Recent Case Study Hard Spots and NTSB Recommendation P-22-3

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Overview

Topics

- Case Study: Danville, Kentucky incident
- History of hard spots
- NTSB findings and recommendations
- PHMSA efforts to address recommendations
- Introduction of speakers

Case Study – Rupture and Fire

Enbridge / Texas Eastern
Danville, Kentucky

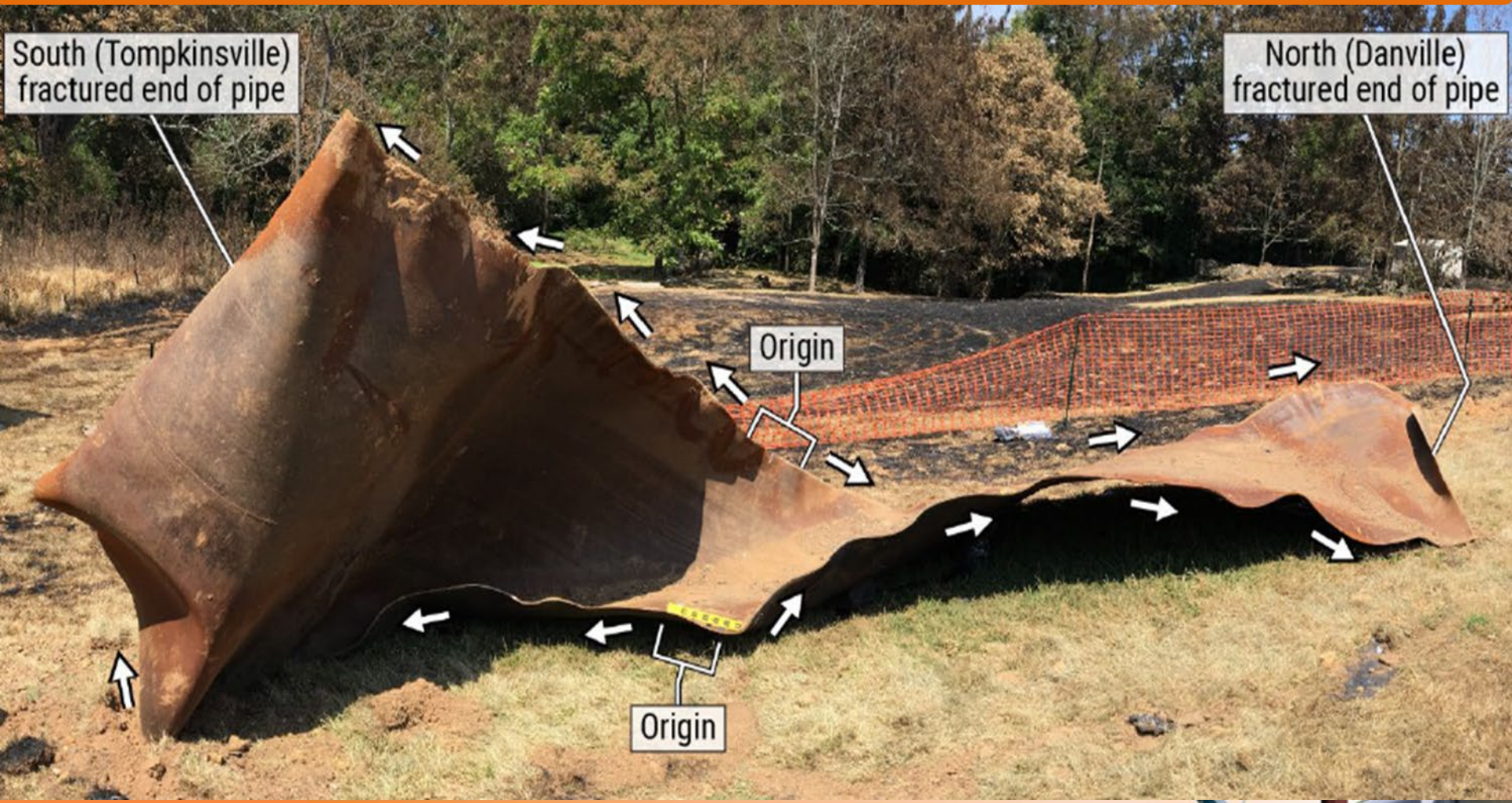
National Transportation Safety Board Investigation Report Number
PIR-22-02

Incident Details

- August 1, 2019, rupture and fire
- 1958 vintage Line 15
- API X-52 pipe 30-inch diameter 0.375-inch WT.
- Pipe manufactured by A.O. Smith using electric flash weld (EFW) longitudinal seam
- Hydrogen cracking of a pre-existing hard spot
- Operator ran hard spot ILI tools in 2004, 2005, and 2011
- Pipeline was cathodically protected with a coal tar coating
- Pipeline had a flow reversal in 2014

Incident Site

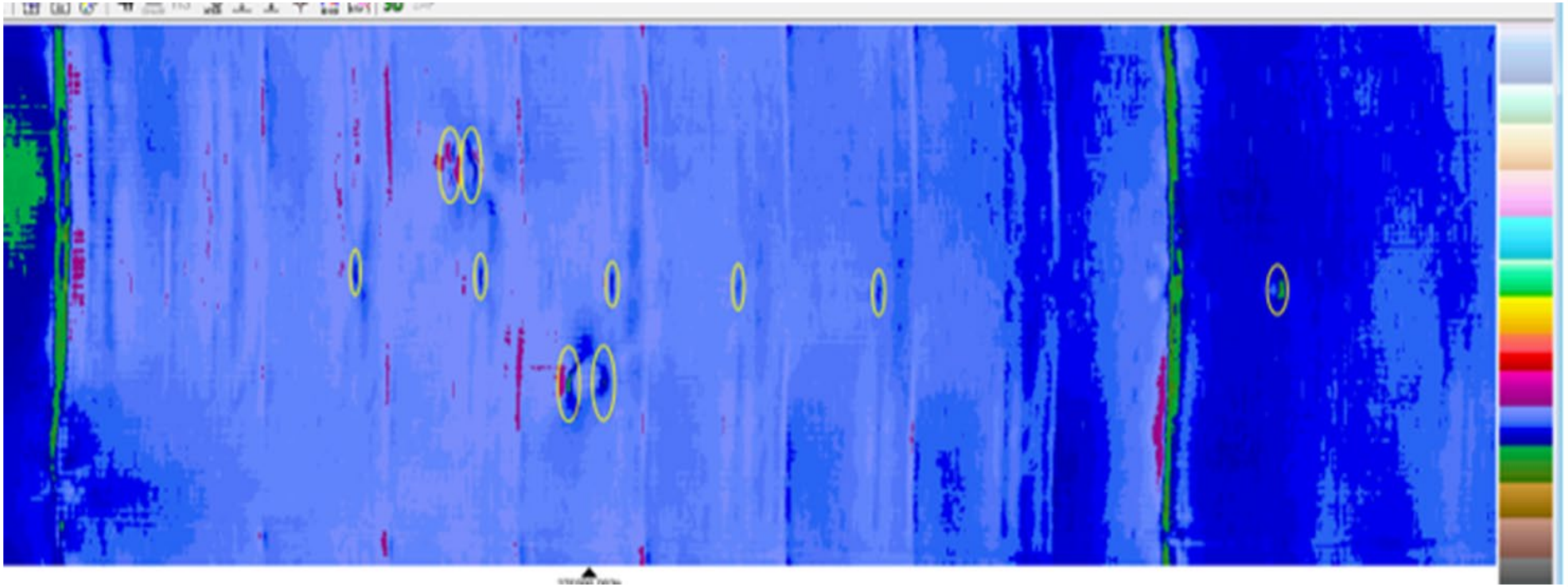
Origin was found in the ejected pipe



Hard Spot History

- November 2, 2003, there was a hard spot rupture located near Moreland, KY. This is in the line section north of the Danville CS
- In response, the operator developed a hard spot ILI pigging program
- During 2004 and 2005 HSMFL tools were run in various line sections and hard spots were identified, removed or mitigated
- The ILI vendor at the time did not identify the hard spot that failed causing this accident
- In 2011, another HSMFL tool was run that found 16 hard spots within the line section. These hard spots were remediated
- Again, the ILI vendor did not identify the hard spot that failed

Analysis of 2011 hard spot ILI scan



Hardness testing by NTSB identified the origin hard spot was 5.85 inches by 3 inches and had hardness values between 362 and 381 Brinell. Hardness readings extended through the wall.

Re-analysis of 2011 hard spot ILI data

- The initial 2011 data analysis found 16 hard spots in the line section downstream of Danville CS
- The re-analysis of the 2011 data in 2019 found 441 hard spots
- The change was attributed to significant improvements in computer hardware, software and data analysis

Lessons Learned

- Older data can have new life.
- The vendor of the 2011 data was NDT Systems & Services and they worked for other operators performing 1,320.8 miles of pipeline analysis.
  - Did your company use this vendor?
- Verify the capabilities of the tool.
- Verify the data.
- Data verification involves more than just a few digs and a unity plot.

Cause of Hard Spot Cracking

Hydrogen from CP

Hard spot Martensite

Deteriorated Coal Tar Coating

2014 to 2017 Flow Reversal

- From 2014 to 2017 there was a flow reversal that shifted the station discharge to pipe with a coal tar coating that was not designed for higher temperatures.
- There were different grades of coal tar each with different temperature recommendations.
- In 2017, the Danville Compressor Station became operational and what was the downstream pipe was subjected to a 30-degree F increase in discharge temperature even with the addition of coolers.
- In the years since the reversal, to meet the cathodic protection requirements of the downstream section of pipe, they increased rectifier output, added a rectifier, and installed new ground beds.
- The CP system is the source of the atomic hydrogen.
- The coal tar was the barrier to prevent hydrogen cracking.
- With the coal tar gone or deteriorated, hydrogen reacted with the hard spot causing cracking.

See PHMSA Advisory Bulletin ADB-2014-04 Titled: Guidance for Pipeline Flow Reversals, Product Changes and Conversion to Service

HCA and Potential Impact Radius

- The PIR was calculated at the rupture site to be about 633 feet.
- Within 633 feet of the rupture site radially were seven private residences.
- Because the number of buildings intended for human occupancy was below 20 and no buildings met the qualifications of an Identified Site under 49 CFR 192.903, the rupture site was deemed a non-HCA.
- Enbridge was not required to implement the IM regulations for the rupture site area, including risk assessments, threat identification, and interaction or integrity assessments.

Investigation Conclusions

NTSB Conclusion

The NTSB concluded that the probable cause of the rupture was the combination of:

- A pre-existing hard spot (a manufacturing defect);
- Enbridge's processes and procedures were inconsistent with PHMSA's guidance and industry knowledge of hard spot threat interactions, leading Enbridge to underestimate the risk posed by hard spots;
- Degraded coating, and ineffective cathodic protection applied following a 2014 gas flow reversal project, which resulted in hydrogen-induced cracking at the outer surface of Line 15 and the subsequent failure of the pipeline.

Contributing to the incident was:

- Enbridge's Integrity Management program, which did not accurately assess the integrity of the pipeline or estimate the risk from interacting threats3

NTSB's Recommendations to Enbridge

- Evaluate the effectiveness of corrosion control equipment and infrastructure following any major change in operations, such as a gas flow reversal

- Revise the Integrity Management program to include:
  a) Data required to support the active or inactive status of each threat, including hard spots;
  b) Conditions and situations that require reassessment and re-evaluation of threat status, including flow reversal and other major projects;
  c) The interactions between hard spots and all types of corrosion.

NTSB's Recommendations to PHMSA

- Revise the calculation methodology used to determine the potential impact radius of a pipeline rupture
- Advise natural gas transmission pipeline operators on:
  a) The circumstances of this accident;
  b) The need to evaluate the risks associated with flow reversals;
  c) The impacts of such projects on hydrogen-induced cracking.
- Advise natural gas transmission pipeline operators of the possible data limitations associated with hard spot magnetic flux leakage ILI tools and analyses used in hard spot management programs and reinforce the need to follow industry best practices when conducting ILI data analysis

PHMSA Response

Issues Regarding Hard Spots

- Hard spots fall under the category of Manufacturing Threats;
- Hard Spot Magnetic Flux Leakage (HSMFL) ILI tools use magnetic flux leakage technology to detect hard spots;
- A. O. Smith manufactured in the 1950s was known by major industry organizations and PHMSA to have a history of hard spots;
- There continues to be a history of failures involving hard spots.

Recent Action

NTSB Recommendation

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Advise natural gas transmission pipeline operators of the possible data limitations associated with hard spot magnetic flux leakage ILI tools and analyses used in hard spot management programs and reinforce the need to follow industry best practices when conducting ILI data analysis.

PHMSA Response

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PHMSA will review accident data and information regarding hard spots and the appropriate methodologies/technologies for detecting hard spots and communicate to operators the results of the data analysis and discuss appropriate in-line inspection technologies for different anomalies including hard spot detection.

PHMSA Plan of Action

- PHMSA has initiated a review of previous incidents/accidents involving hard spots;
- PHMSA is meeting with various ILI vendors to determine available tools and technologies for the identification of hard spots;
- Plans underway to meet with individual operators to get pipe-specific data/information related to experience with hard spots;
- Hold a follow up public meeting and development of the Advisory Bulletin.

Coming Up

Speakers

- Zoe Shall with PRCI and will present information related to efforts in the area of hard spots, ***PRCI Efforts on Hard Spots (Past, Present, and Future)***
- Khanh Tran with ROSEN will present information that was recently shared at the International Pipeline Conference on Assessment and Analysis of Hard spots, ***Hard Spot Assessment & Integrity Analysis.***