

Doc number: FARE-190723-1 Part I Appendix 2

Report

Measurement of Yield strength, Tensile strength and Fracture toughness of API 5L pipe using Instrumented Indentation Testing

(Measured results of additional sample #043A)

Prepared by



July, 2019

Prepared for

GTI

< Appendix 2 >

Measured results of Additional sample (#043A)

Results

Figure below shows locations of the test from AIS 2100. The appendix shows all the detail measured results of #043A pipe.

(1) Analysis results of all locations (Average data)

Pipe #	Location	Yield strength	Tensile strength	Fracture toughness
		ksi	ksi	MPa·m ^{1/2}
#043A	Base 1	54.01	71.26	250.51
	HAZ 1	54.91	69.78	258.16
	Weld	68.33	87.42	303.14
	HAZ 2	54.72	69.72	245.95
	Base 2	50.87	68.26	254.67
	Base 3 (90°)	51.69	65.30	279.26
	Base Avg.	52.19	68.27	261.48

(2) Detail testing results (Base metal)

Pipe #	Location	No.	Yield strength	Tensile strength	Fracture toughness
			ksi	ksi	MPa·m ^{1/2}
#003	Base 1	1	53.12	71.23	229.45
		2	55.12	71.32	285.21
		3	53.80	71.22	236.87
		Avg.	54.01	71.26	250.51
	Base 2	1	51.46	68.86	224.08
		2	50.54	67.29	293.00
		3	50.60	68.62	246.93
		Avg.	50.87	68.26	254.67
	Base 3 (90°)	1	52.28	65.65	273.97
		2	50.50	65.41	254.15
		3	52.28	64.84	309.67
		Avg.	51.69	65.30	279.26
	Total	Total avg.	52.19	68.27	261.48
		Std.	1.61	2.62	30.27

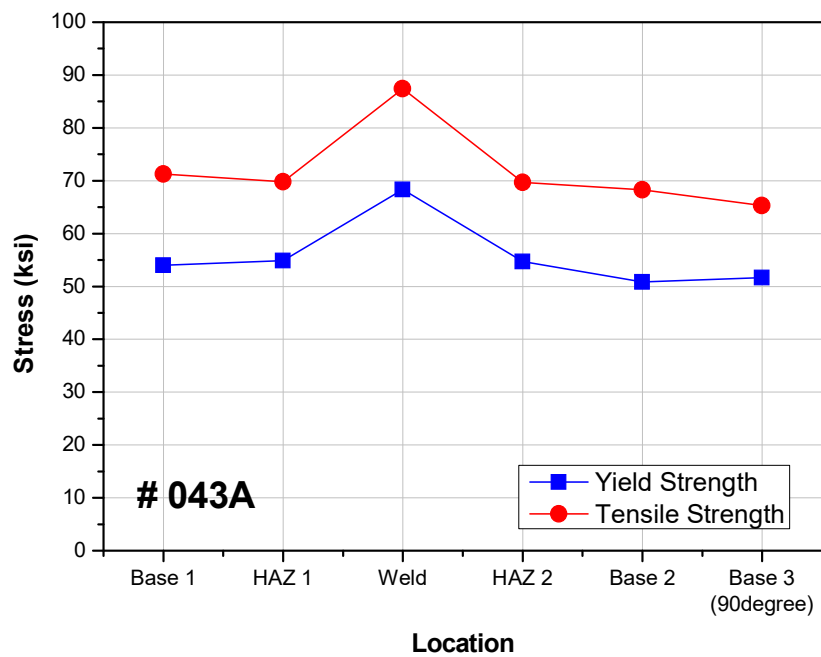
(3) Analysis results of seam weld pipe

Pipe # : # 043A

< Average results >

Location	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
Base 1	54.01	71.26	250.51
HAZ 1	54.91	69.78	258.16
Weld	68.33	87.42	303.14
HAZ 2	54.72	69.72	245.95
Base 2	50.87	68.26	254.67
Base 3 (90°)	51.69	65.30	279.26

< Comparison graph – Yield and Tensile Strength >



< Detail results >

Pipe #	Location	Location	Yield strength	Tensile strength	Fracture toughness
			ksi	ksi	MPa·m ^{1/2}
# 043A	Base 1	1	53.12	71.23	229.45
		2	55.12	71.32	285.21
		3	53.80	71.22	236.87
	HAZ 1	1	57.45	69.59	286.07
		2	53.48	70.58	234.60
		3	53.78	69.18	253.82
	Weld	1	66.51	85.40	297.30
		2	68.77	86.26	325.60
		3	69.72	90.59	286.51
	HAZ 2	1	56.06	70.59	244.09
		2	53.77	71.03	219.62
		3	54.32	67.53	274.14
	Base 2	1	51.46	68.86	224.08
		2	50.54	67.29	293.00
		3	50.60	68.62	246.93
	Base 3 (90°)	1	52.28	65.65	273.97
		2	50.50	65.41	254.15
		3	52.28	64.84	309.67

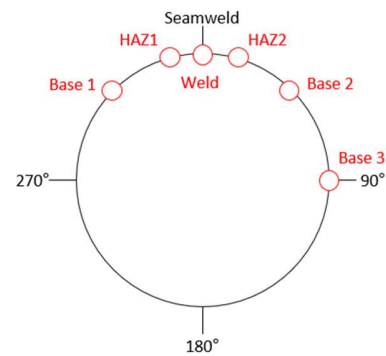
Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

Test Information

Customer	GTI	Pipe #	043A
Location	GTI office (Des Plaines, IL)	Pipe size (in)	20
Test date	7/23/2019	Testing location #	6
Operator	Dongseong Ro	Max. testing depth	150 μ m
Equipment	AIS2100	Indenter #	K05343

Sample



Results

Test location	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
Base 1	54.01	71.26	250.51
HAZ 1	54.91	69.78	258.16
Weld	68.33	87.42	303.14
HAZ 2	54.72	69.72	245.95
Base 2	50.87	68.26	254.67
Base 3	51.69	65.30	279.26

* Analysis result is engineering value

Detail Results

Test location	No.	Yield strength	Tensile strength	Fracture toughness
		ksi	ksi	MPa·m ^{1/2}
Base 1	1	53.12	71.23	229.45
	2	55.12	71.32	285.21
	3	53.80	71.22	236.87
HAZ 1	1	57.45	69.59	286.07
	2	53.48	70.58	234.60
	3	53.78	69.18	253.82
Weld	1	66.51	85.40	297.30
	2	68.77	86.26	325.60
	3	69.72	90.59	286.51
HAZ 2	1	56.06	70.59	244.09
	2	53.77	71.03	219.62
	3	54.32	67.53	274.14
Base 2	1	51.46	68.86	224.08
	2	50.54	67.29	293.00
	3	50.60	68.62	246.93
Base 3	1	52.28	65.65	273.97
	2	50.50	65.41	254.15
	3	52.28	64.84	309.67

* Analysis result is engineering value

Remark

This pipe is additional sample.