Weld Design, Testing, and Assessment Procedures for High Strength Pipelines

CWP Test Protocol and Results

Presented by

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BP Westlake Campus

Houston TX

NIST National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

TC PipeLines, LP

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Center for Reliable Energy Systems

Overview

- CWP test procedures (Dash, 15 minutes)
- Generation of “raw” CWP data (Dash, 15 minutes)
- Post-test data processing (YY, 10 minutes)
- Summary of test results (YY, 5 minutes)

Acknowledgments

- Dave McColskey
- Mark Richards
- Jeff Sowards
- Ross Rentz
- Ken Talley
- Marc Dvorak

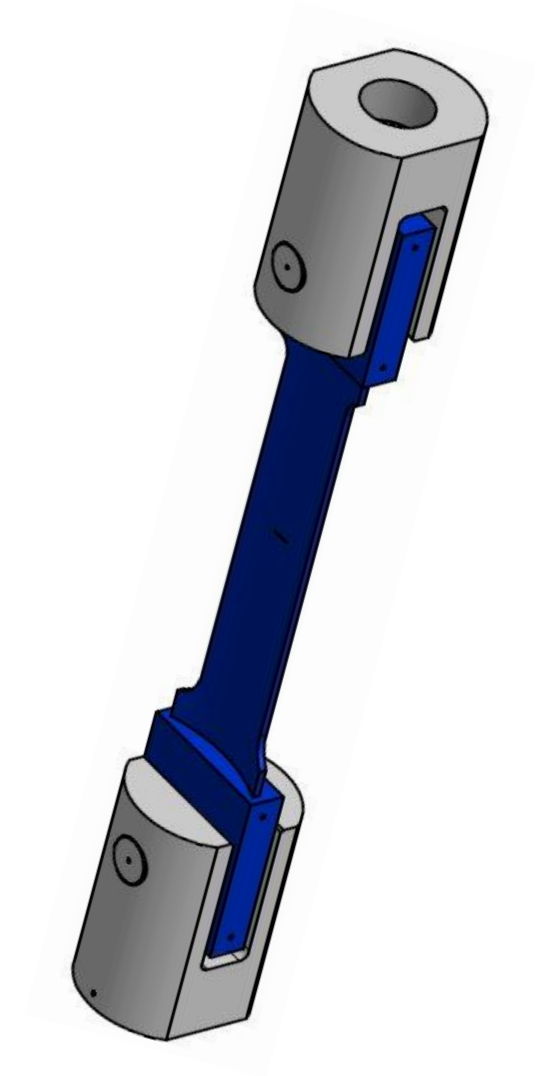
Objectives

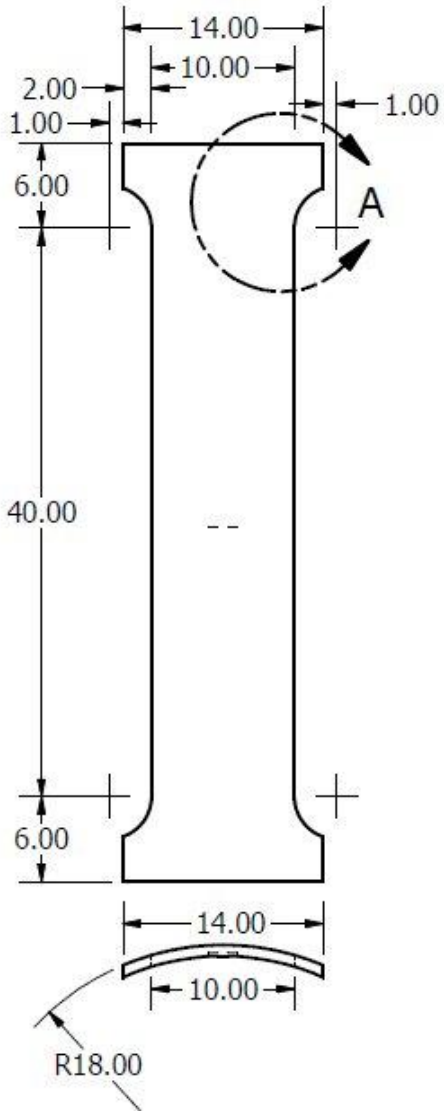
- Developing a test methodology to measure the physical response of a finite-length surface breaking flaw to axial loads applied to a girth welded linepipe section.
- Determining the appropriate instrumentation to fully characterize the bulk stress/strain response of the CWP specimen during loading
- Evaluating the applicability of the test methodology for sub-ambient temperatures
- Developing a standardized test procedure for CWP testing that can be used within a wide range of variability in the test parameters

The standardization of a CWP test procedure will include:

- Drafting and implementing consistent test procedures for CWP tests
- Formulating test data for consistent presentation and comparison
- Understanding the differences and limitations of test specimens of different scales
- Making the best selection of test specimens for a given set of objectives, and
- Making correct interpretation of test data and their relevance to girth weld performance.

Test Scale = Medium





CWP Specimen Life Cycle

Test

Analysis

Gage

Weld End Tabs

Notch and Pre-crack

Section

Weld Pipe

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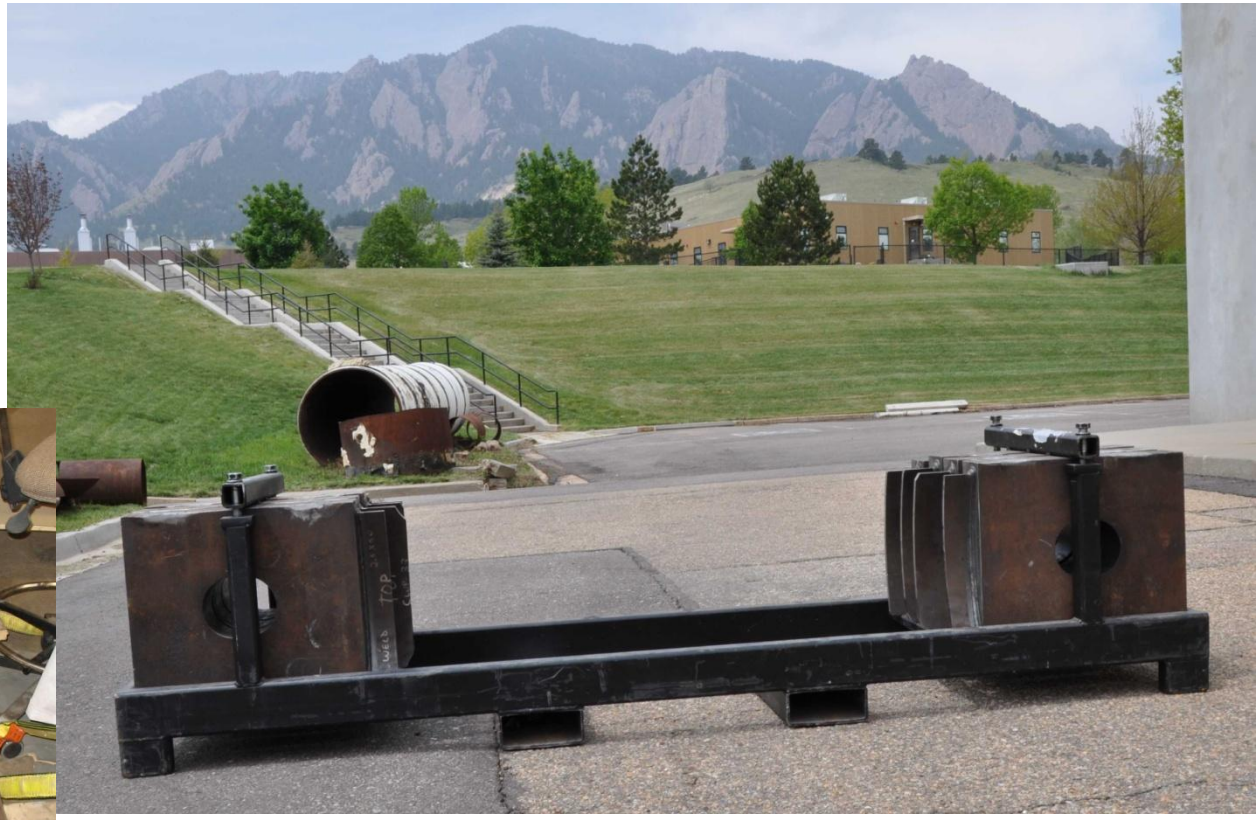
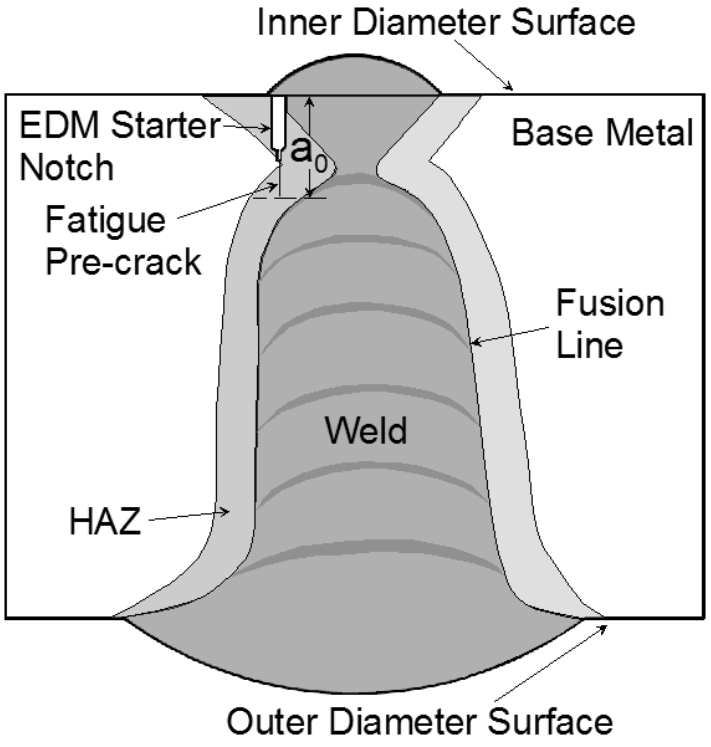
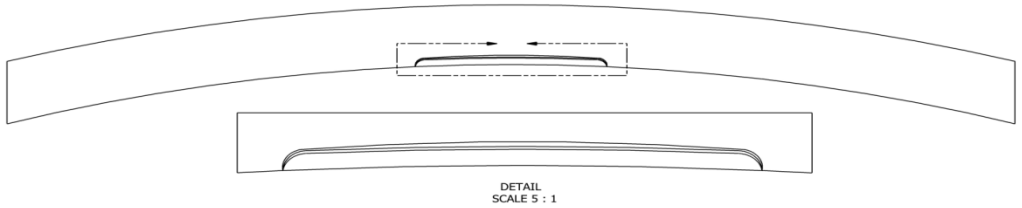
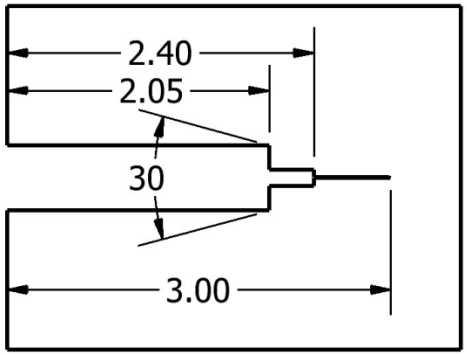
Transit

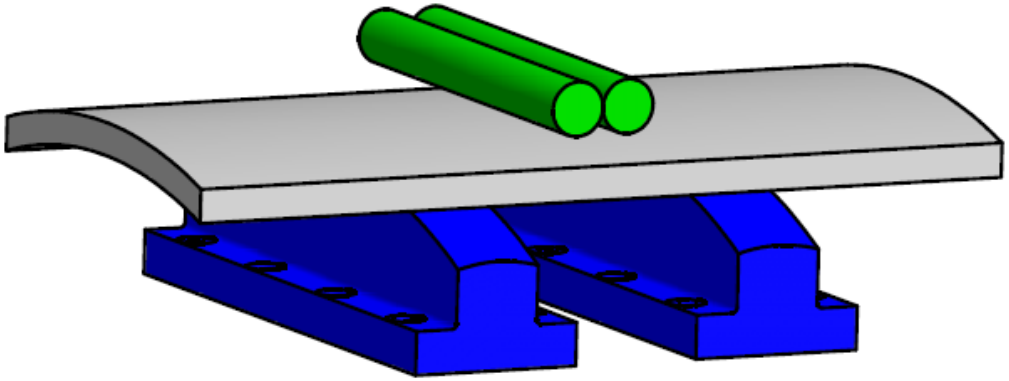


Notch and Precrack

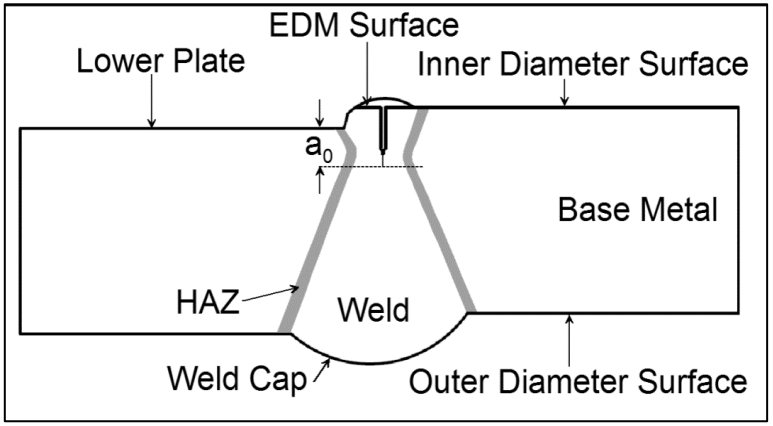


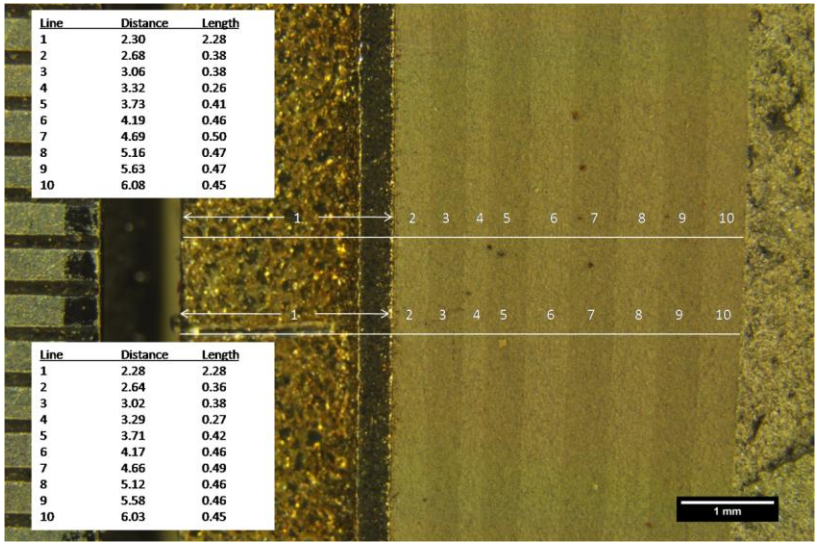


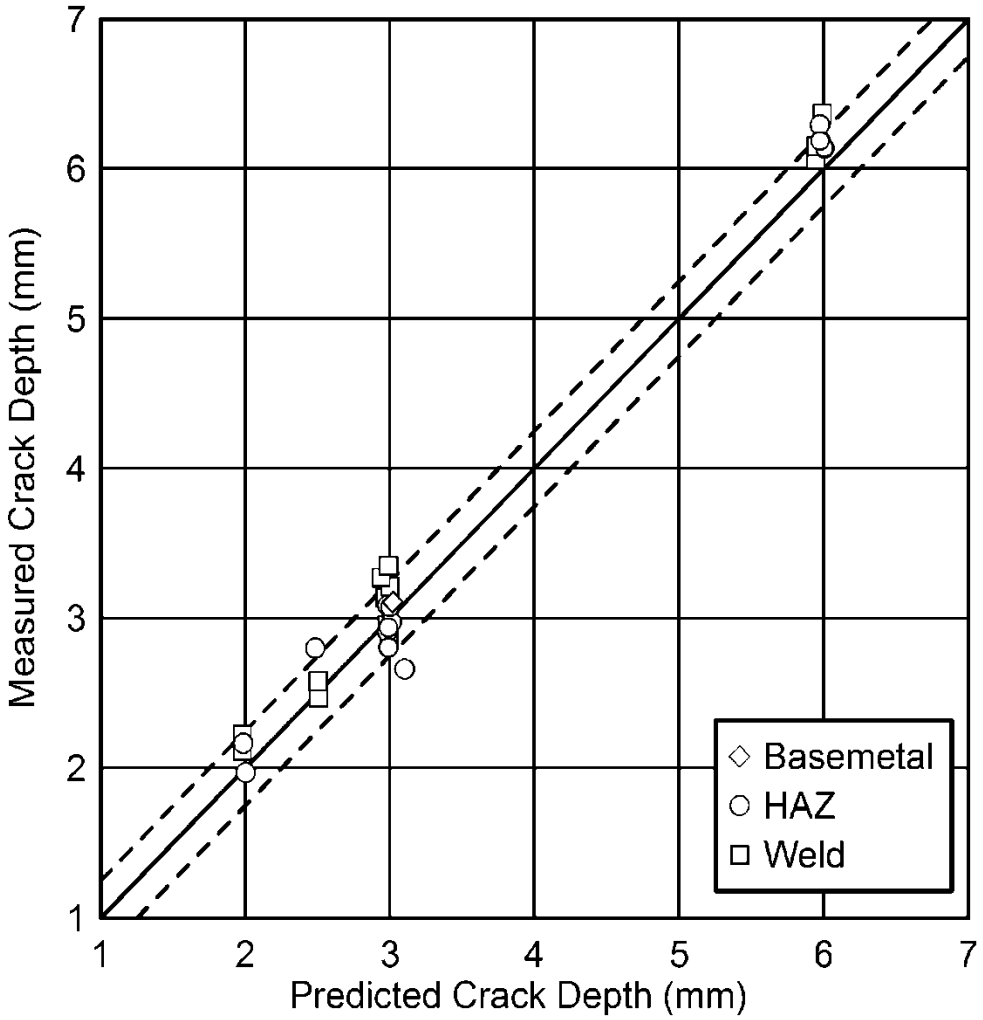




Fatigue Crack Depth







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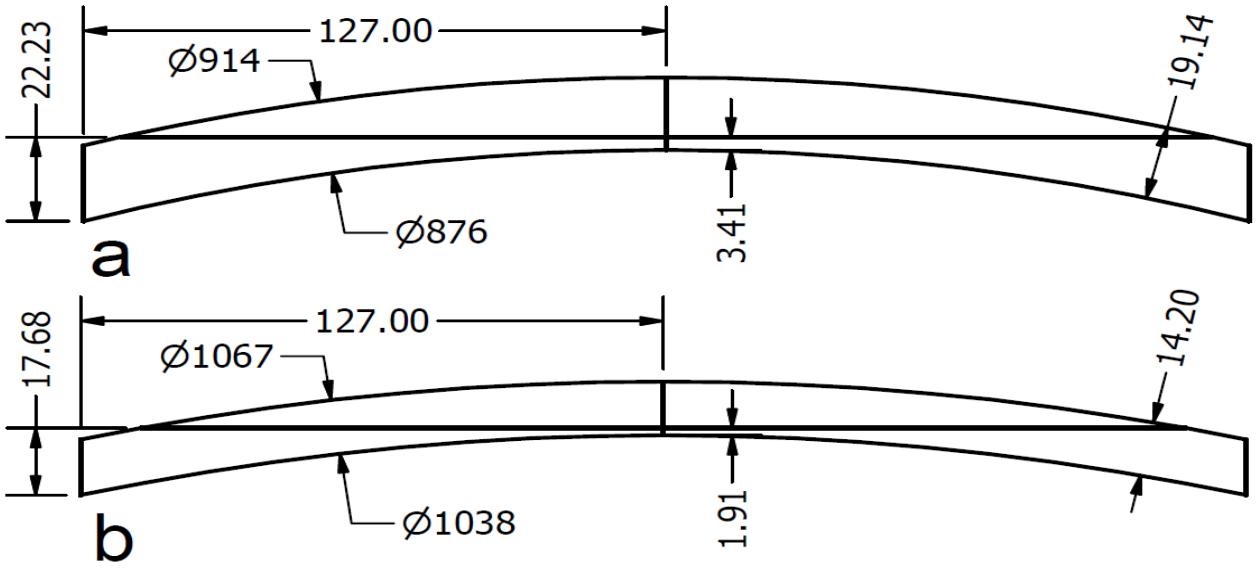
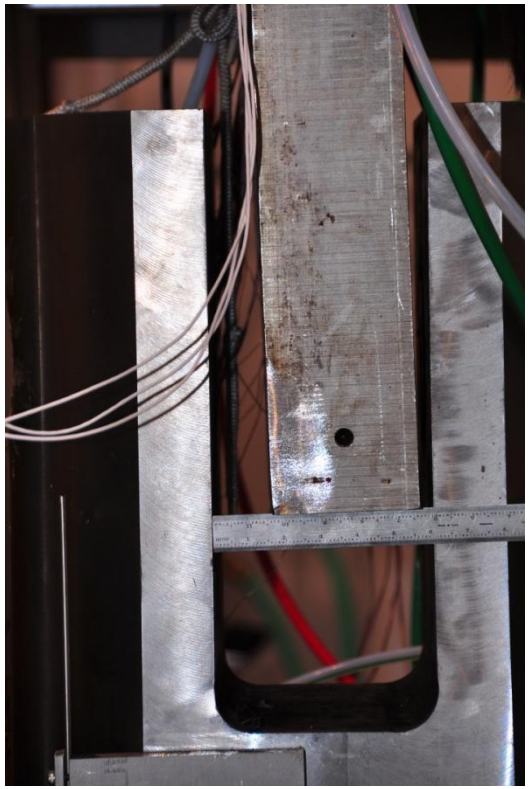
Specimen Welding

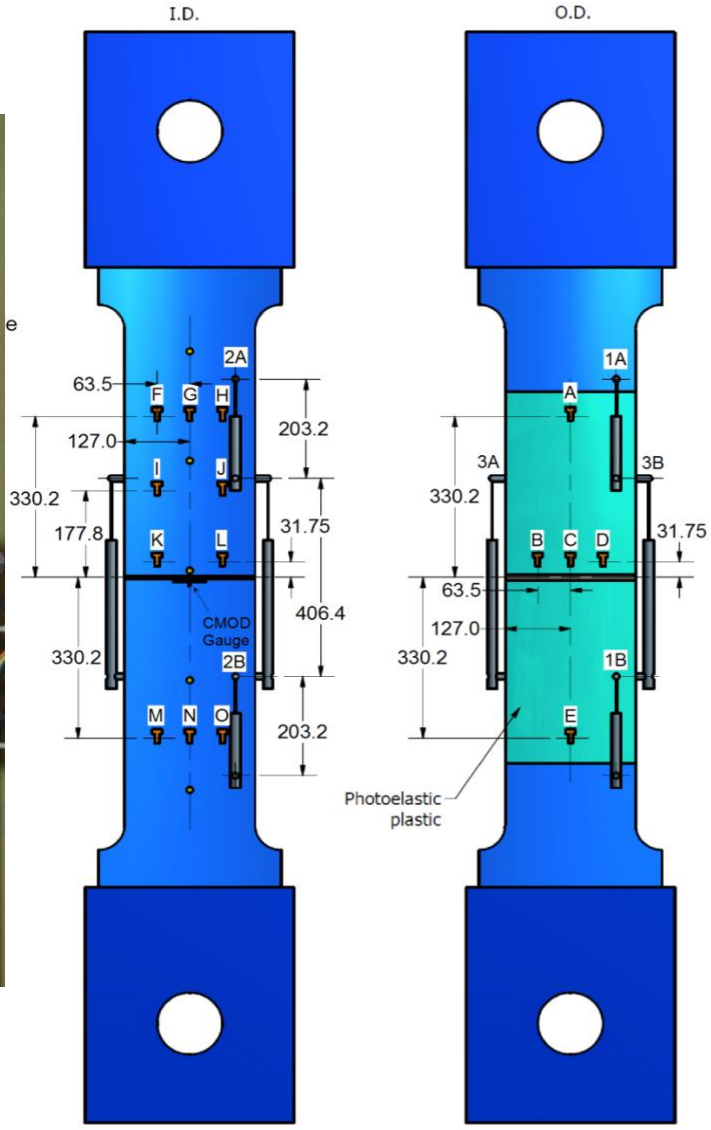
- Specimen Offset to align the specimen with the load-line





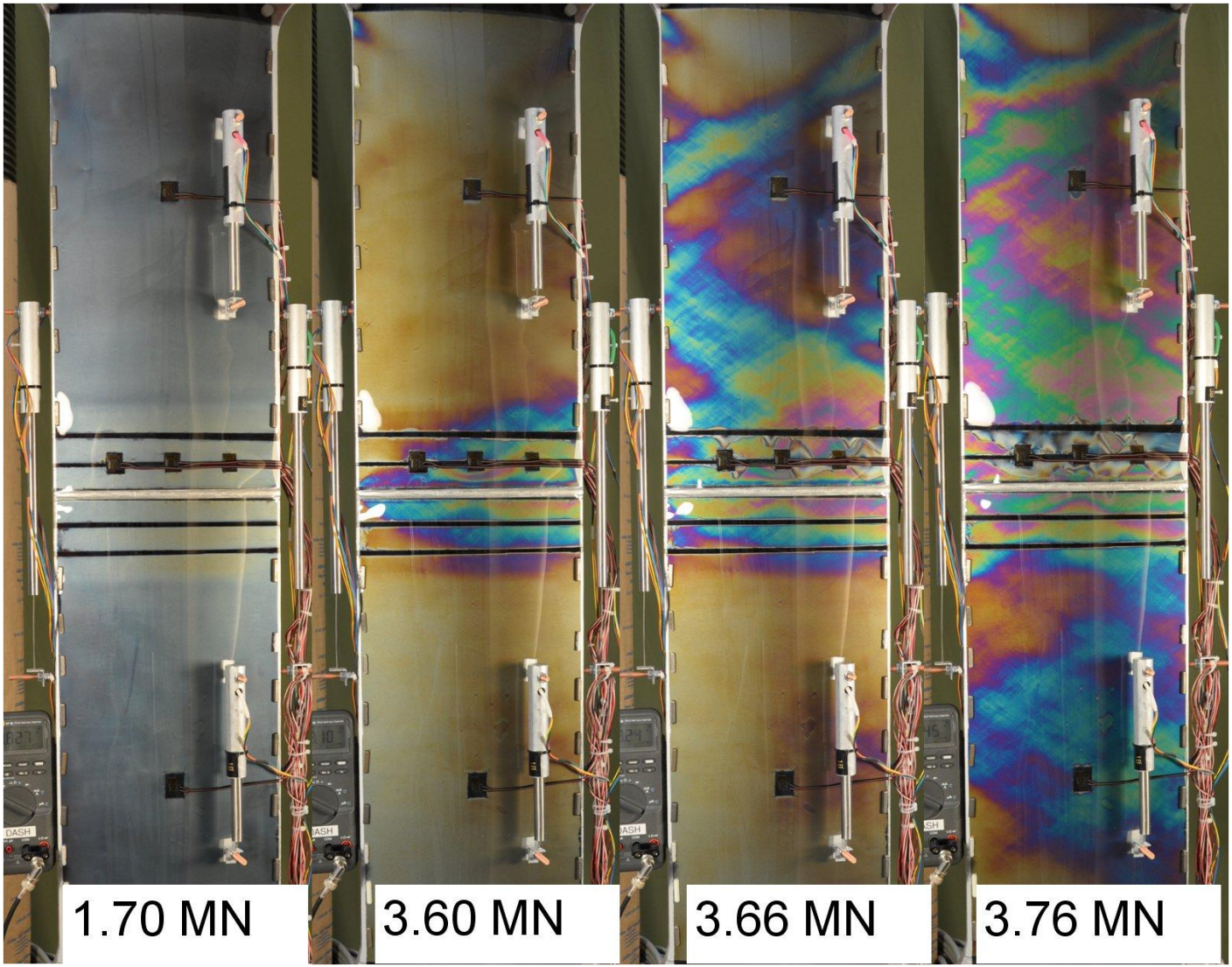
But…..

Instrumentation

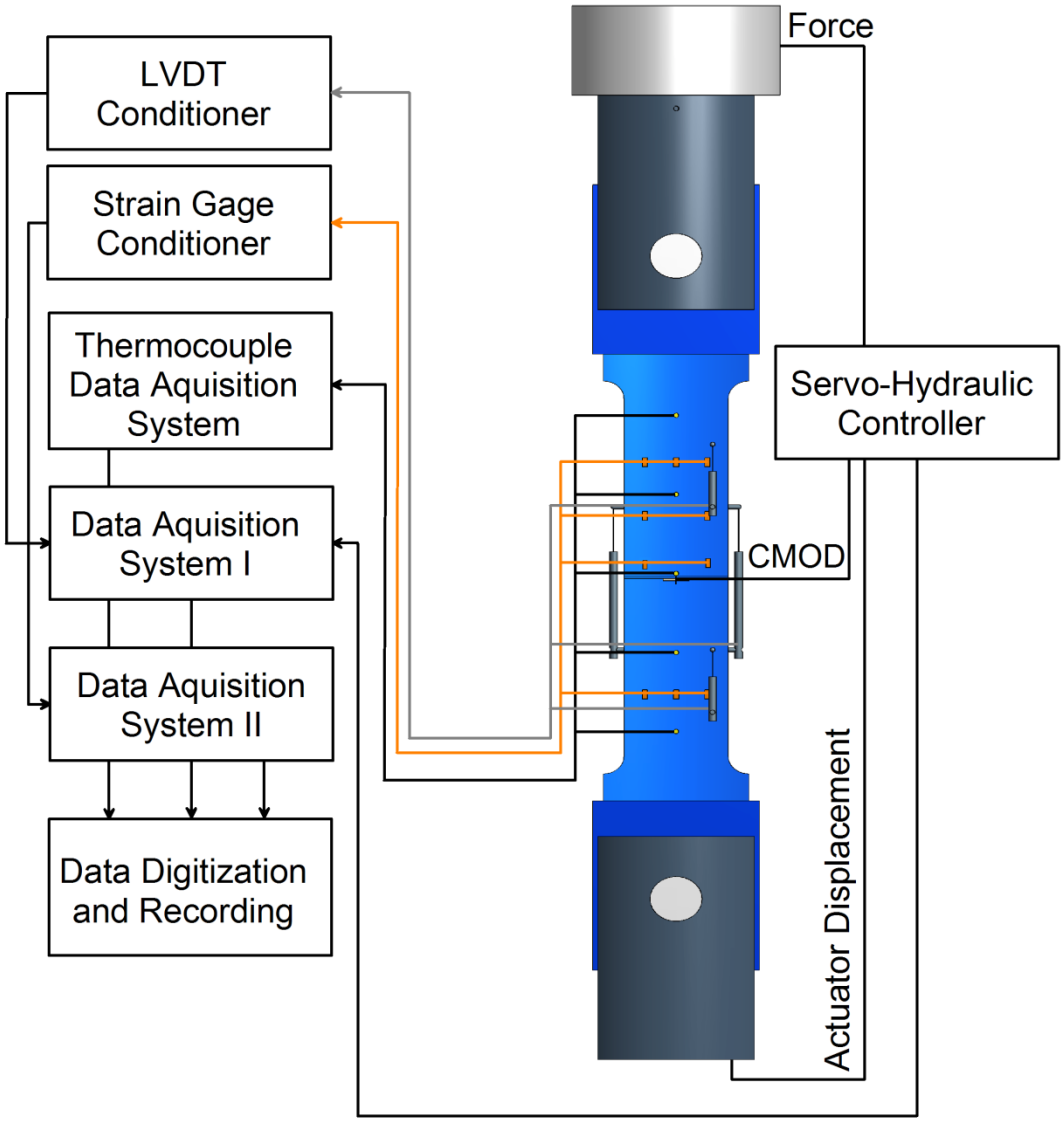


Strain Gage		
Channel	Location	Direction
1	A	Trans
2	A	Axial
3	B	Trans
4	B	Axial
5	C	Trans
6	C	Axial
7	D	Trans
8	D	Axial
9	E	Trans
10	E	Axial
11	F	Trans
12	F	Axial
13	G	Trans
14	G	Axial
15	H	Trans
16	H	Axial
17	I	Trans
18	I	Axial
19	J	Trans
20	J	Axial
21	K	Trans
22	K	Axial
23	L	Trans
24	L	Axial
25	M	Trans
26	M	Axial
27	N	Trans
28	N	Axial
29	O	Trans
30	O	Axial

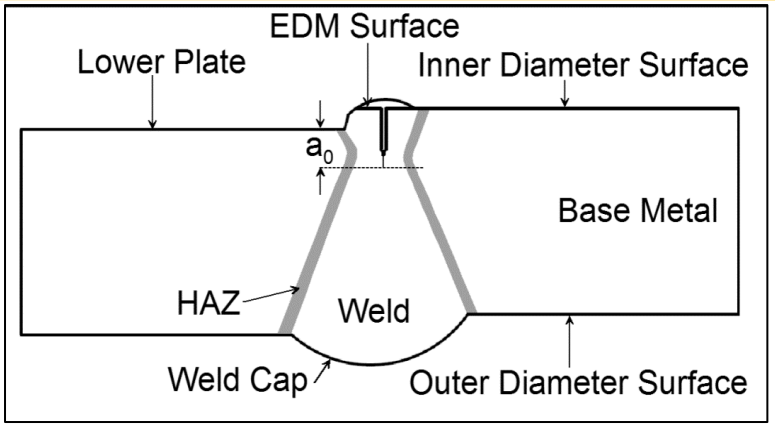
Photoelastic

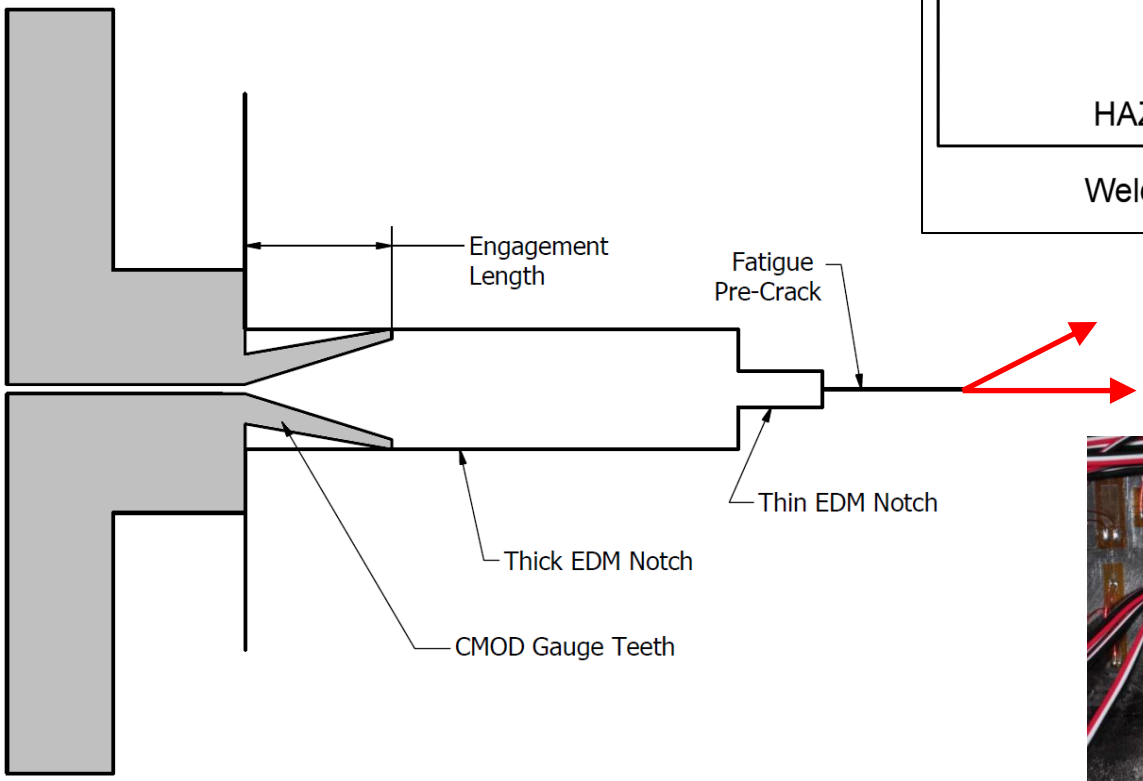


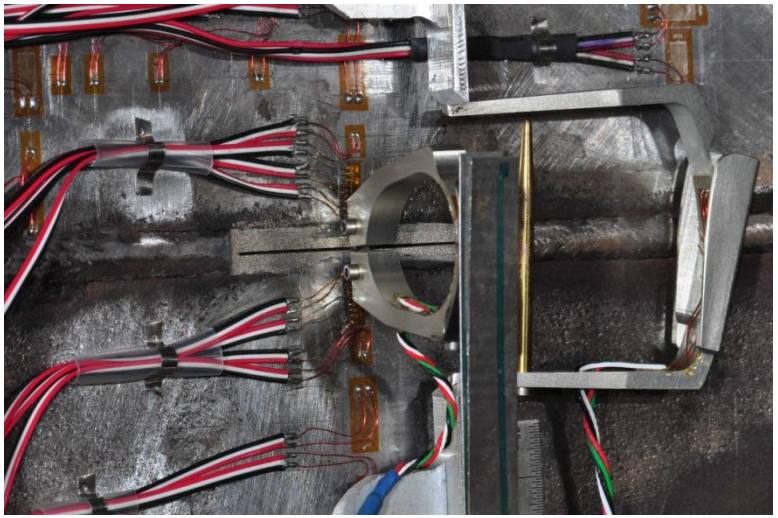
Data Acquisition



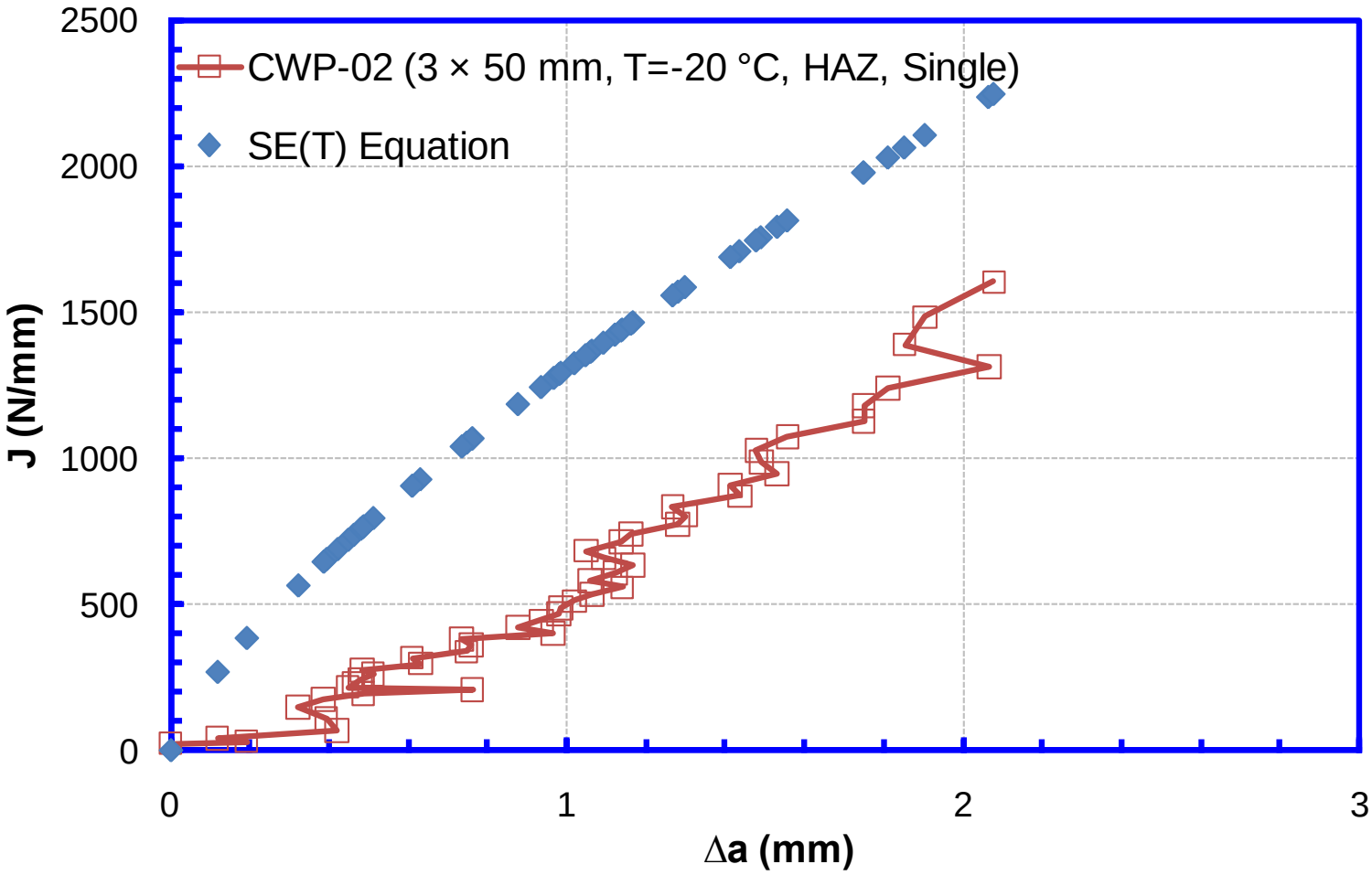
CMOD Measurement







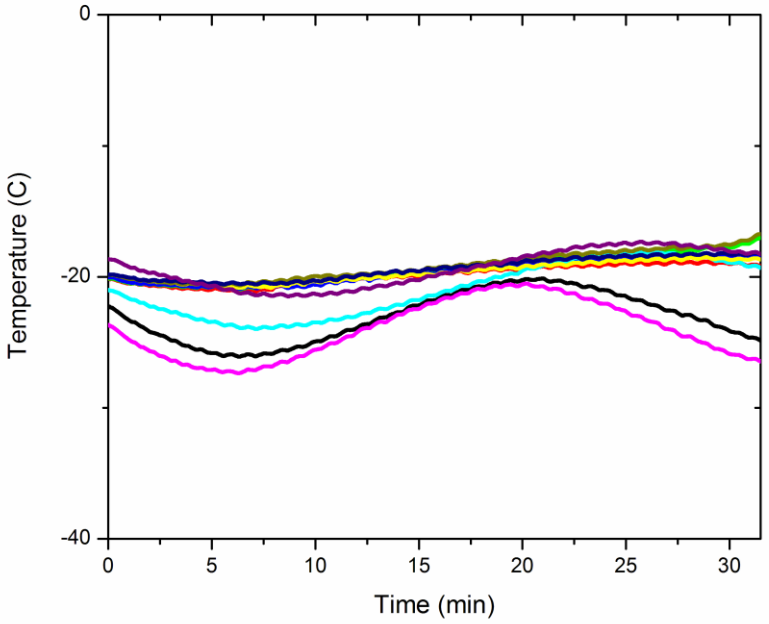
CMOD Motivation

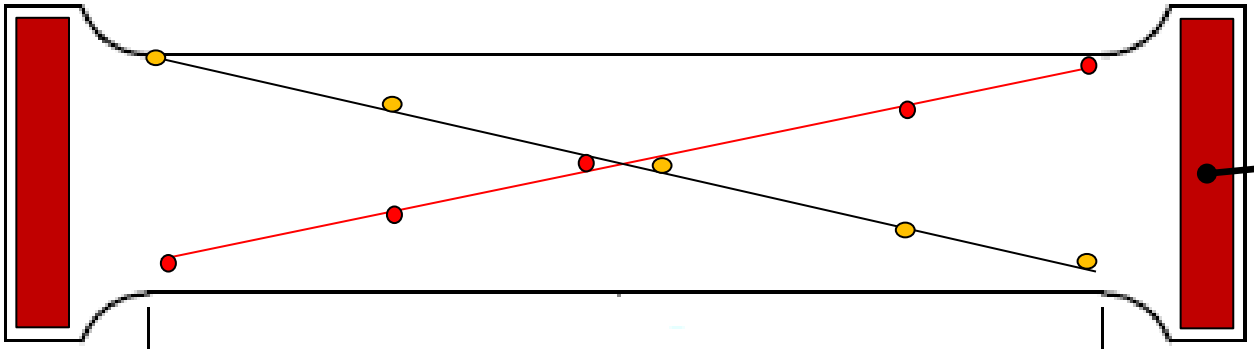


Temperature Control

Controlled Temperature Tests

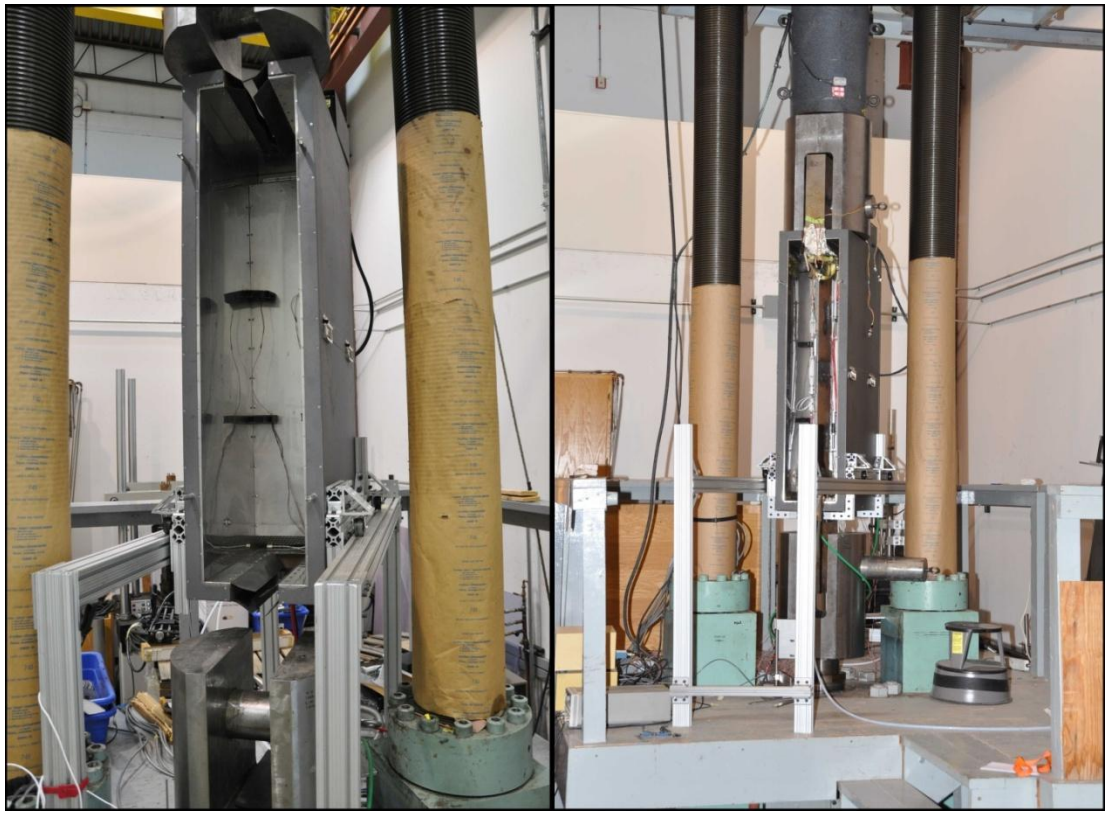
- Custom Low Temperature Environmental Chamber
- Room Temperature, -20° C & -40° C
- Temperature tolerance within ± 10" of the notch is ± 3° C
- Ten Thermocouples within ± 20" of the notch



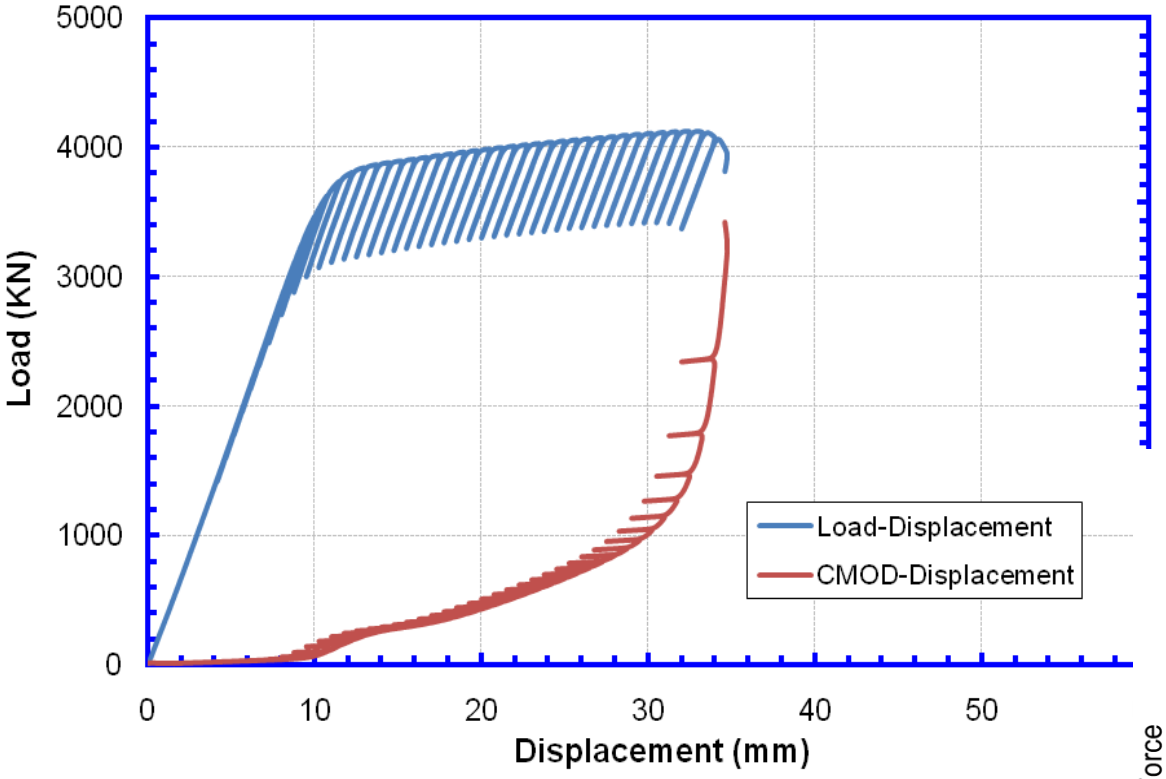


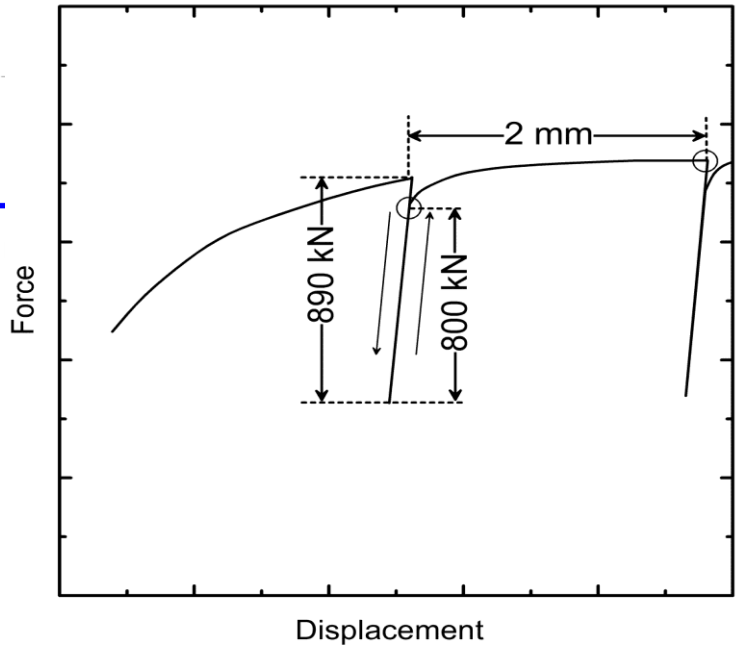
Actively cooled Copper Heat Sinks

Temperature Control

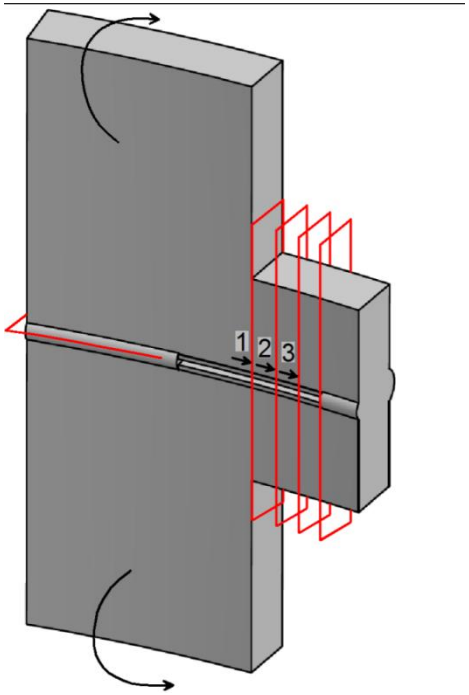


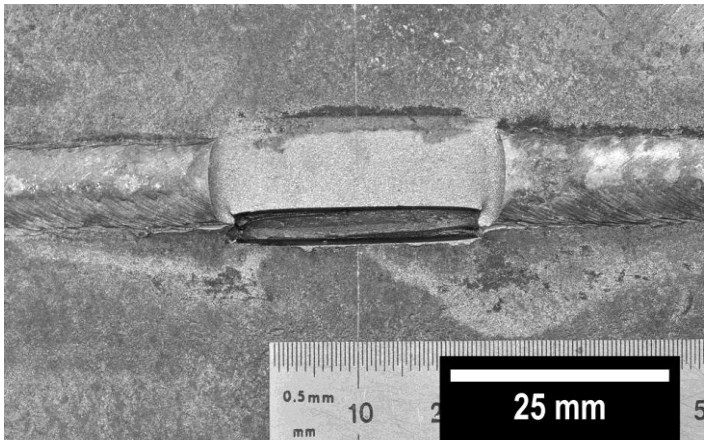
Machine Control

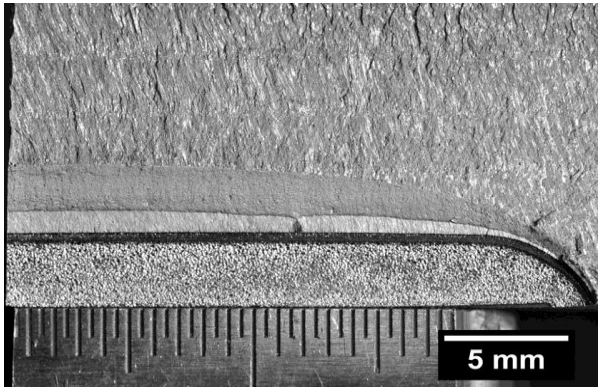


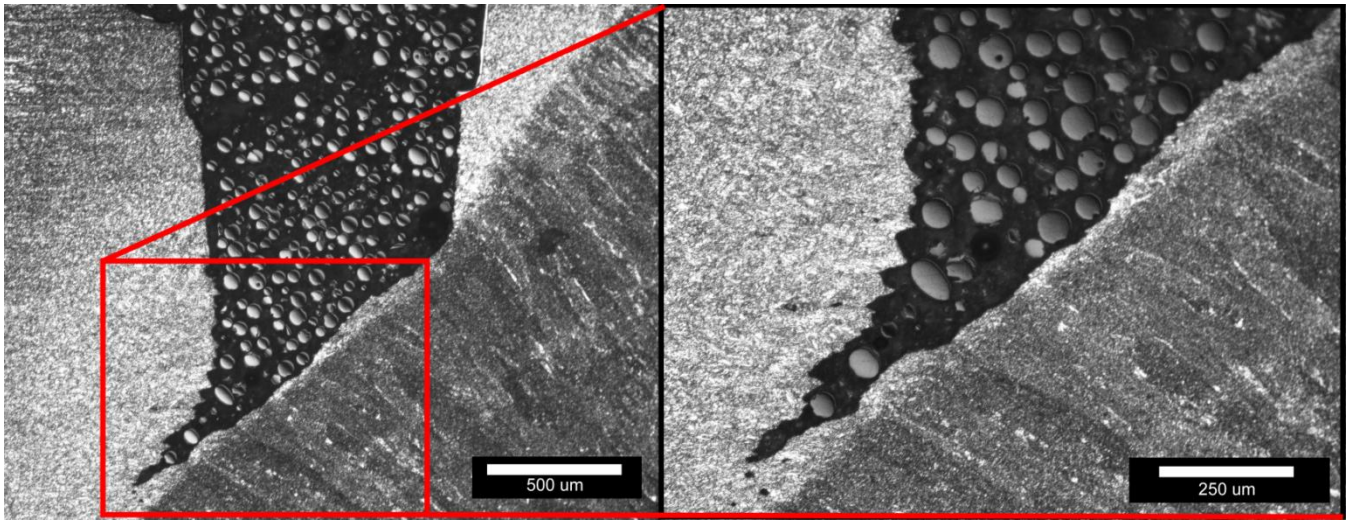


Post Test Metallography









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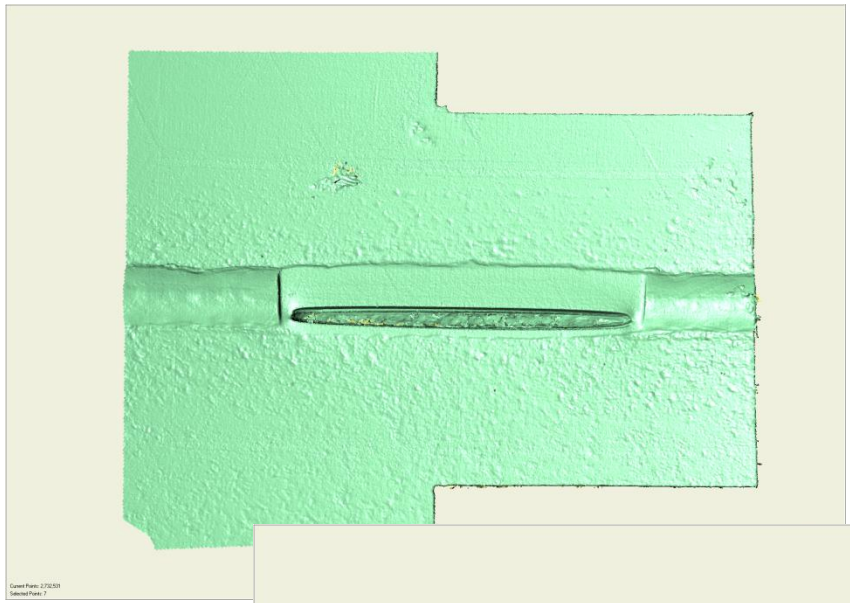
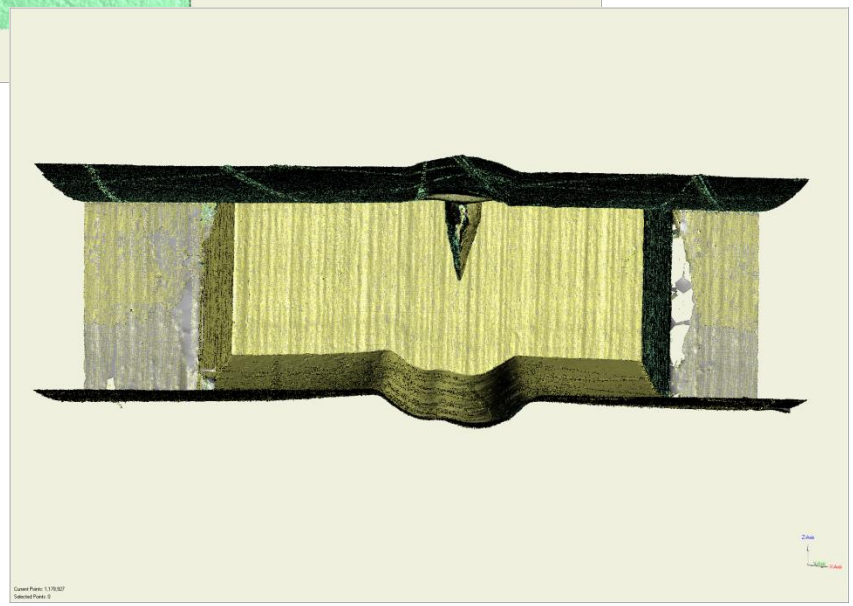
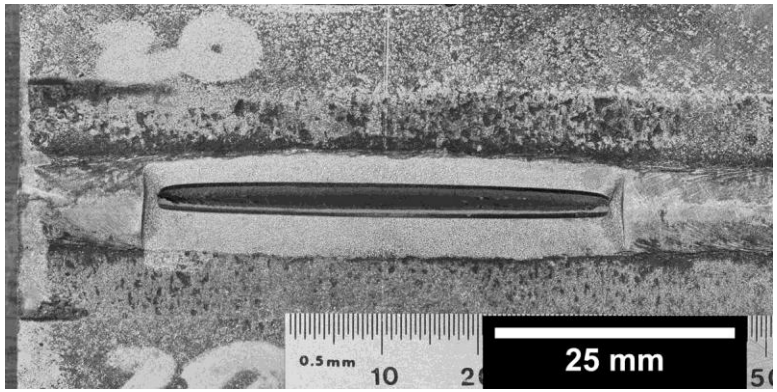
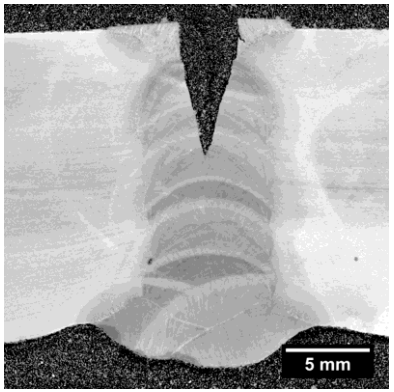
Laser Scans









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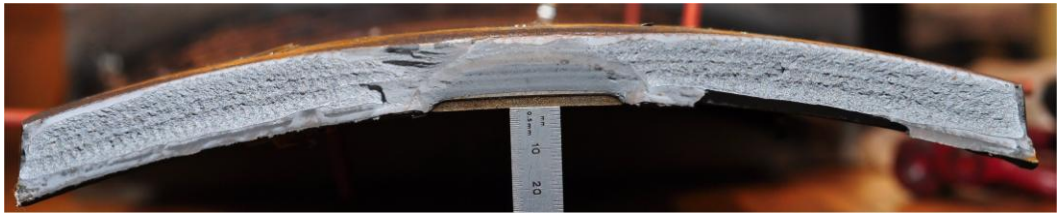
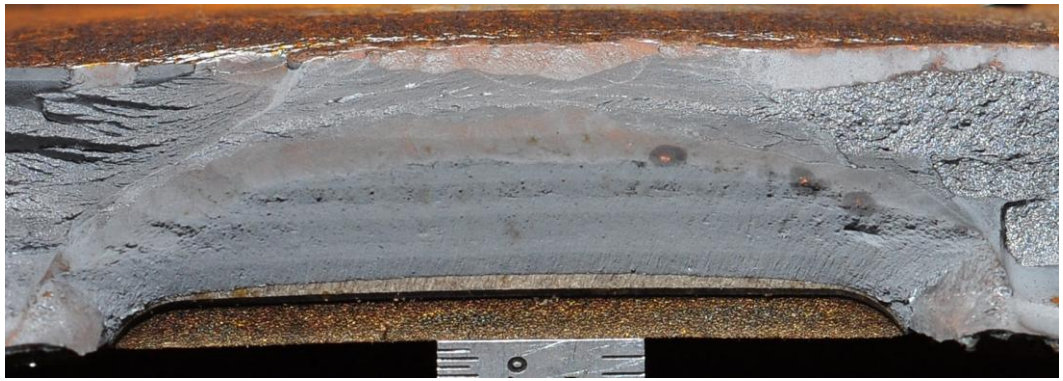
Parameters and Observations

- Test Parameters
  - Nominal Flaw Geometry
  - Flaw Location
  - Temperature
  - Specimen Geometry
- Crack Path





Data For Analysis

- Digital Data
  - Axial Load
  - CMOD
  - Remote Strain
- Physical Measurement Data
  - Specimen Geometry
  - Initial Flaw
  - Final Flaw