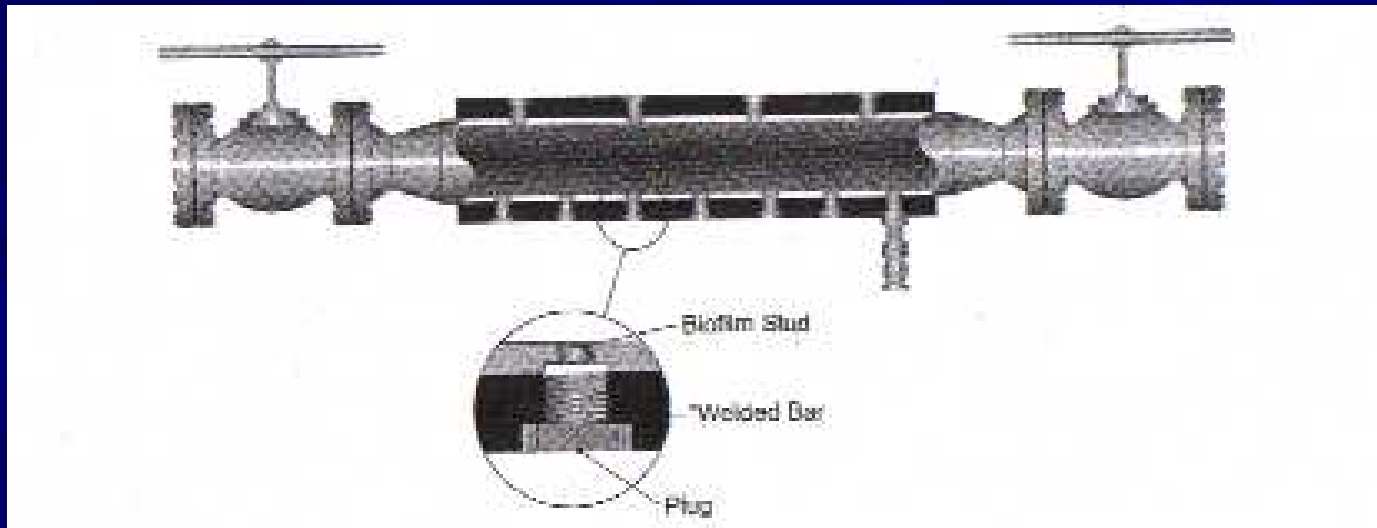
Suffield Shallow Gas Internal Corrosion Mitigation Plan

- Biocide/inhibitor volumes based on average water production per well
- Siphon string wells, 2 chemical treatments (ideally 6 months apart), 5 pigs per year.
- Past siphon string wells, non siphon string wells with failure history, 1 chemical treatment, 3 pigs per year.
- Non siphon string wells with no failure history, 1 pig per year.
- Use of HDPE on new lines as service allows.
- All failed lines are added to the chemical/pigging program.
- Continuous flame ionization detection (FID) surveys to verify effectiveness of program

Suffield Biocide Evaluation

- Biocide comparisons in 1992 – 95 used biofilm spools.
- Spools allowed measurement of:
 - sessile bacteria
 - planktonic bacteria
 - acid analysis
 - chemical residuals
 - corrosion (microscopic photo of biostud)

Suffield Biofilm Spool



- 16 Biostuds along 6:00 position
- All biostuds get same pigging and chemical as the rest of the pipe.

Suffield Caisson Bio-film Spool



Suffield

Corrosion Mitigation Monitoring

- Biospools used in current monitoring of corrosion mitigation.
- Possible changes in water chemistry.
- Due to military activity and early snows, biocide applications sometimes are only 3 months apart.
- Pipelines fed by SWAB wells (potential water)
- Plastic Pipe (935 km since 2000)
 - Normally not treated with chemicals, but these wells are still putting bacteria and water into pipeline

Conclusions

- Management of change process can minimize corrosion potential in a pipeline system
- Adequate pigging facilities/schedules are vital to a corrosion mitigation program
- Gel pigging may be an option of line sweeping in a pipeline system not designed for pigging
- Corrosion monitoring installations in existing pipeline systems can require costly retro-fits; involvement of corrosion advisor in facility design is key
- Production optimization using swab operation can have long-term pipeline integrity benefits compared to siphon strings

Conclusions continued...

- Precise knowledge of cause of corrosion is vital in choosing the correct mitigation program.
- Down-hole biocide treatments can allow bacteria control in the pipeline system for up to 6 months (siphon string wells) and reduced production losses due to foaming
- HDPE pipeline installations can be a useful corrosion mitigating tool in shallow gas pipeline systems
- FID surveys can verify success of a corrosion mitigation program and reduce volumes of gas venting to atmosphere through early leak detection

Thank You!!!

Q & A