Hard Spots

Advisory Bulletin (ADB–2024–01)
Identification and Evaluation of Potential Hard Spots

Hard Spots

Hard spots are a localized increase in hardness produced during the hot rolling of steel plates when localized quenching of the steel occurs during manufacturing. Hard spots can become brittle over time under a range of conditions and are susceptible to cracking. Although hard spots are more prevalent in plate-formed pipe, seamless pipe can also be susceptible to hard spots.

Incidents

- July 18, 2013
- 30-inch natural gas
- Natchitoches, Louisiana
- 1952 - A.O. Smith
- Hydrogen-induced cracking in a hard spot
- Previously reinforced with Type A sleeve
- The leak was repaired with a Type B sleeve

Incidents

- January 14, 2015
- 30-inch natural gas
- Brandon, Mississippi
- 1952 - A.O. Smith
- Hydrogen-induced cracking in a hard spot > 2” long
- Previously reinforced with Type A sleeve

Incidents

- February 13, 2022
- 18-inch natural gas
- Perry county, Mississippi
- 1950 - A.O. Smith
- Hydrogen-induced cracking in a hard spot – .6” x 2.5”
- Rockwell hardness 35 – 45

Incidents

- March 8, 2023
- 30-inch natural gas
- Fauquier county, Virginia
- 1957 – Bethlehem Steel
- Hydrogen-induced cracking in a hard spot
- Base steel Brinell hardness 170 - 180
- Hard spot Brinell hardness 192 – 208
- Post incident ILI revealed 6 hard spots (re-analysis found more)

NTSB Investigation – Danville, Kentucky

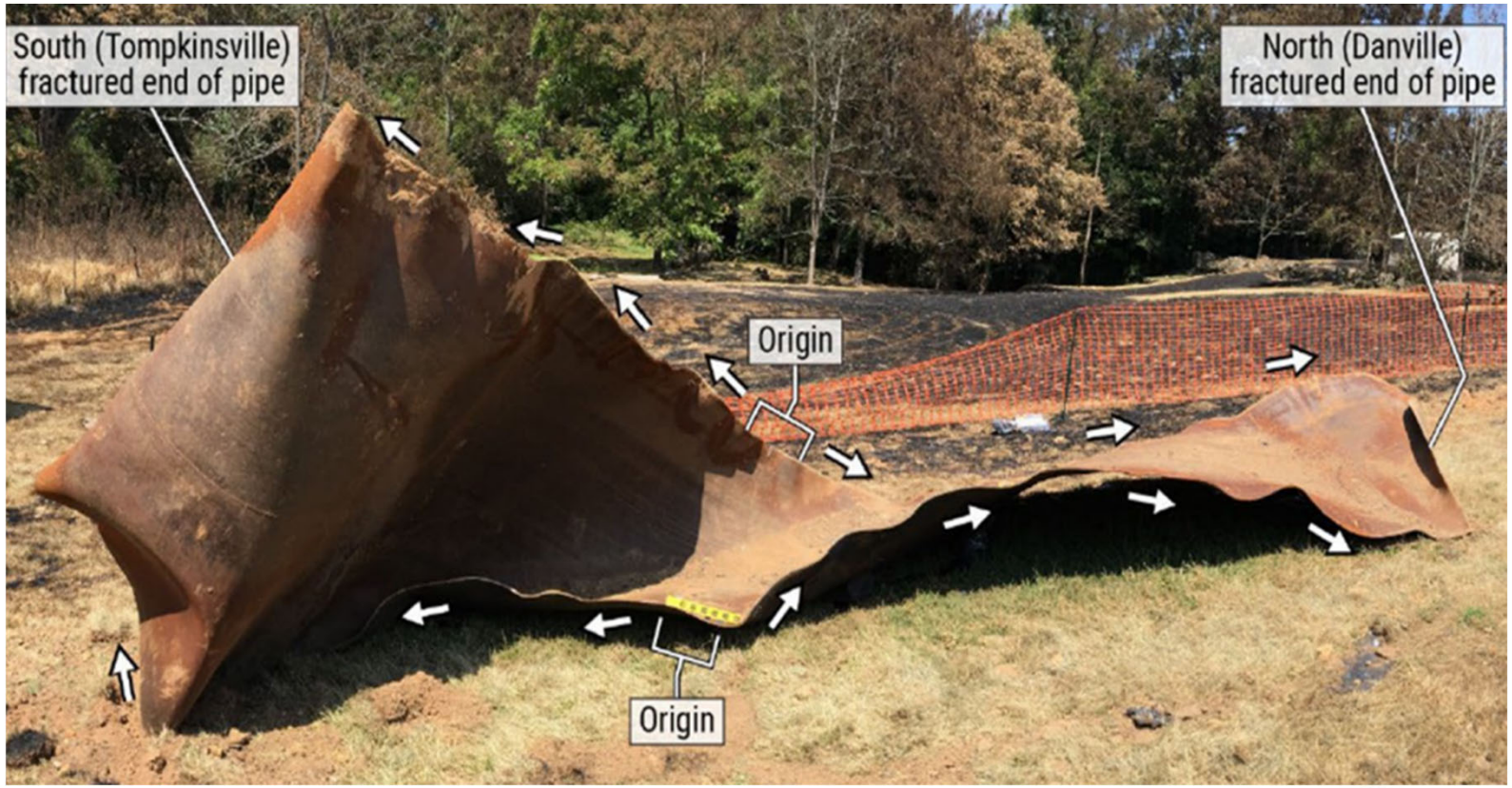
National Transportation
Safety Board Investigation
Report Number PIR-22-02

Danville Incident Investigation

- August 1, 2019
- 30-inch natural gas
- Danville, Kentucky
- 1957 - A.O. Smith
- Hydrogen-induced cracking in a hard spot – 5.85” x 3”
- Brinell hardness 362 – 381 extended through the pipe wall
- Operator ran ILI tools in 2004, 2005, and 2011
- Pipeline was cathodically protected with a coal tar coating
- Pipeline had a flow reversal in 2014

Danville Incident Investigation

Danville Incident Investigation

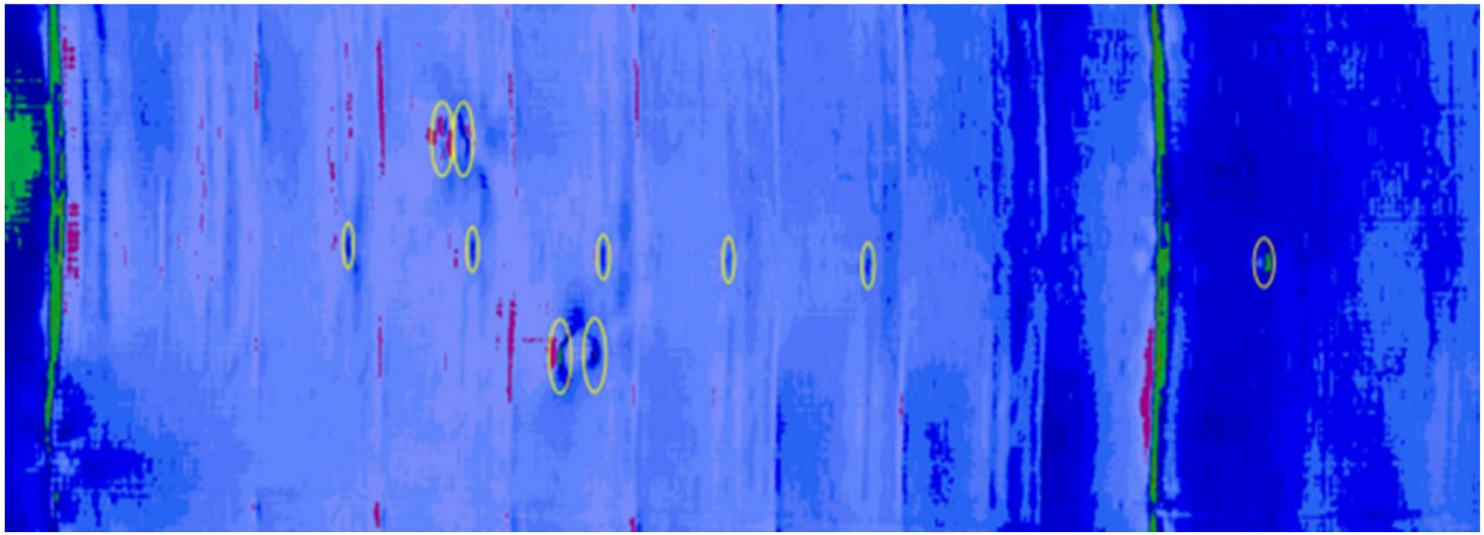


Danville Incident Investigation

- November 2, 2003, there was a hard spot rupture in the section north of Danville CS located near Moreland, KY.
- 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

Danville Incident Investigation

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



Danville Incident Investigation

- 2011 data analysis found 16 hard spots in the line section downstream of Danville CS
- 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

Danville Incident Investigation

- Limitations to MFL technology with respect to hard spot identification
- New technologies and ILI advancements
  - 2011 ILI data analysis – 16 hard spots
  - 2019 re-analysis of 2011 data – 441 hard spots

Hydrogen Cracking

- Hard spots on the surface are generally stable
- Introduction of hydrogen is destabilizing
  - Coating degradation
  - Soil chemistry
  - Cathodic protection
- Hydrogen induced cracking in the presence of stress (pressure)
  - Inclusions
  - Impurities
  - Lattice structure irregularities

December 2022 PHMSA Meetings

- A.O. Smith pipe (originally thought to be isolated to 1948 - 1952)
- Manufacture dates as recent as 1970
  - Bethlehem Steel Corporation
  - Kaiser Steel Corporation
  - National Tube Supply
  - Consolidated Pipe & Supply
  - Youngstown Sheet and Tube
  - United States Steel
  - Claymont Steel
  - Republic Steel

Advisory Bulletin (ADB–2024–01) – Recommendations

1. Review all design and construction records – TVC
   - Pipe manufacturer
   - Steel plate manufacturer
   - Manufacture date
2. Are pipe types in system susceptible to hard spots?
3. Are there known integrity issues?

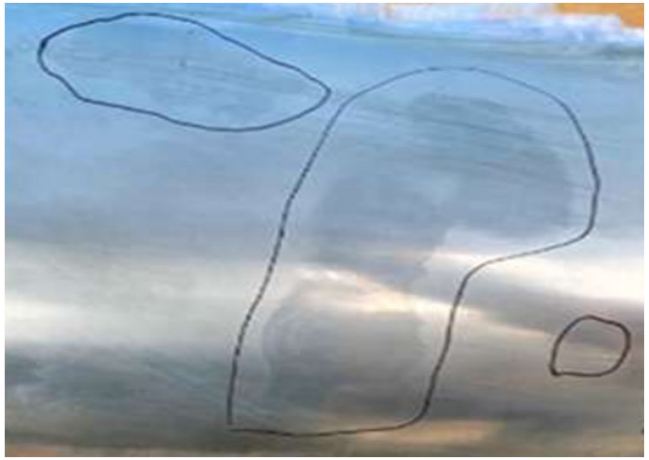
Advisory Bulletin (ADB–2024–01) – Recommendations

4. Develop and implement enhanced assessment program
   - Best approach to material hardness anomaly validations
5. Re-evaluate existing ILI data
6. Share information regarding hard spots
   - Industry
   - Technical meetings
   - Conferences

Regulations - Definitions

§192.3

Hard spot means an area on steel pipe material with a minimum dimension greater than two inches (50.8 mm) in any direction and hardness greater than or equal to Rockwell 35 HRC (Brinell 327 HB or Vickers 345 HV10).



Regulations – Engineering Critical Assessment for MAOP Reconfirmation

§192.632(c) In-line inspection

An inline inspection (ILI) program to determine the defects remaining the pipe for the ECA analysis must be performed using tools that can detect wall loss, deformation from dents, wrinkle bends, ovalities, expansion, seam defects, including cracking and selective seam weld corrosion, longitudinal, circumferential and girth weld cracks, *hard spot cracking*, and stress corrosion cracking.

Regulations – Engineering Critical Assessment for MAOP Reconfirmation

§192.632(c)(1) If a pipeline has segments that might be susceptible to *hard spots* based on assessment, leak, failure, manufacturing vintage history, or other information, then the ILI program must include a tool that can *detect hard spots*.

Regulations – Assessments Outside of HCAs

§192.710(c)(1) Internal inspection

Internal inspection tool or tools capable of detecting those threats to which the pipeline is susceptible, such as corrosion, deformation and mechanical damage (e.g., dents, gouges and grooves), material cracking and crack- like defects (e.g., stress corrosion cracking, selective seam weld corrosion, environmentally assisted cracking, and girth weld cracks), *hard spots with cracking*, and any other threats to which the covered segment is susceptible. When performing an assessment using an in-line inspection tool, an operator must comply with §192.493;

Regulations – Baseline Assessments

§192.921(a)(1) Internal inspection tool or tools capable of detecting those threats to which the pipeline is susceptible.

The use of internal inspection tools is appropriate for threats such as…*hard spots with cracking*, and any other threats to which the covered segment is susceptible.

In addition, an operator must analyze and account for uncertainties in reported results in identifying and characterizing anomalies

- tool tolerance,
- detection threshold,
- probability of detection,
- probability of identification,
- sizing and location accuracy,
- anomaly findings

Regulations – Continual Assessments

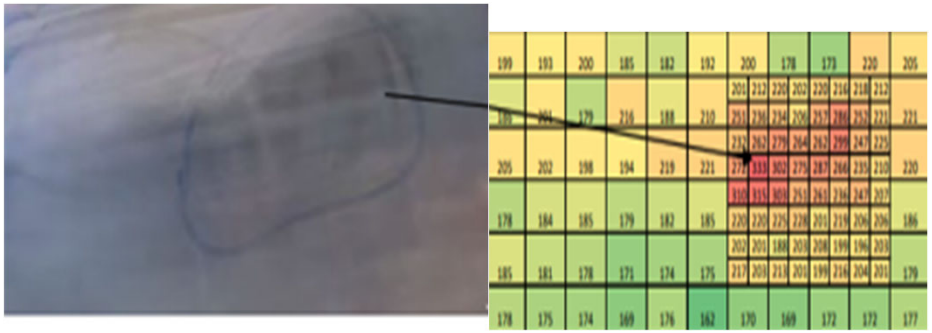
§192.937(c)(1)(ii) Assessment Methods - Internal inspection tools

Select a tool or combination of tools capable of detecting the threats to which the pipeline segment is susceptible such as corrosion, deformation and mechanical damage (e.g. dents, gouges and grooves), material cracking and crack-like defects (e.g. stress corrosion cracking, selective seam weld corrosion, environmentally assisted cracking, and girth weld cracks), *hard spots with cracking*, and any other threats to which the covered segment is susceptible

Hard Spot Integrity Program

Hard Spot Integrity Program

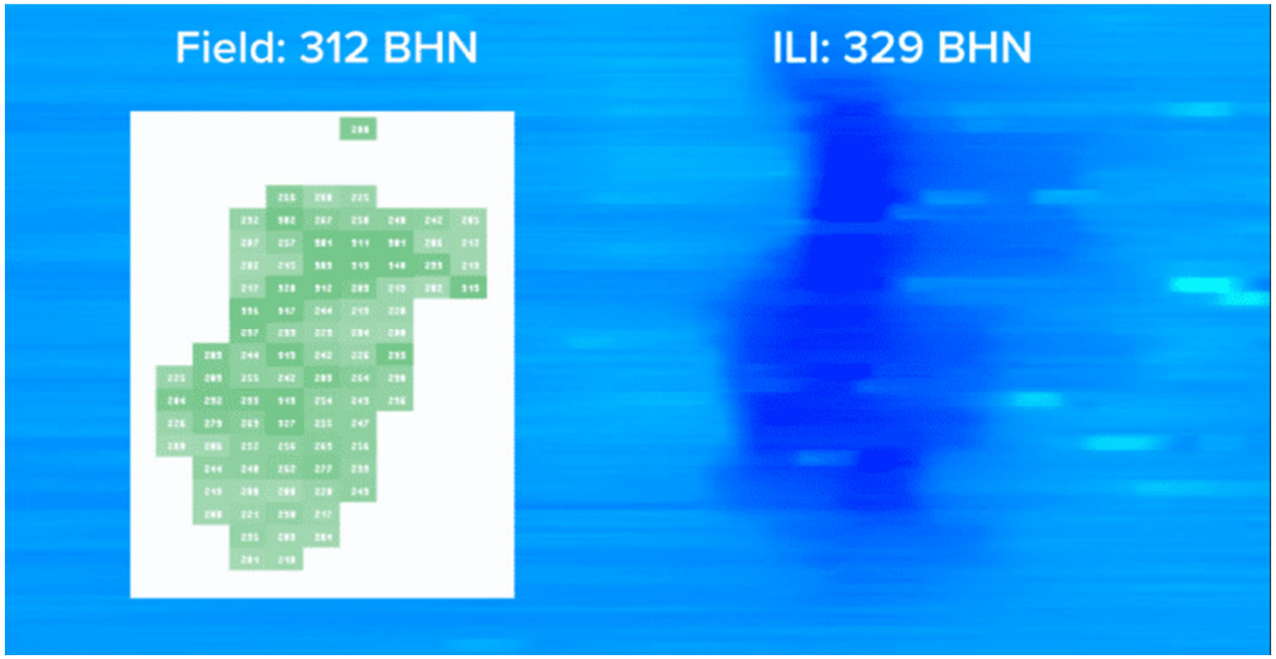
- ✓ Locate ILI anomaly in the field
- ✓ Visual inspection (MPI)
- ✓ NDT technology
- ✓ Prep defect (polish/etch)
- ✓ Measure Hardness



Hard Spot Integrity Program

179	183	189	200	212	198	192	182	195	187	184
199	192	203	249	261	257	229	196	195	187	178
194	198	221	260	266	267	270	242	201	180	176
194	237	256	265	268	266	262	250	210	203	194
199	238	258	274	267	265	259	264	246	201	190
203	240	251	256	268	263	278	262	266	230	252
205	246	247	245	267	270	271	258	271	226	206
186	213	246	256	261	264	265	265	263	200	185
176	190	196	235	243	241	242	227	261	203	182
174	182	188	186	198	200	199	191	220	203	184

Hard Spot Integrity Program



Ask Yourself

- Do we know and have detailed records of our pipeline's manufacturing history, and are they sufficient to identify potential hard spot risks?
- Have we re-evaluated our ILI data with newer technologies or methodologies to detect hard spots that might have been missed?
- Do we have a history of hard spots on any of our systems?
- Are we actively participating in industry discussions and forums to share and gain knowledge about hard spot management?

Advisory Bulletin (ADB–2024–01)

Questions?