

A grayscale microscopic image of a metal surface. The surface shows a complex, layered structure with various textures and patterns. A prominent feature is a dark, irregularly shaped area on the right side, which appears to be a defect or a specific material region. The overall appearance is that of a highly detailed, textured material.

ROSEN

empowered by technology

Hard Spot Assessment & Integrity Analyses

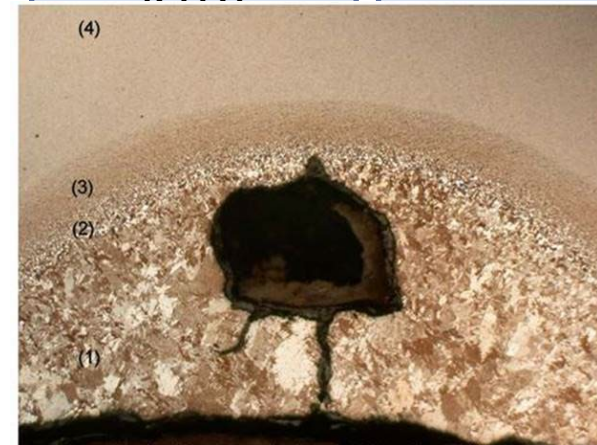
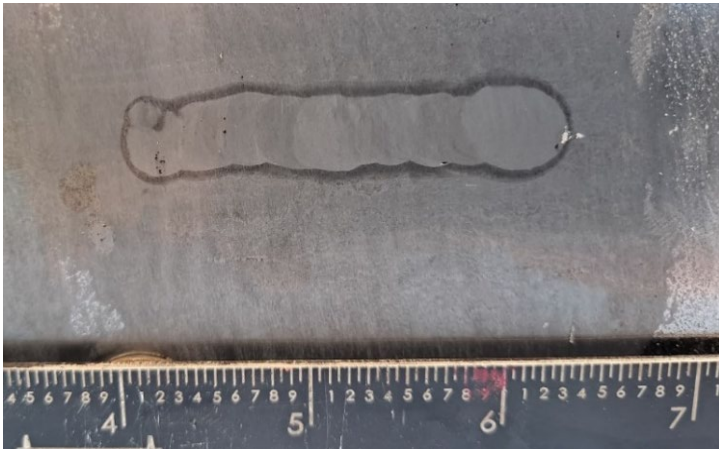
Tuesday, December 13th, 2022

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- Hard Spot in Regulations
- In-Line Inspection Technology, History and Hard Spot Susceptibility
- Hard Spot Validation
- Types of Material Hardness Anomalies
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REFERENCES TO HARD SPOT IN REGULATIONS

- **§ 192.3:** “A 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).”



MAOP
reconfirmation

Assessment
outside of
HCAs

Baseline and
continued
assessment

192.632 (c) and
(c) (1)

192.710 (c) (1)

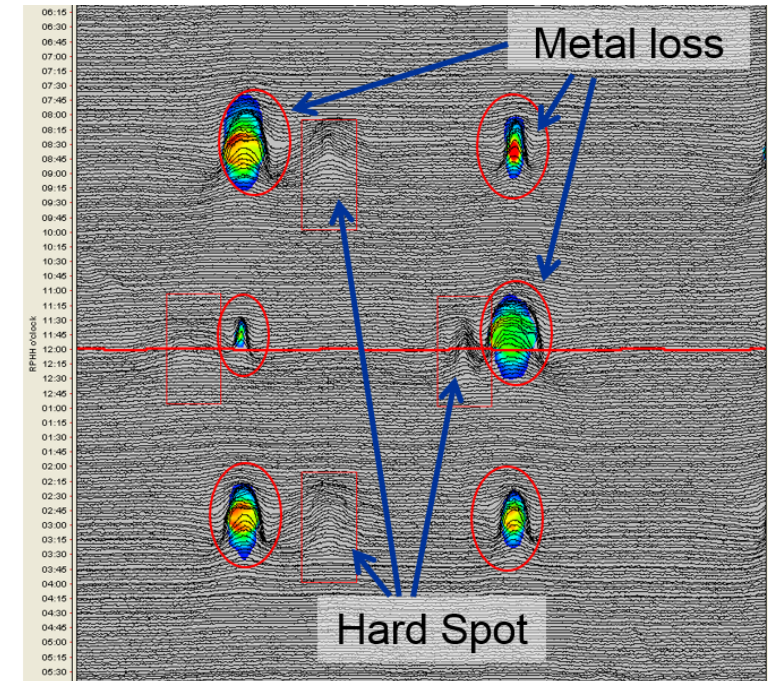
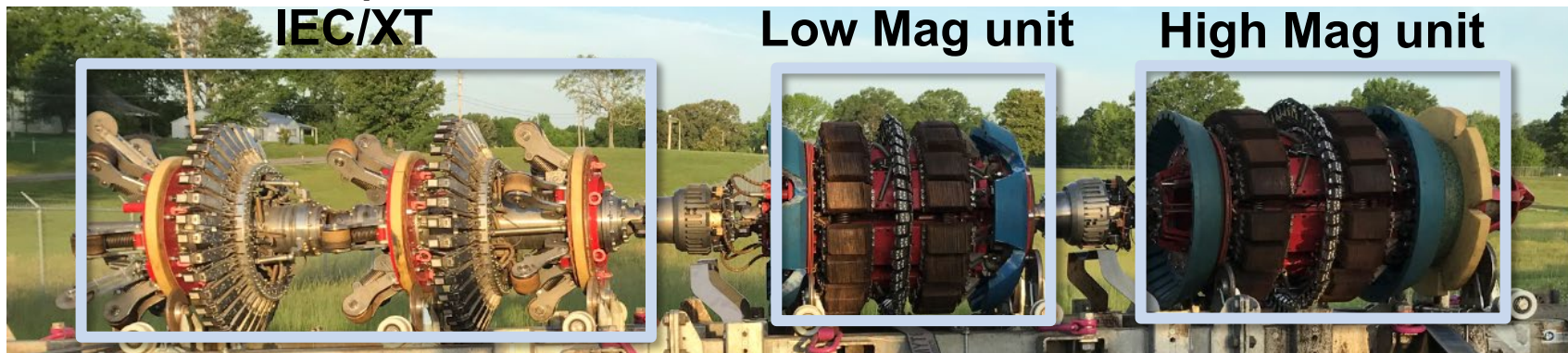
192.921 (a)(1)
& 192.937
(c)(1)(ii)

Be to hard spots,
detect hard spots.

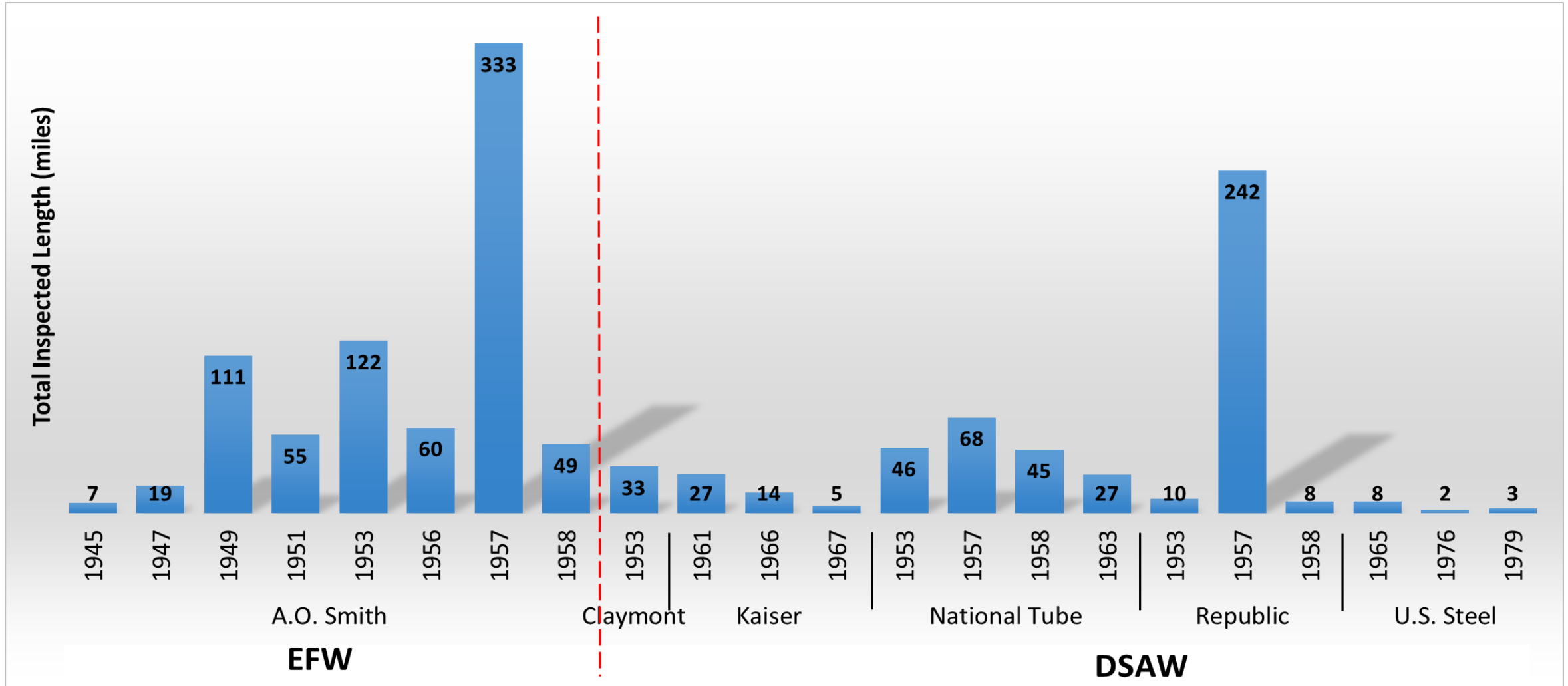
IN-LINE INSPECTION TECHNOLOGY

- Dual Magnetization (DMG) utilizes standard magnetic flux technology (MFL):
 - Conventional MFL magnetizes on a high level (high mag.) to saturate a pipeline with a magnetic field to be **independent from microstructure changes**.
 - DMG also magnetizes on a low level (low mag.) to **detect microstructure changes**.

DMG ILI tool setup:



DMG INSPECTION HISTORY (2019 – 2021)



DMG INSPECTION HISTORY (2019 – 2021)

What known integrity issues do I have on this line?

Do I have a good understanding of the type of pipes in my line?

Are the types of pipes in my line susceptible to hard spots?

Manufacturer	Year of Manufacture	Total Inspected Length (miles)	Total # HS reported	# HS reported per mile
A.O. Smith	1945 – 1970	869	282	0.32
Republic	1953 – 1960	330	79	0.24
National Tube	1953 - 1970	279	54	0.19
Consolidated	1949 - 1955	173	55	0.32
Kaiser	1957 – 1968	131	40	0.31
Bethlehem	1954 - 1991	106	30	0.28

Hard Spot Validation

HARD SPOT VALIDATION

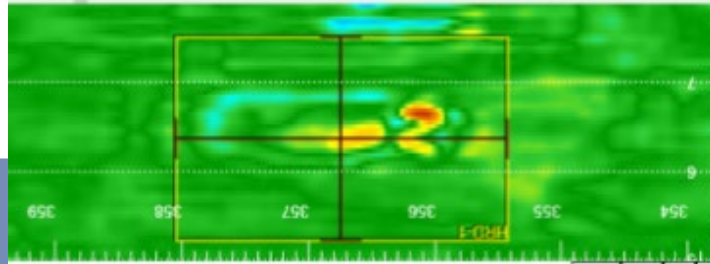
1. Visual Inspection



Locate ILI call out

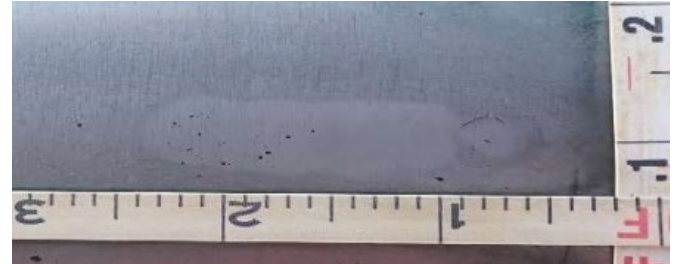
Visual inspection (MPI)

2. Supplementary Technology to locate ILI call out Eddy Current Array Technology

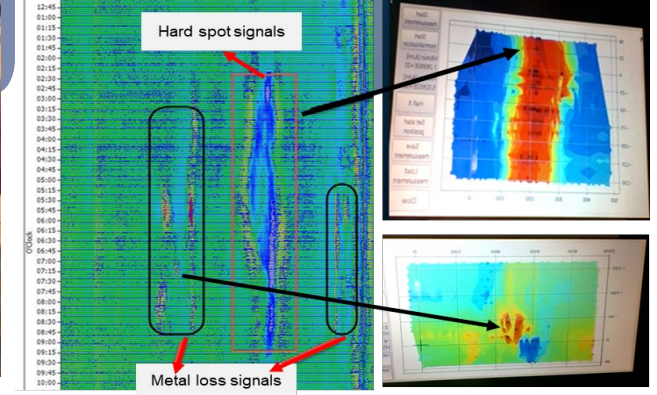


NDI Technology (recommended)

Polish / etch

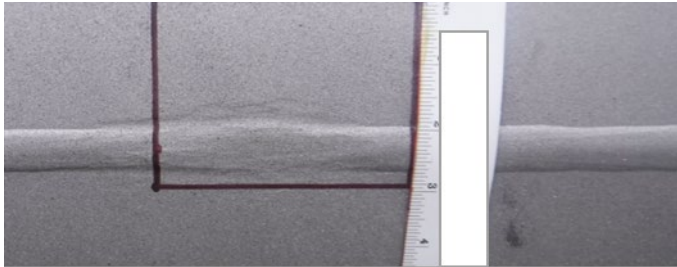


Remnant Magnetic Field Measurement Technology

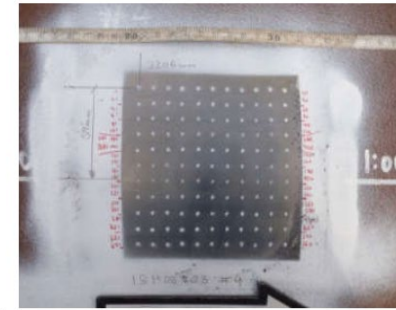
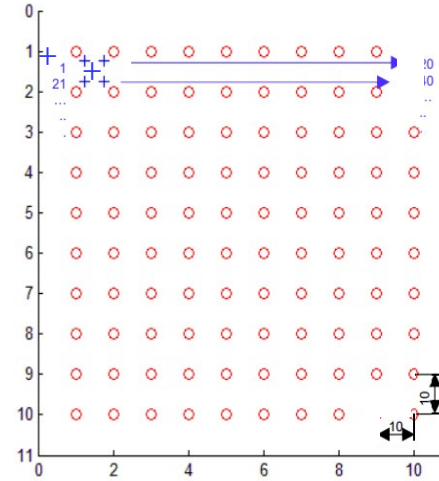


HARD SPOT VALIDATION

3. Polishing / Etching



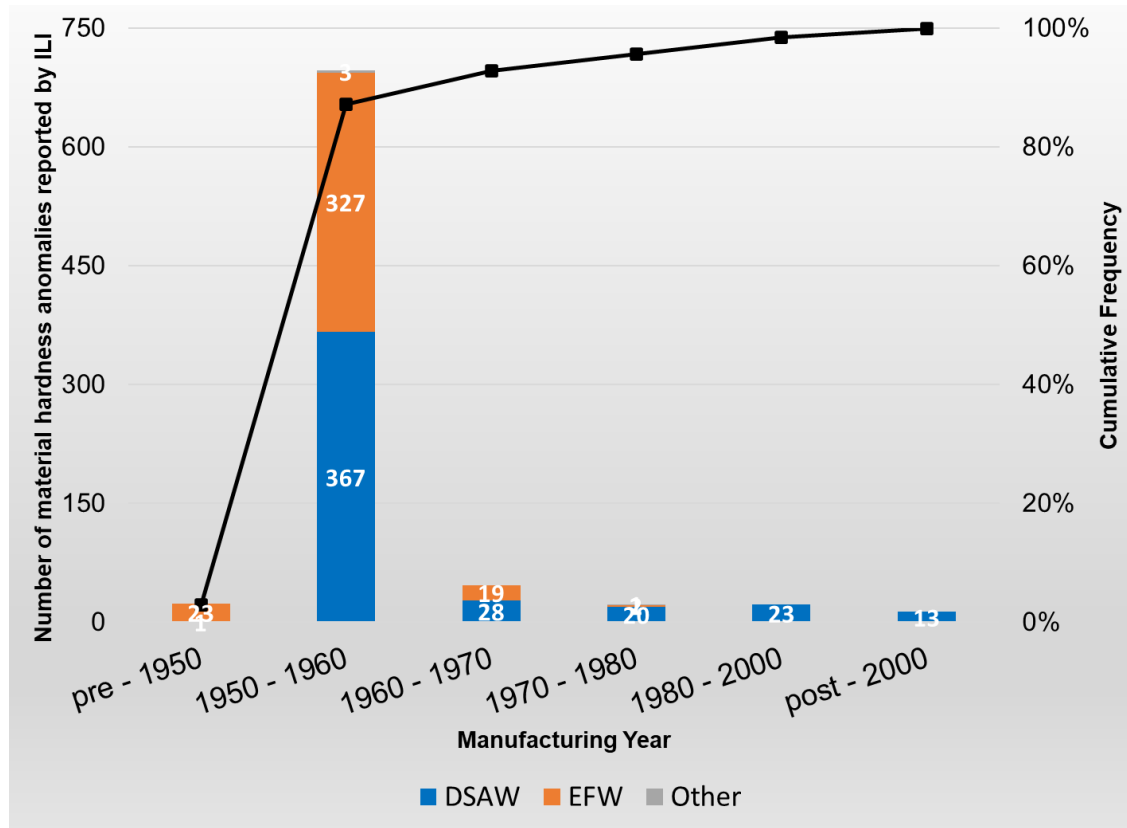
4. Hardness Measurement



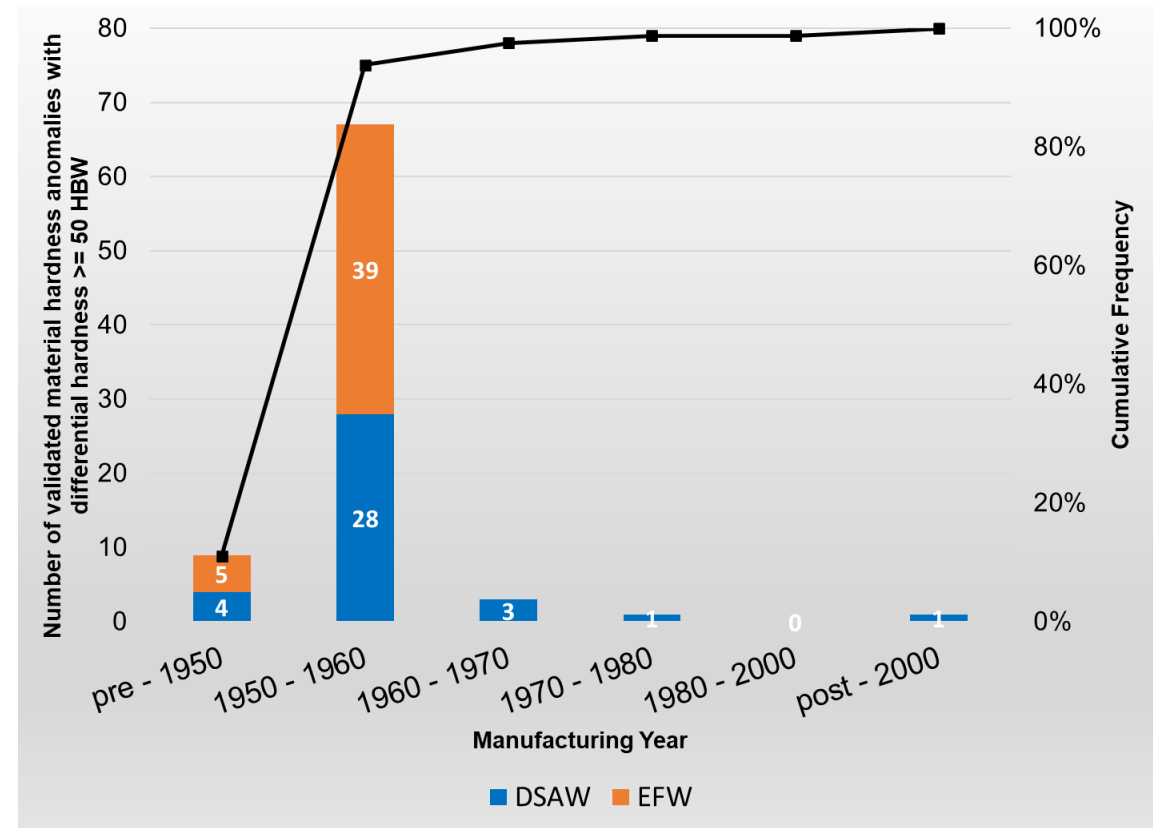
179	179	179	183	189	200	212	198	192	182	195	187	184	187	184
175	174	199	192	203	249	261	257	229	196	195	187	178	174	175
165	192	194	198	221	260	266	267	270	242	201	180	176	172	172
174	189	194	237	256	265	268	266	262	250	210	203	194	185	183
179	191	199	238	258	274	267	265	259	264	246	201	190	185	181
186	182	203	240	251	256	268	263	278	262	266	230	252	217	171
178	186	205	246	247	245	267	270	271	258	271	226	206	197	189
180	187	186	213	246	256	261	264	265	265	263	200	185	185	186
179	177	176	190	196	235	243	241	242	227	261	203	182	186	184
186	172	174	182	188	186	198	200	199	191	220	203	184	188	180

INSPECTION & VALIDATION RESULTS

ILI Reported Anomalies



Validated Material Hardness Anomalies with Hardness Differential ≥ 50 HBW



Types of Material Hardness Anomalies

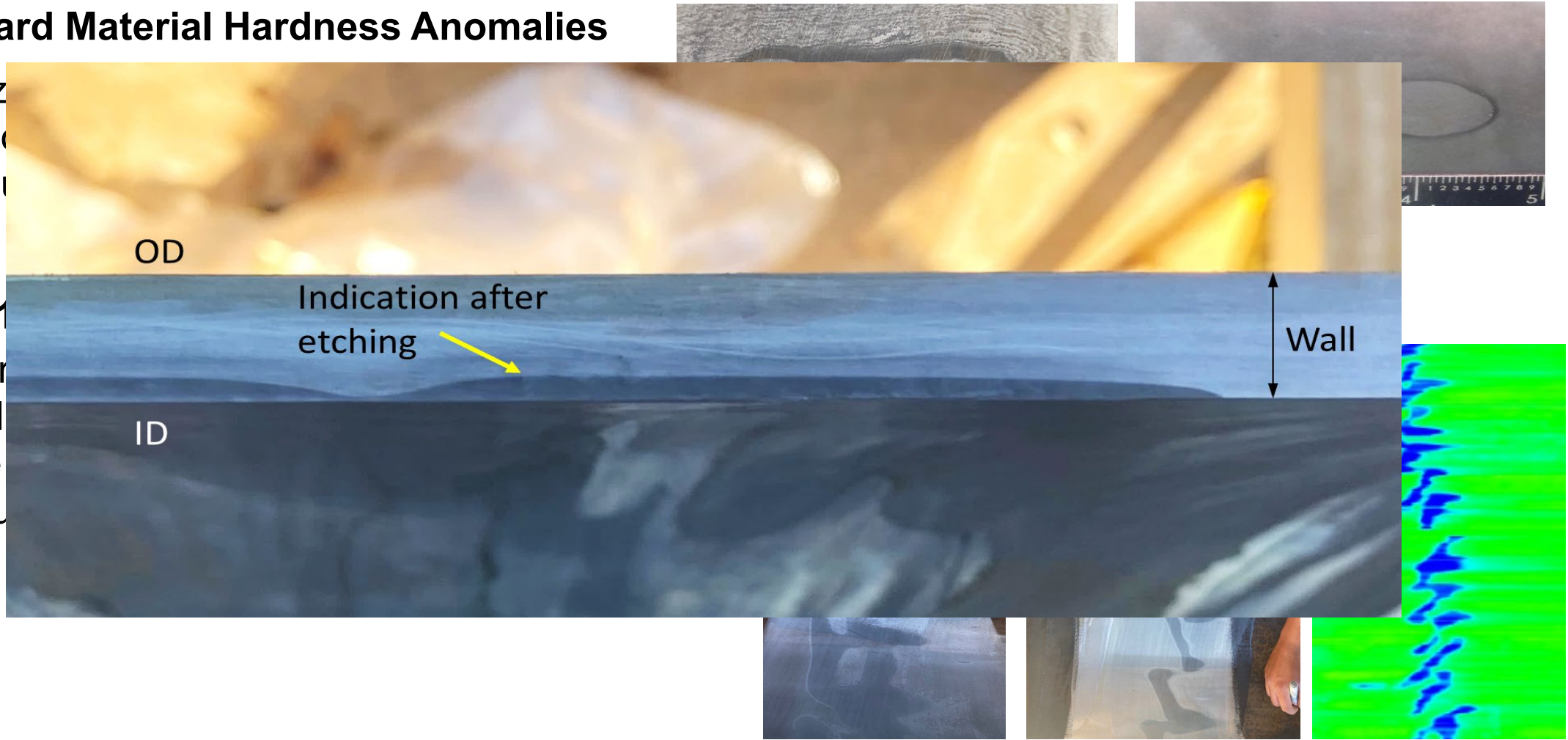
TYPES OF MATERIAL HARDNESS ANOMALIES

1. Standard Material Hardness Anomalies

- Localized
- Dark band
- Maximum

2. 'Type 1'

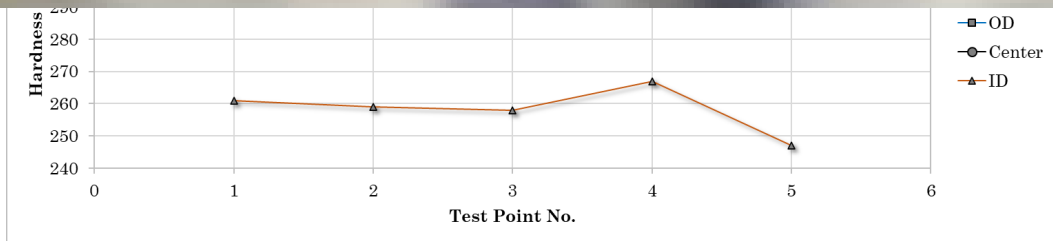
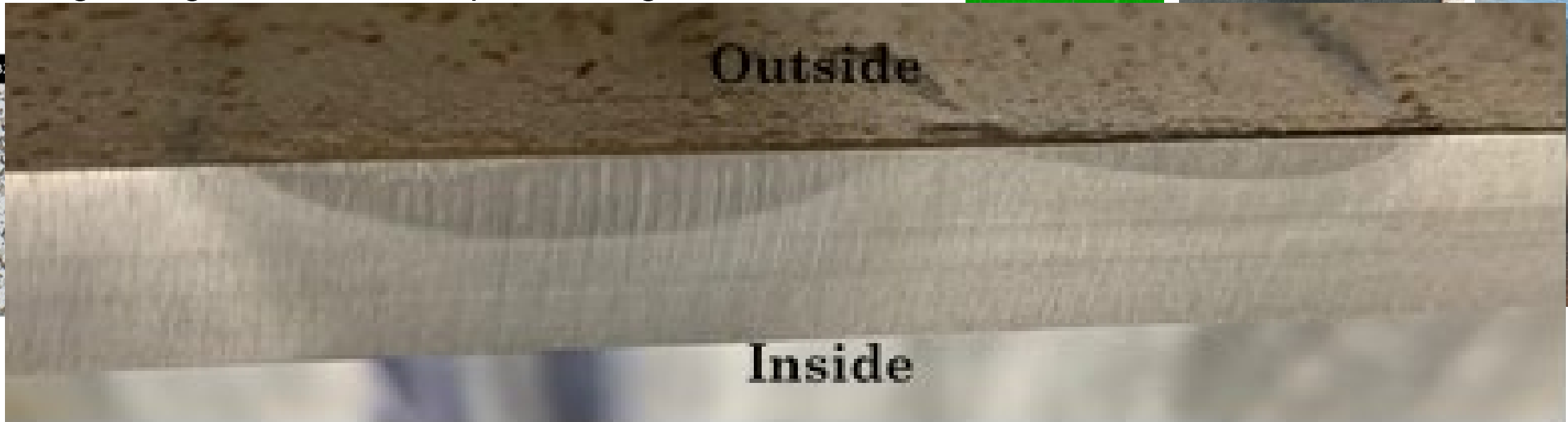
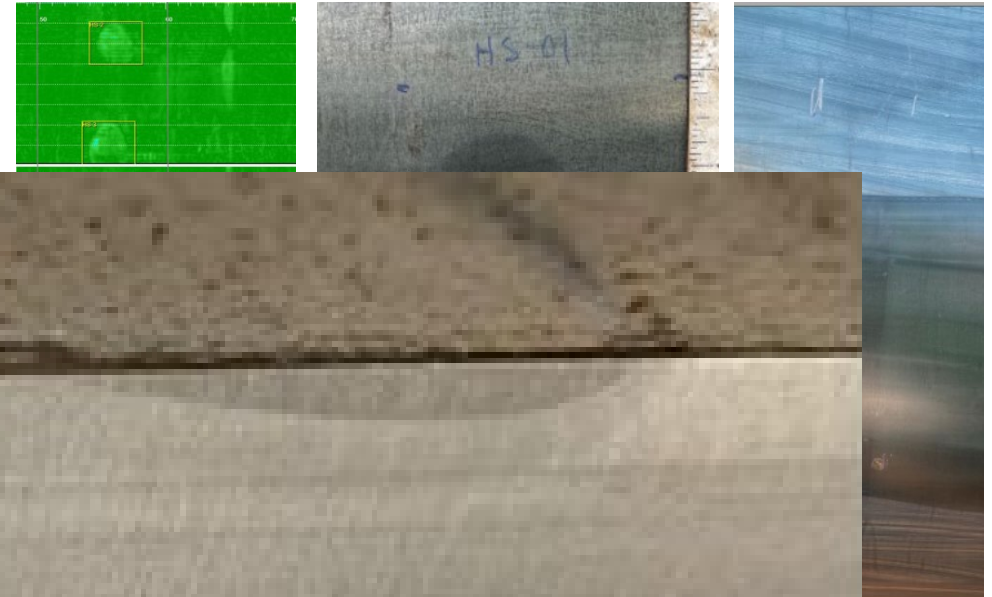
- Fully circumferential
- internal
- Can be
- Maximum



TYPES OF MATERIAL HARDNESS ANOMALIES

3. 'Type 2' Anomalies

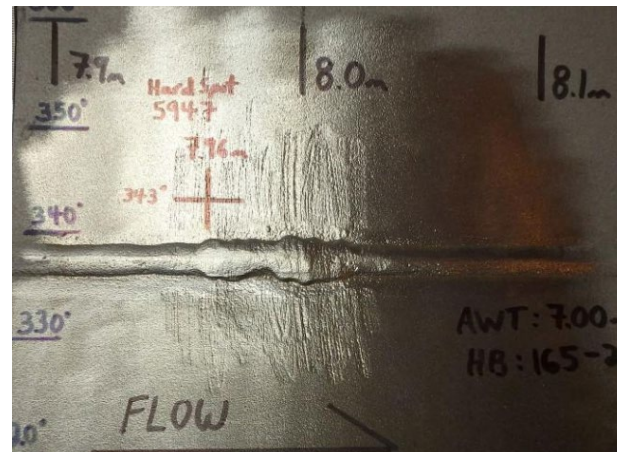
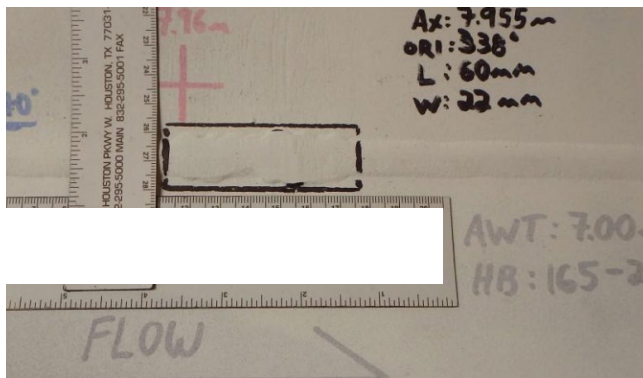
- Existing in groups
- Originating on the OD and penetrating to the ID



In-field Validation Examples

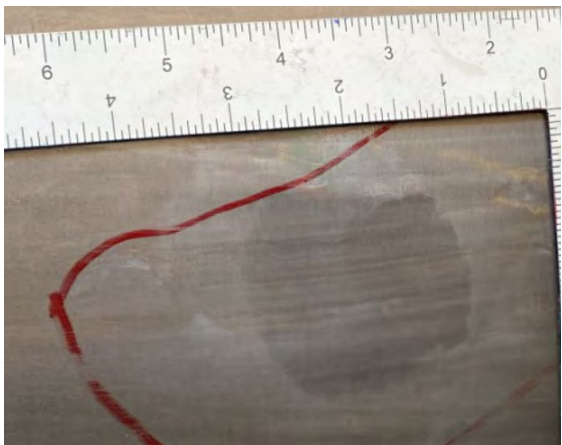
INTERNAL HARDNESS ANOMALY

- DSAW, 1957, Welland Tube, X-52
- ILI reported: length 3.70 in, width 2.36 in, hardness 278 HB

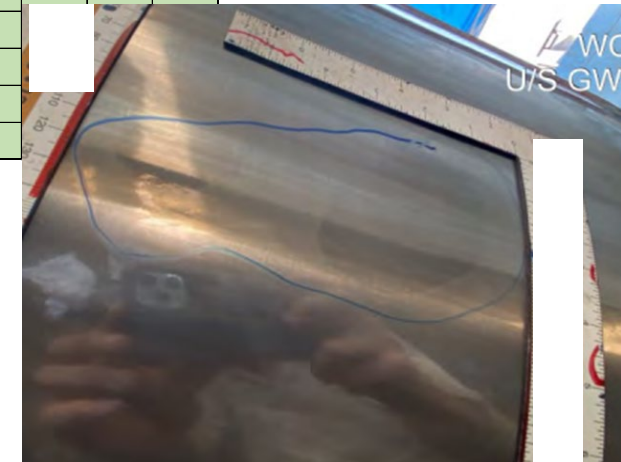


VALIDATED HARDNESS > 327 HB

- Multiple Type 2 Anomalies at one area; 1957 EFW A.O. Smith; X-52

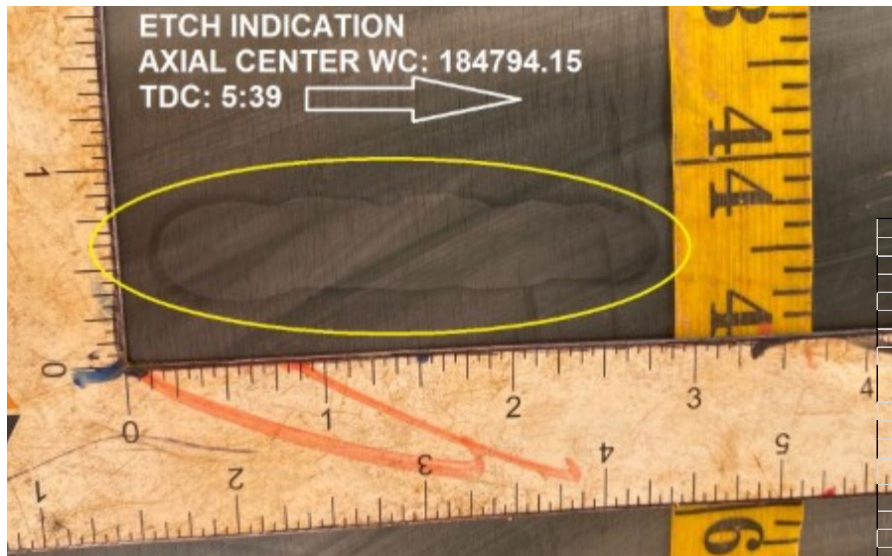


	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"
1"						186	192	179	190	191	188					
2"						172	176	196	191	189	199					
3"						175	198	188	201	178	182					
4"						200	197	198	193	201	191					
5"						188	210	189	190	200	192					
6"	199	193	200	185	182	192	200	178	173	220	205	201	183	200	199	196
7"	186	201	179	216	188	210	201	212	220	202	220	216	218	212		
8"	205	202	198	194	219	221	232	262	279	264	262	299	247	225	221	221
9"	178	184	185	179	182	185	272	333	302	275	287	266	235	210	220	203
10"	185	181	178	171	174	175	310	315	303	251	261	236	247	207		
11"	178	175	174	169	176	162	220	220	225	228	201	219	206	206	186	182
12"						170	202	201	188	203	208	199	196	203	182	182
13"						173	217	203	213	201	199	216	204	201	180	180
14"						179	217	203	213	201	199	216	204	201	179	178
15"						170	195	190	184	181	178					
16"						170	190	178	171	175	169					



VALIDATED HARDNESS > 327 HB

- Standard Material Hardness Anomaly; 1957 DSAW Republic Pipe
- ILI Reported 315 HBW
- >> Max hardness measured: 353 HBW



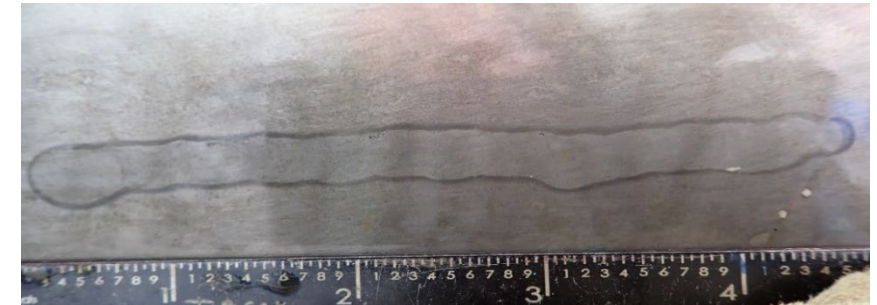
	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
0.5																														
1	162	142	149	149	150	148	141	140	140	142	152	150	154	154	148															
1.5	151	146	164	146	149	147	156	144	152	174	154	157	151	138	153															
2	154	149	151	145	154	154	151	158	143	151	152	153	152	140	144															
2.5	157	158	153	157	161	169	146	156	160	155	152	161	155	153	152															
3	153	146	146	154	154	154	162	154	147	149	173	152	151	151	155															
3.5	145	146	133	153	153	147	146	147	142	153	147	153	142	145	138															
4	145	147	144	145	158	182	209	149	147	156	150	202	152	149	146	168	155	140	149											
4.5	147	152	147	147	151	150	185	190	185	192	214	353	298	149	146	168	155	140	149											
5	147	152	147	147	151	162	149	151	154	135	146	150	145	143	136															
5.5	148	146	156	151	154	151	172	159	155	149	156	149	151	155	143															
6	152	148	150	149	151	153	155	156	151	153	154	145	148	143	147															
6.5	148	153	142	148	152	150	154	151	148	144	142	147	143	137	142															
7	147	145	146	135	142	142	142	145	141	140	144	135	137	142	145															
7.5	143	140	142	146	146	143	139	147	145	139	127	135	141	134	150															

VALIDATED HARDNESS < 327 HB

- Standard Material Hardness Anomaly; 1954 Bethlehem DSAW; X-52
- ILI Reported 285 HBW

>> Max hardness measured: 295 HBW

>> Average of the max grid: 222 HBW



- Type 2 Anomaly; 1957 EFW A.O. Smith; X-52

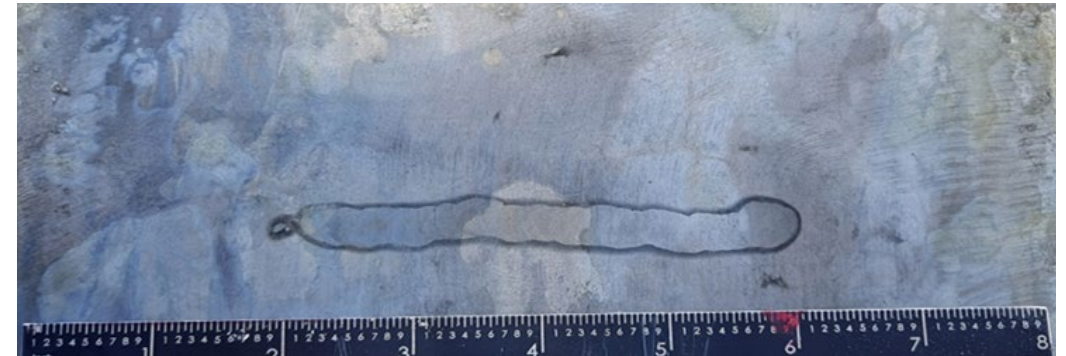
>> Max hardness measured: 287 HBW

	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"	19"	20"	21"	22"	
1"							149	149	149	147	143	154	152	151	148	147							
2"							149	158	152	152	153	148	148	146	150	151							
3"							155	150	148	152	151	156	154	154	148	148							
4"							150	166	149	147	147	154	155	152	153	152							
5"							155	145	148	151	147	150	149	152	152	151							
6"							152	147	158	153	152	149	151	152	153	156							
7"	154	154	147	159	152	152	146	148	145	147	148	148	147	149	151	151	148	151	149	151	154	150	151
8"	152	144	148	148	142	146	143	143	143	144	144	151	150	149	148	148	157	153	156	182	173	158	153
9"	152	146	142	139	141	144	144	144	146	151	150	152	152	147	148	152	154	148	215	240	231	241	225
10"	165	146	150	144	145	143	145	146	147	144	150	148	147	153	152	149	248	263	271	270	273	263	241
11"	151	151	151	151	141	146	146	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149
12"	147	153	150	146	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147
13"	154	149	150	148	148	147	146	151	150	148	148	148	148	148	148	148	148	148	148	148	148	148	148
14"	145	144	147	147	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148
15"	149	149	148	145	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147
16"							153	146	154	153	149	155	153	153	150	151							
17"							148	150	151	149	152	152	154	151	147	148							
18"							149	152	148	154	152	150	151	149	153	155							
19"							151	152	150	147	146	150	149	145	147	150							
20"							147	149	151	146	148	153	150	148	146	150							
21"							152	154	150	148	149	151	153	149	152	154							



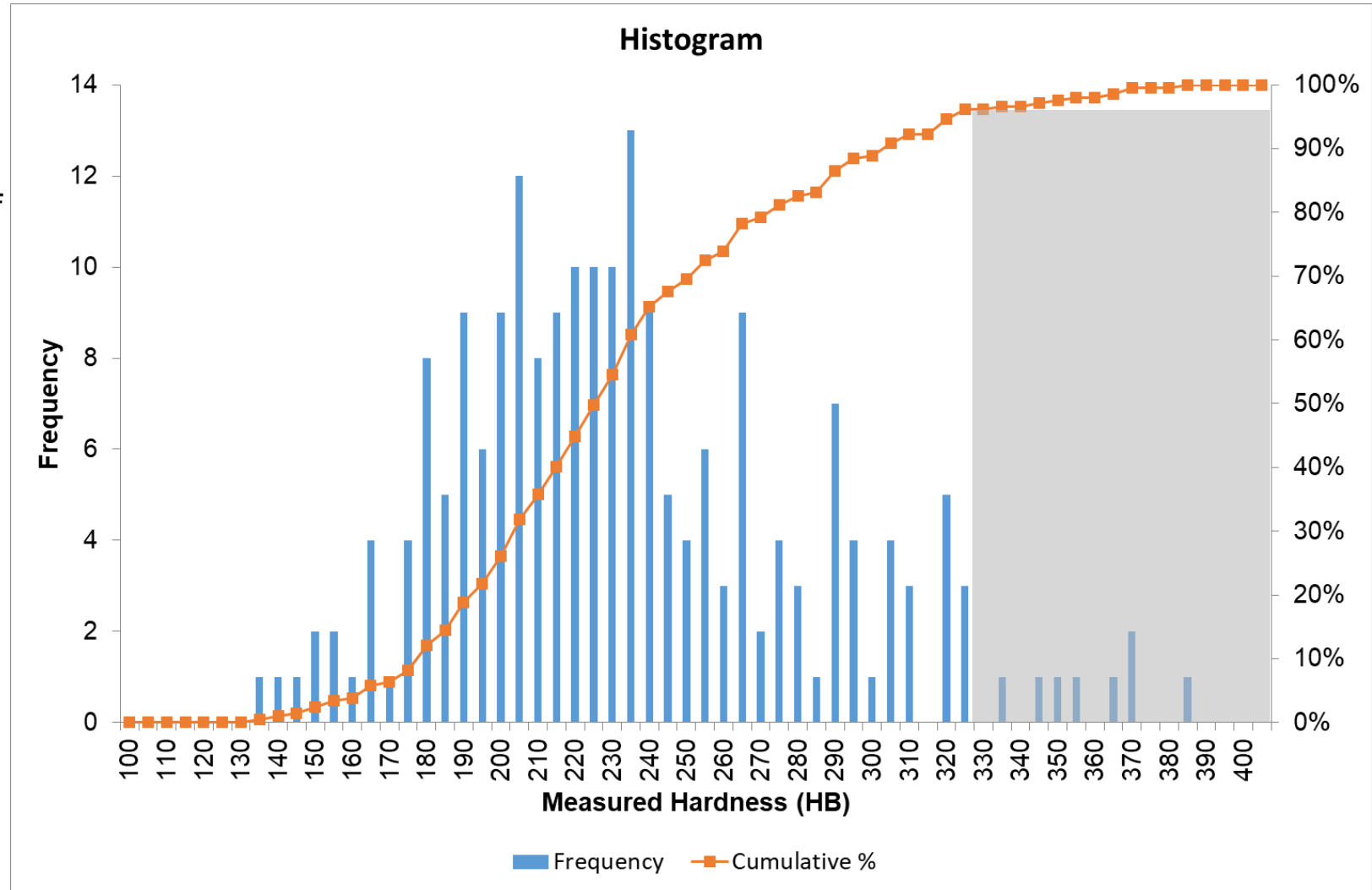
VALIDATED HARDNESS < 250 HB

- Standard Material Hardness Anomaly; 1954 DSAW Bethlehem Steel; X-52
 - ILI Reported 254 HBW
- >> Measured hardness value: 250 HBW



VALIDATED ILI REPORTED ANOMALIES

- 208 validated anomalies up to date
 - Validated anomalies with measured hardness < 327 HB make up of 96% of all validated anomalies.
- We are managing a portion of the threat.



CONCLUSIONS

- Industry now has an improved understanding of hard spot susceptibility.
 - *Not only A.O. Smith pipes are susceptible*
- There are different types of material hardness anomalies and not all constitute a threat to pipeline integrity.
- Experience has been used to establish best approach to material hardness anomaly validation.
- It is important for all stakeholders to continue sharing knowledge and experience with the industry.

PHMSA PUBLIC WORKSHOP

HARD SPOT ASSESSMENT & INTEGRITY ANALYSES

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