Bentonite Contamination in Plastic Pipe Installed by HDD

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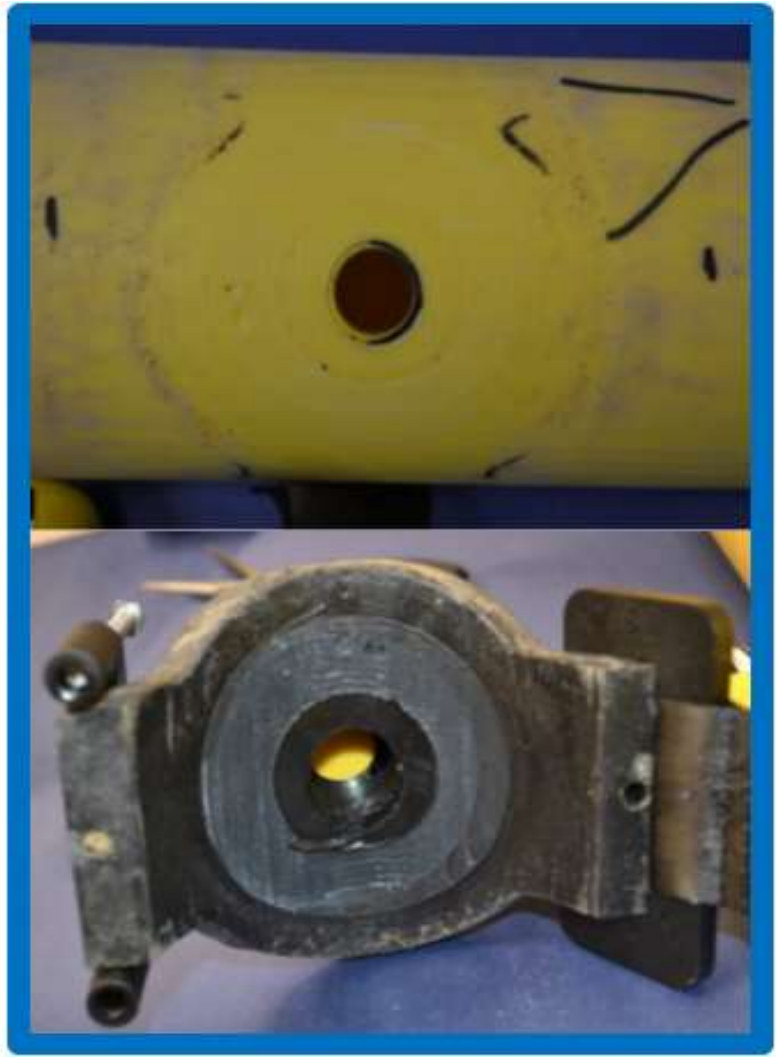
Background

Electrofusion Failure Evaluation

- In 2014, 3 electrofusion tapping tee failures were reported to DIMP engineering through the material problem report (MPR) process
- Initial inspection revealed contamination and poor scraping on the material fusion zone
- DIMP requested samples to be dug-up from the jobs where the failed fittings were located
- Out of 7 samples collected from the 3 jobs, 4 failed bend tests
- Following these tests PG&E retained Exponent



Determining Root Cause of Failures

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Root Cause Analysis

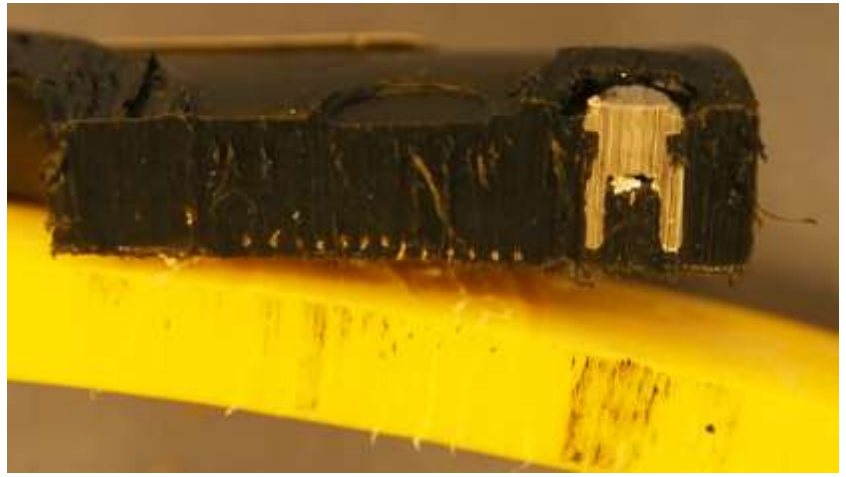
Electrofusion Failure Evaluation

- **Human Error**
  - Knowledge of employees
  - Training
  - Work method and procedures
- **Material**
  - Plastic pipe
  - Plastic tee
  - Cleaning products
- **Equipment**
  - Assist tools
  - Electrofusion processors
  - Power supply generators
  - Extension cords
- **Environment Conditions**
  - Drilling fluid components
  - Native soil
  - Machinery lubricants
  - Skin oil, sunscreen, etc.

Root Cause Analysis

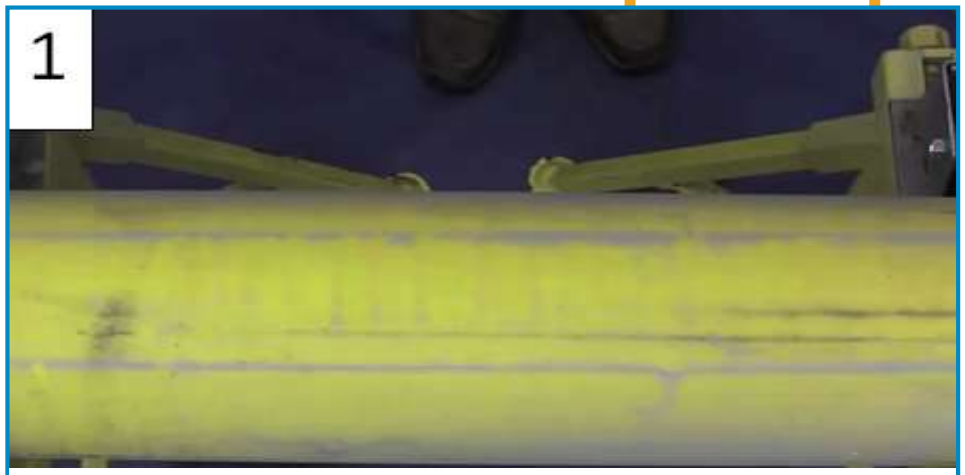
Laboratory Analysis

- **Material characterization**
  - Pipe and tee materials
- **Simulated contamination tests**
  - Evaluation of potential contaminants during field work
  - Fusions created and tested
- **Fourier Transformation Infrared Transformation**
- **Scanning Electron Microscopy & Energy Dispersive Spectroscopy (SEM/EDS)**



Potential Cause of Contamination

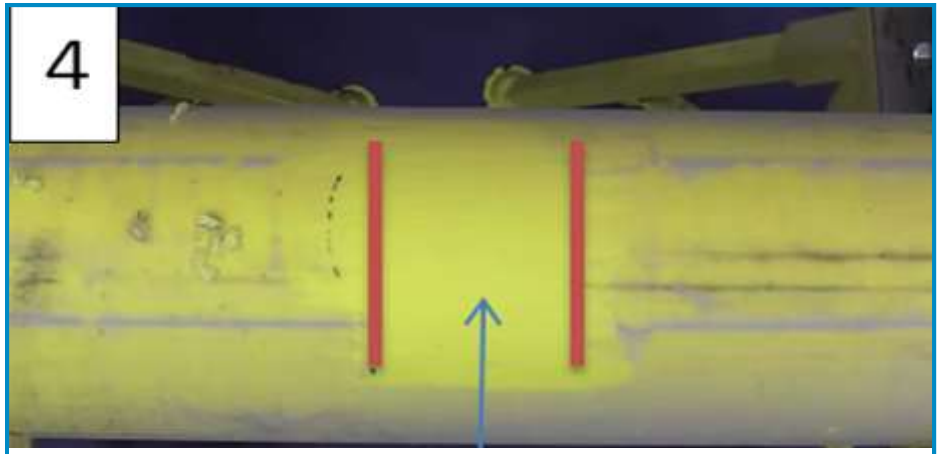
Electrofusion Pipe Preparation



PE pipe contaminated with drilling mud

Establishing the fusion/scraping zone

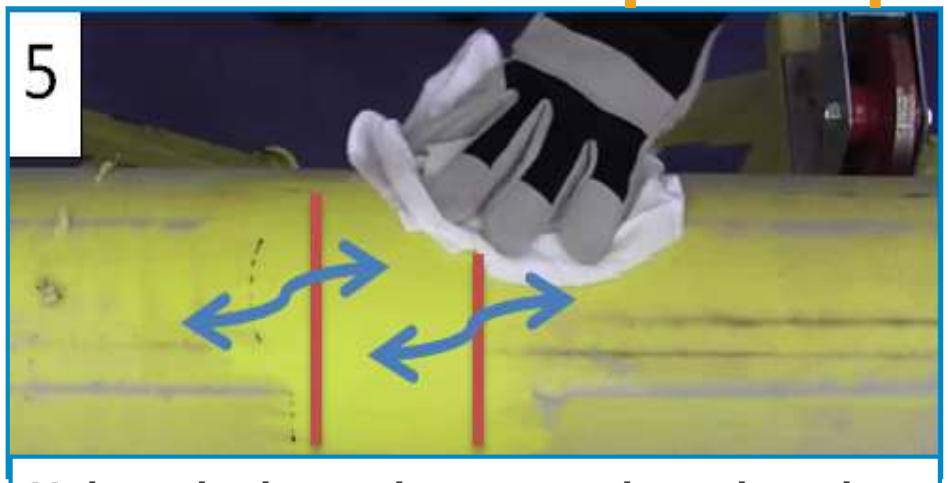
Fusion zone highlighted



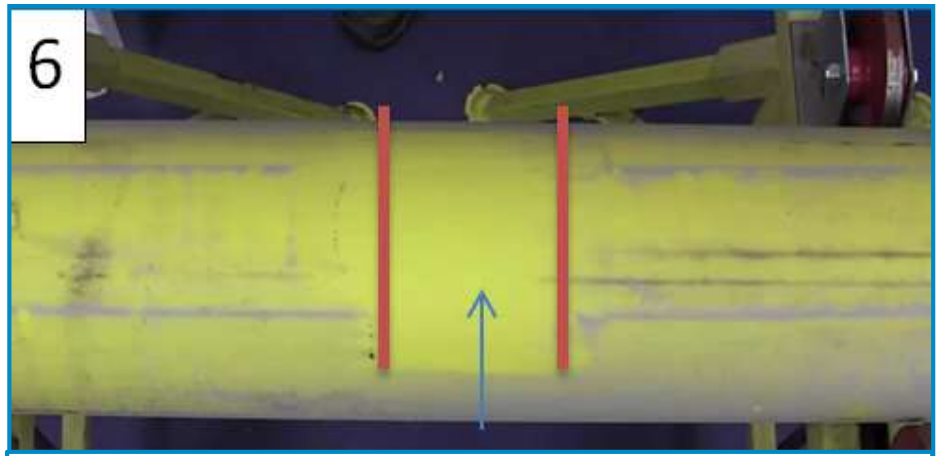
Cleaned and scraped area

Potential Cause of Contamination

Electrofusion Pipe Preparation



Unknowingly moving contaminant into the scraped/clean zone while applying alcohol



Clean and seemingly decontaminated fusion zone

Often, the same cloth is used to clean the PE pipe and electrofusion saddle fitting

Presence of film of contamination on what appears to a clean pipe and fitting

Laboratory Analysis of Drilling Mud

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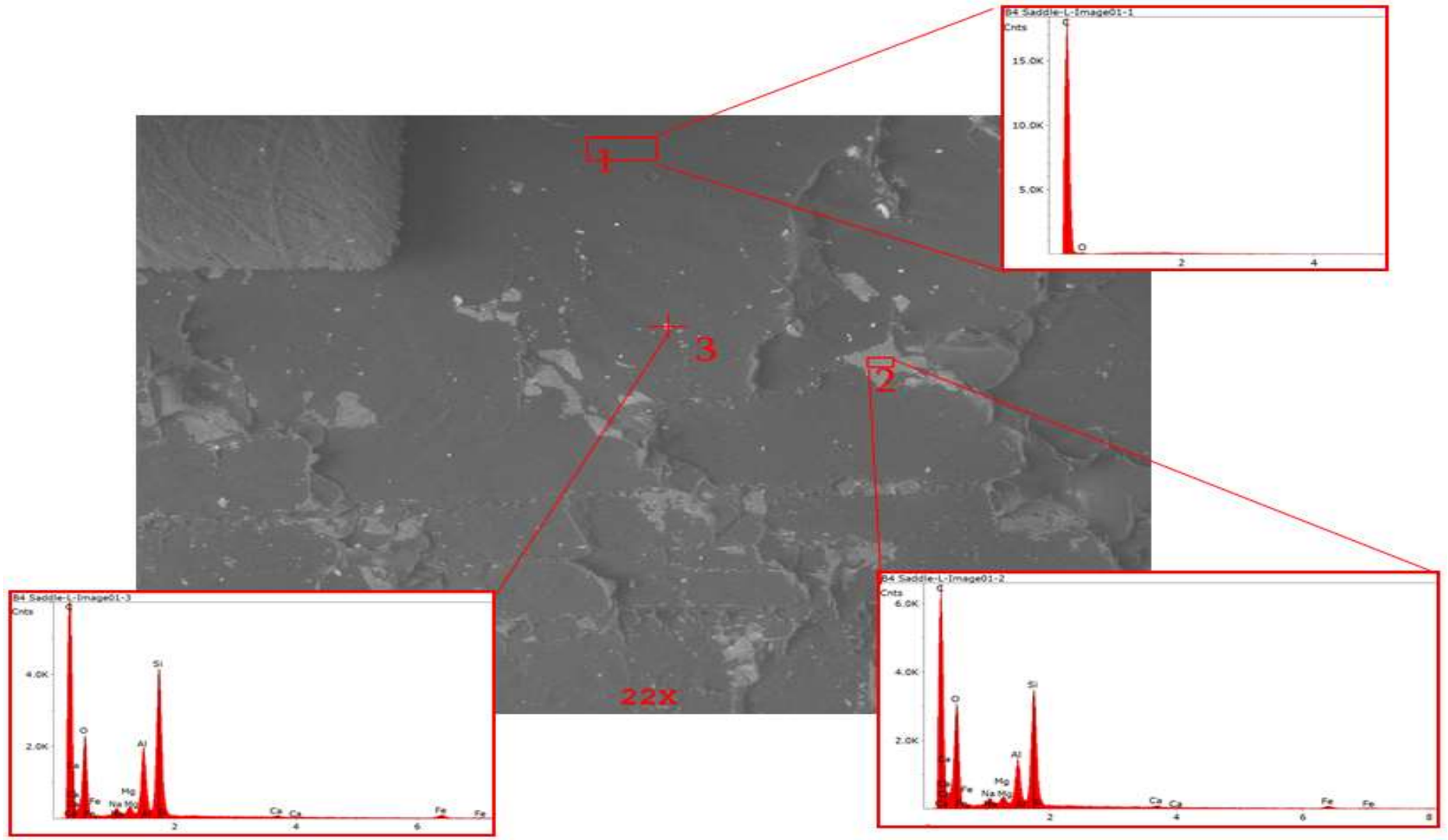
Failed Joint SEM/EDS Test Result

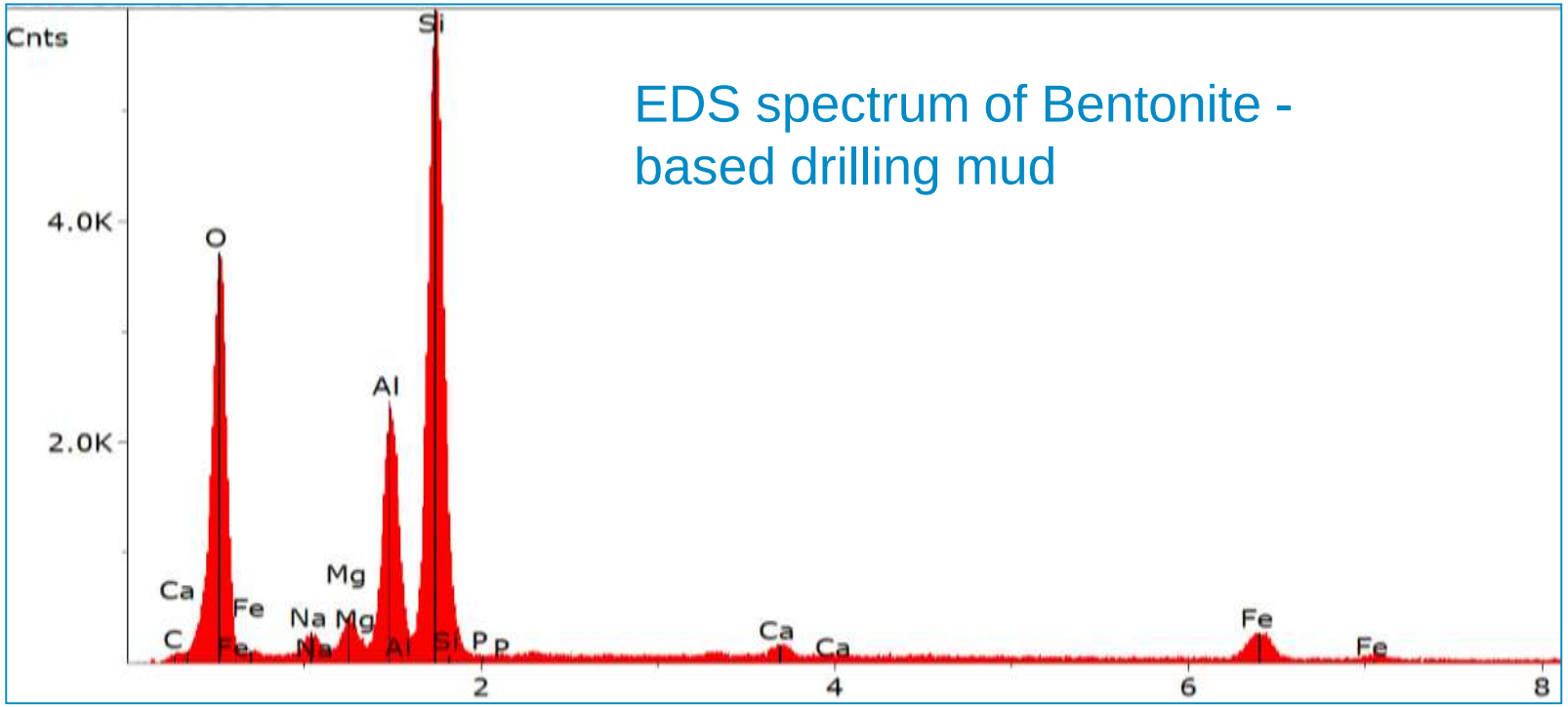
Electrofusion Failure Evaluation



Drilling Mud SEM/EDS Test Result

Electrofusion Failure Evaluation

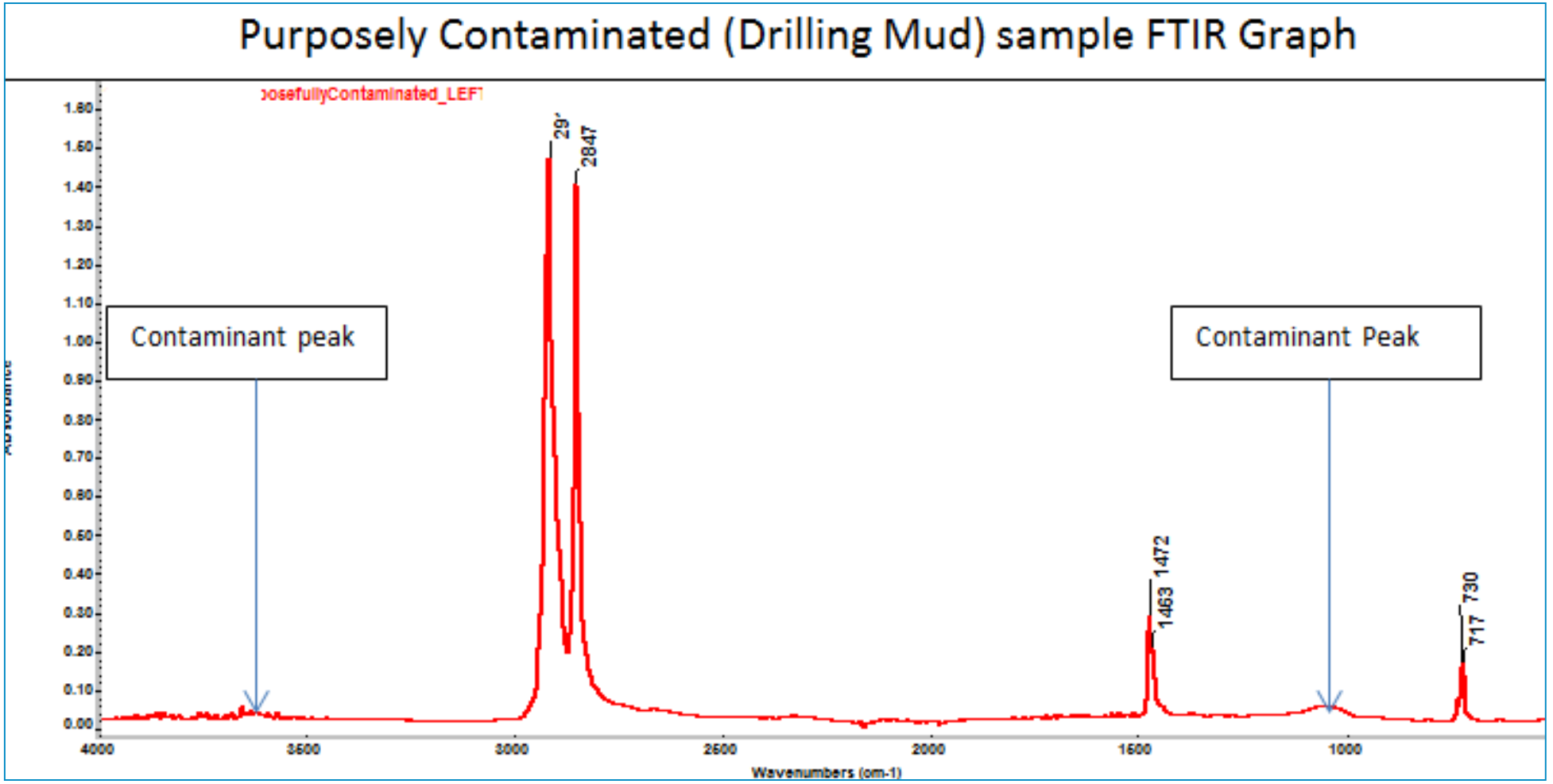
- Si, Al, Ca, Mg, Fe, Na are “fingerprints” of bentonite contamination.
- Native soil with these elements was not nearly as potent as bentonite in reducing fusion integrity.



EDS spectrum of Bentonite - based drilling mud

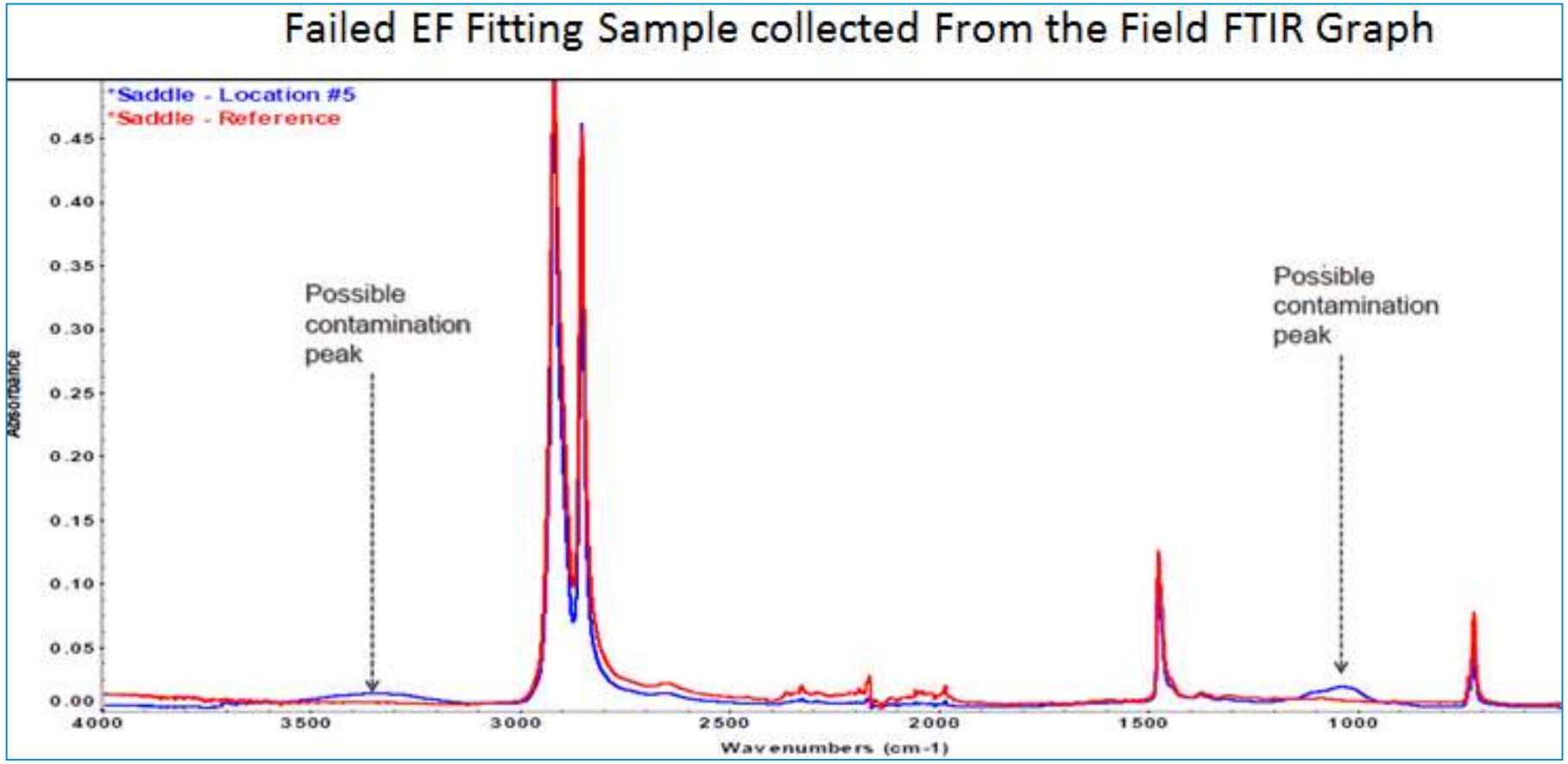
Drilling Mud “Samples” FTIR Test

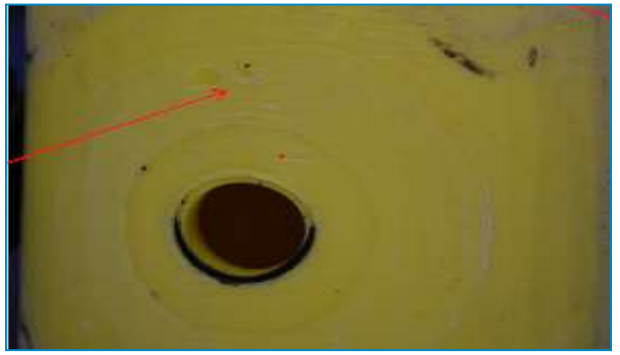
Electrofusion Failure Evaluation



Failed EF Sample FTIR Test

Electrofusion Failure Evaluation





Root Cause of Failures

Electrofusion Failure Evaluation

- Bentonite clay consists of small plate-like nano-particles suspended in water.
- The particles tend to line up to form a fluid barrier.
- Bentonite forms a filter cake that inhibits the flow of liquid water.
- It appears that bentonite also inhibits the flow and intermixing of molten polyethylene.
- Talc, which has similar plate-like nano-structure, is a proven barrier to successful EF bonding.

Root Cause of Failures

Electrofusion Failure Evaluation

- Exponent's laboratory testing shows that even an invisible film of bentonite contamination blocks proper EF joint formation.

Root Cause of Failures

Electrofusion Failure Evaluation

- Lab experiments including SEM/EDS and FTIR evaluations concluded drilling mud contamination as the cause of failures

Contamination VIDEO

new electrofusioncompressed.mov

Corrective Action

Improved Cleaning

- **Revised Electrofusion connection procedures to improve the cleaning process**
  - Added required cleaning area for fusion area
  - Established a “clean zone”, maintained throughout the fusion procedure

Table 2. Required Cleaning Area

Pipe Size (Inches)	Clean Area from Centerline (Inches)
1-1/4 thru 4	No Less Than 12
6 thru 8	No Less Than 16

Table 3. Clean Zone Line Measurements

Pipe Size (Inches)	Clean Zone Lines from Centerline (Inches)
1-1/4 thru 4	Approximately 12
6 thru 8	Approximately 16

New Cleaning Procedure Video

PG&E Cleaning Procedure

- Mandatory tailboard for all electrofusion qualified personnel
- Online virtual learning sessions to communicate changes to affected personnel

VIDEO (4 minutes)

TD-4170P-41 Electrofusion Saddle - 4 min.m4v

Final Steps

Effectiveness Review

- **Evaluate effectiveness of corrective actions**
  - Monitoring for fusion leaks through leak management system
  - Monitoring EF leaks through Material Problem Reporting system (MPR)

Final Steps Continued

Industry Evaluation and Standards

- **GTI-OTD Study on – "Guidelines/Best Practices for Scraping PE Pipe and Fittings"**
  - Evaluated methods for removing contamination and used bentonite as the contaminating agent
  - Provided suggested scraping and cleaning guideline to minimize contamination

- **ASTM Update – "Standard Practice For EF Polyethylene and Polyamide Pipe and Fitting"**
  - Update in progress for the adoption of a natural gas specific electrofusion procedure
  - Working with PPI, PHSMA, users, and manufacturers for industry alignment
  - The procedure leverages recent industry knowledge and is intended to conform with manufacturers procedures

Bibliography

Additional Reading

- Spak KS, Klopp RW. “Traces of bentonite prevent bonding of electrofusion pipeline joints.” *Pipeline & Gas Journal*, pp. 50-52, December 2017.
- Klopp RW, Davis BR. “The advantages of pressure-testing electrofusion saddle tees prior to tapping the main.” *American Gas Association Operations Conference & Biennial Exhibition*, Orlando, FL. May 2-5, 2017.
- Lever O, et al. ”Guidelines/Best Practices for Scraping PE Pipe and Fittings.” *GTI-OTD Draft Final Report*, Project No. 21674. June 2017.

Questions?

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