

Changes in Linepipe Specifications to Prevent Girth Weld Failures in Newly Constructed Pipelines

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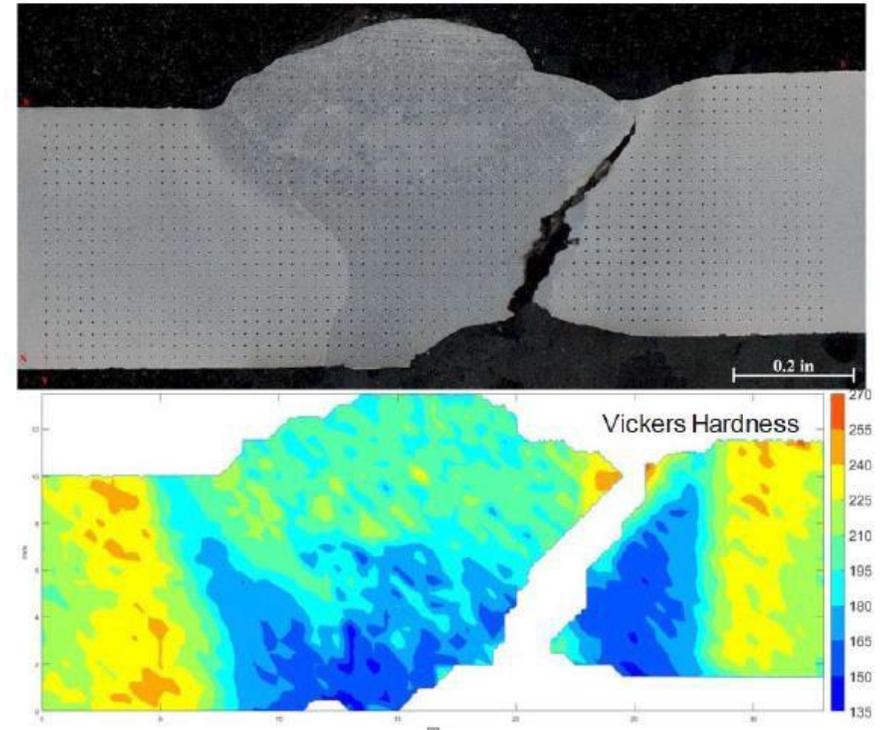
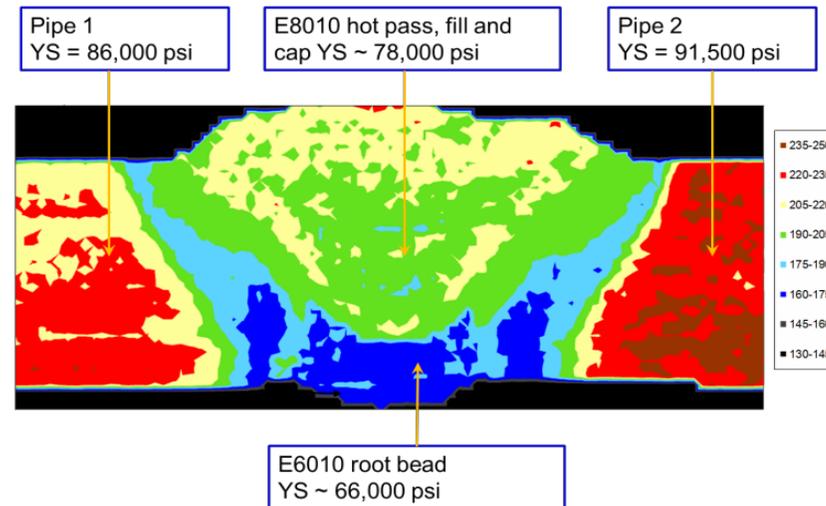
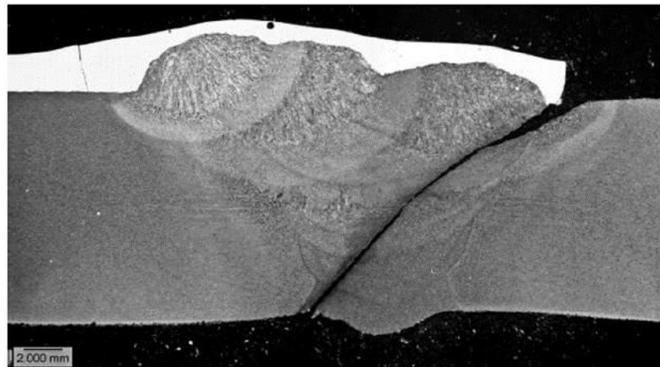
Problem Statement – Girth Weld Failures

- ❑ Girth weld failures
 - ❖ Occurred in-service and during hydrostatic testing
 - ❖ About a dozen known in the US
 - ▶ Ten incidents with confirmed information, shown in the table
 - 6 in-service rupture
 - 1 in-service leak
 - 3 hydrostatic test leak
 - ❖ More incidents are suspected to have occurred, but might not have been reported or known to the outside.
 - ❖ At least a dozen incidents have occurred in Asian countries. (all manual or semi-automatic welds)
- ❑ Characteristics of failures in US
 - ❖ X52 to X80, most X70
 - ❖ Welding - all manual
 - ▶ SMAW: E6010 root, E8010 fill and cap passes
 - ▶ X70/X80: SMAW/E6010 root, FCAW fill and cap passes

Incident No.	OD (inch)	Grade	Nature of Incident	Approximate Elapsed Time for Start of Service
1	20"	X70 PSL2	In-Service Rupture	1 Year
2	30"+	X80/X70	In-Service Rupture	6 years
3	12.75"	X52	In-Service Leak	14 years
4	30"	X70M	Hydrostatic Leak	N/A
5	30"	X70	Hydrostatic Leak	N/A
6	42"	X70 PSL2	In-Service Rupture	3 years
7	12.75"	X52/X65	In-Service Rupture	4-5 years
8	24"	X70	In-Service Rupture	3.5 years
9	36"	X70	Hydrostatic Leak	N/A
10	Information can't be released	X70	In-Service Rupture	Less than 1 year

Major Contributing Factor – Weld/HAZ Strength Undermatching

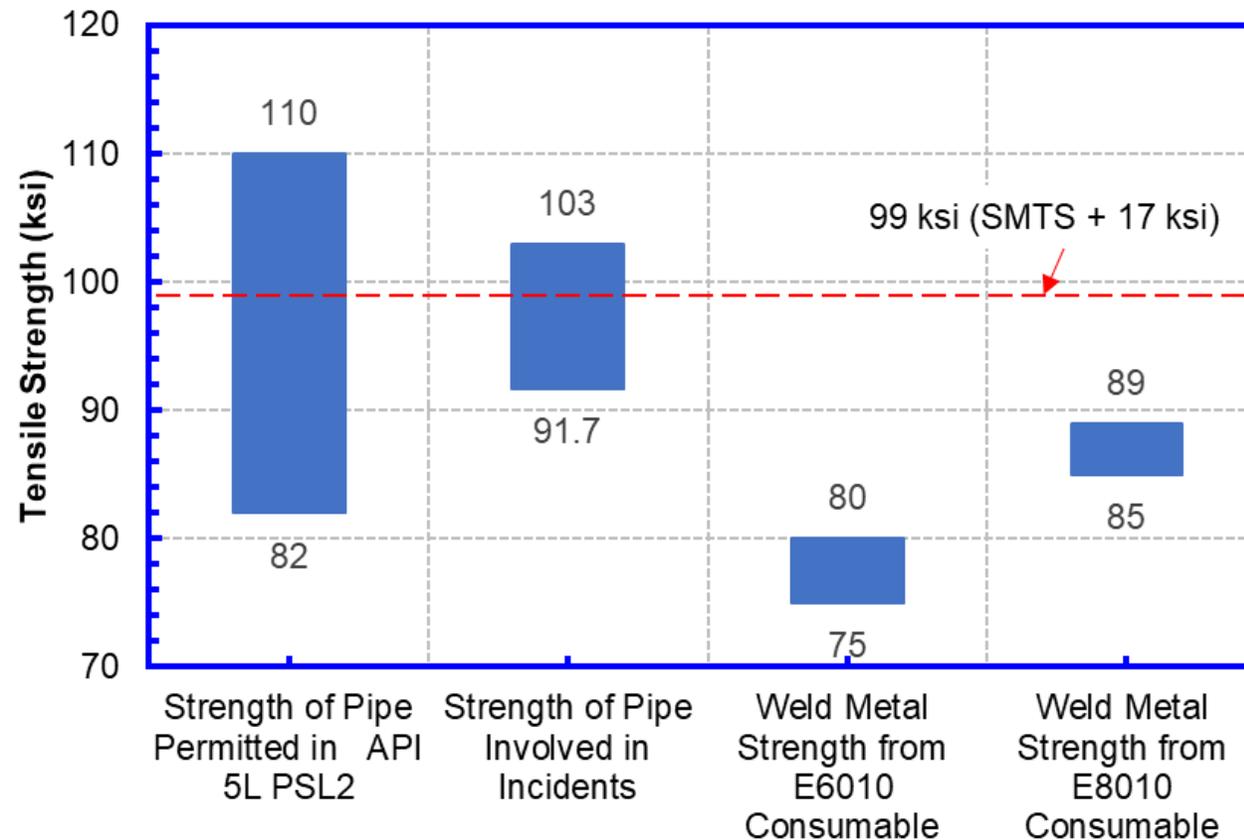
- ❑ Strain concentration in the weld/HAZ leading to rupture
 - ❖ Severe undermatch of weld relative to actual longitudinal pipe strength
 - ❖ Severe softening of HAZ
- ❑ Industry practice & codes have not kept pace with evolution in pipe materials



Weld Strength Undermatching in X70 Girth Welds

❑ Comparison of pipe vs. weld strength

- ❖ The weld strength from the E6010/E8010 consumables undermatches the strength of the X70 pipes.



Impact to Industry

- ❑ Failures in brand new pipelines further enhances the negative opinion surrounding the dangers caused by pipelines. Further impacting the industries abilities to get permitting for future expansion projects or even key replacement efforts.
- ❑ Each incident of in-service failure can have extensive economic impacts.
- ❑ These failures occur despite full compliance with the requirements in existing codes and standards.

Supplemental Linepipe Specifications

- ❑ Specify maximum longitudinal pipe strength limits

- ❖ SMYS + 17 ksi

- ❖ SMTS + 17 ksi

(Goal: control pipe longitudinal tensile properties to facilitate girth weld overmatching)

- ❑ Enhance HAZ hardenability

- ❖ For example, through minimum composition limits on pipe chemistry

- ▶ $P_{cm} \geq 0.140$

- ▶ $C \geq 0.040$

(Goal: control / limit HAZ softening)

Simultaneous Changes to Girth Welding Practice

- ❑ Eliminate E6010/E8010 cellulosic for X70 and X65 pipelines
- ❑ Use low hydrogen processes with increased weld metal strength
(Goal: use welding procedures to produce girth weld overmatching)

Long-Term Changes and Work to Support Them

- ❑ Work to support further refinement
 - ❖ New tensile test protocol
 - ▶ Less variation in yield strength determination
 - ▶ More representative yield strength
 - ▶ Allow for meaningful use of Y/T ratio as a proxy for strain hardening capacity
 - ❖ Performance-based test protocol to assess the propensity of HAZ softening
 - ▶ Allow reasonable freedom in chemical composition and steel making process as long as HAZ softening is within an acceptable limit.
- ❑ Expected changes in linepipe specifications
 - ❖ Tighter range of tensile properties for a given grade, both hoop and longitudinal, than that in API 5L PSL2
 - ❖ Lower limit of Y/T ratio than the upper limits permitted in API 5L
 - ❖ Criterion for the acceptance of HAZ softening