

Doc number: FARE-190603-1 Part II

Report

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

PART II

Annex A. Test Results of Each Location

Annex B. Reference Paper

Prepared by



June, 2019

Prepared for

GTI

<Annex A> Test Results of Each Location

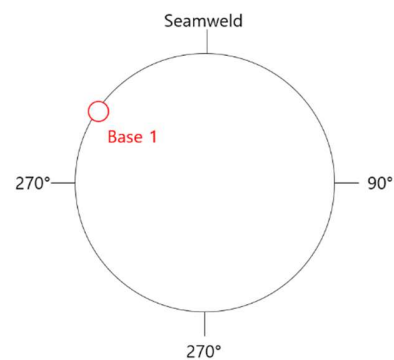
All the detail measured results

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1

**2. Condition**

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.10	80.02	297.46
2	57.25	80.67	294.22
3	57.46	80.24	292.09
Avg.	57.60	80.31	294.59

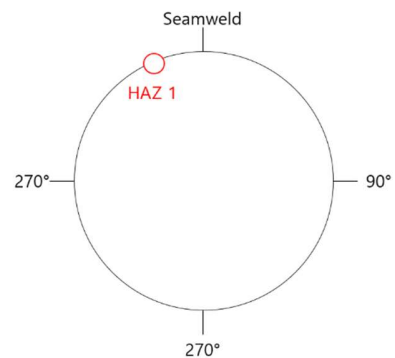
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.89	83.24	331.31
2	62.67	83.26	337.76
3	59.82	84.20	293.21
Avg.	61.46	83.56	320.76

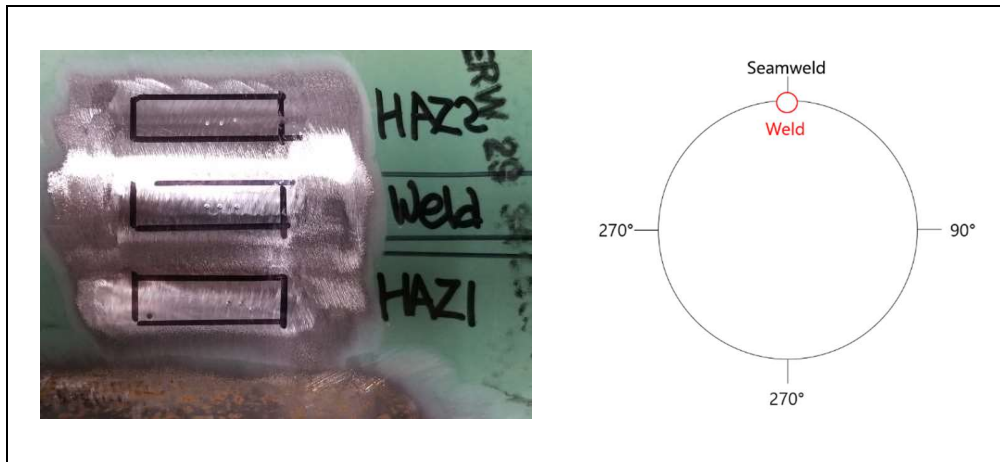
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.33	82.02	279.08
2	58.33	80.90	281.32
3	58.32	80.72	273.64
Avg.	58.00	81.21	278.01

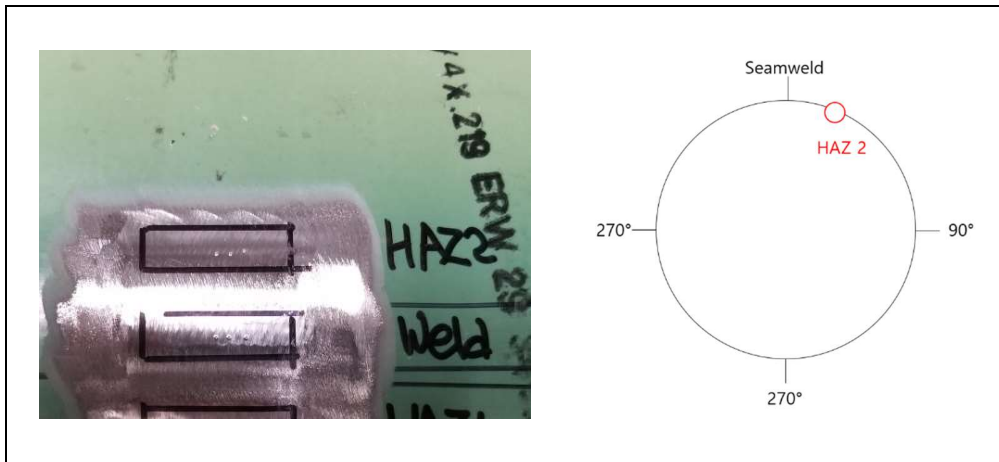
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.72	84.74	301.48
2	61.72	86.24	277.61
3	62.77	85.53	295.02
Avg.	62.40	85.50	291.37

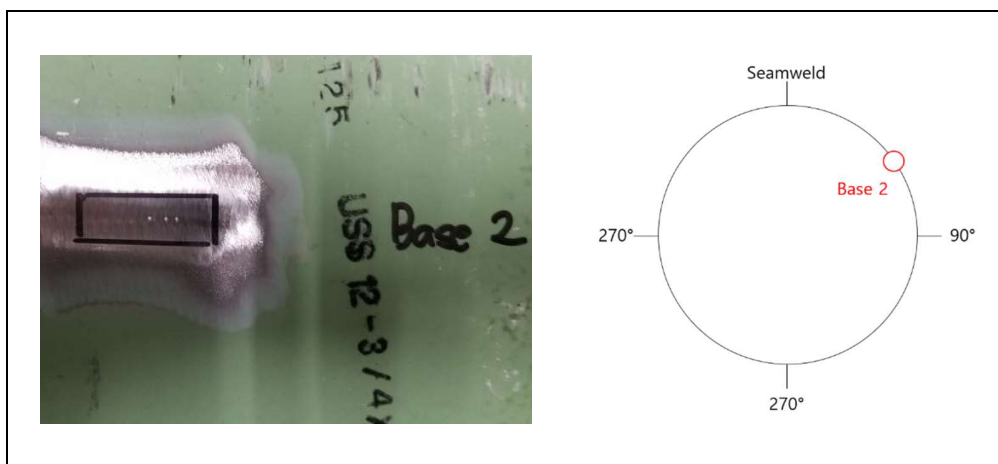
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.84	77.80	311.40
2	57.47	77.76	283.48
3	59.08	80.84	265.15
Avg.	58.46	78.80	286.68

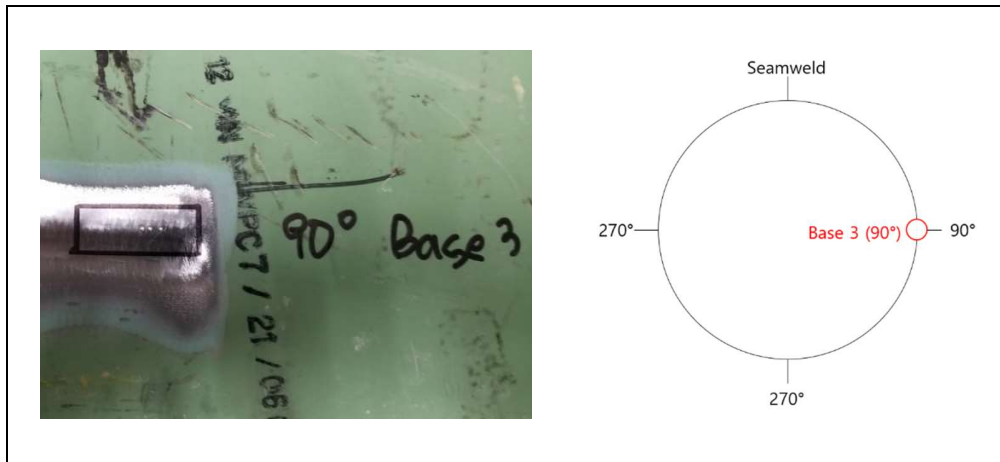
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 003
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.43	77.53	290.80
2	60.06	79.21	329.87
3	60.94	81.58	292.45
Avg.	59.14	79.44	304.37

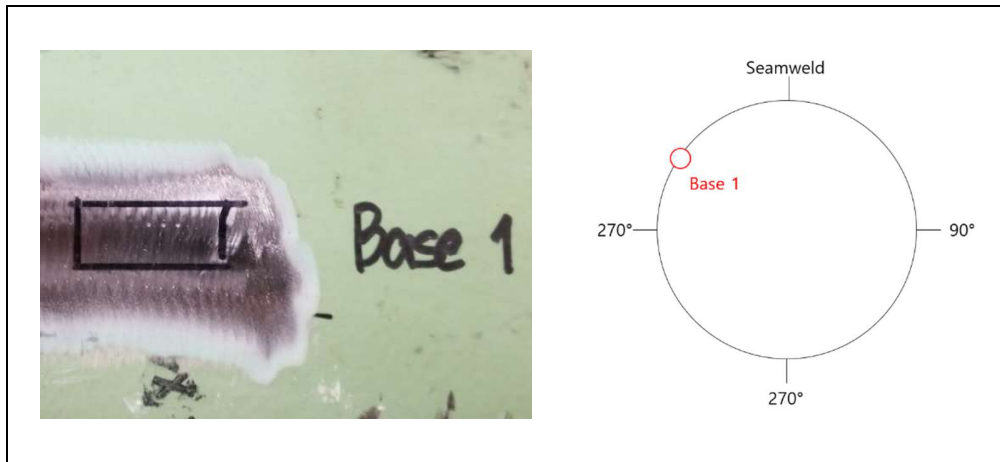
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.70	77.27	256.24
2	56.19	79.92	264.49
3	61.59	82.50	295.67
Avg.	58.16	79.90	272.13

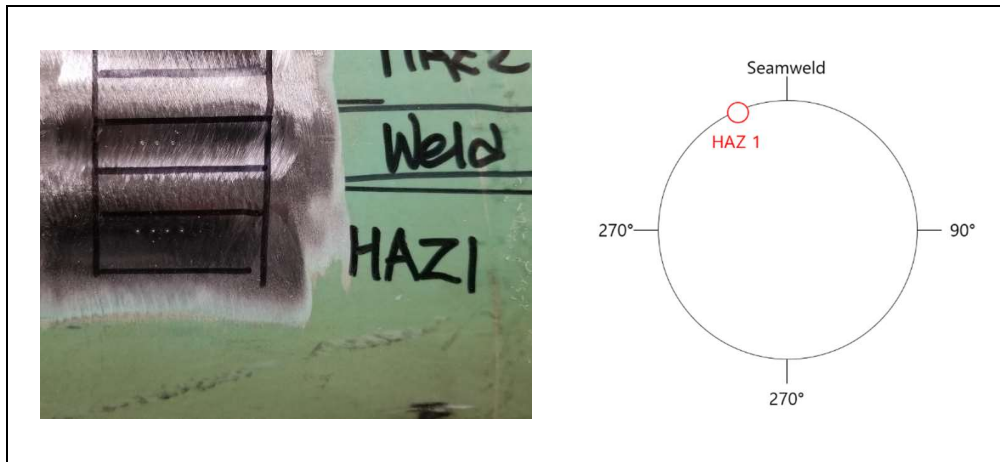
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.32	87.14	306.63
2	63.77	87.21	308.85
3	64.15	87.21	317.16
Avg.	63.74	87.18	310.88

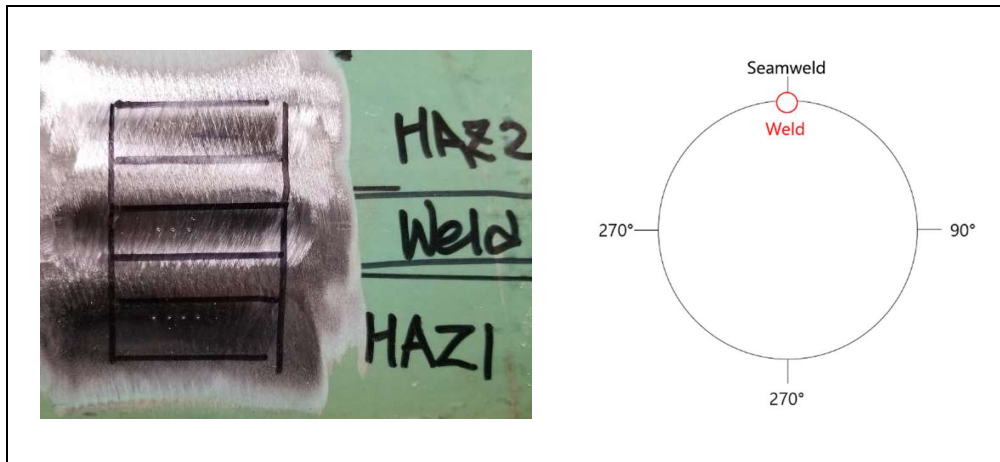
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Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.22	85.75	331.14
2	61.58	86.81	283.60
3	63.08	85.67	325.91
Avg.	62.63	86.08	313.55

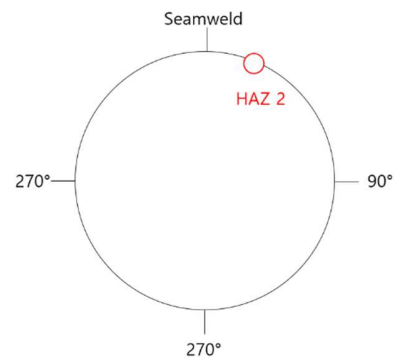
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	66.38	89.51	311.97
2	62.55	87.49	300.50
3	65.28	87.56	329.48
Avg.	64.74	88.18	313.98

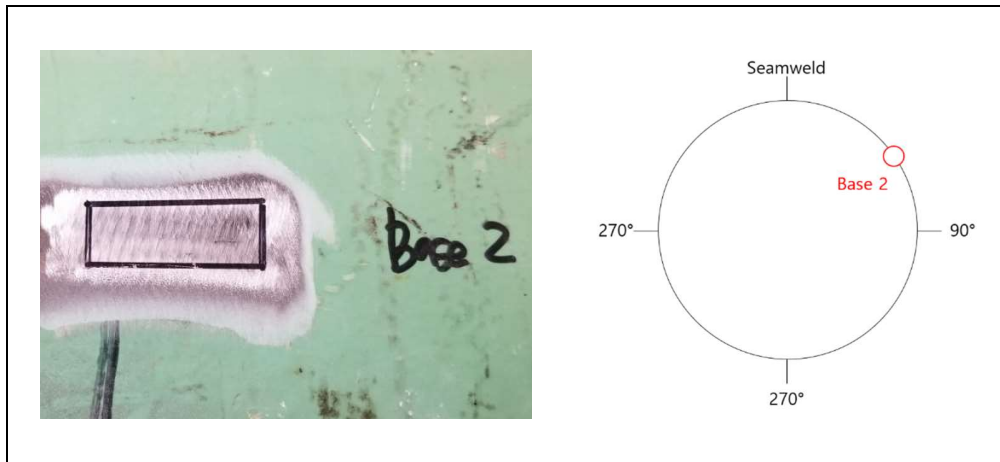
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.43	82.72	343.22
2	60.45	81.29	320.04
3	57.48	80.59	298.38
Avg.	60.45	81.53	320.54

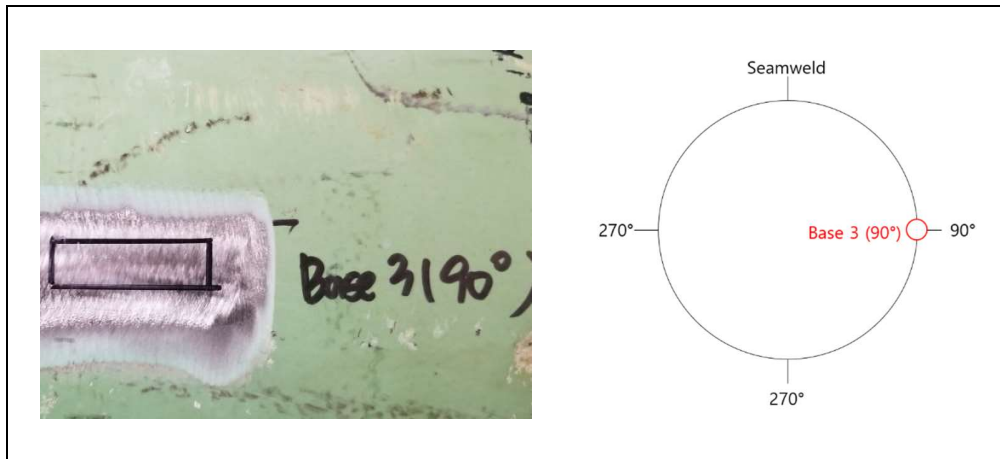
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 004
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.40	78.98	338.16
2	58.07	79.21	305.48
3	59.13	79.41	332.58
Avg.	58.87	79.20	325.41

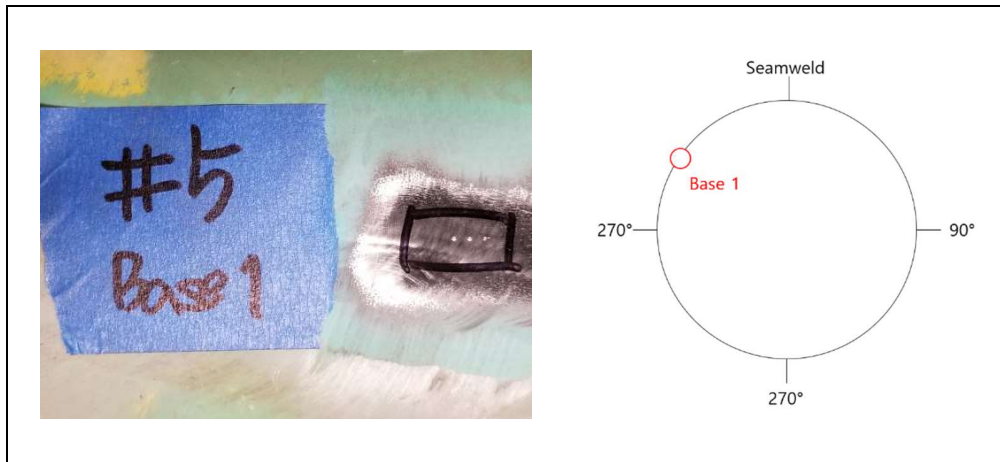
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 005
- (3) Pipe OD (inch) : 24
- (4) Location : Base 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.89	71.99	303.62
2	58.15	75.19	297.90
3	53.89	71.34	272.17
Avg.	55.98	72.84	291.23

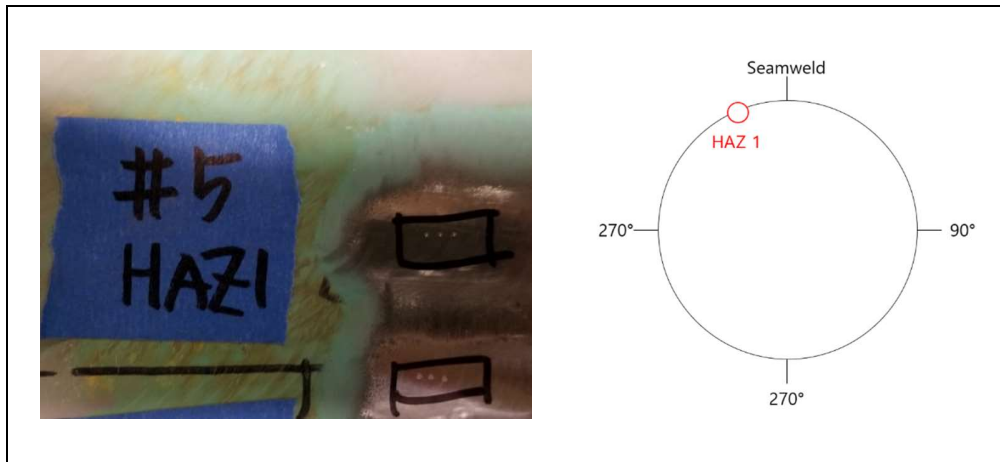
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 005
- (3) Pipe OD (inch) : 24
- (4) Location : HAZ 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.48	75.59	256.20
2	56.27	76.73	257.81
3	57.73	76.11	270.98
Avg.	56.49	76.14	261.66

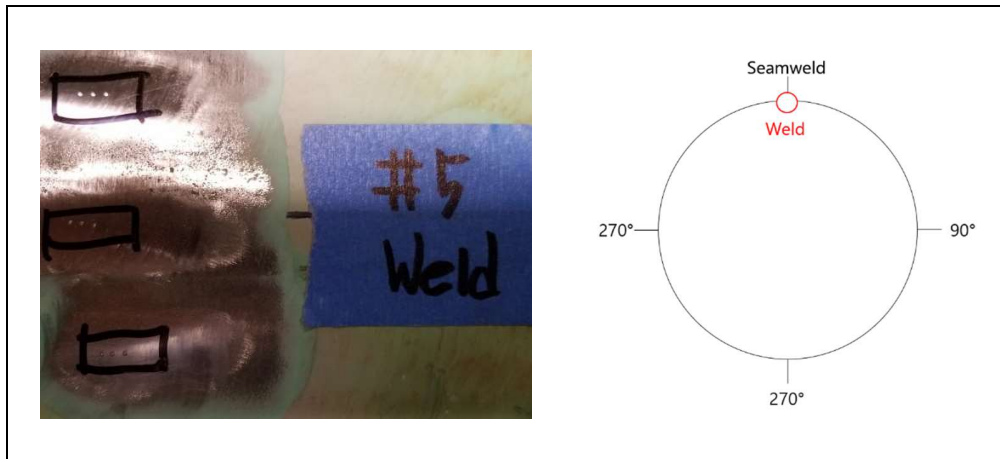
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 005
- (3) Pipe OD (inch) : 24
- (4) Location : Weld



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.42	79.06	245.33
2	57.22	78.41	262.95
3	56.22	77.45	249.87
Avg.	56.62	78.31	252.72

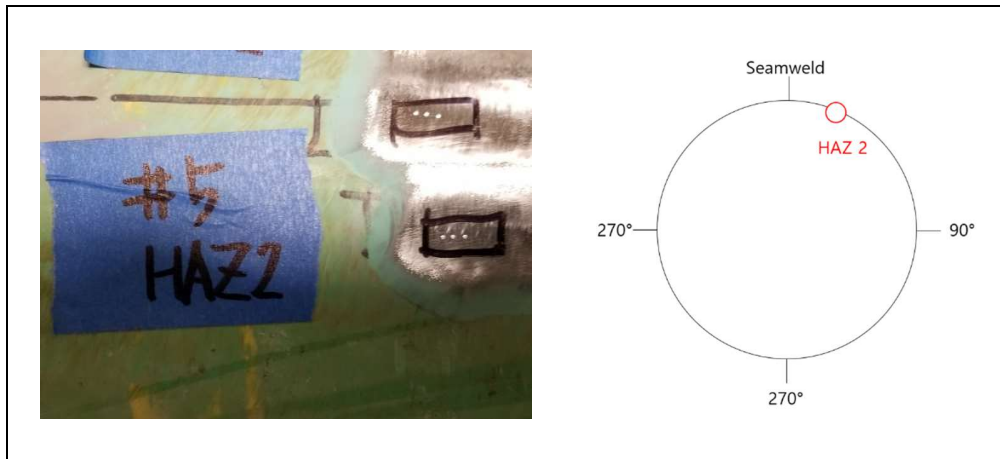
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Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 005
- (3) Pipe OD (inch) : 24
- (4) Location : HAZ 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.69	75.29	342.89
2	57.22	76.18	279.64
3	62.49	78.94	475.68
Avg.	59.80	76.80	366.07

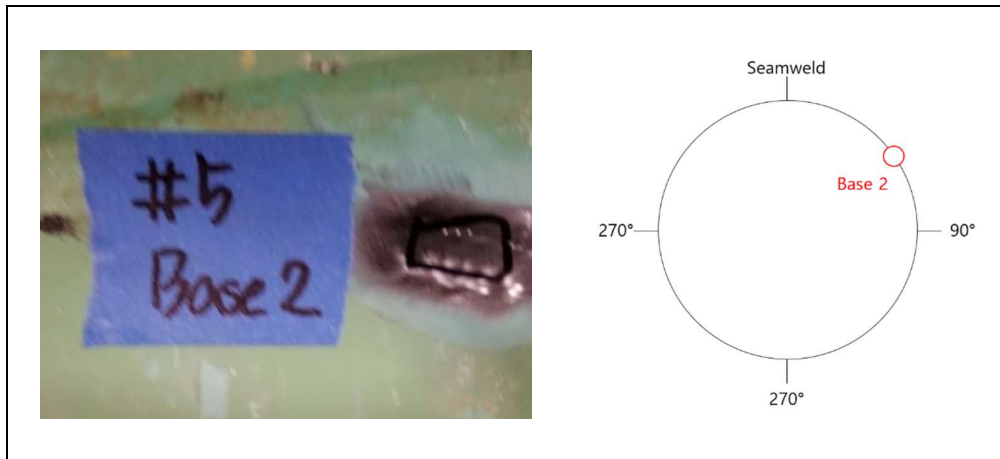
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Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 005
- (3) Pipe OD (inch) : 24
- (4) Location : Base 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.89	71.22	242.94
2	51.02	69.44	256.59
3	51.92	68.89	258.24
Avg.	51.61	69.85	252.59

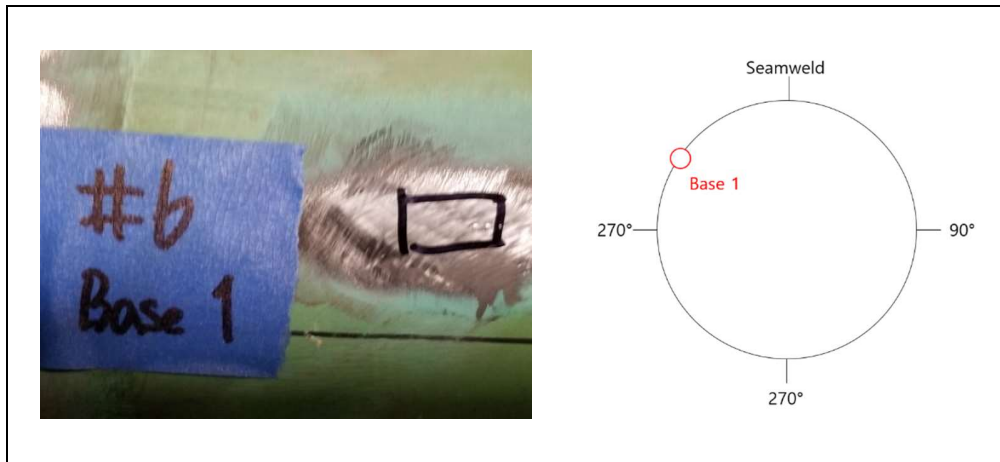
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : Base 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.44	67.33	194.09
2	49.54	66.52	197.54
3	50.62	65.21	205.74
Avg.	50.20	66.35	199.12

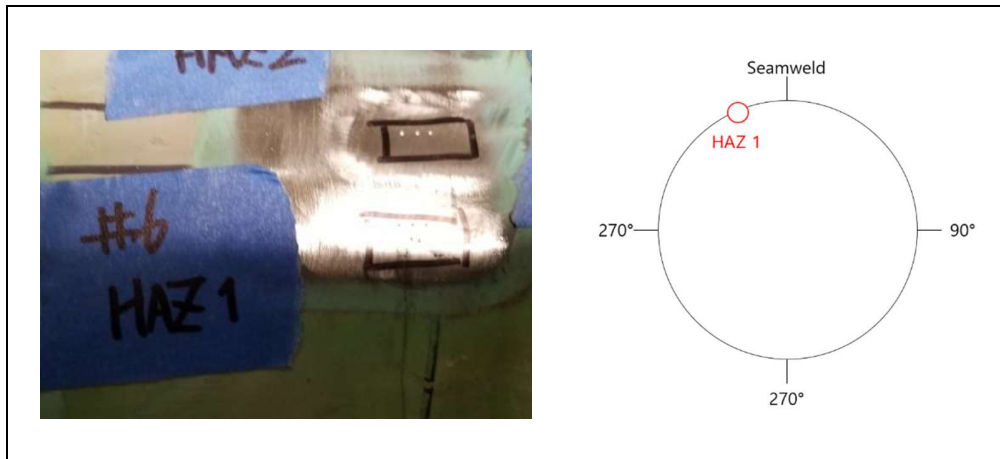
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : HAZ 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.36	73.71	202.47
2	56.33	73.82	236.90
3	57.09	73.44	247.26
Avg.	55.60	73.66	228.87

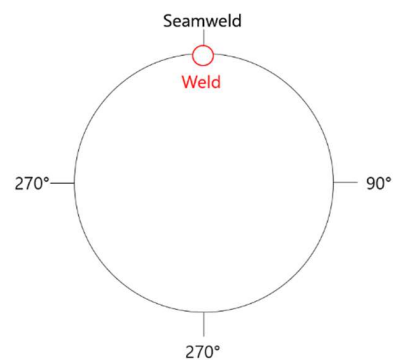
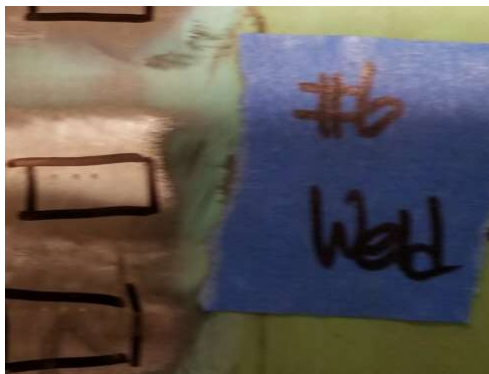
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : Weld



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.80	75.54	264.75
2	58.58	78.09	249.38
3	57.54	77.19	262.88
Avg.	57.97	76.94	259.00

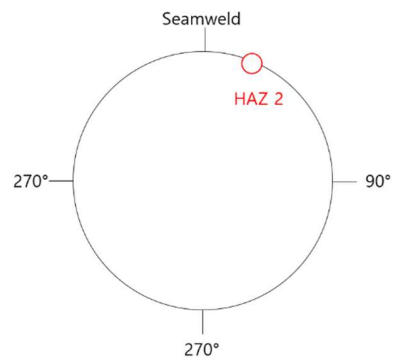
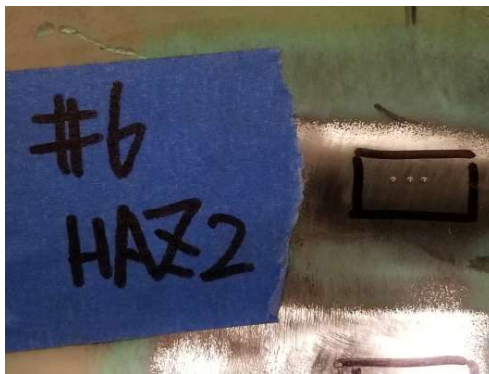
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : HAZ 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.25	75.17	270.48
2	56.72	76.04	274.36
3	56.76	76.76	268.47
Avg.	56.57	75.99	271.10

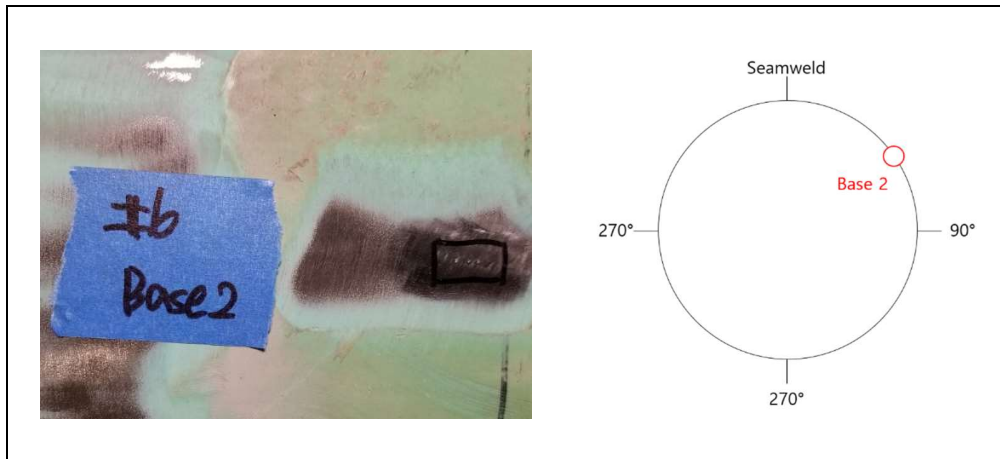
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : Base 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.53	71.59	252.68
2	53.37	72.99	240.98
3	54.00	73.41	241.34
Avg.	53.30	72.66	245.00

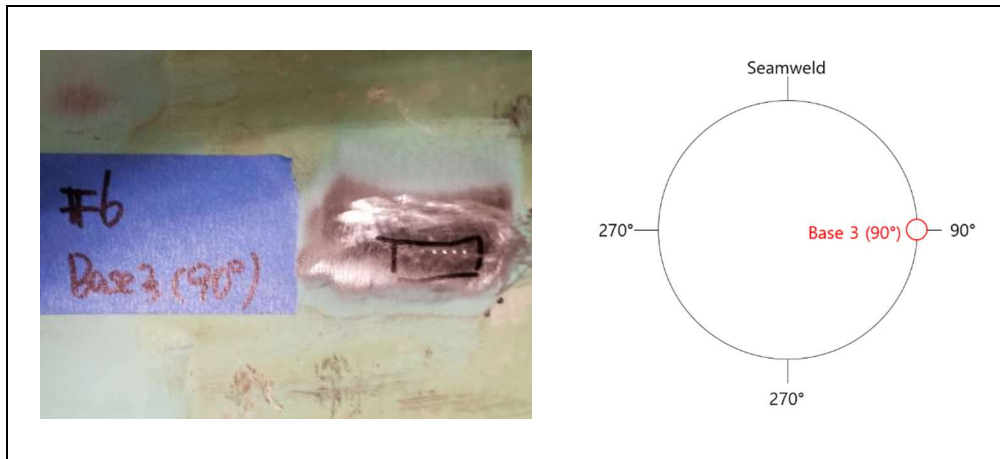
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 006
- (3) Pipe OD (inch) : 24
- (4) Location : Base 3 (90°)



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.59	70.94	243.42
2	52.53	70.23	265.63
3	51.94	72.61	216.72
Avg.	52.35	71.26	241.92

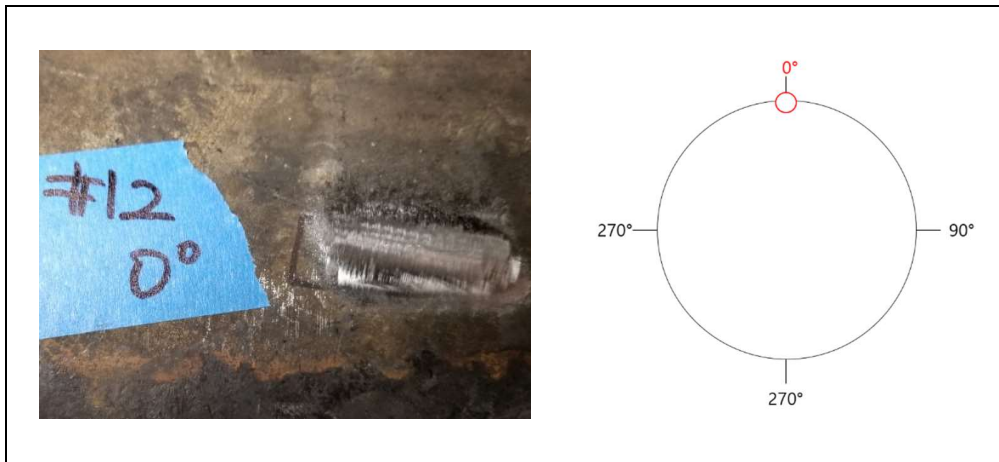
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 012
- (3) Pipe OD (inch) : 12
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.75	66.83	309.48
2	50.23	68.14	297.95
3	51.63	70.51	268.39
Avg.	50.53	68.49	291.94

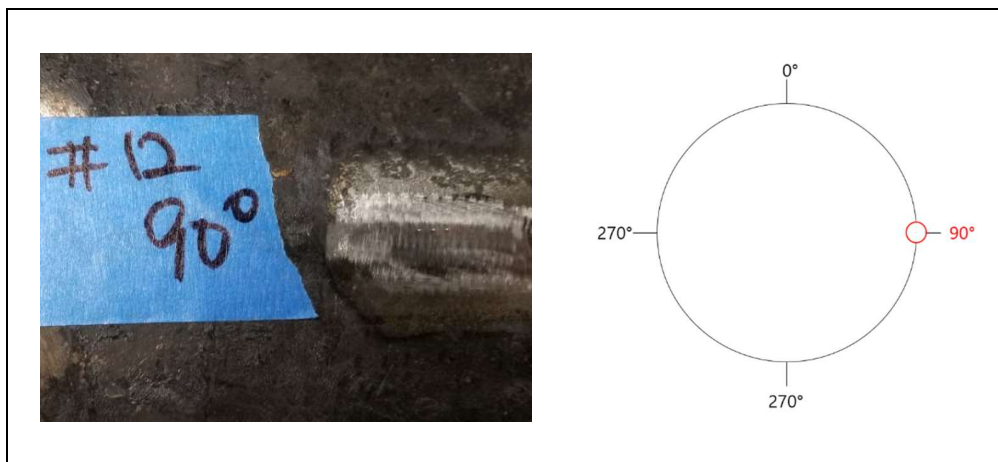
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 012
- (3) Pipe OD (inch) : 12
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.46	71.85	301.86
2	50.46	70.11	282.62
3	50.07	68.60	339.05
Avg.	50.99	70.18	307.84

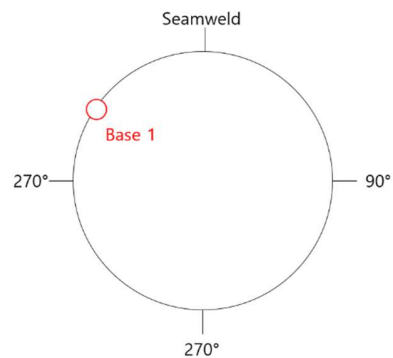
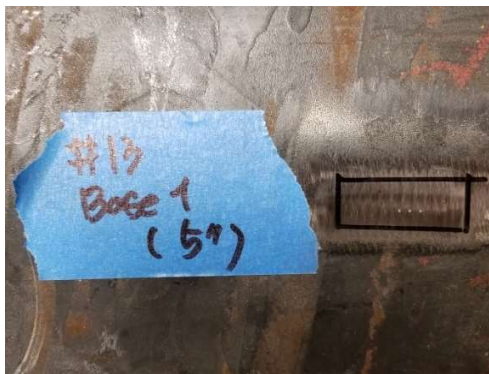
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : Base 1



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.25	71.77	294.79
2	51.35	71.90	262.59
3	52.77	71.65	274.58
Avg.	52.46	71.77	277.32

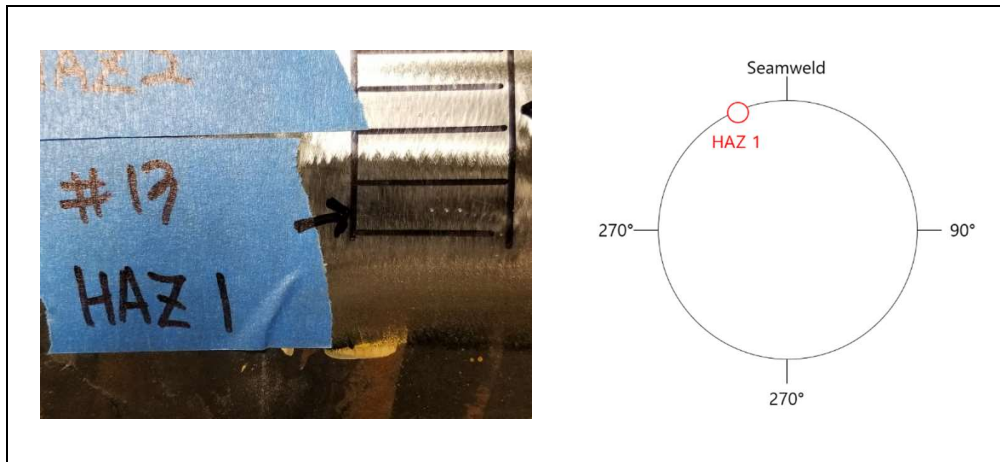
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : HAZ 1



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.83	81.04	301.66
2	58.05	80.40	291.92
3	58.53	80.37	289.19
Avg.	58.81	80.60	294.26

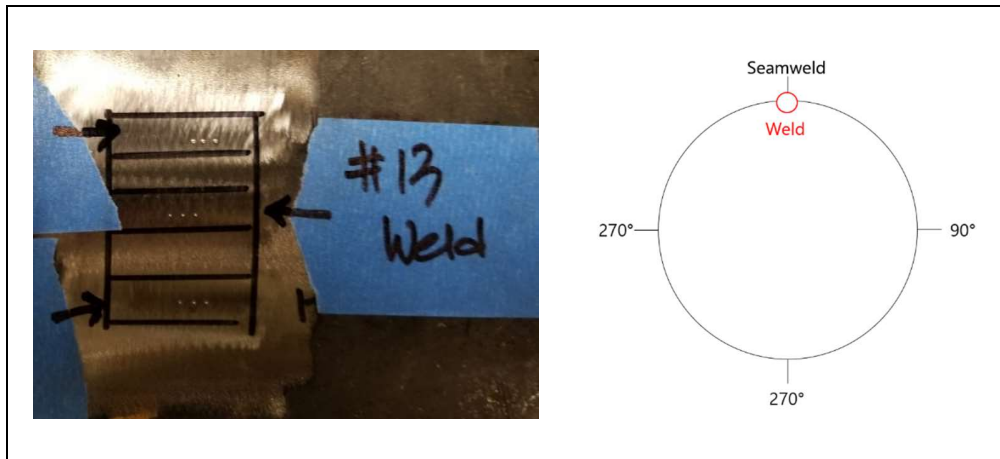
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : Weld



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	69.62	93.55	340.05
2	70.41	92.92	376.12
3	68.82	91.53	367.81
Avg.	69.62	92.67	361.33

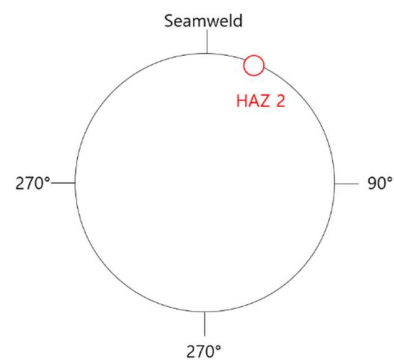
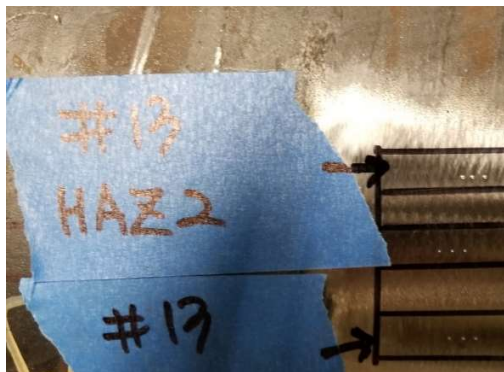
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : HAZ 2



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.23	84.65	303.91
2	63.42	85.80	316.85
3	64.13	87.31	310.12
Avg.	63.26	85.92	310.29

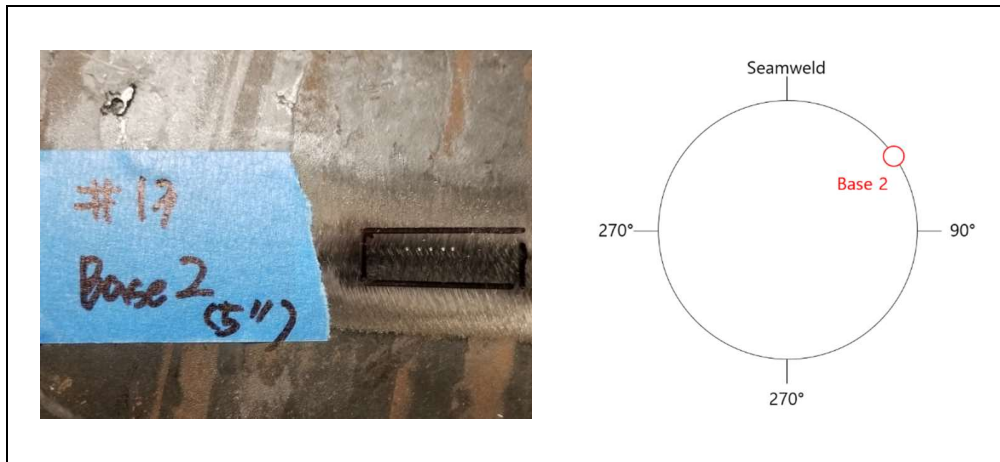
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : Base 2



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.02	73.11	234.67
2	54.68	73.62	248.56
3	55.40	72.70	279.24
Avg.	54.37	73.14	254.16

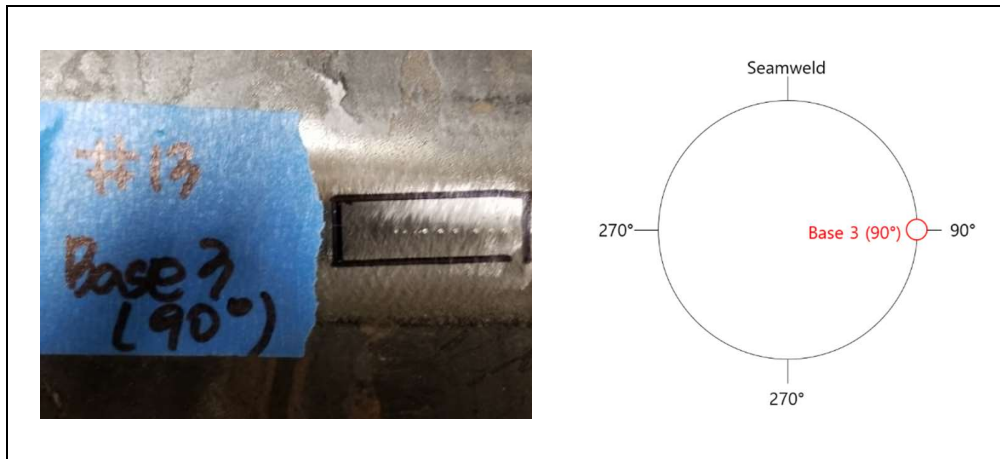
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 013
- (3) Pipe OD (inch) : 16
- (4) Location : Base 3 (90°)



2. Condition

Date	4/1/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.36	71.51	234.55
2	50.44	72.17	237.07
3	52.75	72.44	245.73
Avg.	51.52	72.04	239.11

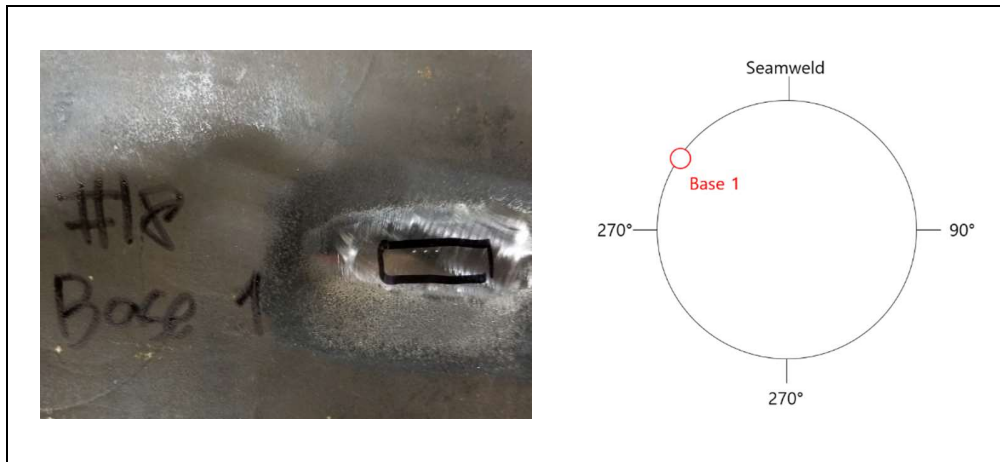
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : Base 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.11	79.12	367.38
2	56.98	77.23	329.24
3	58.09	78.53	375.25
Avg.	58.06	78.29	357.29

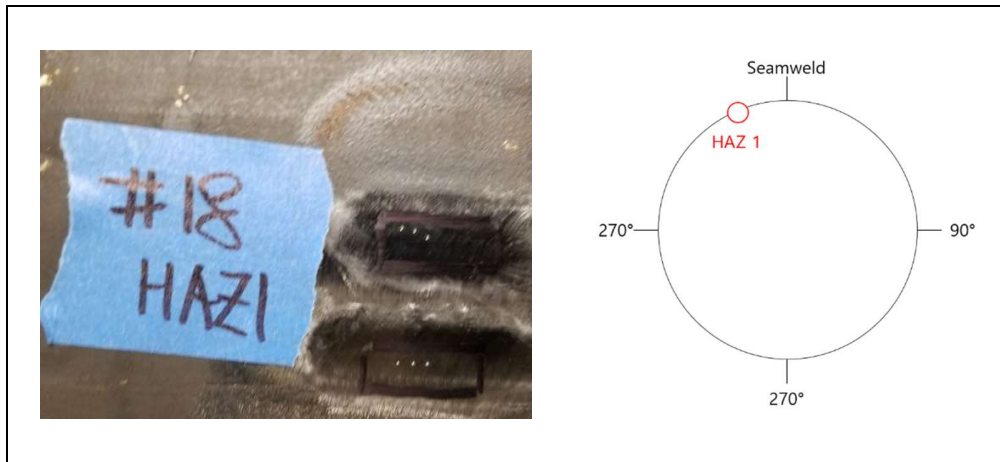
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.88	86.53	376.41
2	63.46	86.17	354.41
3	64.47	86.82	359.55
Avg.	64.27	86.51	363.46

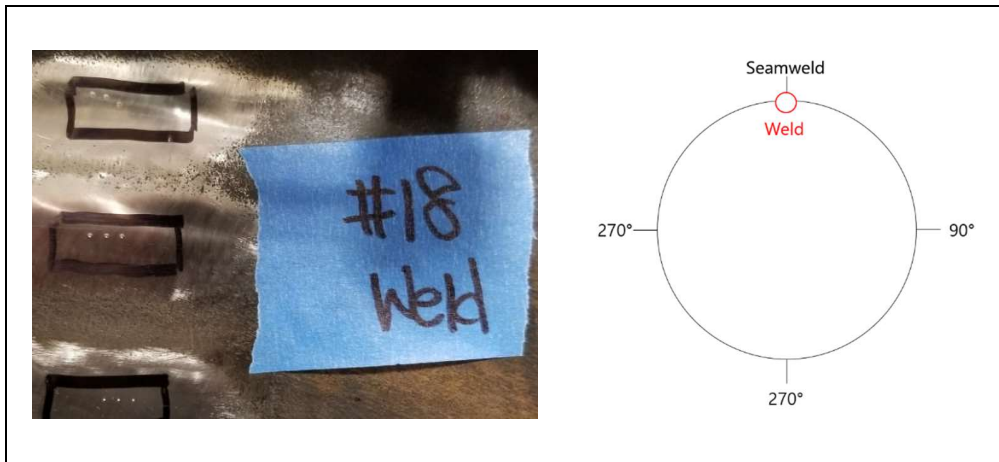
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : Weld



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	72.09	94.43	448.54
2	70.94	94.16	404.73
3	70.14	93.62	384.58
Avg.	71.06	94.07	412.62

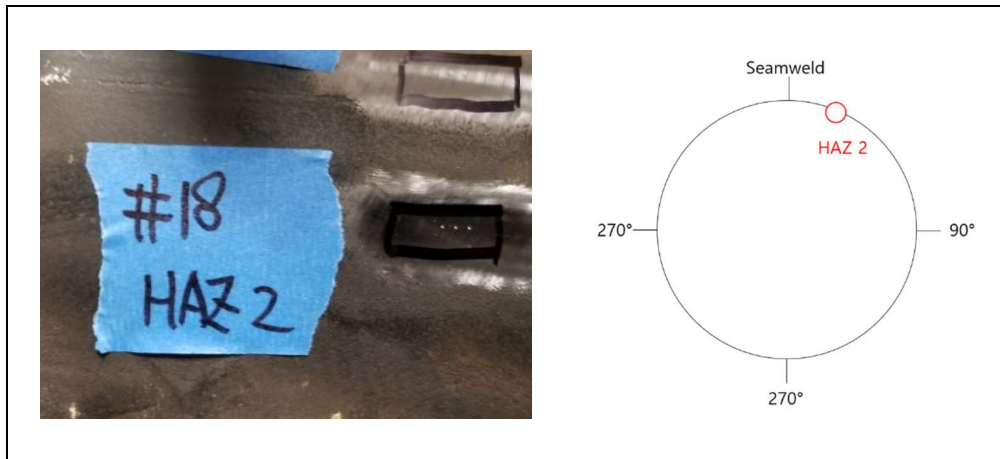
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 2



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.14	86.46	312.19
2	65.58	86.46	391.03
3	64.27	86.50	372.63
Avg.	64.00	86.47	358.61

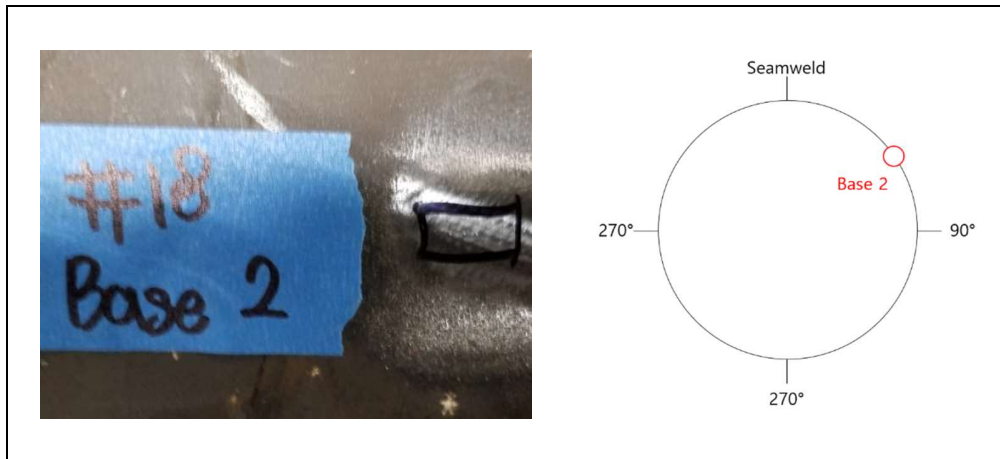
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : Base 2



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.25	79.98	360.88
2	61.45	82.05	343.03
3	60.39	81.75	305.14
Avg.	60.36	81.26	336.35

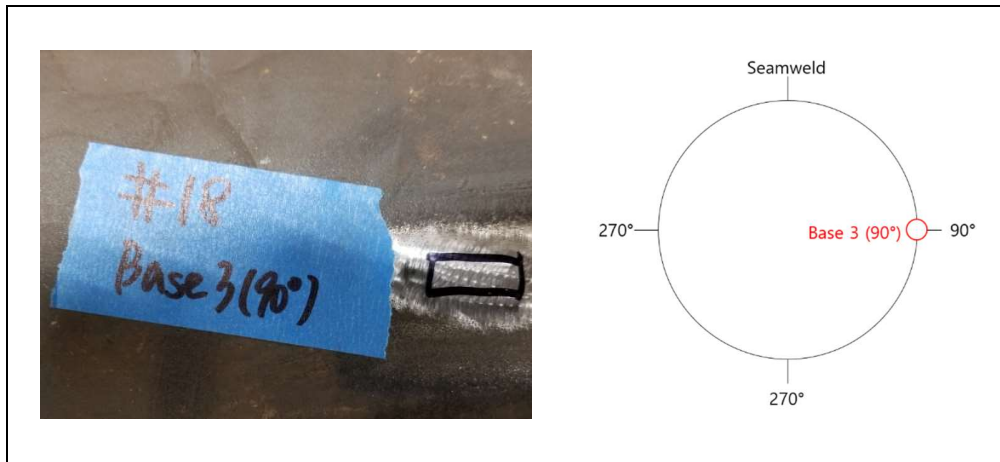
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 018
- (3) Pipe OD (inch) : 20
- (4) Location : Base 3 (90°)



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.18	76.24	324.83
2	58.53	78.92	324.54
3	58.48	78.16	379.75
Avg.	57.73	77.77	343.04

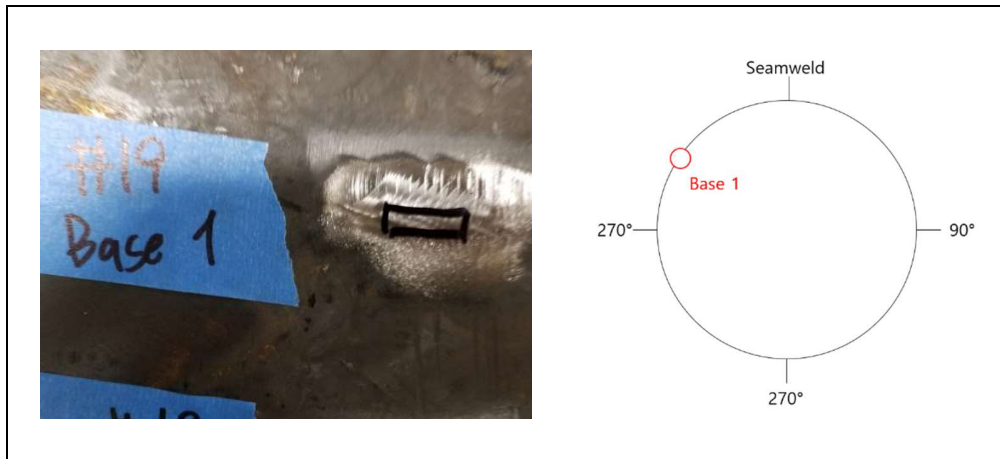
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : Base 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.48	65.88	247.45
2	48.51	64.58	275.58
3	49.66	65.41	285.20
Avg.	48.89	65.29	269.41

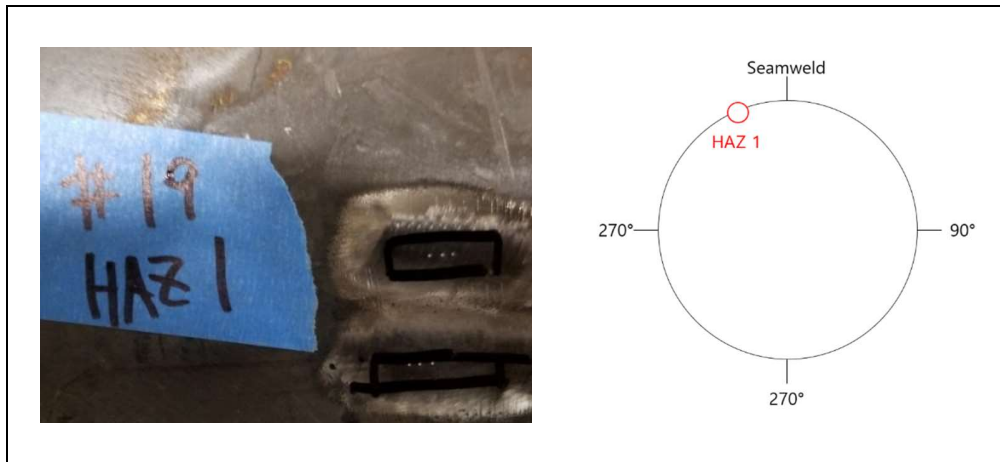
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.89	73.39	294.70
2	57.05	74.16	349.43
3	57.22	74.66	346.62
Avg.	56.38	74.07	330.25

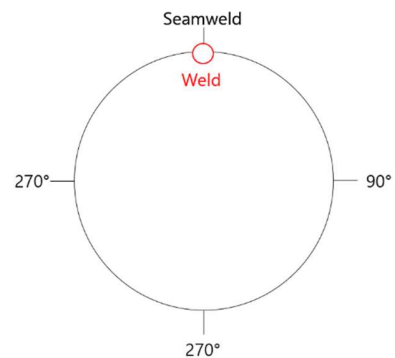
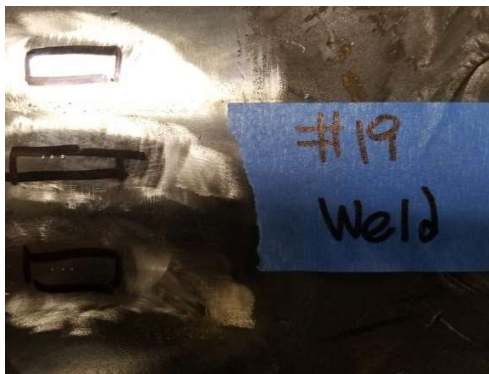
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : Weld



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.96	83.44	310.65
2	62.40	81.94	353.45
3	59.88	82.40	339.82
Avg.	61.75	82.59	334.64

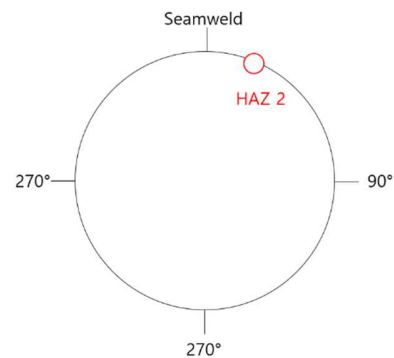
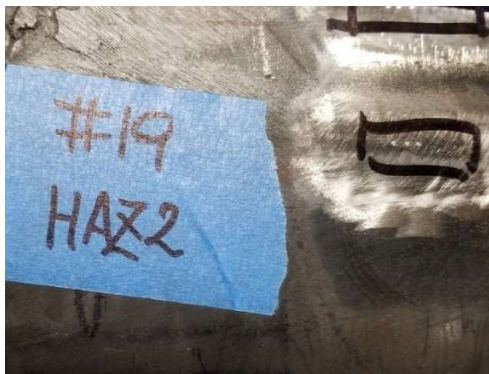
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 2



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.57	72.07	297.85
2	52.06	71.48	271.22
3	54.45	72.26	294.70
Avg.	53.69	71.94	287.92

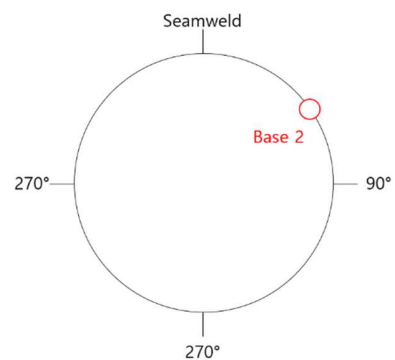
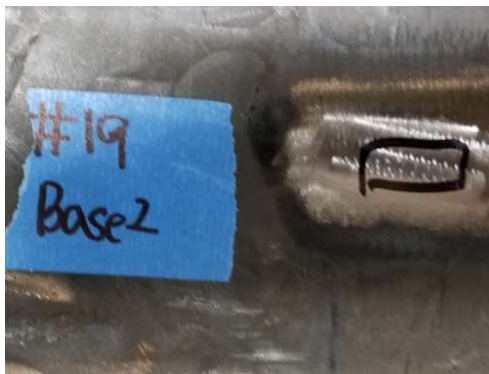
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : Base 2

**2. Condition**

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	47.99	65.76	245.18
2	51.01	66.94	296.99
3	46.36	66.07	240.38
Avg.	48.46	66.25	260.85

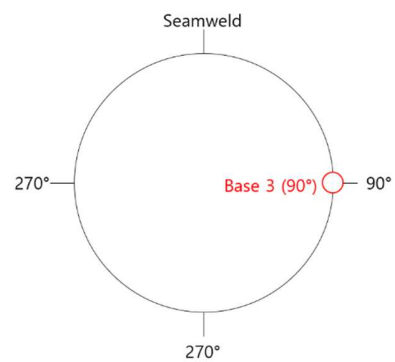
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 019
- (3) Pipe OD (inch) : 20
- (4) Location : Base 3 (90°)



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.13	66.47	225.14
2	49.36	66.28	278.63
3	48.55	67.78	214.93
Avg.	48.68	66.85	239.56

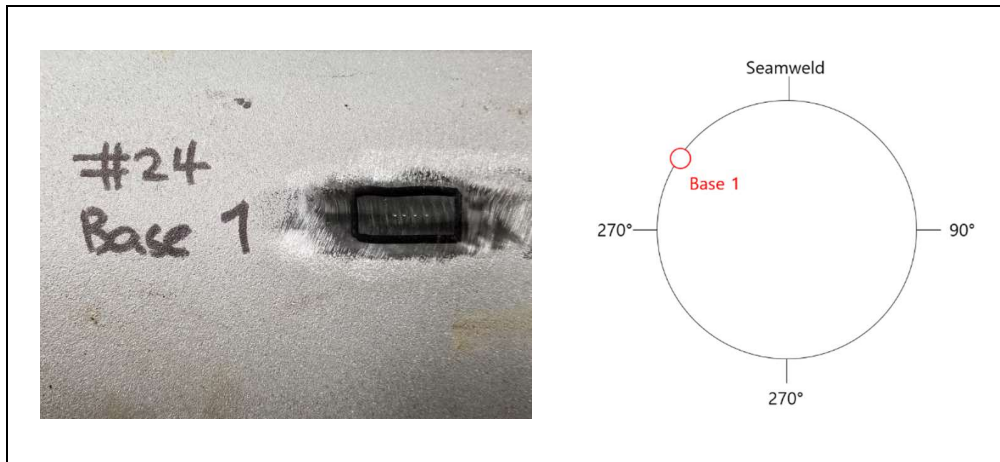
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.82	65.42	294.87
2	50.85	66.84	303.54
3	49.85	66.80	296.97
Avg.	50.17	66.35	298.46

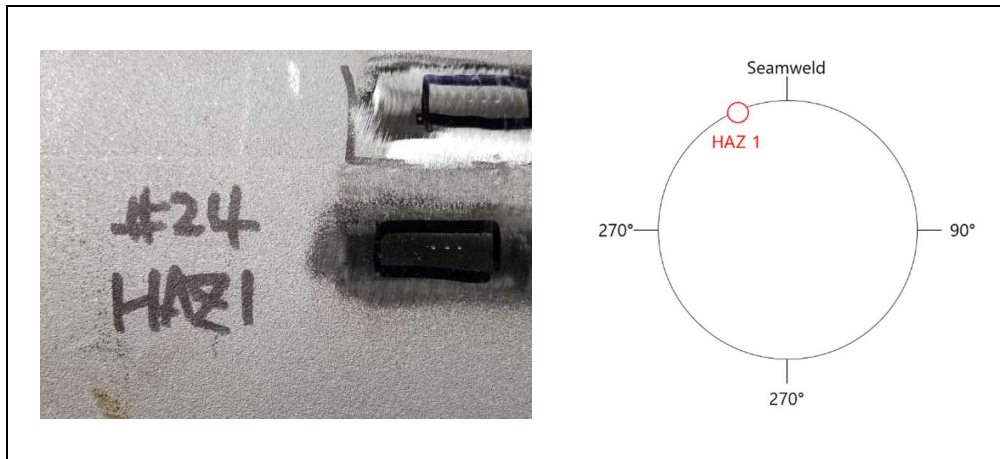
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.87	69.77	291.23
2	53.93	70.42	315.64
3	53.24	70.27	299.24
Avg.	53.35	70.15	302.04

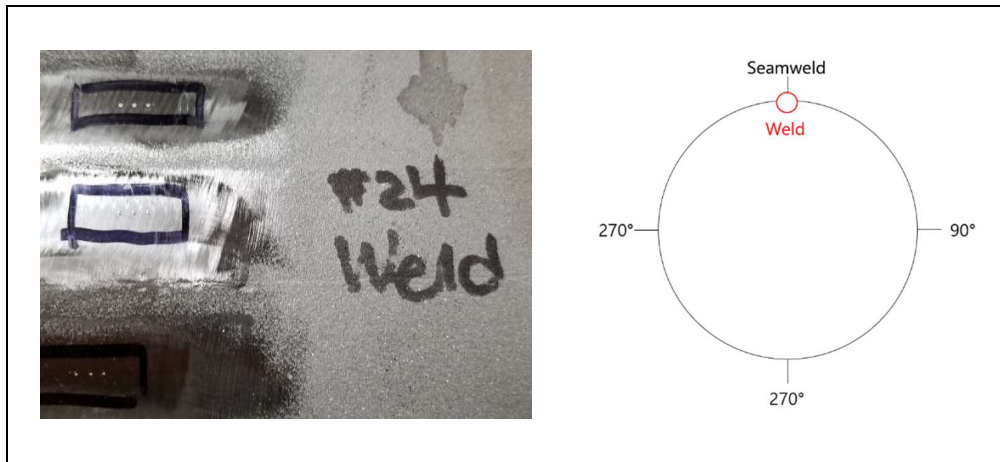
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.91	82.90	360.05
2	63.02	83.09	355.62
3	63.03	83.29	331.92
Avg.	63.32	83.09	349.19

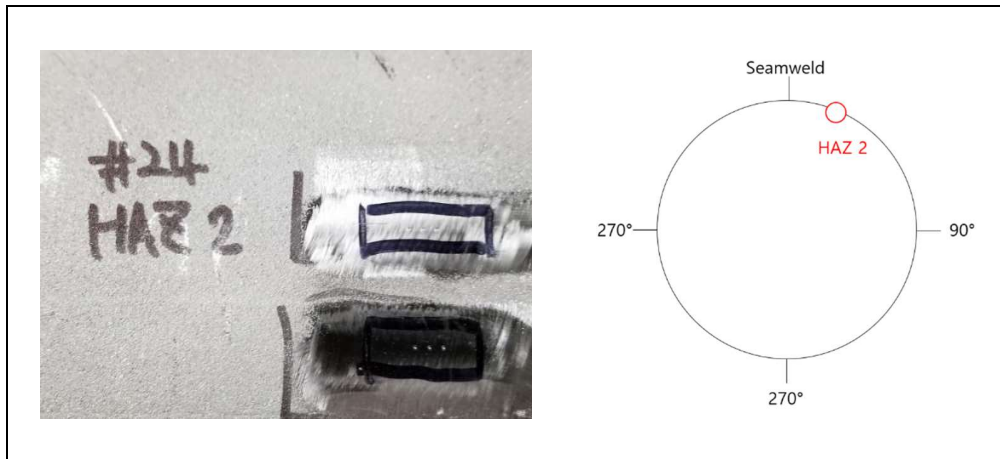
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.28	77.07	333.31
2	58.10	75.88	318.76
3	58.68	75.18	344.06
Avg.	59.02	76.04	332.04

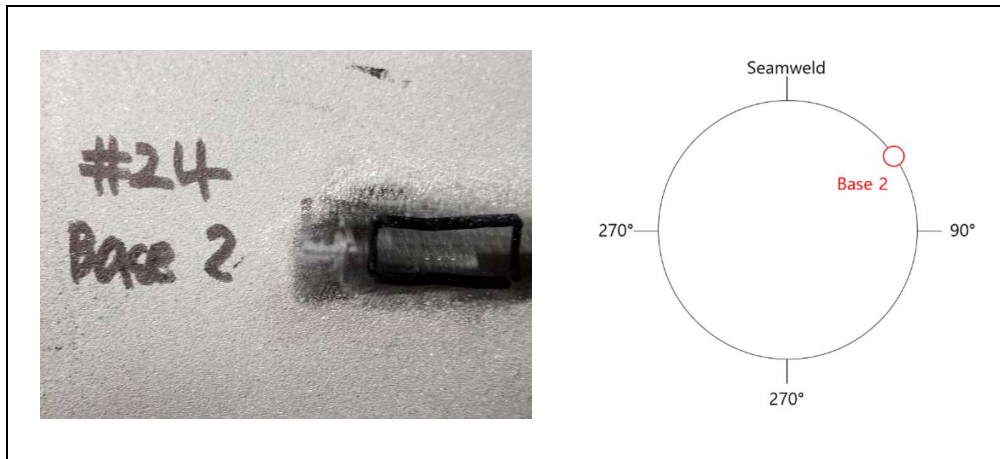
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.97	68.61	246.39
2	50.70	68.41	273.69
3	51.72	68.66	298.24
Avg.	50.79	68.56	272.77

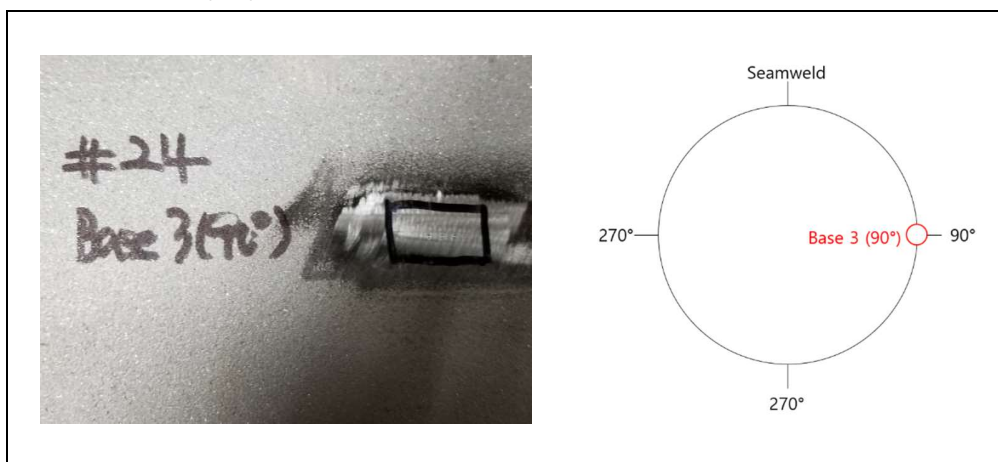
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 024
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.56	67.00	298.88
2	50.87	67.33	306.41
3	50.46	67.08	277.04
Avg.	50.63	67.14	294.11

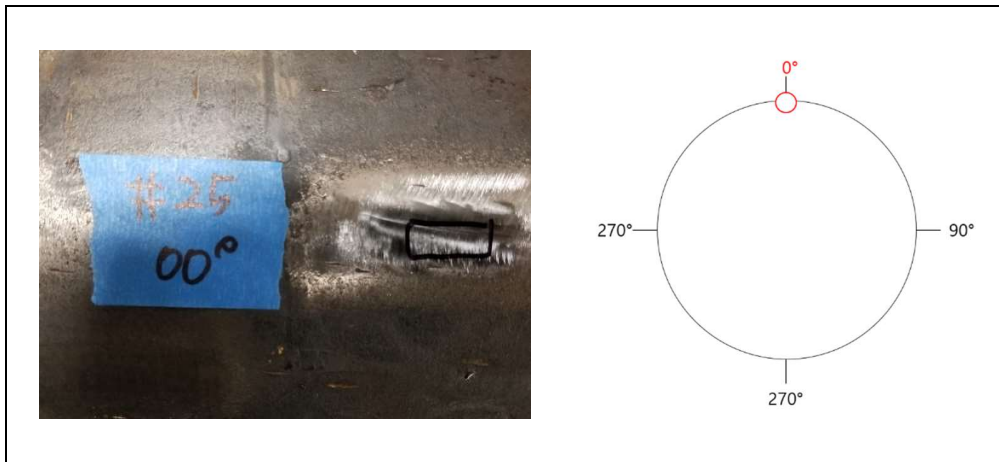
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 025
- (3) Pipe OD (inch) : 18
- (4) Location : 0°



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.17	76.18	299.55
2	57.42	76.50	321.49
3	56.38	76.80	289.76
Avg.	56.66	76.49	303.60

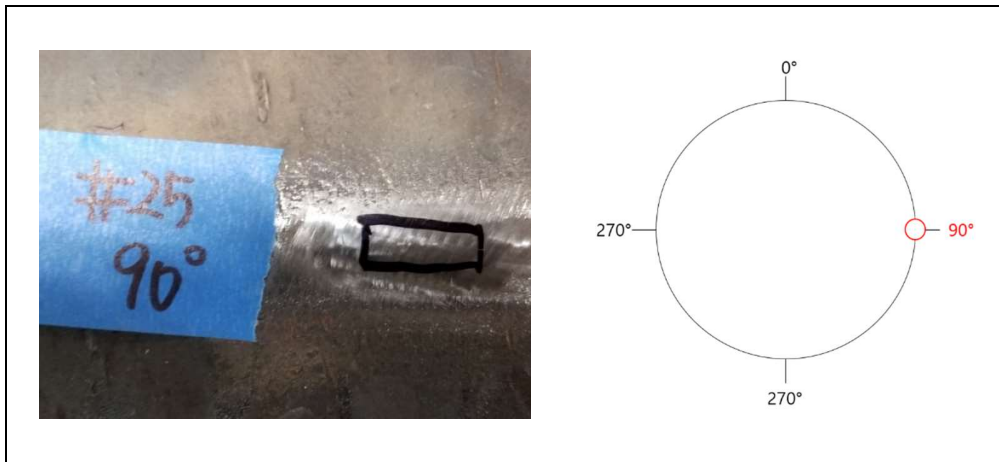
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 025
- (3) Pipe OD (inch) : 18
- (4) Location : 90°



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.62	78.24	286.70
2	57.90	77.62	321.34
3	59.64	77.92	333.88
Avg.	58.05	77.93	313.97

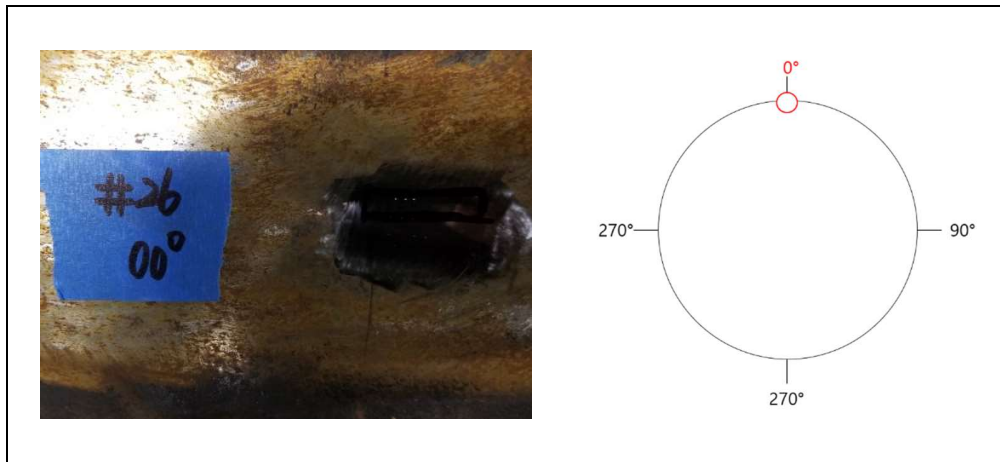
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 026
- (3) Pipe OD (inch) : 18
- (4) Location : : 0°



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.46	82.65	418.61
2	62.57	83.72	422.62
3	60.63	81.97	396.81
Avg.	61.22	82.78	412.68

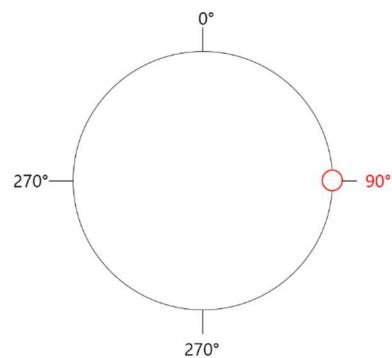
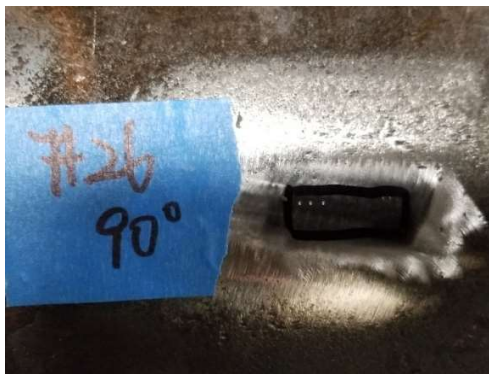
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 026
- (3) Pipe OD (inch) : 18
- (4) Location : : 90°



2. Condition

Date	4/16/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.41	83.99	419.00
2	62.87	83.92	396.54
3	62.88	84.32	421.94
Avg.	62.72	84.08	412.49

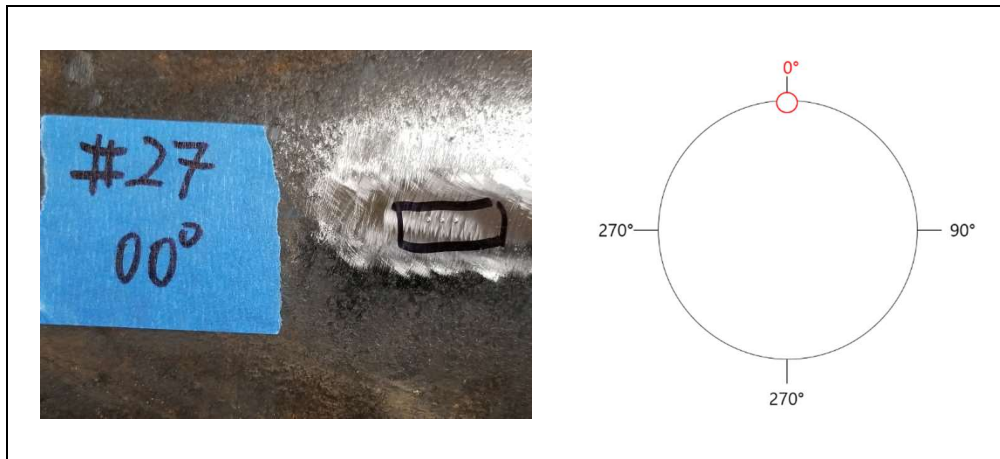
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 027
- (3) Pipe OD (inch) : 18
- (4) Location : : 0°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	69.12	91.90	474.85
2	66.43	90.71	468.56
3	66.60	90.28	457.71
Avg.	67.39	90.96	467.04

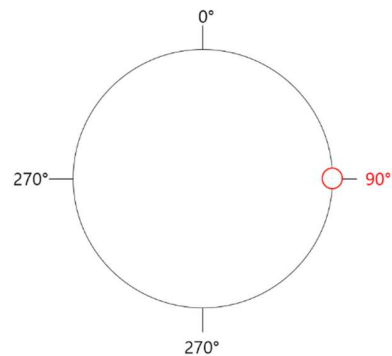
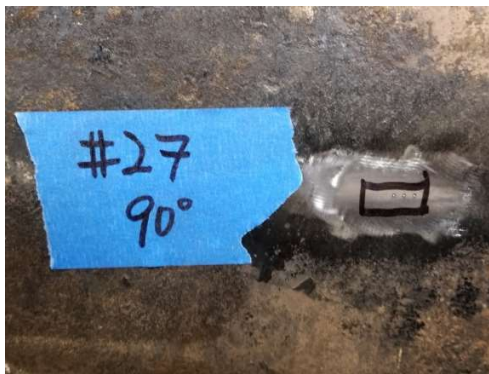
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 027
- (3) Pipe OD (inch) : 18
- (4) Location : : 90°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	67.44	90.01	459.89
2	68.60	90.43	465.37
3	68.07	90.25	459.84
Avg.	68.04	90.23	461.70

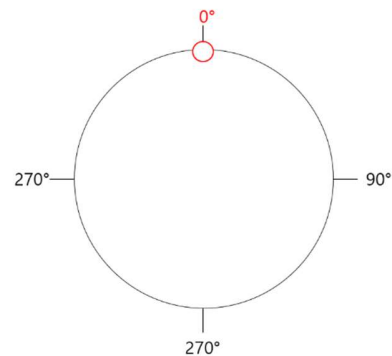
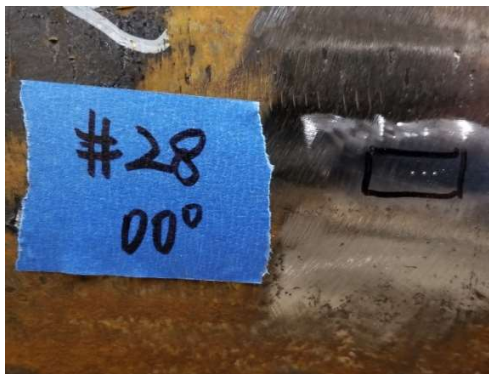
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 028
- (3) Pipe OD (inch) : 16
- (4) Location : 0°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.90	71.10	336.75
2	49.60	70.07	330.50
3	50.09	70.78	338.19
Avg.	50.20	70.65	335.15

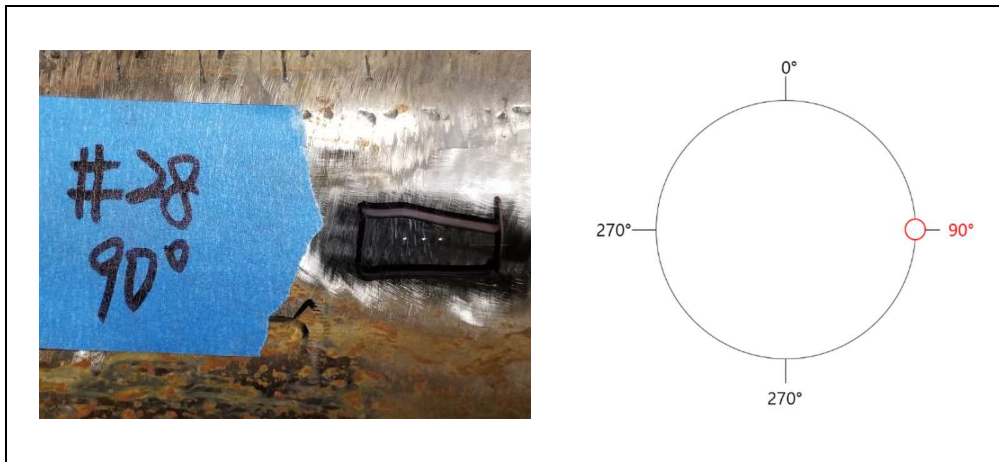
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 028
- (3) Pipe OD (inch) : 16
- (4) Location : 90°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.93	74.19	377.37
2	54.81	75.66	387.42
3	54.51	75.35	375.33
Avg.	54.41	75.07	380.04

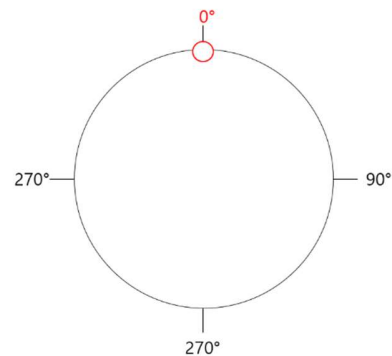
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 029
- (3) Pipe OD (inch) : 16
- (4) Location : 0°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.40	68.43	317.42
2	49.75	68.65	334.94
3	49.61	68.84	333.31
Avg.	49.58	68.64	328.55

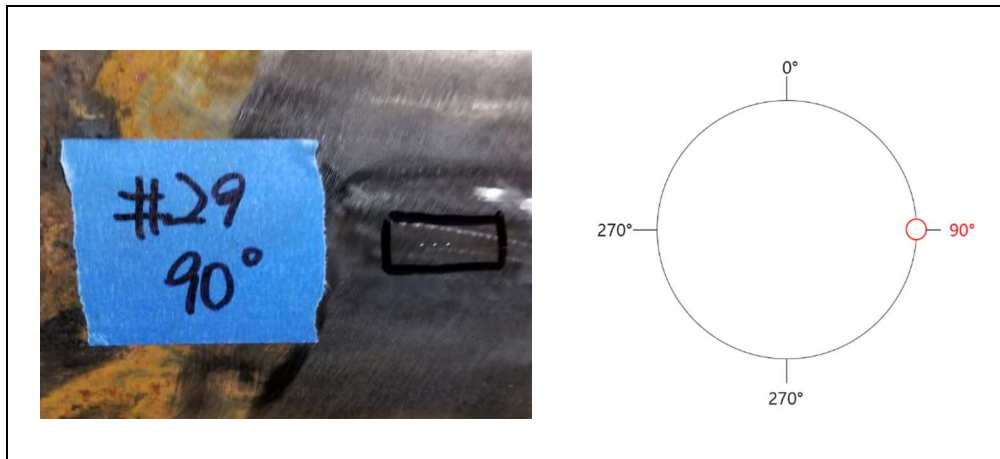
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 029
- (3) Pipe OD (inch) : 16
- (4) Location : 90°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.13	72.25	350.17
2	57.62	76.05	373.19
3	52.82	72.66	342.83
Avg.	54.19	73.65	355.40

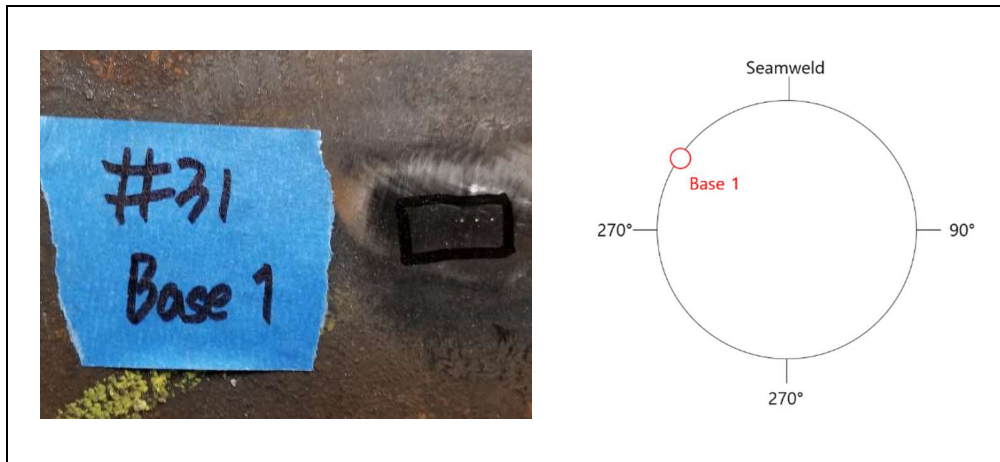
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : Base 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.99	69.06	336.75
2	51.74	69.41	335.90
3	51.78	69.23	332.47
Avg.	51.84	69.23	335.04

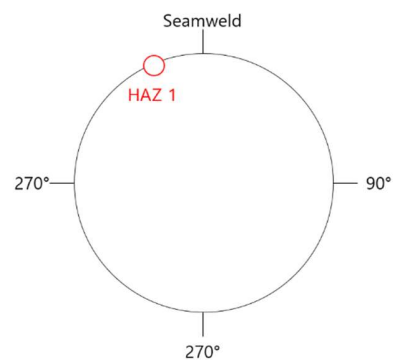
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : HAZ 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.14	71.92	356.36
2	54.50	72.06	350.92
3	54.38	71.91	359.59
Avg.	54.34	71.96	355.62

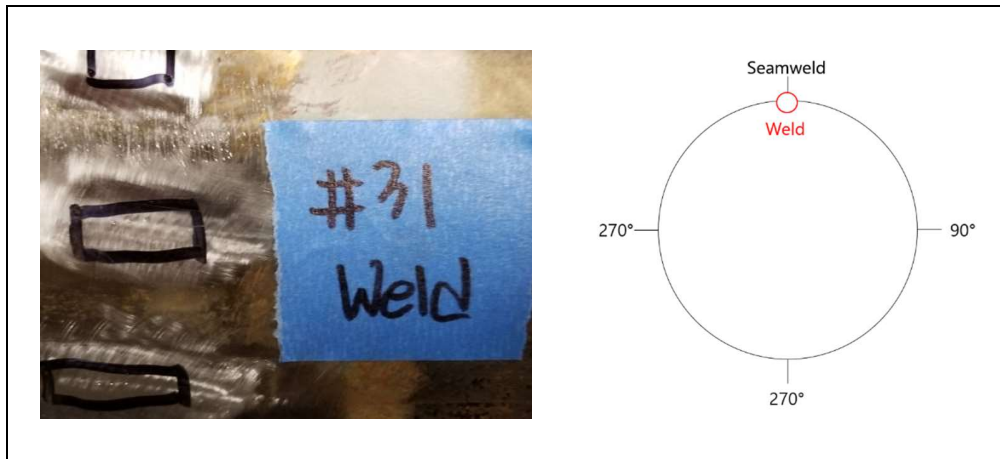
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : Weld



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	66.29	83.76	445.20
2	65.35	83.61	404.21
3	65.42	82.83	410.09
Avg.	65.69	83.40	419.83

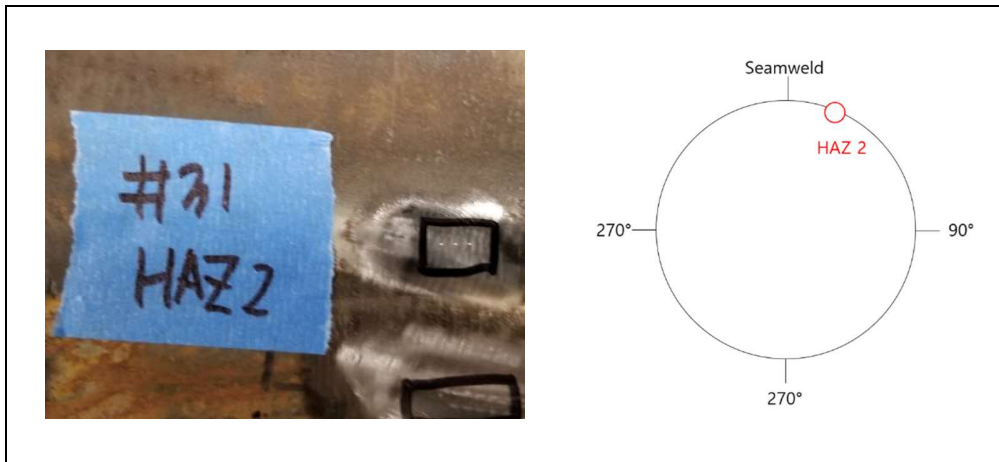
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : HAZ 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.58	70.25	330.54
2	53.28	70.82	307.95
3	53.04	71.06	341.03
Avg.	52.97	70.71	326.51

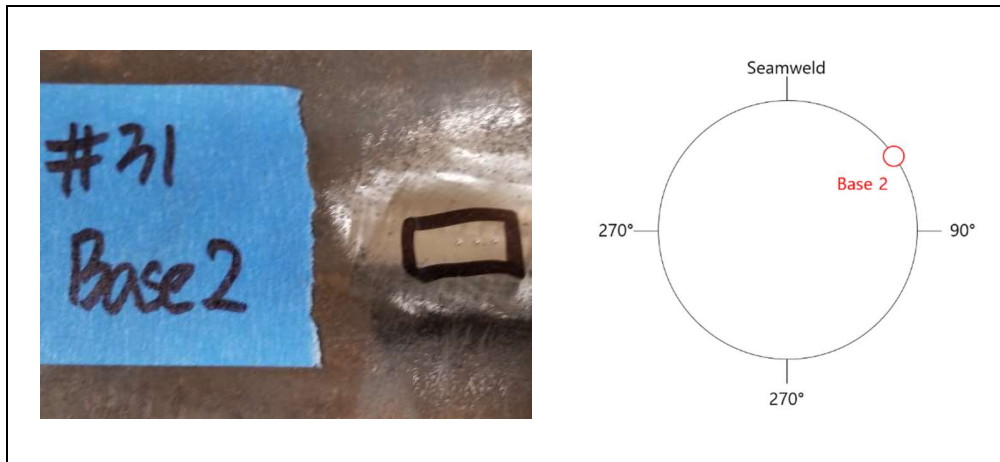
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : Base 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.49	70.74	328.47
2	51.93	69.45	322.27
3	52.03	69.28	312.37
Avg.	52.48	69.82	321.03

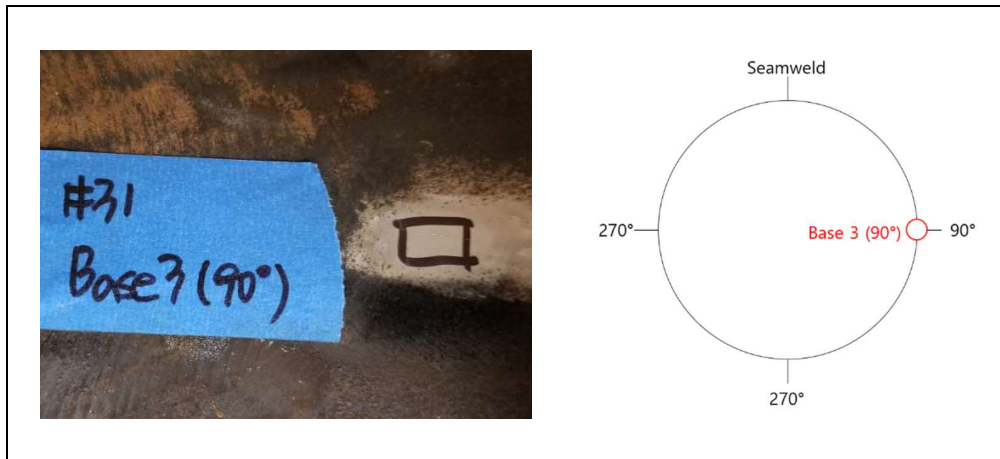
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 031
- (3) Pipe OD (inch) : 16
- (4) Location : Base 3 (90°)



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.80	68.19	326.94
2	50.93	68.12	321.13
3	51.59	68.99	339.41
Avg.	51.11	68.43	329.16

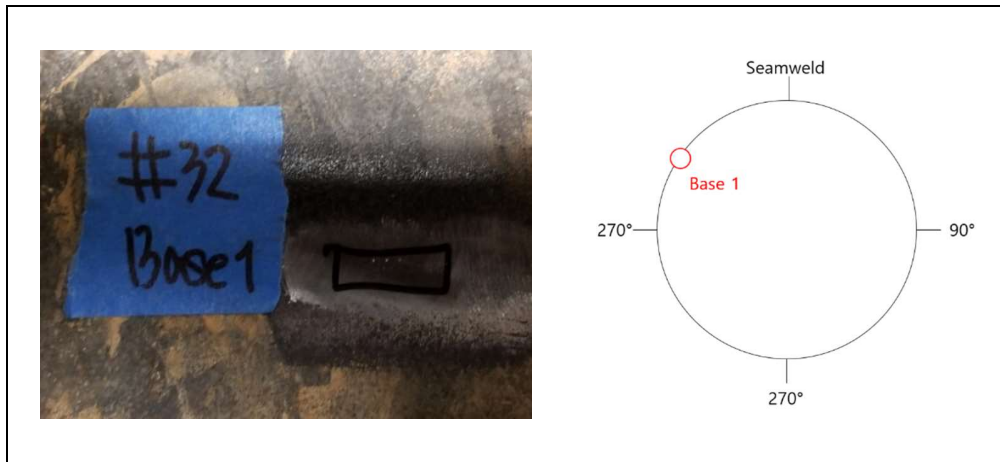
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : Base 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.30	72.50	246.74
2	54.44	72.74	296.38
3	51.76	69.66	315.82
Avg.	52.83	71.63	286.31

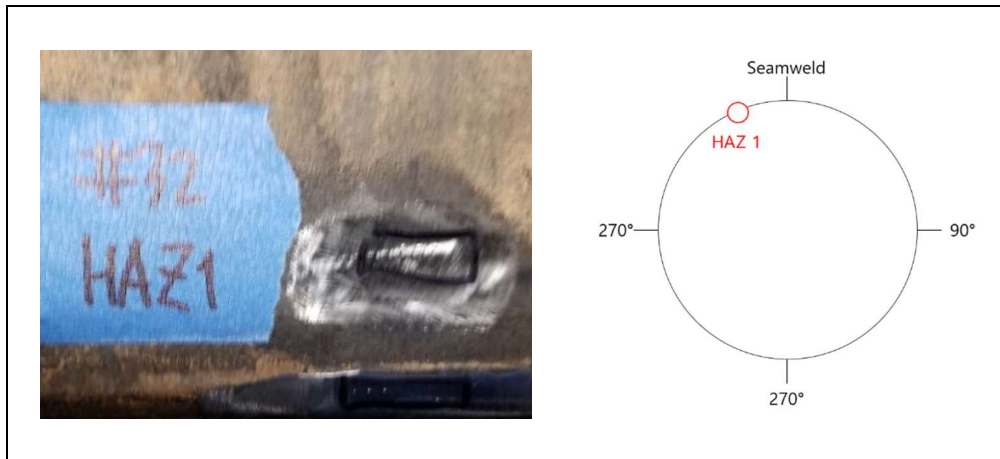
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : HAZ 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.94	71.79	300.10
2	54.13	74.60	267.41
3	55.04	73.76	318.05
Avg.	53.70	73.39	295.19

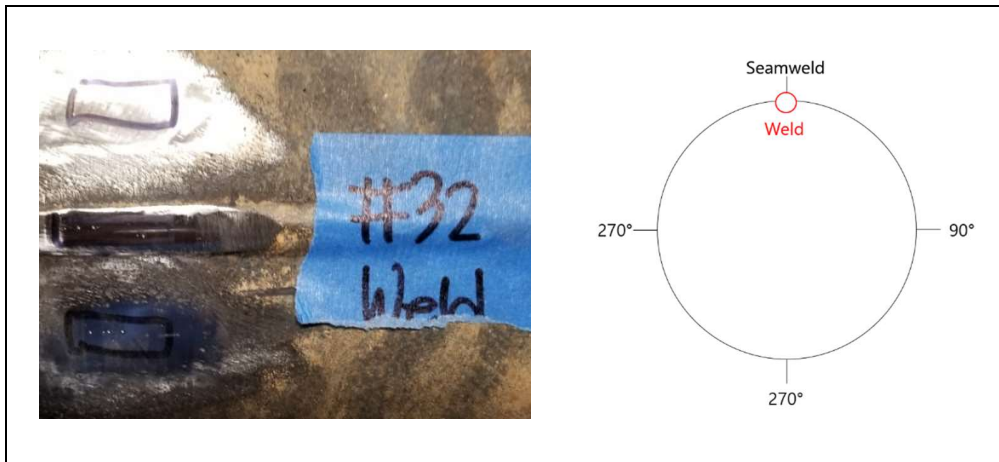
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : Weld



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.08	72.00	349.54
2	53.61	72.68	352.06
3	53.09	71.84	349.43
Avg.	53.26	72.17	350.34

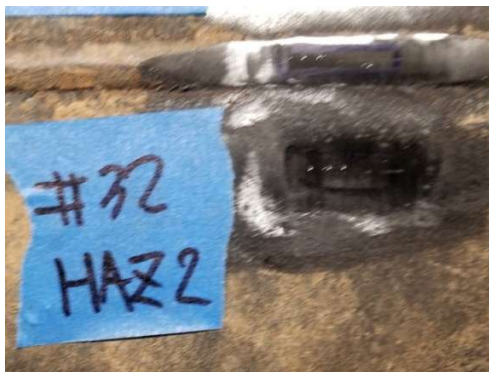
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : HAZ 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.17	74.59	253.71
2	57.22	76.12	348.42
3	57.62	78.94	259.62
Avg.	56.00	76.55	287.25

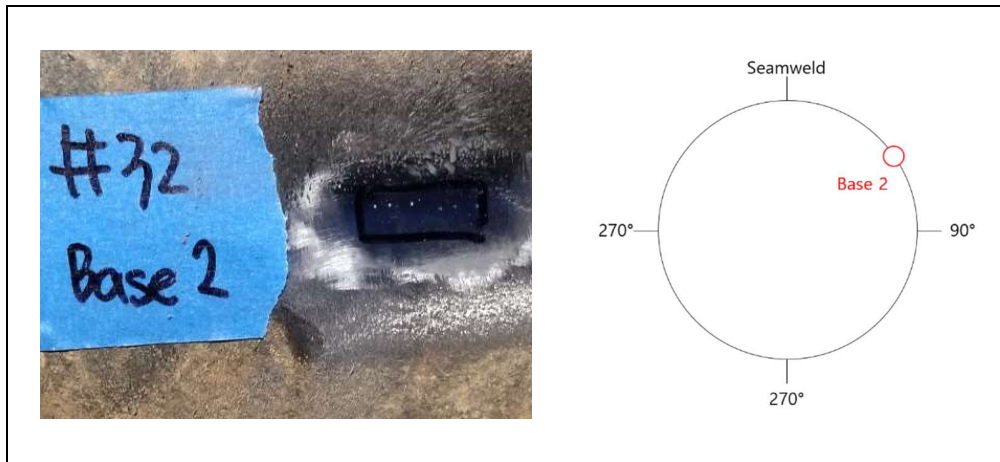
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : Base 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.77	72.24	313.10
2	48.41	68.41	287.06
3	54.78	74.28	289.72
Avg.	51.65	71.64	296.63

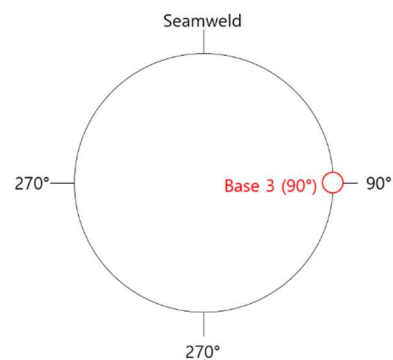
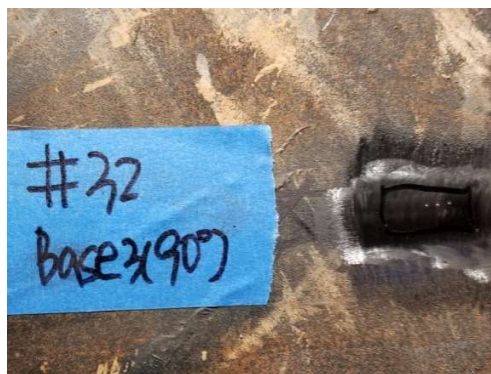
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 032
- (3) Pipe OD (inch) : 26
- (4) Location : Base 3 (90°)



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.24	66.73	288.20
2	50.93	68.61	318.64
3	51.11	69.26	319.66
Avg.	50.76	68.20	308.83

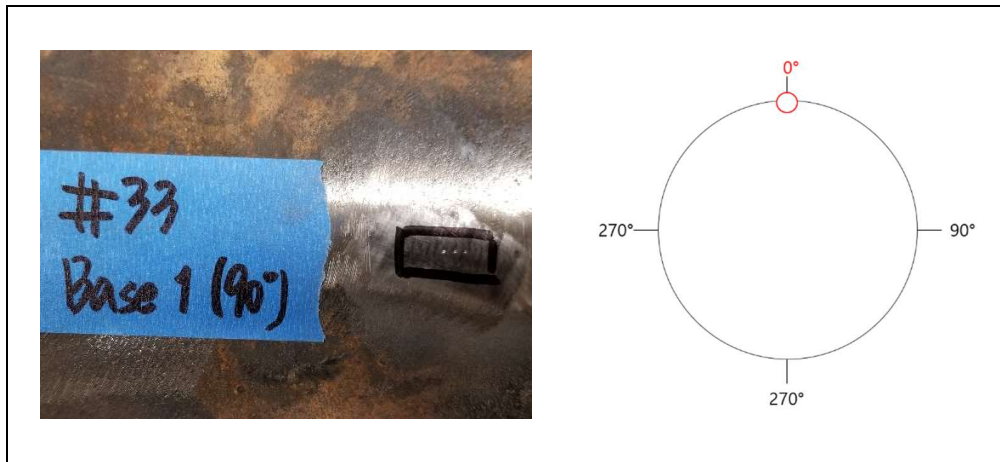
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 033
- (3) Pipe OD (inch) : 16
- (4) Location : 90°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.30	80.01	290.62
2	58.99	76.70	337.87
3	61.51	82.33	289.85
Avg.	59.93	79.68	306.11

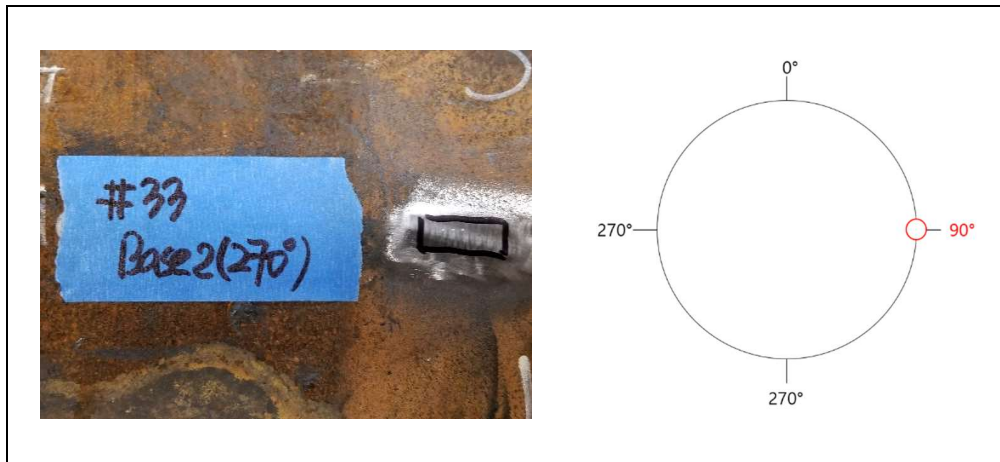
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 033
- (3) Pipe OD (inch) : 16
- (4) Location : 270°



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.24	78.32	323.27
2	58.93	80.75	266.14
3	57.52	76.55	298.44
Avg.	58.89	78.54	295.95

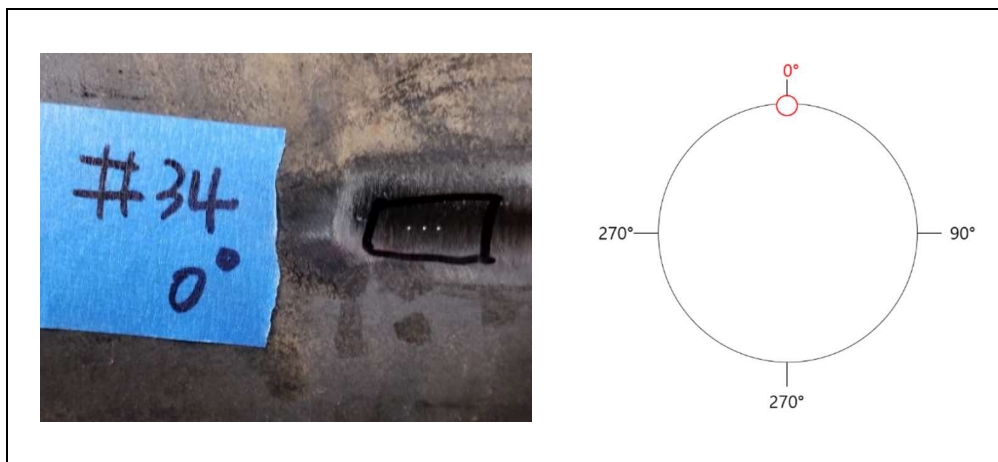
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 034
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	42.21	57.30	202.00
2	41.05	57.76	199.57
3	42.48	57.69	225.33
Avg.	41.91	57.58	208.97

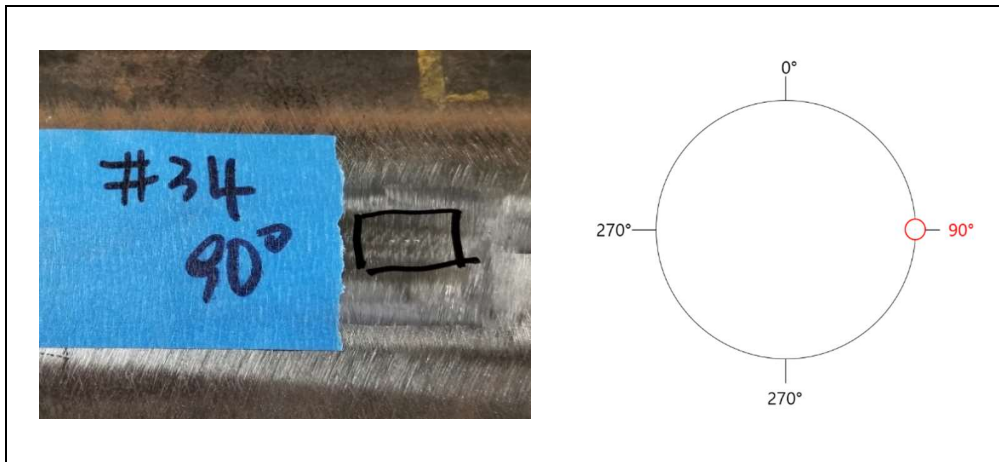
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 034
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	42.40	57.38	232.70
2	43.09	58.14	252.06
3	43.86	58.35	248.46
Avg.	43.12	57.96	244.41

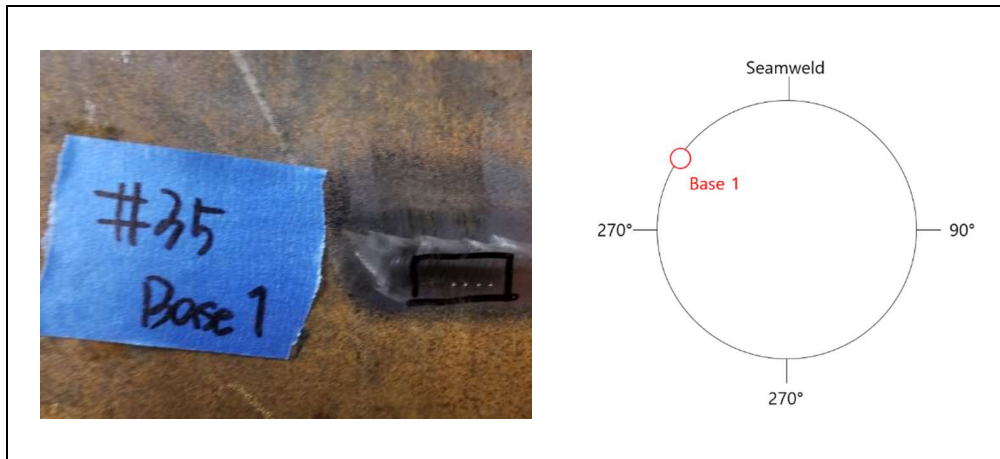
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	42.55	56.96	190.57
2	45.18	57.25	235.76
3	41.54	58.11	168.00
Avg.	43.09	57.44	198.11

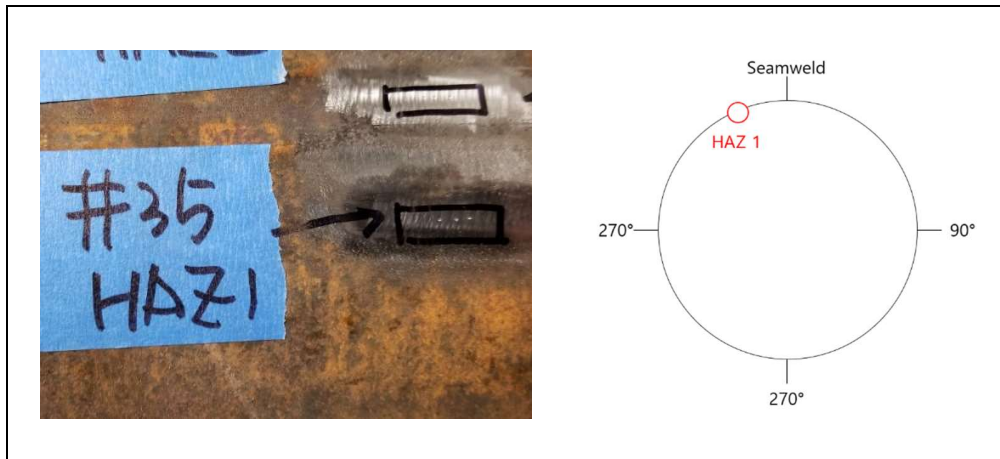
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	44.80	58.30	220.38
2	43.70	59.38	198.80
3	43.84	58.24	226.37
Avg.	44.11	58.64	215.19

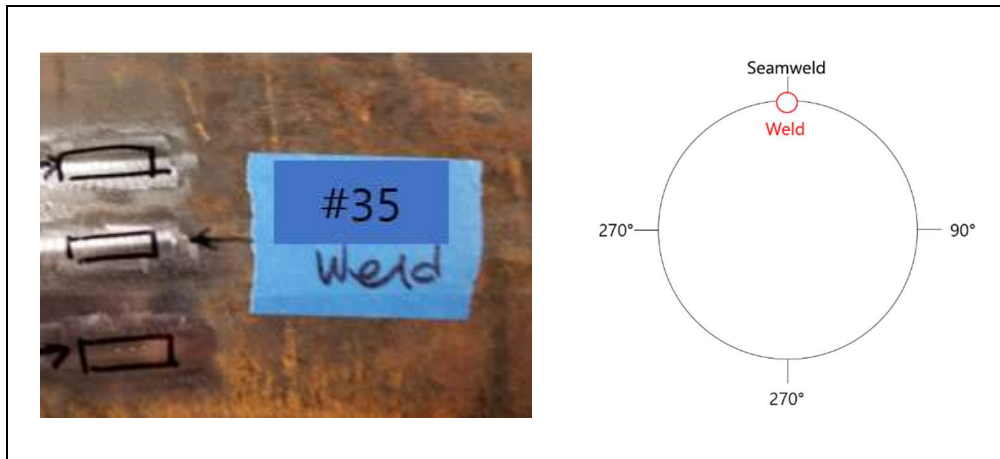
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.96	72.83	255.26
2	53.78	72.21	268.20
3	53.09	71.45	255.68
Avg.	53.61	72.16	259.71

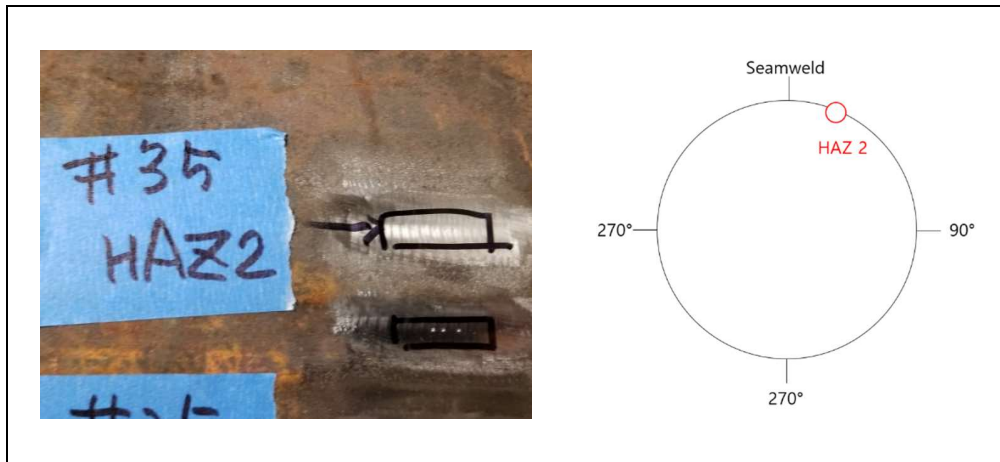
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	42.57	58.68	191.25
2	44.13	58.59	221.31
3	43.23	58.43	211.31
Avg.	43.31	58.57	207.96

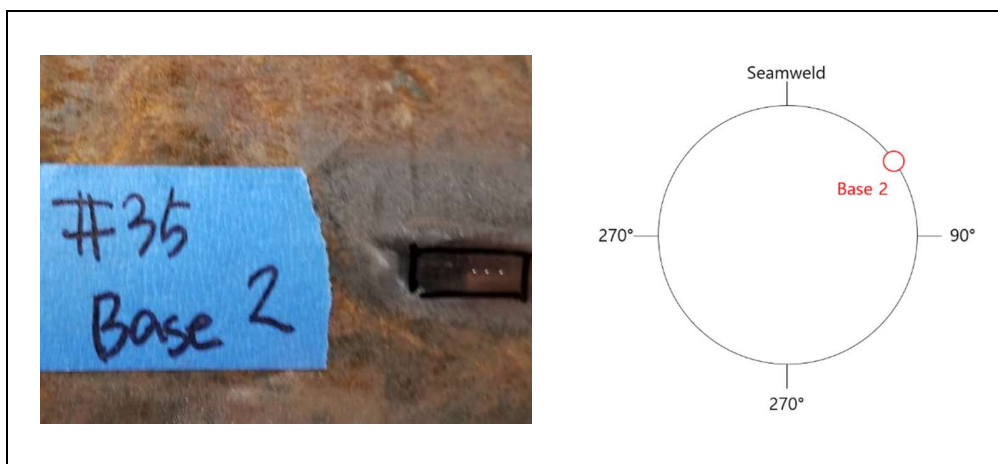
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	40.03	55.76	179.73
2	40.95	56.37	186.64
3	40.63	56.52	185.33
Avg.	40.54	56.21	183.90

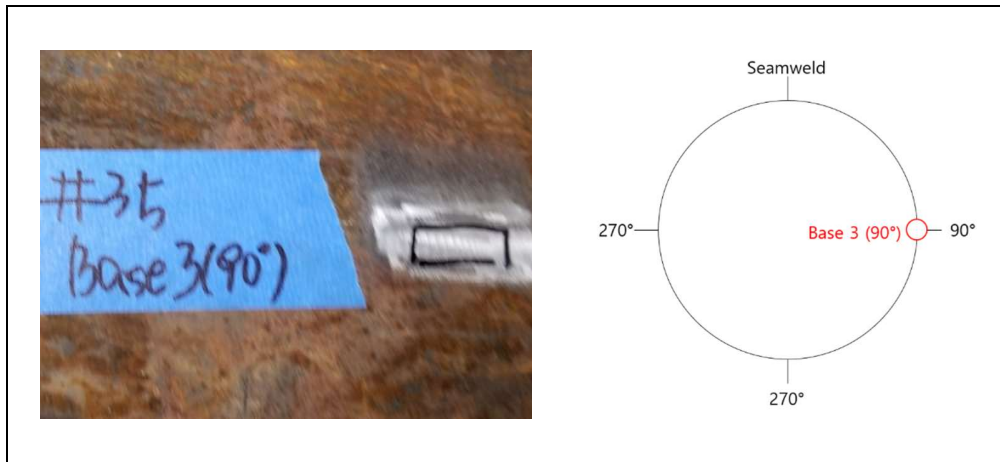
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 035
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	43.71	57.36	238.53
2	43.11	58.32	200.69
3	43.66	57.11	227.33
Avg.	43.49	57.60	222.18

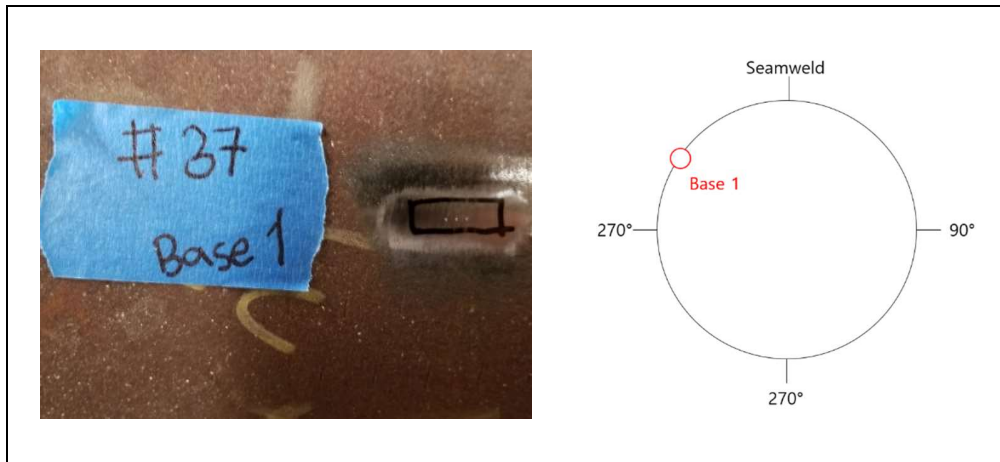
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	ksi	ksi	MPa·m ^{1/2}
2	53.26	74.26	251.40
3	55.44	74.36	302.06
Avg.	52.24	73.24	258.88

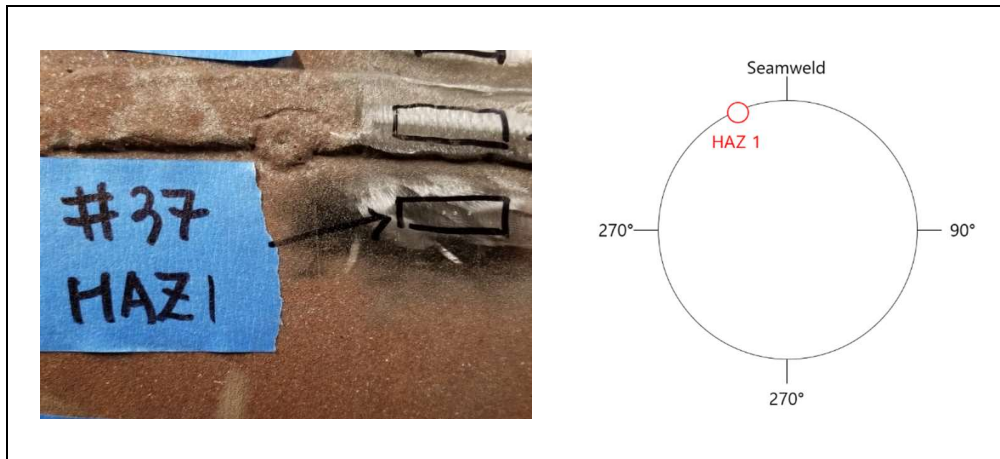
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.89	75.00	275.93
2	55.47	74.00	287.95
3	53.55	73.05	276.17
Avg.	54.64	74.01	280.02

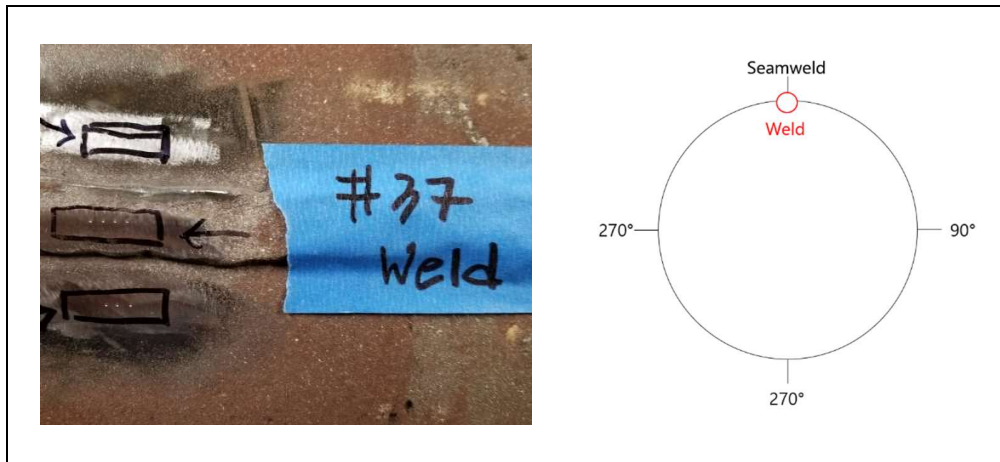
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.25	66.02	294.27
2	46.22	62.15	280.56
3	47.94	65.61	252.27
Avg.	48.14	64.59	275.70

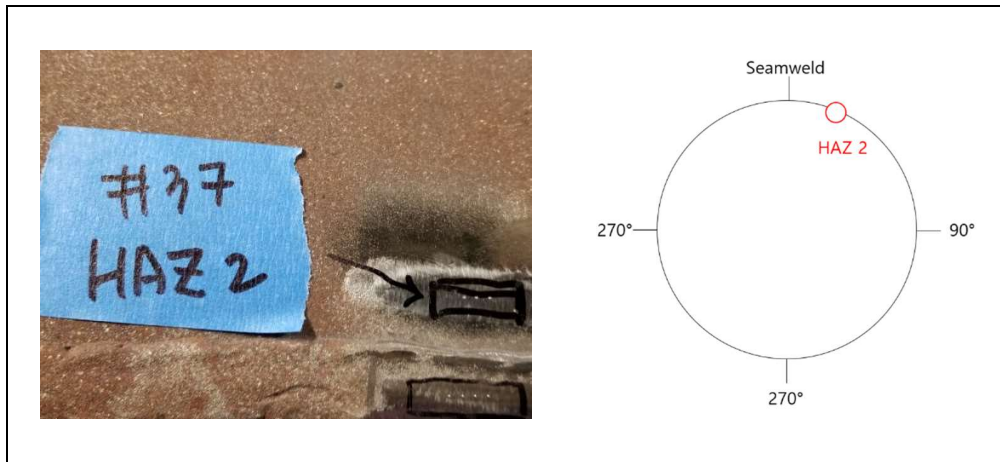
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.38	71.47	300.53
2	53.12	71.44	230.98
3	54.45	70.03	267.57
Avg.	54.65	70.98	266.36

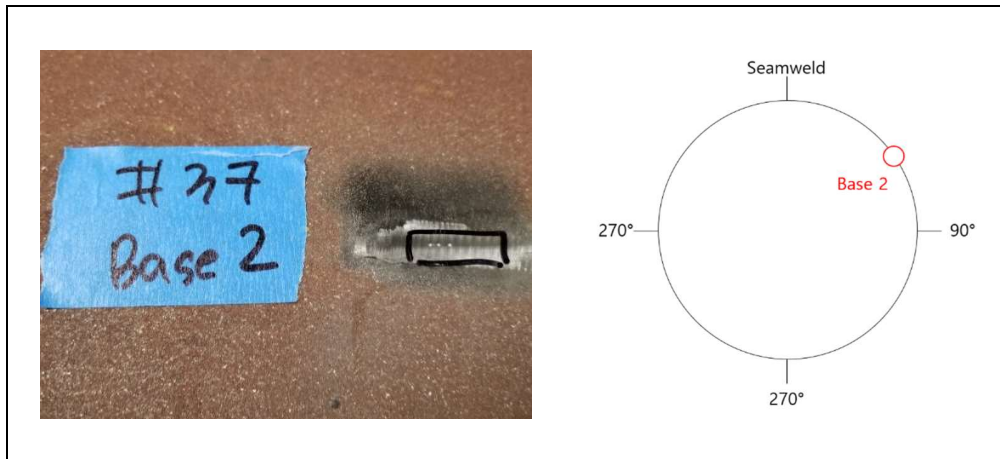
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.30	71.31	234.19
2	52.65	74.31	235.84
3	56.62	75.70	275.01
Avg.	53.85	73.77	248.35

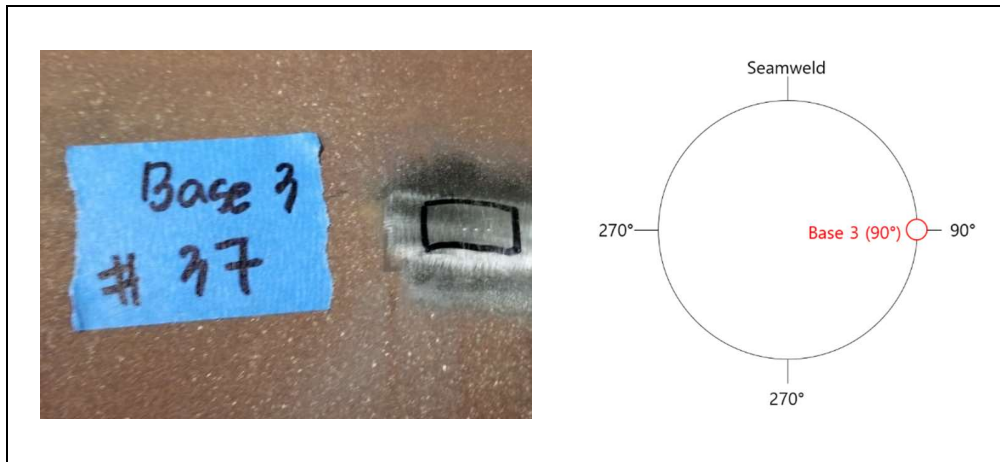
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 037
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.97	73.02	283.29
2	57.61	75.02	325.70
3	57.77	75.57	311.60
Avg.	56.45	74.53	306.86

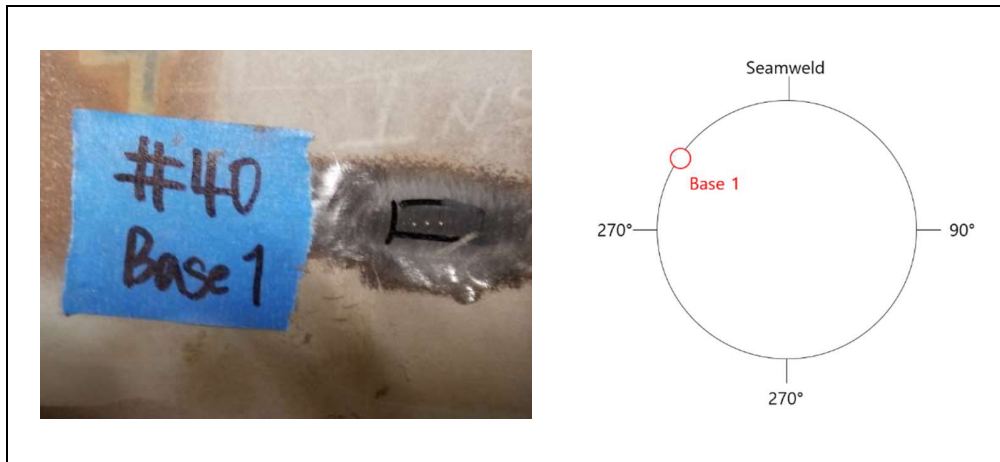
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : Base 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.79	83.63	365.67
2	65.49	84.28	395.26
3	66.17	84.76	378.43
Avg.	65.15	84.22	379.79

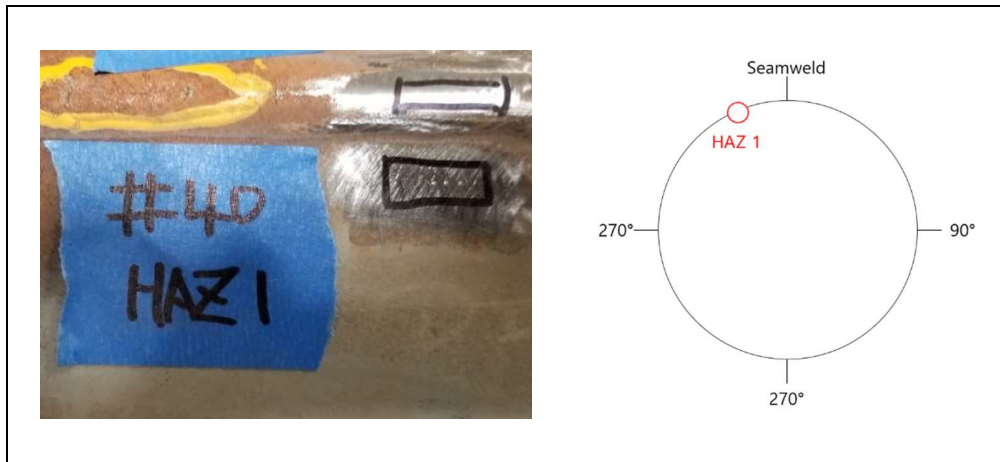
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : HAZ 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	66.26	84.51	327.71
2	68.09	86.08	356.44
3	71.19	89.38	406.03
Avg.	68.51	86.65	363.39

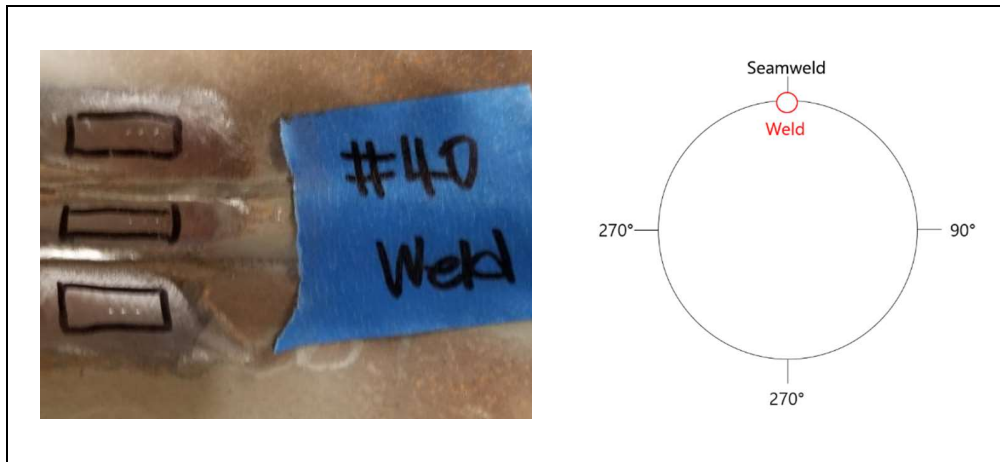
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : Weld



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.45	75.23	275.97
2	55.28	72.62	316.58
3	58.13	79.13	279.45
Avg.	56.29	75.66	290.67

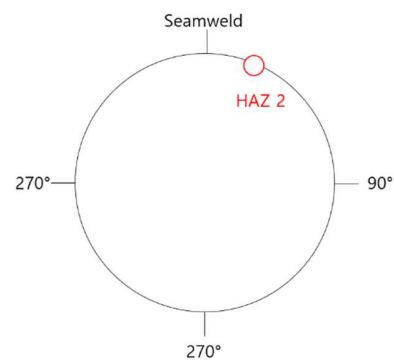
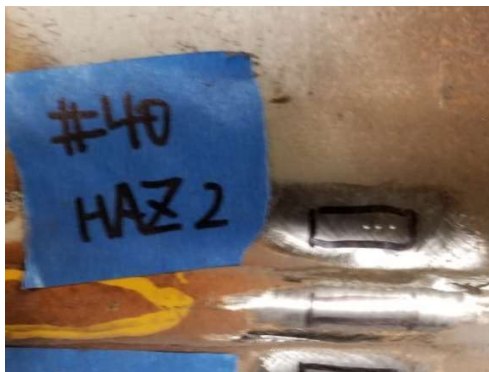
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : HAZ 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	67.43	89.02	387.18
2	69.49	89.94	404.58
3	70.41	90.99	430.17
Avg.	69.11	89.98	407.31

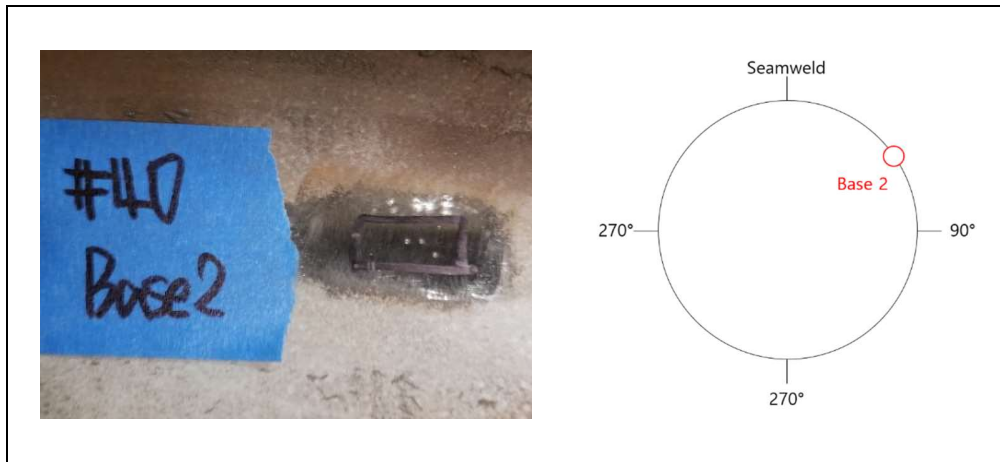
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : Base 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.32	85.48	398.17
2	67.01	87.50	418.16
3	67.16	87.35	426.36
Avg.	66.16	86.78	414.23

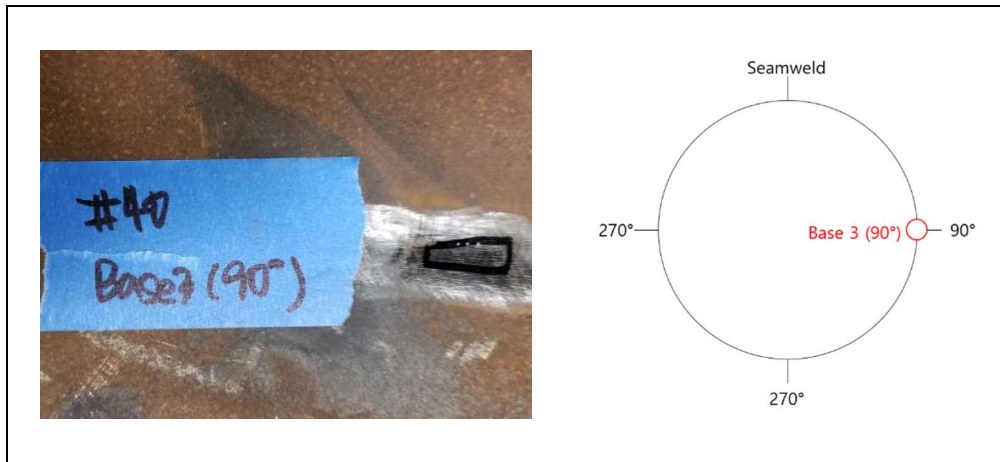
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 040
- (3) Pipe OD (inch) : 30
- (4) Location : Base 3 (90°)



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.18	77.22	318.19
2	59.93	78.68	261.42
3	62.06	76.12	332.45
Avg.	61.39	77.34	304.02

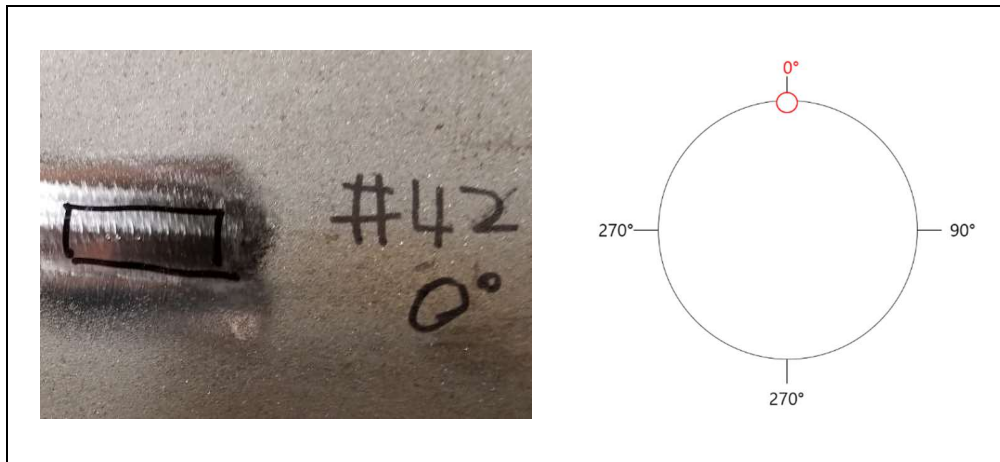
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 042
- (3) Pipe OD (inch) : 12
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	47.18	64.40	287.17
2	47.69	64.57	296.63
3	46.97	64.33	275.09
Avg.	47.28	64.43	286.29

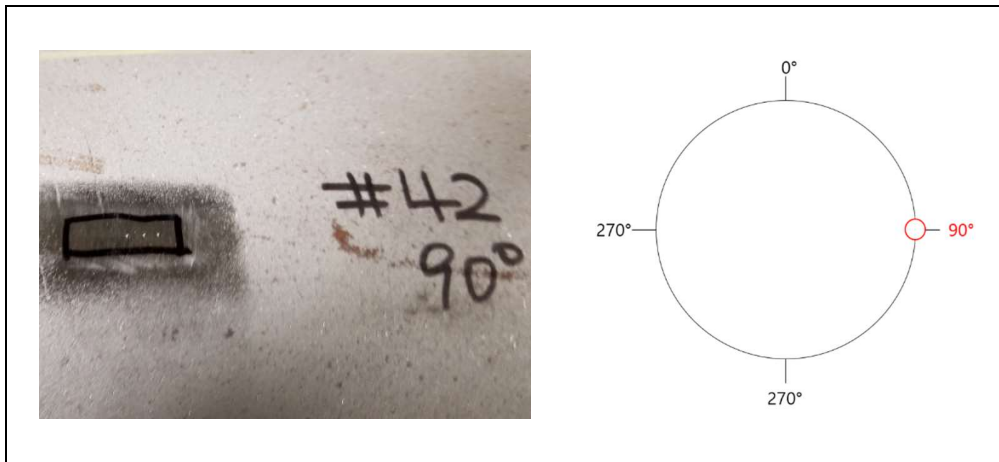
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 042
- (3) Pipe OD (inch) : 12
- (4) Location : 90°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.89	65.22	246.95
2	46.52	65.57	244.26
3	43.95	63.25	243.20
Avg.	45.79	64.68	244.80

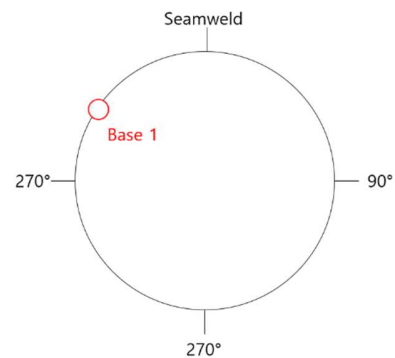
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : Base 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.72	66.89	333.80
2	49.28	66.56	306.81
3	49.00	66.12	319.33
Avg.	49.34	66.52	319.98

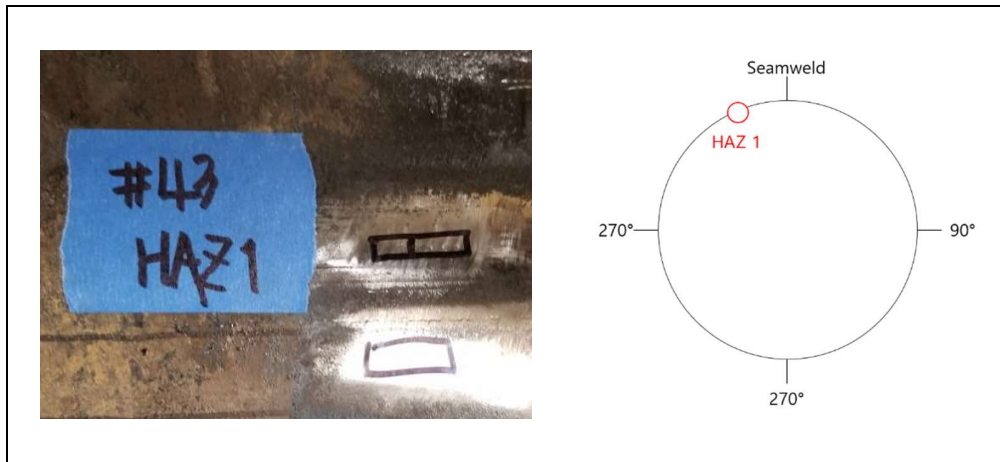
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 1



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.82	77.75	336.51
2	59.88	77.64	336.48
3	60.29	77.57	359.82
Avg.	60.00	77.65	344.27

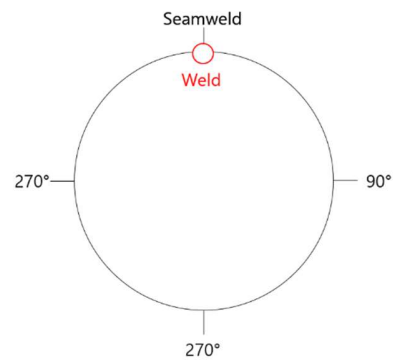
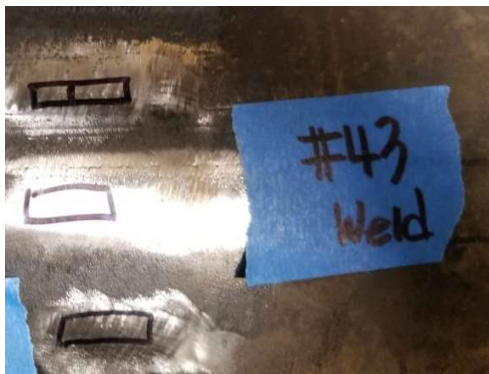
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : Weld



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.14	75.11	311.27
2	55.41	74.37	302.35
3	56.81	74.57	340.64
Avg.	56.12	74.68	318.09

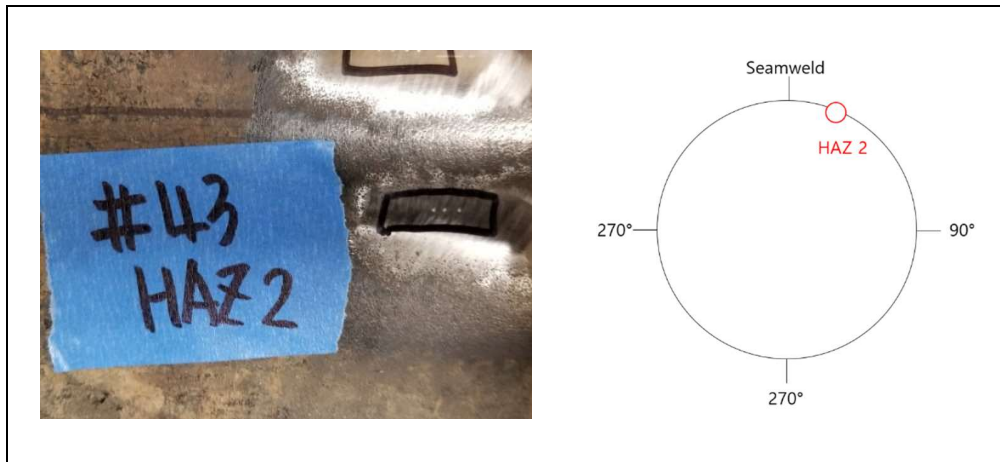
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.18	71.53	307.69
2	52.74	71.20	271.73
3	56.75	72.78	329.02
Avg.	54.56	71.84	302.81

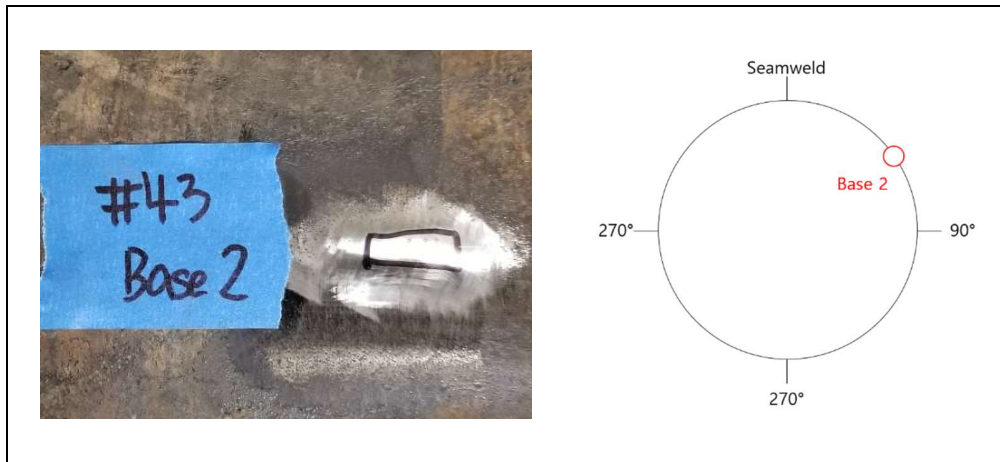
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : Base 2



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.01	70.38	318.25
2	51.47	68.73	295.09
3	53.74	69.75	319.90
Avg.	53.07	69.62	311.08

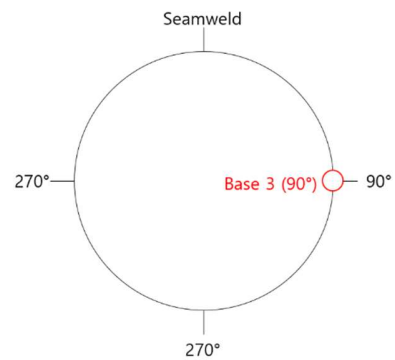
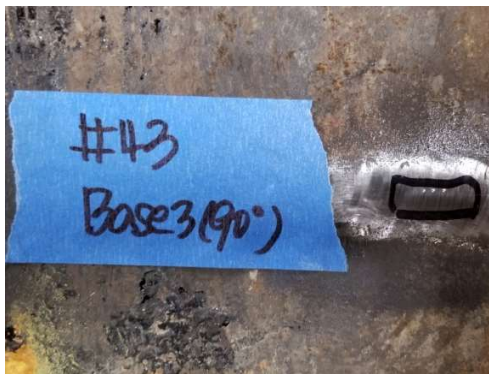
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 043
- (3) Pipe OD (inch) : 20
- (4) Location : Base 3 (90°)



2. Condition

Date	4/17/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.44	68.06	324.97
2	54.40	70.83	322.27
3	52.74	69.15	327.48
Avg.	53.20	69.35	324.91

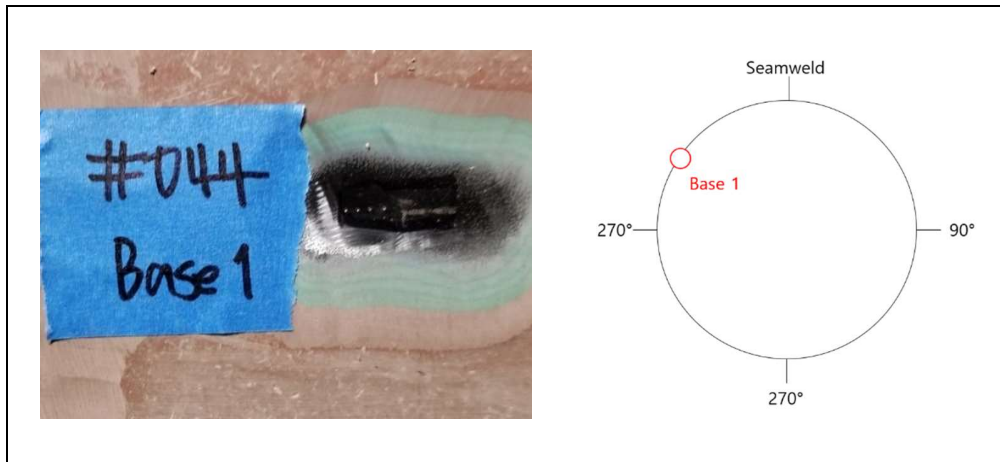
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 044
- (3) Pipe OD (inch) : 26
- (4) Location : Base 1



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.68	86.38	271.95
2	63.54	85.93	277.20
3	62.43	83.16	279.26
Avg.	62.88	85.16	276.14

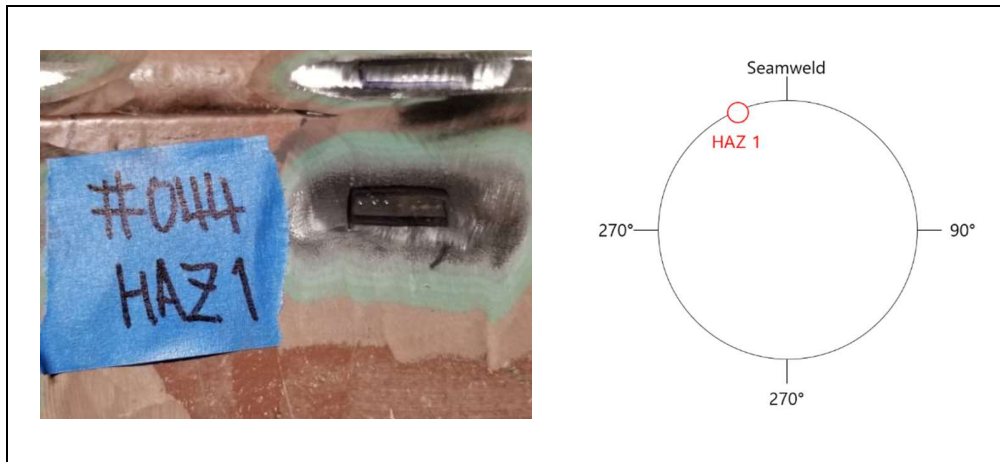
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 044
- (3) Pipe OD (inch) : 26
- (4) Location : HAZ 1



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.98	83.05	294.24
2	59.63	81.54	290.64
3	61.89	83.40	293.14
Avg.	60.83	82.66	292.67

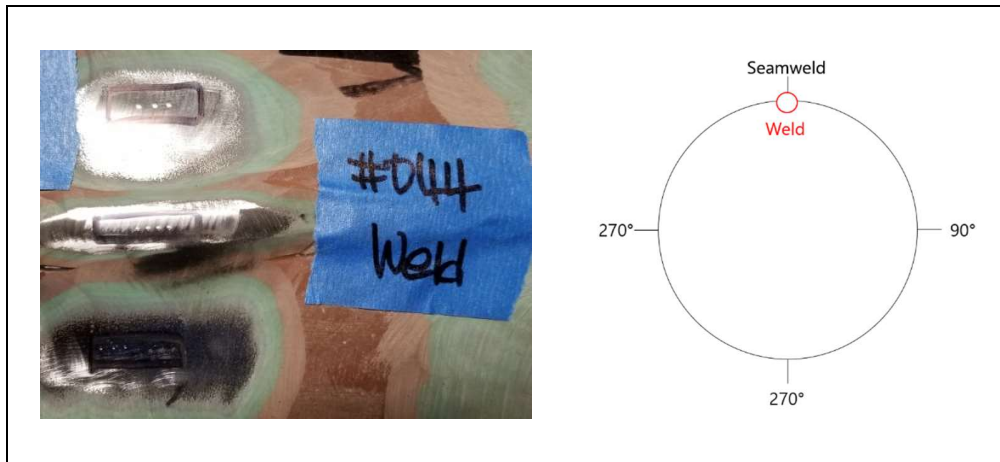
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 044
- (3) Pipe OD (inch) : 26
- (4) Location : Weld



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.00	83.08	376.67
2	69.55	87.68	422.10
3	68.61	86.71	427.90
Avg.	67.39	85.82	408.89

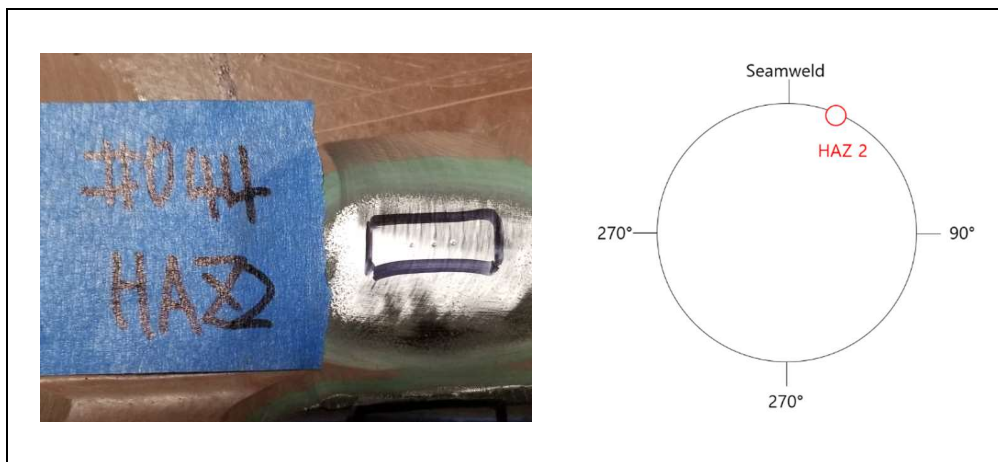
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 044
- (3) Pipe OD (inch) : 26
- (4) Location : HAZ 2



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.92	83.06	277.48
2	58.40	81.47	261.31
3	60.60	82.85	285.29
Avg.	60.31	82.46	274.69

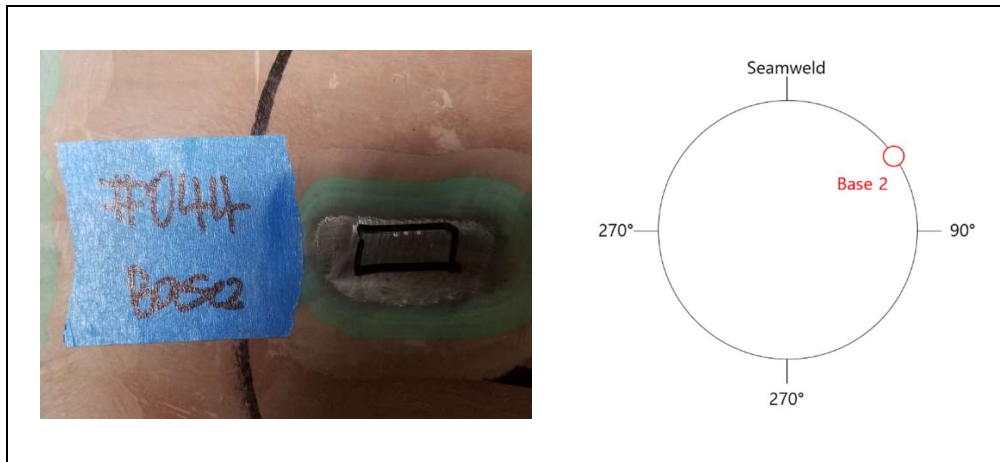
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 044
- (3) Pipe OD (inch) : 26
- (4) Location : Base 2



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.90	82.77	276.97
2	62.43	89.16	251.60
3	62.02	85.00	265.09
Avg.	61.78	85.64	264.55

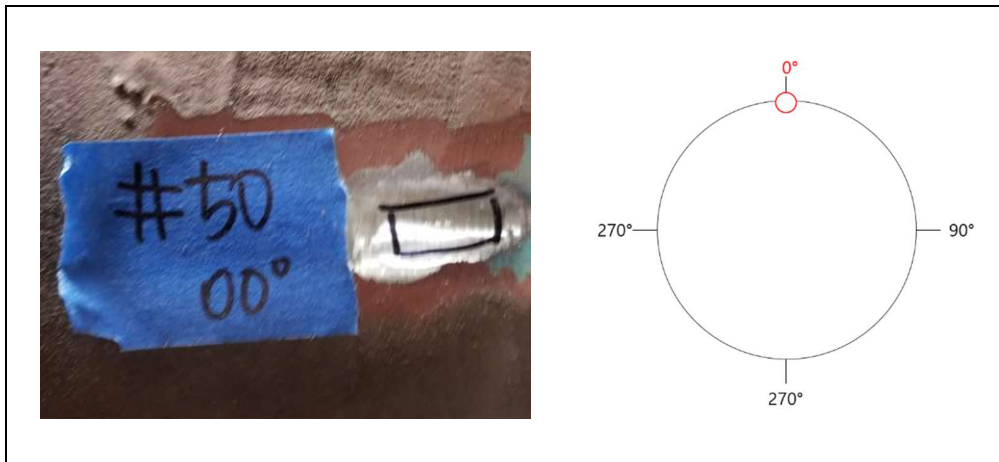
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 050
- (3) Pipe OD (inch) : 24
- (4) Location : 0°



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.15	76.73	323.64
2	58.12	76.26	351.54
3	56.17	75.93	354.60
Avg.	57.15	76.31	343.26

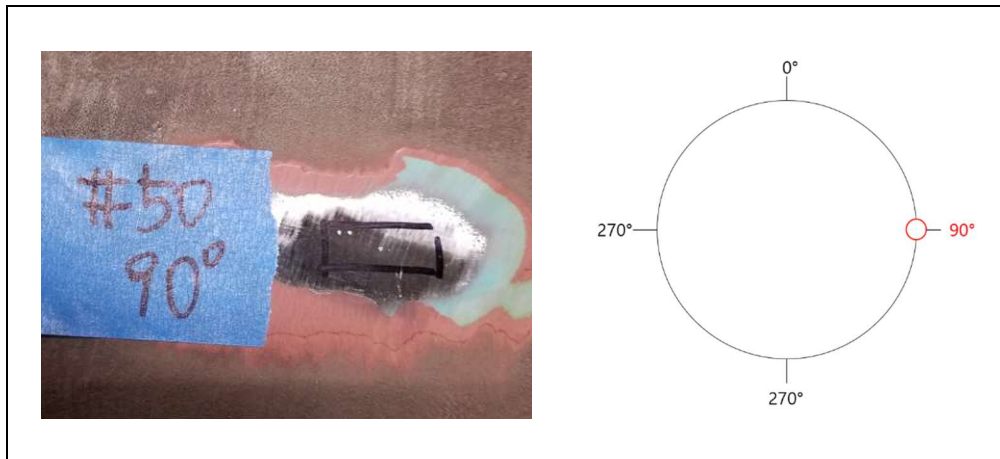
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 050
- (3) Pipe OD (inch) : 24
- (4) Location : 90°



2. Condition

Date	4/19/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	68.01	88.93	259.91
2	58.35	72.17	292.90
3	57.75	72.01	300.72
Avg.	61.37	77.70	284.51

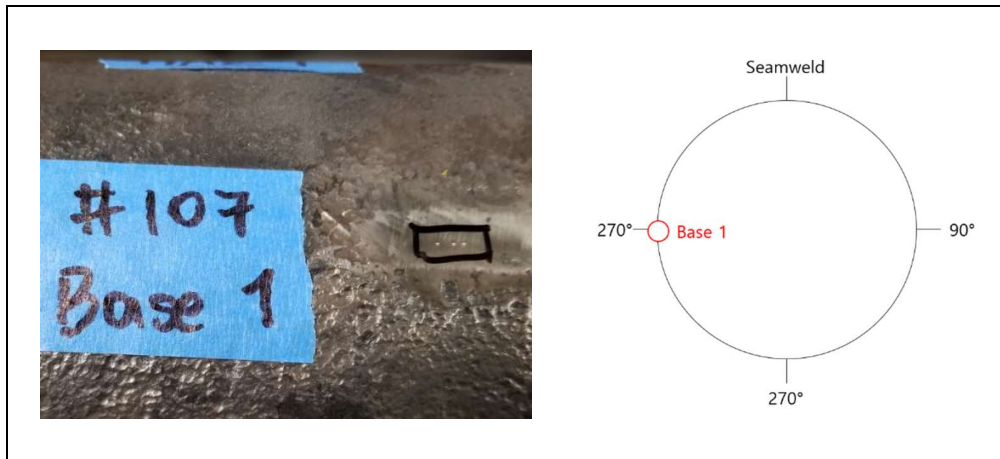
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 107
- (3) Pipe OD (inch) : 6
- (4) Location : Base 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	38.26	49.78	183.95
2	38.29	50.87	230.42
3			
Avg.	38.27	50.32	207.18

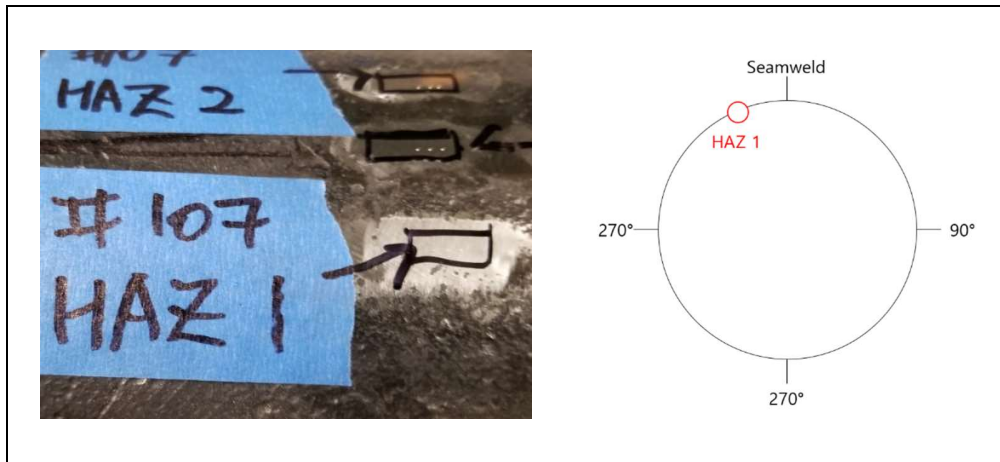
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 107
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	38.73	51.09	183.52
2	37.56	50.54	210.95
3	38.76	52.58	230.07
Avg.	38.35	51.40	208.18

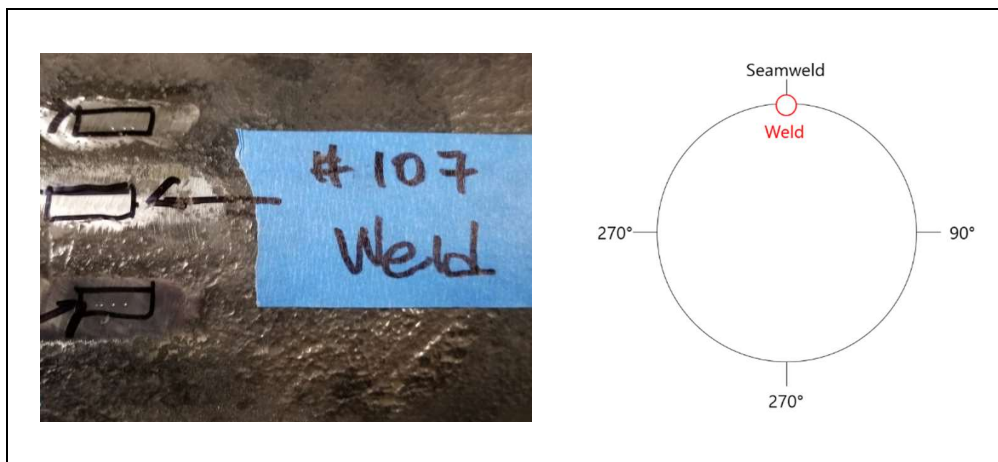
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 107
- (3) Pipe OD (inch) : 6
- (4) Location : Weld



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	39.65	53.93	227.62
2	41.04	53.76	215.91
3	41.01	55.47	216.87
Avg.	40.56	54.39	220.13

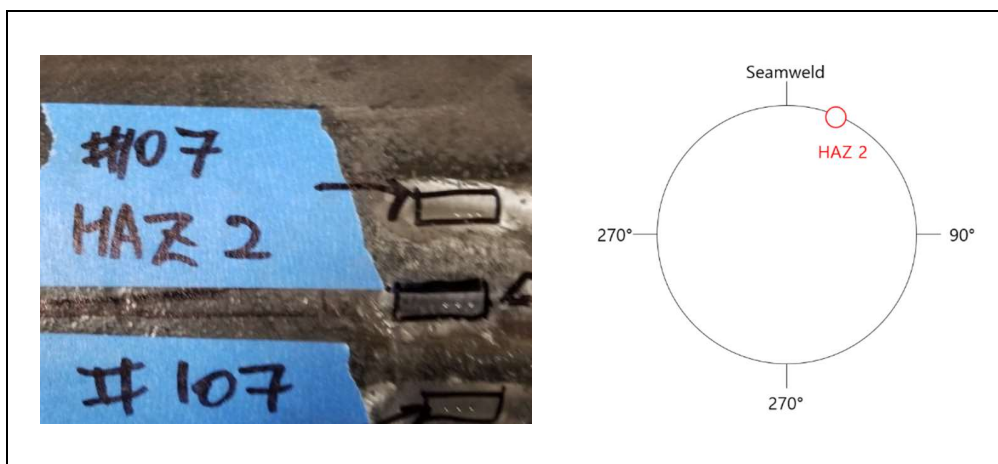
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 107
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	42.22	57.65	197.61
2	40.56	55.78	201.69
3	41.33	55.97	222.30
Avg.	41.37	56.47	207.20

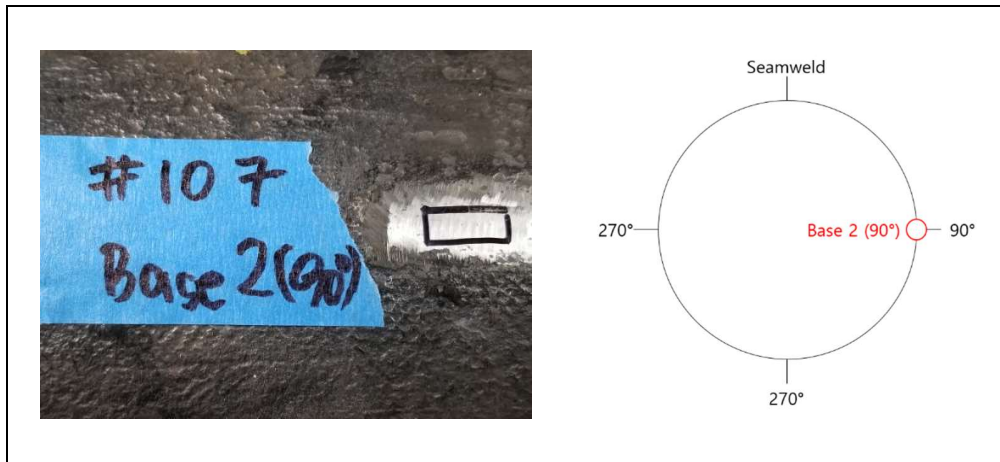
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 107
- (3) Pipe OD (inch) : 6
- (4) Location : Base 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	38.77	52.94	224.24
2	36.06	51.41	212.25
3	35.13	50.50	211.35
Avg.	36.65	51.62	215.95

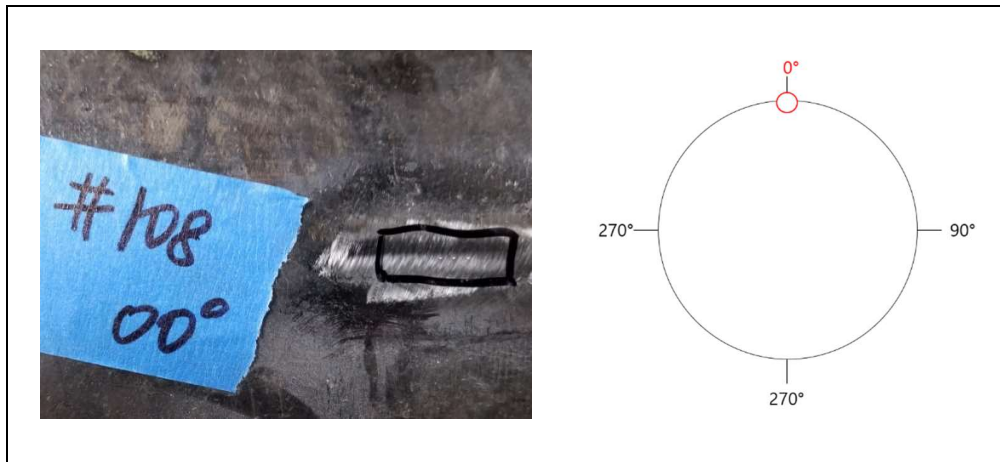
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 108
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.04	73.34	334.85
2	54.94	73.42	342.87
3	54.55	73.07	342.70
Avg.	54.84	73.28	340.14

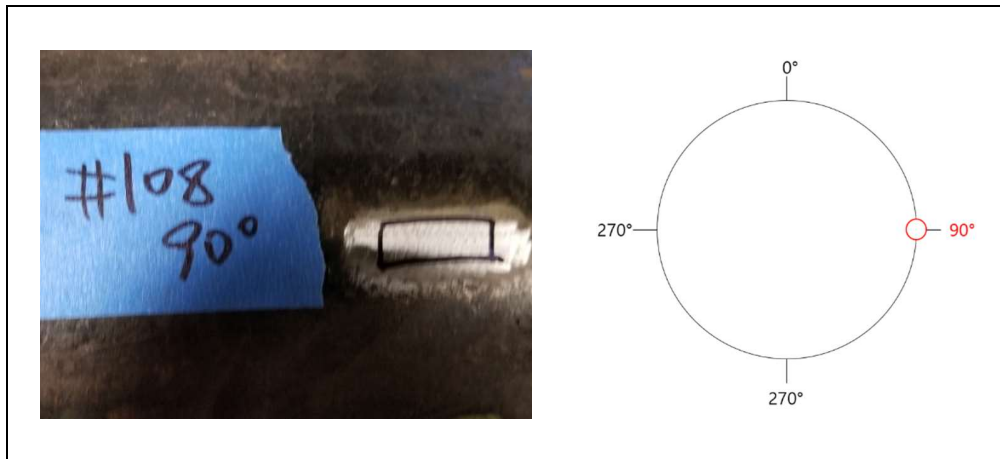
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 108
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.00	74.95	367.74
2	59.32	77.43	322.63
3	54.46	73.77	342.46
Avg.	56.93	75.38	344.28

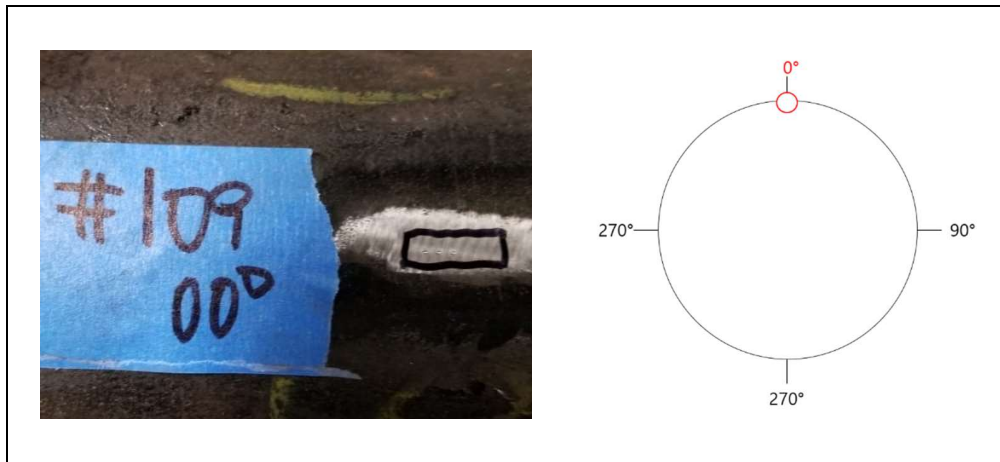
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 109
- (3) Pipe OD (inch) : 4
- (4) Location : 0°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	44.43	60.45	283.36
2	44.20	60.57	288.00
3	43.12	60.44	268.58
Avg.	43.92	60.49	279.98

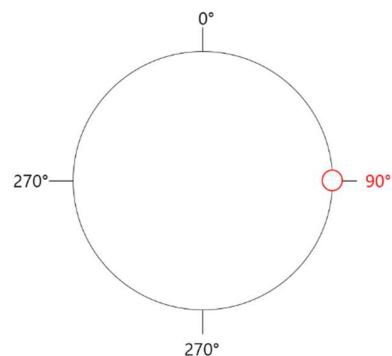
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 109
- (3) Pipe OD (inch) : 4
- (4) Location : 90°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	45.42	62.05	273.94
2	44.50	61.52	266.55
3	43.84	61.71	286.01
Avg.	44.59	61.76	275.50

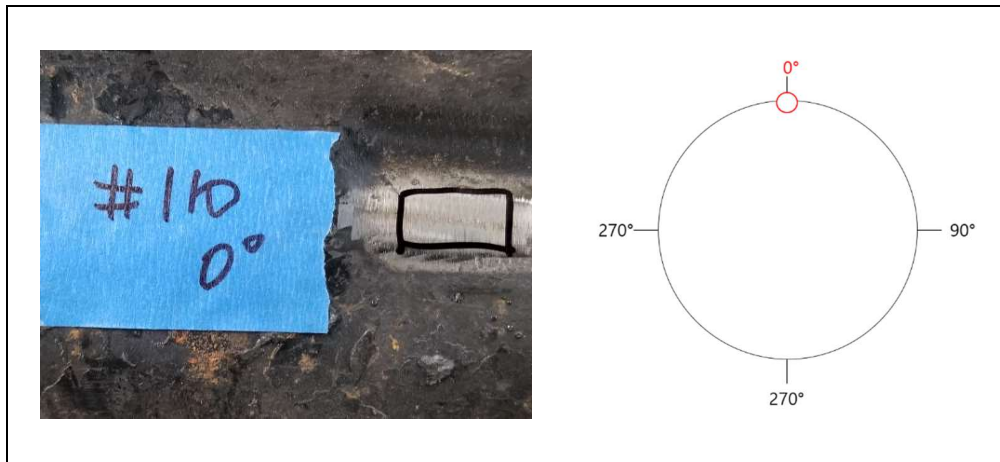
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 110
- (3) Pipe OD (inch) : 6
- (4) Location : 0°



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.26	67.28	305.09
2	51.32	67.22	299.61
3	52.48	66.38	303.28
Avg.	51.35	66.96	302.66

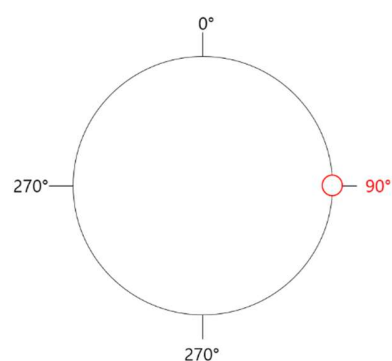
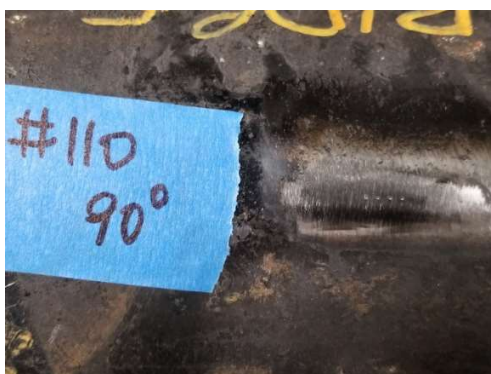
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 1010
- (3) Pipe OD (inch) : 6
- (4) Location : 90°



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.85	69.07	326.15
2	51.16	70.10	312.15
3	51.78	72.49	296.87
Avg.	52.26	70.55	311.72

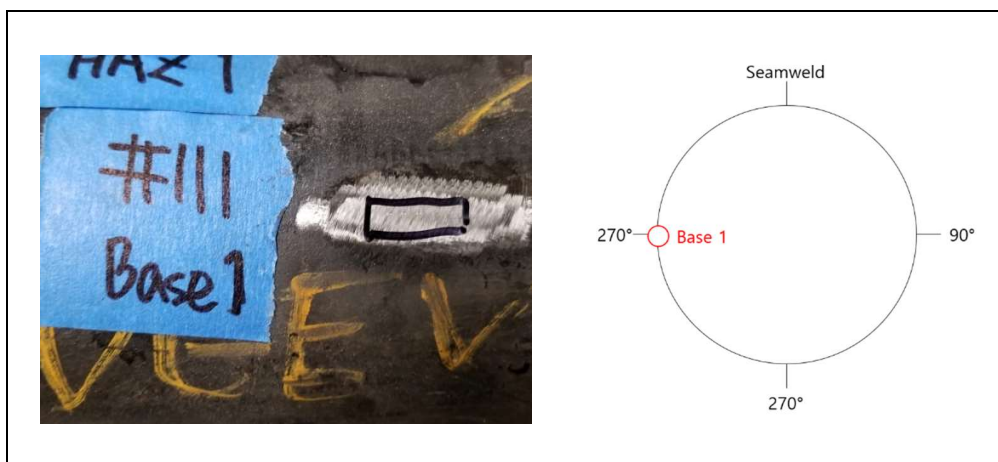
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 111
- (3) Pipe OD (inch) : 4
- (4) Location : Base 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.87	62.93	293.69
2	46.88	61.04	277.14
3	47.18	60.63	264.89
Avg.	46.98	61.53	278.57

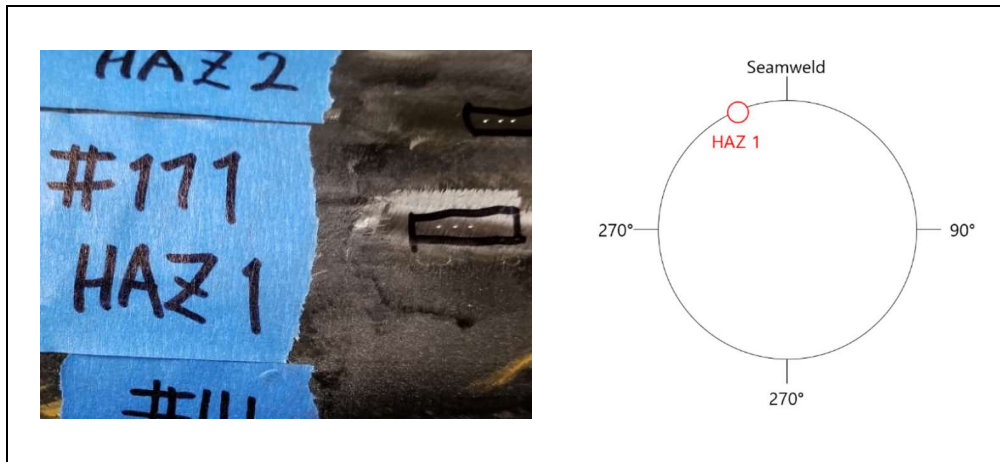
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 111
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	47.36	62.13	288.53
2	44.57	61.90	277.65
3	44.71	61.68	289.92
Avg.	45.54	61.90	285.37

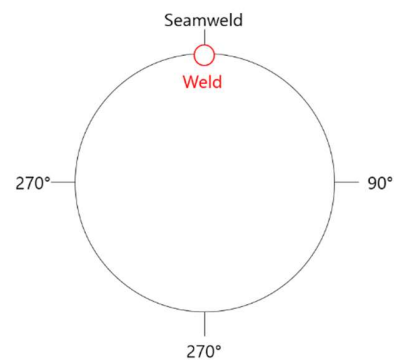
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 111
- (3) Pipe OD (inch) : 4
- (4) Location : Weld



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.02	63.74	304.51
2	45.85	62.80	274.10
3	47.25	64.29	272.94
Avg.	47.04	63.61	283.85

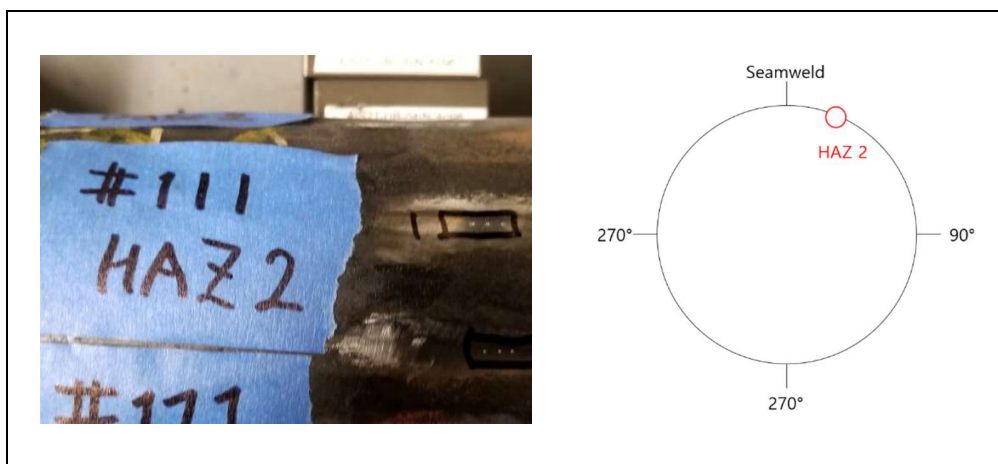
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 111
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.00	64.89	279.75
2	47.20	64.52	293.76
3	47.58	64.68	292.73
Avg.	47.59	64.69	288.75

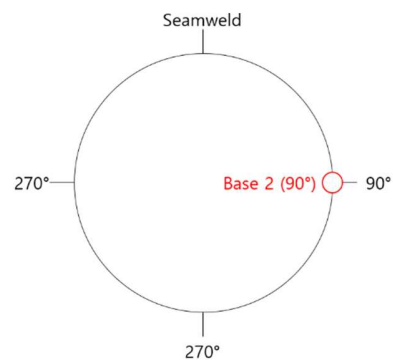
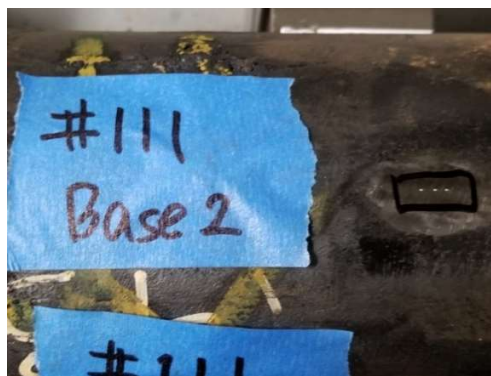
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 111
- (3) Pipe OD (inch) : 4
- (4) Location : Base 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.95	67.06	317.36
2	47.32	64.96	299.36
3	46.23	63.77	283.57
Avg.	47.83	65.26	300.10

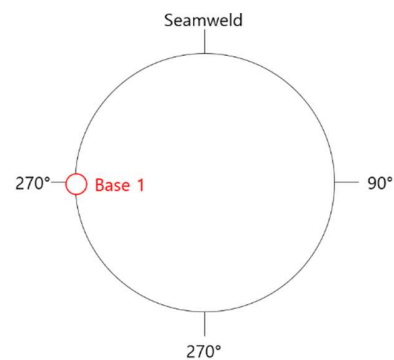
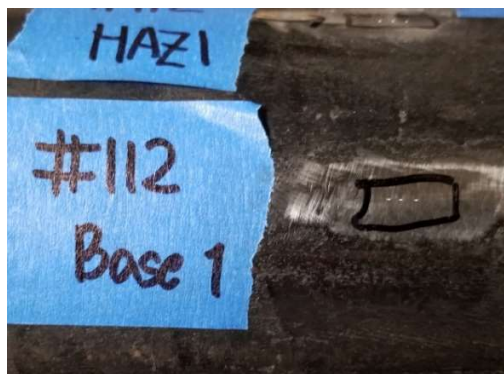
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 112
- (3) Pipe OD (inch) : 4
- (4) Location : Base 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.63	63.91	313.38
2	45.40	62.08	275.52
3	45.05	62.00	276.07
Avg.	45.70	62.66	288.32

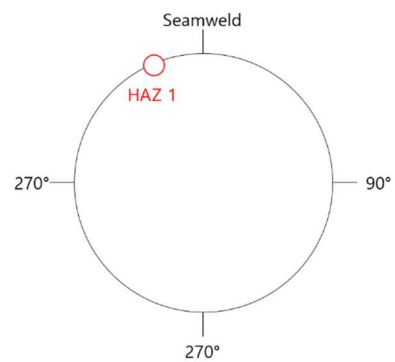
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 112
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	44.61	62.88	281.74
2	45.16	62.22	287.47
3	47.24	63.90	307.84
Avg.	45.67	63.00	292.35

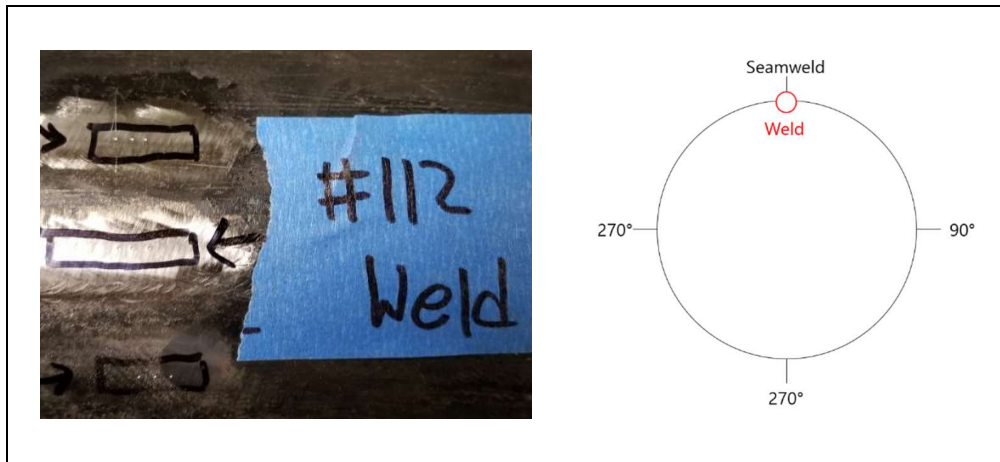
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 112
- (3) Pipe OD (inch) : 4
- (4) Location : Weld



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.16	62.70	284.66
2	47.70	64.19	308.91
3	47.23	63.83	292.70
Avg.	47.03	63.57	295.42

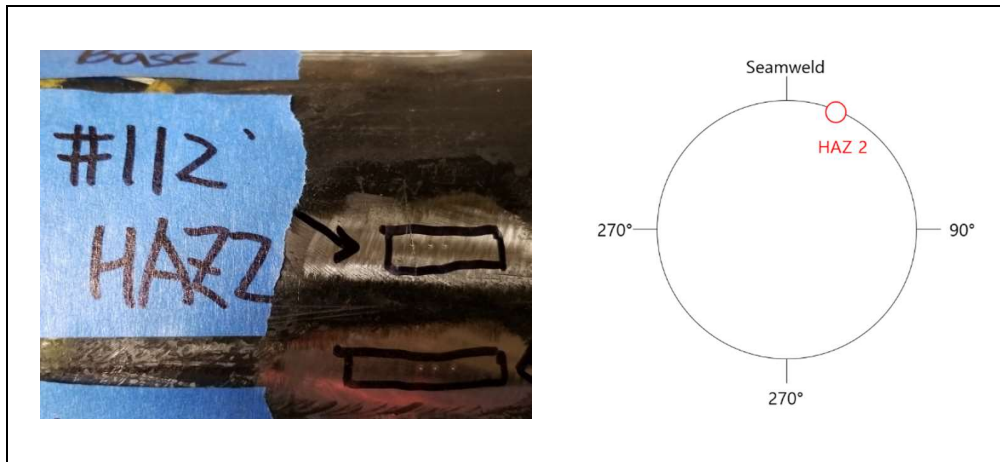
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 112
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.06	63.49	245.18
2	48.71	65.00	287.95
3	48.98	65.82	313.24
Avg.	47.92	64.77	282.12

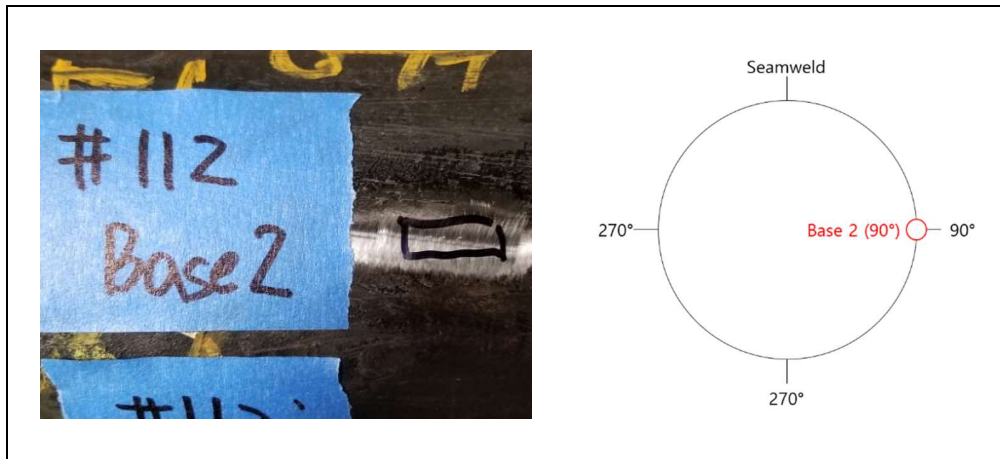
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 112
- (3) Pipe OD (inch) : 4
- (4) Location : Base 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.02	65.31	308.31
2	47.65	65.06	291.14
3	48.68	65.61	312.05
Avg.	48.45	65.33	303.83

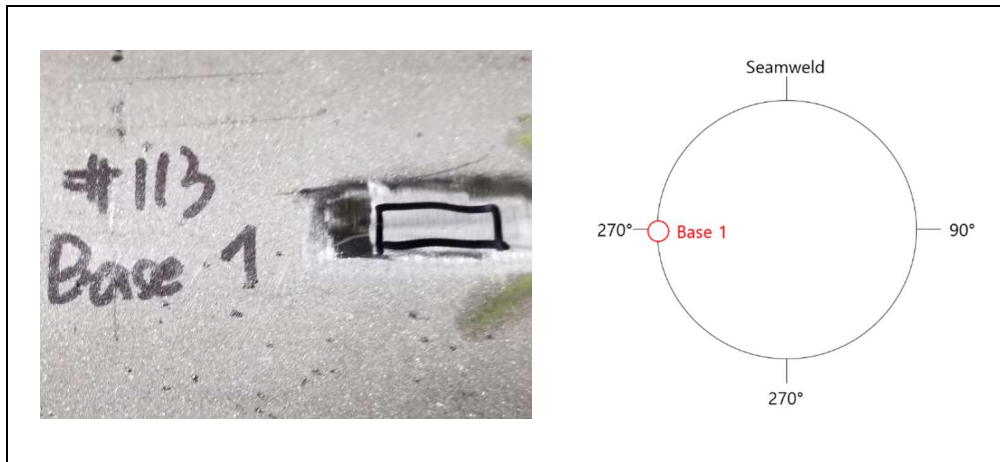
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 113
- (3) Pipe OD (inch) : 6
- (4) Location : Base 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.37	64.69	287.73
2	47.40	64.50	286.36
3	47.21	64.33	272.90
Avg.	47.66	64.51	282.33

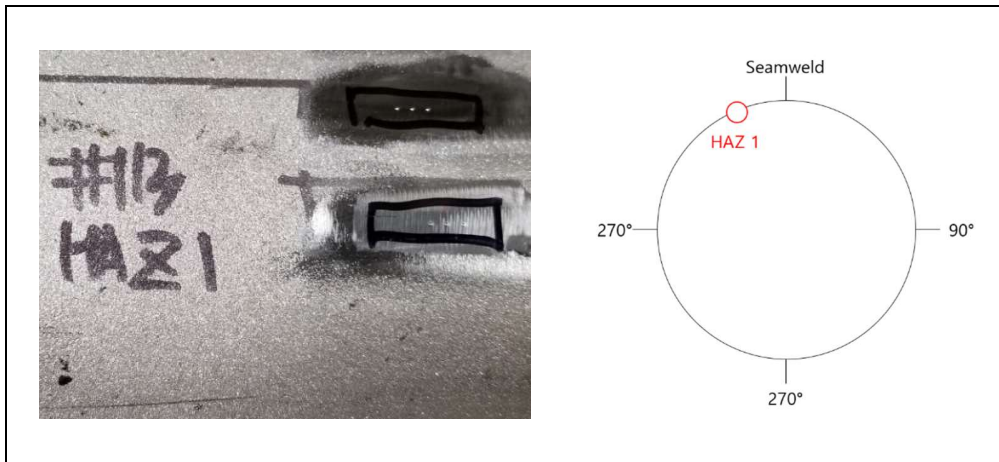
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 113
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.07	68.26	306.80
2	50.90	68.57	283.31
3	51.87	68.69	300.57
Avg.	51.61	68.51	296.89

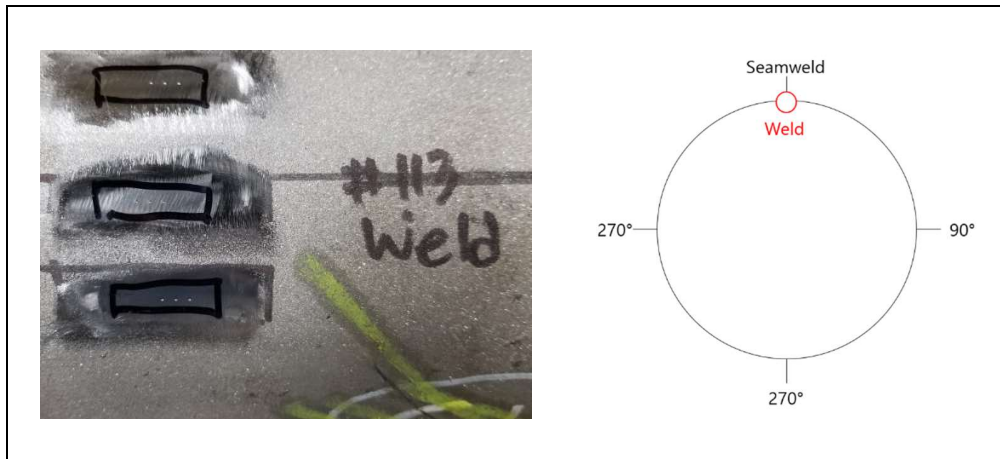
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 113
- (3) Pipe OD (inch) : 6
- (4) Location : Weld



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.91	79.00	350.80
2	59.44	79.03	365.60
3	59.48	78.99	373.07
Avg.	59.28	79.01	363.16

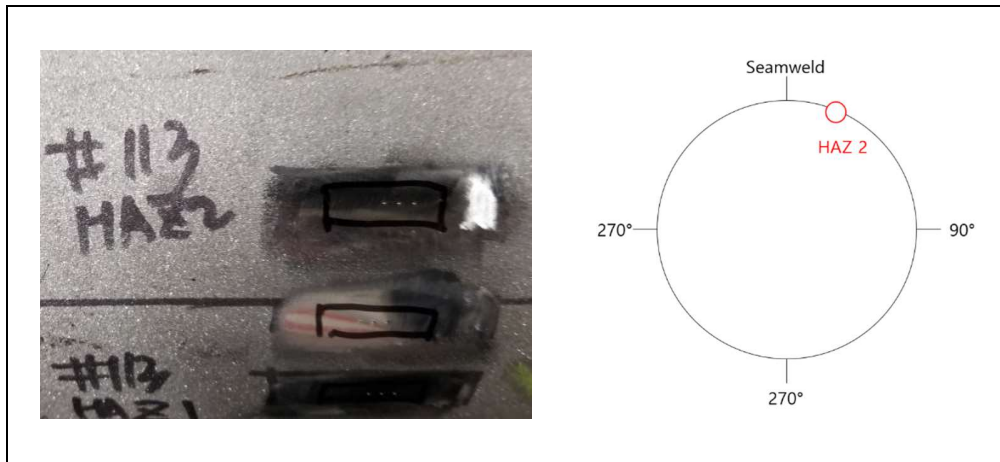
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 113
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.91	71.12	330.06
2	52.76	70.42	318.09
3	52.49	69.97	302.14
Avg.	53.05	70.50	316.76

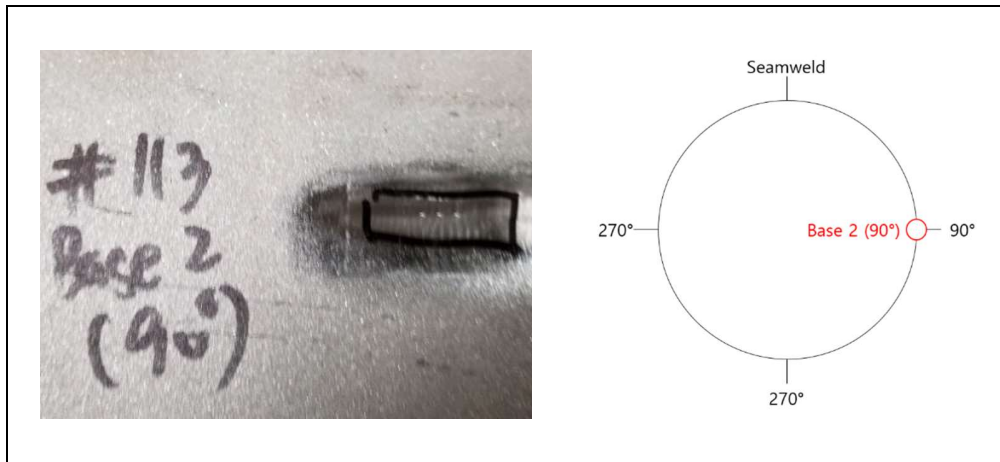
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 113
- (3) Pipe OD (inch) : 6
- (4) Location : Base 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.38	64.52	306.07
2	47.87	64.25	287.35
3	46.99	64.10	293.89
Avg.	47.75	64.29	295.77

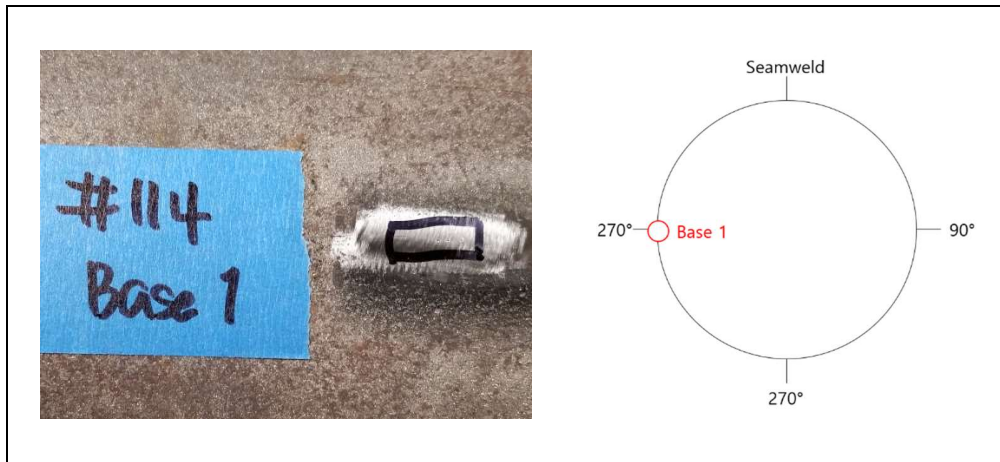
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 114
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.25	64.03	310.95
2	48.32	64.25	306.46
3	47.48	63.41	284.80
Avg.	48.01	63.90	300.74

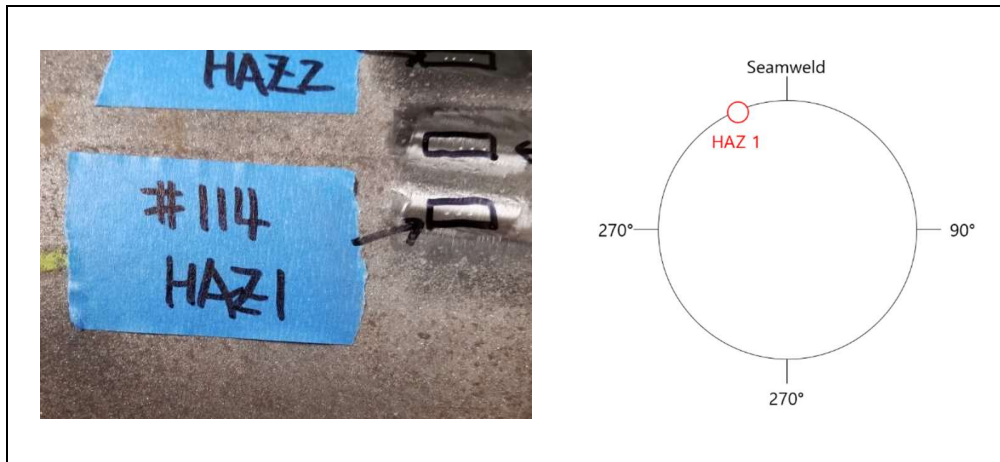
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 114
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.01	69.52	287.28
2	55.13	71.17	349.11
3	53.44	70.21	310.21
Avg.	53.52	70.30	315.53

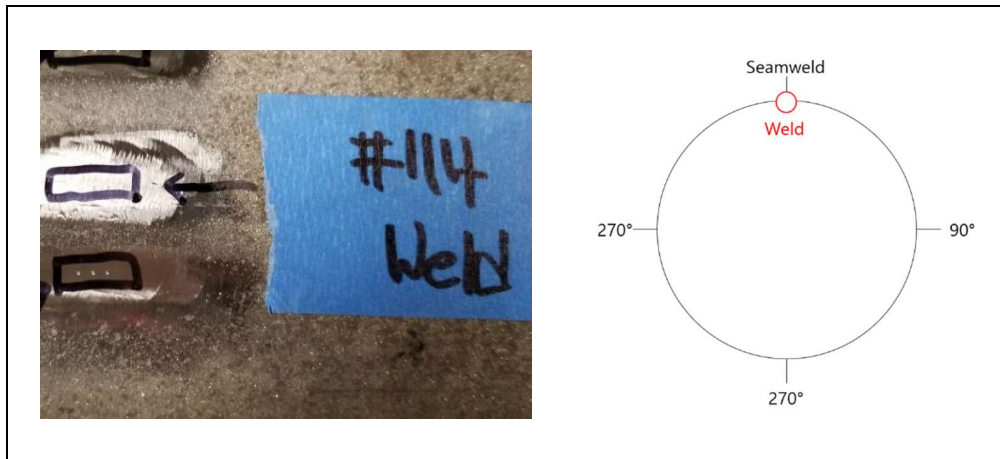
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 114
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.56	82.94	387.38
2	64.20	83.09	391.57
3	61.99	81.67	370.15
Avg.	63.58	82.57	383.03

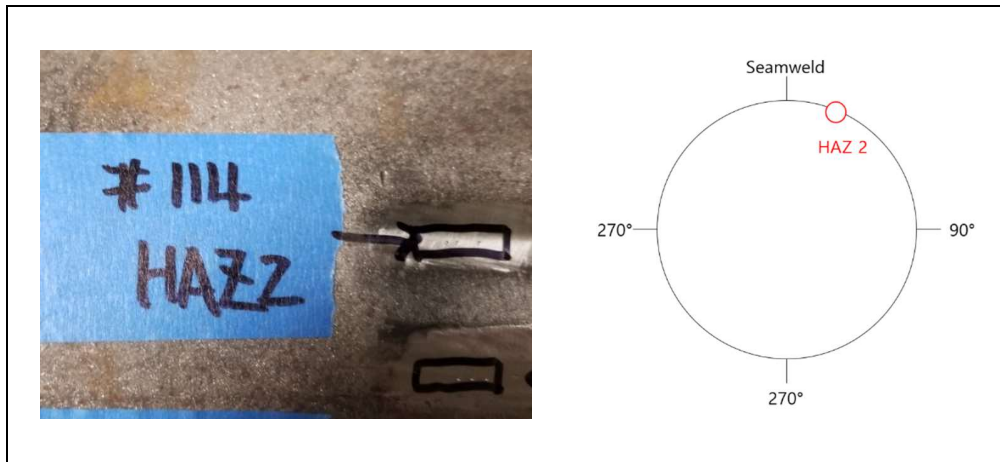
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 114
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.66	69.08	314.14
2	51.47	68.57	291.14
3	52.22	68.52	299.61
Avg.	52.45	68.73	301.63

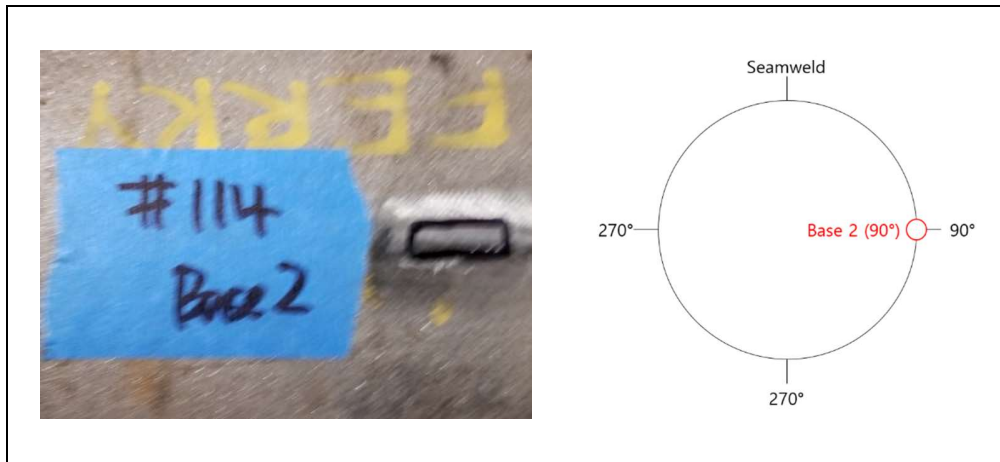
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 114
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	45.98	56.10	251.92
2	45.91	56.01	249.28
3	43.01	55.45	197.22
Avg.	44.96	55.86	232.81

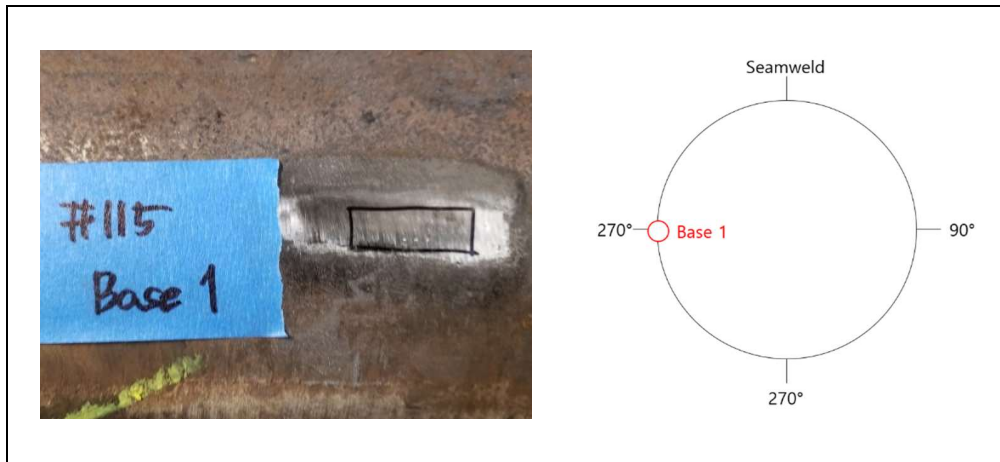
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 115
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	43.64	59.80	244.60
2	45.47	60.55	261.80
3	46.27	61.35	265.44
Avg.	45.13	60.57	257.28

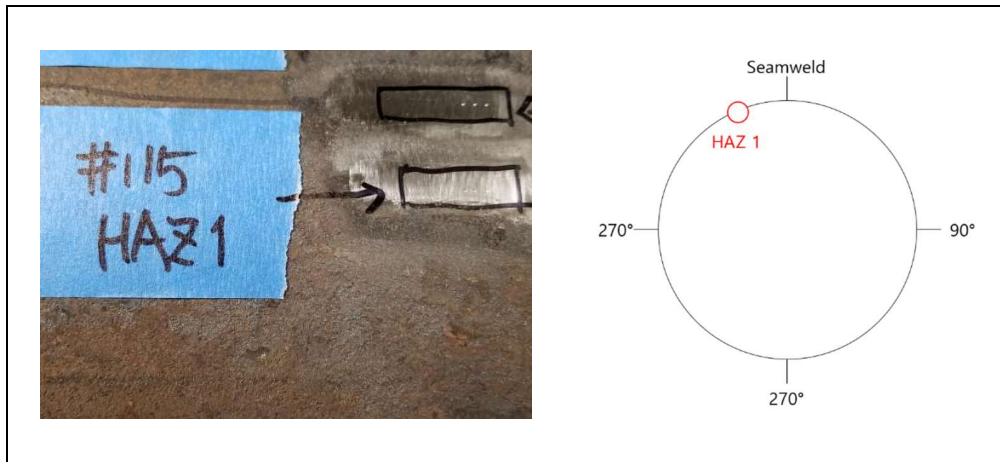
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 115
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	47.32	64.19	279.87
2	44.73	62.31	245.90
3	46.81	63.08	277.66
Avg.	46.29	63.19	267.81

* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 115
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.19	70.81	310.53
2	52.77	69.84	311.11
3	51.82	69.56	286.10
Avg.	52.93	70.07	302.58

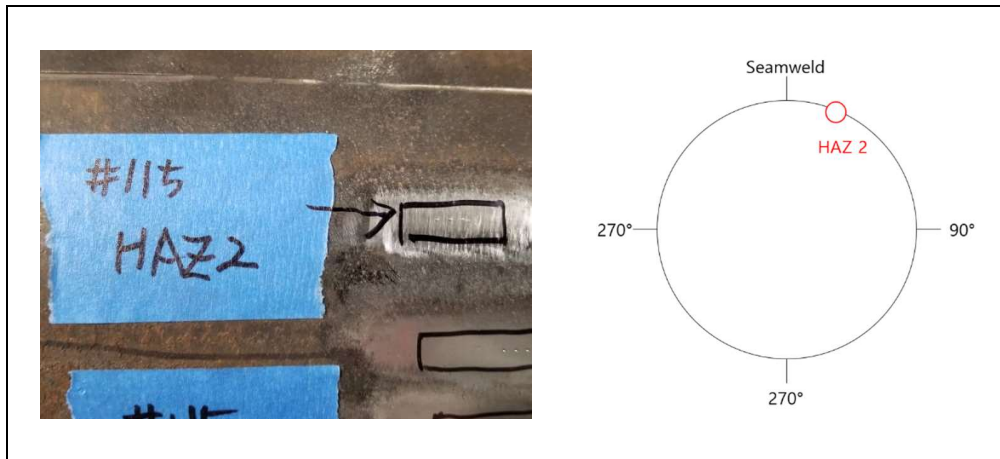
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 115
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.94	67.86	271.16
2	52.40	68.48	300.49
3	51.93	67.58	287.56
Avg.	51.76	67.98	286.40

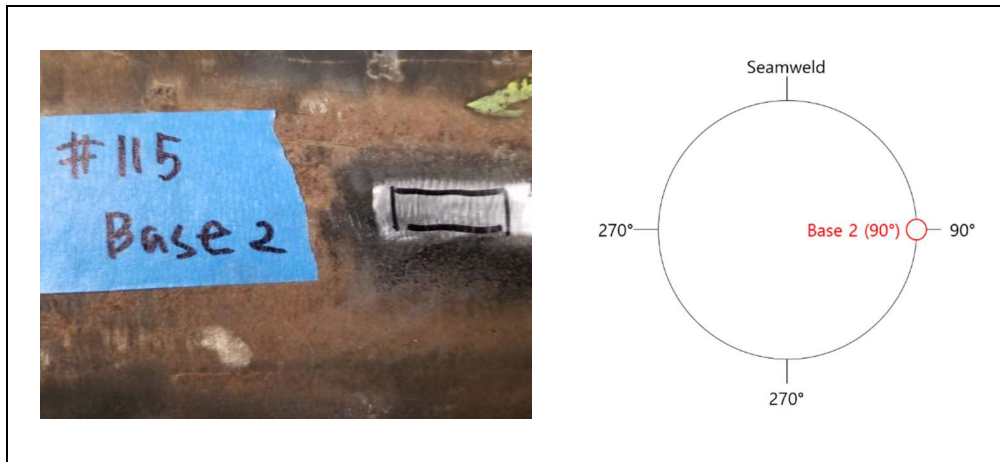
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 115
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.58	61.39	275.76
2	46.64	61.51	284.79
3	46.02	60.87	265.91
Avg.	46.41	61.26	275.49

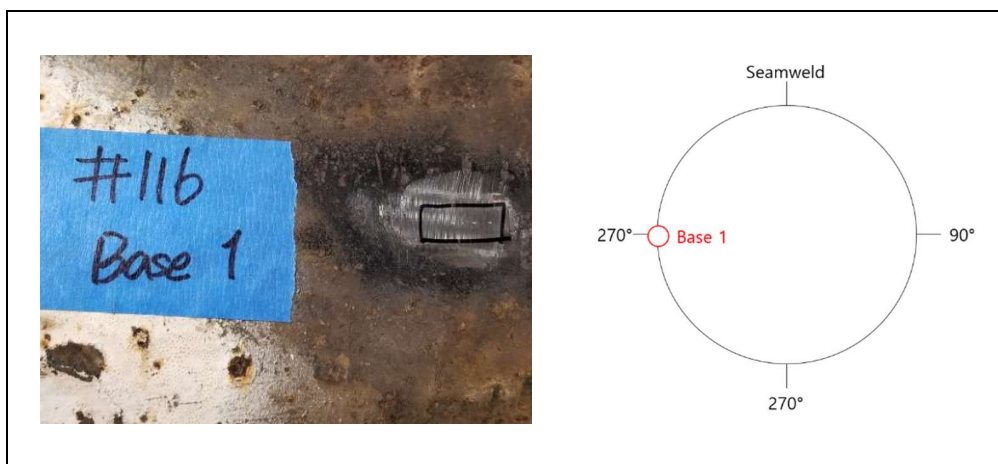
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 116
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	44.00	56.56	246.95
2	46.01	59.81	266.61
3	46.21	61.87	275.75
Avg.	45.41	59.41	263.11

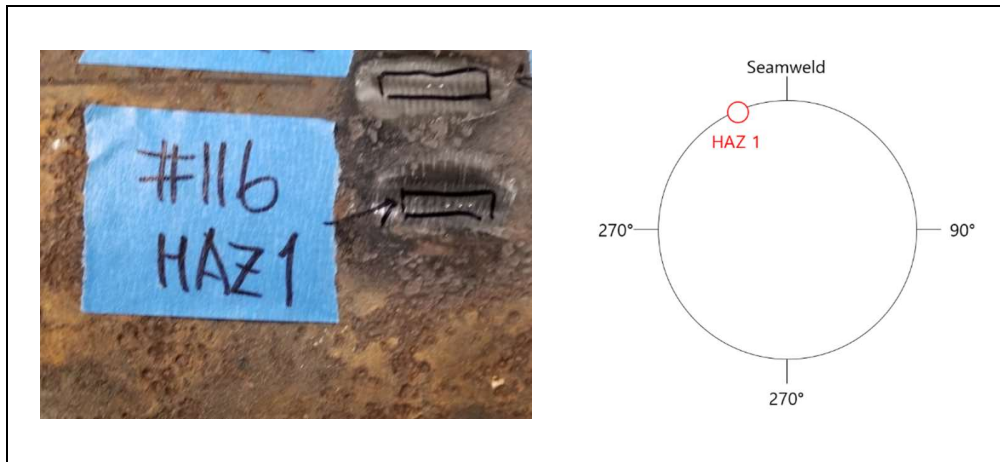
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 116
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.74	64.69	316.91
2	45.86	62.23	261.45
3	47.24	62.98	279.34
Avg.	47.61	63.30	285.90

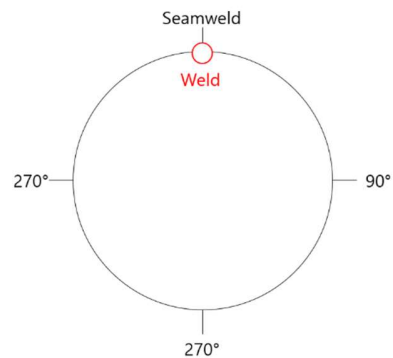
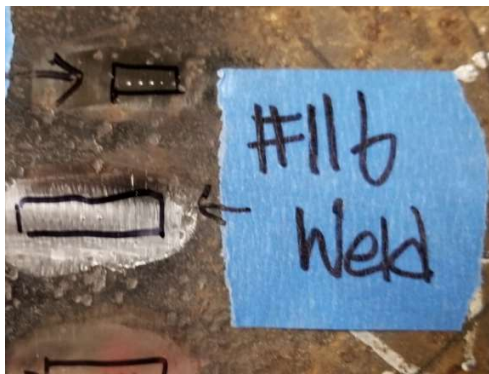
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 116
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.96	86.30	384.80
2	66.17	87.80	402.44
3			
Avg.	65.56	87.05	393.62

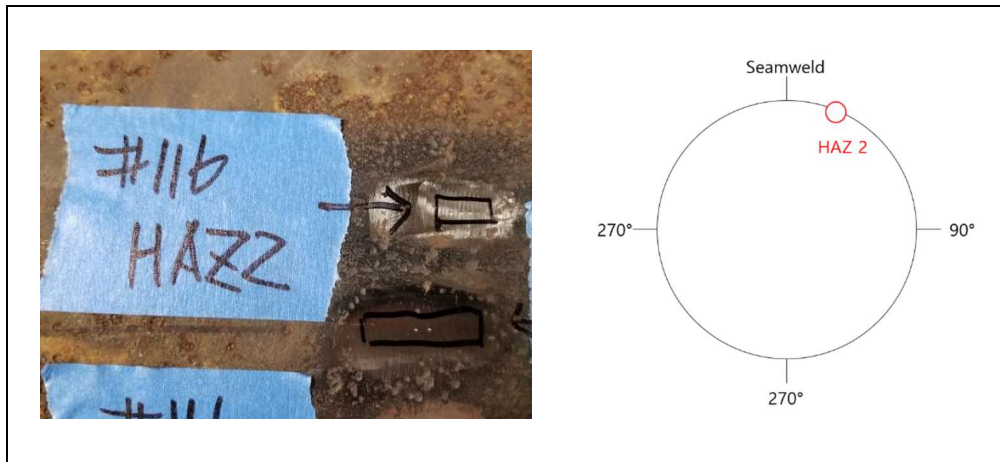
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 116
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.71	66.78	279.63
2	49.50	65.74	283.65
3	48.94	65.40	280.20
Avg.	49.72	65.97	281.16

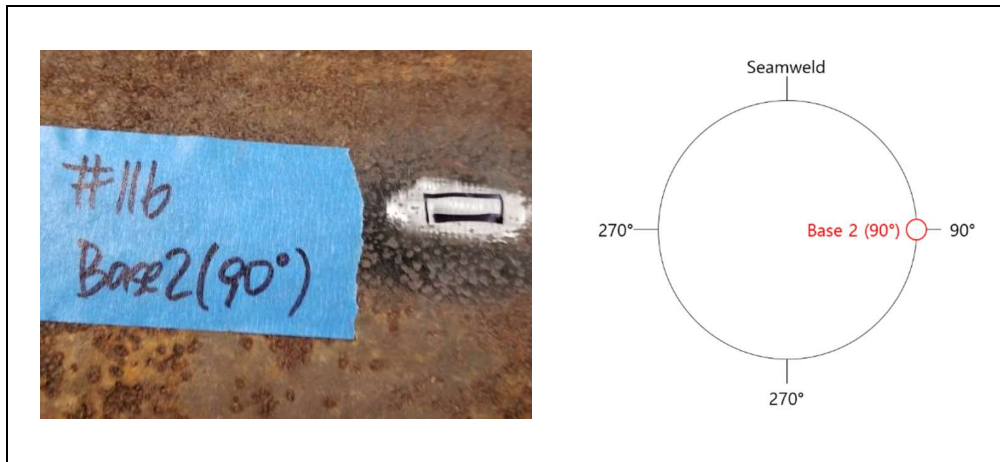
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 116
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	45.80	61.93	282.49
2	45.34	61.42	284.05
3	44.59	61.42	288.59
Avg.	45.24	61.59	285.04

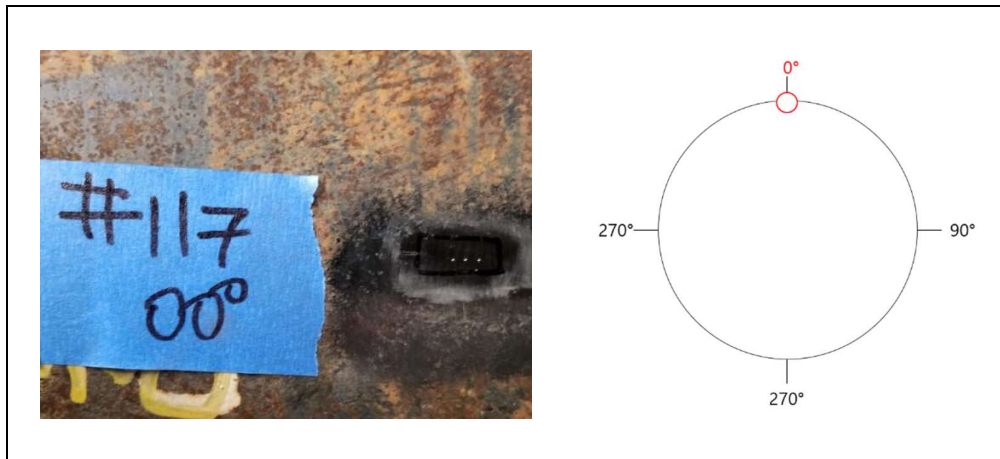
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 117
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.42	76.27	377.42
2	55.74	74.86	344.34
3	55.39	74.60	328.47
Avg.	55.52	75.24	350.08

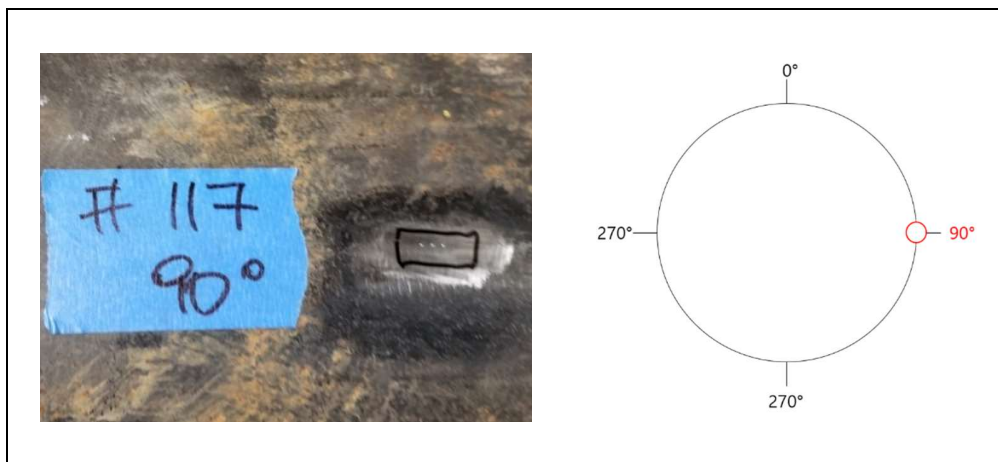
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 117
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.35	77.94	372.32
2	58.17	78.19	373.82
3	58.16	78.89	380.21
Avg.	58.23	78.34	375.45

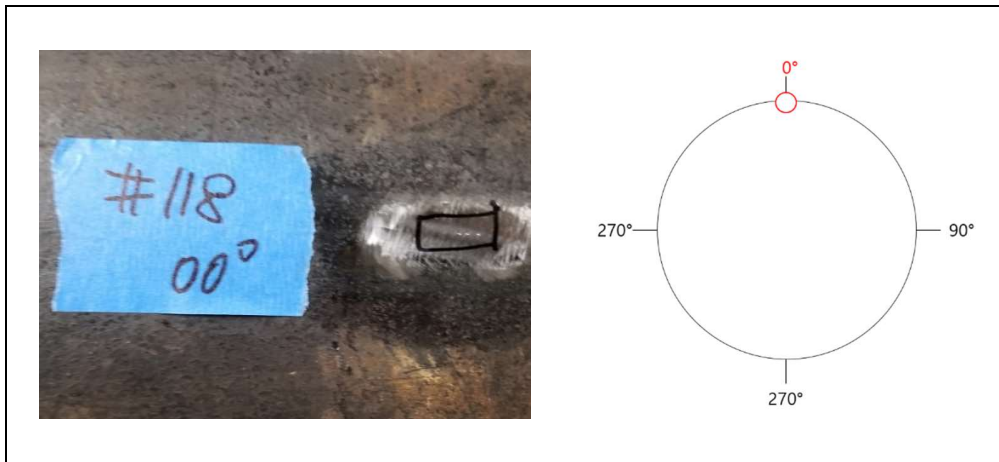
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 118
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.53	74.23	345.90
2	53.80	73.48	330.68
3	54.13	73.32	345.84
Avg.	54.49	73.68	340.81

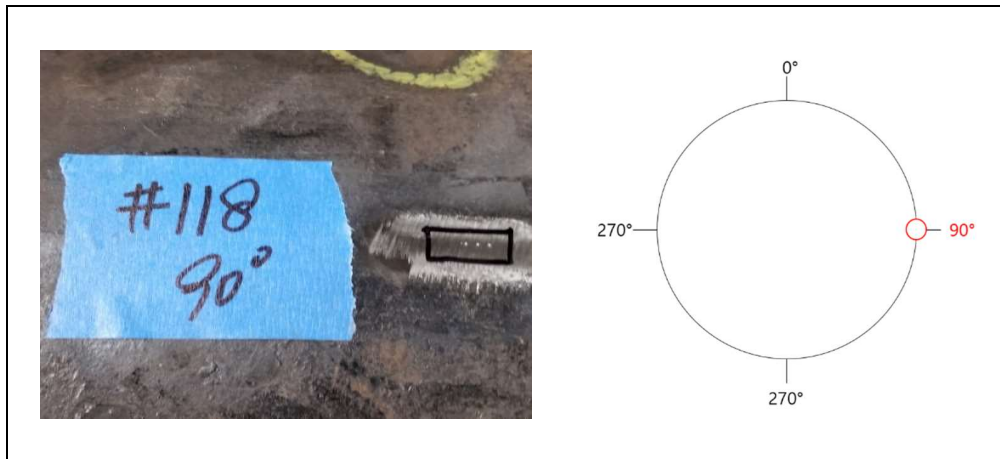
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 118
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.59	73.63	362.67
2	55.80	74.24	369.72
3	55.63	74.89	381.65
Avg.	56.01	74.25	371.35

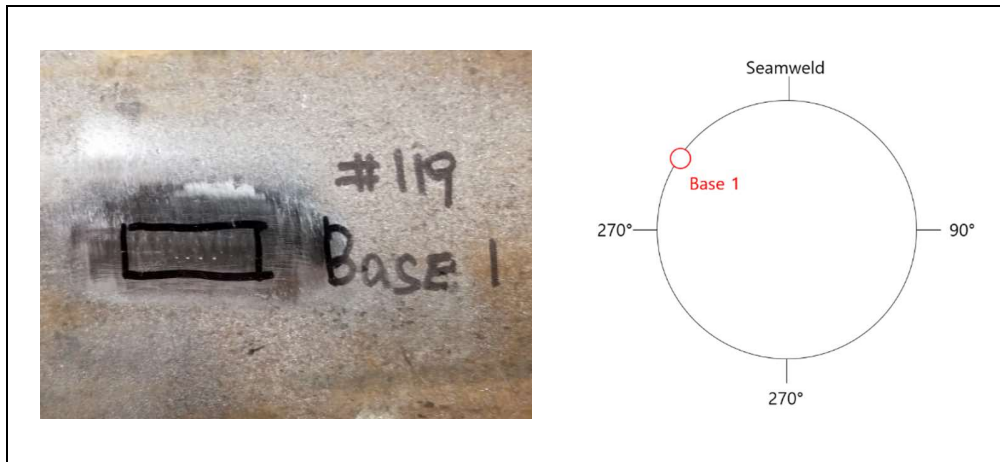
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.57	78.41	393.59
2	58.01	78.29	392.84
3	59.03	79.39	377.39
Avg.	58.54	78.70	387.94

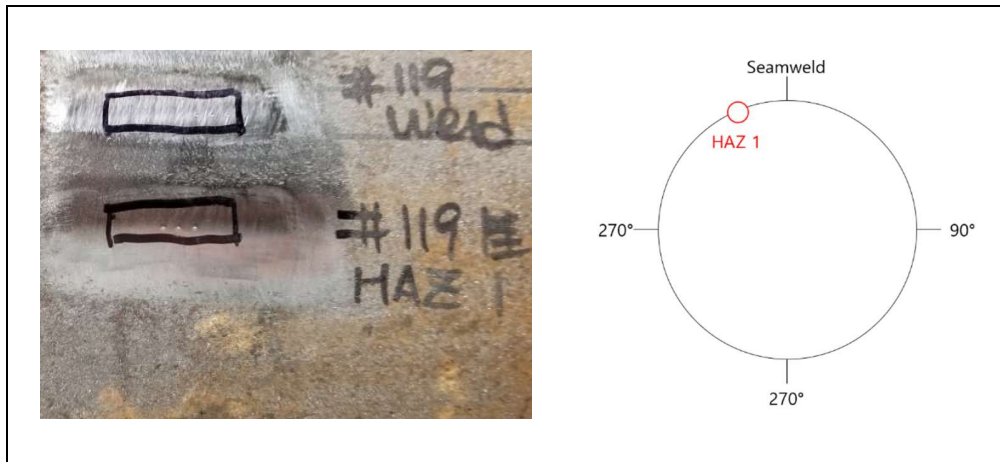
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.19	78.67	367.96
2	57.87	79.80	415.38
3	55.12	77.12	349.92
Avg.	57.06	78.53	377.75

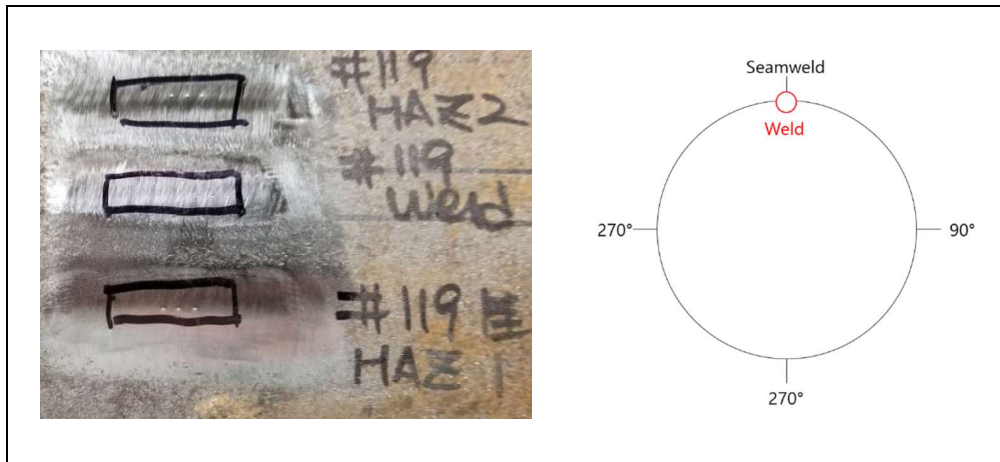
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.41	77.72	371.37
2	57.40	77.81	380.58
3	58.54	79.16	397.49
Avg.	57.78	78.23	383.14

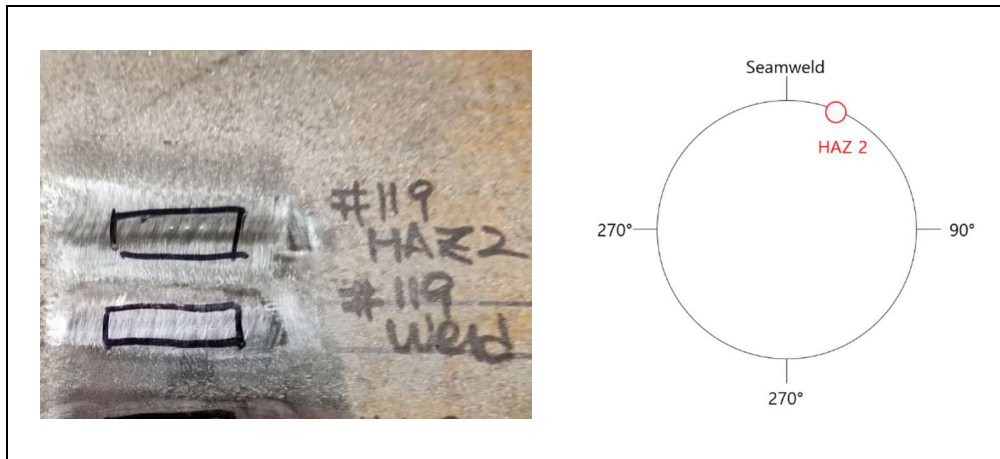
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.12	78.62	367.82
2	57.72	78.71	385.81
3	55.42	77.07	336.94
Avg.	57.09	78.13	363.52

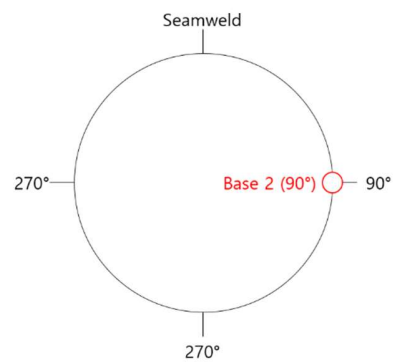
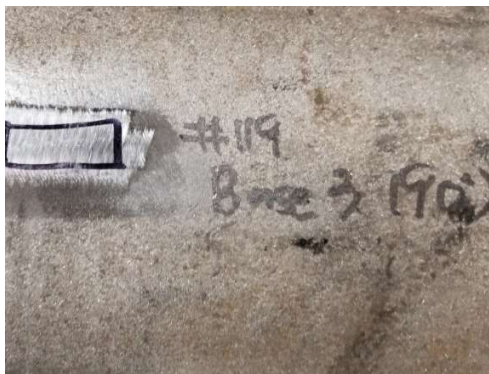
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.51	77.29	371.63
2	57.00	77.25	368.42
3	56.75	77.15	365.56
Avg.	56.51	77.29	371.63

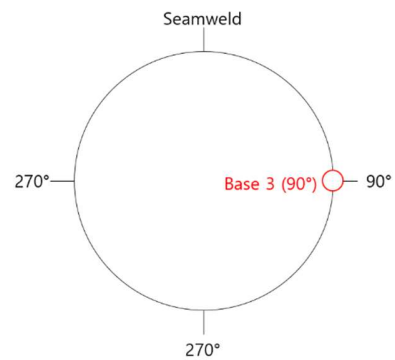
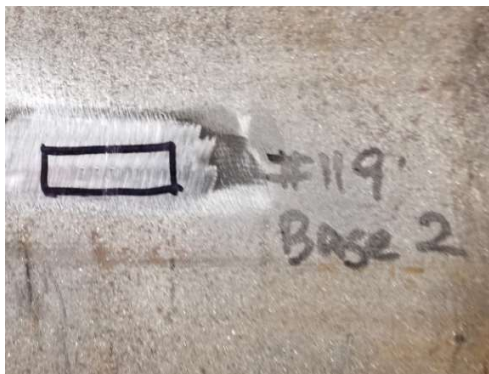
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 119
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3 (90°)



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.45	81.04	422.56
2	59.52	80.84	385.89
3	59.46	80.51	413.82
Avg.	59.81	80.80	407.42

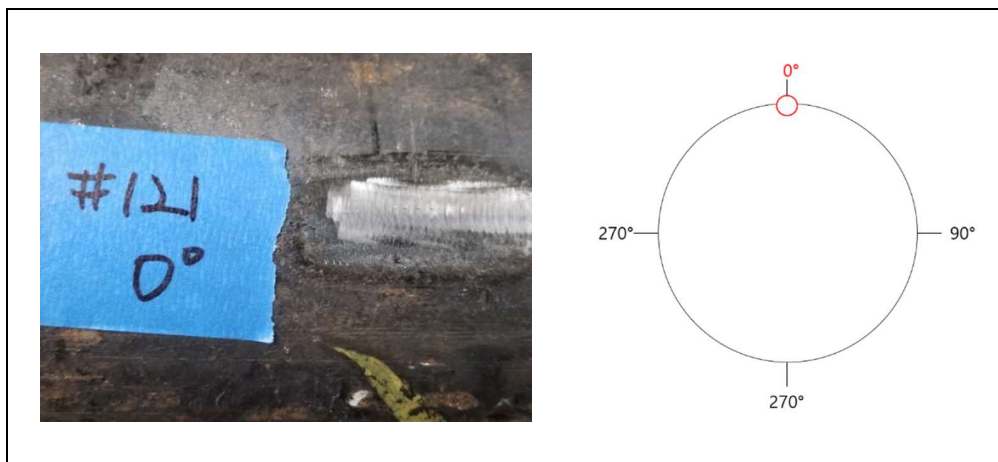
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 121
- (3) Pipe OD (inch) : 6
- (4) Location : 0°



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.92	74.59	300.77
2	52.74	71.51	293.30
3	52.77	70.34	333.94
Avg.	54.14	72.15	309.34

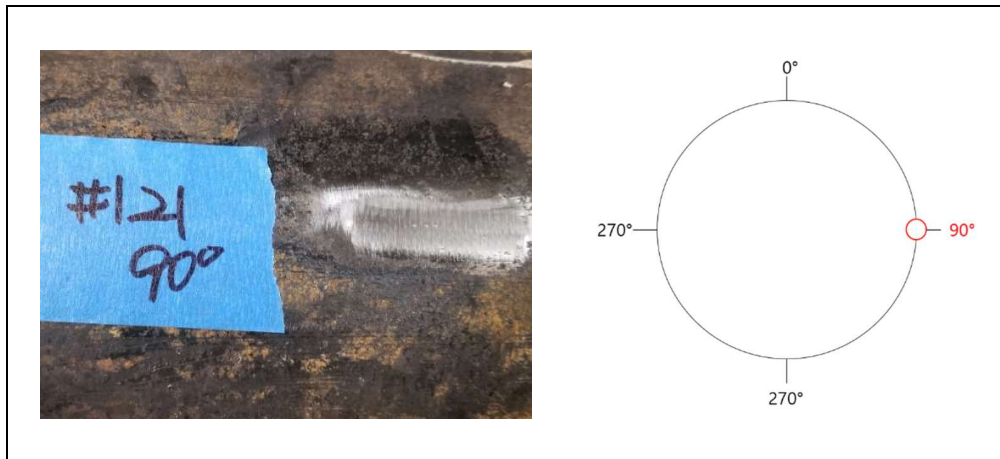
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 121
- (3) Pipe OD (inch) : 6
- (4) Location : 90°



2. Condition

Date	4/2/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.48	68.81	303.79
2	50.88	69.15	301.27
3	52.15	69.57	314.42
Avg.	51.51	69.18	306.49

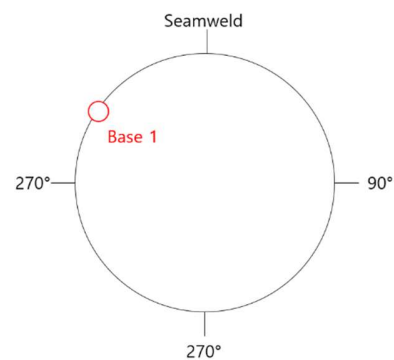
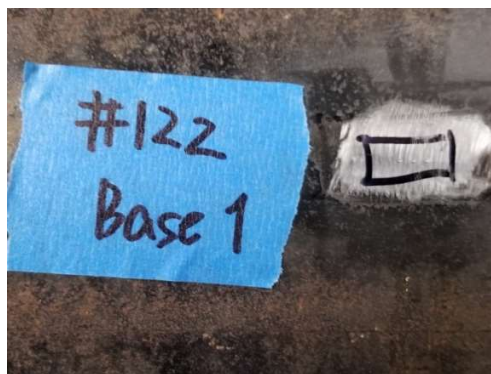
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.69	76.34	362.17
2	57.46	76.56	365.26
3	56.40	75.97	340.31
Avg.	57.52	76.29	355.91

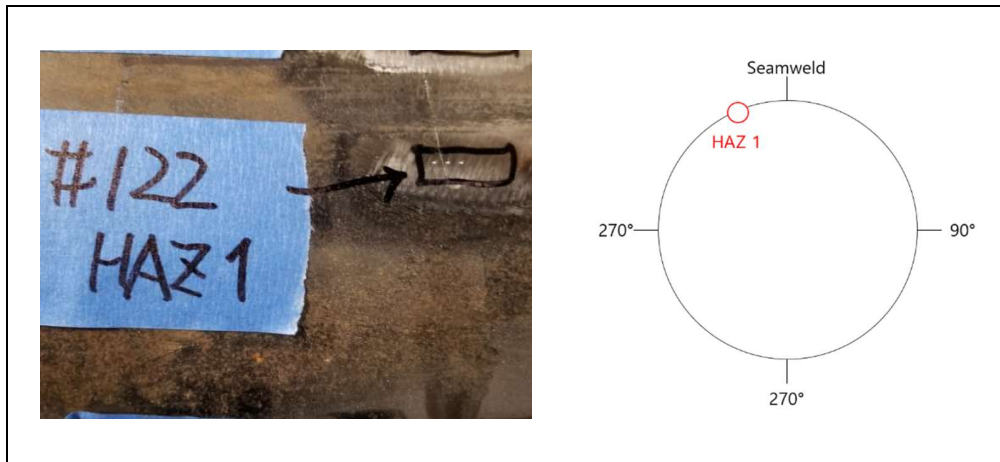
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.15	83.66	366.69
2	64.61	84.59	396.54
3	64.04	84.30	396.24
Avg.	63.93	84.18	386.49

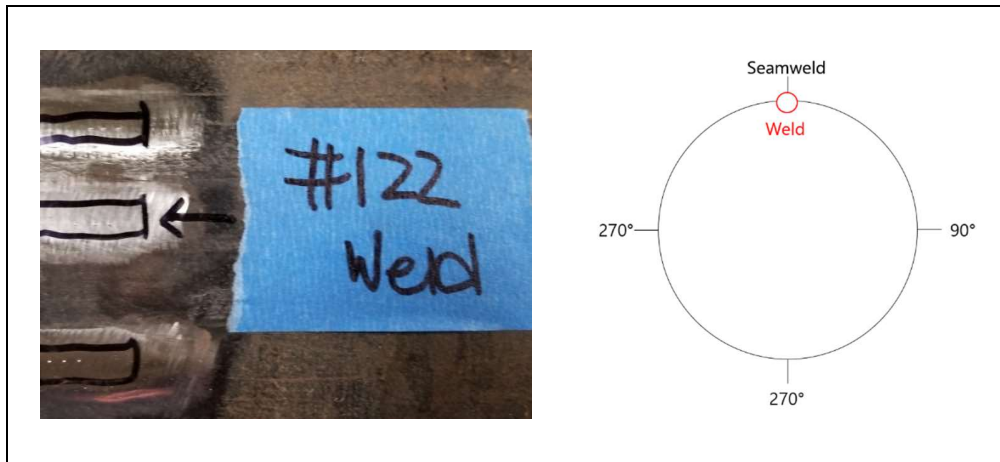
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	65.58	86.22	422.77
2	63.16	84.74	383.54
3	62.92	84.82	407.44
Avg.	63.89	85.26	404.59

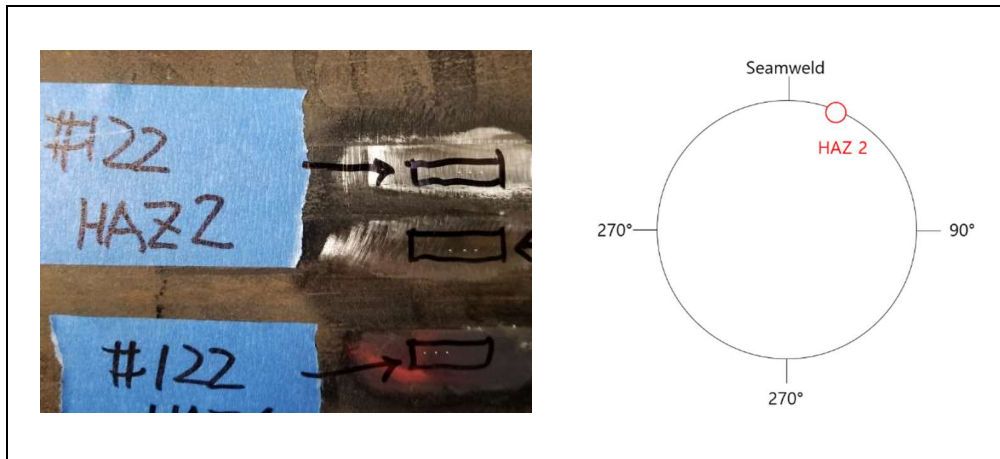
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	65.61	84.09	396.18
2	65.06	84.29	412.50
3	63.95	83.56	393.39
Avg.	64.87	83.98	400.69

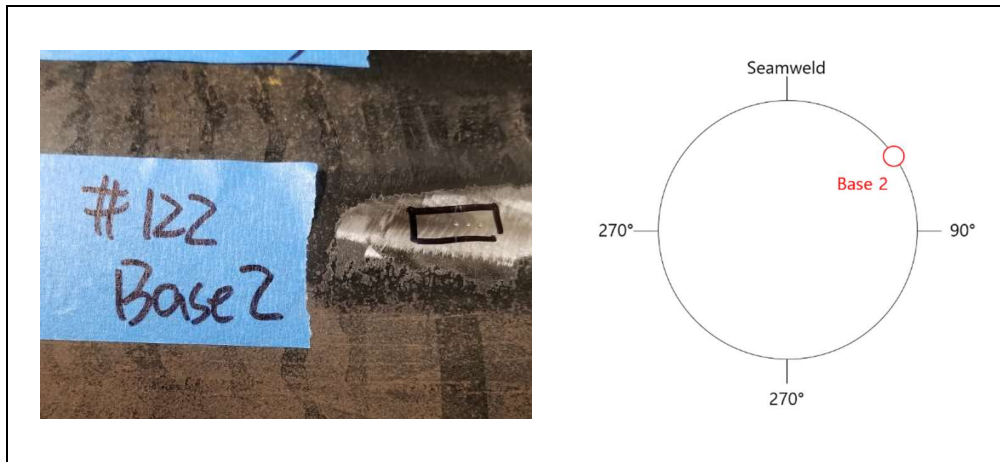
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.31	74.83	352.36
2	55.96	74.70	342.61
3	56.21	75.13	343.22
Avg.	56.16	74.89	346.06

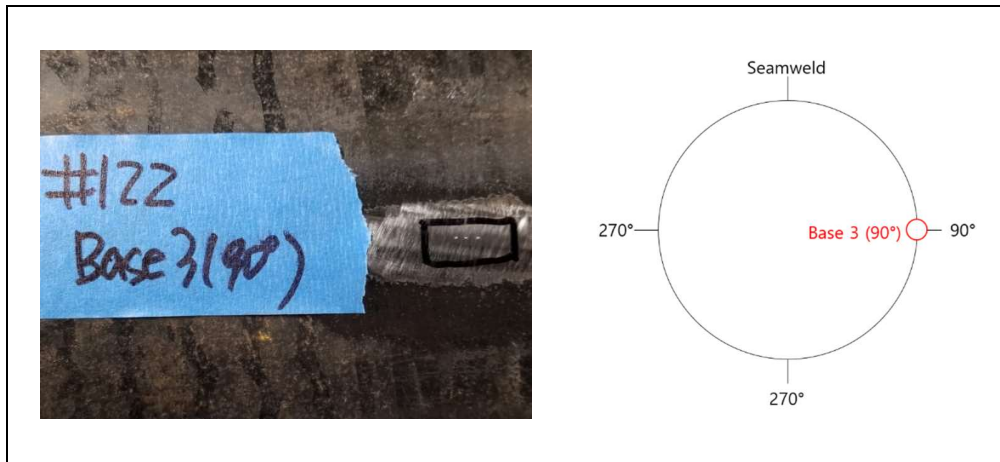
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 122
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3(90°)



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.94	75.73	364.83
2	57.65	75.77	365.46
3	57.23	76.17	370.44
Avg.	57.27	75.89	366.91

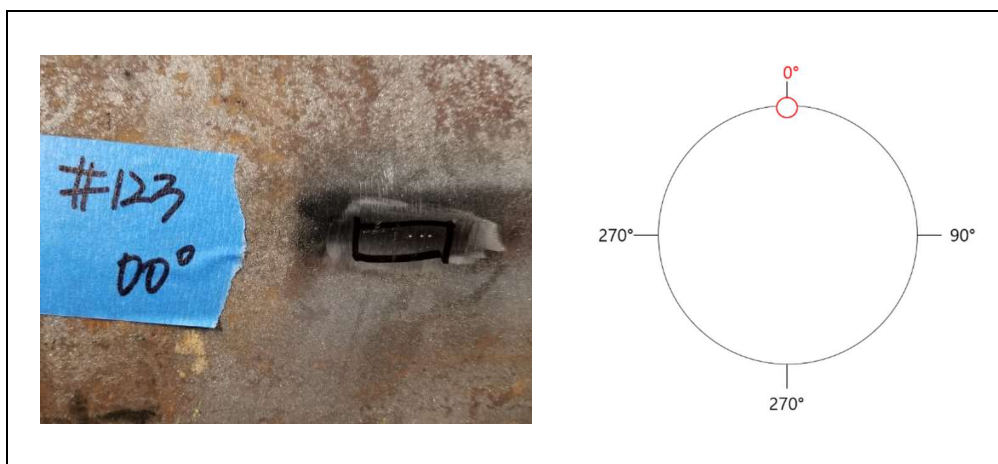
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 123
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.69	77.86	309.62
2	59.63	78.72	353.45
3	58.99	78.49	364.15
Avg.	58.77	78.36	342.41

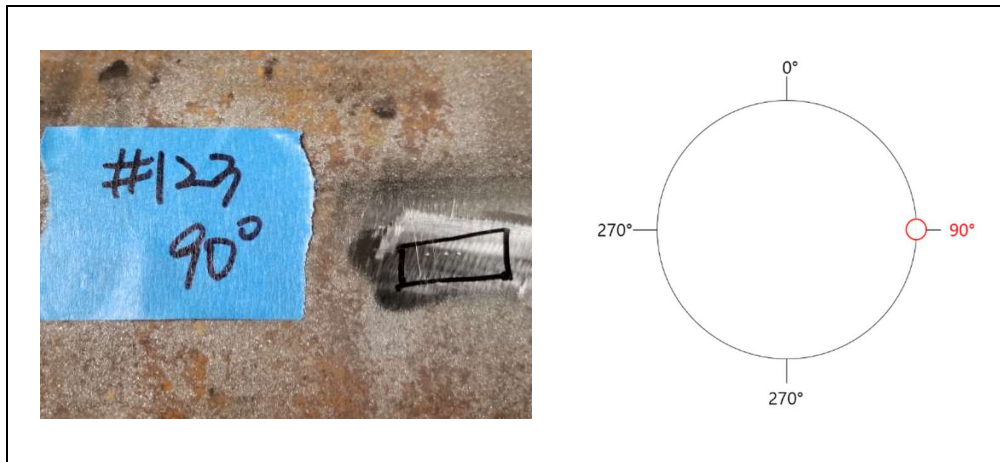
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 123
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.03	79.54	360.46
2	61.03	79.44	336.16
3	59.71	79.02	350.34
Avg.	60.59	79.33	348.98

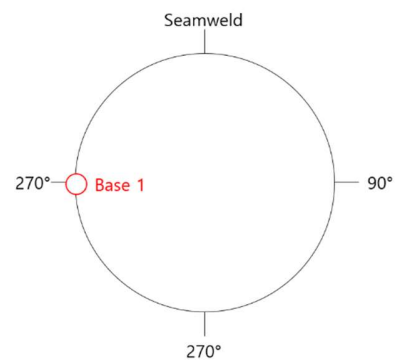
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 124
- (3) Pipe OD (inch) : 6
- (4) Location : Base 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	47.25	65.52	238.22
2	47.48	65.59	235.81
3	46.72	64.93	252.28
Avg.	47.15	65.34	242.10

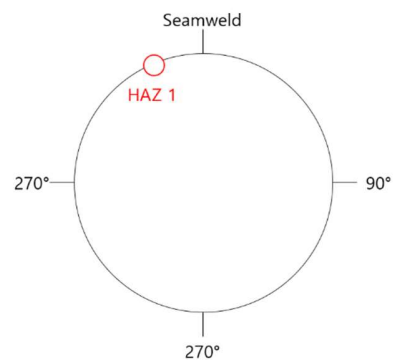
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 124
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.08	68.20	275.77
2	48.95	68.35	251.64
3	50.30	68.46	258.56
Avg.	50.11	68.34	261.99

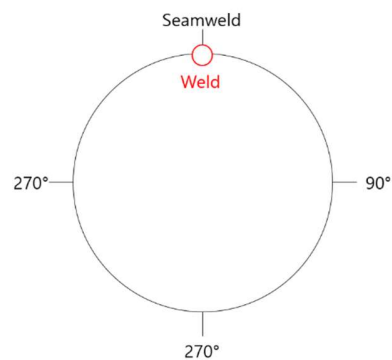
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 124
- (3) Pipe OD (inch) : 6
- (4) Location : Weld



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.20	78.92	251.61
2	57.60	78.27	281.36
3	58.43	78.87	288.41
Avg.	57.41	78.69	273.79

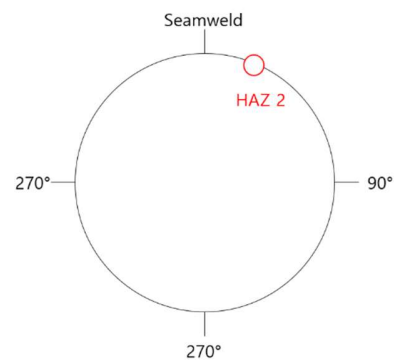
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 124
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.25	68.14	239.29
2	50.11	68.29	236.79
3	49.99	67.87	234.40
Avg.	49.78	68.10	236.83

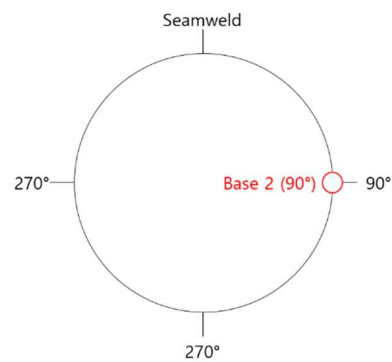
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 124
- (3) Pipe OD (inch) : 6
- (4) Location : Base 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	46.43	63.93	227.30
2	49.16	66.58	228.25
3	47.28	65.26	231.76
Avg.	47.63	65.26	229.11

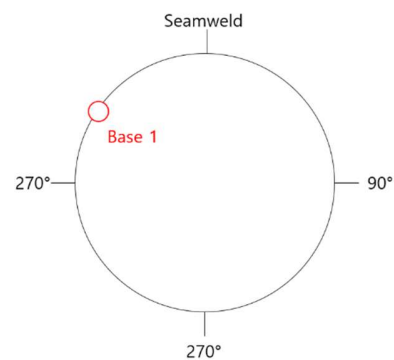
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.42	79.23	302.70
2	59.38	79.63	309.33
3	60.09	79.98	317.65
Avg.	59.30	79.62	309.89

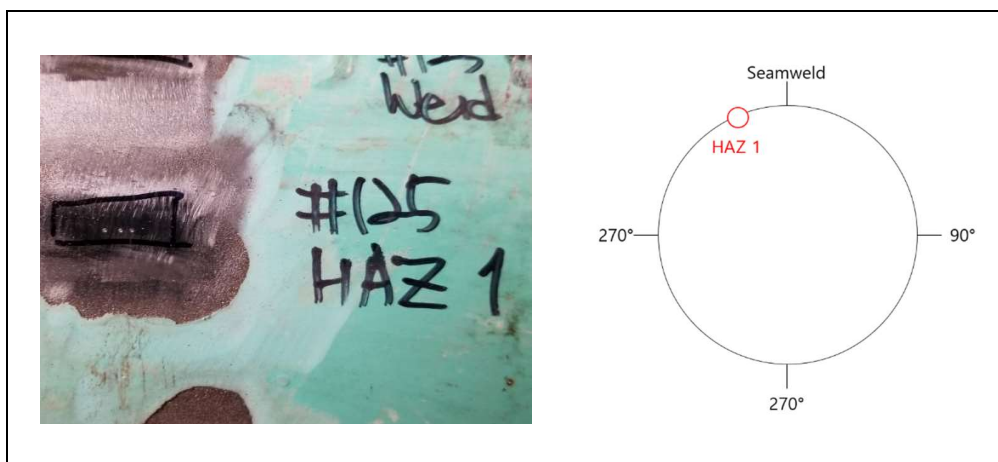
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.61	83.59	343.27
2	62.87	84.63	320.24
3	61.42	85.95	297.34
Avg.	62.63	84.72	320.28

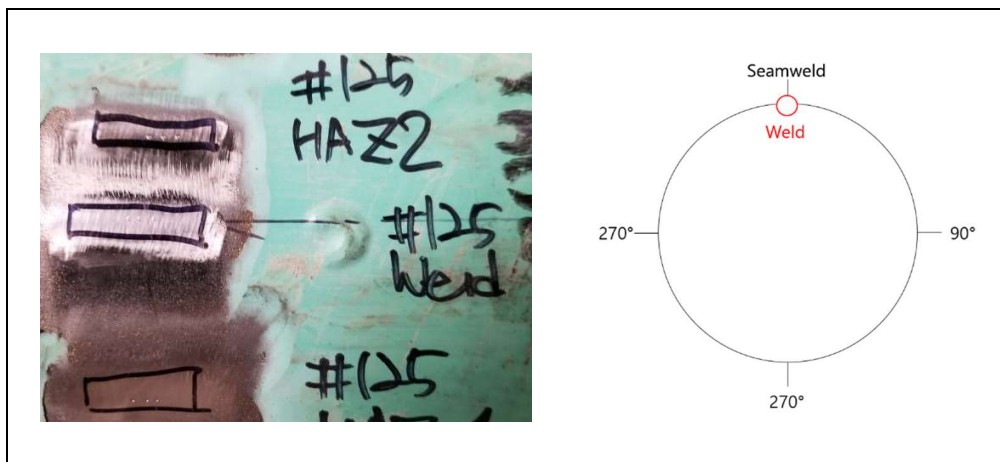
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.43	85.02	321.22
2	61.34	84.88	282.04
3	62.79	83.41	318.52
Avg.	62.52	84.44	307.26

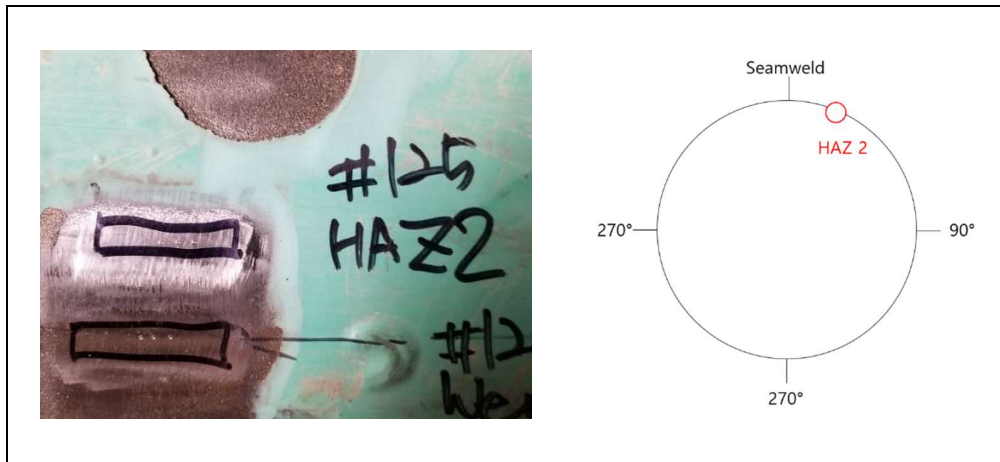
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.46	88.20	326.30
2	64.56	87.38	342.06
3	62.59	86.59	331.03
Avg.	63.87	87.39	333.13

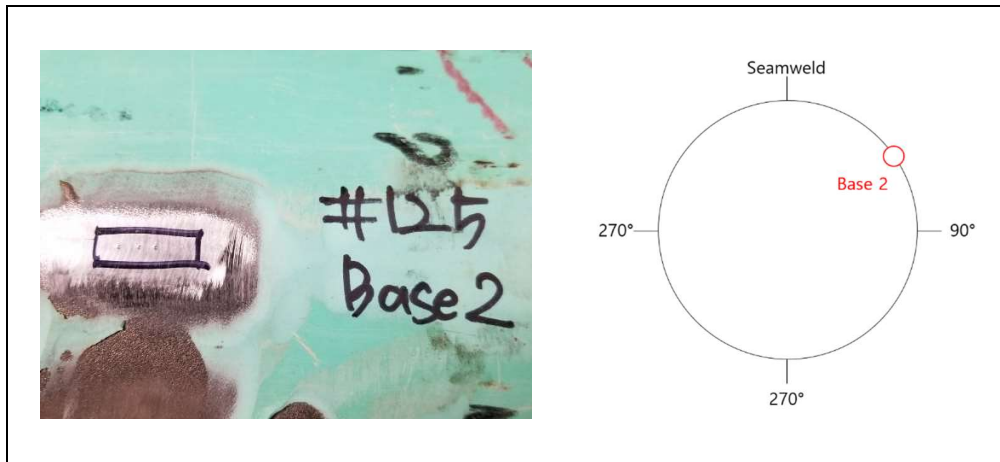
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.92	79.45	334.26
2	57.71	79.33	288.29
3	57.51	78.58	325.96
Avg.	58.38	79.12	316.17

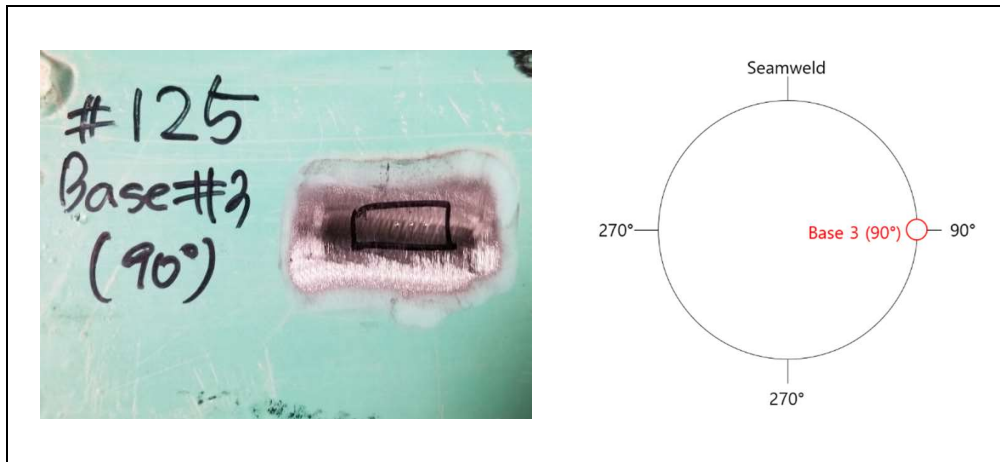
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 125
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3 (90°)



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.73	81.50	297.26
2	60.29	81.58	288.35
3	60.35	82.12	301.86
Avg.	60.45	81.74	295.82

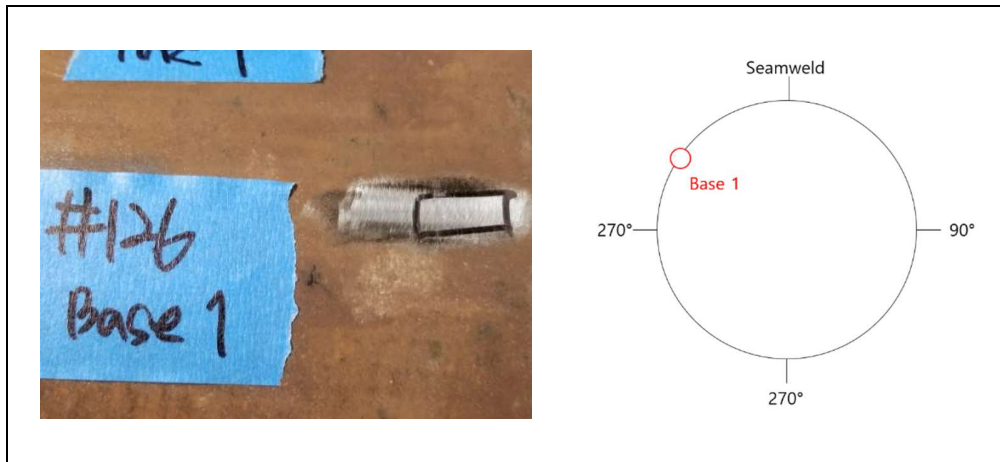
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.96	75.84	284.29
2	54.72	75.68	298.81
3	55.97	75.55	323.81
Avg.	55.22	75.69	302.30

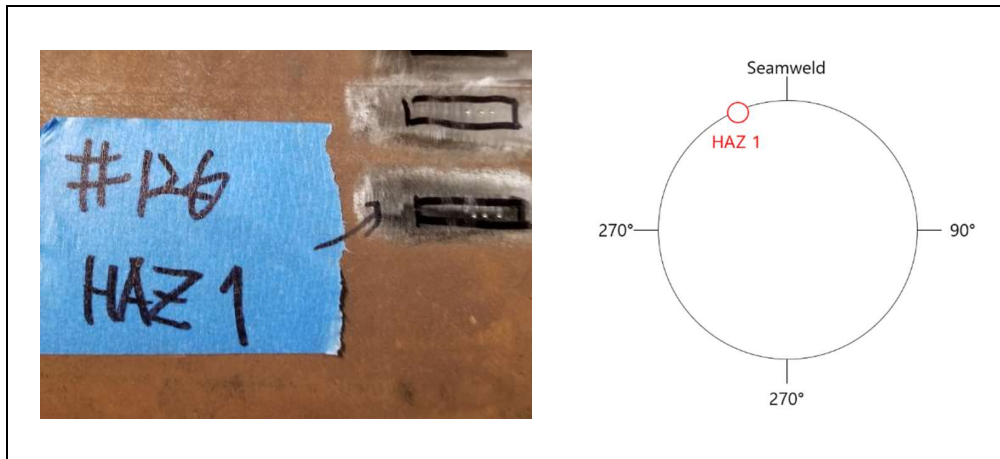
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.33	82.54	342.63
2	59.44	82.55	296.34
3	58.81	82.73	277.92
Avg.	59.86	82.61	305.63

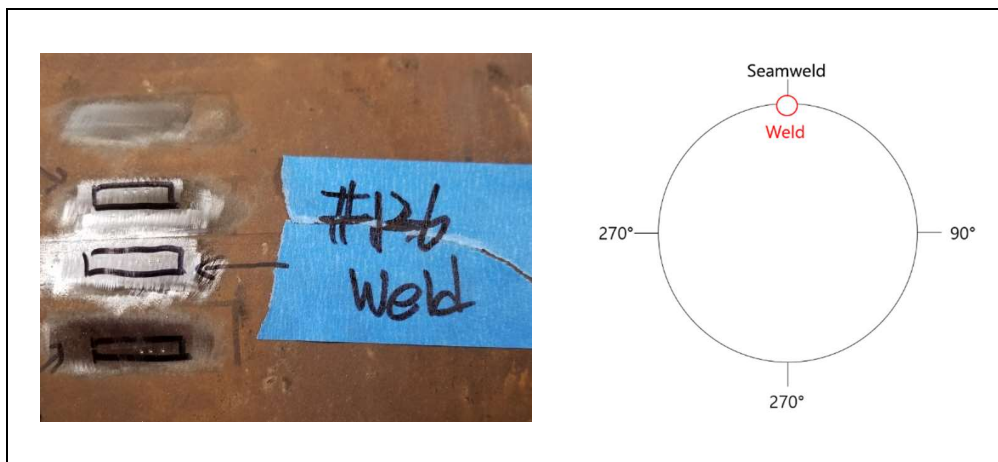
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.37	82.17	294.30
2	58.80	81.79	299.45
3	57.98	80.84	296.36
Avg.	58.72	81.60	296.70

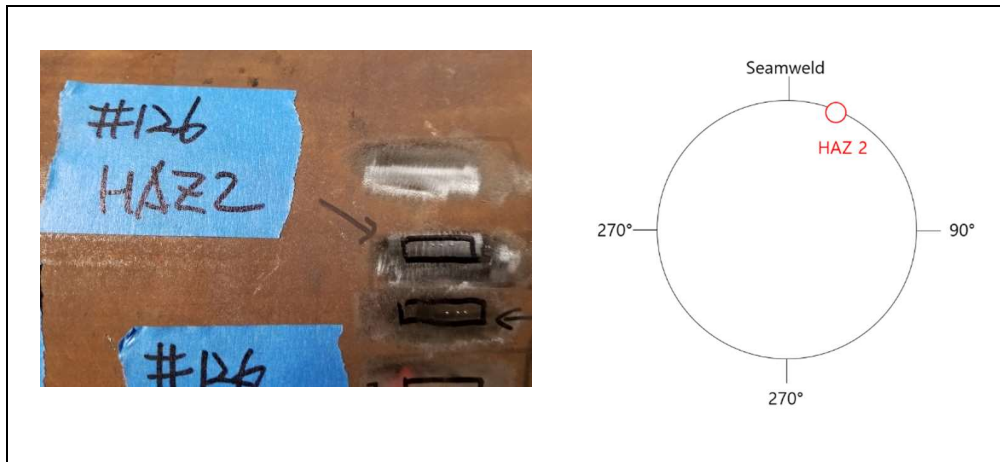
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.20	81.65	350.74
2	60.40	80.44	371.06
3	58.54	81.09	301.97
Avg.	60.38	81.06	341.26

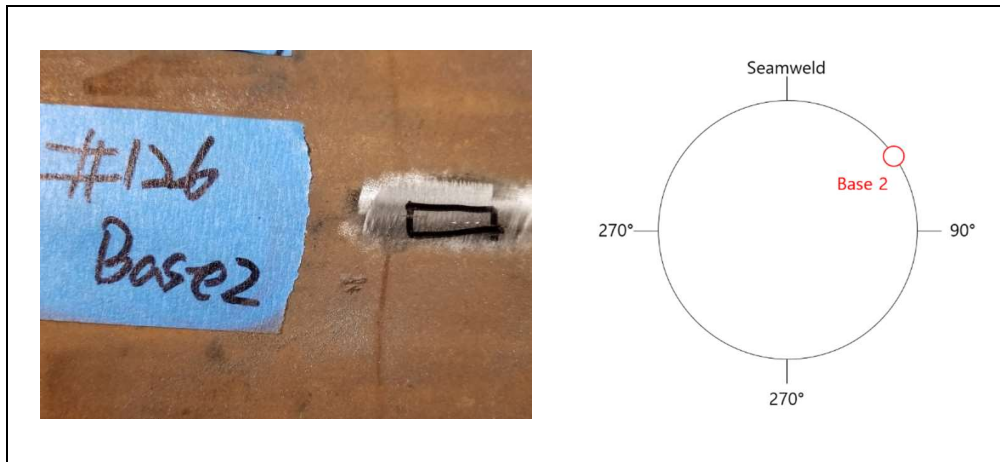
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.73	79.27	255.21
2	61.48	79.67	407.36
3	59.16	79.38	327.77
Avg.	58.79	79.44	330.11

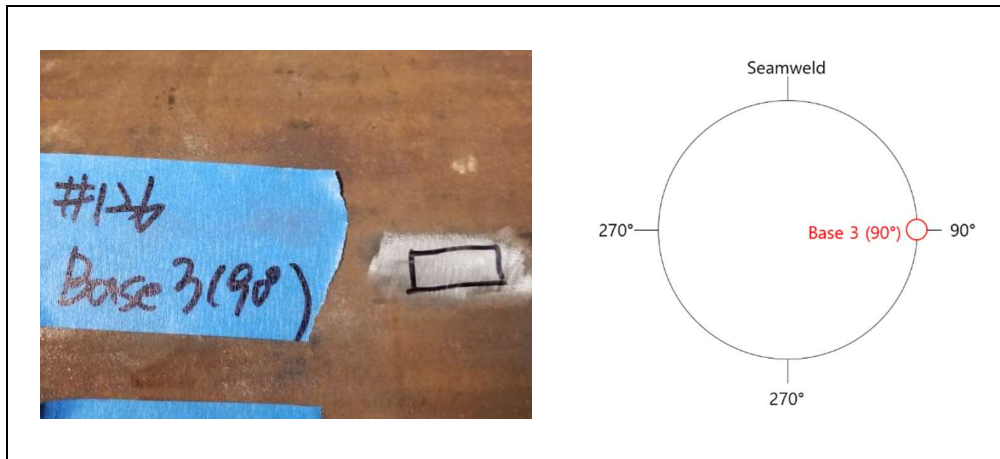
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 126
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3 (90°)



2. Condition

Date	4/8/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	63.55	81.71	391.65
2	60.75	81.19	361.38
3	57.49	80.01	307.20
Avg.	60.60	80.97	353.41

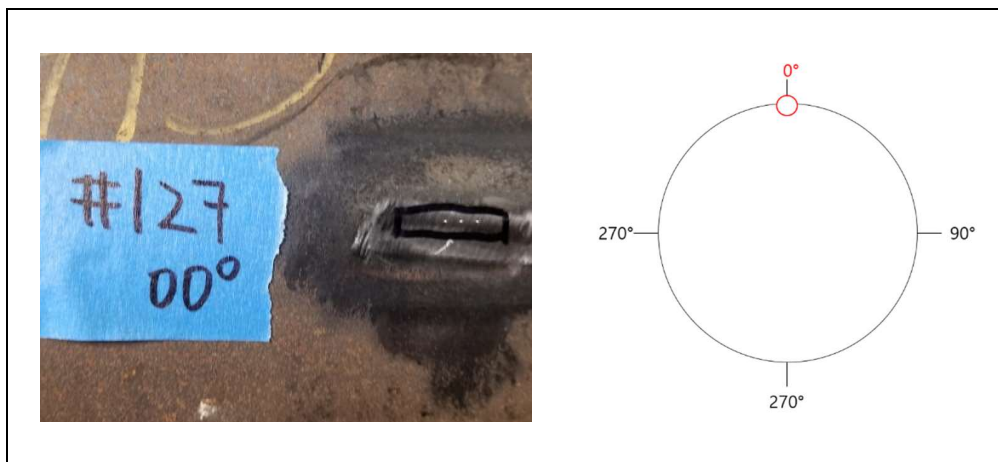
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 127
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.04	74.70	344.89
2	55.46	74.45	340.08
3	55.78	74.59	344.74
Avg.	55.76	74.58	343.24

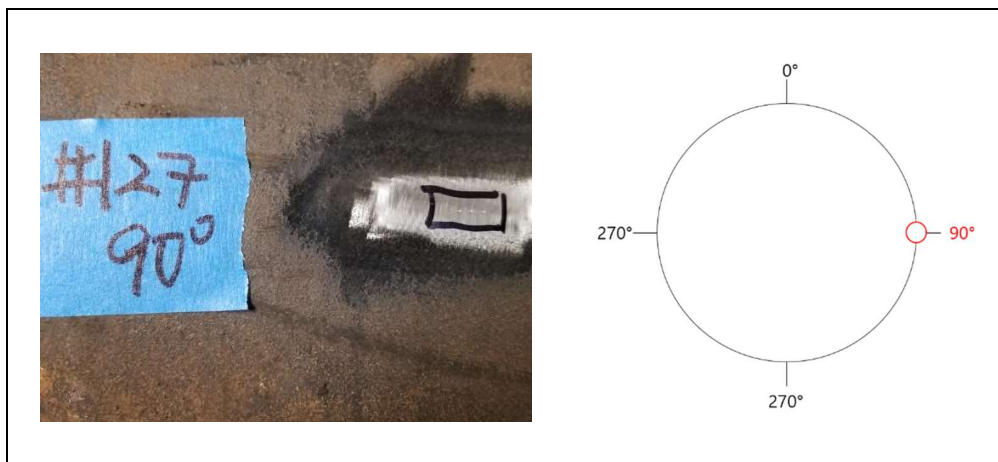
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 127
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.32	76.58	294.71
2	56.22	76.86	317.89
3	56.85	77.18	325.25
Avg.	56.13	76.88	312.61

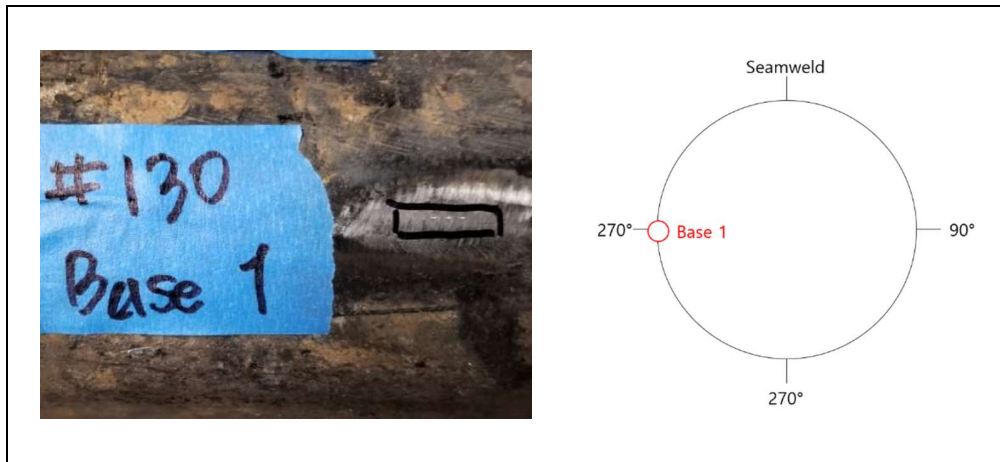
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 130
- (3) Pipe OD (inch) : 4
- (4) Location : Base 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.66	70.14	329.04
2	51.79	69.67	297.09
3	52.53	69.93	314.12
Avg.	52.66	69.91	313.41

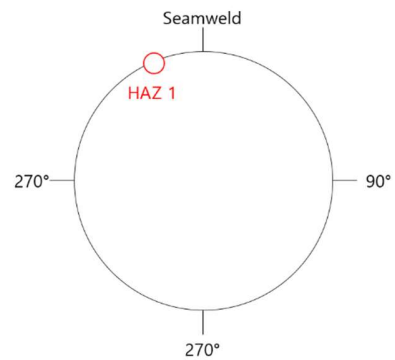
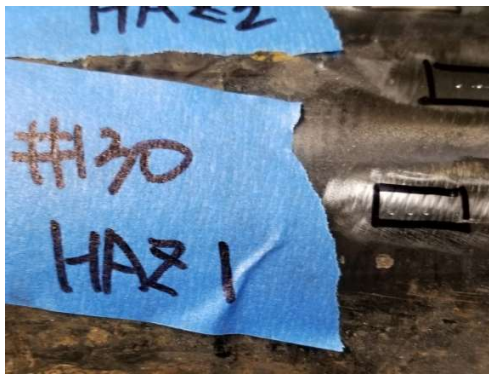
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 130
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 1



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.39	69.16	325.27
2	51.41	68.94	310.02
3	50.18	68.60	287.24
Avg.	51.33	68.90	307.51

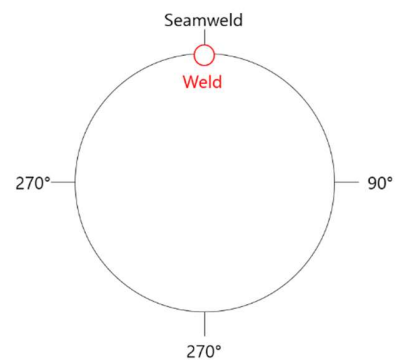
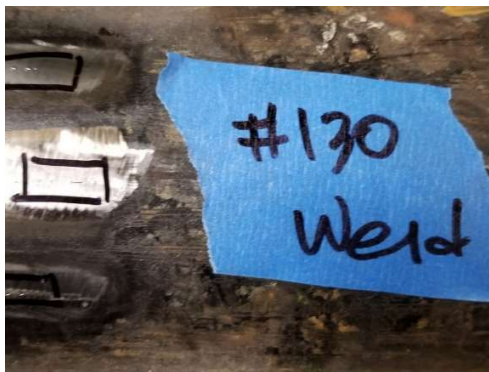
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 130
- (3) Pipe OD (inch) : 4
- (4) Location : Weld



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	69.62	88.99	438.82
2	70.29	88.80	421.20
3	76.56	93.71	456.95
Avg.	72.16	90.50	438.99

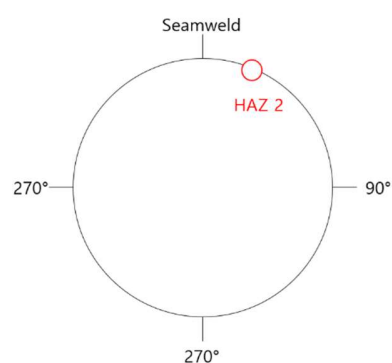
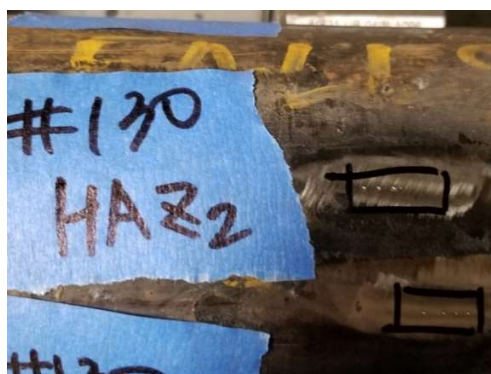
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 130
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.63	68.88	318.27
2	50.38	68.48	302.86
3	50.09	68.01	295.28
Avg.	50.70	68.46	305.47

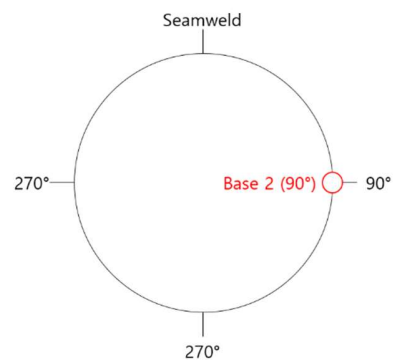
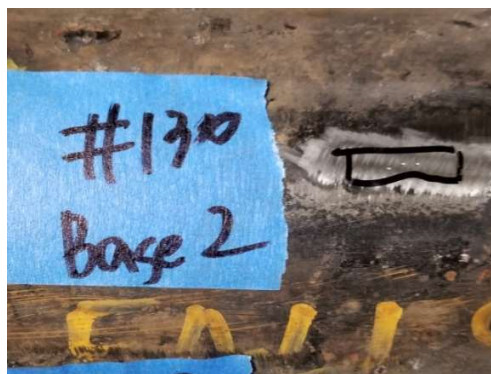
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 130
- (3) Pipe OD (inch) : 4
- (4) Location : Base 2



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.06	69.38	312.79
2	52.09	69.50	301.77
3	53.22	70.22	326.95
Avg.	52.46	69.70	313.84

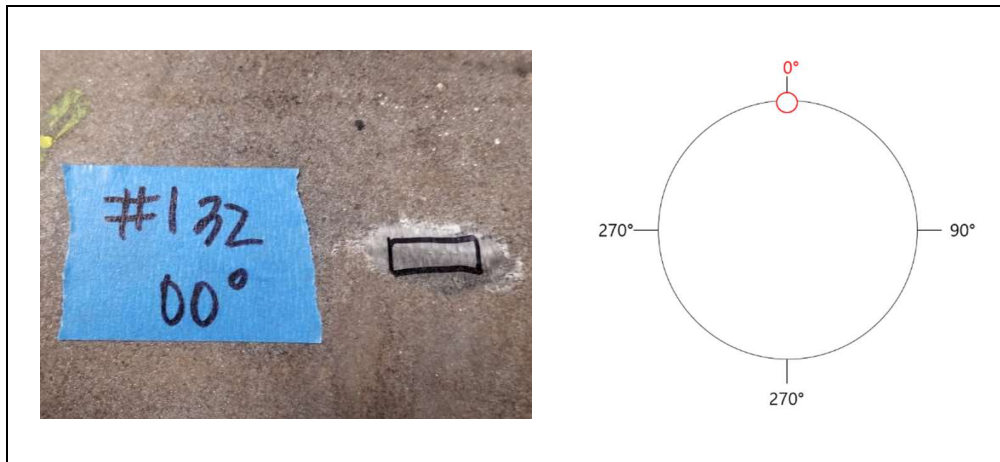
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 132
- (3) Pipe OD (inch) : 12
- (4) Location : 0°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.44	73.59	324.49
2	54.70	75.06	320.14
3	57.34	77.19	367.92
Avg.	56.16	75.28	337.52

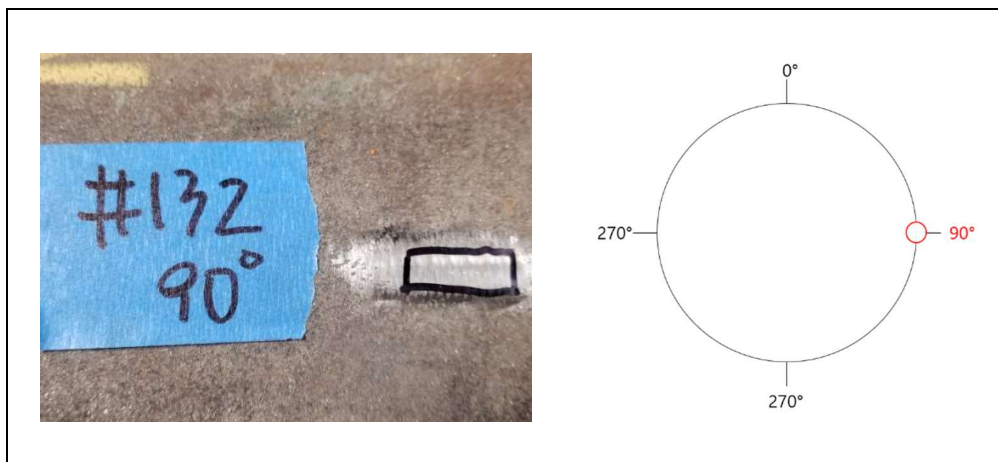
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 132
- (3) Pipe OD (inch) : 12
- (4) Location : 90°



2. Condition

Date	4/9/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.21	76.34	292.53
2	55.41	76.64	322.30
3	57.22	77.70	348.89
Avg.	55.61	76.89	321.24

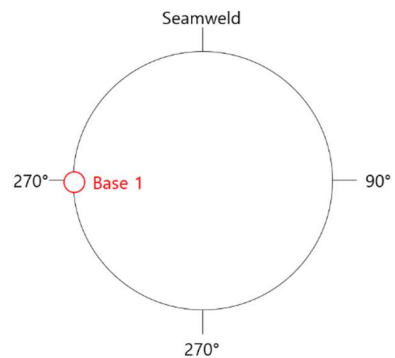
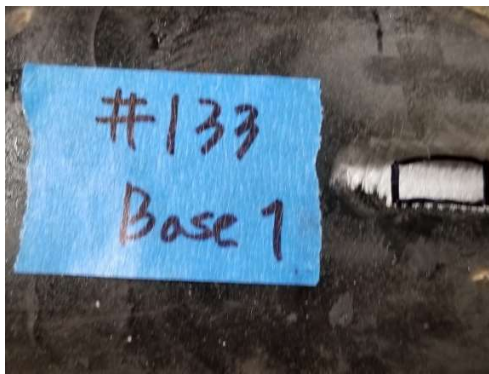
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 133
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.04	66.09	305.43
2	49.15	66.23	310.78
3	48.31	65.89	294.91
Avg.	48.83	66.07	303.71

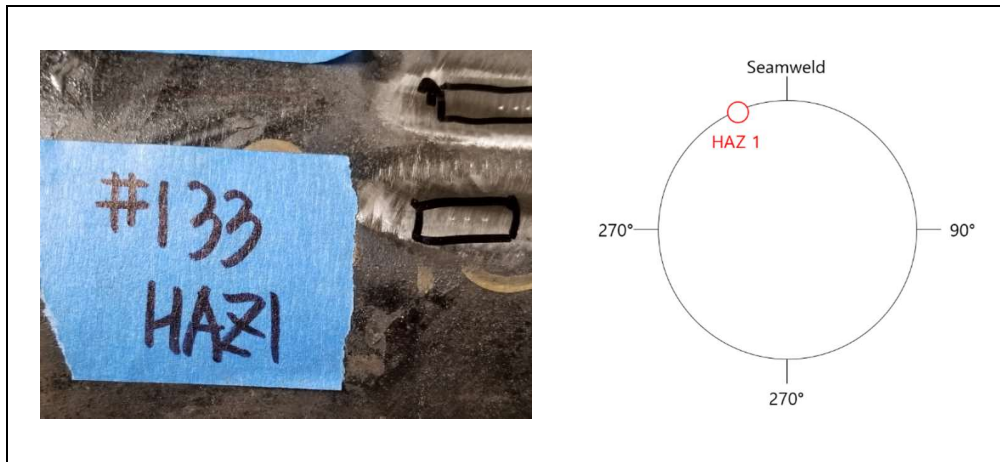
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 133
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.68	71.25	314.82
2	53.44	71.55	320.25
3	53.43	71.54	316.75
Avg.	53.52	71.45	317.27

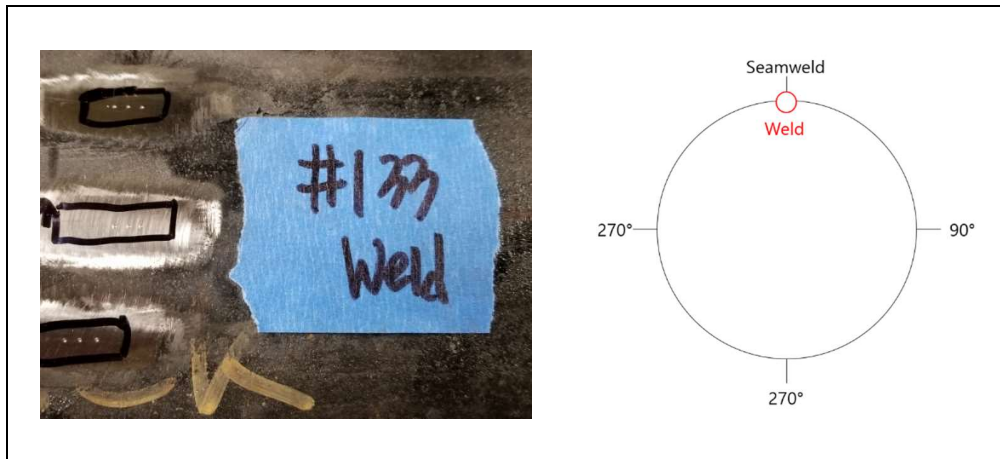
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 133
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.62	83.73	321.02
2	65.36	85.20	400.48
3	61.51	84.91	303.14
Avg.	62.50	84.62	341.55

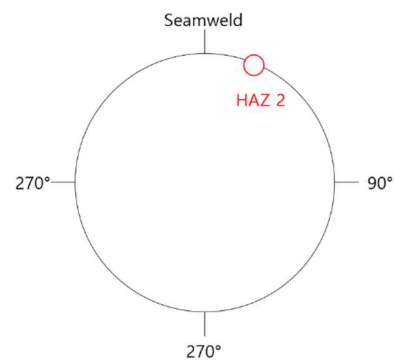
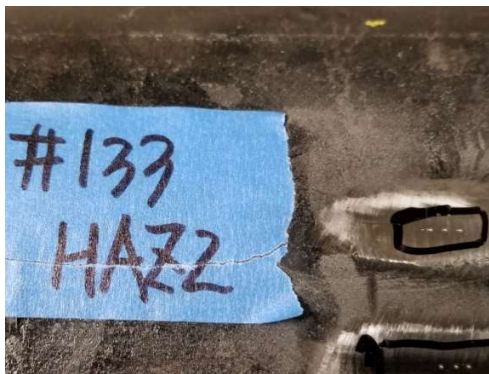
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 133
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.12	70.12	279.95
2	52.61	70.82	310.02
3	52.98	71.09	316.98
Avg.	52.57	70.68	302.32

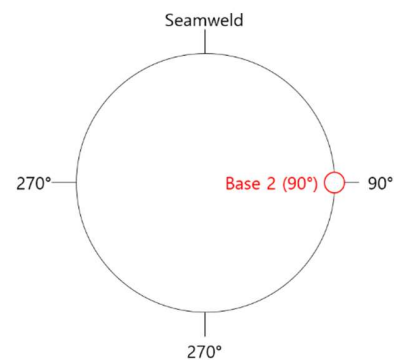
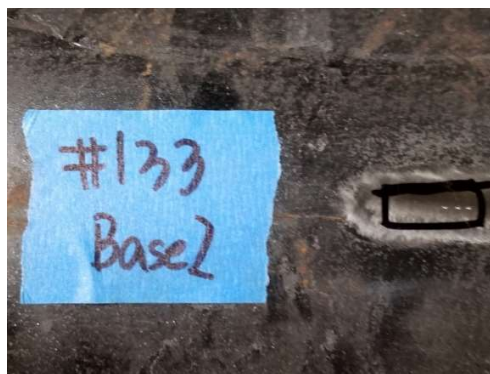
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 133
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	48.89	65.81	299.83
2	48.90	66.08	311.25
3	48.66	65.94	304.36
Avg.	48.82	65.94	305.15

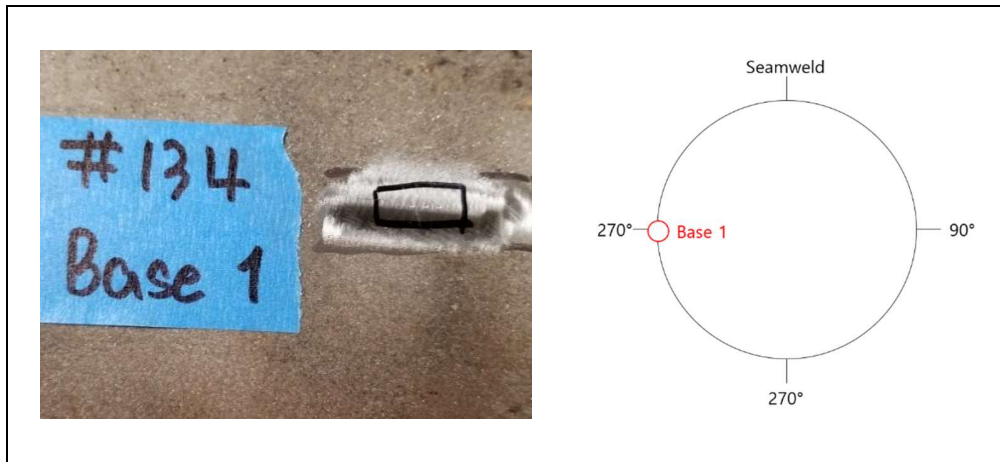
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 134
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.38	63.12	229.79
2	47.90	63.43	247.17
3	50.56	66.25	259.23
Avg.	49.28	64.27	245.40

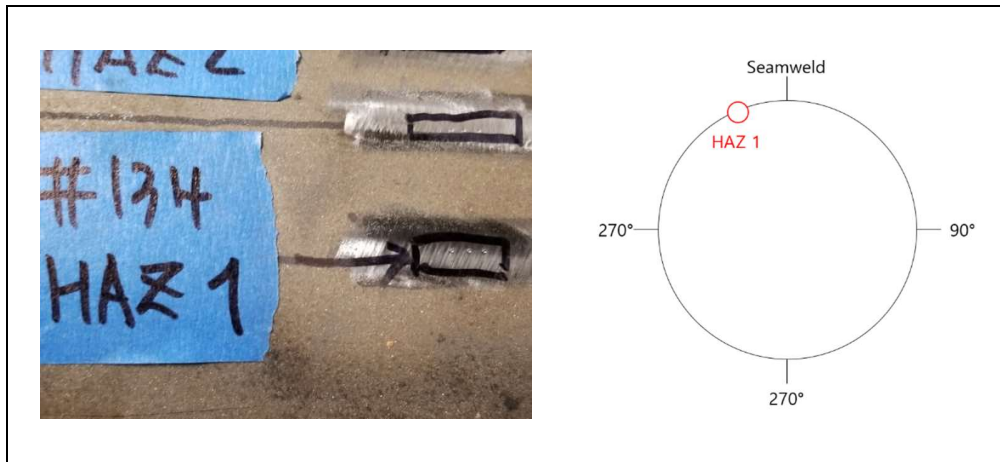
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 134
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.34	71.02	245.18
2	52.02	70.74	276.80
3	52.86	71.06	284.83
Avg.	52.08	70.94	268.93

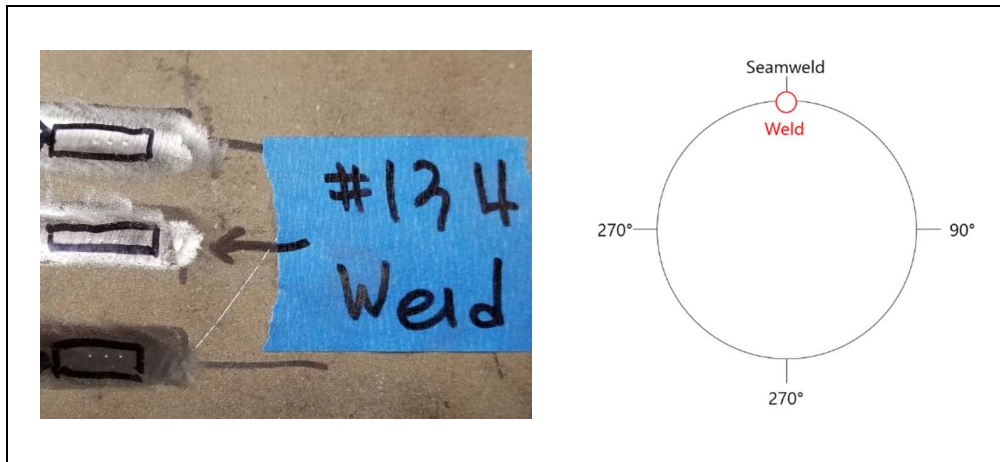
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 134
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	66.27	85.87	379.13
2	64.19	86.09	323.11
3	64.96	85.59	366.69
Avg.	65.14	85.85	356.31

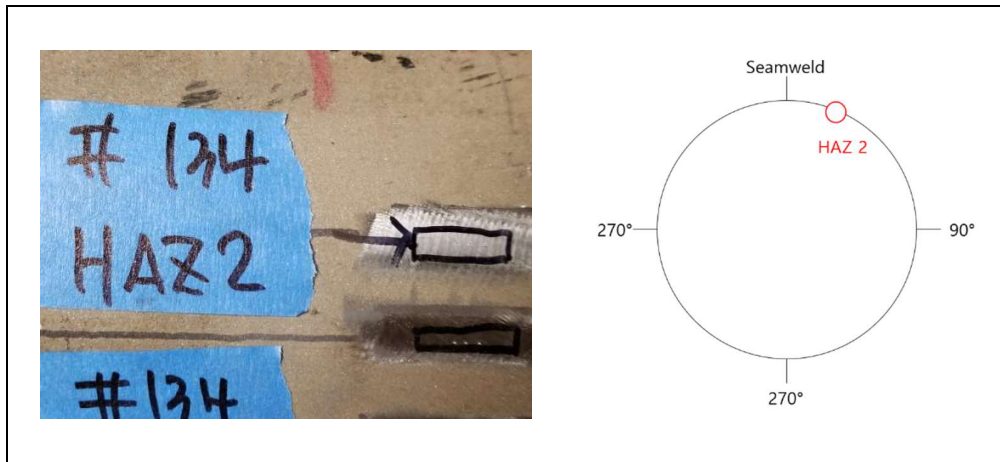
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 134
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.10	75.34	315.39
2	56.60	75.31	315.79
3	58.36	75.86	330.66
Avg.	57.35	75.50	320.61

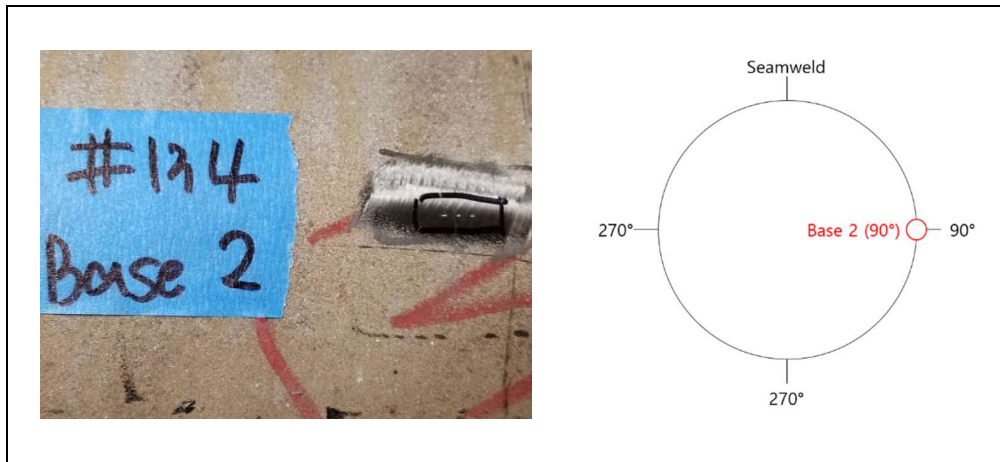
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 134
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.81	68.71	294.14
2	47.96	67.36	240.34
3	51.24	68.35	297.66
Avg.	50.67	68.14	277.38

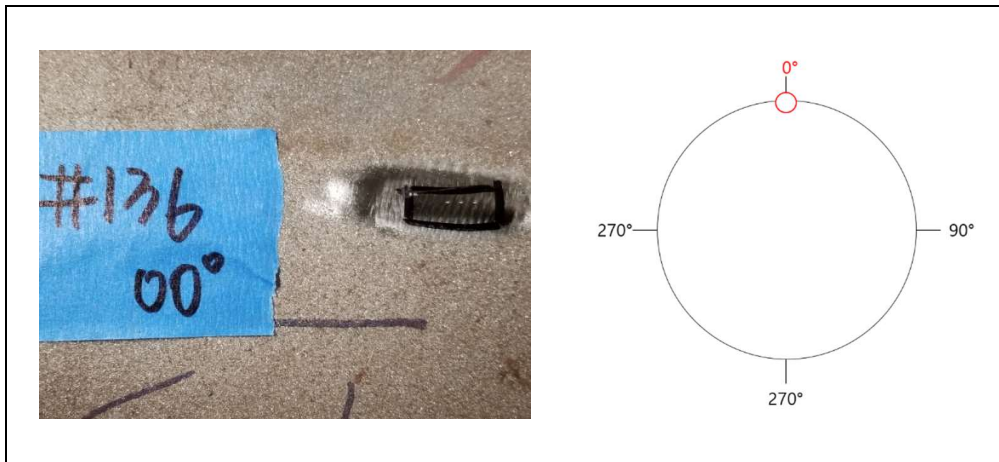
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 136
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.87	80.07	321.57
2	57.89	80.00	330.61
3	58.99	80.59	358.72
Avg.	57.58	80.22	336.97

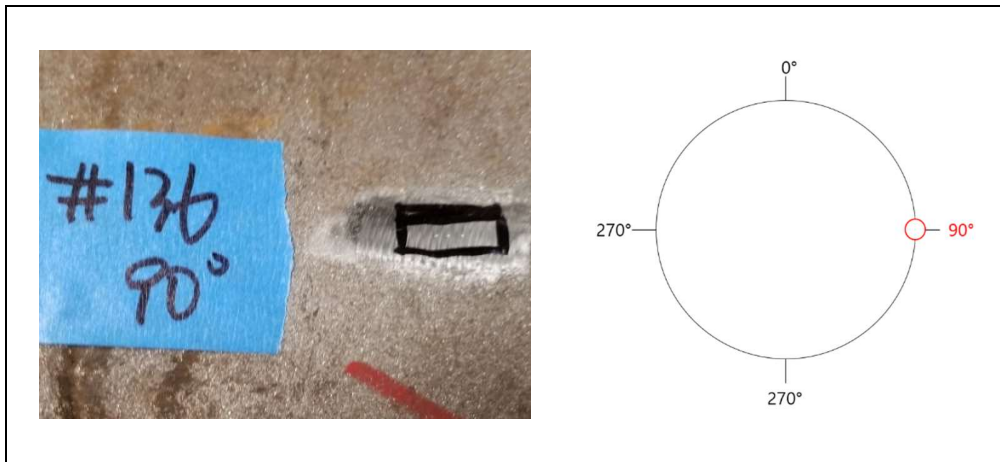
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 136
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	62.95	82.38	354.89
2	61.37	81.57	368.19
3	59.22	82.50	285.61
Avg.	61.18	82.15	336.23

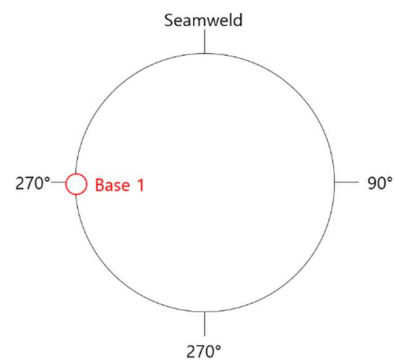
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 137
- (3) Pipe OD (inch) : 6
- (4) Location : Base 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.90	68.27	272.75
2	51.75	68.41	318.61
3	48.43	67.58	233.33
Avg.	50.36	68.09	274.90

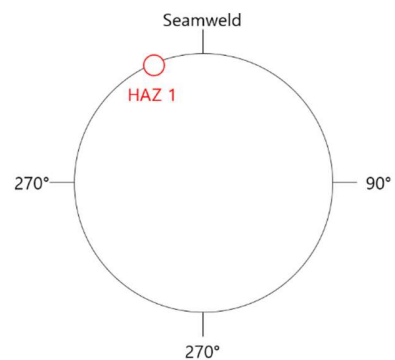
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 137
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.53	71.21	320.71
2	52.43	69.59	292.74
3	53.84	70.89	288.79
Avg.	53.60	70.57	300.75

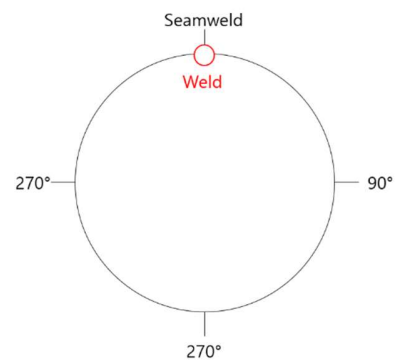
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 137
- (3) Pipe OD (inch) :6
- (4) Location : Weld



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	68.99	90.12	382.29
2	68.60	90.73	354.19
3	69.05	89.96	374.37
Avg.	68.88	90.27	370.28

* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 137
- (3) Pipe OD (inch) : 6
- (4) Location : HAX 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.61	75.55	358.68
2	56.60	74.80	299.49
3	58.52	75.96	322.53
Avg.	58.24	75.44	326.90

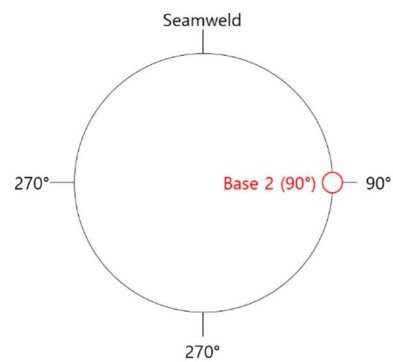
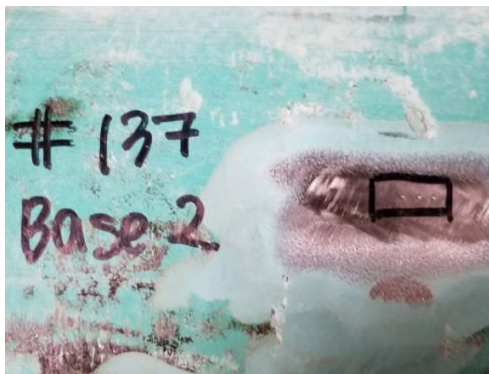
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 137
- (3) Pipe OD (inch) : 6
- (4) Location : Base 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.82	70.95	300.94
2	55.36	71.14	320.28
3	51.53	68.98	277.34
Avg.	54.24	70.36	299.52

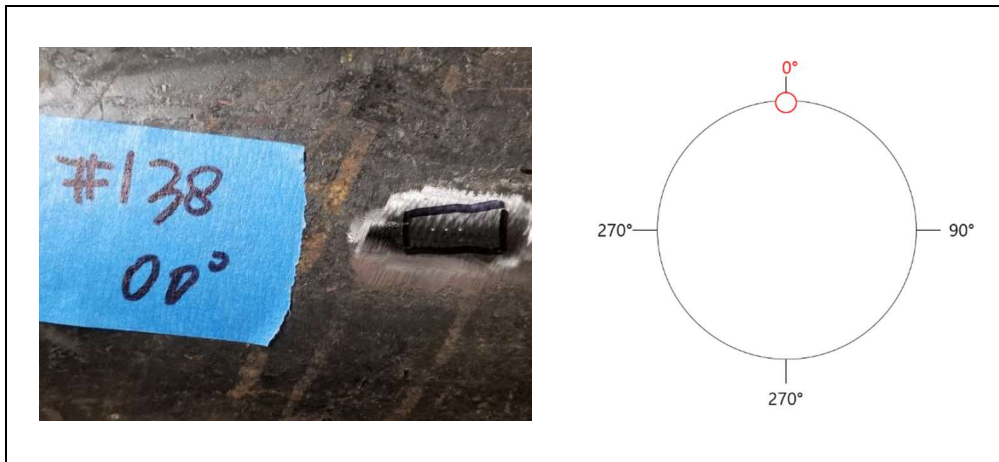
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 138
- (3) Pipe OD (inch) : 6
- (4) Location : 0°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.63	72.31	337.28
2	53.87	72.80	345.63
3	53.01	72.23	325.47
Avg.	53.17	72.45	336.12

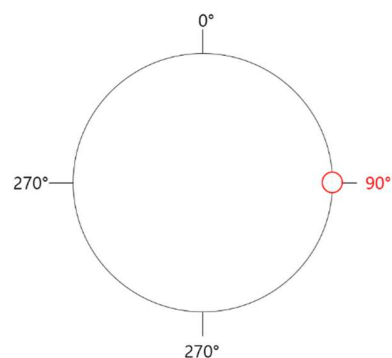
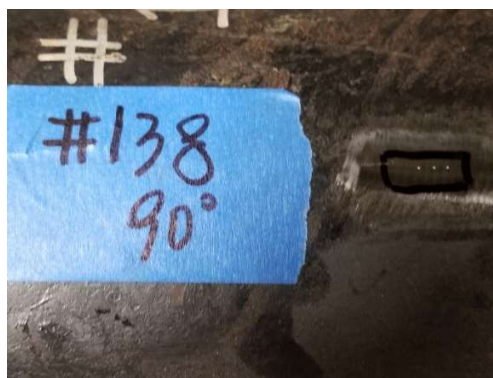
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 138
- (3) Pipe OD (inch) : 6
- (4) Location : 90°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.81	73.13	337.33
2	53.39	73.23	283.98
3	54.05	73.91	345.02
Avg.	53.75	73.42	322.11

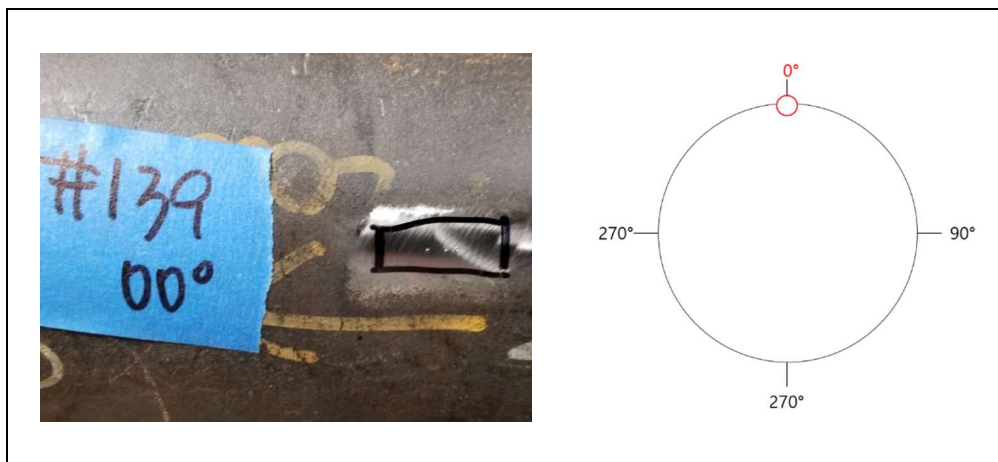
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 139
- (3) Pipe OD (inch) : 6
- (4) Location : 0°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.05	77.83	346.17
2	57.03	78.01	293.58
3	55.61	78.49	283.22
Avg.	56.90	78.11	307.65

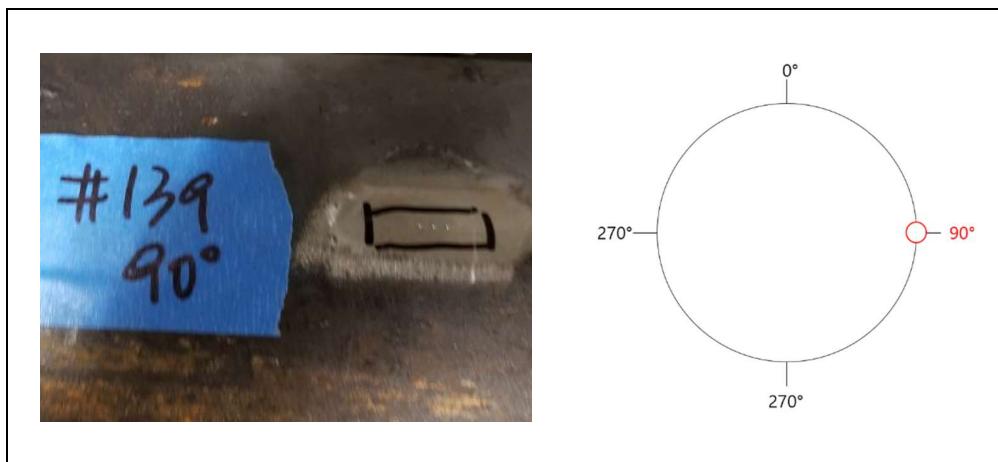
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 139
- (3) Pipe OD (inch) : 6
- (4) Location : 90°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.86	76.72	308.42
2	56.17	76.94	310.23
3	56.34	77.27	295.35
Avg.	56.12	76.97	304.67

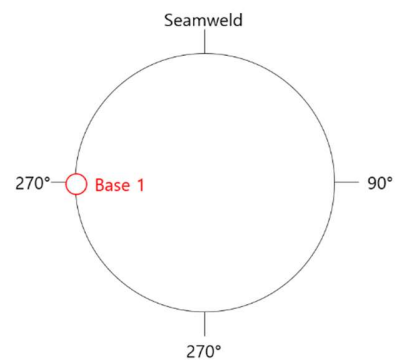
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 140
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.58	74.63	358.55
2	57.43	75.71	373.25
3	54.89	74.69	370.39
Avg.	55.97	75.01	367.40

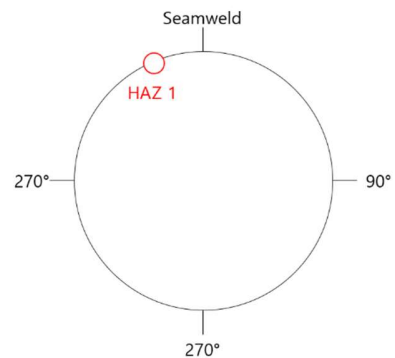
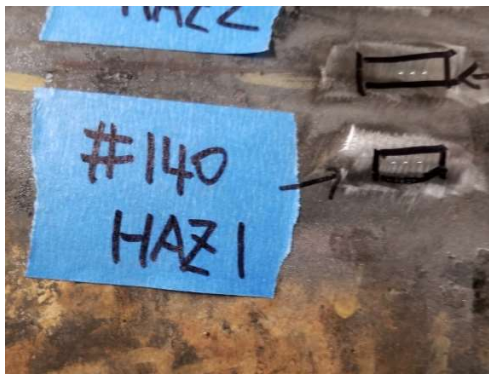
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 140
- (3) Pipe OD (inch) : 8
- (4) Location : HAX 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.36	74.25	354.14
2	54.54	73.54	326.23
3	56.26	75.44	358.60
Avg.	55.39	74.41	346.32

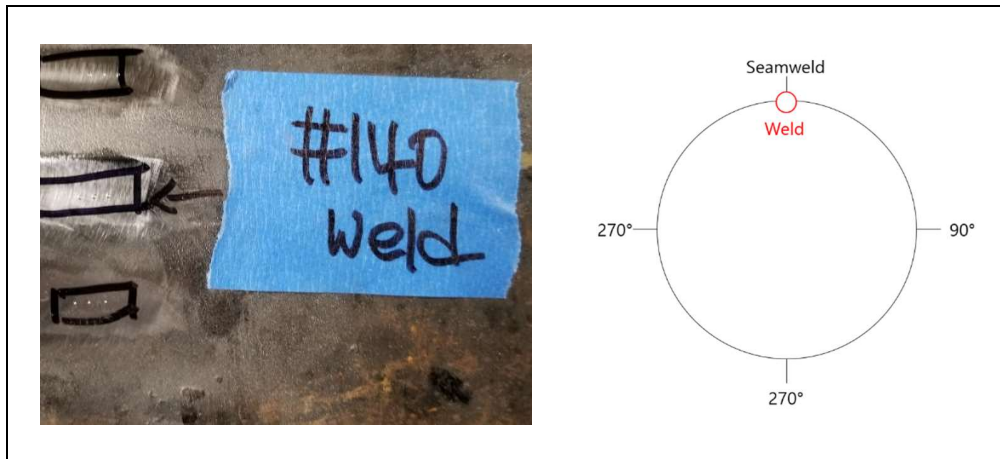
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 140
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	71.58	94.26	477.41
2	71.08	93.73	446.85
3	65.53	91.88	356.03
Avg.	69.39	93.29	426.77

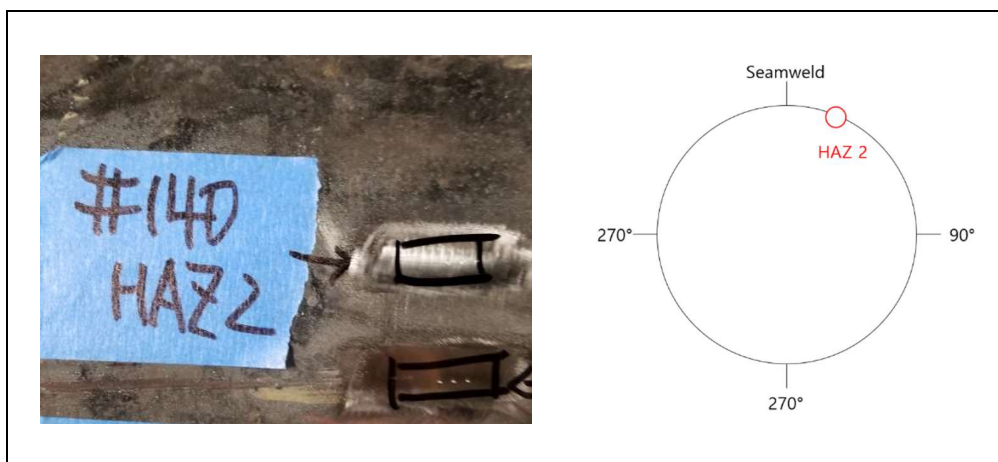
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 140
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	57.77	75.31	346.30
2	55.83	74.21	324.63
3	54.44	67.46	333.79
Avg.	56.01	72.32	334.91

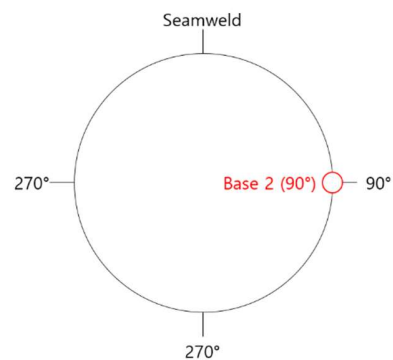
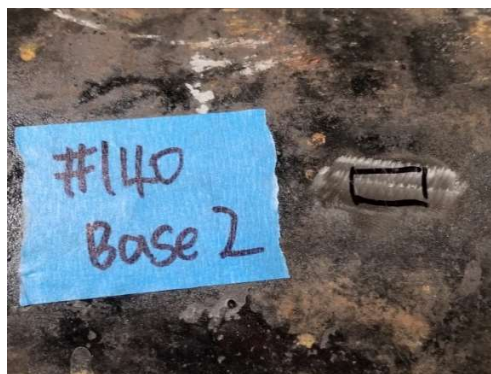
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 140
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.42	70.28	315.87
2	55.58	72.09	351.48
3	56.17	73.43	382.98
Avg.	55.73	71.93	350.11

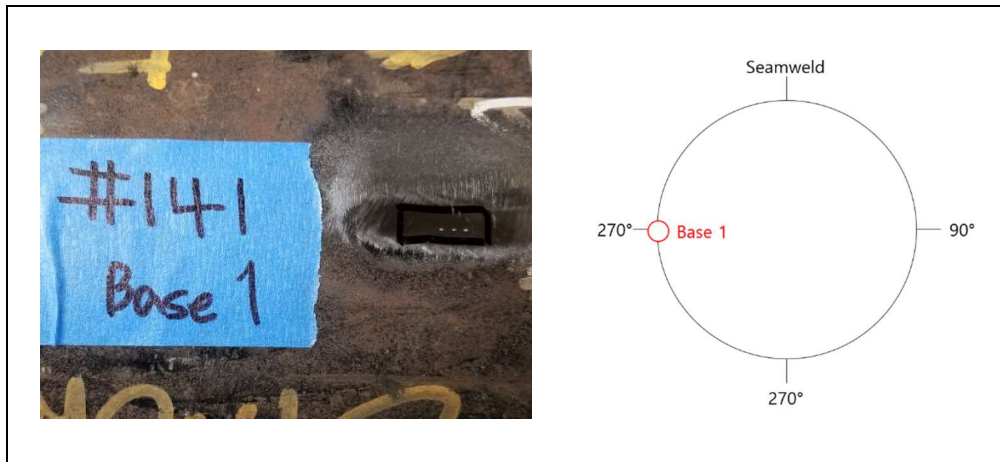
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 141
- (3) Pipe OD (inch) : 8
- (4) Location : Base 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.34	77.73	353.11
2	57.19	77.82	323.36
3	54.98	78.55	253.74
Avg.	57.17	78.03	310.07

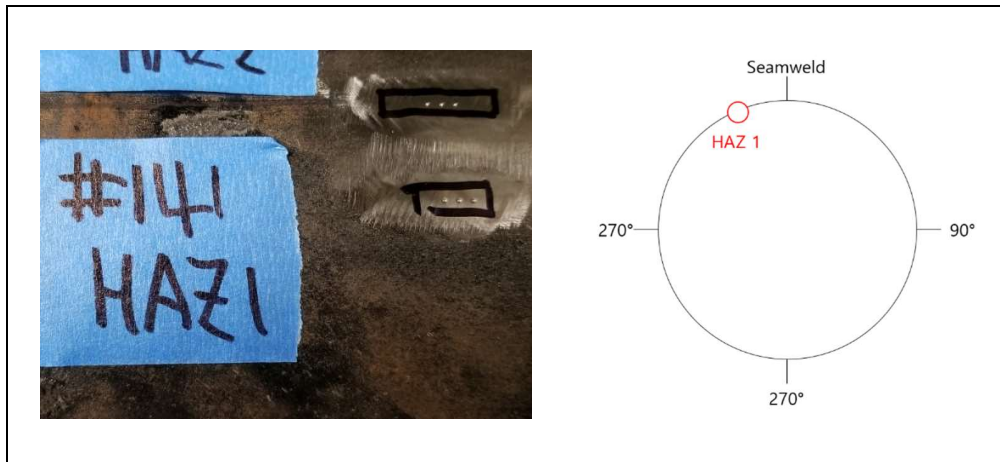
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 141
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 1



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.40	82.59	382.84
2	62.16	82.47	363.73
3	59.87	81.80	331.40
Avg.	61.14	82.29	359.32

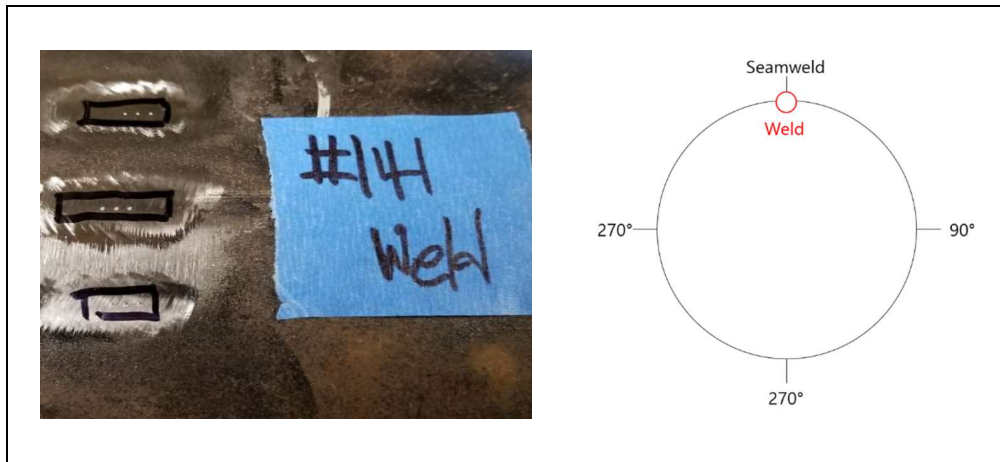
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 141
- (3) Pipe OD (inch) : 8
- (4) Location : Weld



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	68.05	89.03	384.23
2	64.77	87.78	340.93
3	66.19	88.07	381.68
Avg.	66.34	88.30	368.95

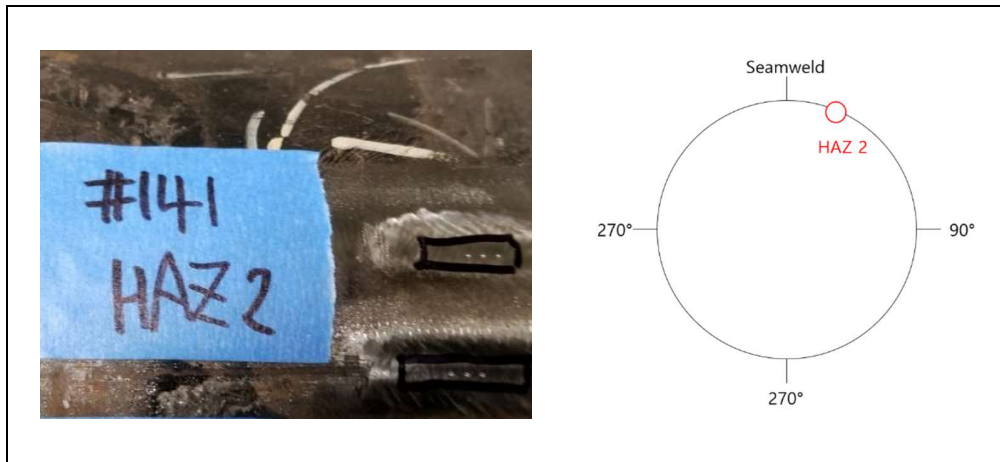
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 141
- (3) Pipe OD (inch) : 8
- (4) Location : HAZ 2



2. Condition

Date	4/10/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	64.96	85.51	380.54
2	60.52	84.25	340.02
3	62.62	84.30	339.54
Avg.	62.70	84.69	353.36

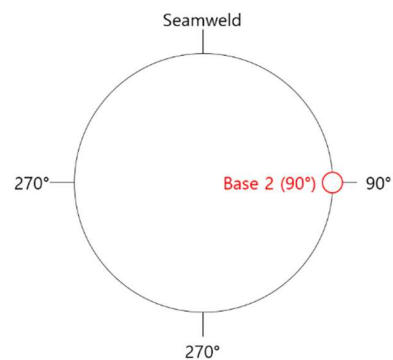
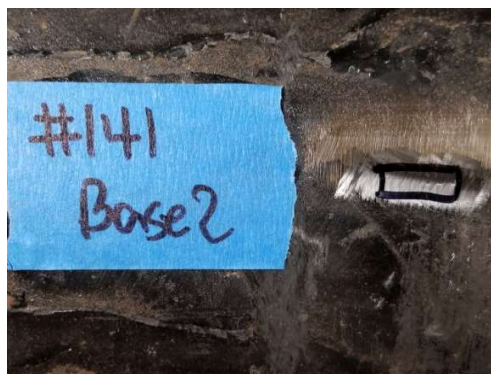
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 141
- (3) Pipe OD (inch) : 8
- (4) Location : Base 2



2. Condition

Date		Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.11	80.12	364.61
2	59.54	80.04	352.37
3	59.48	80.03	360.12
Avg.	59.71	80.07	359.03

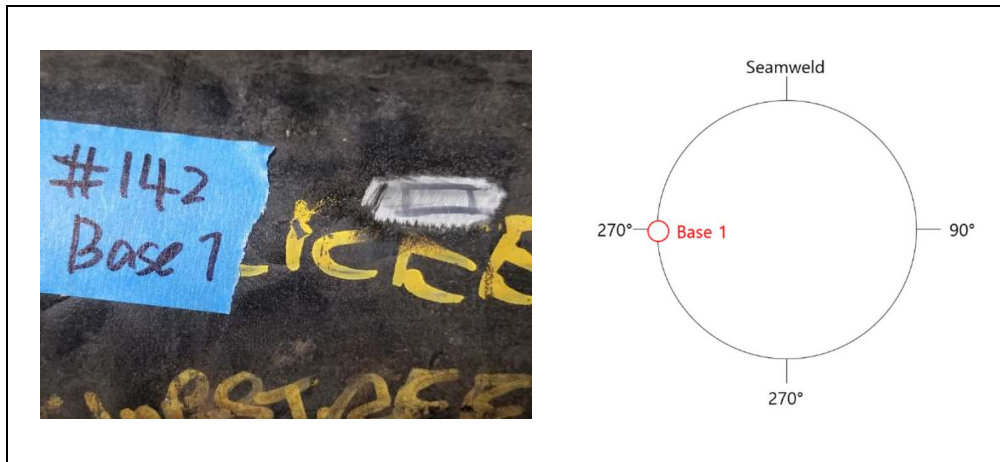
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 142
- (3) Pipe OD (inch) : 6
- (4) Location : Base 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.35	64.19	284.39
2	49.81	65.59	273.34
3	51.98	68.30	291.57
Avg.	51.05	66.03	283.10

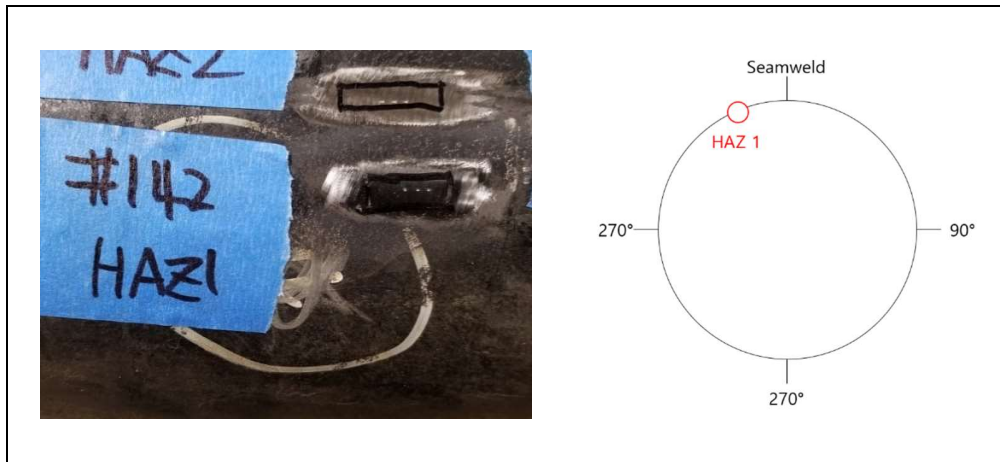
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 142
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.69	77.81	324.87
2	58.86	78.21	338.75
3	56.37	77.06	307.99
Avg.	57.97	77.70	323.87

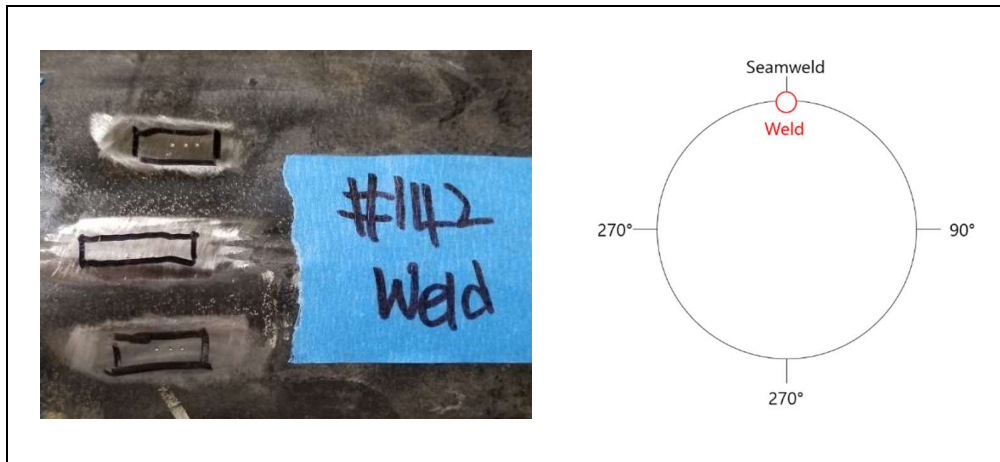
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 142
- (3) Pipe OD (inch) : 6
- (4) Location : Weld



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	65.38	85.79	380.58
2	64.86	85.34	407.18
3	63.00	84.38	383.19
Avg.	64.41	85.17	390.32

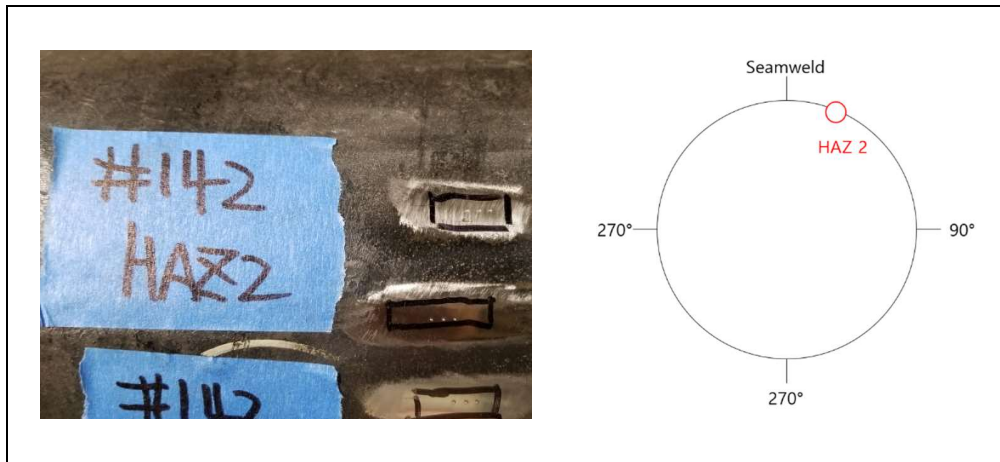
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 142
- (3) Pipe OD (inch) : 6
- (4) Location : HAZ 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.70	75.54	354.23
2	56.36	75.52	321.78
3	57.80	75.91	349.67
Avg.	56.95	75.66	341.90

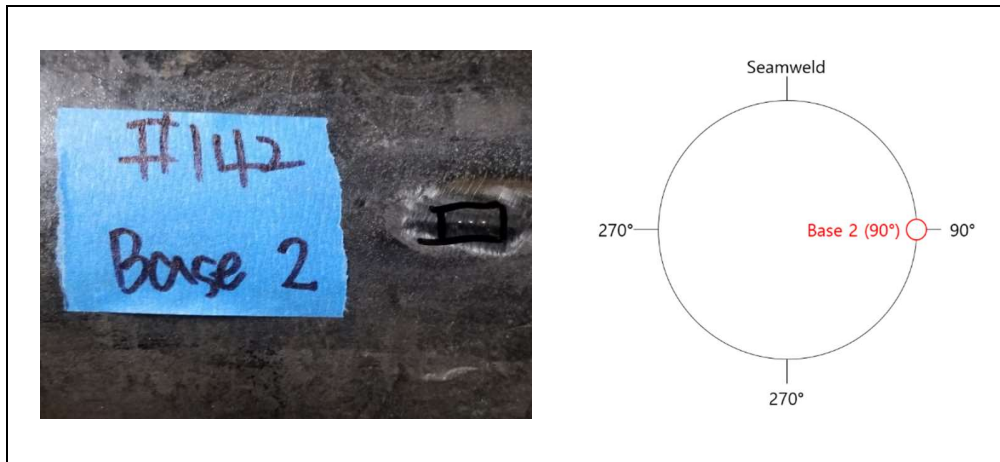
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 142
- (3) Pipe OD (inch) : 6
- (4) Location : Base 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.09	71.72	323.13
2	51.39	69.12	283.80
3	51.49	70.55	282.23
Avg.	52.66	70.46	296.39

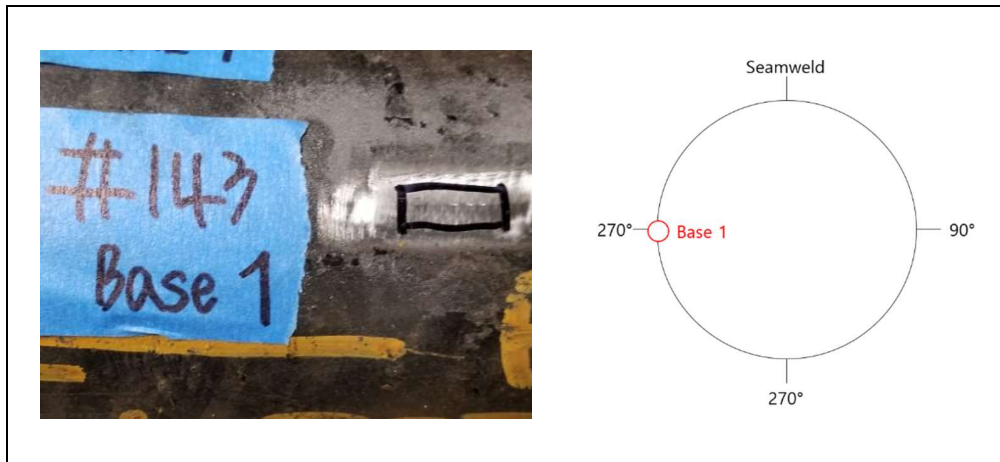
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 143
- (3) Pipe OD (inch) : 4
- (4) Location : Base 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.53	72.55	311.10
2	51.50	71.63	262.07
3	52.57	71.76	284.18
Avg.	52.87	71.98	285.78

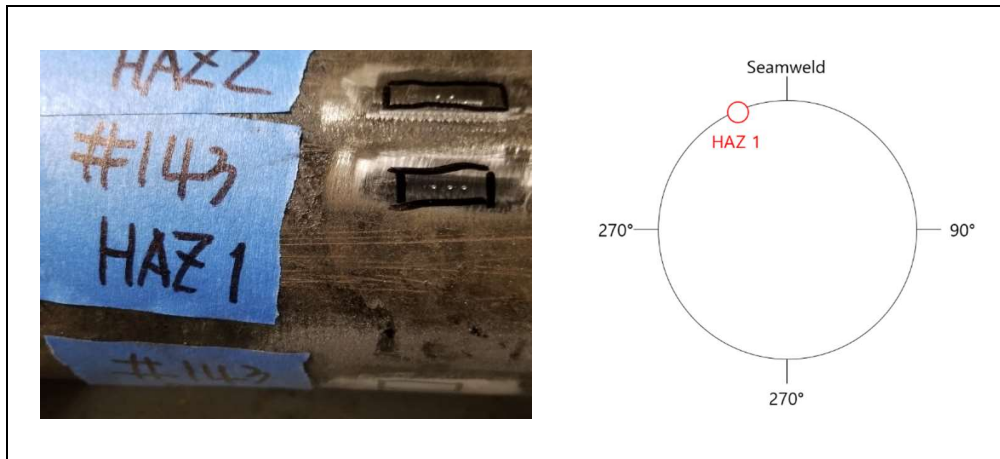
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 143
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.95	76.03	289.99
2	56.60	75.85	297.38
3	56.85	75.29	316.55
Avg.	56.80	75.73	301.31

* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 143
- (3) Pipe OD (inch) : 4
- (4) Location : Weld



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.98	78.64	318.32
2	57.17	78.27	314.55
3	58.19	78.62	319.19
Avg.	58.11	78.51	317.35

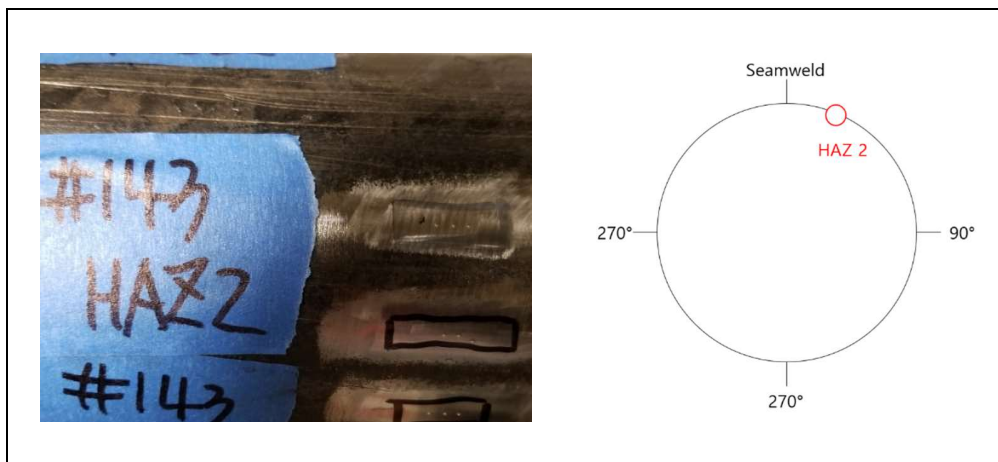
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 143
- (3) Pipe OD (inch) : 4
- (4) Location : HAZ 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.28	77.34	342.23
2	55.66	77.74	267.07
3	57.44	76.54	332.55
Avg.	57.13	77.21	313.95

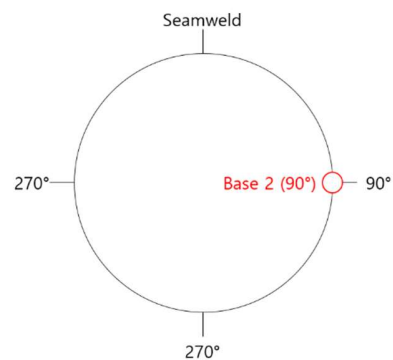
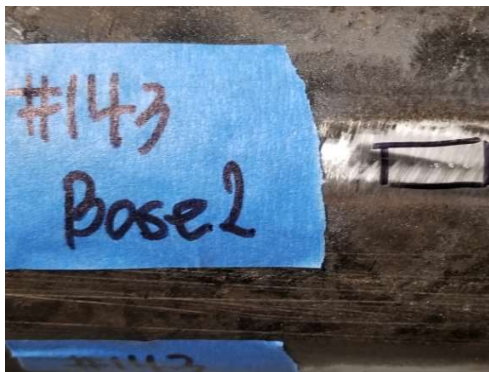
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 143
- (3) Pipe OD (inch) : 4
- (4) Location : Base 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.06	70.51	283.16
2	54.78	72.72	282.81
3	53.73	72.01	266.34
Avg.	53.86	71.74	277.44

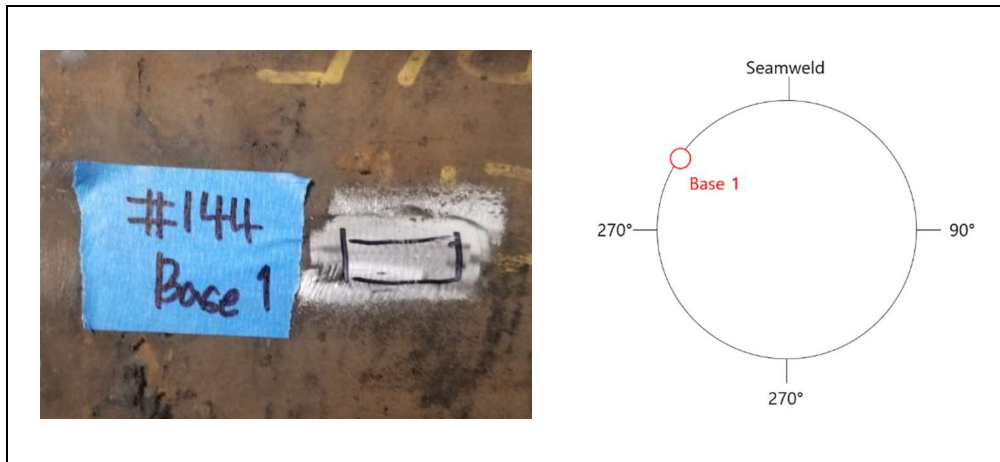
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	56.83	75.79	325.09
2	54.32	73.64	314.81
3	54.79	74.71	285.31
Avg.	55.31	74.71	308.40

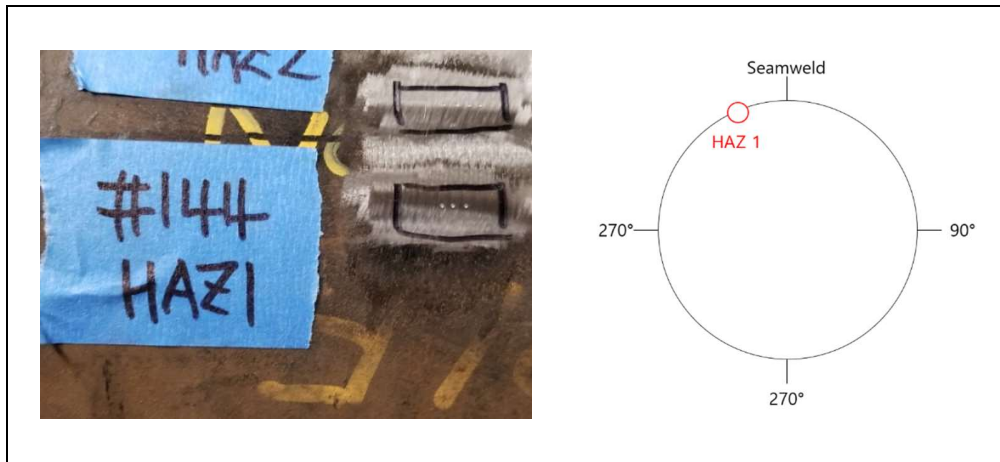
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	61.50	81.85	351.48
2	69.48	86.34	483.92
3	60.36	81.94	300.86
Avg.	63.78	83.38	378.76

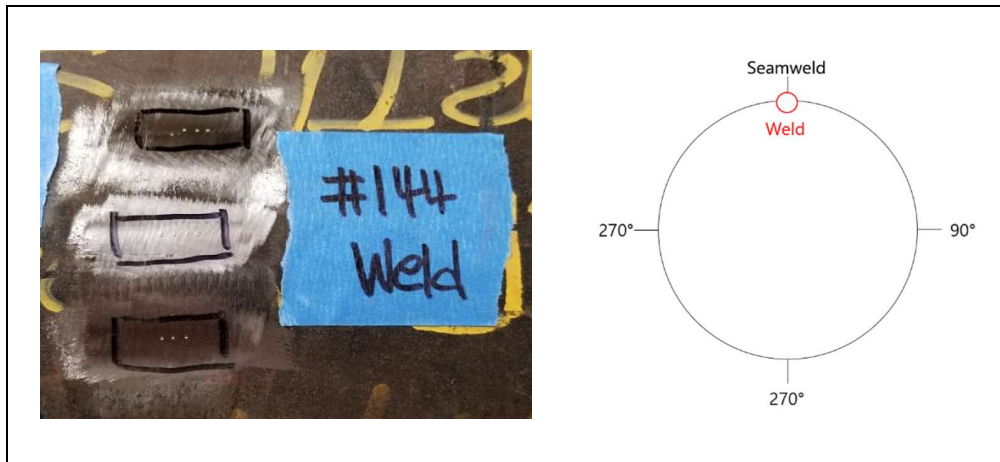
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	65.92	93.44	360.41
2	66.68	89.21	390.74
3	70.96	92.37	408.53
Avg.	67.85	91.67	386.56

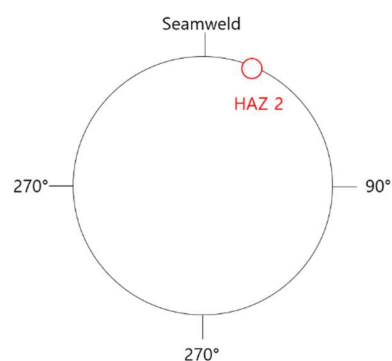
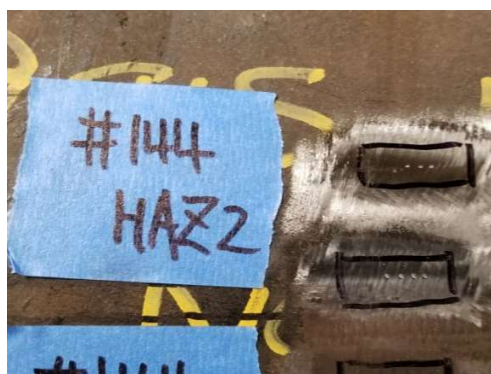
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.45	83.27	297.19
2	60.69	82.69	292.41
3	59.78	80.70	335.96
Avg.	60.31	82.22	308.52

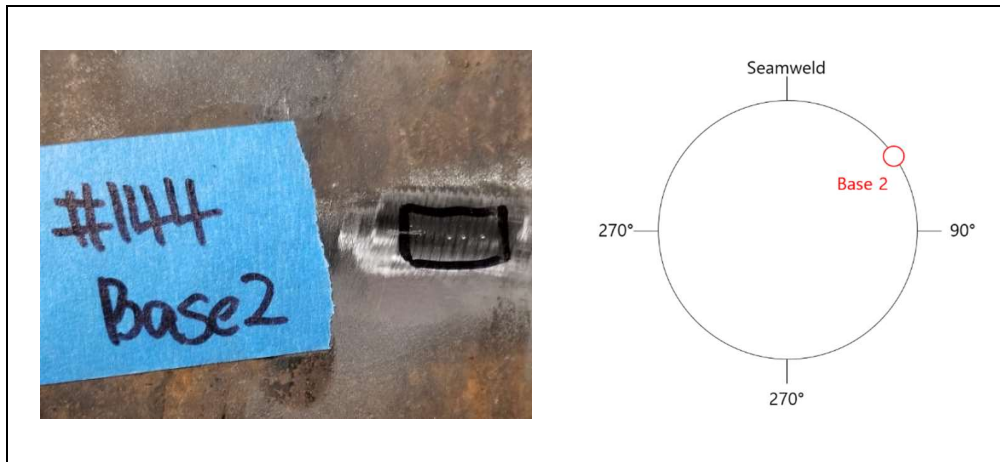
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.72	73.83	346.23
2	53.51	73.87	305.49
3	56.42	74.63	346.51
Avg.	55.22	74.11	332.74

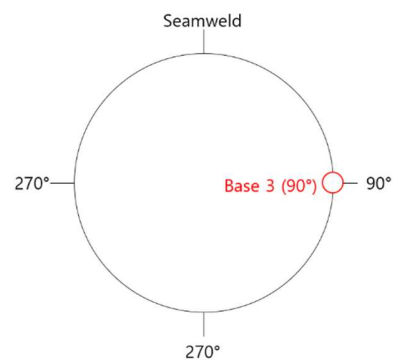
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 144
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.70	78.68	253.67
2	53.87	76.07	262.81
3	56.25	74.96	324.38
Avg.	55.27	76.57	280.29

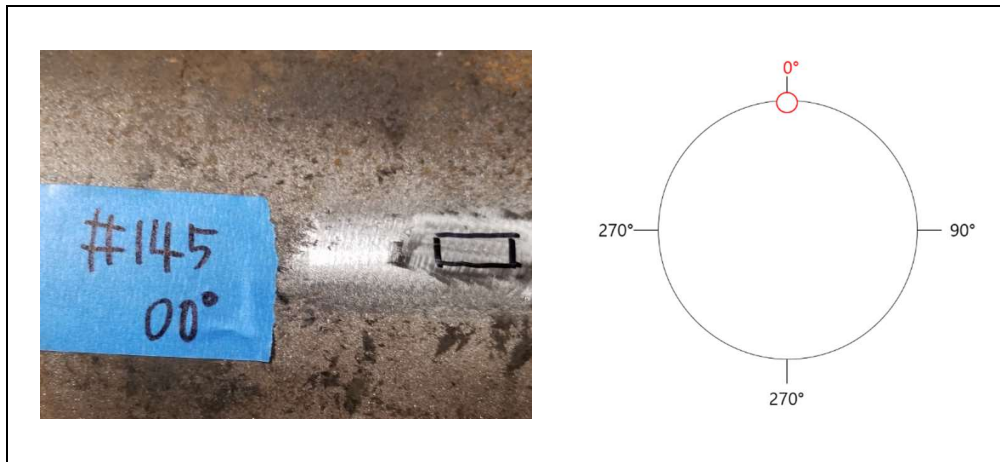
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 145
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.49	71.36	337.24
2	52.46	72.03	343.77
3	52.02	71.52	337.72
Avg.	52.32	71.63	339.58

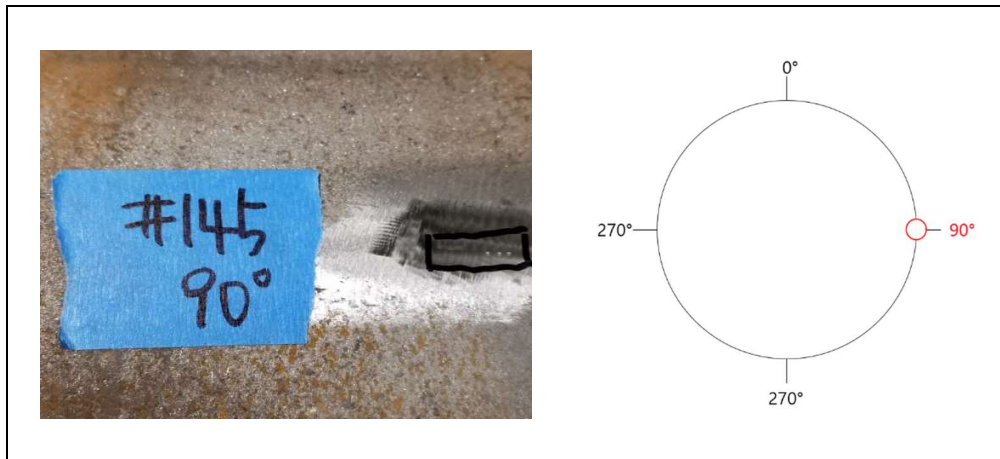
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 145
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.02	72.38	337.47
2	52.06	71.53	315.32
3	52.88	72.26	341.17
Avg.	52.99	72.06	331.32

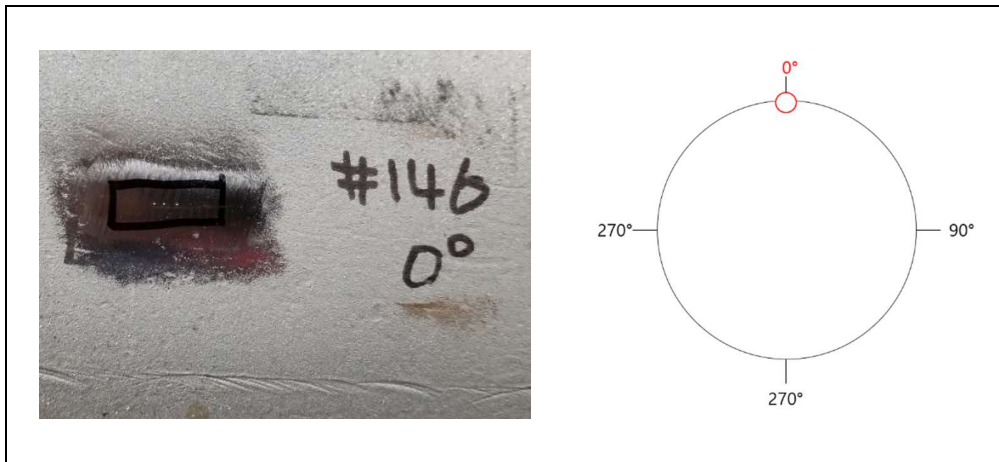
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 146
- (3) Pipe OD (inch) : 10
- (4) Location : 0°



2. Condition

Date	4/13/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	38.65	54.47	192.01
2	39.83	54.67	212.53
3	39.95	54.19	216.03
Avg.	39.48	54.45	206.86

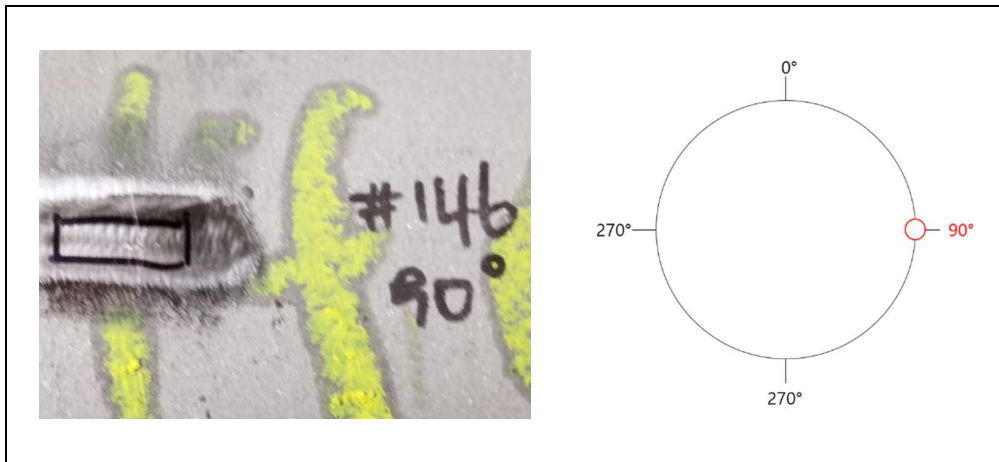
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 146
- (3) Pipe OD (inch) : 10
- (4) Location : 90°



2. Condition

Date	4/13/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	39.07	52.48	210.14
2	39.12	52.84	222.29
3	38.47	52.20	221.54
Avg.	38.89	52.51	217.99

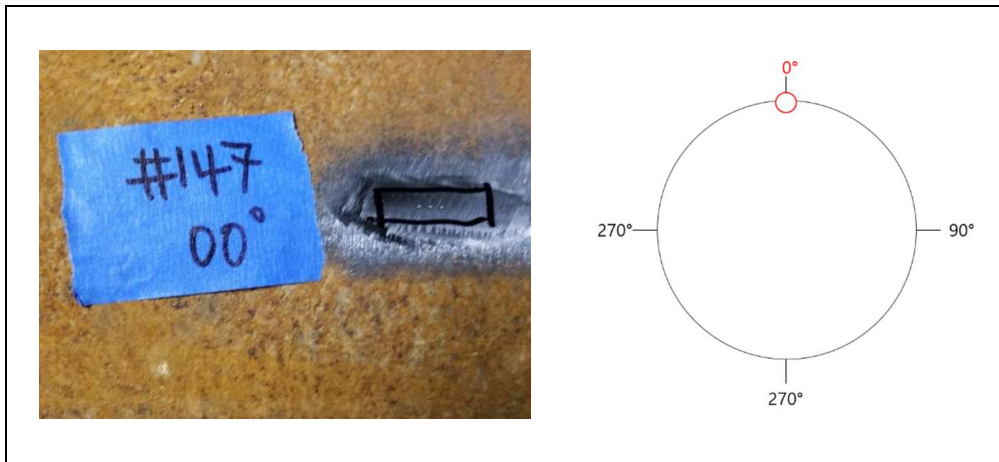
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 147
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date		Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.91	72.24	335.40
2	52.29	70.57	318.84
3	49.81	67.80	281.18
Avg.	52.34	70.21	311.81

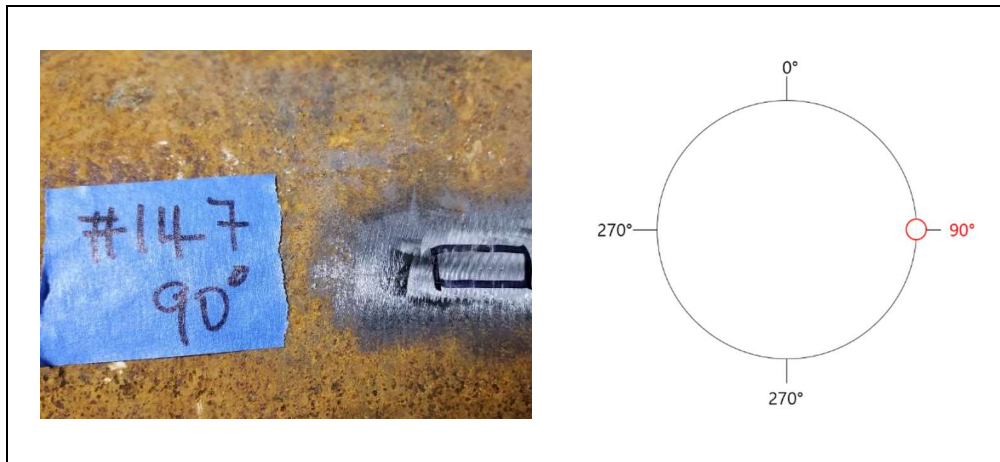
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 147
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/11/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.01	68.46	314.14
2	51.24	67.45	318.81
3	50.63	67.38	317.67
Avg.	50.96	67.76	316.87

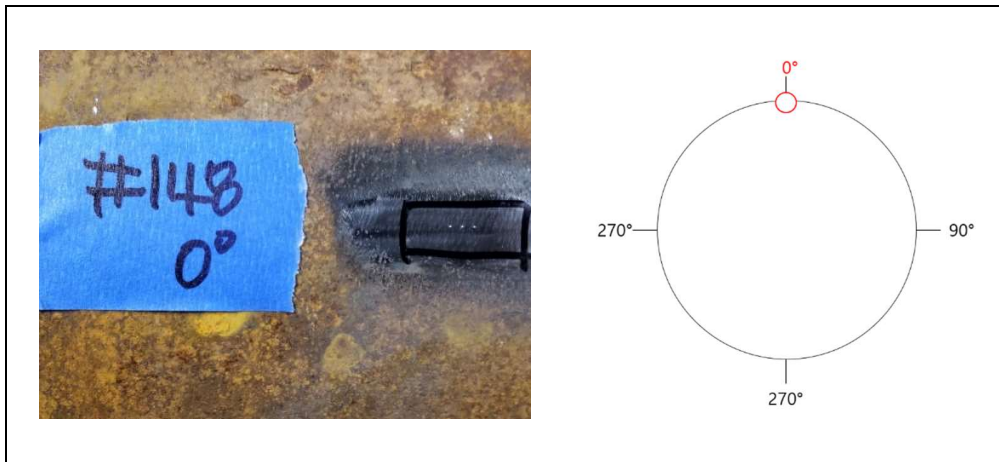
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 148
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/13/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	49.37	67.73	304.91
2	51.36	68.32	315.92
3	52.11	69.49	306.33
Avg.	50.95	68.51	309.05

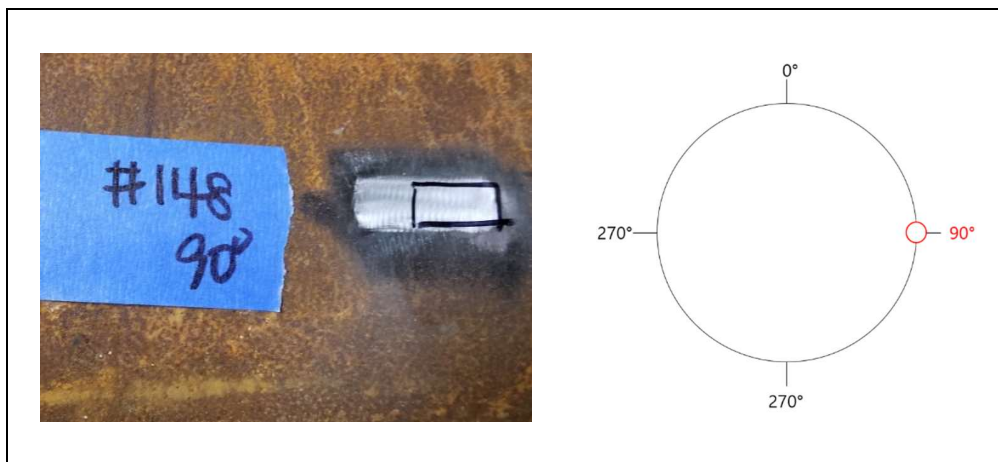
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 148
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/13/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.85	70.03	380.87
2	52.51	69.48	343.68
3	51.47	68.32	318.45
Avg.	52.61	69.28	347.67

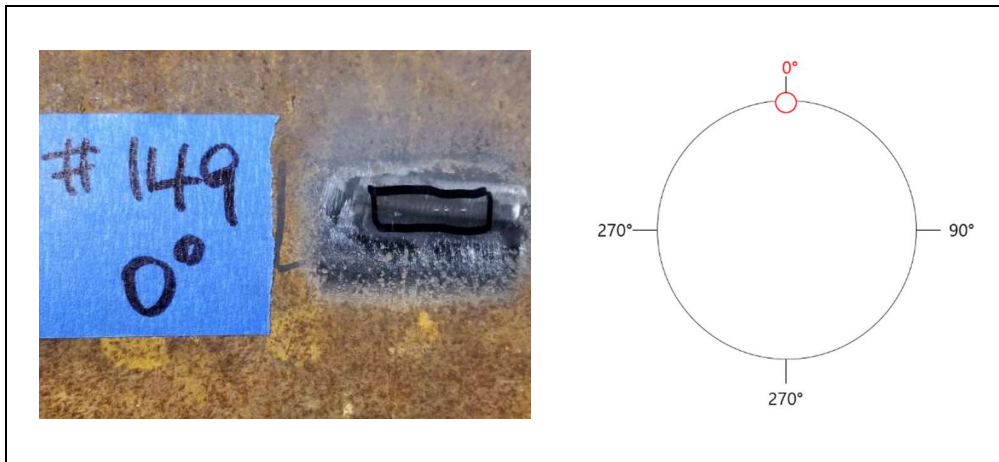
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 149
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.31	70.26	352.93
2	50.59	69.92	345.01
3	51.98	71.12	347.18
Avg.	51.29	70.43	348.37

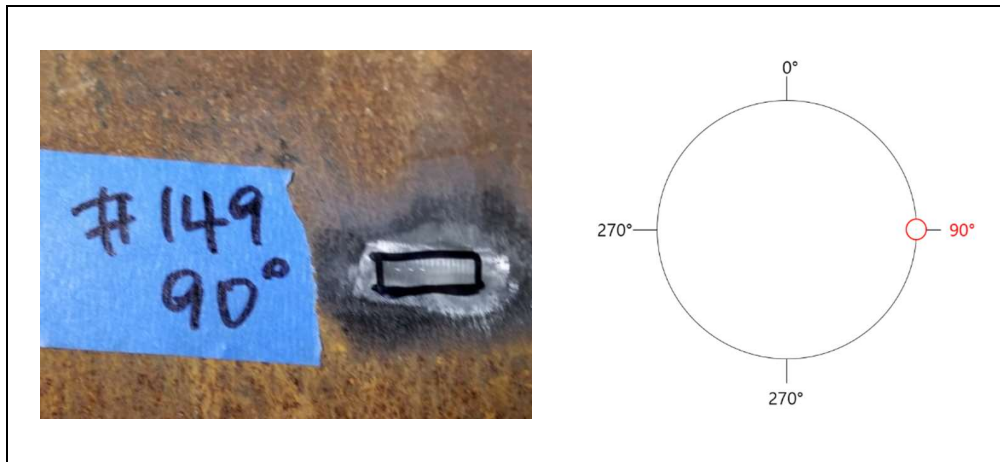
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 149
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/5/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.43	72.71	358.35
2	52.87	71.74	322.26
3	52.72	71.54	317.97
Avg.	53.01	71.99	332.86

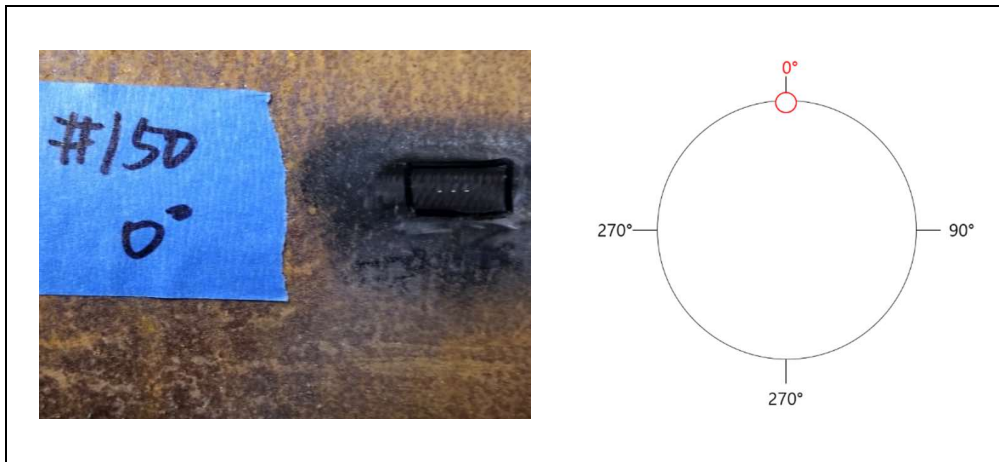
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 150
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.31	69.47	315.78
2	50.38	69.83	302.01
3	51.53	69.75	294.25
Avg.	51.41	69.68	304.02

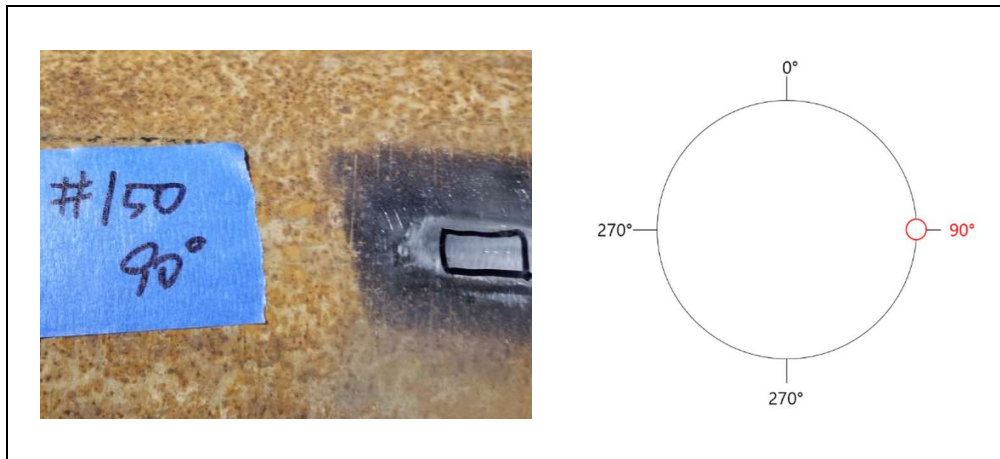
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 150
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.46	68.16	313.03
2	49.69	68.03	317.42
3	49.50	68.39	291.00
Avg.	49.88	68.19	307.15

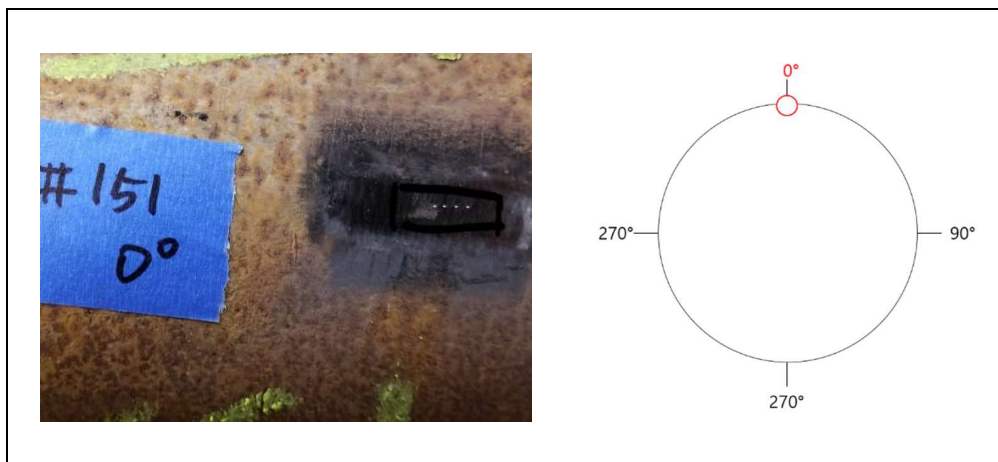
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 151
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.64	70.48	335.50
2	54.98	74.16	310.08
3	54.62	73.10	352.59
Avg.	55.08	72.58	332.72

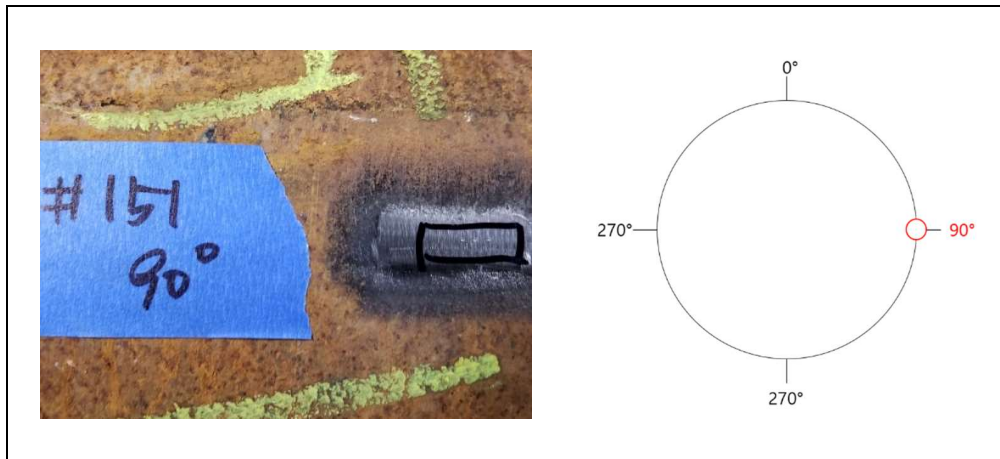
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 151
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/3/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.21	70.16	327.63
2	49.49	68.66	268.77
3	50.89	68.89	303.83
Avg.	50.86	69.24	300.07

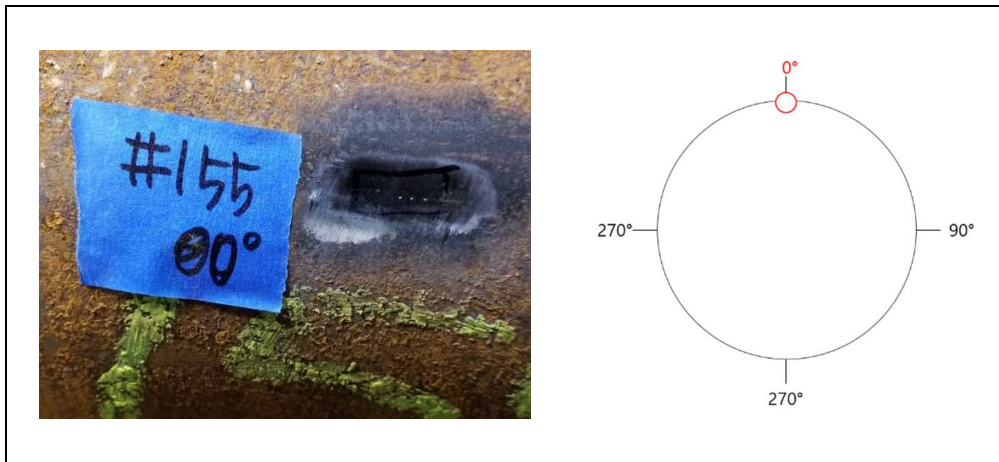
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 155
- (3) Pipe OD (inch) : 8
- (4) Location : 0°



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.72	68.96	314.75
2	51.77	69.54	327.39
3	50.64	68.75	273.58
Avg.	51.05	69.09	305.24

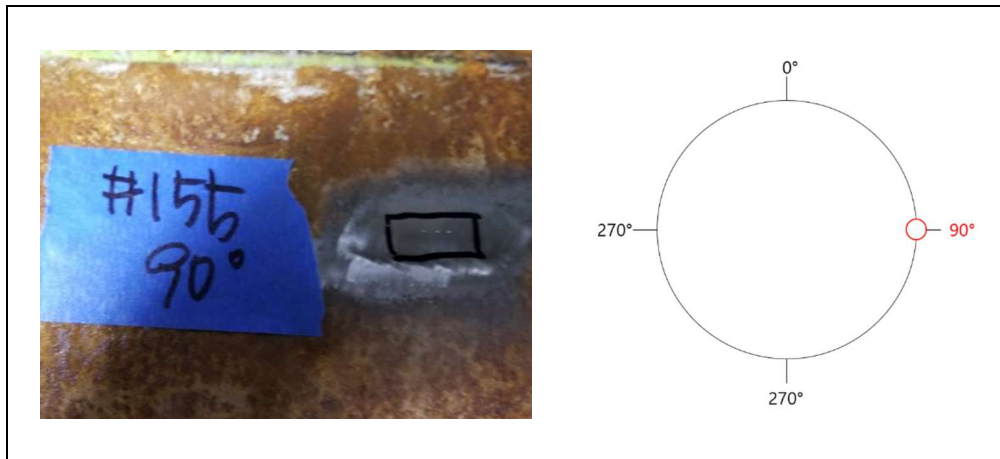
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 155
- (3) Pipe OD (inch) : 8
- (4) Location : 90°



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.84	70.15	333.20
2	51.38	69.60	272.24
3	52.34	70.24	326.48
Avg.	51.85	70.00	310.64

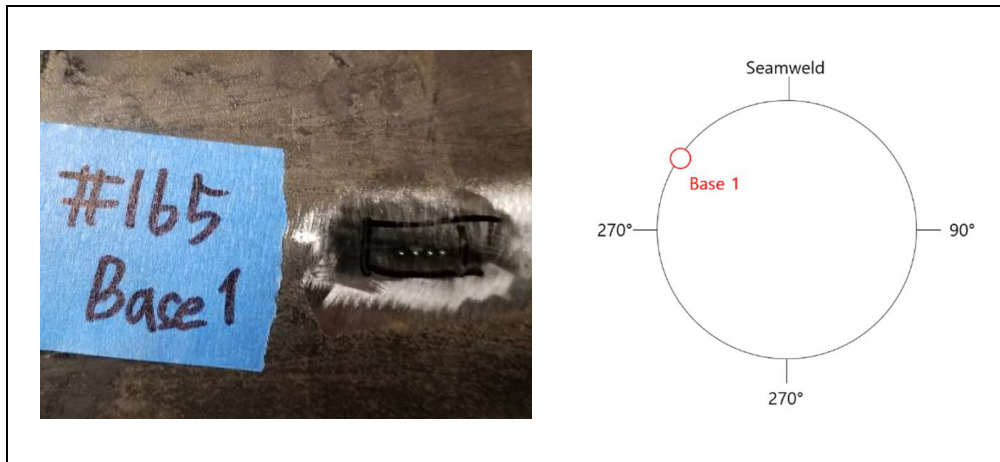
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.32	67.81	291.99
2	51.25	69.11	298.50
3	52.44	69.51	325.89
Avg.	51.34	68.81	305.46

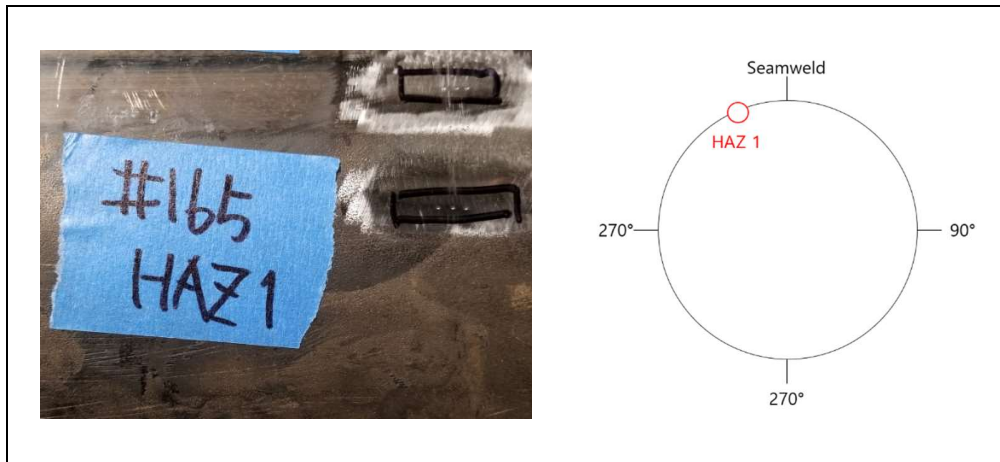
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.22	70.01	307.02
2	52.17	70.35	312.63
3	52.45	70.79	325.85
Avg.	52.28	70.38	315.17

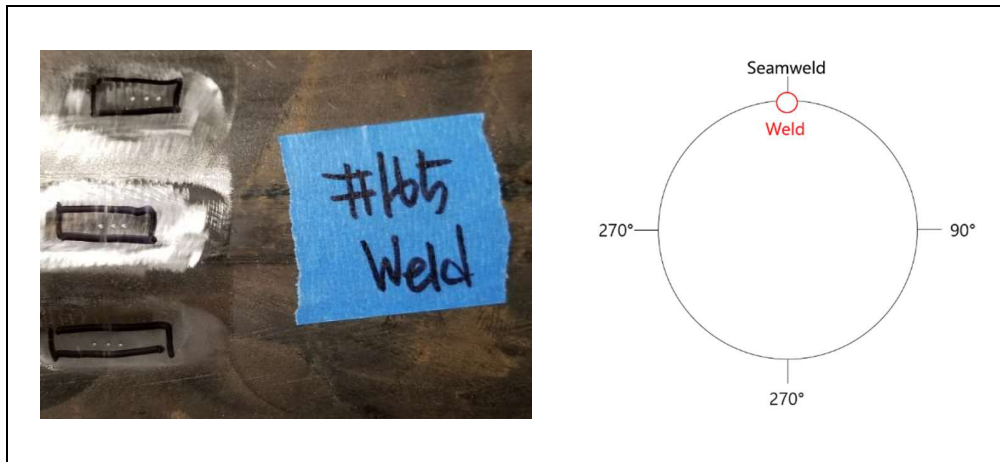
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	71.71	94.63	477.65
2	70.77	94.06	469.48
3	71.53	94.98	489.29
Avg.	71.34	94.55	478.81

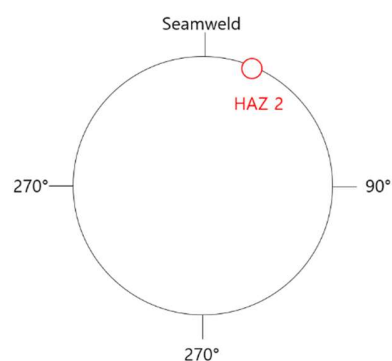
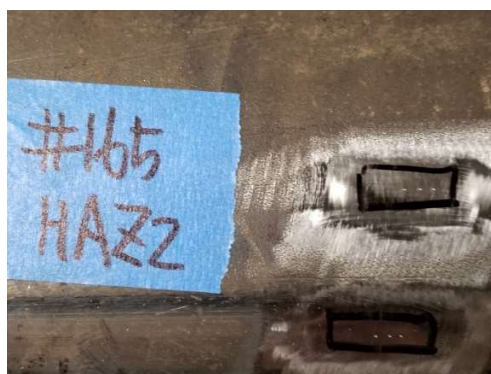
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.82	70.97	320.96
2	52.90	70.92	320.05
3	51.93	70.92	313.29
Avg.	52.55	70.94	318.10

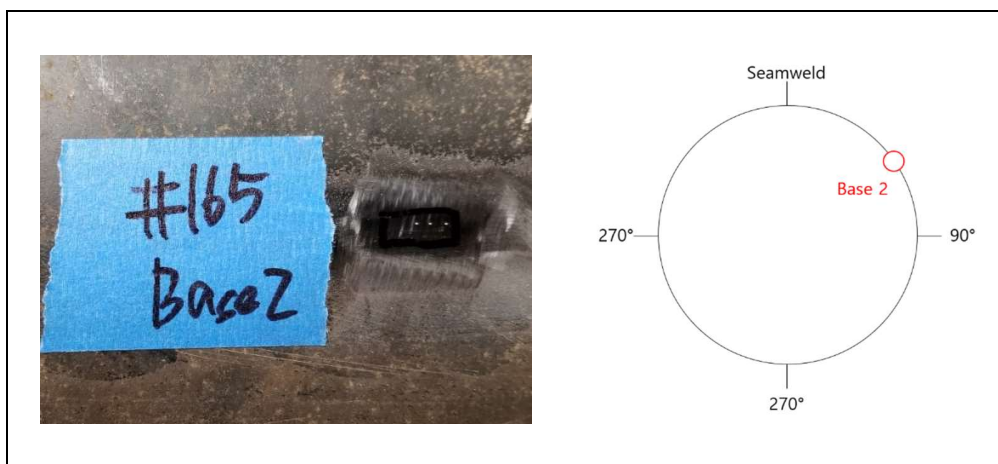
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.63	69.01	316.71
2	50.47	68.27	292.21
3	51.32	68.57	317.06
Avg.	51.14	68.62	308.66

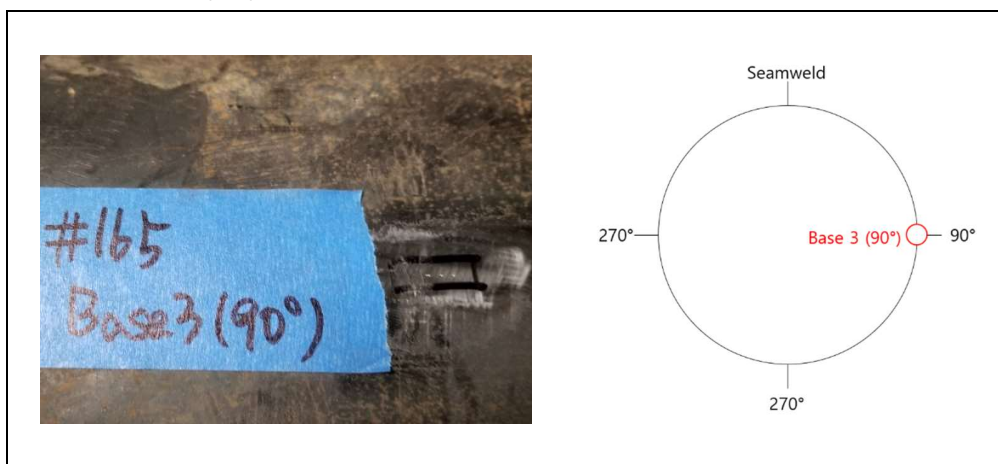
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 165
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3 (90°)



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.84	67.93	319.32
2	52.82	69.53	313.37
3	50.46	67.80	311.43
Avg.	52.04	68.42	314.71

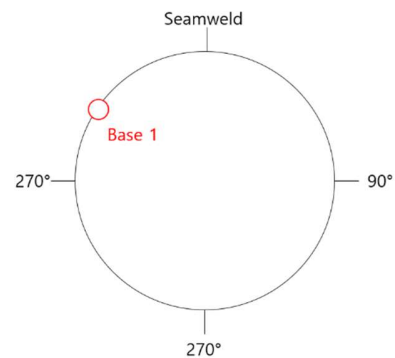
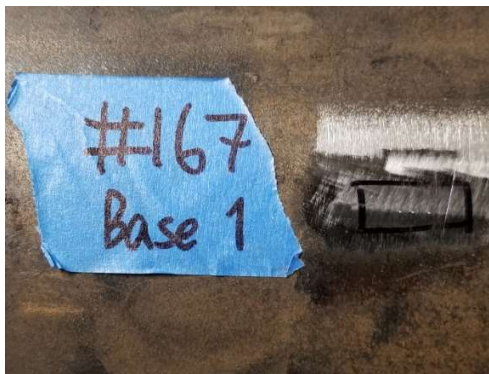
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : Base 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.25	73.26	333.47
2	54.50	73.02	326.55
3	55.72	73.67	323.10
Avg.	55.16	73.31	327.71

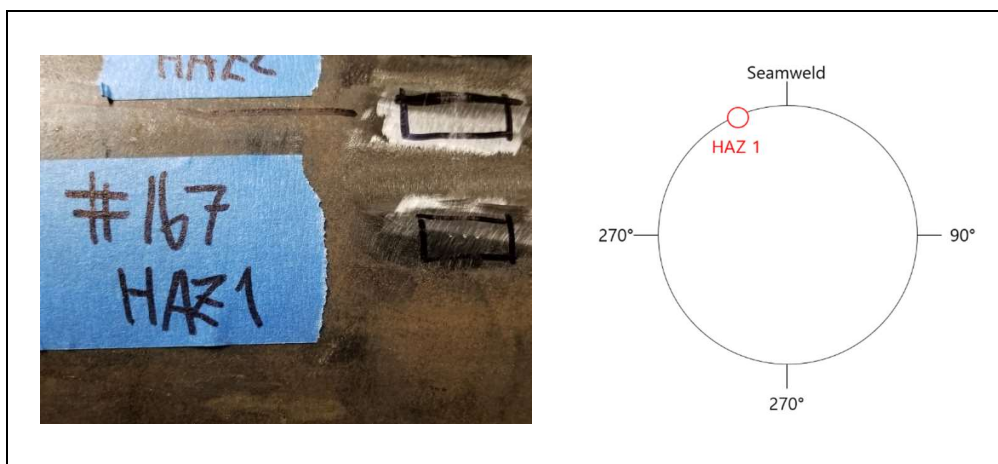
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.45	74.08	317.85
2	56.22	74.56	337.33
3	54.92	73.71	319.65
Avg.	55.53	74.12	324.94

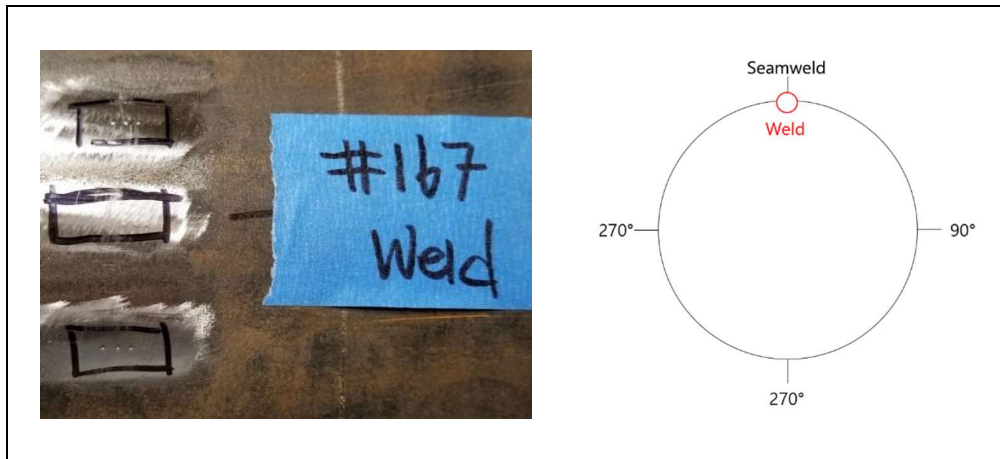
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : Weld



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	69.77	92.41	424.14
2	68.21	91.90	407.20
3	69.23	92.59	399.30
Avg.	69.07	92.30	410.21

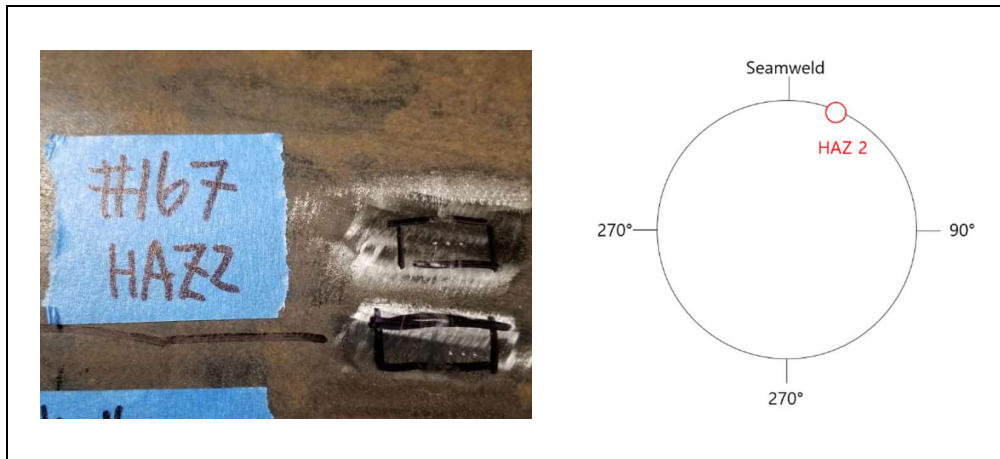
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : HAZ 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.29	78.22	350.35
2	64.14	81.02	462.70
3	58.12	77.53	316.40
Avg.	60.51	78.92	376.49

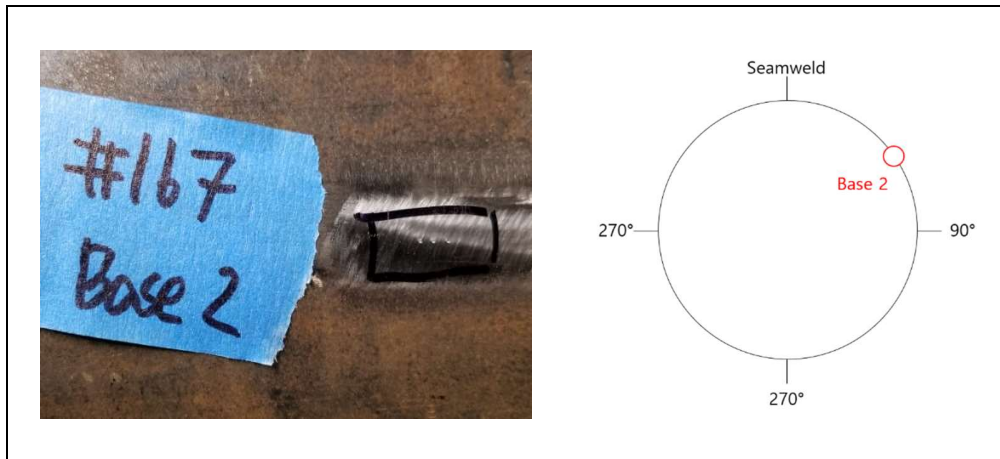
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : Base 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.31	73.88	316.68
2	54.49	73.83	284.14
3	55.23	73.60	329.76
Avg.	55.01	73.77	310.19

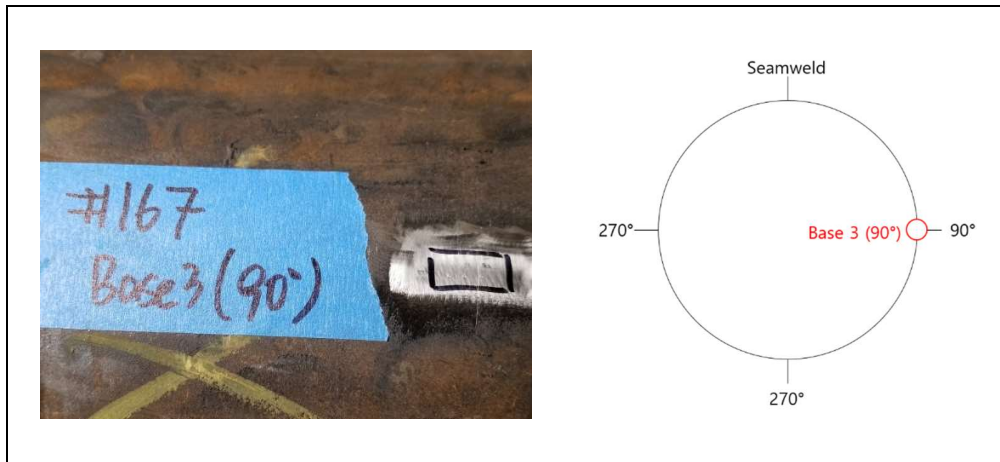
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 167
- (3) Pipe OD (inch) : 10
- (4) Location : Base 3 (90°)



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	54.86	72.89	318.00
2	53.52	72.22	320.47
3	55.59	73.50	356.30
Avg.	54.66	72.87	331.59

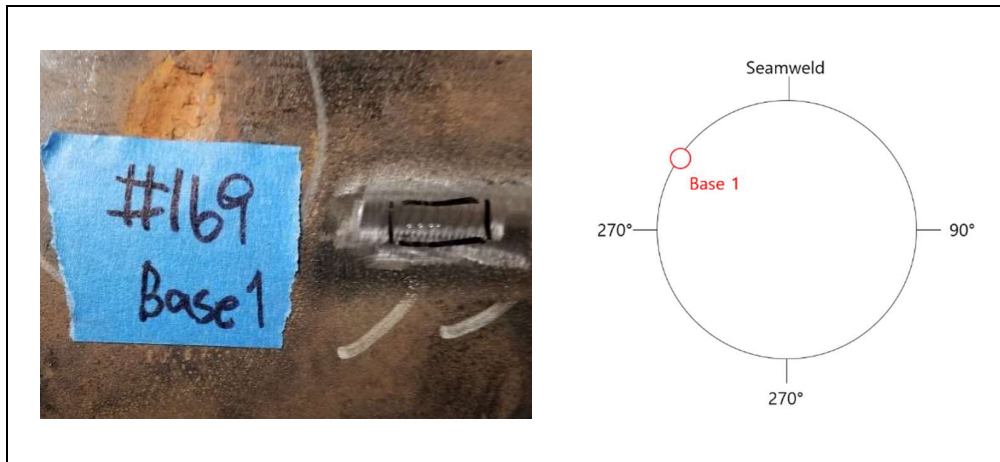
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : Base 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	51.18	68.39	290.48
2	51.86	69.04	315.47
3	49.50	67.56	264.07
Avg.	50.85	68.33	290.01

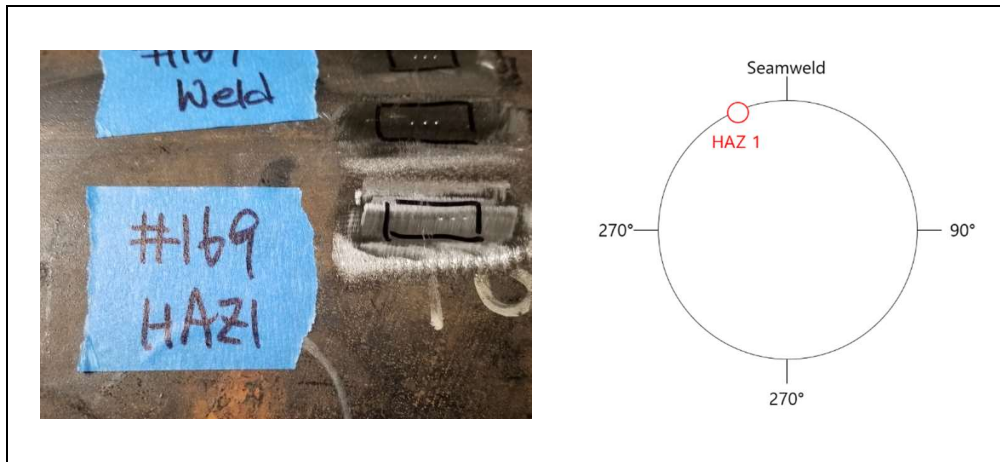
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 1



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.31	76.01	350.50
2	58.01	75.49	313.86
3	58.12	76.26	321.40
Avg.	58.48	75.92	328.59

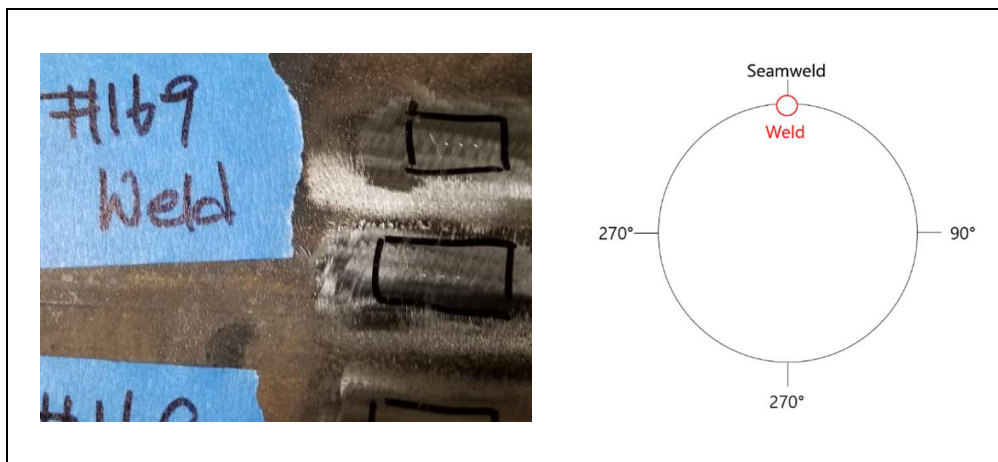
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : Weld



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.87	81.39	374.25
2	61.43	81.87	363.40
3	61.03	81.62	377.04
Avg.	61.11	81.63	371.56

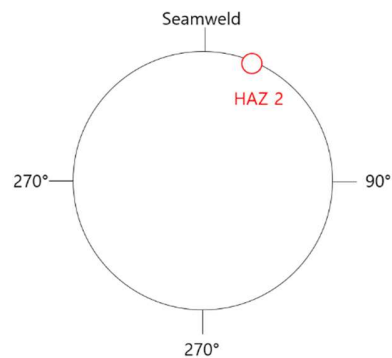
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : HAZ 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.80	74.35	311.96
2	57.66	75.63	339.70
3	56.69	75.47	330.36
Avg.	56.72	75.15	327.34

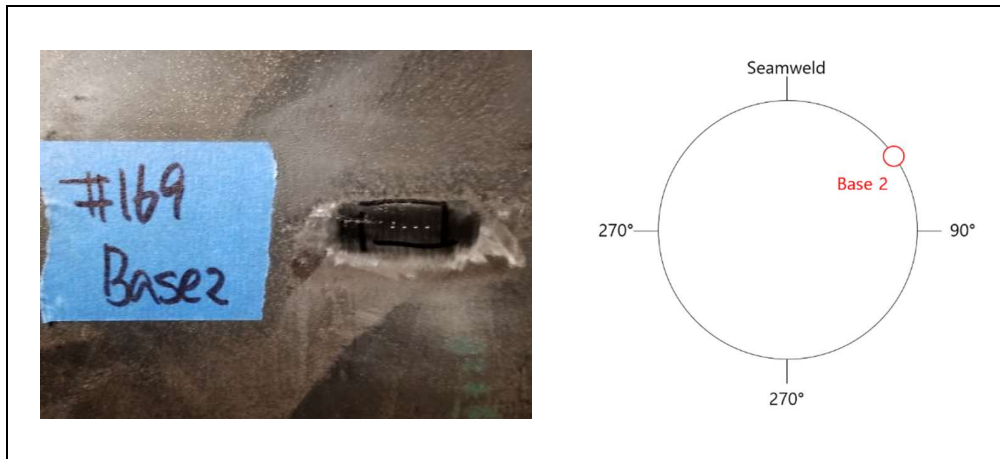
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : Base 2



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	50.53	67.96	306.92
2	50.41	68.10	286.40
3	50.67	68.34	298.42
Avg.	50.54	68.14	297.25

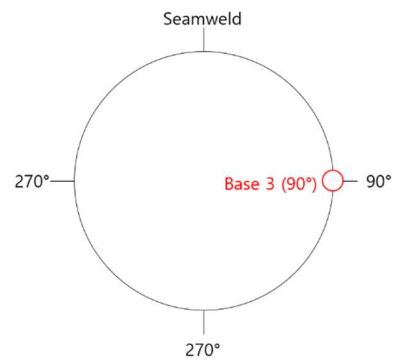
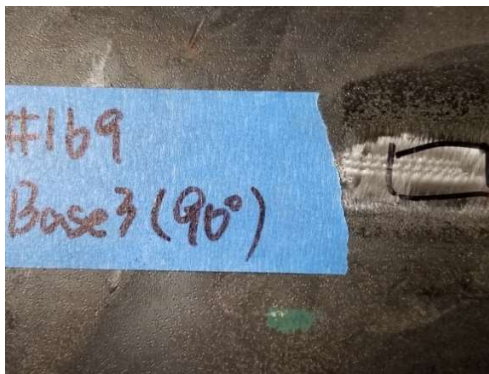
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 169
- (3) Pipe OD (inch) : 12
- (4) Location : Base 3 (90°)



2. Condition

Date	4/12/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	52.04	69.82	317.02
2	52.01	70.14	334.24
3	52.67	71.09	303.22
Avg.	52.24	70.35	318.16

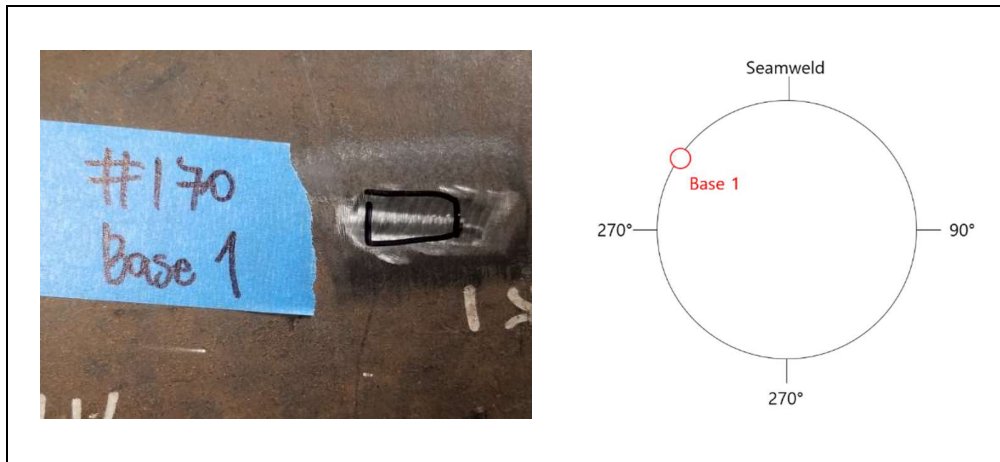
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : Base 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	55.73	72.36	294.66
2	56.03	73.77	319.05
3	55.15	68.28	281.30
Avg.	55.64	71.47	298.34

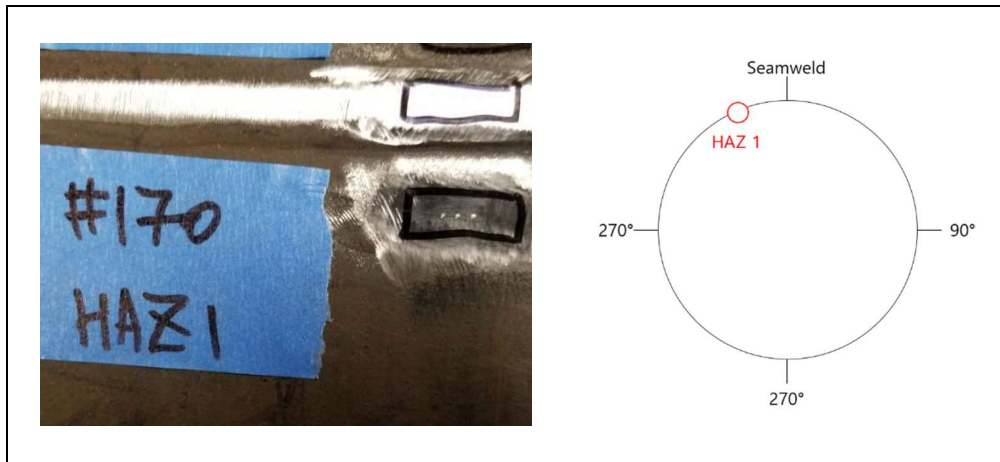
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 1



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	53.01	69.69	265.30
2	55.76	71.78	327.44
3	55.94	74.14	326.53
Avg.	54.90	71.87	306.43

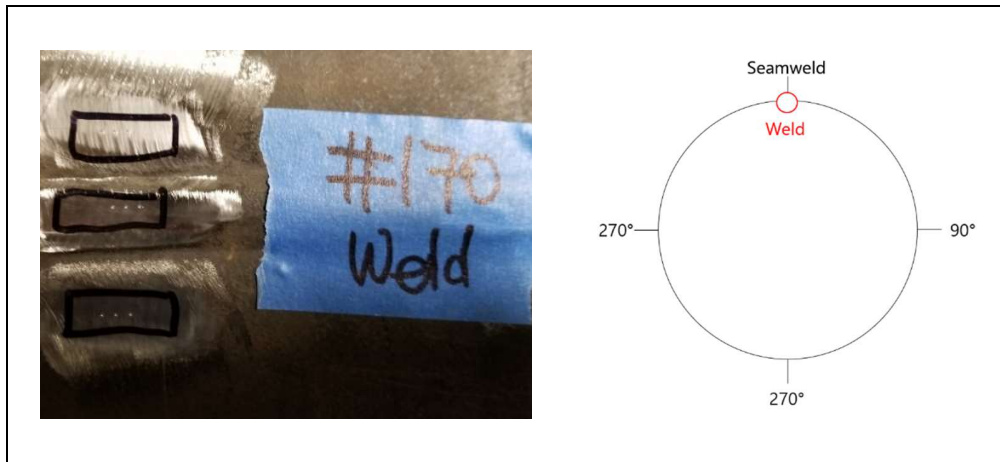
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : Weld



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.97	75.20	383.78
2	56.96	73.08	350.73
3	57.19	70.98	346.23
Avg.	57.71	73.09	360.25

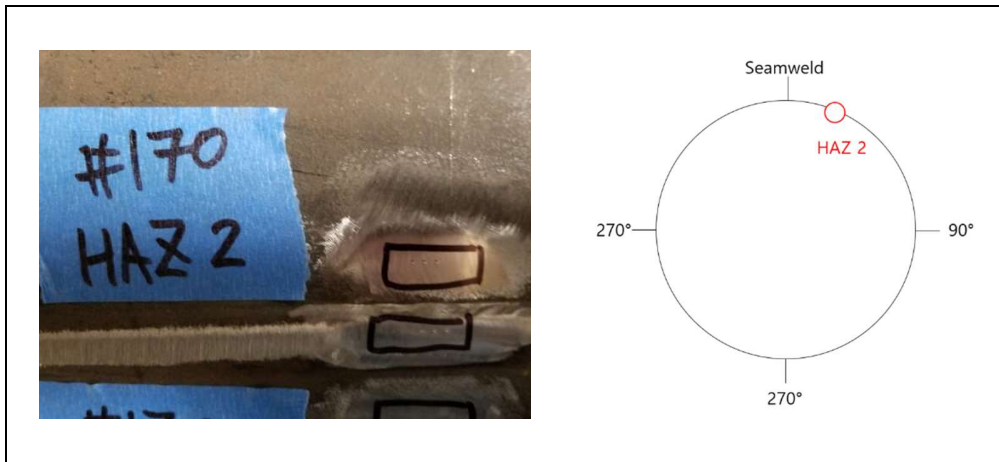
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : HAZ 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	58.00	73.61	331.37
2	59.10	76.91	346.89
3	59.57	77.71	371.87
Avg.	58.89	76.08	350.04

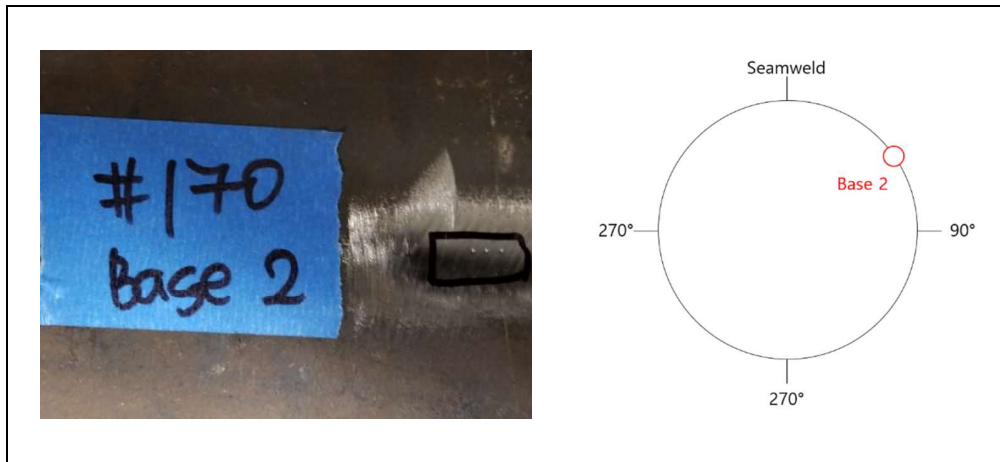
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : Base 2



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	60.24	77.47	343.86
2	56.97	76.01	328.91
3	59.05	77.86	329.74
Avg.	58.76	77.11	334.17

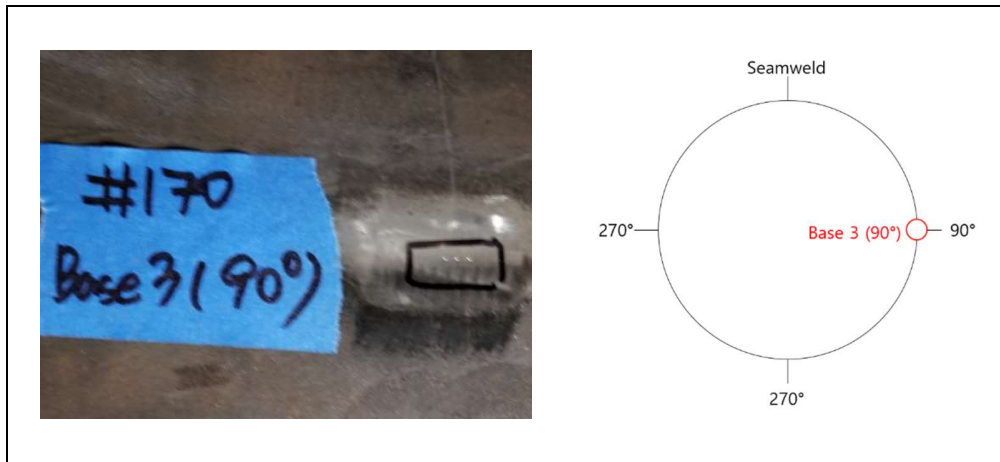
* Analysis result is engineering value

Instrumented Indentation Test (IIT) Results

- Yield strength, Tensile strength and Fracture toughness

1. Test Information

- (1) Purpose: Measurement of mechanical properties of API 5L pipe
- (2) Pipe # : 170
- (3) Pipe OD (inch) : 20
- (4) Location : Base 3 (90°)



2. Condition

Date	4/18/2019	Operator	Dongseong Ro
Equipment	AIS2100	Test load/depth	150 um
Indenter	K05343	Analysis SW	AIS2100 TS/FT

3. Results

No.	Yield strength	Tensile strength	Fracture toughness
	ksi	ksi	MPa·m ^{1/2}
1	59.63	77.73	336.99
2	57.54	74.93	357.83
3	57.95	75.60	347.10
Avg.	58.38	76.09	347.31

* Analysis result is engineering value

<Annex B> Reference Paper for Algorithm

Reference paper for Algorithm

- 1. Tensile Properties**
- 2. Fracture Toughness**
- 3. Brinell Hardness**

1. Algorithm of the tensile properties

Technology for Evaluating the Tensile Properties of a Metallic Material with the Instrumented Indentation Technique

The technology for evaluating the tensile properties with the instrumented indentation technique can be introduced from the aspect of the representative stress and strain. The evaluation of the tensile properties of a material with the representative stress and strain defined in the instrumented indentation technique is composed of four stages (Figure 1). The first stage is to calibrate the contact depth from the measured indentation depth load data. The second stage is to define the representative stress and strain. The third stage is to decide the constitutive equation. The last fourth stage is to evaluate the tensile properties [16 and 17]. The algorithm with four stages is to be introduced in detail in the next chapter.

Technology for Evaluating the Tensile Properties with the Representative Stress and Strain

1. Determination of the Contact Area of the Instrumented Indentation Technique with the Spherical Indenter

In order to interpret the deformation occurring from the instrumented indentation test, it is important to correctly evaluate the contact area which the indenter and the material contact during the indentation test. The contact area is derived from the contact depth (h_c) on the basis of the geometrical shape of an indenter. The load and displacement are continuously measured in the instrumented indentation test so that it tends to be easily thought that the contact depth at the moment of indentation can be measured immediately. However, the direct contact area cannot be measured only with the maximum indentation depth (h_{max}) measured as the indentation depth from the standard point due to the occurrence of the phenomenon of elastic deflection(h_d) and plastic pile-up (h_{pile}) caused by the elastic and plastic deformation occurring around the material at the moment of material indentation (Figure 2).

Fig. 1. The Tensile Properties Evaluation Algorithm and Diagram with the Representative Stress and Strain

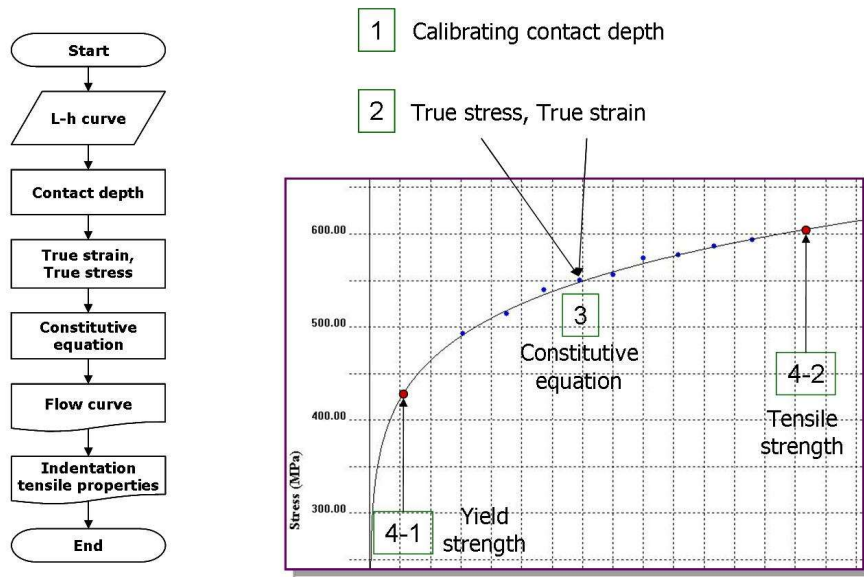
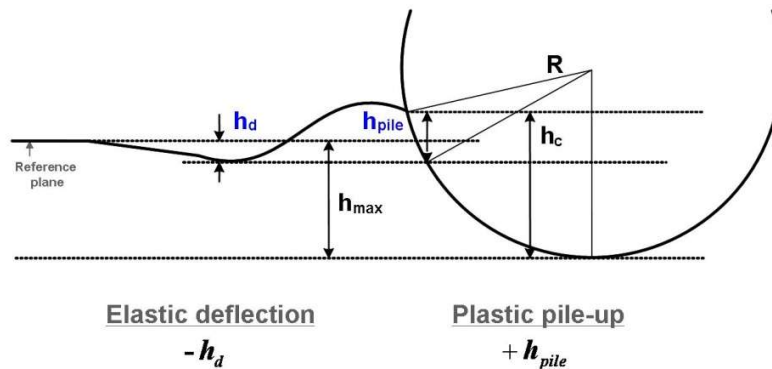


Fig. 2. The Diagram of the Elastic deflection and Plastic Pile-up under a Spherical Indenter [15]



The problem of contact depth determination occurs in the same manner during the measurement of the tensile properties and the hardness and elasticity coefficients as well so that a lot of studies have been done to solve the problem [2, 3, 12, 13, 14, and 15]. As for the phenomenon of the elastic deflection caused by the elastic deformation, the study of Oliver-Pharr based on the elastic contact analysis by Sneddon is accepted the most universally. It is represented with the formula (1) [3 and 12].

$$h_d = \chi \frac{S}{L_{max}} \quad (1)$$

Here, L_{max} is the maximum indentation load. S is the initial slope of the unloading curve. χ is the constant based on the shape of an indenter and has the value of 0.75 for a Spherical indenter. Differently from the elastic deflection for which the universal analysis exists, the analysis on the elastic pile-up is complex so that there is no available universal formula with an analytic method. Most studies to adjust the pile-up were the ones to clarify the relation between effect factors affecting the pile-up and to formularize the relation [12, 13, 14, and 15]. The work-hardening exponent (n), the property representing the plastic deformation, and the ratio of the yield strength corresponding to the maximum elastic strain and the elasticity coefficient has been accepted as the core factor affecting the pile-up. On the basis of the study, the following formula (2) for the change based on the material of the contact depth, indentation depth, and indenter radius (R) was generated through the finite element analysis [15].

$$\frac{h_{pile}^*}{h_c^*} = f(n_{IT}, \frac{h_{max}}{R}) \quad (2)$$

The height of the pile-up is represented with the multiplication of the function dependent on the physical property of the material by the function dependent on the indentation depth, and the formula for the final contact depth is presented by reflecting the value of the elastic deflection is presented. The contact radius and area with the material can be converted through the indentation depth and the indentation radius on the basis of the geometrical shape.

$$A_c = \pi a_c^2 = \pi(2Rh_c - h_c^2) \quad (3)$$

2. Representative Stress and Strain

The Spherical indenter is used for the evaluation of the tensile properties through the instrumented indentation test. Vickers or conical indenter has the geometrical self-similarity so that as the indentation depth increases, the size of the plastic area gets bigger, but the shapes of plastic zone size as the increasing indentation depth are the same [13]. Contrary to it, as for the Spherical indenter without the geometrical self-similarity, the contact angle contacting the material continuously changes depending on the indentation depth, and the shape of the stress field generated in the lower part of the indenter continuously changes. Therefore, the individually different representative stress and strain can be defined by analyzing the continuously changing stress field.

2.1 Determination of the Representative Stress

When the material is contacted with the indenter by the indentation load, the elastic deformation that can be fully recovered after the test with unloading occurred initially, and it finally reaches the stage of the full elastic deformation.

In case of using the Spherical indenter, the interval in which the initial elastic- elastic plastic deformation occurs is so short that the whole interval with the indentation being made is assumed as the full plastic deformation interval. The study relating the average stress occurring during indentation to the flow stress of a material was done. On the basis of the analysis on the slip line theory, the following formula (4) through the plastic constraint factor (ψ) was introduced [9,16].

$$\sigma_r = \frac{1}{\psi} \frac{L_{\max}}{A_c} \quad (4)$$

It is known that the plastic constraint factor has the value of about 3, but there is the result of a study that it is affected by the work-hardening exponent of a material. However, on the basis of the result of the finite element analysis on 24 metallic materials and 12 ideal metallic materials, it was shown that the dependency is not so great for the most of metallic materials [16].

2.2 Strain

The strain is defined by the formula proposed by Tabor and by Ahn and Kwon. On the basis of the experiment, Tabor presented the strain with the sine function [9].

$$\varepsilon_r = K_1 \left(\frac{a_c}{R} \right) = K_1 \sin\theta \quad (5)$$

The value with 0.2 is usually used for K_1 , the constant determined experimentally, and θ is the contact half angle between the indenter and the material. From the characteristics of the sine function, the tendency that the work-hardening increases linearly is reflected depending on the indentation depth. Therefore, it is thought that it is the suitable definition in case that the work-hardening of a material appears in a linear function like the

austenitic steel, and Lee and Kwon introduced the result of evaluating the intensity of the austenitic stainless steel by connecting it with the evaluation of tensile properties in 2008 [18].

As the strain increases, most metallic materials show the decrease of the work-hardening level compared to the linear work-hardening introduced before. Ahn and Kwon presented the strain based on the tangent function as the formula (6) by analyzing the shape of the strain field occurring in the lower part of a Spherical indenter [14]. The shear strain was derived by defining and differentiating the displacement in the direction of the indentation axis, and the strain in proportion with the maximum shear strain was presented.

$$\varepsilon = \left(\frac{\alpha}{\sqrt{1-(a_c/R)^2}} \right) \left(\frac{a_c}{R} \right) = \alpha \tan \theta \quad (6)$$

The proportion constant α was determined by introducing the finite element analysis, and it is known that it takes the value of 0.14 [15]. The possible range of applying the representative stress and strain on various materials through the selection of the proper strain reflecting the work-hardening type of a material is expanded.

3. Determination of the Constitutive Equation

Each representative stress and strain can be found at each multiple indentation time with the multiple loading-unloading technologies. The representative stress and strain obtained through the indentation test present only the multiple points under the tensile curve so the constitutive equation of the tensile curve on the basis of the obtained representative stress and strain points should be presented to make it possible to draw the true stress and strain tensile curve. The method that used the most generally for describing the plastic range of the tensile curve is to use the Hollomon equation.

$$\sigma = K\varepsilon^n \quad (7)$$

In case of the Hollomon equation, it is suitable to the material using the tangent function introduced before. The work-hardening exponent takes the value less than 1 so that the work-hardening level of a material shows the decreasing tendency as the strain increases. However, the austenitic steels show the linear work-hardening so that they are not suitable to the Hollomon equation. Therefore, in order to easily describe the linear work-hardening, the following formula was proposed [18].

$$\sigma = A + E_T \varepsilon \quad (8)$$

A and E_T are material constants, and the value of A can be approximated with the yield strength.

4. Determination of Tensile Properties

The representative stress and strain analyzing the stress field in the perfect plasticity present the value corresponding to the plastic range in the flow curve. The initial linear elastic part is found with the elastic modulus obtained through the unloading curve of the instrumented indentation test. The reduced elastic modulus (E_r) generated in case of the contact of two materials is described with the initial slope of unloading curve and contact area like equation (9) [1-13].

$$E_r = \frac{\sqrt{\pi}}{2} \frac{S}{\sqrt{A_c}} \quad (9)$$

The elastic modulus of a material is derived from the reduced elastic modulus through the equation (10).

$$E = (1 - \nu^2) \left(\frac{1}{E_r} - \frac{(1 - \nu_{tip}^2)}{E_{tip}} \right)^{-1} \quad (10)$$

Here, ν represents the Poisson's ratio of a specimen, and E_{tip} and ν_{tip} represent the elastic modulus and Poisson's ratio of an indenter respectively. The elastic behavior of a material is represented with the elastic modulus and the strain so that it is represented as follows.

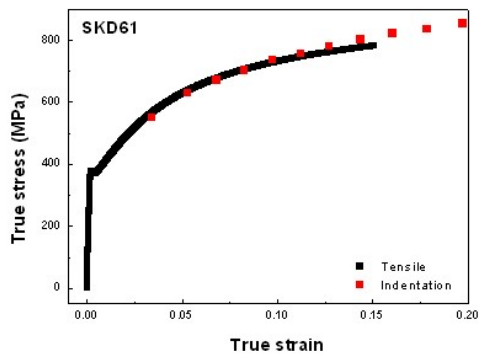
$$\sigma = E \varepsilon \quad (11)$$

After the elastic range of a material is defined, the yield strength of the material with the 0.2% offset can be obtained. The yield strain can be found like the equation (12) with the equations (7) and (11) and can be put into the equations (7) or (11) to determine the yield strength [16].

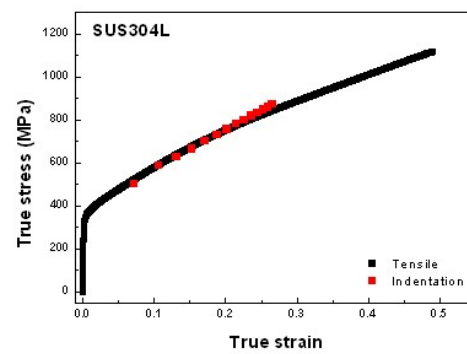
$$K \varepsilon_y^n = E(\varepsilon_y - 0.002) \quad (12)$$

The tensile strength is measured from the tensile strain ($\epsilon_{tensile}$) obtained through the equation (13) derived under the condition of instability in tension.

$$\epsilon_{tensile} = n \quad (13)$$



(a) SKD61



(b) SUS304L

Fig. 3. Comparison of the Tensile Curve with the Representative Stress and Strain

(a) SKD61, (b) SUS304L

Table 1 Comparison of Yield Strength and Tensile Strength through between the Tensile Test and the Indentation Test

Materials	Yield strength (MPa)			Tensile strength (MPa)		
	Tensile test	IIT	Error (%)	Tensile test	IIT	Error (%)
SKD61	371.45	357.21	-3.83	781.33	806.7	3.25
S45C	352.72	344.12	-2.44	774.19	786.11	1.54
SK3	315.08	329.18	4.48	706.53	720.38	1.96
SUS420J2	398.47	411.63	3.3	797.69	790.68	-0.88
SUS304L	338.68	340.35	0.49	1117.73	1147.06	2.62
SUS316L	304.67	313.87	3.02	950.7	914.9	-3.77

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2. Algorithm of the Fracture toughness

Technology for Evaluating the Fracture toughness of a Metallic Material with the Instrumented Indentation Technique

The fracture toughness, which is resistance against crack propagation, can be defined as energy absorbed from the vicinity of crack tip to its fracture[1-2]. The assessment of fracture toughness (K_{IC}) using an instrumented indentation test of FRONTICS is decided by associating energy absorbed from the vicinity of crack tip to its fracture with energy absorbed from the critical indentation depth corresponding to the characteristic fracture initiation point.

The crack existent inside material induces high stress and strain fields at the vicinity of crack tip when external load acts, and the stress and strain fields is controlled according to plastic constraint effects of crack[3-7]. The large strain fields are generated under the indenter in the instrumented indentation test using a spherical indenter similarly to this, and at this time, because the deformation zone by an indenter is very small, the locally high plastic constraint is generated by the surrounding materials. The research result that the stress concentration level beneath a spherical indenter is similar to the stress concentration level at the crack tip is already reported in the previous study [8]. Accordingly, if the critical indentation depth, that is imaginary fracture time at an instrumented indentation test using a spherical indenter corresponding to fracture, the indentation energy that material absorbs to the depth can be associated with fracture energy.

Because any physical change that can distinguish fracture time is not generated in an instrumented indentation test of ductile material, the continuum damage mechanics was introduced to decide the critical indentation depth. If the continuous loading unloading is repetitively carried out in an instrumented indentation test using a spherical indenter, it is supposed that the plastic deformation as well as localized damage are generated in the material below an indenter according to increase of indentation depth. The change due to localized damage of a lower part of an indenter becomes a reason of change of strain energy density. According to the existing researches, when it is supposed that material is an assembly of continuous units, the deformation of material is caused by shape change of the units, and the fracture of material is caused by its volume change. Accordingly, the localized damage generation at the lower portion of an indenter, where the load is applied to, induces increase of localized volume of material, and as a result, the strain energy density becomes reduced. Accordingly,

the reduction of strain energy density can be regarded as time that the fracture of material starts.

The time the reduction of strain energy density occurs is explained by using a concept of a critical void volume fraction. The existing researches view that when the void volume fraction (f) is around 0.15, the union of void volume occurs, and when it is around 0.25, the stable growth starting point of crack [10-12]. In general, the shape of CTOD curve of ductile-fractured material shows a fracture pattern of δ_u and δ_m type. It can be said that as the load of material with a δ_u type rapidly decreases at the maximum load, the sudden propagation of crack is generated after the union of void volume. On the other hand, as the material with a δ_m type shows reduction of a gentle curve even after maximum load, it can be regarded stable growth of crack as fracture time. If the critical damage variable value is calculated through a geometrical relationship between a void volume fraction and a damage variable by applying the critical void volume fraction like this, the critical indentation depth that the reduction of strain energy density occurs can be decided.

Reference

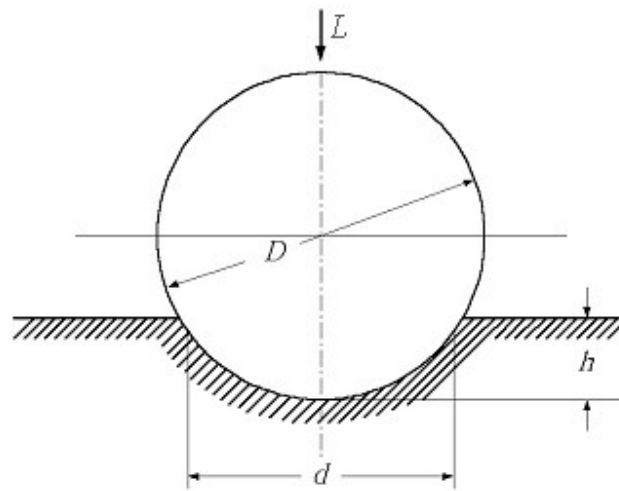
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3. Algorithm of the Brinell hardness

Measurement of Non-optical Brinell Hardness using Instrumented Indentation Technique

The Brinell hardness test is a method that is much used for analogizing the strength of material fast. Also, the properties change and residual lifetime of material could be estimated through variation of a hardness value. The Brinell hardness is evaluated by indenting a spherical indenter into a specimen with fixed load and observing pressure marks.

Fig. 1. Schematic Diagram of Brinell Hardness Test



After a specimen is indented with test load of $L(\text{kgf})$ by using a spherical indenter with a diameter of $D(\text{mm})$ as shown in Fig. 1, permanent marks are remained in the specimen if the load is removed. If the diameter of this indentation mark is $d(\text{mm})$ and the surface area of the indentation mark is $A(\text{mm}^2)$, the Brinell hardness equation is given as follows. [1].

$$HB = \frac{L}{A} = \frac{2L}{\pi D(D - \sqrt{D^2 - d^2})} \quad (1)$$

Like this, the Brinell hardness test includes troublesomeness that an experiment should measure a contact diameter by observing indents in an optical way after the indentation test was carried out. The shortcoming of a Brinell hardness test can be overcome through instrumented indentation technique. The size of indents can be analogized without optical observation by analyzing a load-depth curve measured through instrumented indentation test using a spherical indenter

The technology understanding a behavior of material accurately and correcting the indentation depth is necessary to measure the size of indents through a load-depth curve. If the material is indented, the elastic deflection and plastic pile-up occur due to an elastic and plastic behavior of material, so its accurate indentation depth cannot be estimated by the displacement being measured in a load-depth curve, and thus the accurate size of indents cannot be measured.

The elastic deflection(h_d) of material is assessed by using the maximum indentation load(L_{max}), initial tangential slope(S) and constant(χ) according to the shape of an indenter. [2-6].

$$h_d = \chi \frac{S}{L_{max}} \quad (2)$$

Also, the plastic pile-up(h_p) of material can be compensated through a work-hardening exponent(n) and a strain factor of an indentation test(h_{max}/R), which are factors representing plastic deformation of material. Here, R means a radius of a spherical indenter. [7-11].

$$h_p = f(n_{IT}, \frac{h_{max}}{R}) \quad (3)$$

The accurate contact depth (h_c) is finally decided through compensation of the elastic deflection and plastic pile-up and is finally converted into a diameter of indentation marks by using shape information of a spherical indenter. If the equation (5) is substituted for the equation (1), the Brinell hardness

$$h_c = h_{max} - h_d + h_p \quad (4)$$

$$d = 2\sqrt{(2Rh_c - h_c^2)} \quad (5)$$

The Brinell hardness can be directly assessed without troublesomeness of optical observation by assessing a diameter of indentation marks through a load-depth curve of an indentation test through an algorithm correcting the instrumented indentation test and contact depth.

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