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IN-DITCH NDE FOR PIPE STRENGTH AND TOUGHNESS

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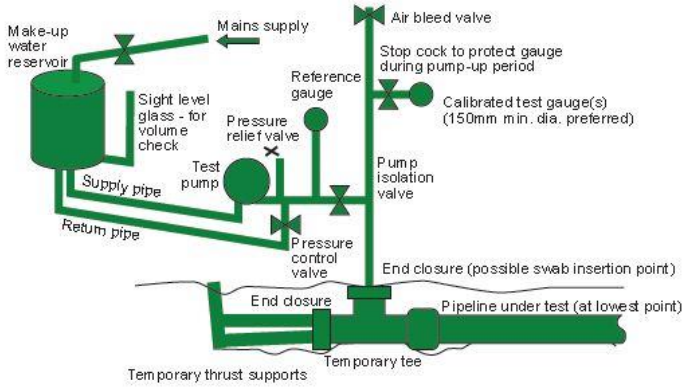
DOT – PHMSA R&D Forum

Cleveland, OH

16 November 2016

Inspection / NDE of Transmission Pipelines



Steel strength and toughness currently unknown for many pipelines.

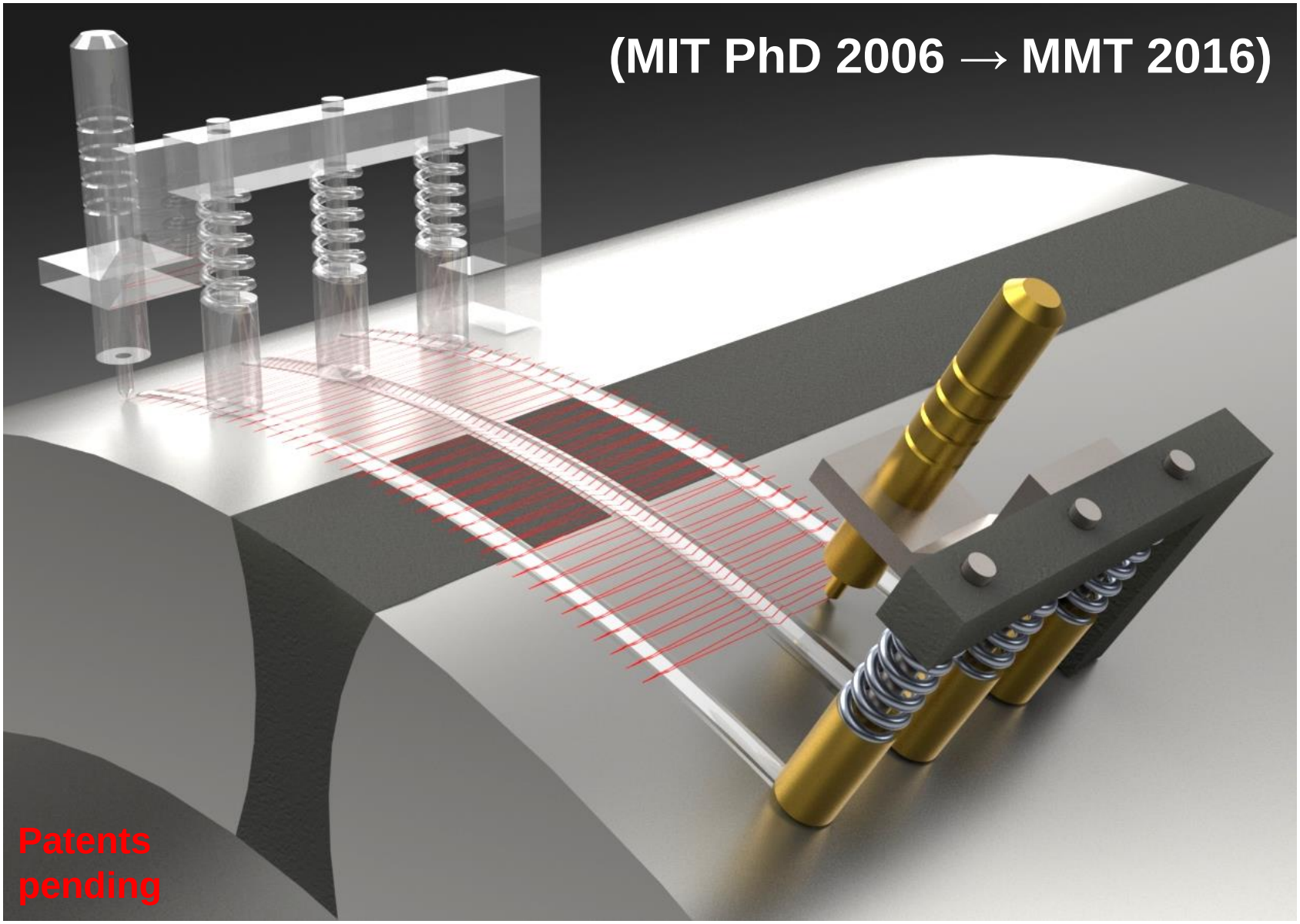
Benefits of material data

- Tune MAOP (Steel typically 15% above minimum yield)
- Reduce re-test intervals (effect of corrosion)
- Identify critical flaw size for different vintages of pipes
- Extending life

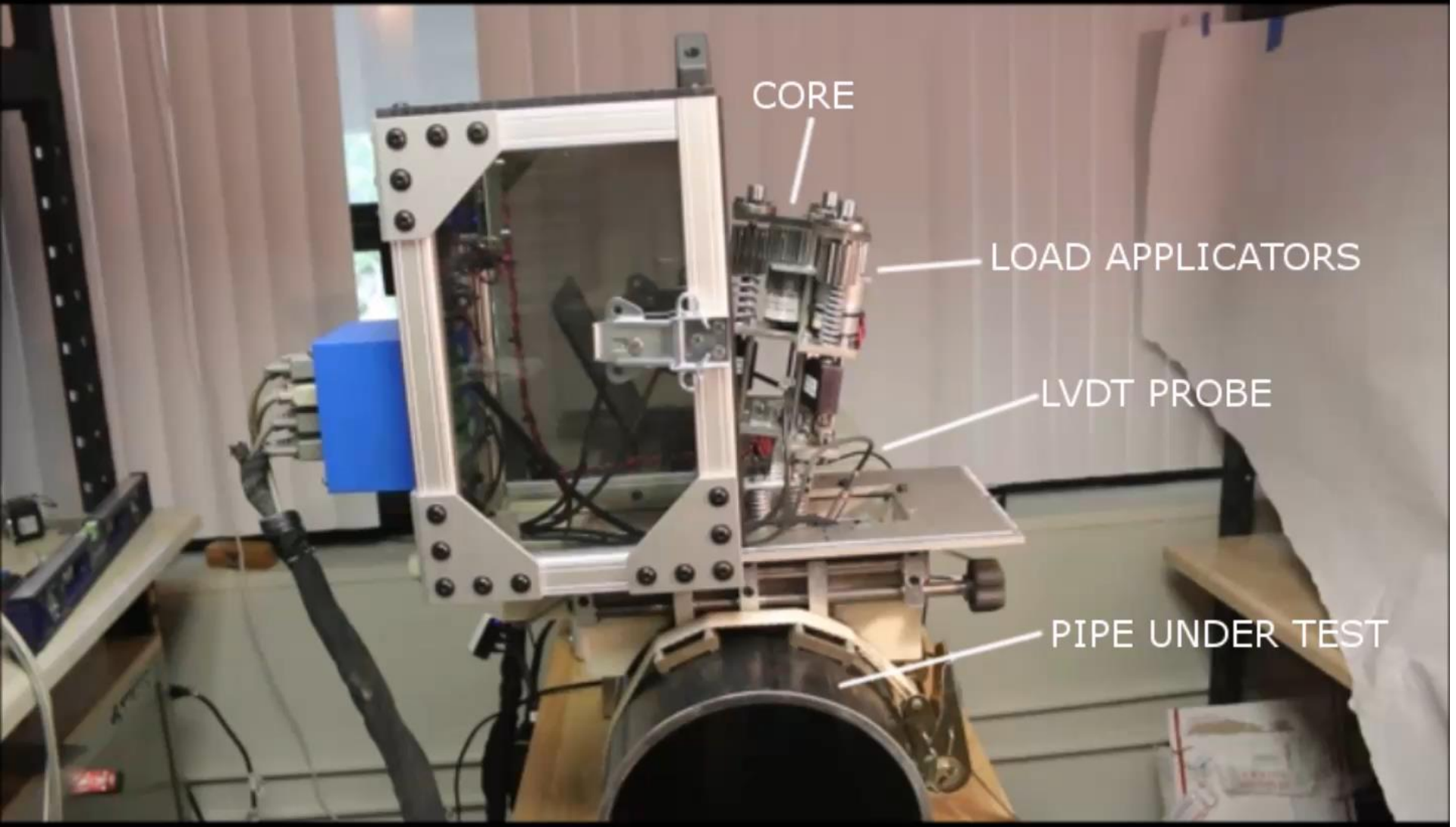
Need accurate data:

- +/- 15 % intrinsic material variation between joints
- In-ditch measurement confidence internal is an added uncertainty. +/- 10% makes sense. +/- 5% adds value?
- IIT & methods using different data sources

Hardness, Strength and Ductility (HSD) Tester

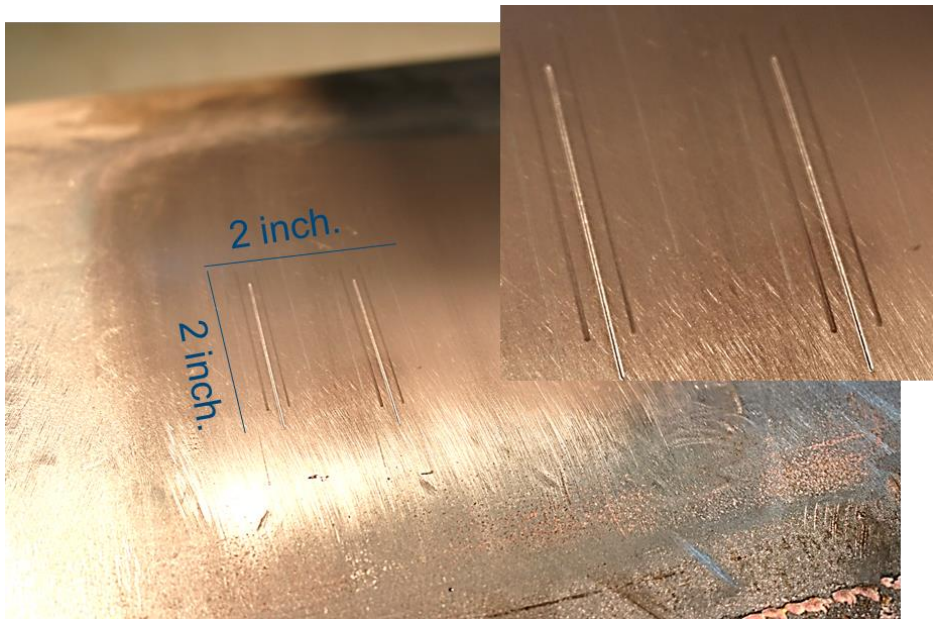


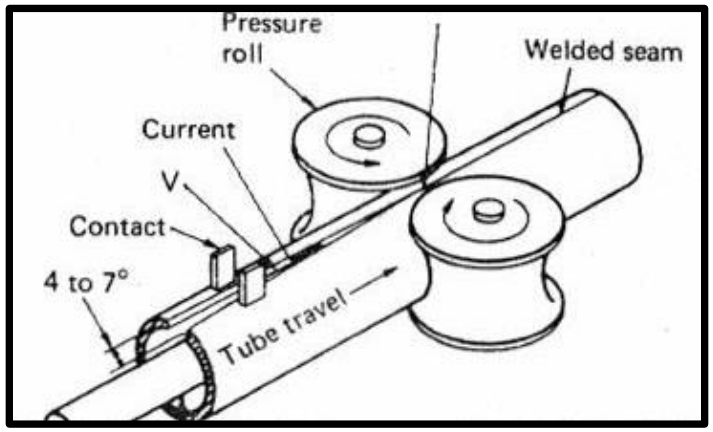
HARDNESS, STRENGTH, AND DUCTILITY (HSD) UNIT

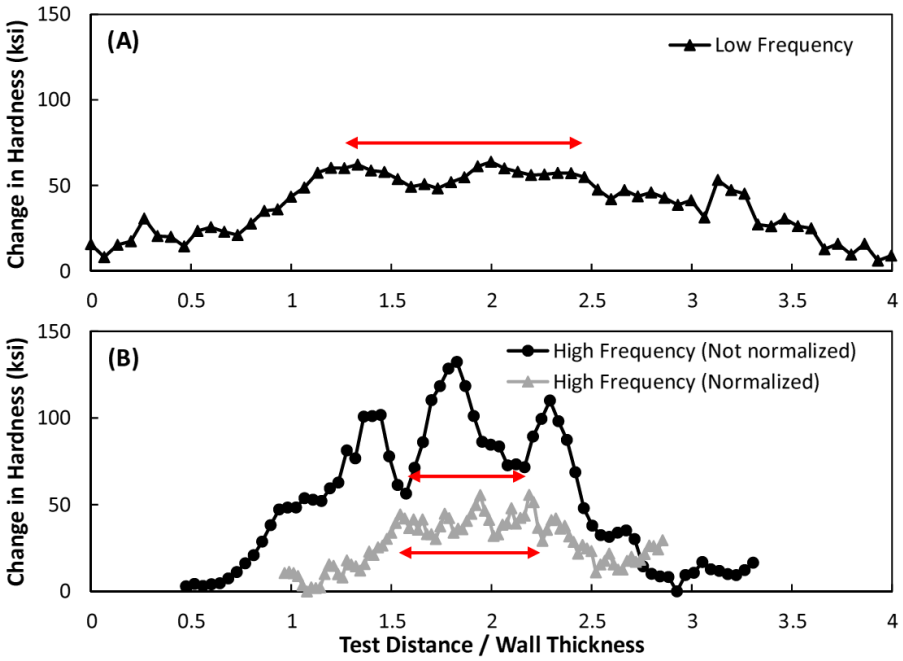


Scribing the Surface and Collecting Groove Info

Imprint < 1% of wall thickness

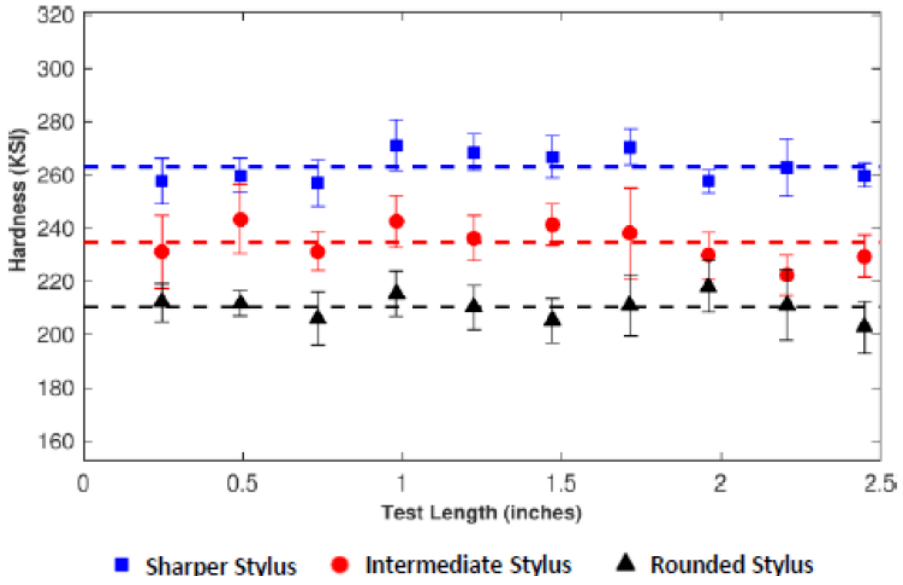






- **High quality surface test (redundancy is good).**
- **Surface versus mid-wall correlation**
- **Welded seams**

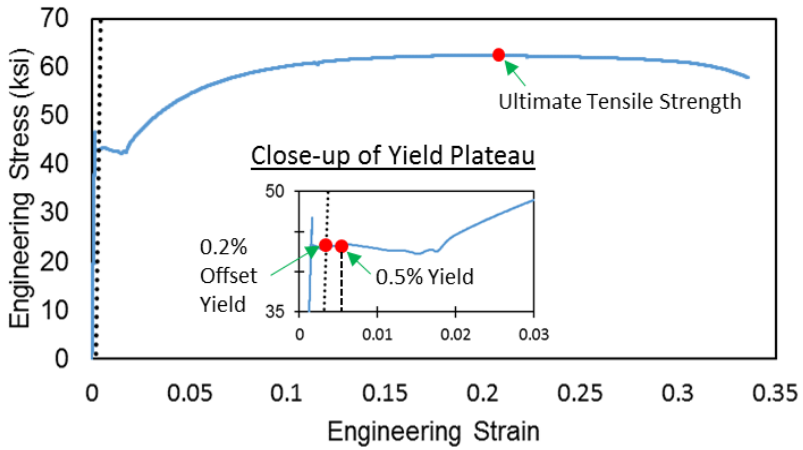
Validation of HSD

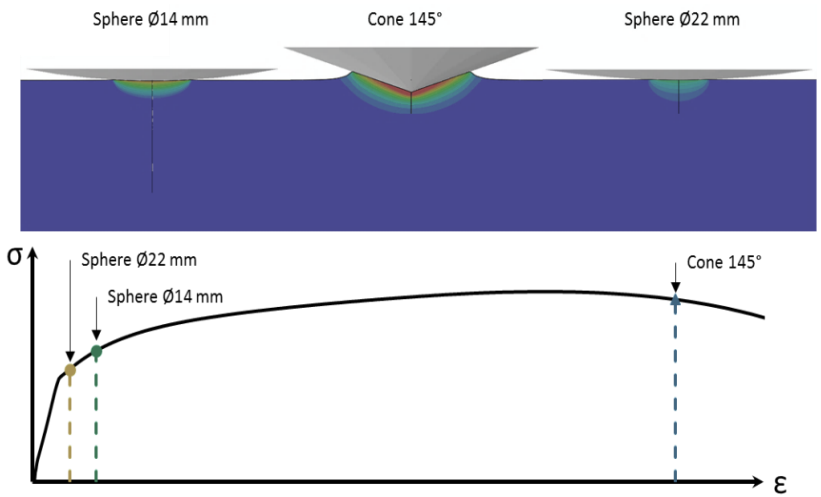


Sample	Tensile Yield Strength (ksi)			HSD Tester Yield Strength (ksi)			
	Min.	Max.	Avg.	Test 1	Test 2	Avg.	Range Error
SCB (MW)	35.1	40.3	37.0	38.3	35.8	37.0	0.0%
1020	43.3	43.6	43.4	40.1	41.9	41.0	-5.3%
Grade B (MW)	42.8	51.7	47.3	50.7	48.0	49.4	0.0%
LF (MW)	47.2	47.3	47.3	46.0	45.2	46.0	-2.7%
ENBL82 (MW)	49.7	51.5	50.6	51.8	50.3	51.1	0.0%
4130	53.5	54.0	53.8	53.8	55.5	54.6	1.1%
X42 (MW)	54.1	58.1	55.7	58.0	57.0	57.5	0.0%
HF (MW)	64.1	66.0	65.0	60.8	63.0	61.9	-3.4%
x52 (MW)	68.5	70.7	69.7	64.9	--	64.9	-5.3%
A572	70.6	72.7	71.7	68.9	71.3	70.1	-0.7%
Gasunie (MW)	72.5	73.0	72.7	69.6	70.0	69.8	-3.7%

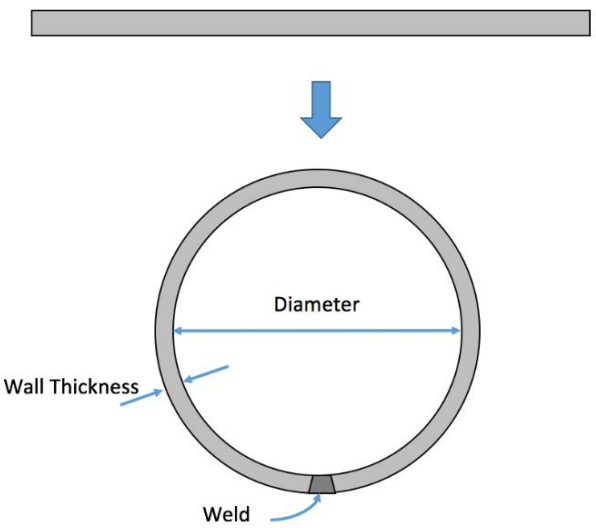
Source: https://www.regulations.gov/document?D=PHMSA-2011-0023-0371

Yield plateau in a low strength steel





Vintage ERWs and other line pipes



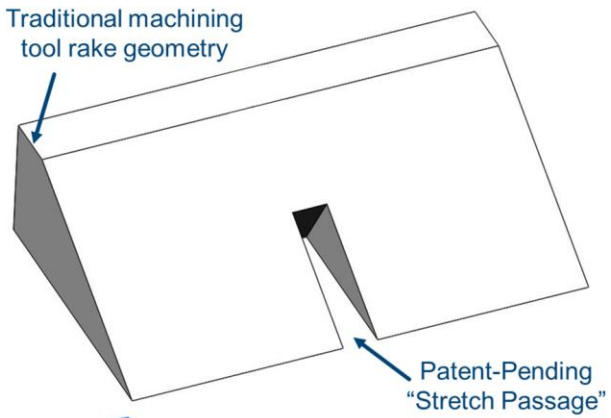
Sample Name	O.D. (in.)	Wall (in.)	Tensile Test (ksi)		HSD (ksi)	HSD v. Tensile	
			Min / Max	Avg	Avg	Avg Error	Range Error
12SLF	12.75	0.25	43.3 / 47.7	45.5	47.4	4.2%	0.0%
14GRB	14.0	0.39	42.8 / 51.7	47.3	47.1	-0.5%	0.0%
22SLF	22.0	0.38	49.7 / 49.9	49.8	47.4	-4.8%	-4.5%
12Y64	12.8	0.22	49.4 / 54.7	52.1	48.7	-6.5%	-1.5%
16SLF	16.0	0.38	51.1 / 53.9	52.6	53.7	2.2%	0.0%
16X42	16.0	0.38	54.1 / 58.0	55.7	55.3	-0.7%	0.0%
08SHF-2	8.6	0.25	57.0 / 57.2	57.1	56.4	-1.2%	-1.0%
08SHF-1	8.6	0.25	64.2 / 64.9	64.6	68.9	6.7%	6.2%
16GRB	16.0	0.25	69.8 / 70.2	70.0	63.3	-9.6%	-9.4%
16X52	16.0	0.75	68.5 / 73.8	70.8	74.3	5.0%	0.7%
22SLF-2	22.0	0.24	49.1	49.1	52.3	6.4%	6.4%
16Y69-1	16.0	0.26	57.8	57.8	61.8	6.9%	6.9%
19Y72-1	20.0	0.26	63.1	63.1	64.1	1.7%	1.7%
20Y68-1	20.0	0.25	53.5	53.5	51.1	-4.4%	-4.4%
26Y52-1	26.0	0.28	58.5	58.5	55.5	-5.1%	-5.1%
20X42-1	20.0	0.25	58.8	58.8	60.0	2.0%	2.0%

MMT Team

- Mechanics and metallurgy
- Working on industry advisers and financial support to speed up
- Packaged solutions:
  - Hardness, Strength and Ductility (HSD) – yield / seams
  - Fracture Toughness Tester (FTT) – CTOD

- NSF-SBIR R&D Support → **Industry-Specific Support**

Fracture Toughness Tester (FTT)

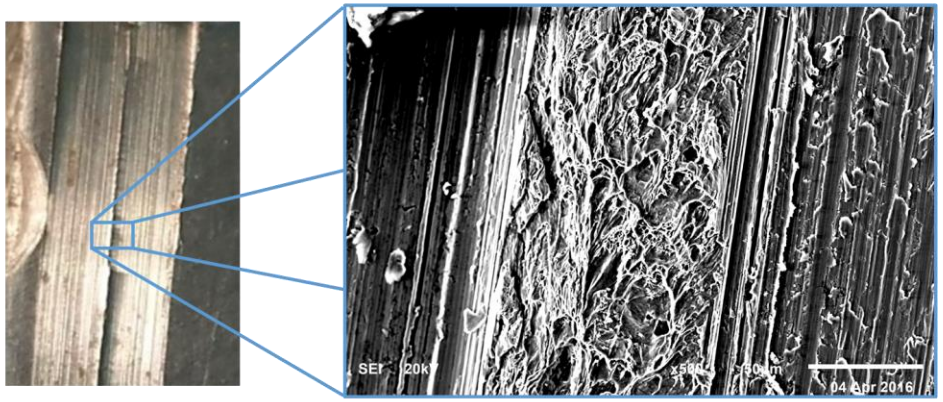


Patents pending

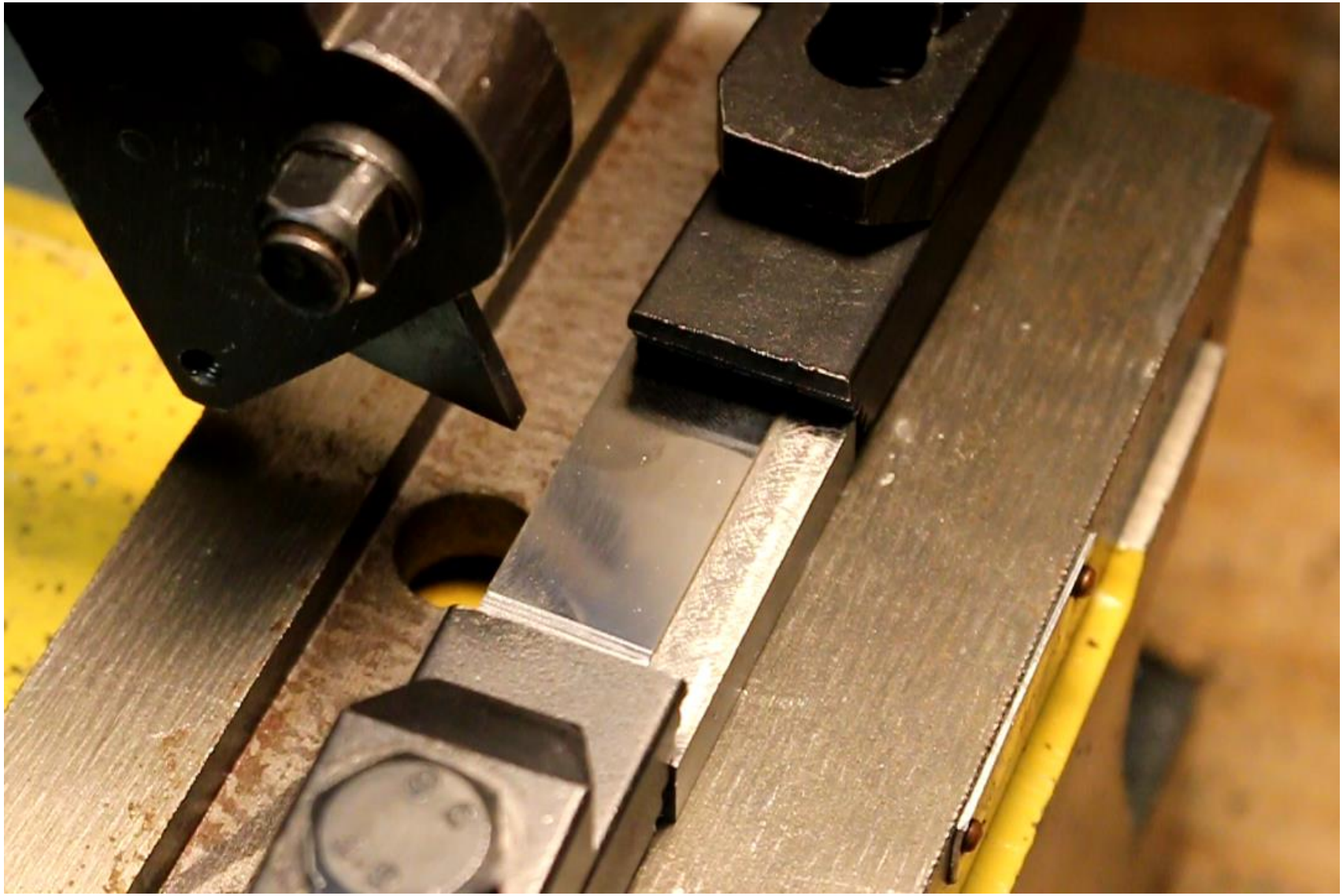
With only 0.003 inch removed

- Local / controlled fracture
- Measurement of toughness
- Profile across welds

No need for detailed surface prep!



FTT Worked In the Lab the Very First Time Tried!



1020 Steel, Standard 2016A Stretch Passage, 125 µm Set Cut Depth.

Solutions as a Path to Efficiency / Safety

Where In-Line Inspection tools are used in addition to in-ditch, build a robust database for each 40 ft long joint of the pipeline as follows:

In-Ditch Direct Assessment

In-Line Inspection Tools

Pipe joints in batches of original manufacturing

MMT's In-Ditch NDE strength, ductility and toughness for each batch

A complete strength inventory allowing:

- **Prioritize repairs**
- **Reduce being over-conservative**

Benefits of material data

- Tune MAOP (Steel typically 15% above minimum yield)
- Reduce re-test intervals (effect of corrosion)
- Identify critical flaw size for different vintages of pipes
- Extending life
- Quality assurance on new installations

$$K = Y\sigma\sqrt{\pi\, a}$$

Steps forward:

- Beta test services
- Permanent inventory of samples to re-test
- Set of very well characterized samples
- Packaging of the solution and delivering high value