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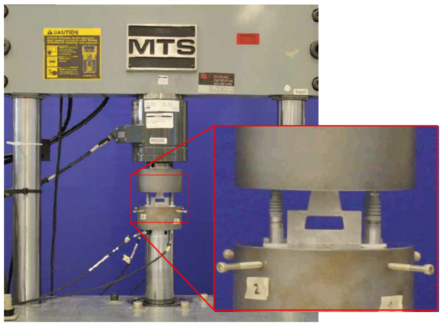

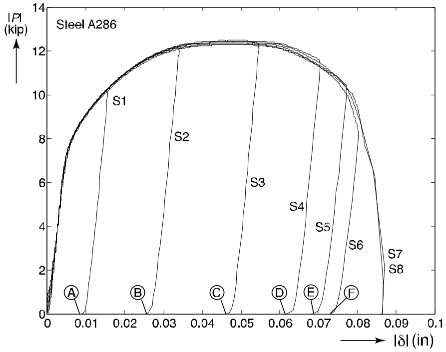

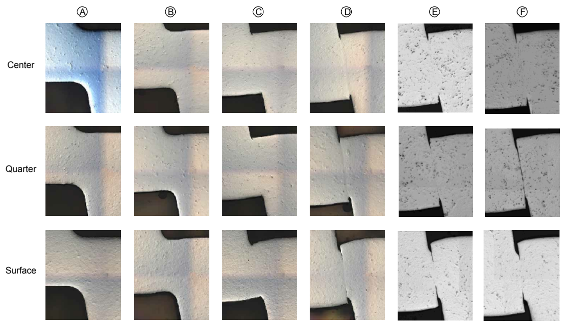

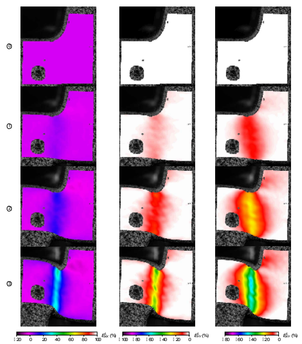

Shear Dominated Ductile Failure in Steel and Aluminum Compression Specimens

Edmundo Corona, Lisa Deibler, Benjamin Reedlunn and Mathew Ingraham

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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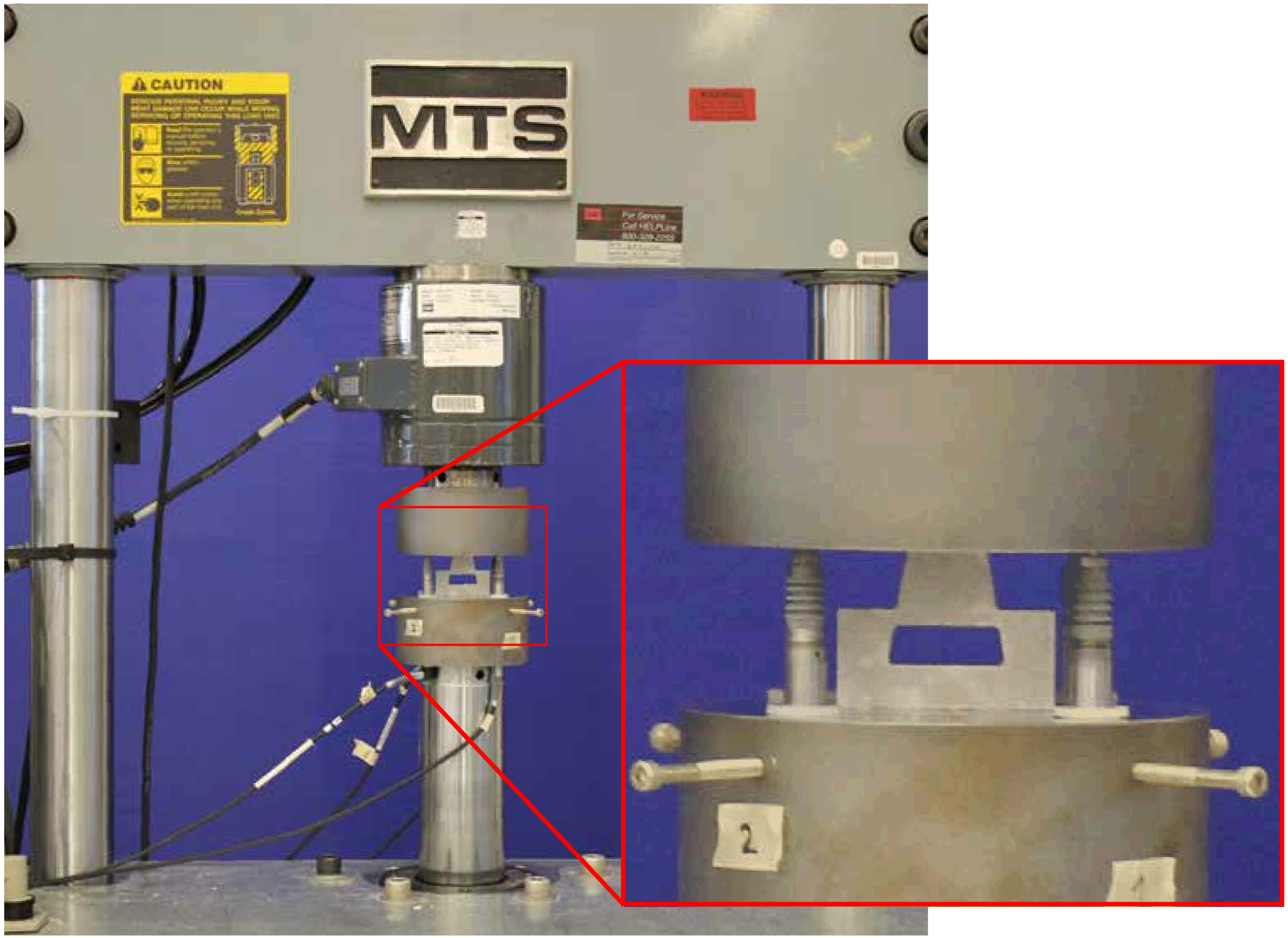
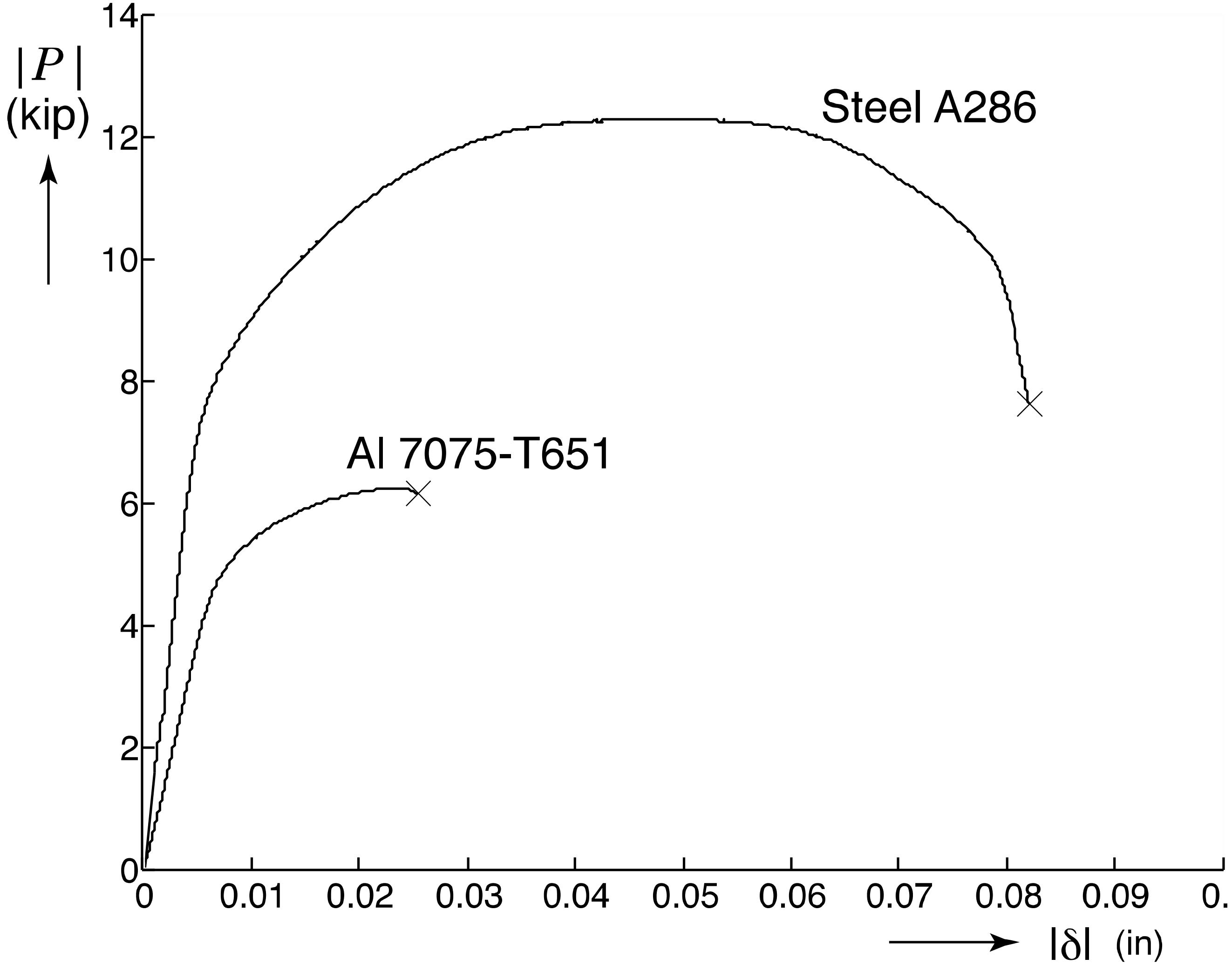
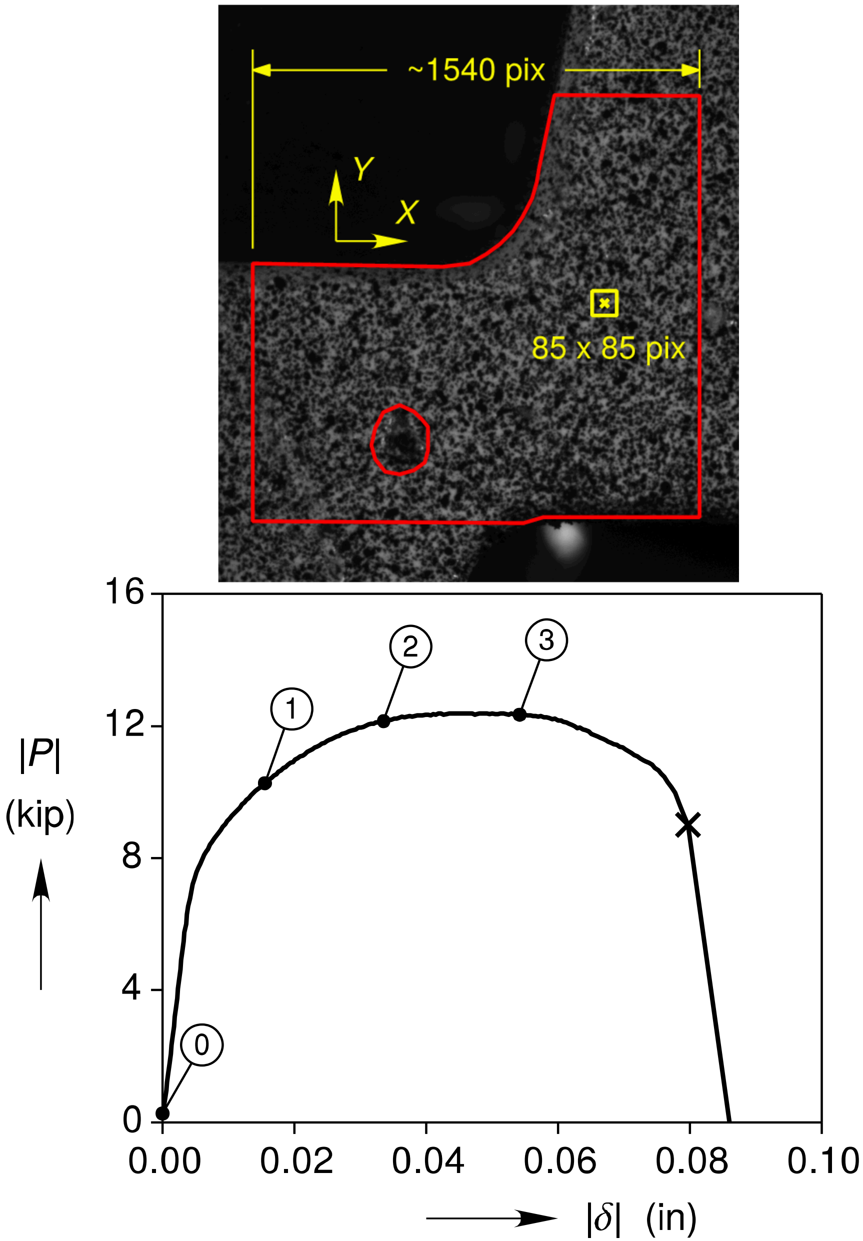
Experimental Setup

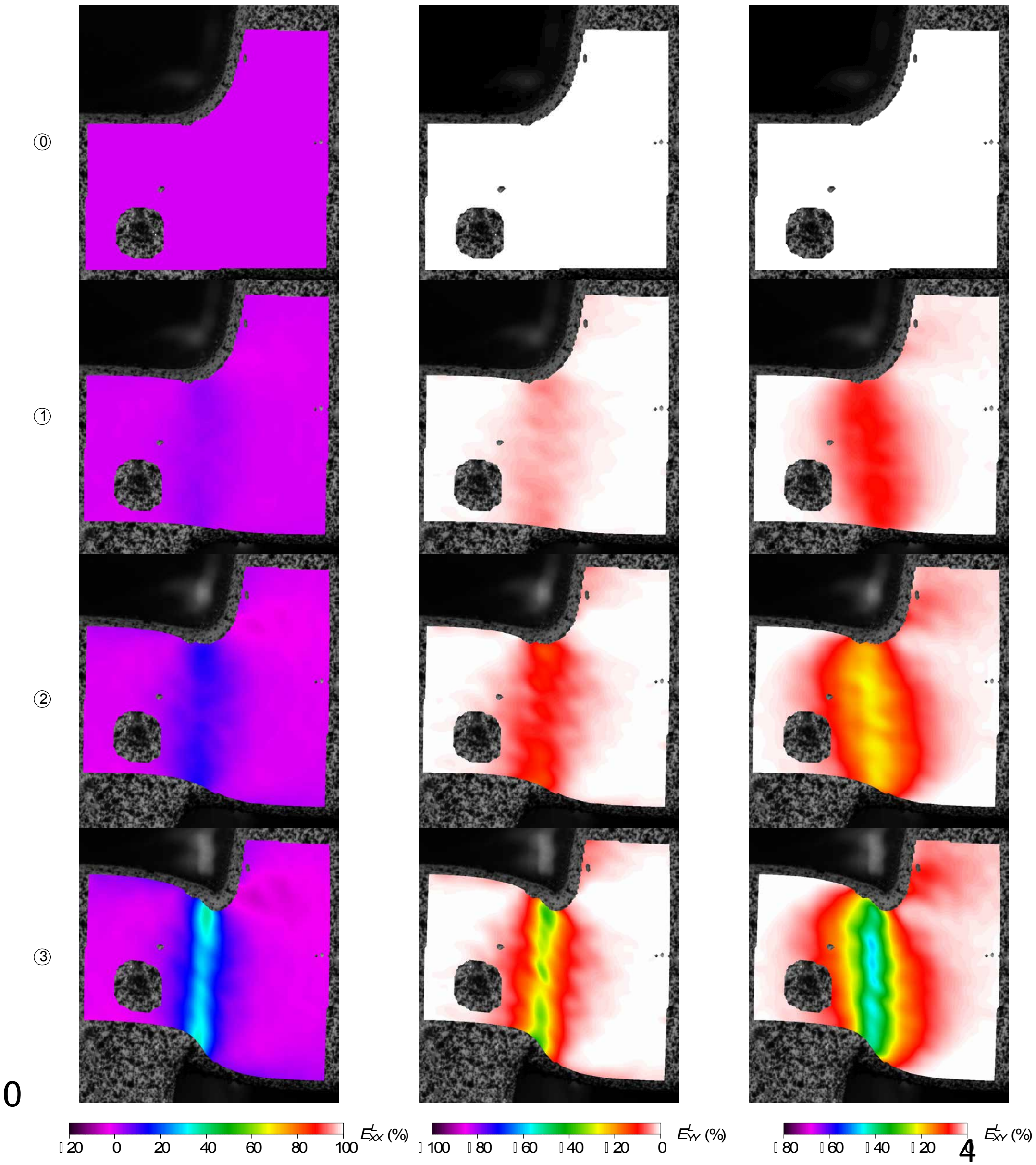


Load-Deflection Response

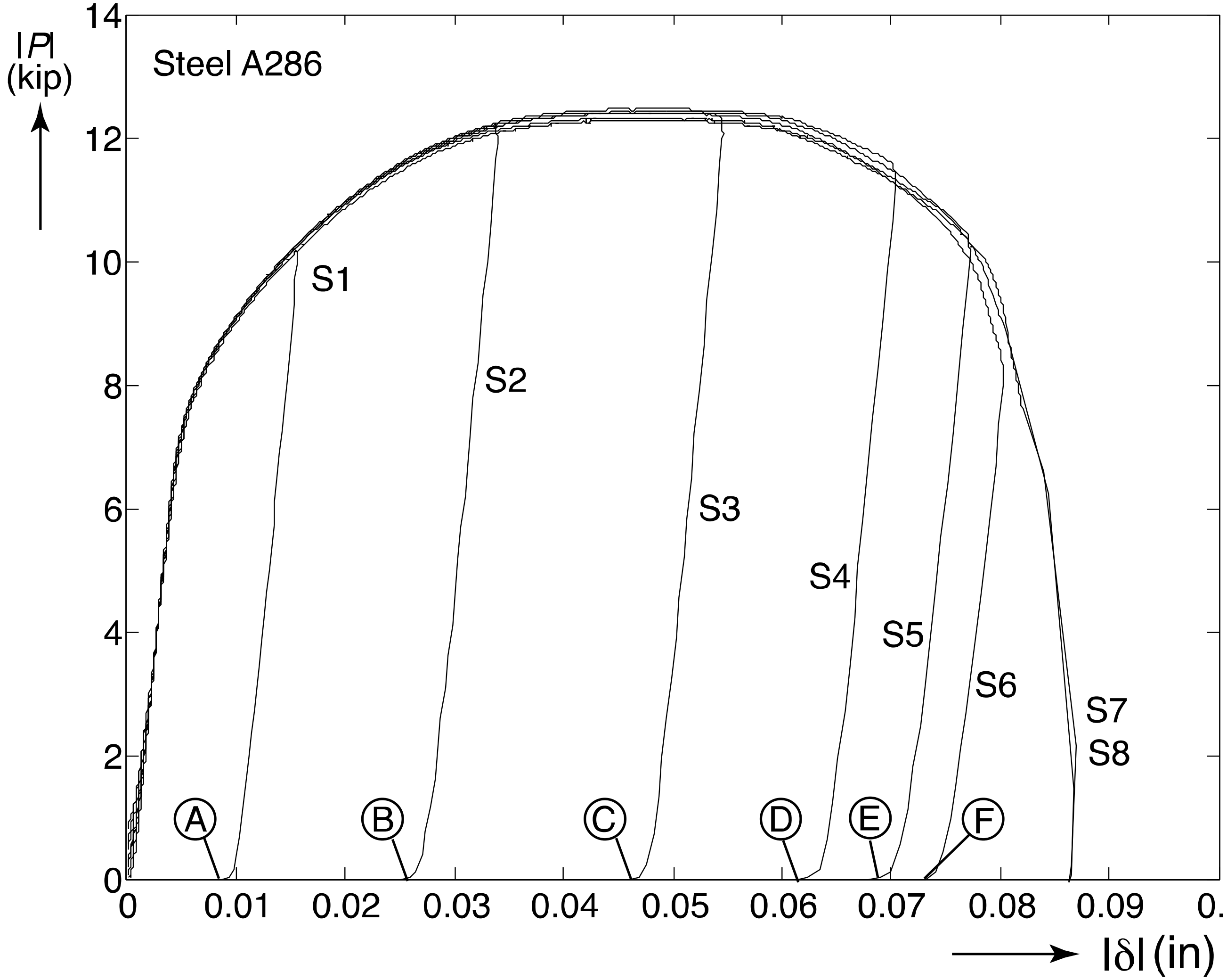


Strain Measurement by DIC – Steel A286

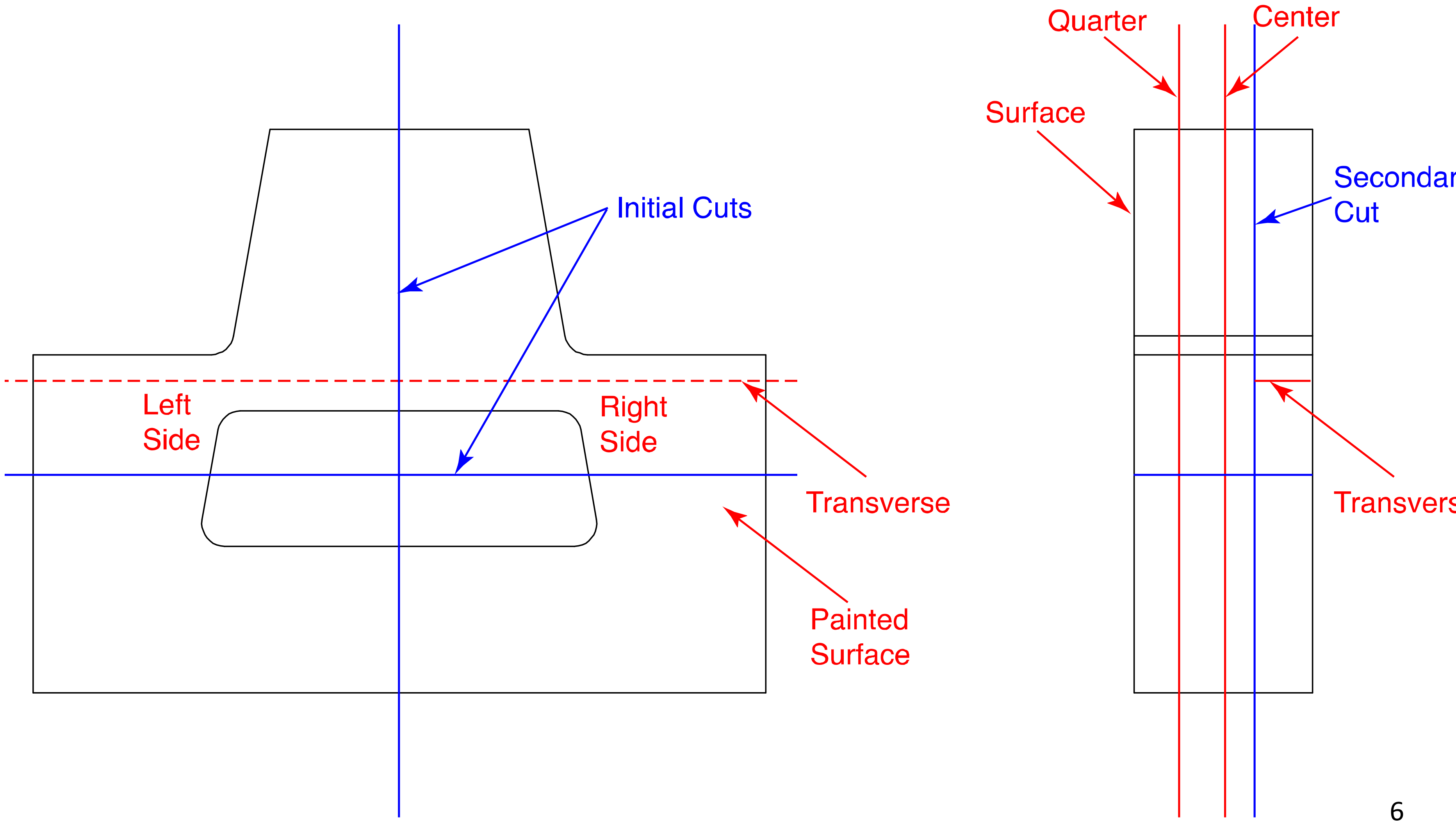




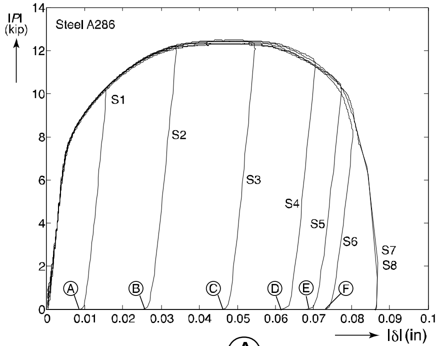
Load-Deflection Responses for All Steel A286 Specimens

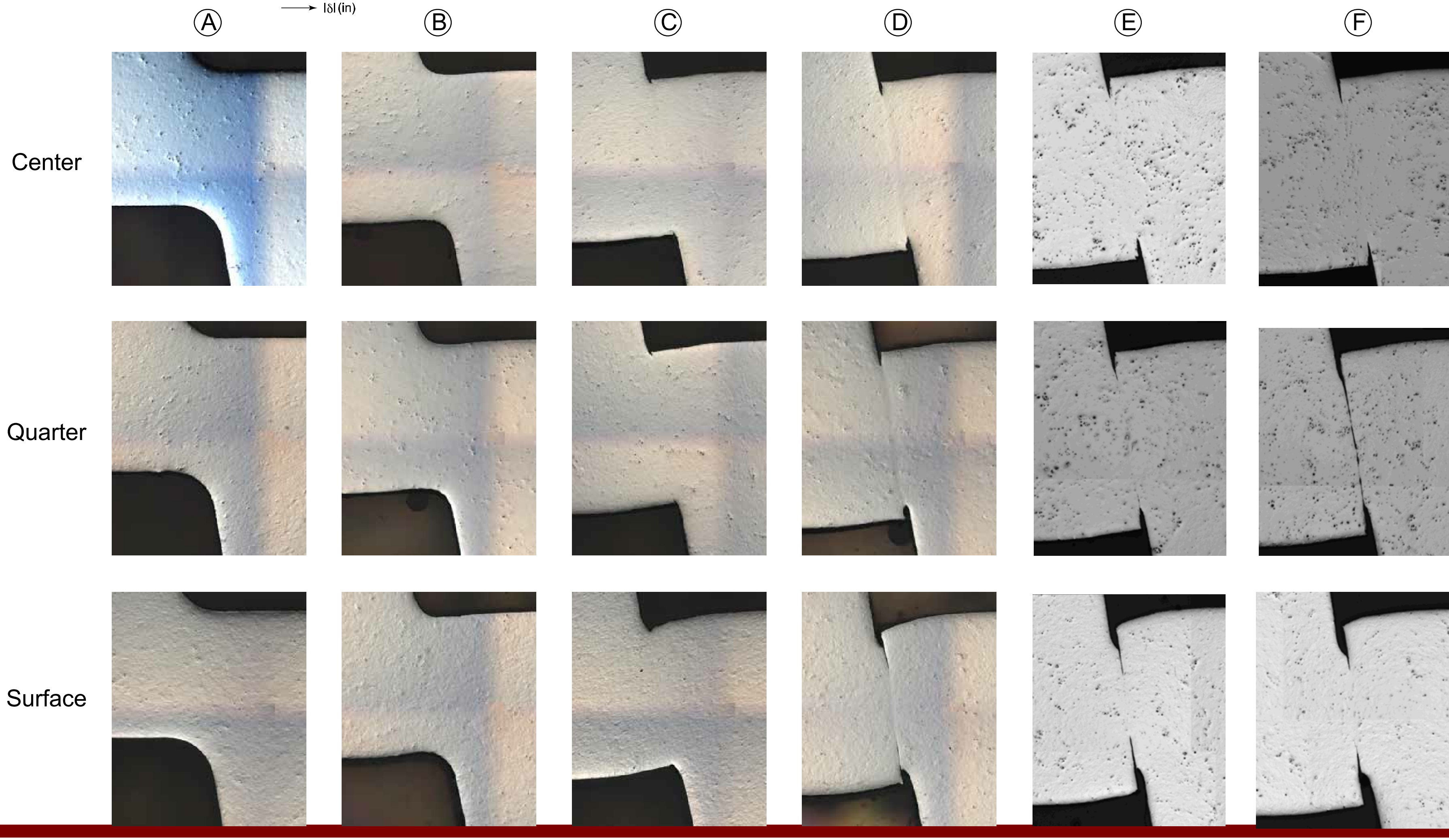


Specimen Sectioning

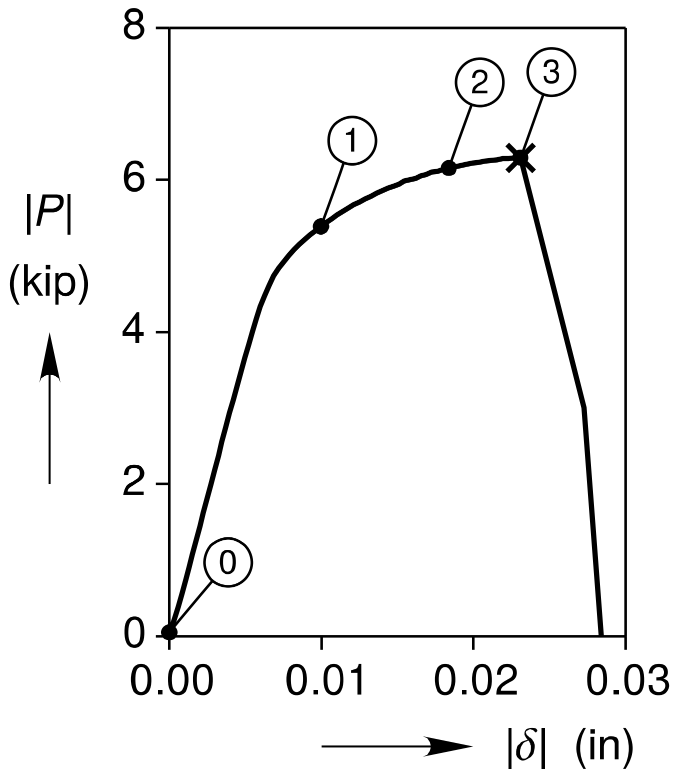


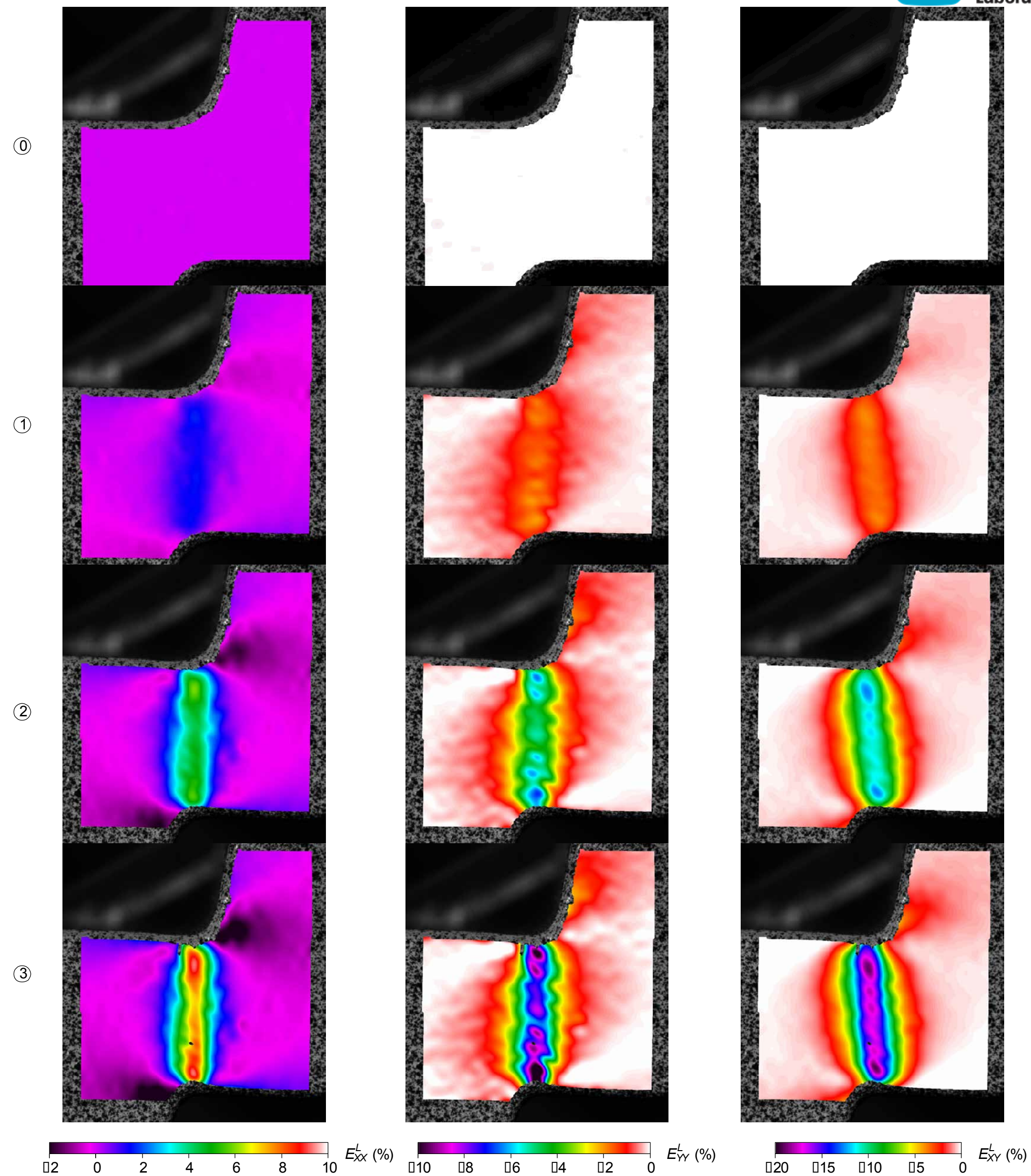
Micrographs for Steel A286 Specimens (Right Side)



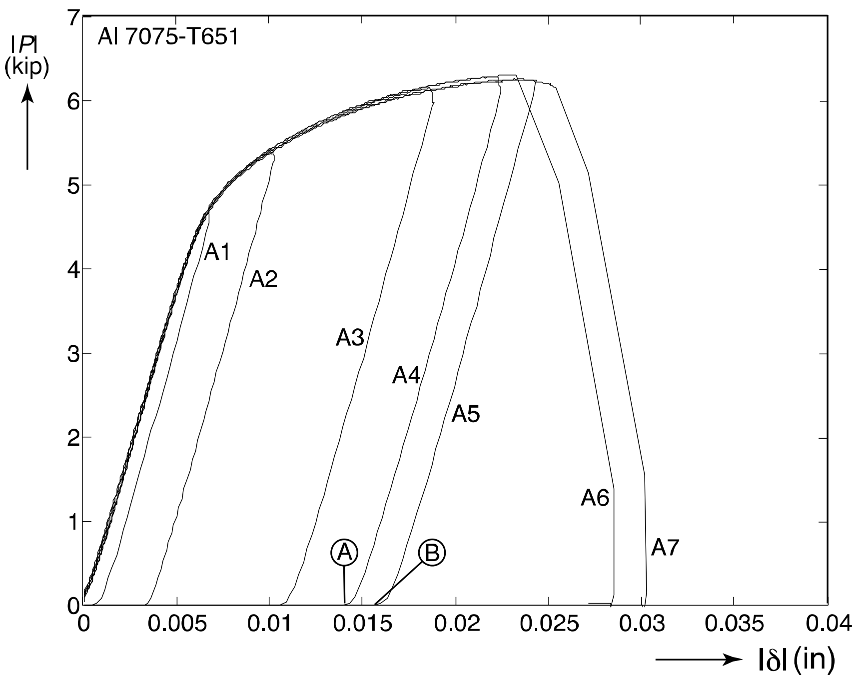


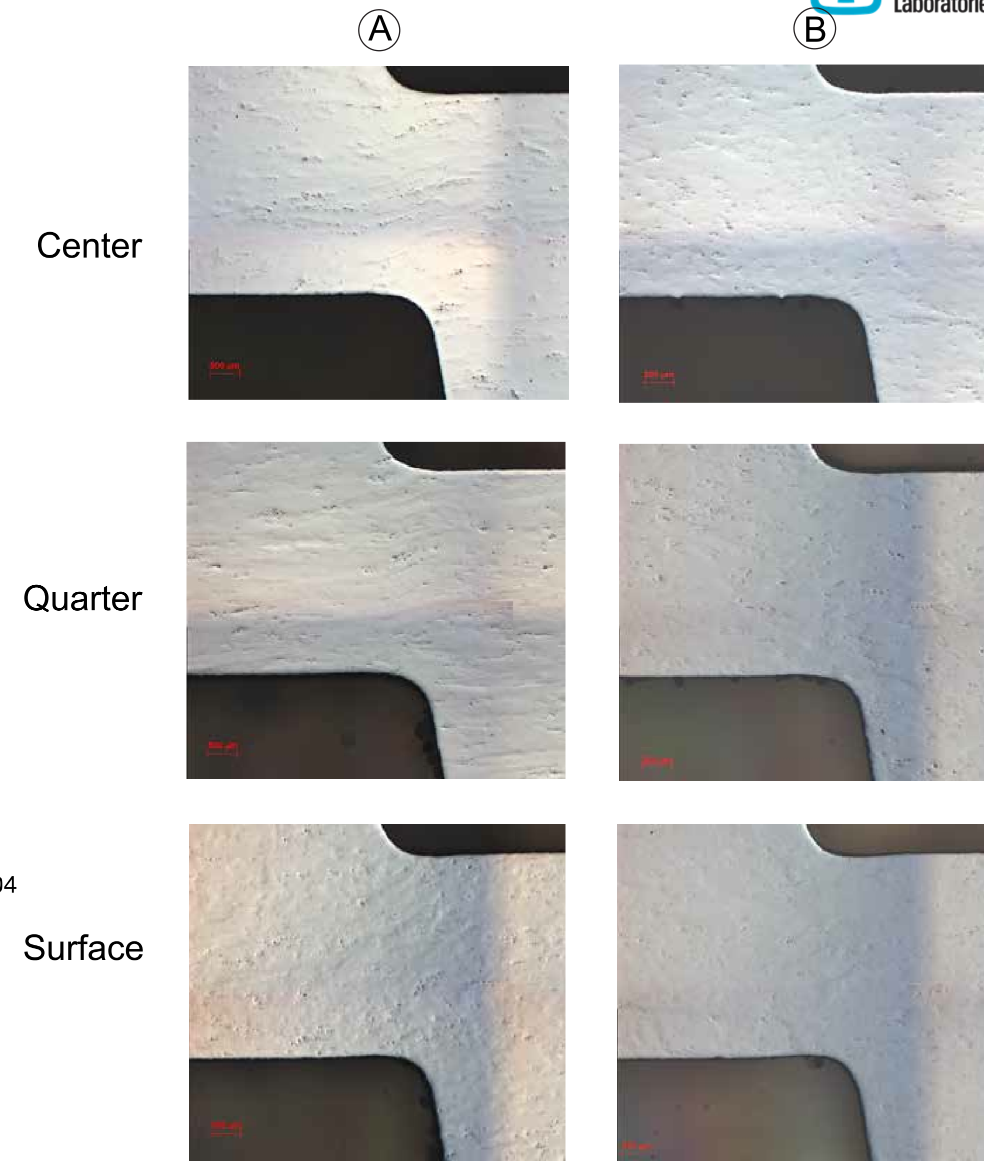
Strain Measurement by DIC – Al7075-T651



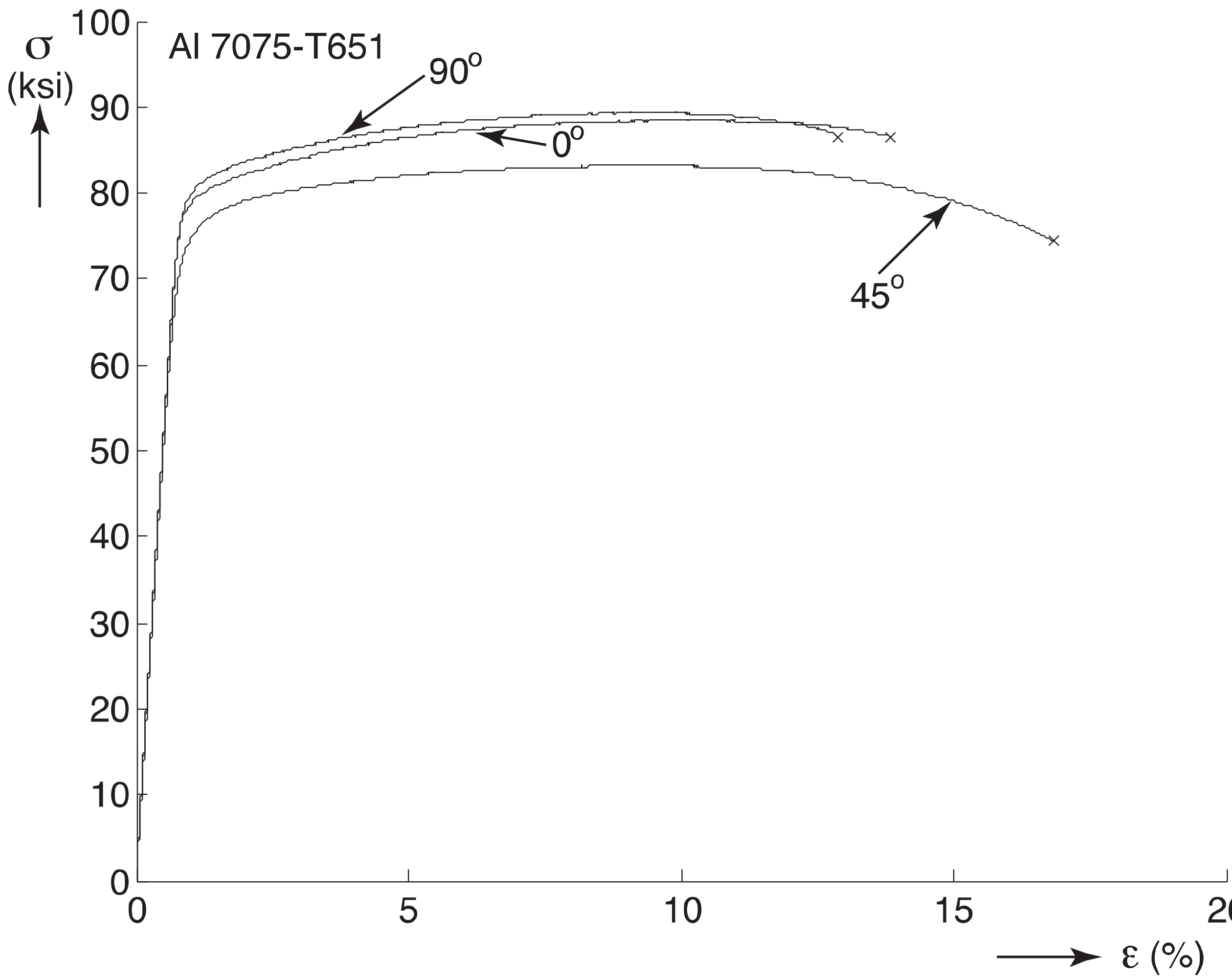


Images for Al 7075-T651 Specimens



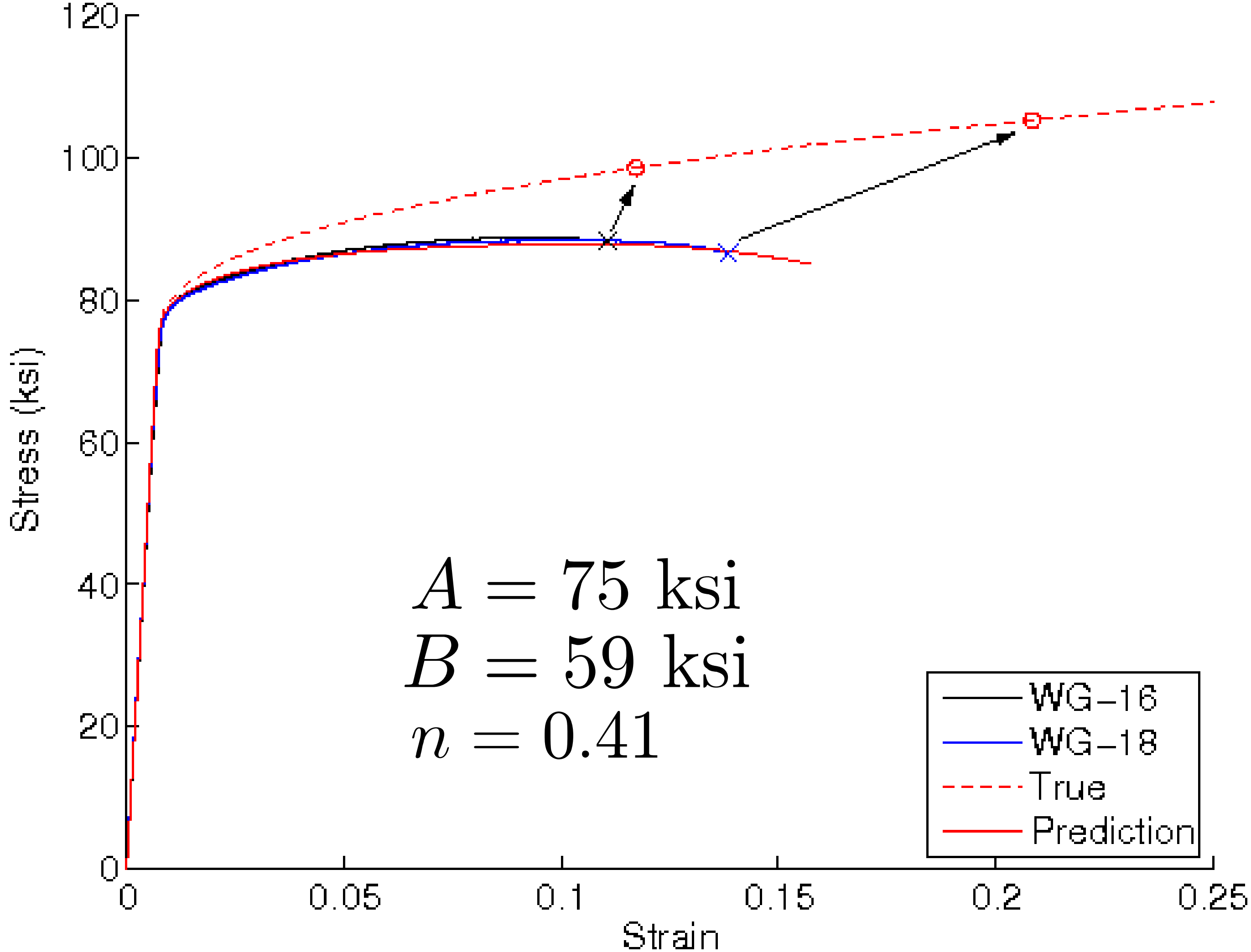


Uniaxial Stress-Strain Curves – Al7075-T651



Johnson-Cook Model Calibration – Al7075-T651 (0°)

$$\sigma = A + B(\varepsilon_e^p)^n$$



$$A = 75 \text{ ksi}$$
$$B = 59 \text{ ksi}$$
$$n = 0.41$$

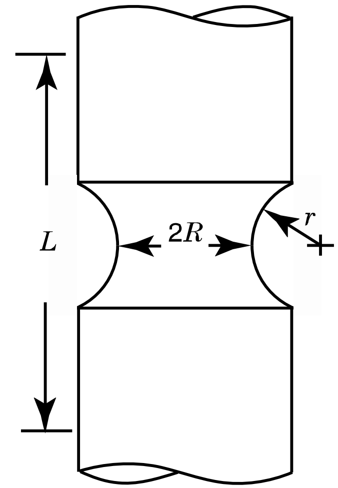
Calibration of Failure Model – Al7075-T651

$$\varepsilon^{p}_{ef} = d_1 + d_2 e^{d_3 \eta}, \ \eta = \sigma_m / \sigma_e$$

$$d_1 = 0.025, 0.015, 0.005 \ \text{(L, M, H)}$$

$$d_2 = 0.15, 0.24, 0.34$$

$$d_3 = -1.5$$



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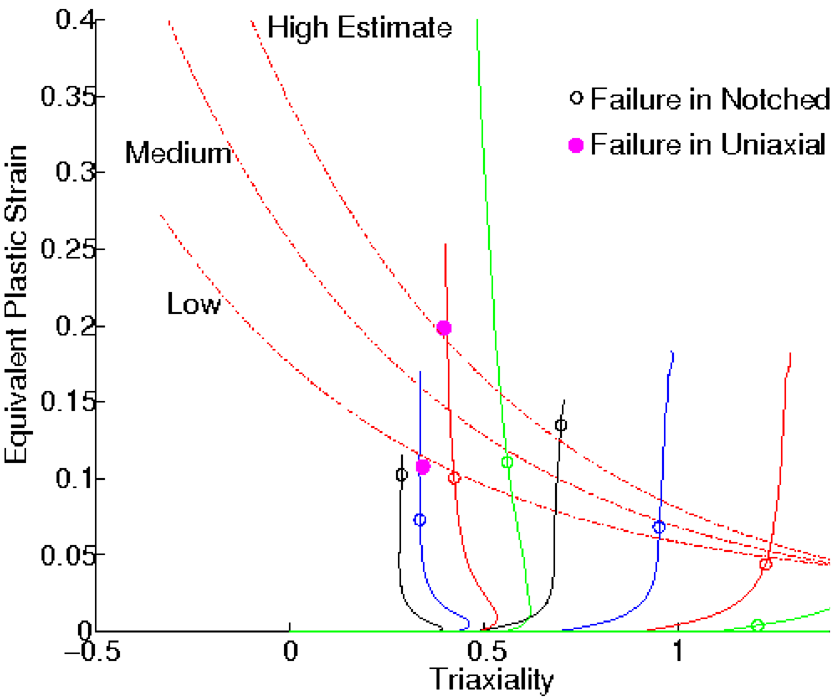
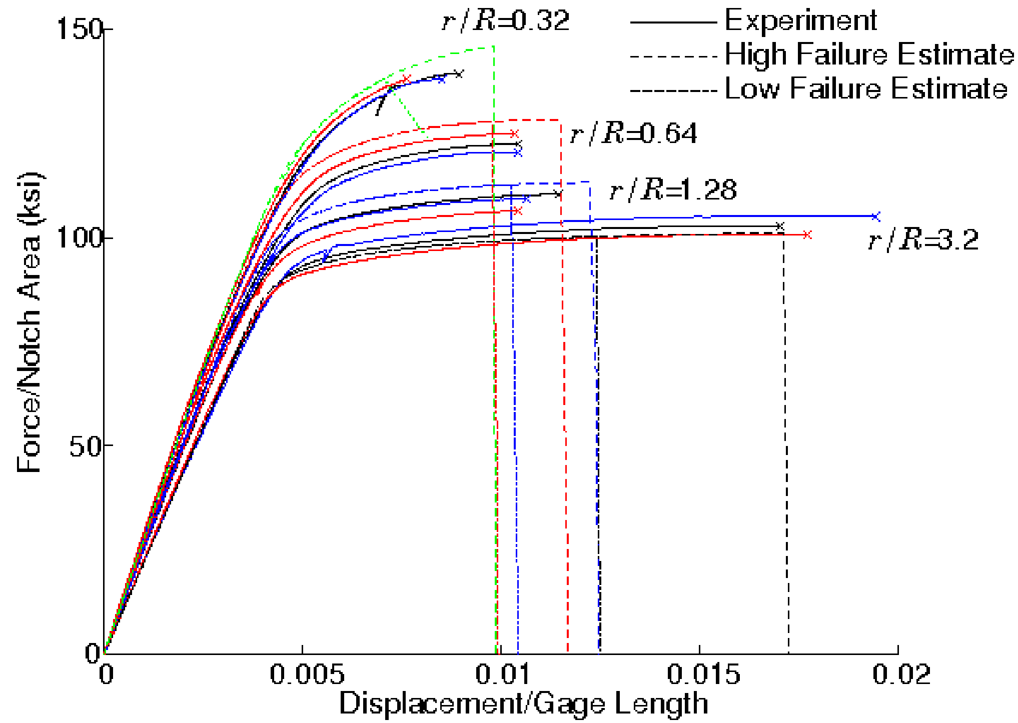
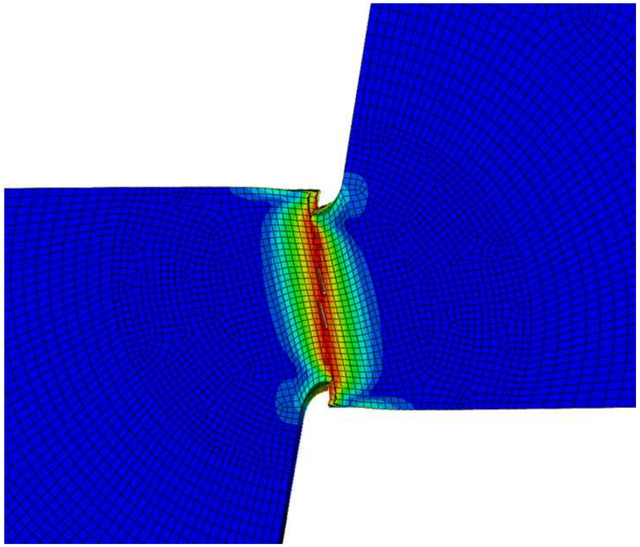
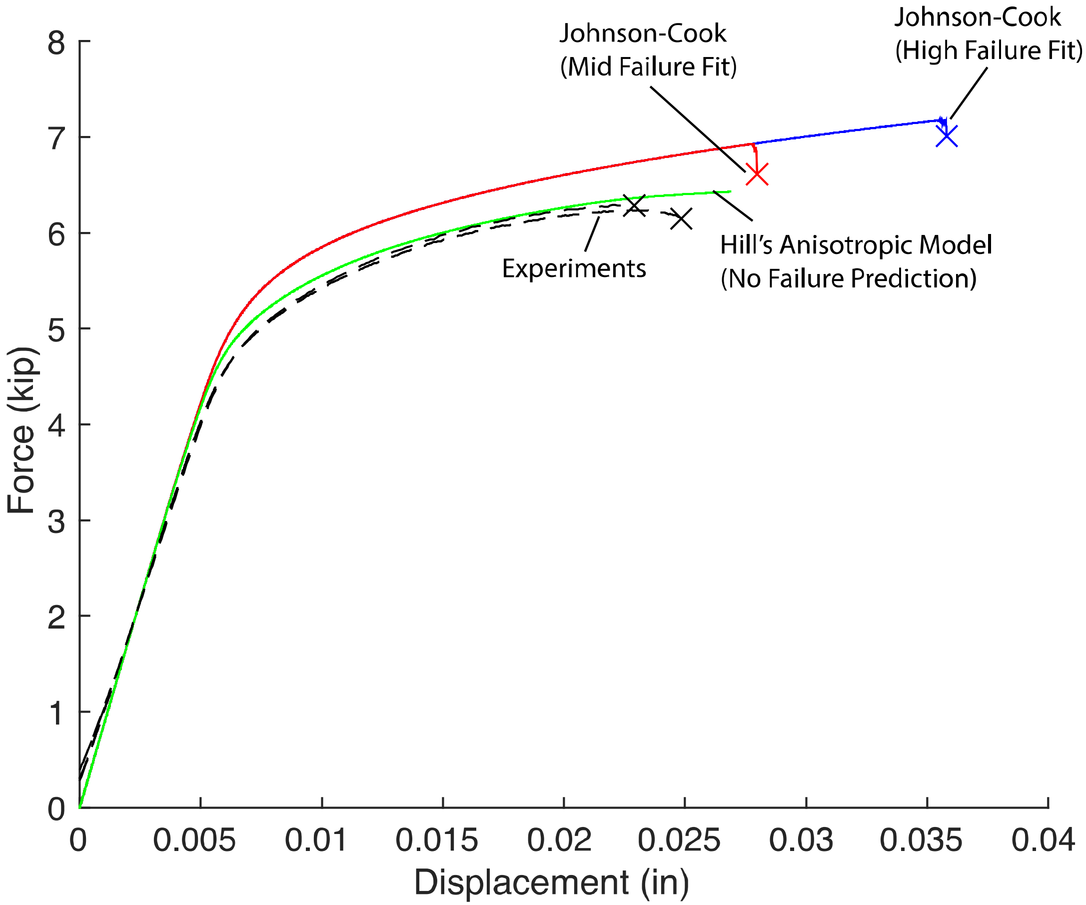


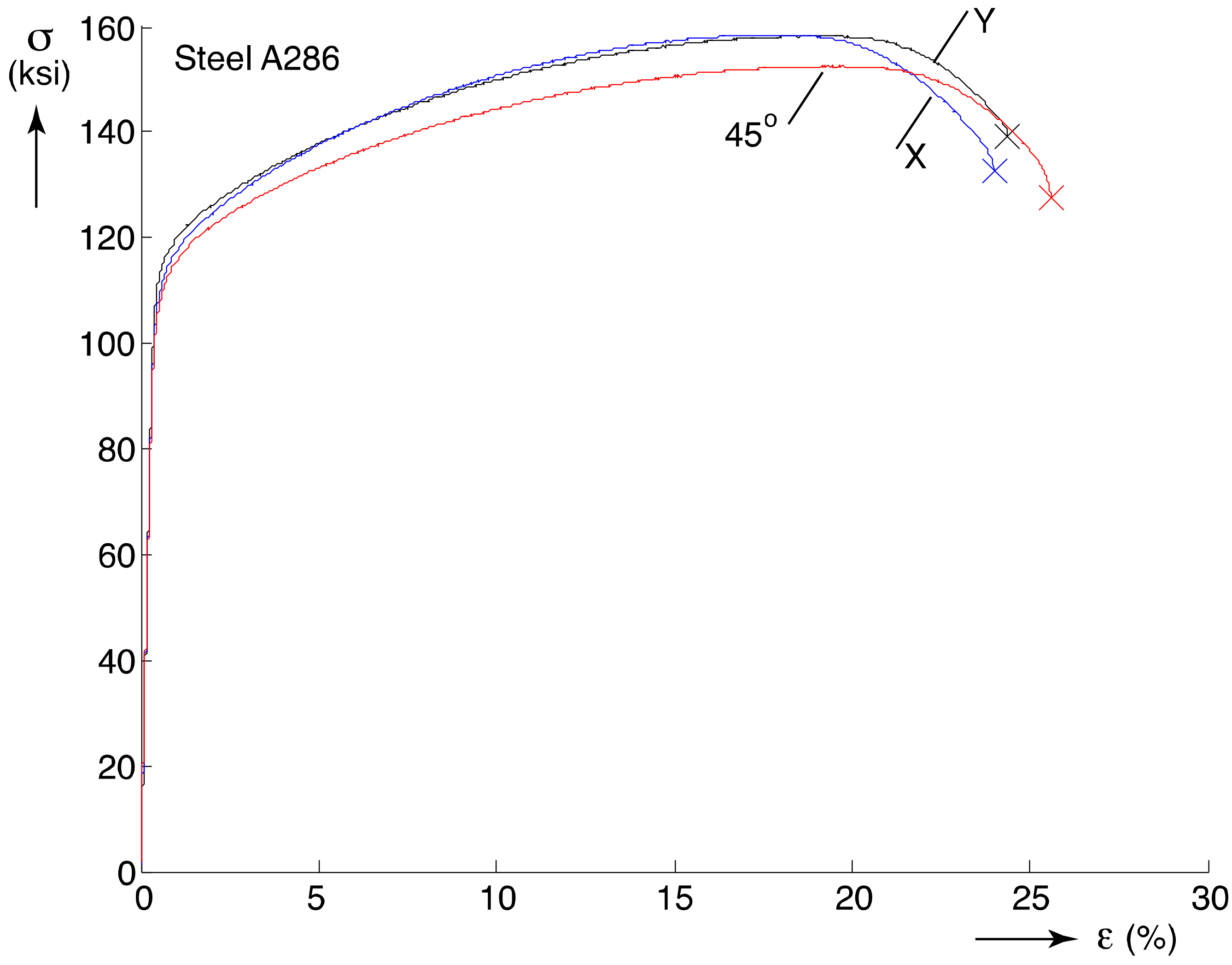


Model Results – Al7075-T651

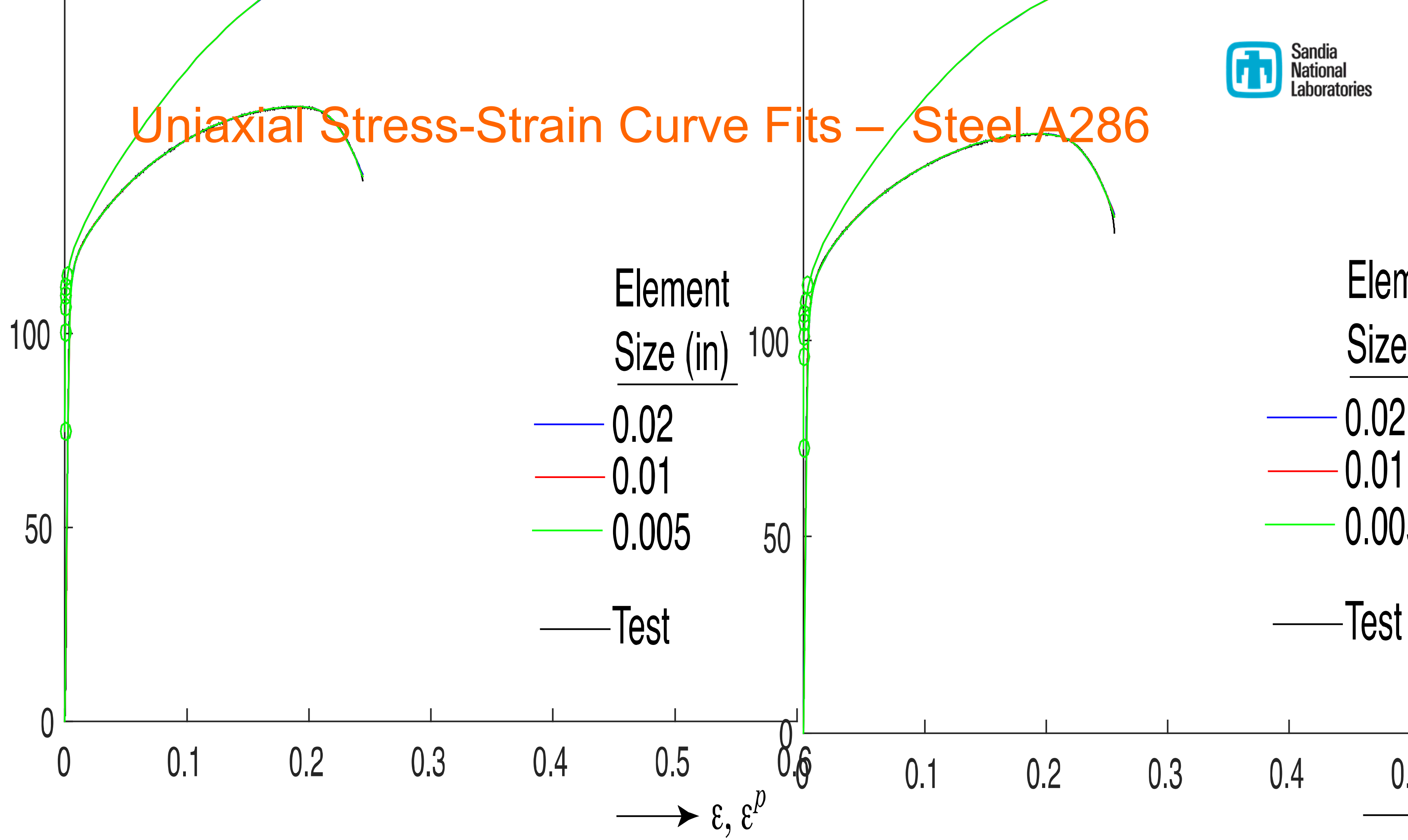




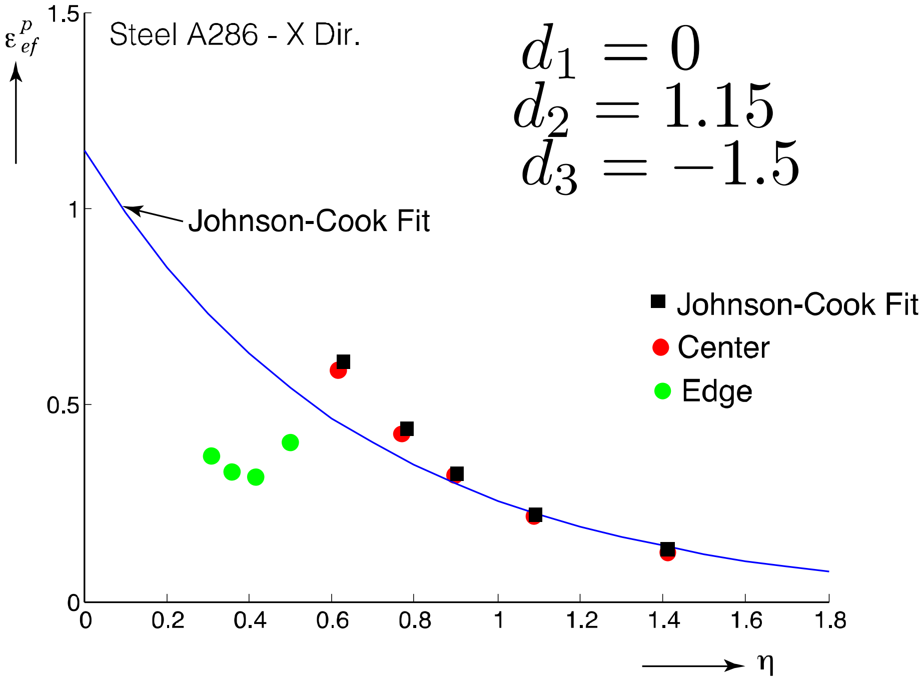
Uniaxial Stress-Strain Curves – Steel A286



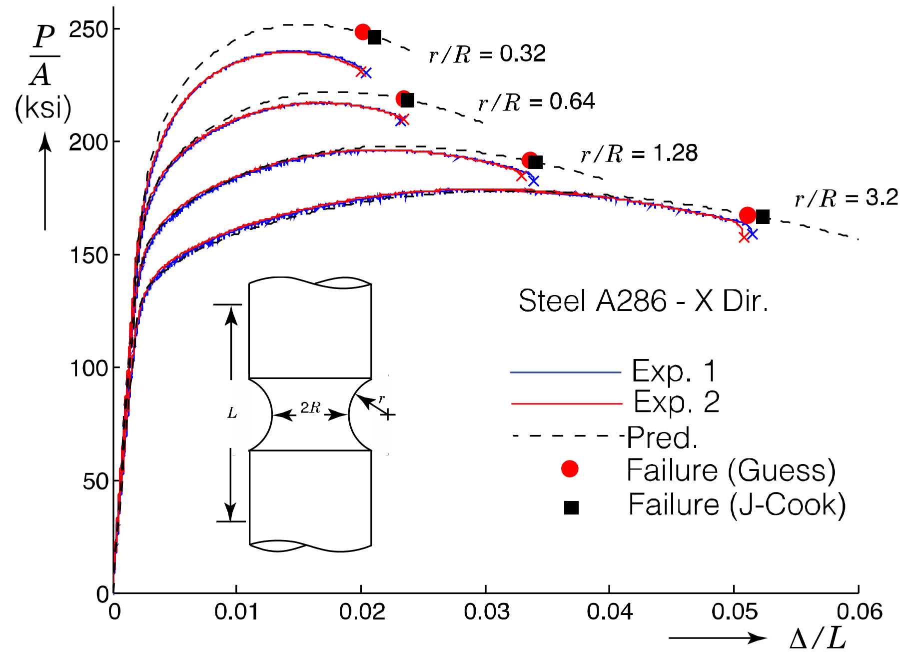
Uniaxial Stress-Strain Curve Fits – Steel A286



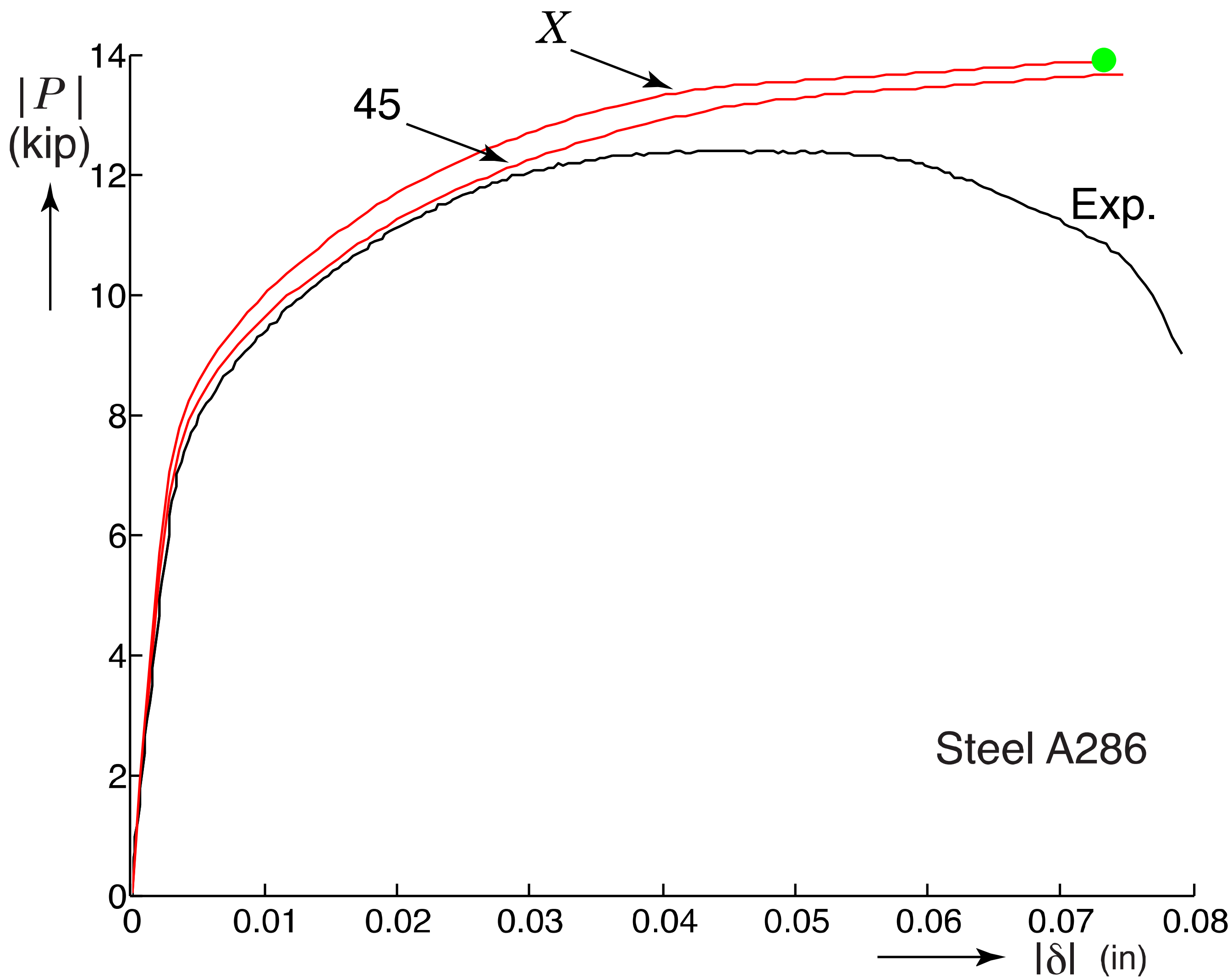
Notched Specimen Tension Test Results



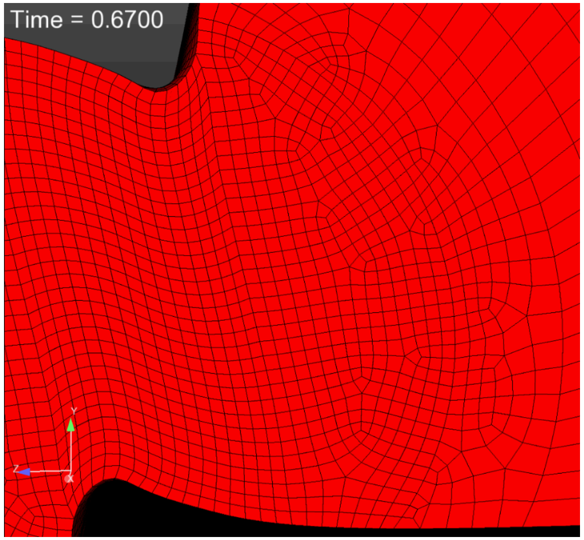
$$d_1 = 0$$
$$d_2 = 1.15$$
$$d_3 = -1.5$$

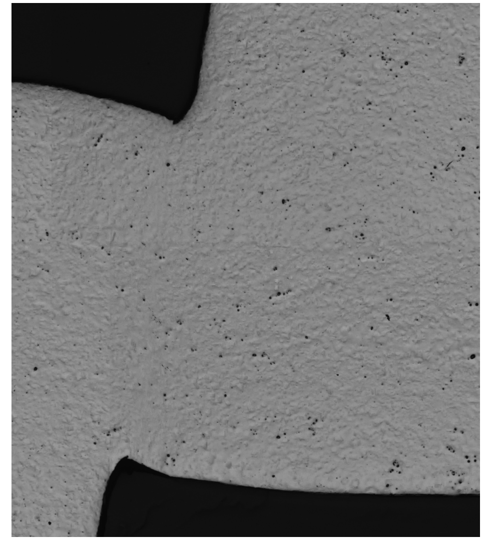


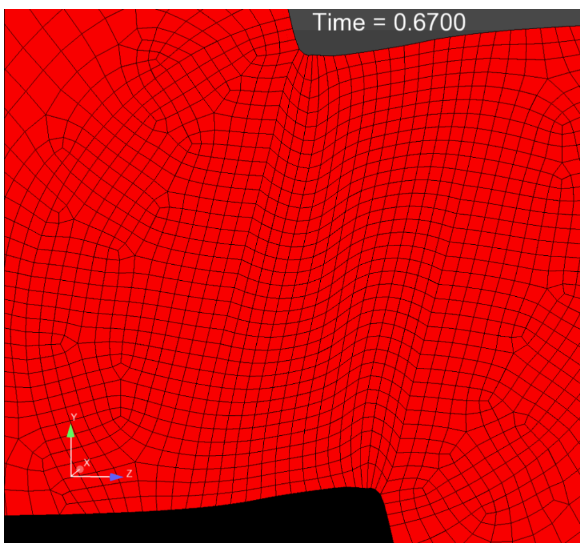
Prediction for Compression Specimen



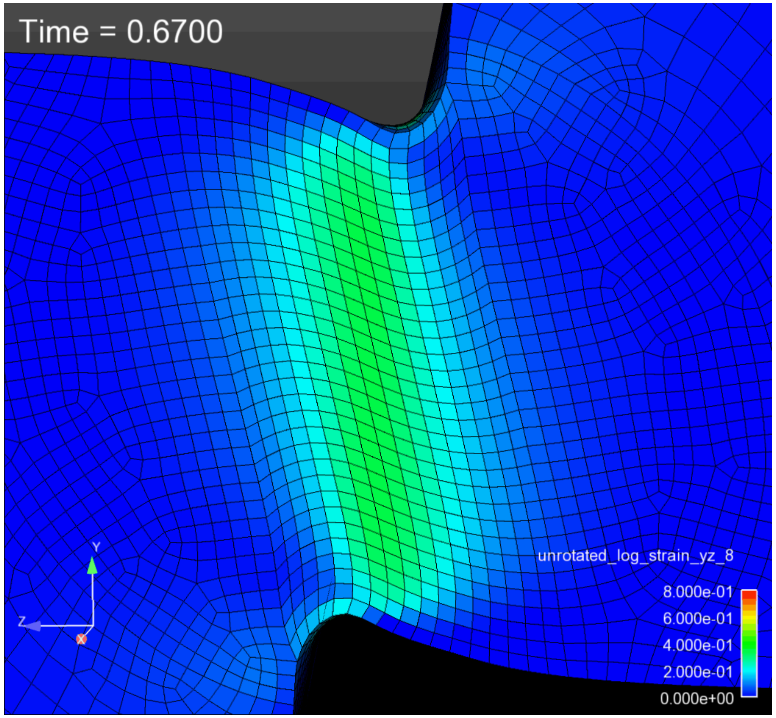
Deformed Shapes – Steel A286

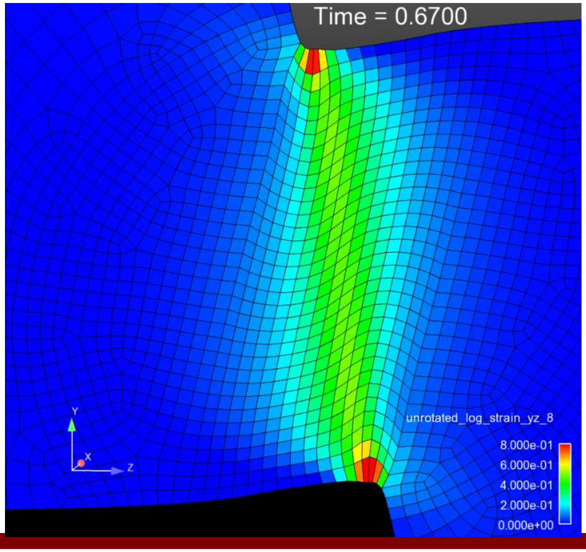


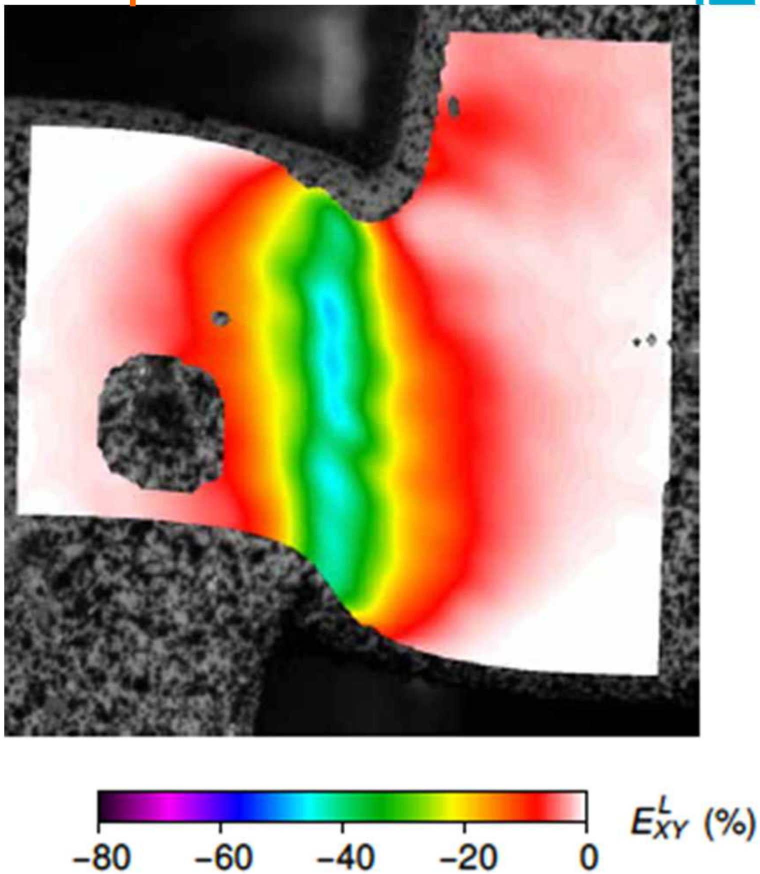




Shear Strain Contour Comparison





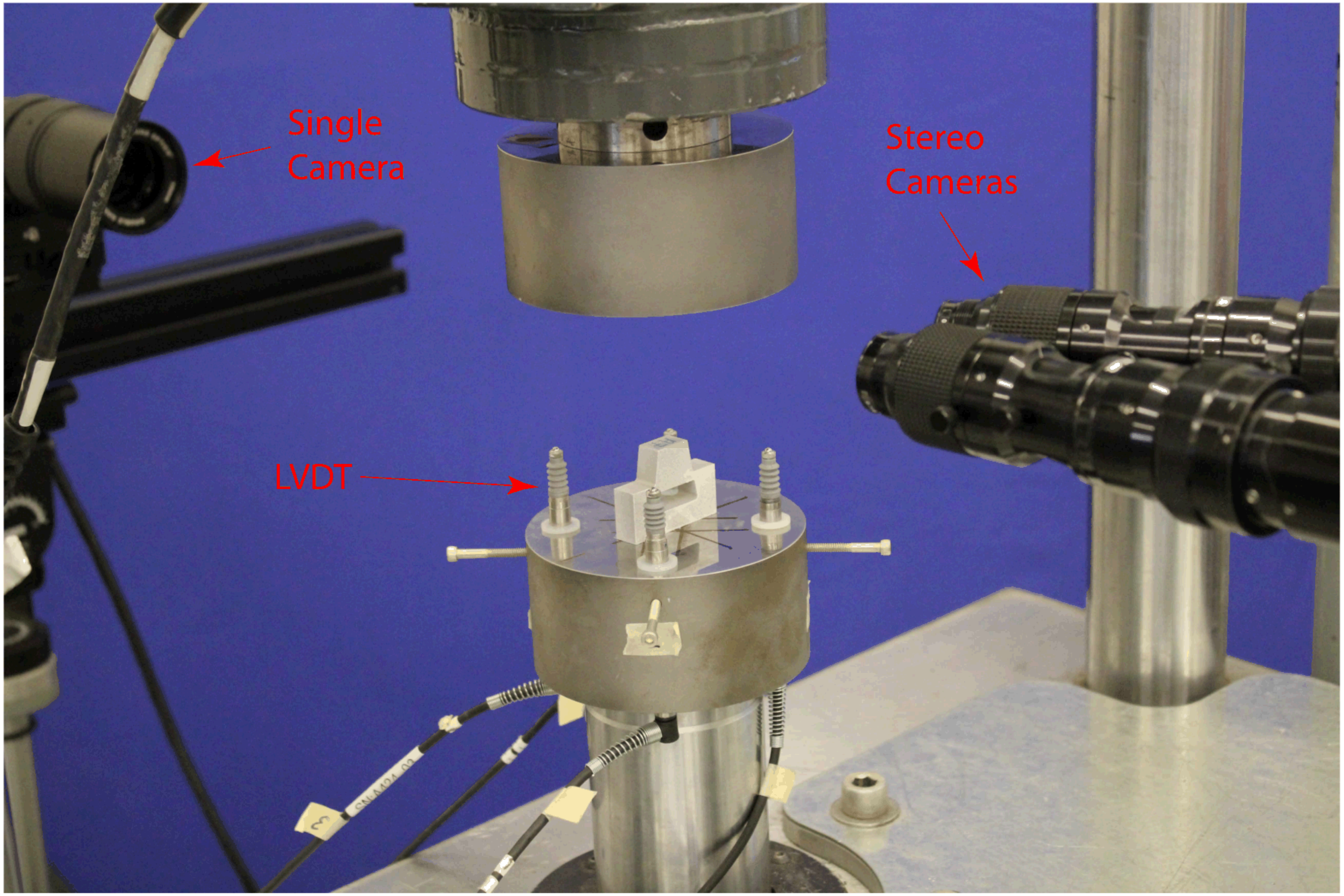


Conclusions

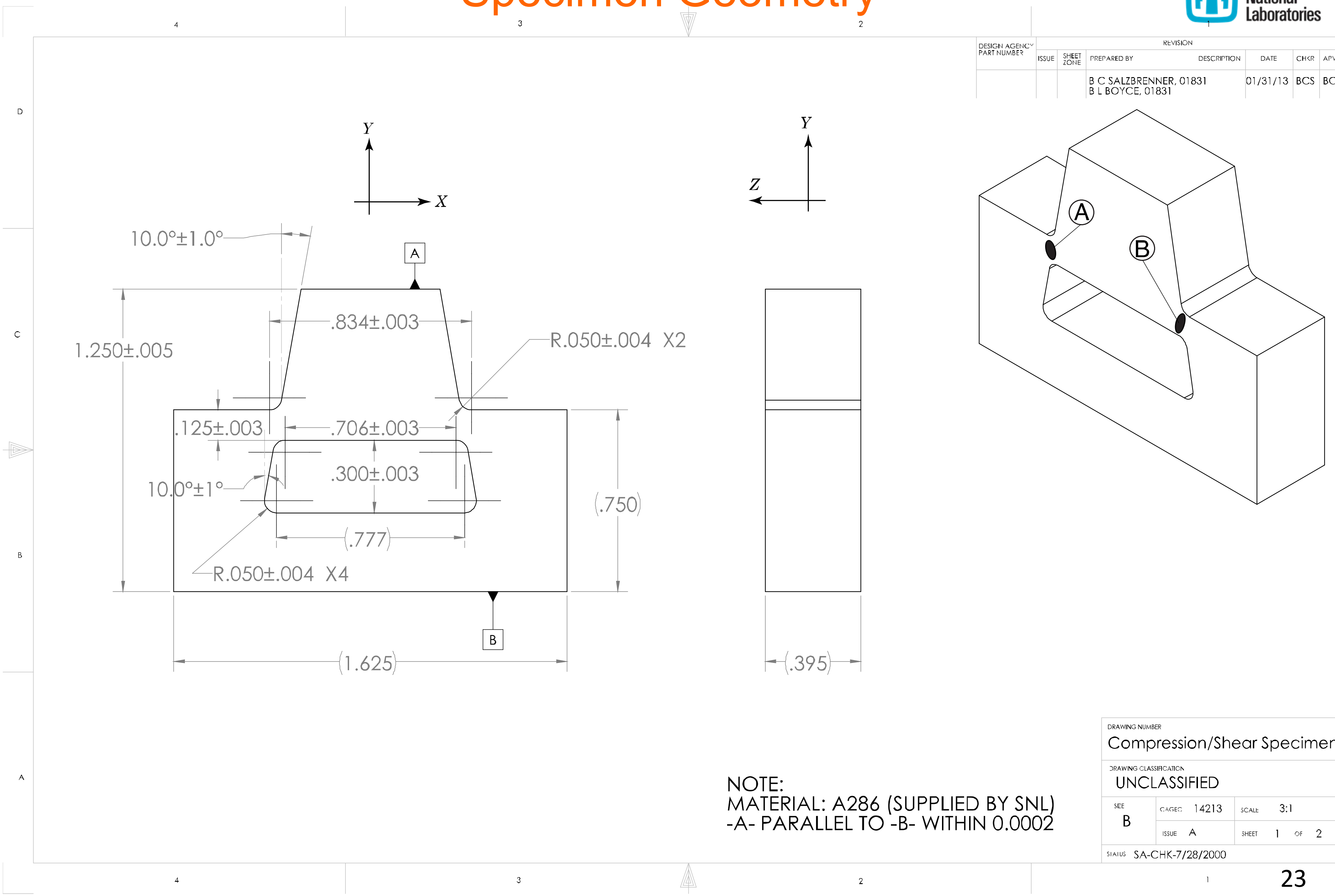
- Conducted quasi-static testing on compression specimens with shear-dominant state
- Steel specimens exhibited a maximum load and significant load drop prior to failure
- Aluminum specimens failed with little warning
- Sectioning revealed aspects of the progression of damage in steel specimens
- No apparent damage was observed in aluminum specimens prior to failure
- Both materials exhibited yield anisotropy
- Isotropic, J2 plasticity models calibrated from uniaxial tension tests
- Johnson-Cook failure model calibrated through tension tests on notched specimens
- Failure predictions seemed reasonable for aluminum specimens
- Work remains to improve response and failure predictions for steel specimens.

Extra Slides

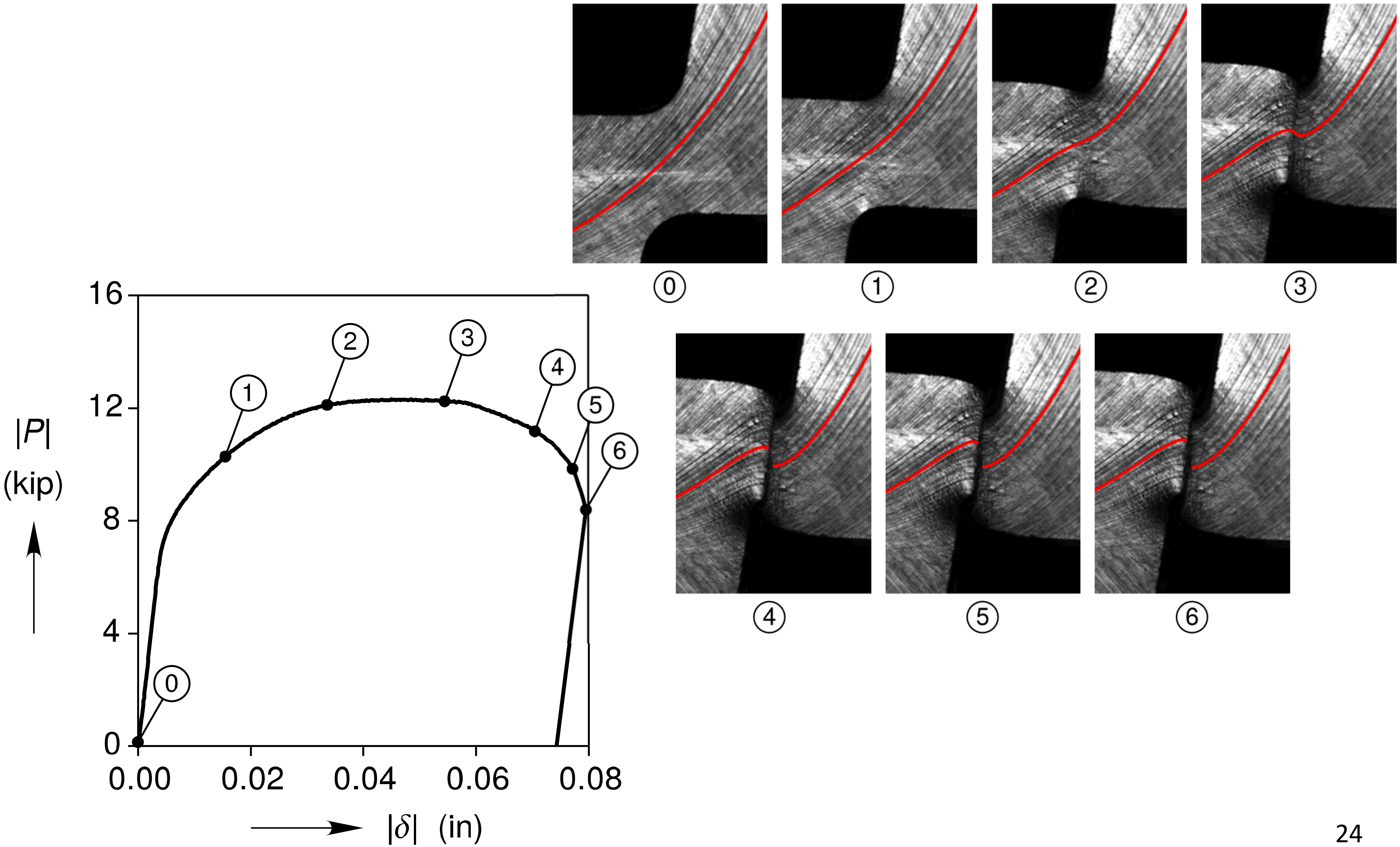
DIC Camera Arrangement



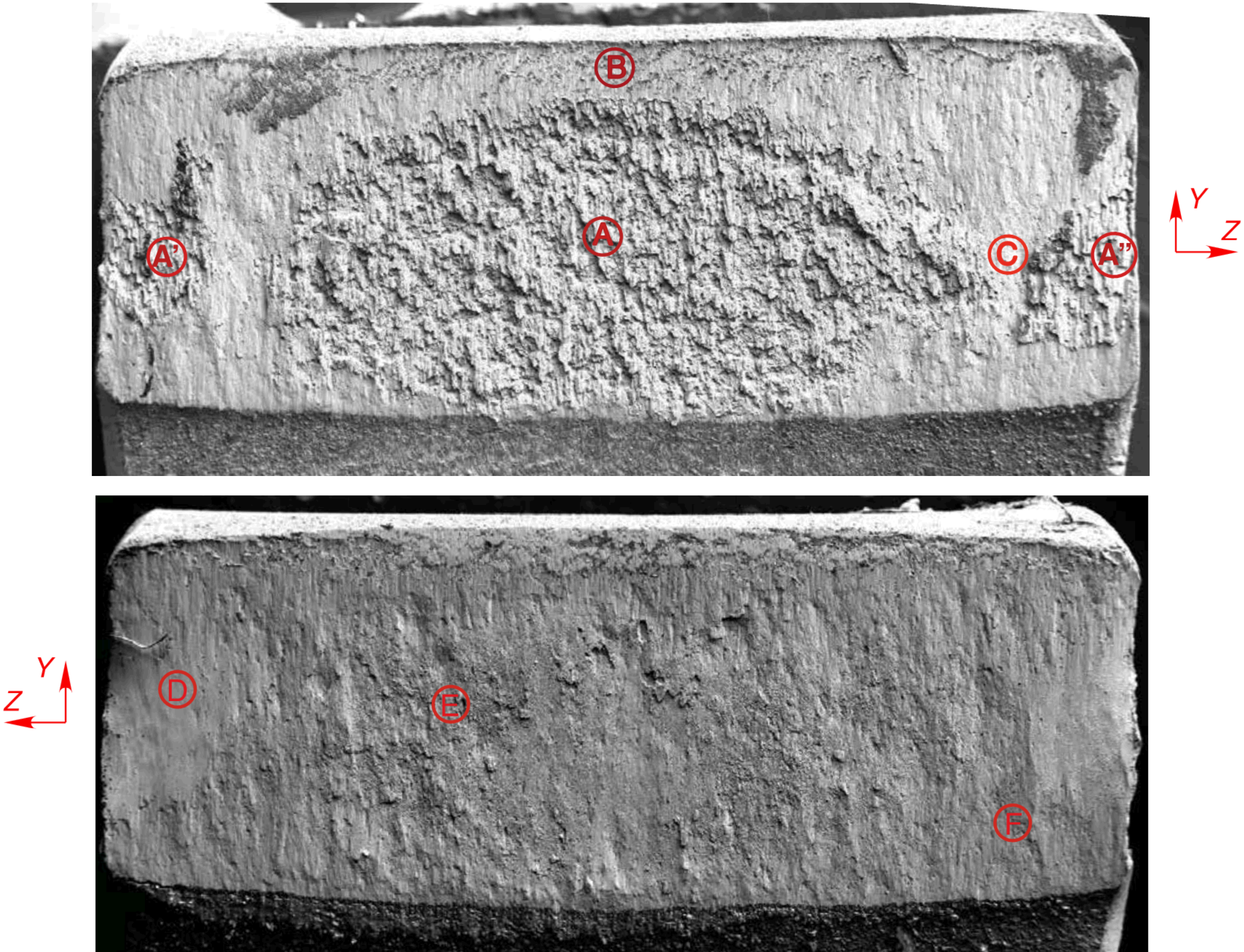
Specimen Geometry



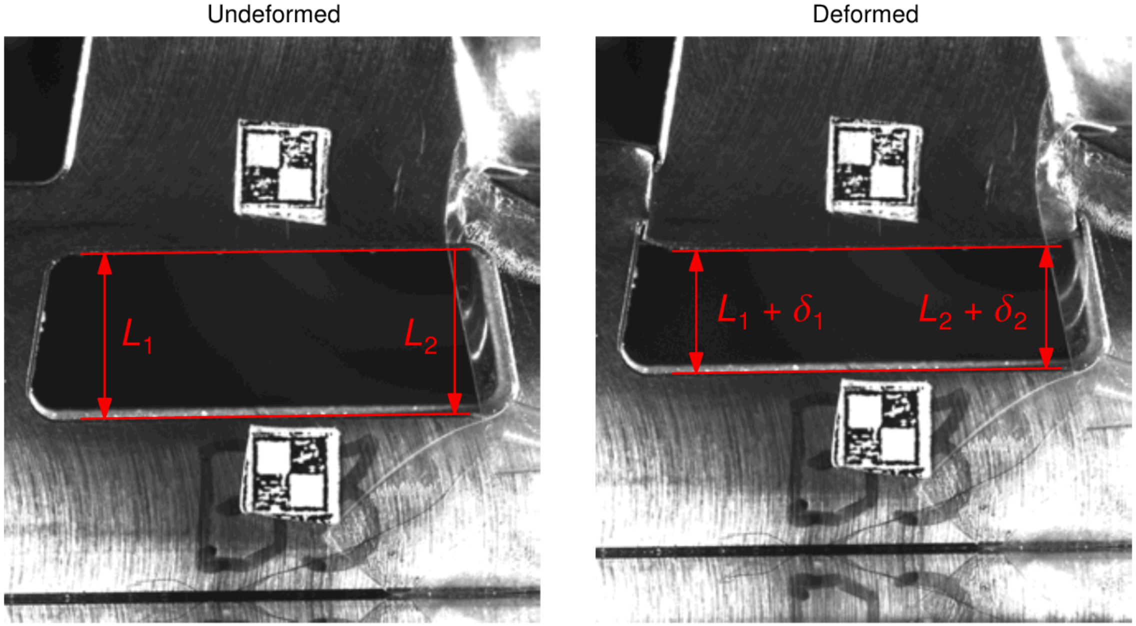
Example of Specimen Deformation for Steel A286 Specimen

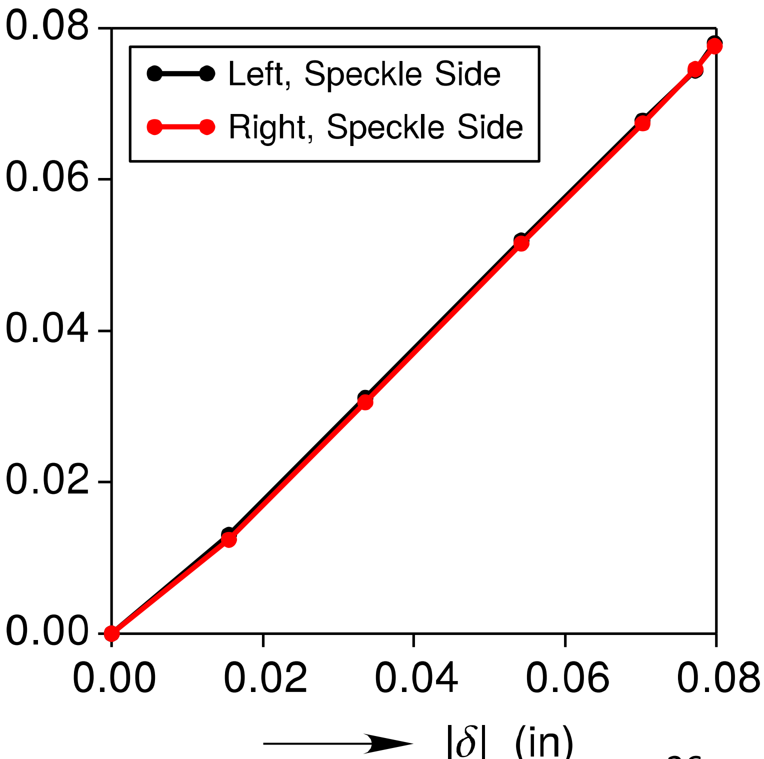


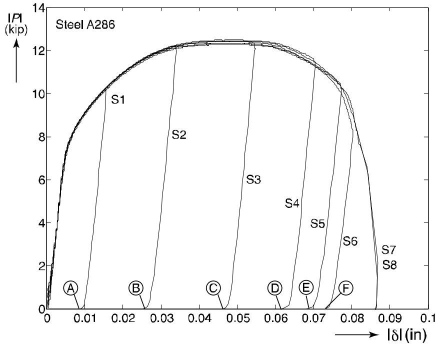
Fracture Surfaces for a Steel A286 Specimen



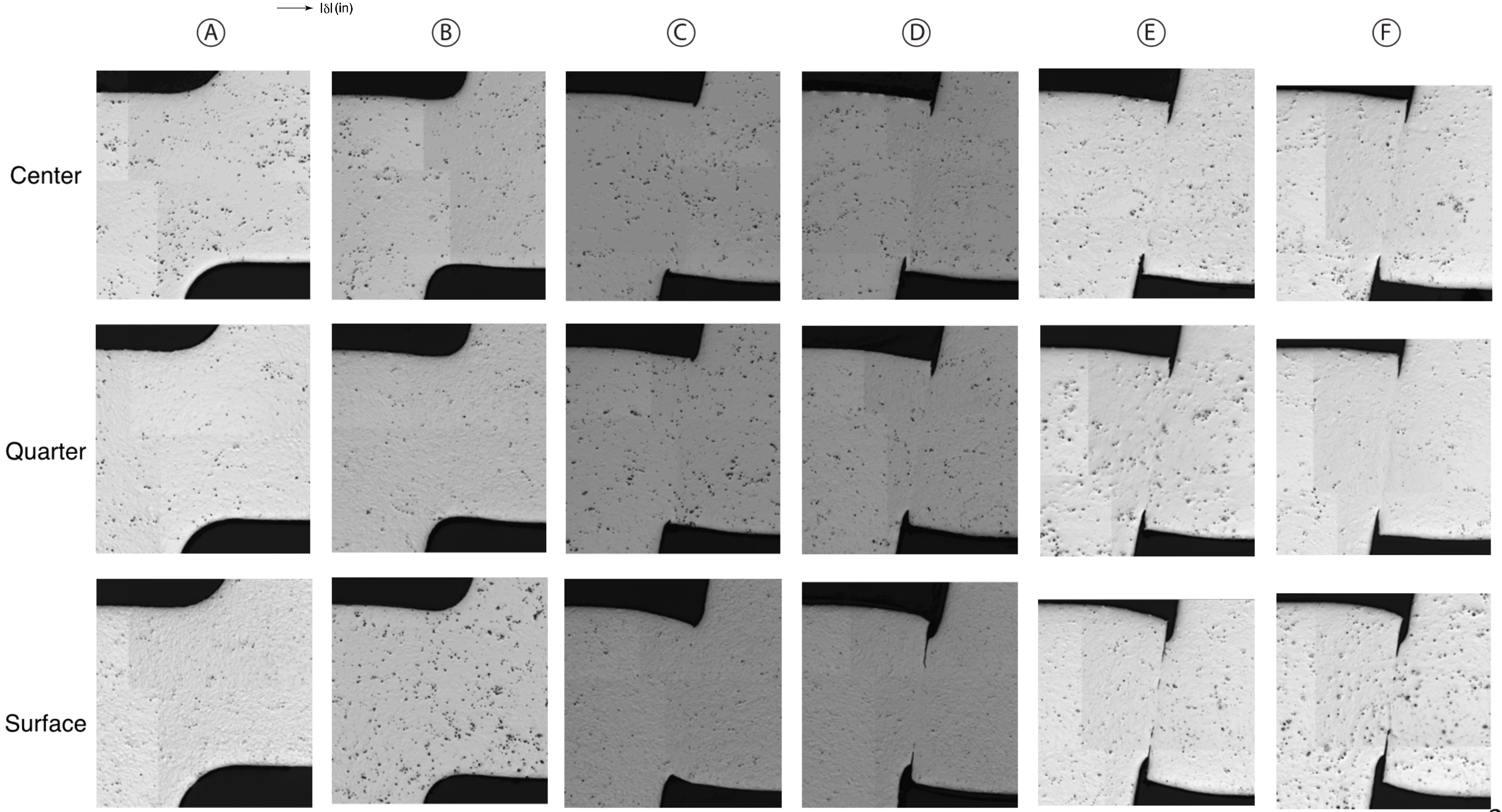
Parallelism of Deformation







Micrographs for Steel A286 Specimens (Left Side)



Micrographs for Steel A286 Specimens
Comparison of Left and Right Sides at Highest Displacement

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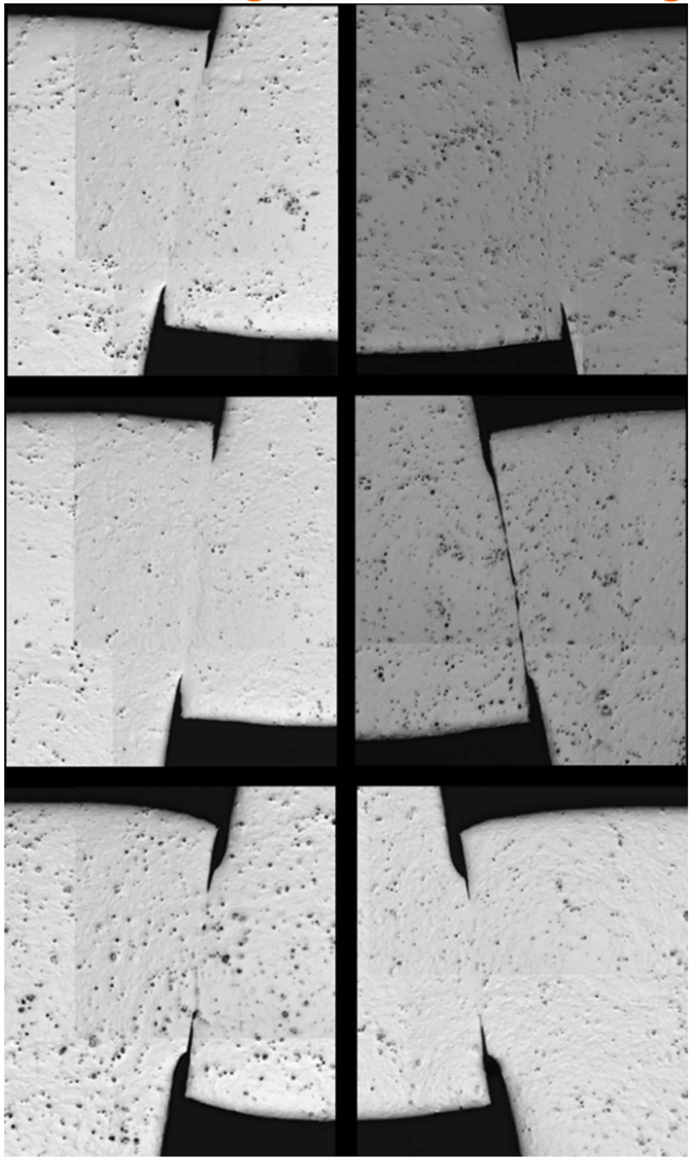
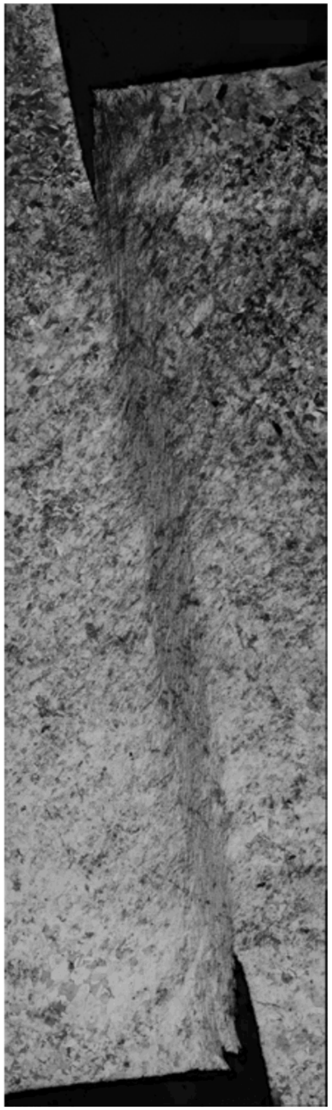
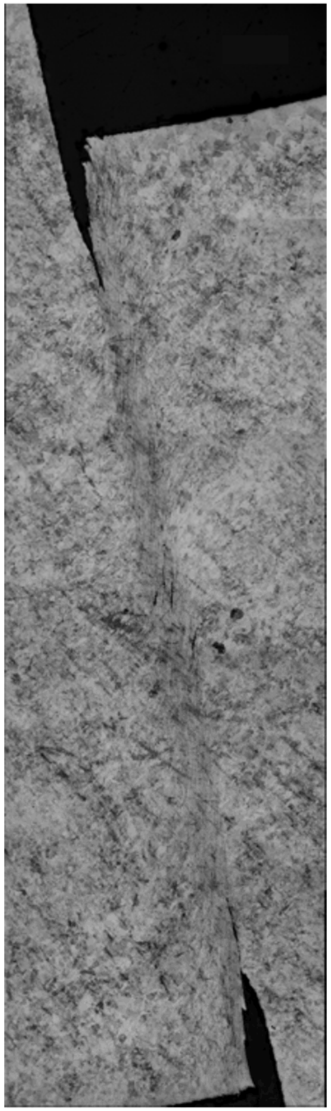


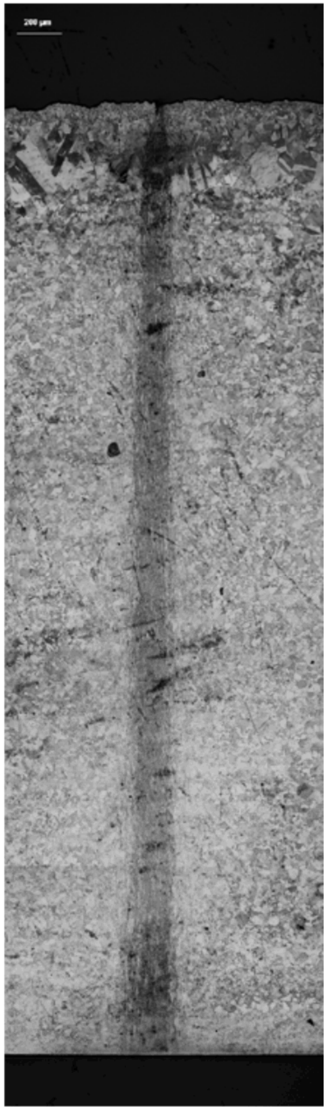
Micrographs of Etched Specimen – Steel A286



Center

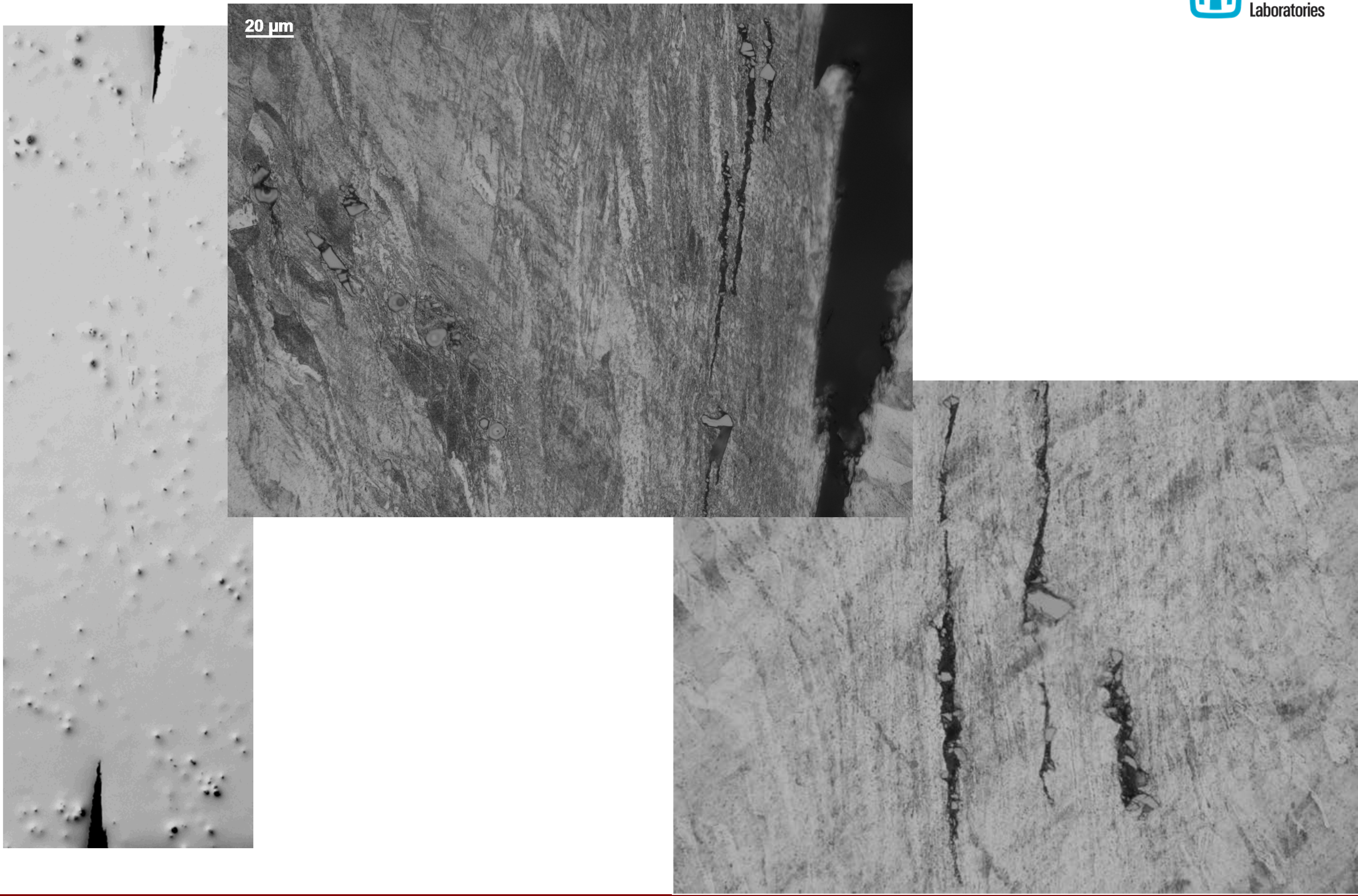


Quarter

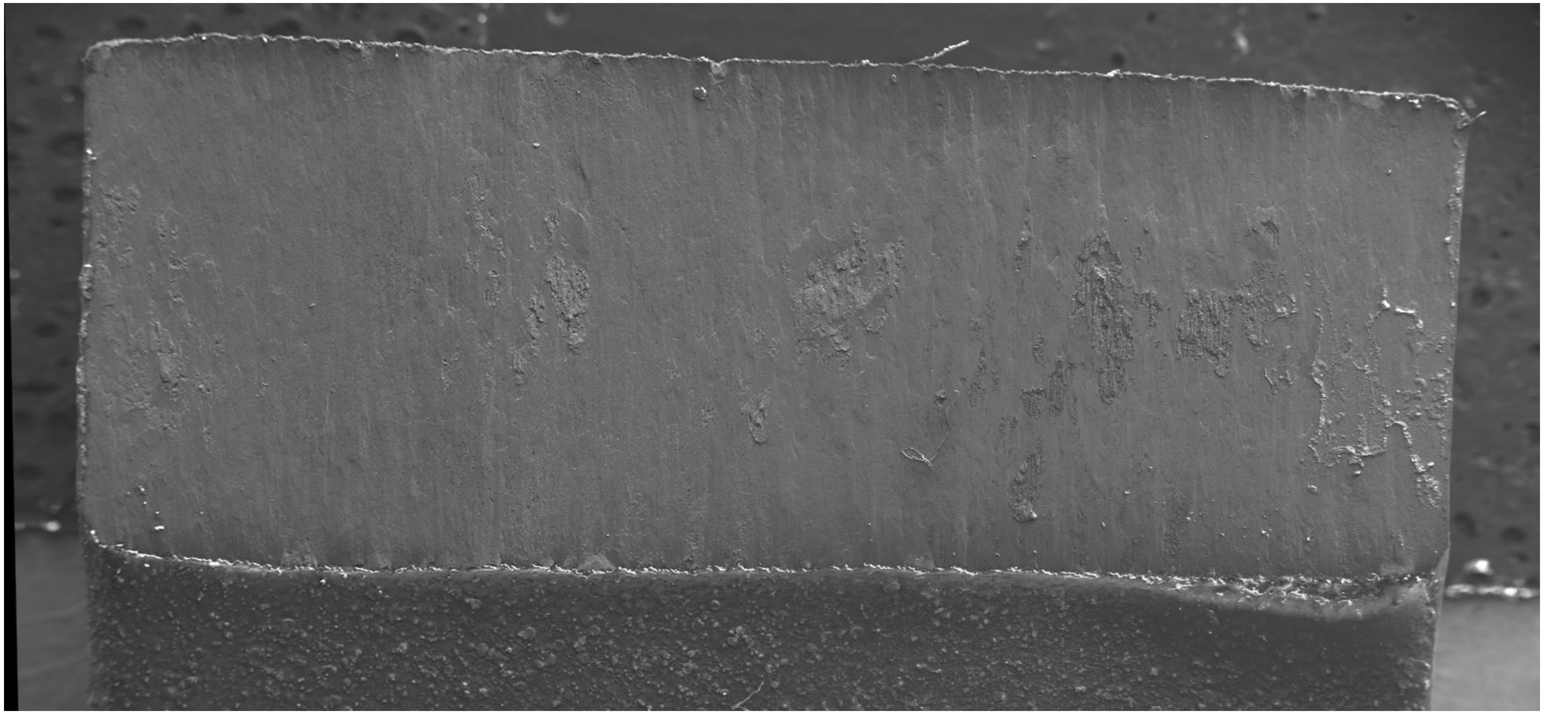


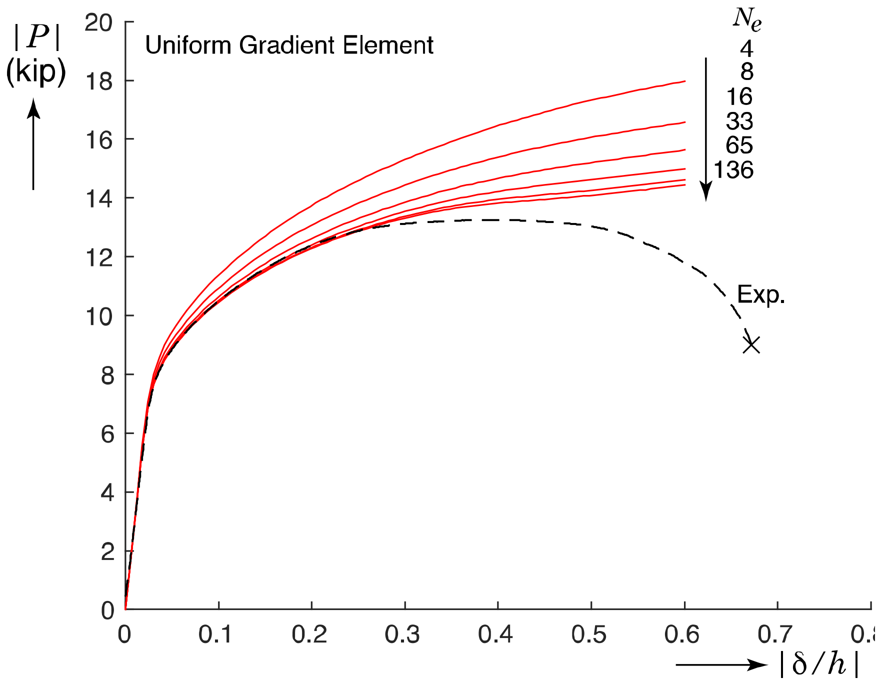
Transverse

Examples of Higher Magnification Images

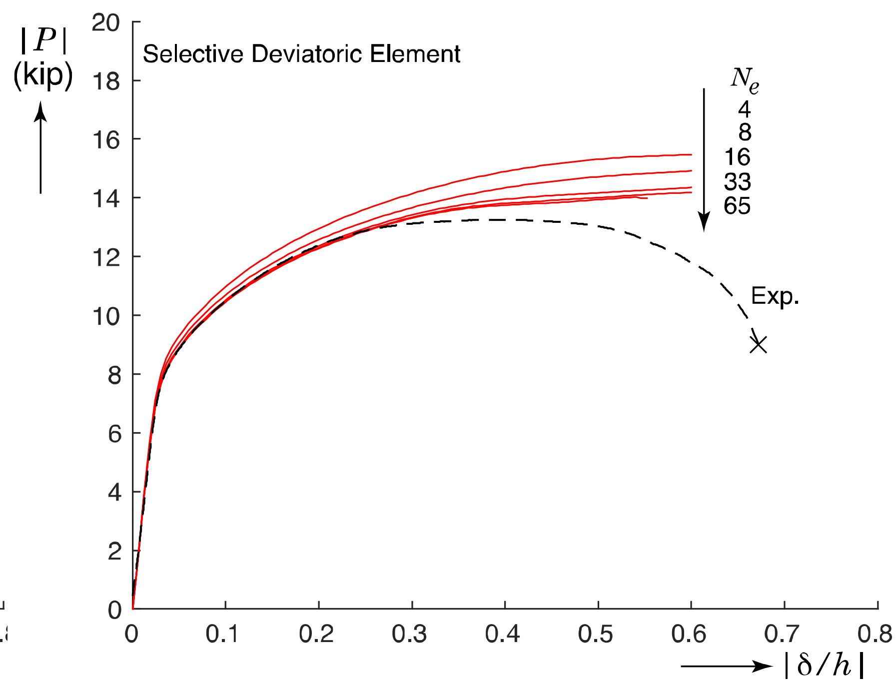


Example of Fracture Surface– Al7075-T651





|P|
(kip)
Uniform Gradient Element
N_e
4
8
16
33
65
136
Exp.
20
18
16
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
|δ/h|



|P|
(kip)
Selective Deviatoric Element
N_e
4
8
16
33
65
Exp.
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18
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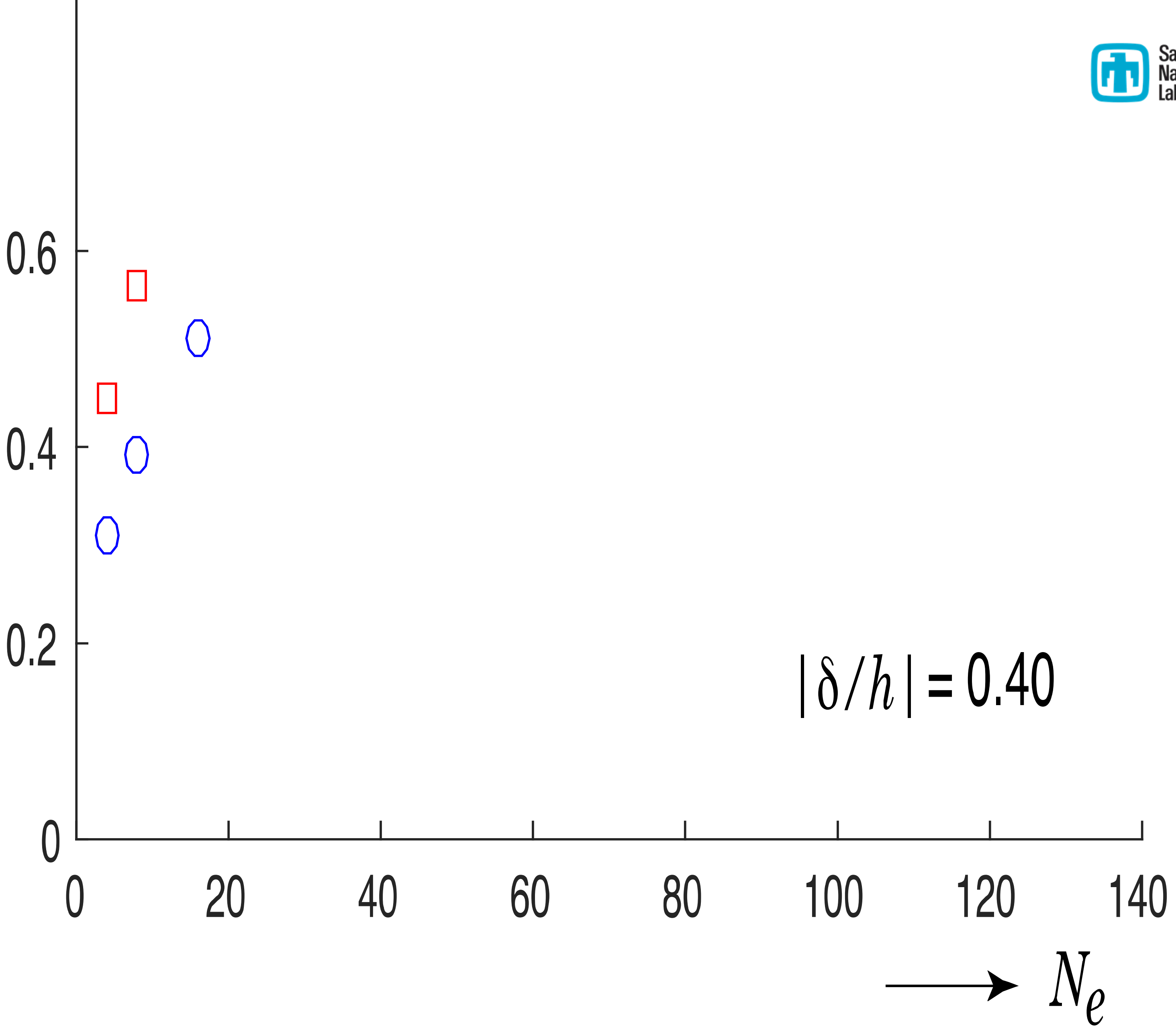
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
|δ/h|


0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
$|\delta/h| = 0.40$
N_e