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Dynamic Behavior of Ceramic Powders Impacted in a Cylindrical Configuration

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Dynamic Response of Materials

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Outline

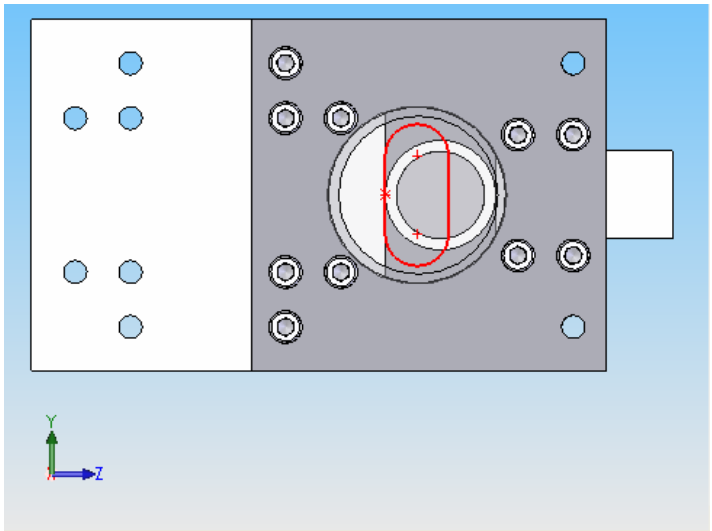
- Target Design
- Impact Setup – Use of Portable Gas Gun
- Results of Impact Tests
- Post Impact Measurements
- Summary of Work

Target Design

Objective: Constrain deformation of inert powder during impact to capture deformation using a high speed camera, take post impact measurements, and compare to simulations.

1/4” Bolts used to clamp steel walls against Steel Cylinder.

Bolts used to restrain the vertical motion of the impact buffer.



Actual Assembly

1”Thick Steel Wall at Center

1” Thick Steel Wall

Ring (1” ID, 1.25” OD, 1” H)
Impact Buffer (1” square, 2”L)

1” Thick Steel Wall
with 2” OD Slot for Window

Front and Top View of Target Assembly

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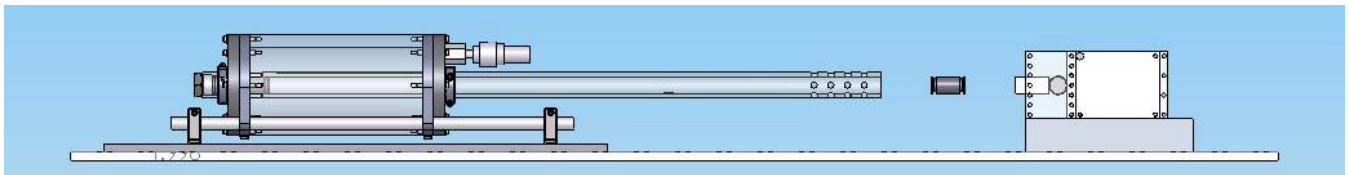
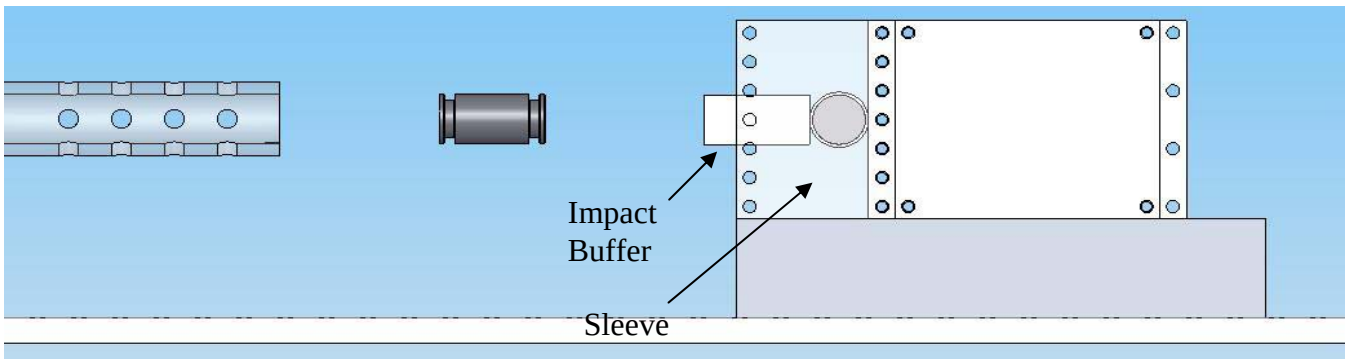
Impact Setup – Use of Portable Gas Gun

- Wrap-around breach design using Helium as the pressurized gas.
- The gas gun has a 1” ID x 40” length barrel.
- A steel projectile is used to impact the target.
  - 1” OD x 2” length
  - 194 grams
- A 194 gram steel projectile driven at 200 m/s:
  - Energy of 3.88 kJ
  - Momentum of 38.8 kg m/s.

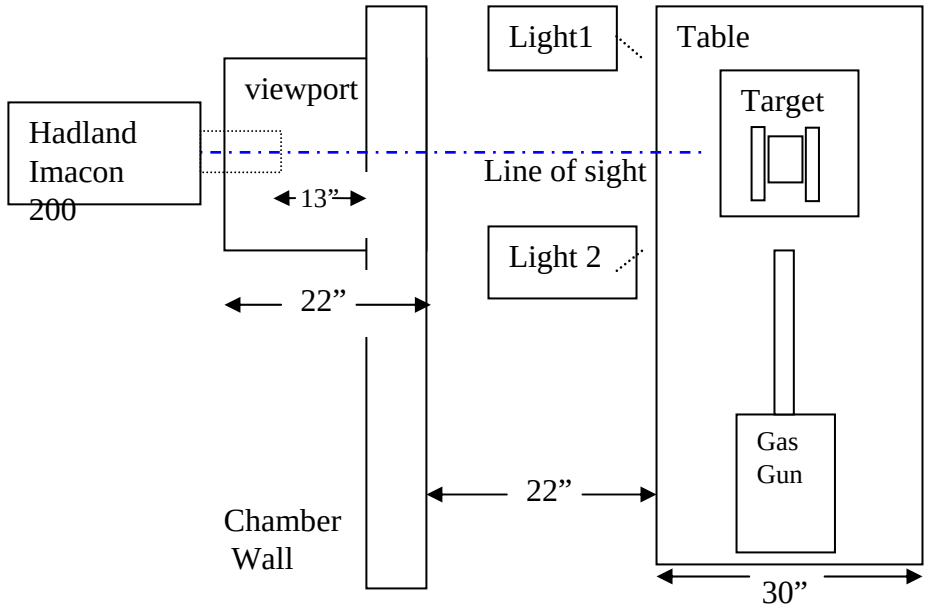


Gas Gun Design



Projectile exiting the gun barrel to impact target

Gas Gun Setup in Firing Pad



Photogenic
Lights

Top View of Gas Gun Setup

High Speed Camera

Target Setup

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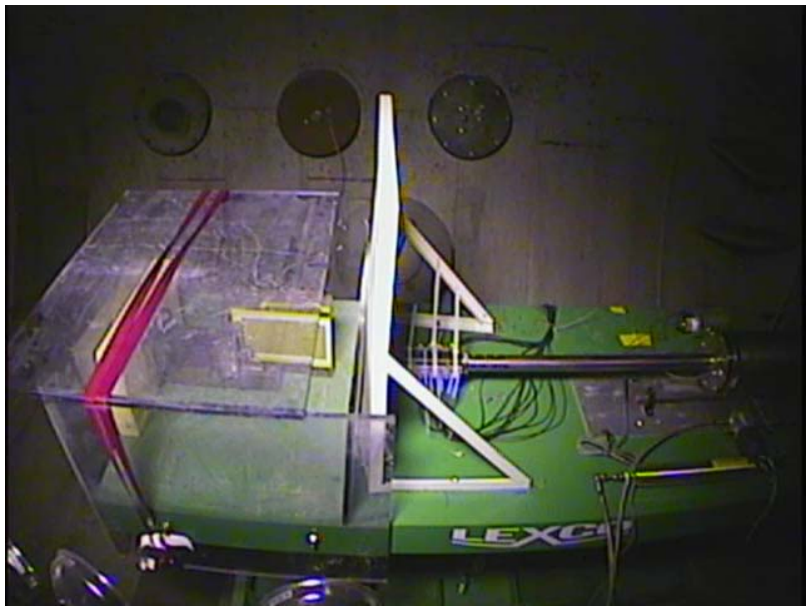
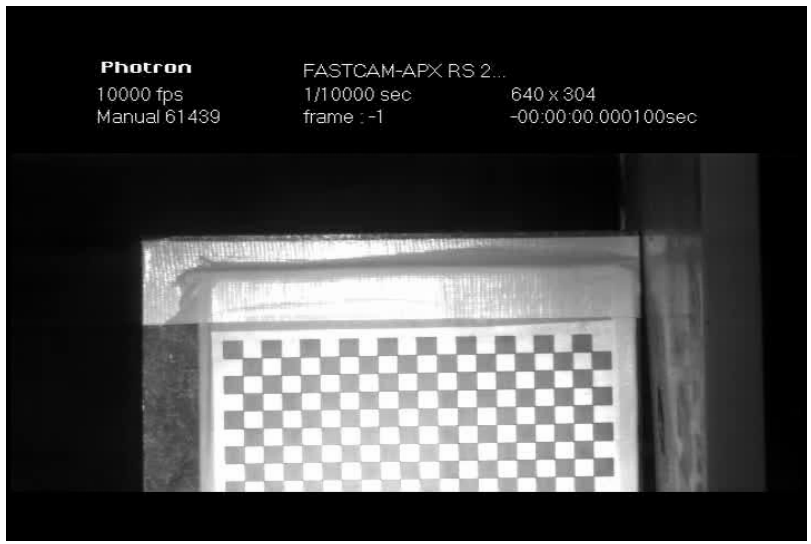
Use of Gas Gun



Lexan box used to minimize spread of debris

Movie – Regular Speed



High Speed Camera Used to verify projectile velocity and travel.

Movie – High Speed

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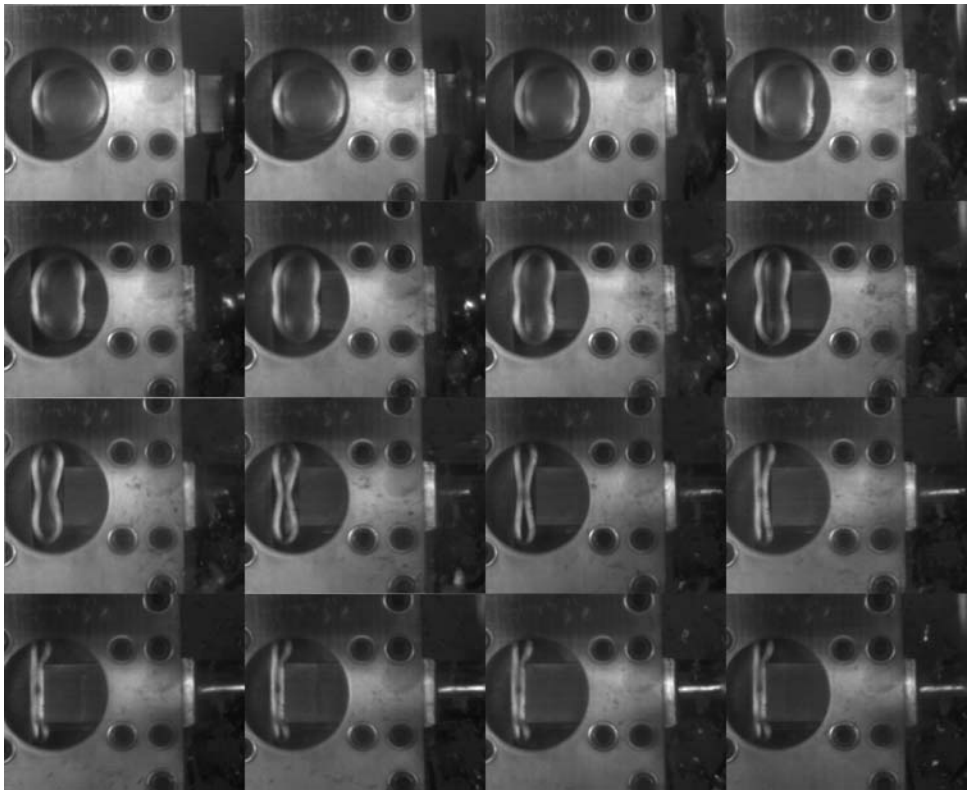
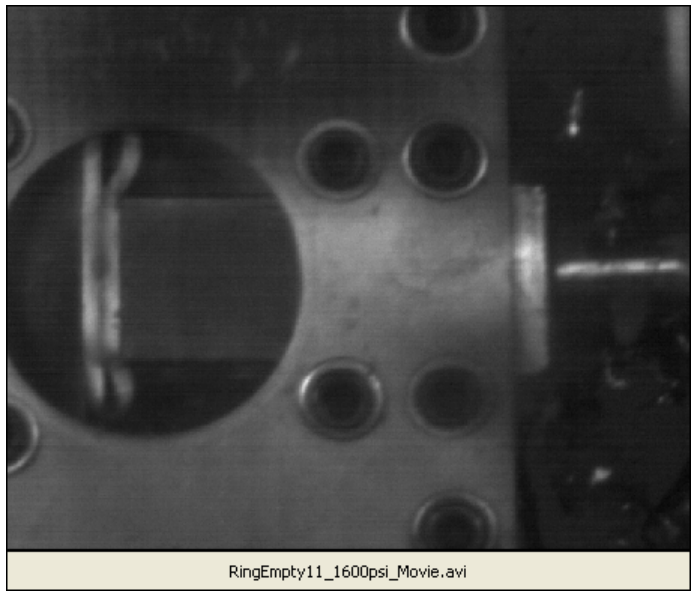
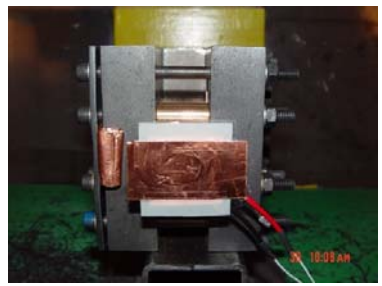
Empty Ring Impact



Frames – 20 µsec interframe time



Video



Make circuit setup consisting of copper foil

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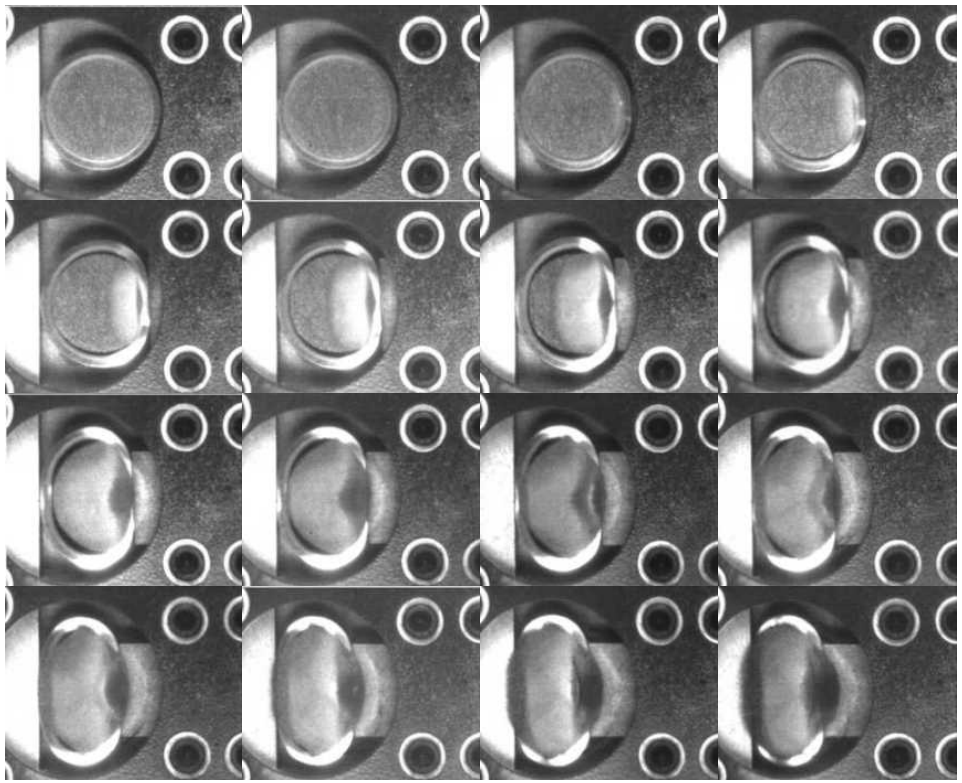
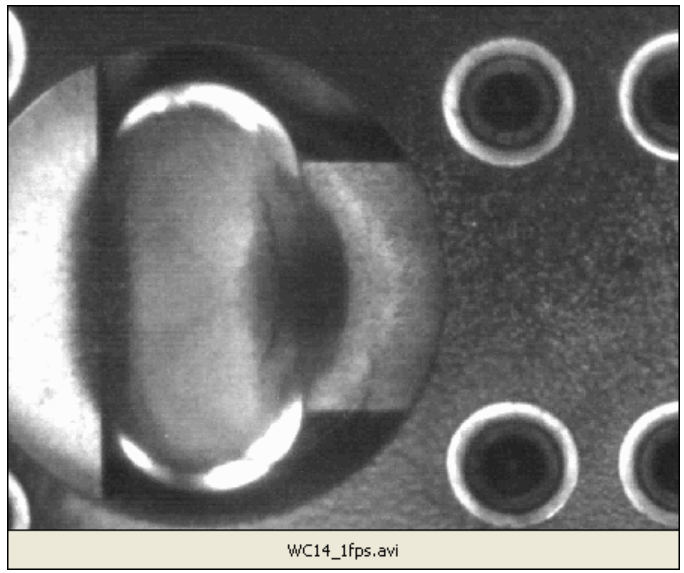
WC Impact

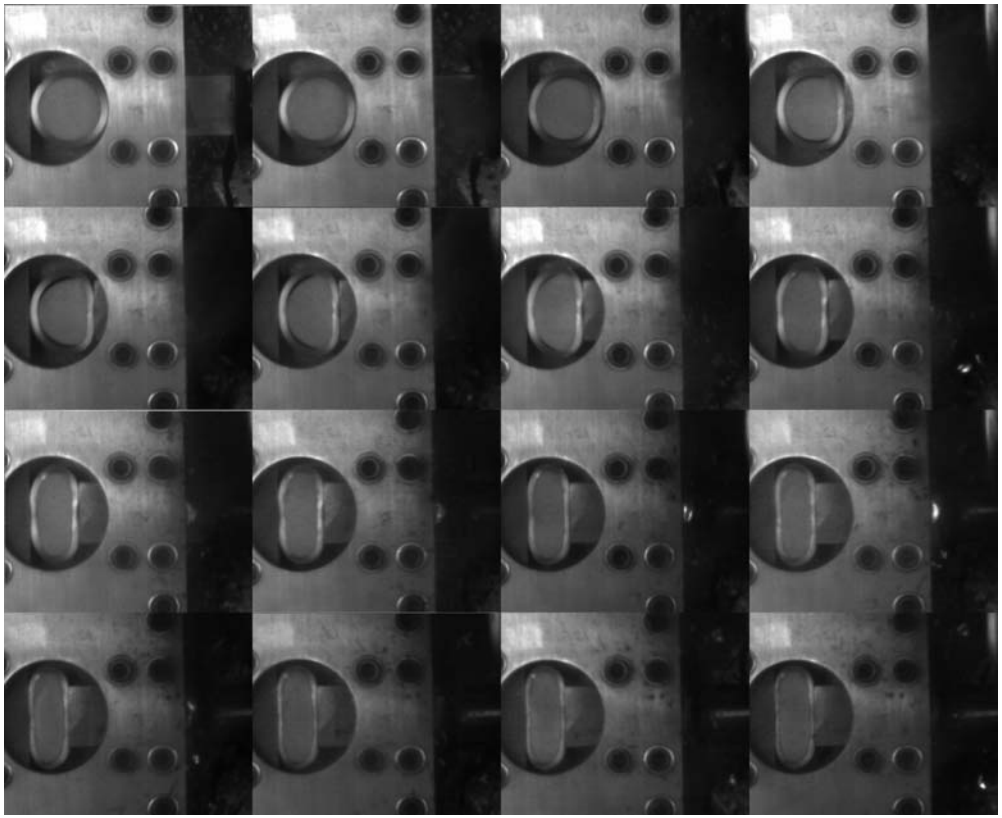


Frames – 10 µsec interframe time

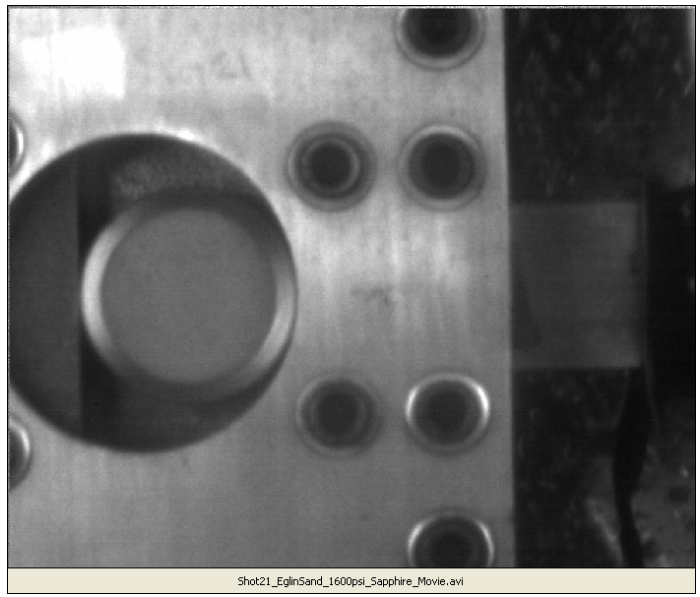


Video

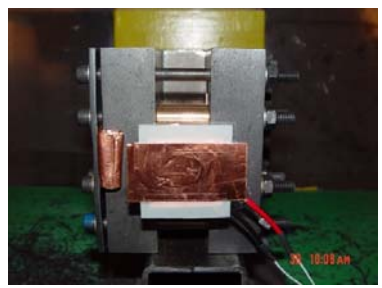
Eglin Sand Impact



Frames – 20 µsec interframe time



Video



Make circuit setup consisting of copper foil

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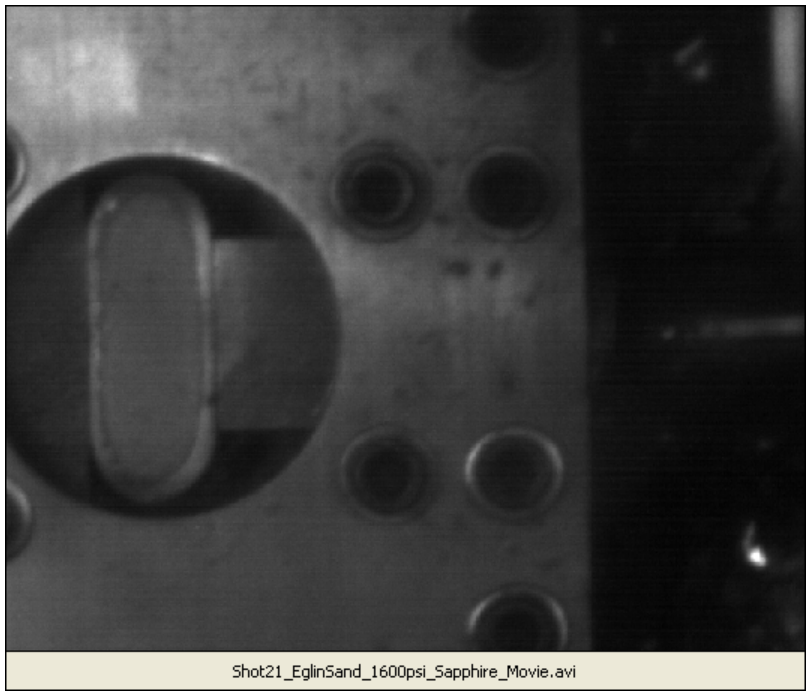
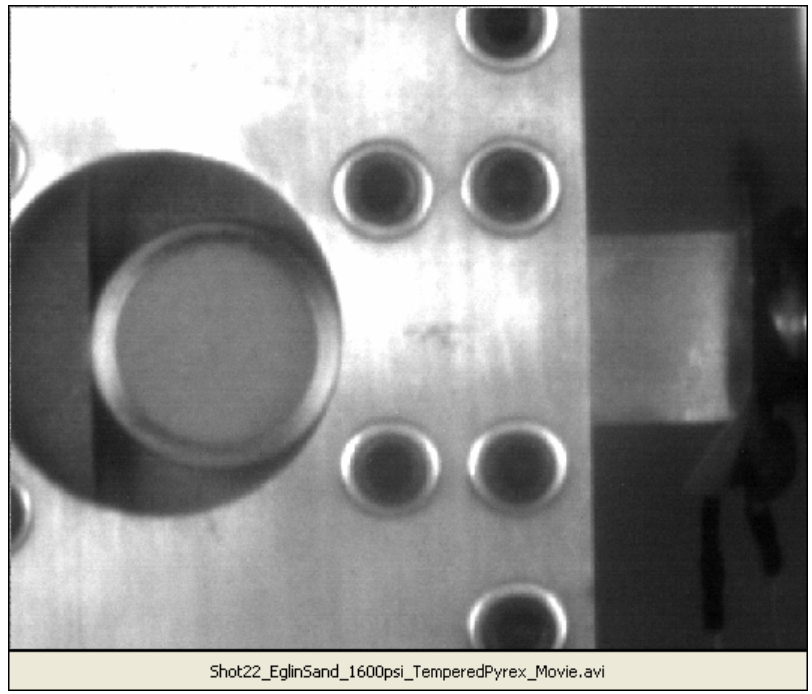
Eglin Sand Impact Videos



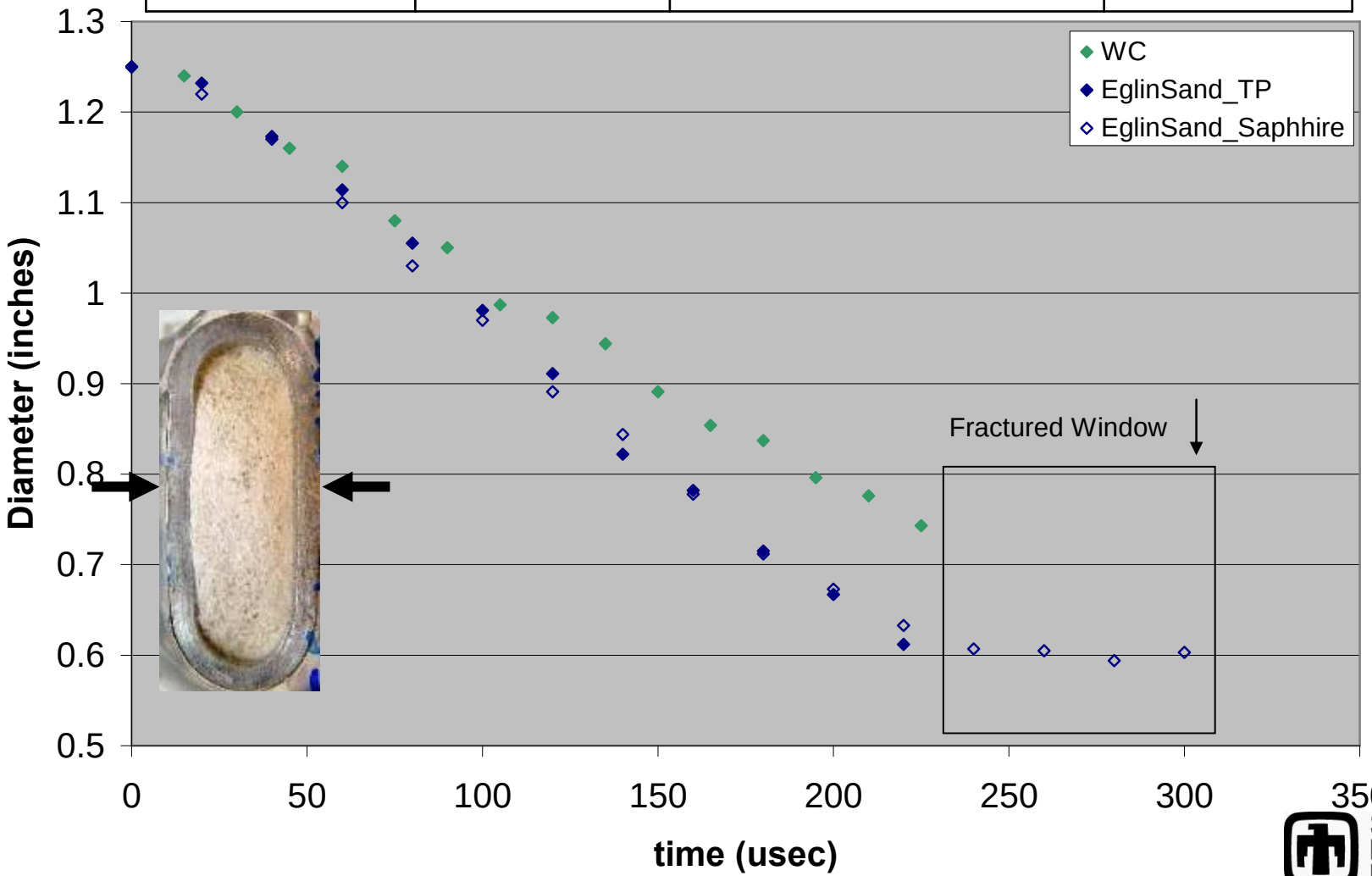
Sapphire Window remained intact during the impact



Tempered Pyrex and Quartz Window fractured during the impact

Width Deformation of Ring Filled with Powders

	Initial OD	Average Deformed Width	Deformation
Eglin Sand	1.25	0.665	46 %
WC	1.25	0.700	43 %



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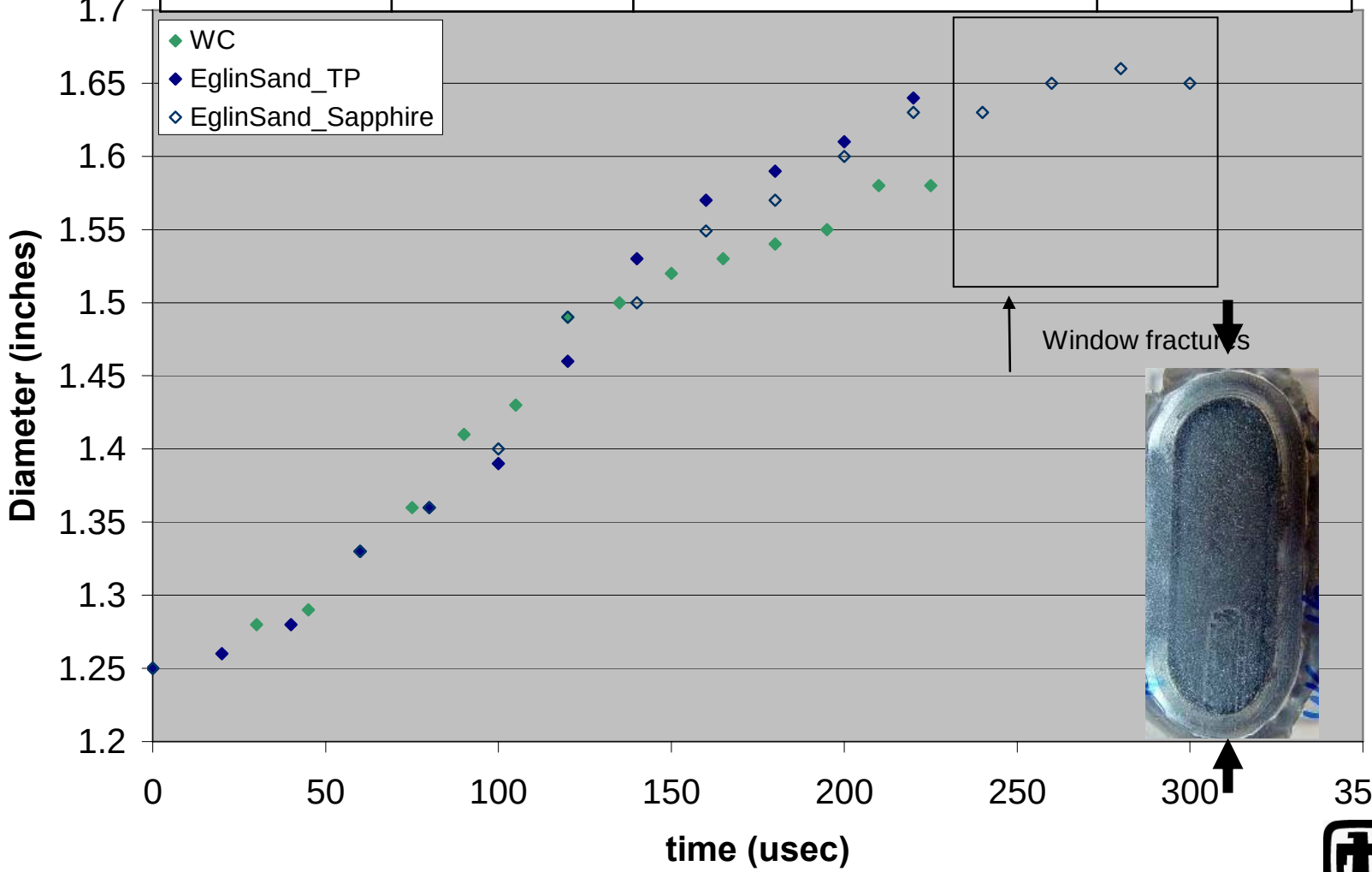
Length Deformation of Ring Filled with Powders

	Initial OD	Average Deformed Length	Lengthening
Eglin Sand	1.25	1.654	32%
WC	1.25	1.602	28%



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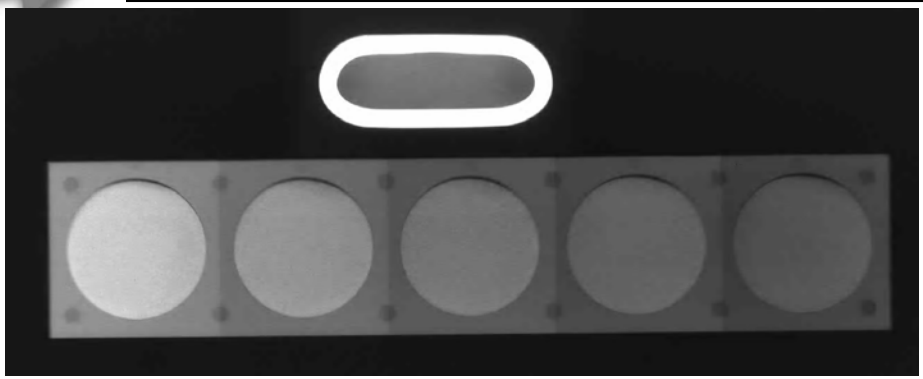
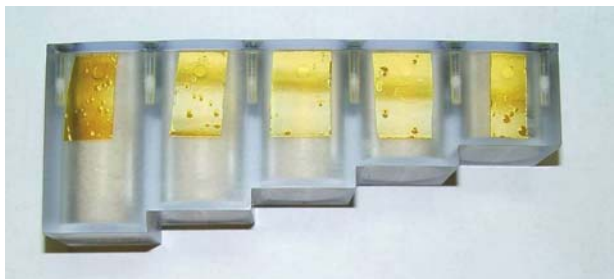
X-Ray



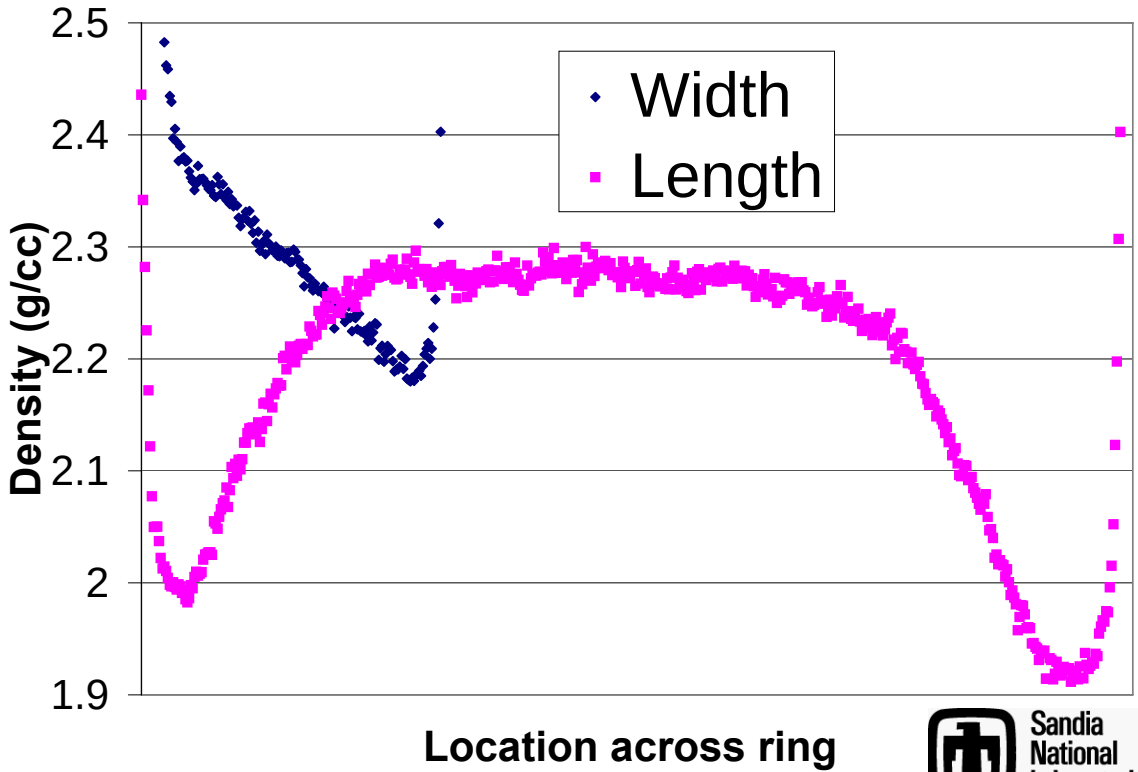
Equation for equivalent sand thickness
y = 1.020927Ln(x) - 9.038116
y – equivalent thickness
x – image intensity
2.27 g/cc - Average density of impacted sand

Step # 1 2 3 4 5

Step #	Image Intensity	Thickness (in)
1	21221	1
2	24671	1.25
3	29398	1.5
4	37810	1.75
5	50802	2



Step wedge filled with sand



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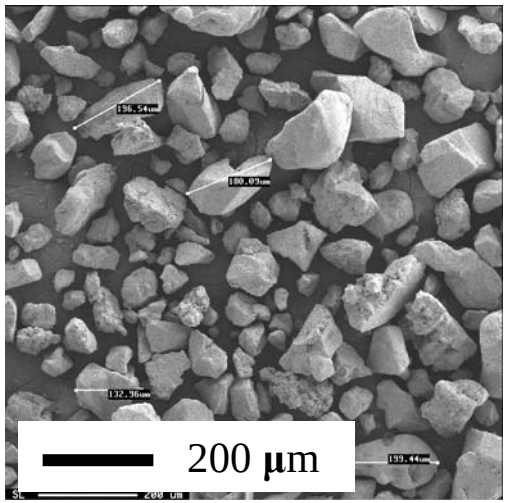
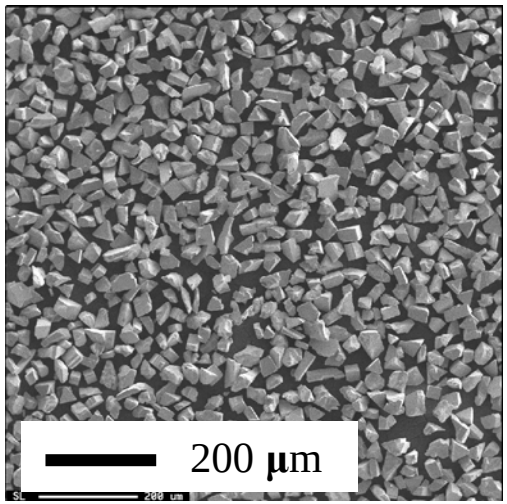
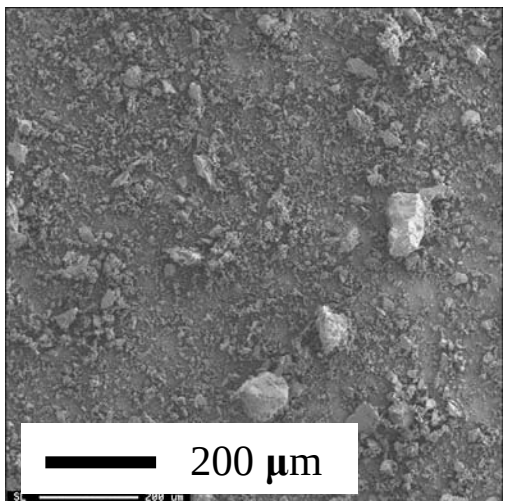
Impacted Powders



Sand



WC



Impacted Sand

Name	Density	Solid Crystal Density	Mean Particle Size	Particle Size St. Dev.
	g/cc	g/cc	µm	µm
Sand	1.53	2.56	298.1	169.8
Sand Impacted	2.25		28.7	28.0
WC	7.7	15.7	39.9	11.6
WC Impacted			28.0	13.5

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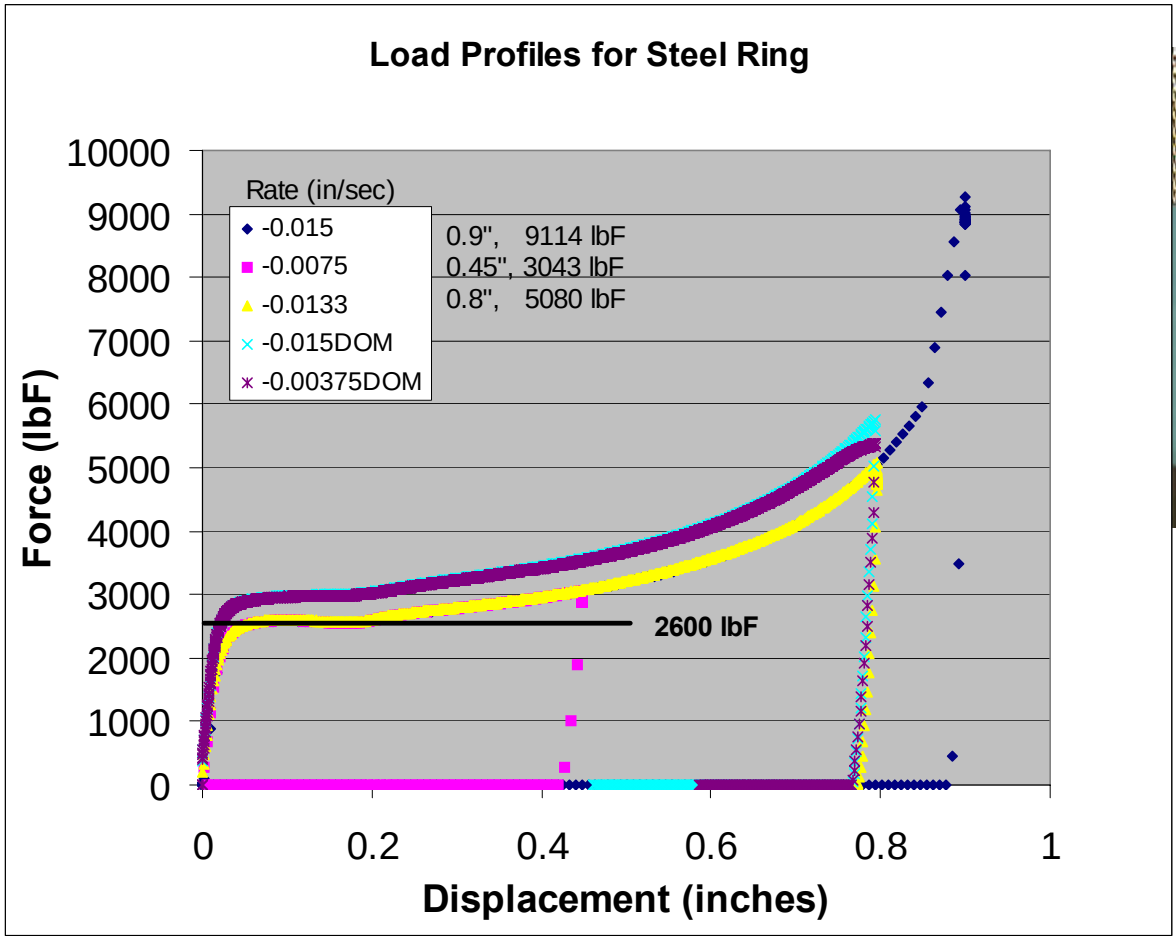
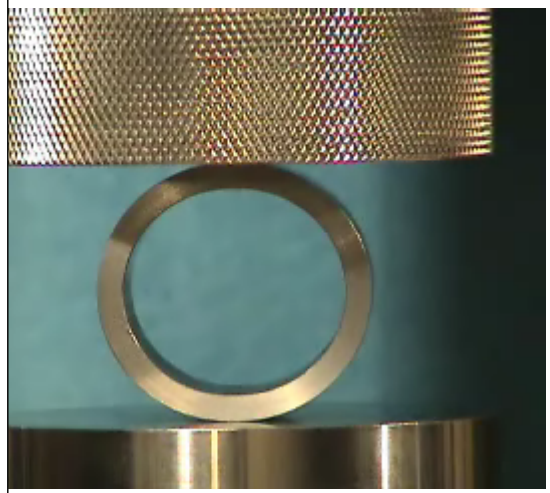
Ring Loading in Quasistatic Compression





Deformation	0.9”	0.45”	0.8”
Rate (in/sec)	0.015	0.0075	0.0133

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Summary of Work

- **Current Work**
  - **Designed a 2D experiment for dynamic loading of powders.**
  - **Use of high speed framing camera used to capture deformation.**
  - **Use of sapphire window to withstand and capture deformation.**
  - **Sensitivity of measurements (crush of material) occur roughly after 150 µsecs.**
  - **Made a step wedge to correlate X-ray image of sand powder to measure density of impacted sand.**

- **Future Work**
  - **Continue experiments using a sapphire window.**
  - **Improve modeling using a FEA and/or ALE code.**