Sealing Ring Testing and Characterization
Final Presentation

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Sponsored by: Cummins, Inc.
Advised by: Dr. Oates and Dr. Alvi

Outline

- Introduction
- Design Process
- Testing Procedure and Results
- Interface: How It Works
- Project Management
- What We've Learned
- Conclusion
- Future Work

Introduction

- Cummins, Inc. designs and manufactures high-performance engines

- For a competitive, efficient product:
  - Leak-free joints
  - Sealing rings

- Sealing rings
  - Fit between mating parts
  - Resistant to harsh conditions
  - Wide variety of applications

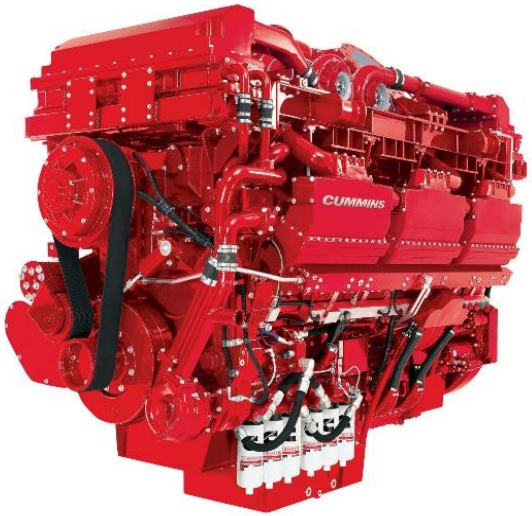


Figure 1: An engine produced by Cummins, Inc. [1]

Background

- Sealing rings vary in size and shape
- Common material used is fluoroelastomeric rubber
- Current selection process involves
  - Finite element analysis
  - Time
  - Money

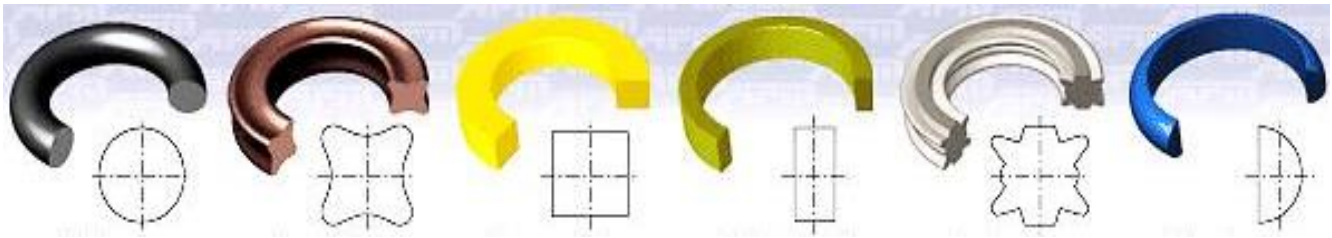


Figure 2: Examples of sealing ring cross-section variety [2]

Motivation

- Current sealing ring selection process:
  - Complicated FEA
  - Time Consuming
  - Costly

- We aim to ***reduce the time, cost, and effort*** of selecting an appropriate sealing ring for application by identifying relationships between component properties

Objectives

- Test selected sealing rings in static face-seal compression
  - Load
  - Displacement
  - Sealing pressure
- Define relationships between cross-section geometry, sealing pressure, and percent crush
  - Circular
  - Rectangular
  - Irregular
- Create a user interface to access data

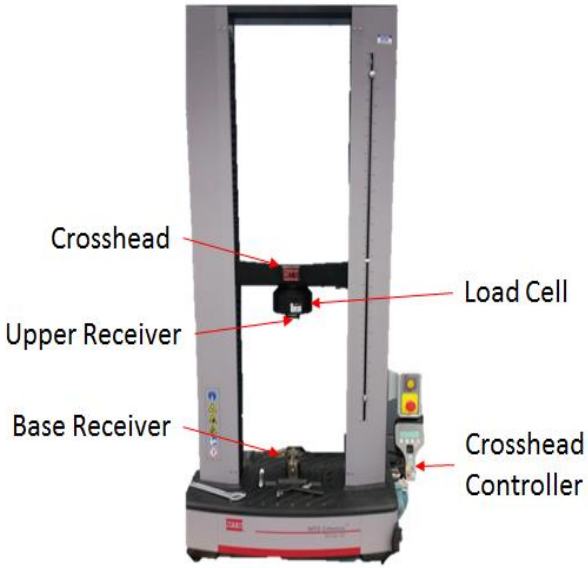


Figure 3: MTS Machine

Figure 4: Irregular Seals - Diamond and Pseudo-Diamond Cross-sections

Test Fixture Prototypes

- Design Considerations
  - Rigidity
  - Groove plate interchangeability
  - Simplicity
  - Ease of use with existing equipment

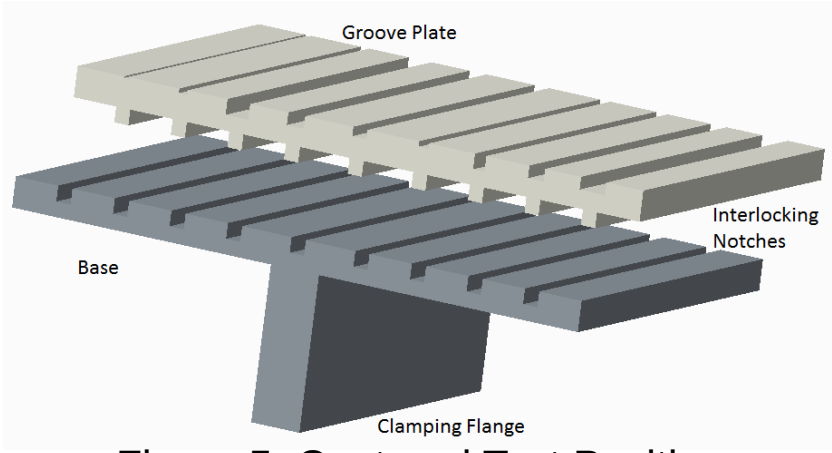


Figure 5: Centered Test Position

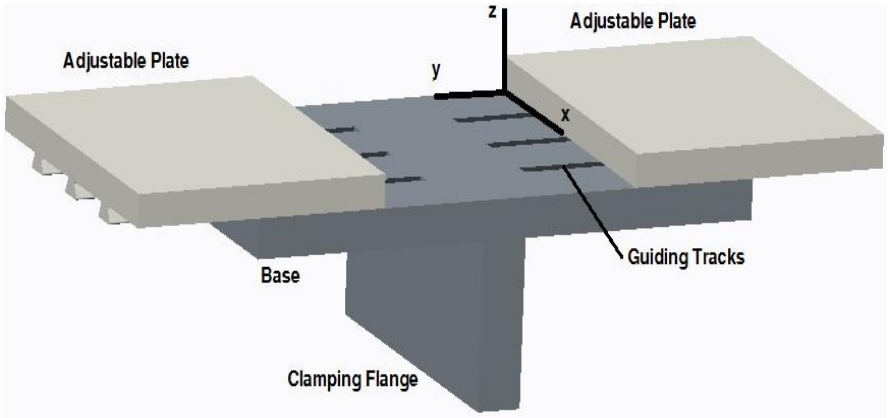


Figure 6: Adjustable Groove Plates

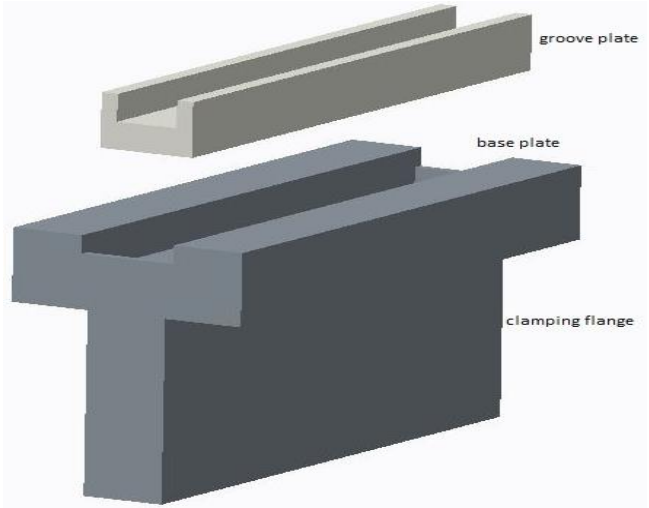


Figure 7: Individual Groove Plates

Final Test Fixture Design

- Material: Aluminum 6061
  - Surface hardness
  - Machinability
  - Low cost

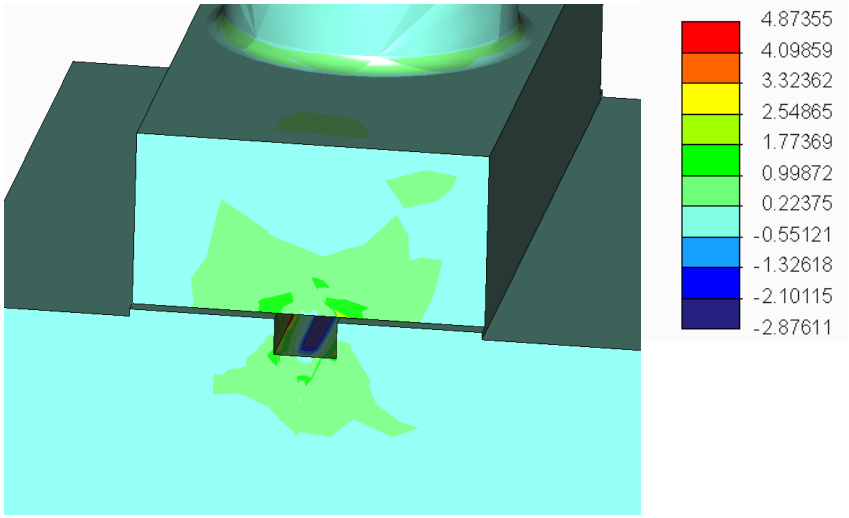


Figure 8: FEM Results (MPa)

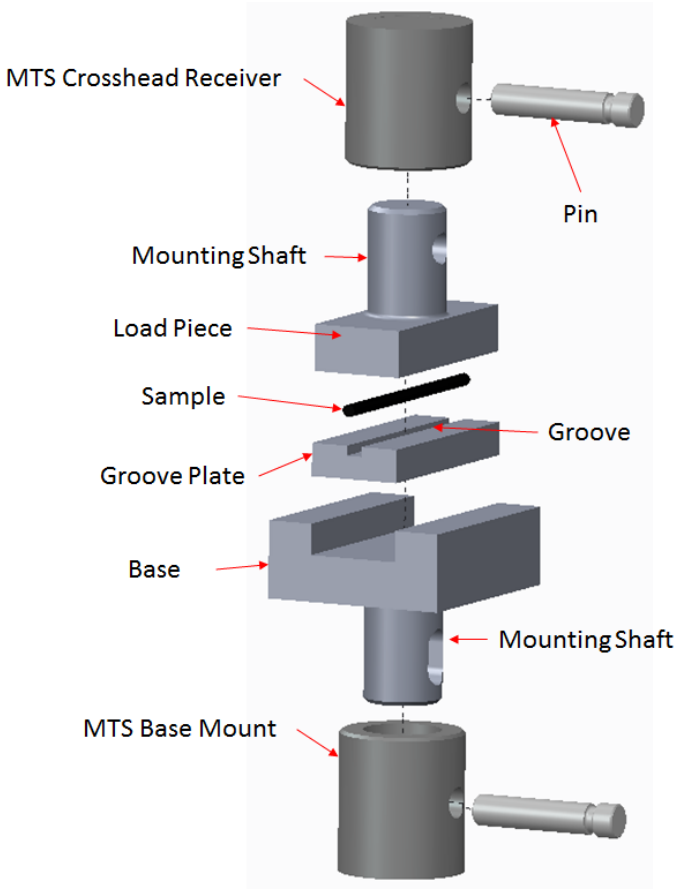


Figure 9: Mounted Test Fixture

Test Procedure

- Mount sample and place film
- Input displacement corresponding to percent crush
  - 5%, 10%…40%
- Reset crosshead and exchange film
- Data Collection
  - Sealing pressure measured with Fujifilm Prescale
  - 3 sensitivities used (Low, Super Low, Ultra Low)

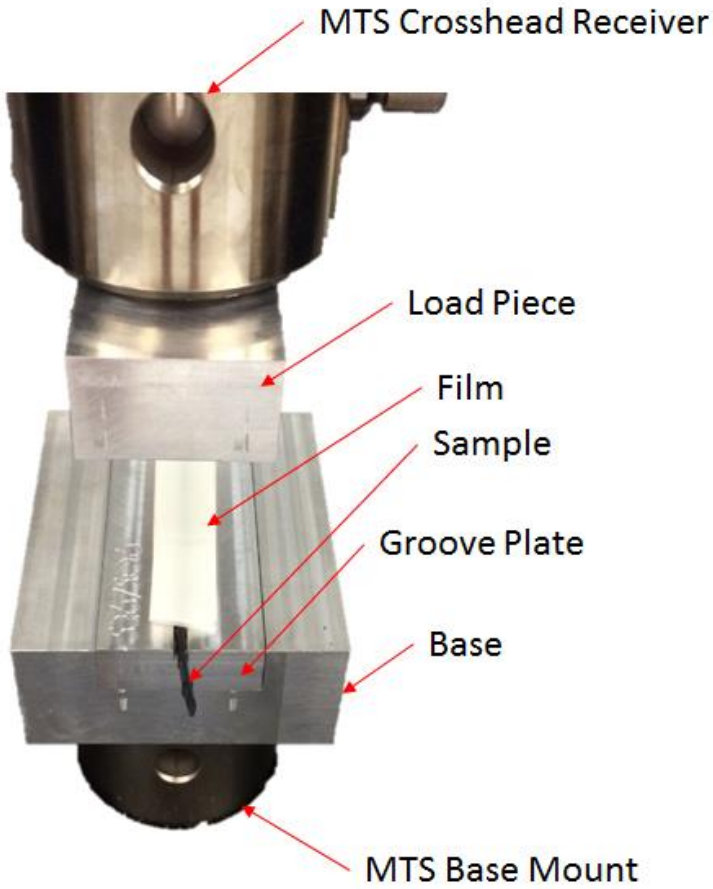


Figure 10: Test FIxture

Testing Results

- Leaks occur when fluid pressure exceeds contact pressure
- Retrieved maximum continuous pressure of each seal

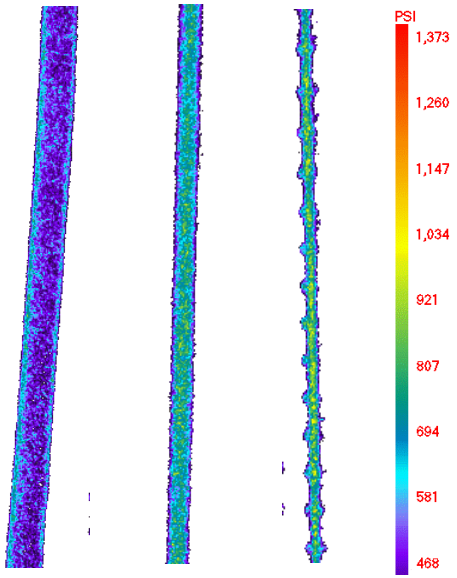


Figure 11: Sample Fujifilm

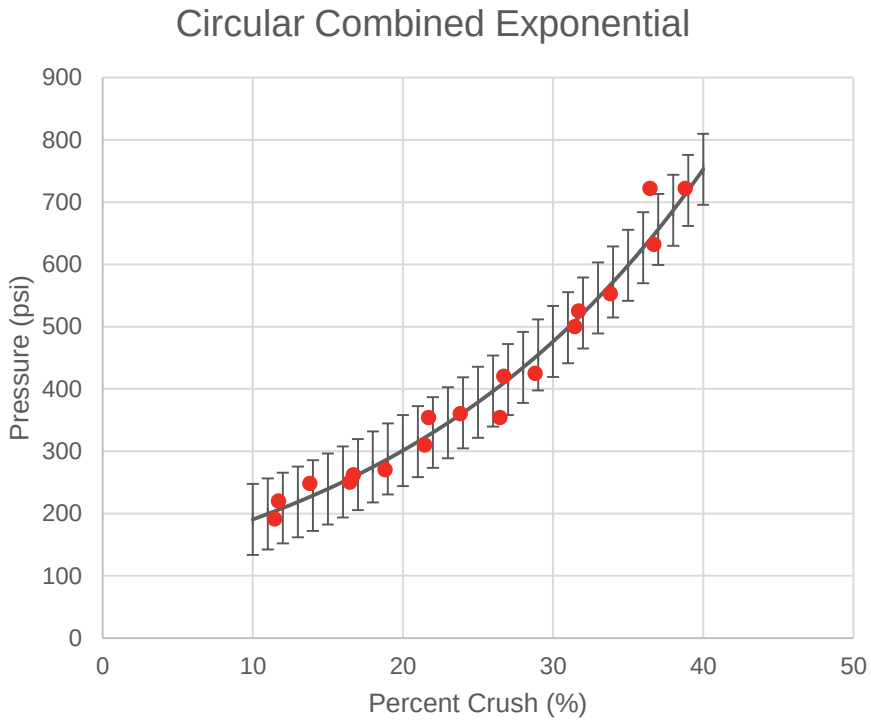


Figure 12: Sample Data

Correlations

- Correlations between percent crush and pressure were found
- Cross-sectional scaling does not affect sealing pressures at the same percent crush

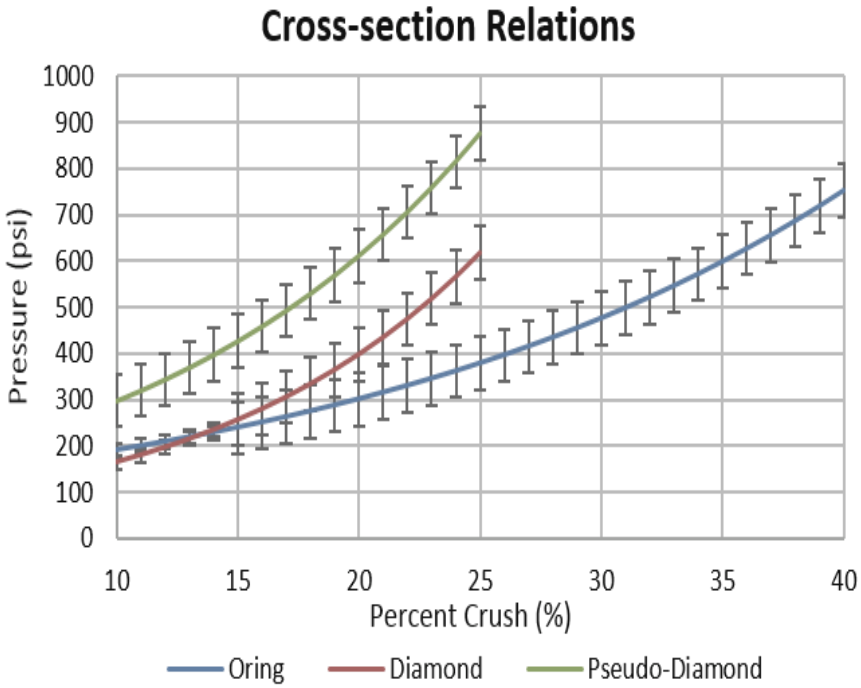


Figure 13: Correlations found

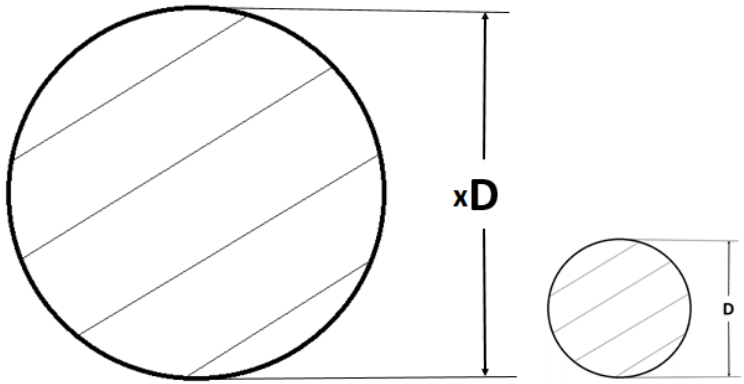
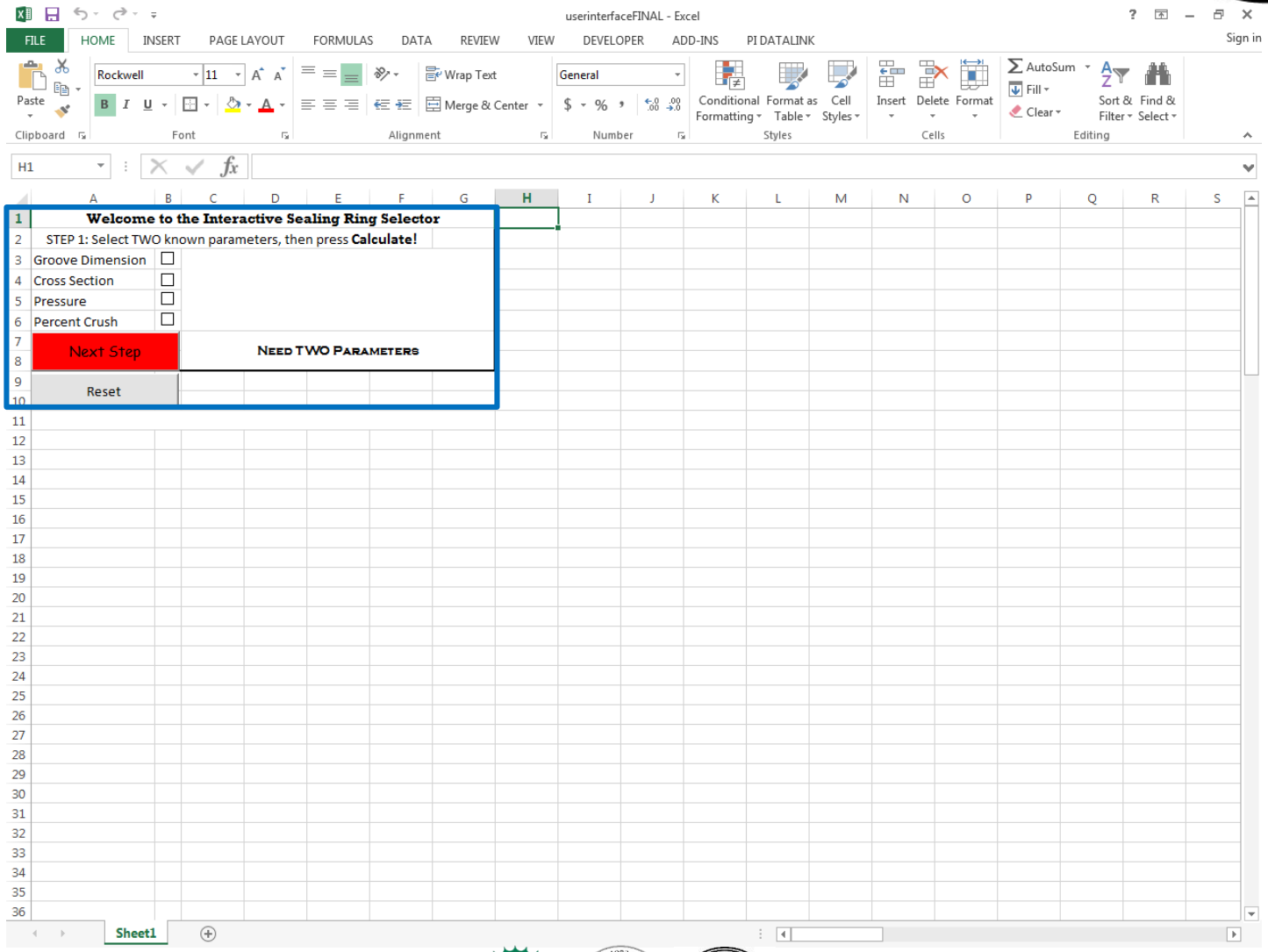
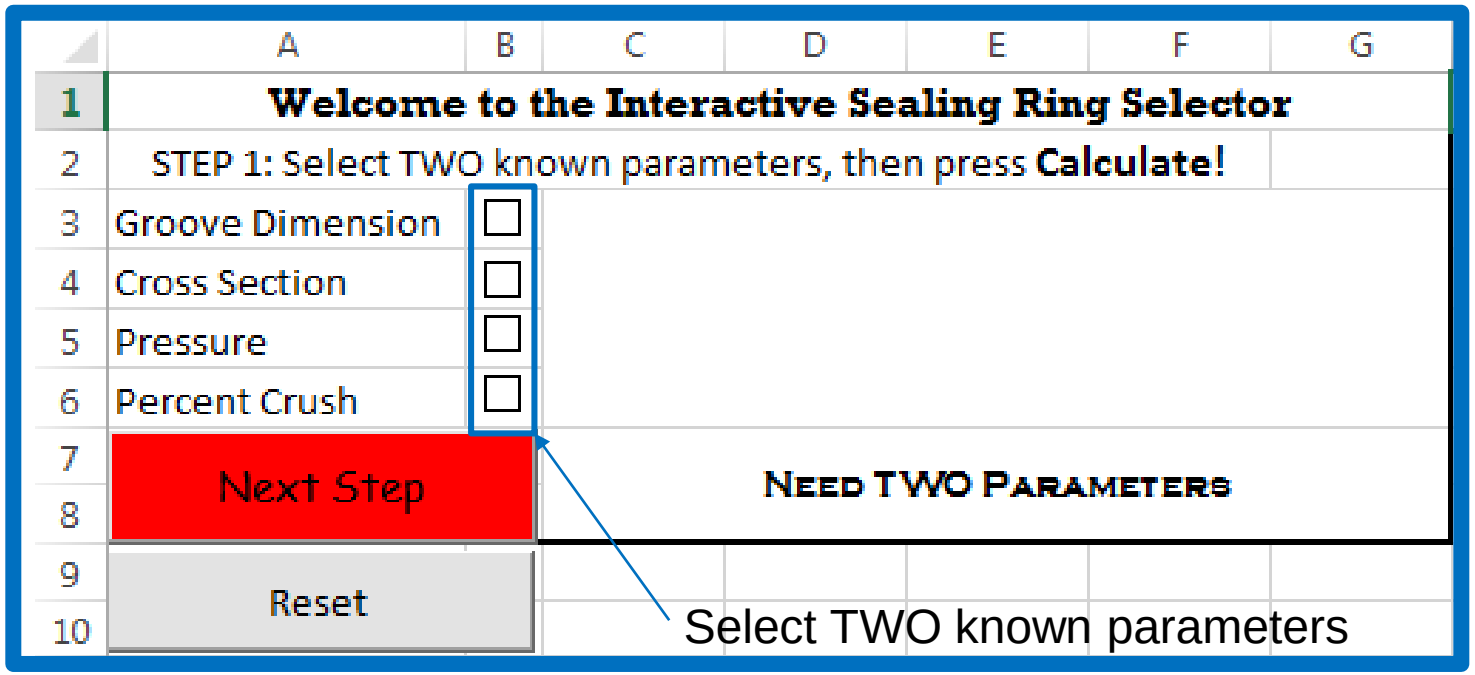


Figure 14: Scaling

User Interface: How It Works



User Interface: How It Works

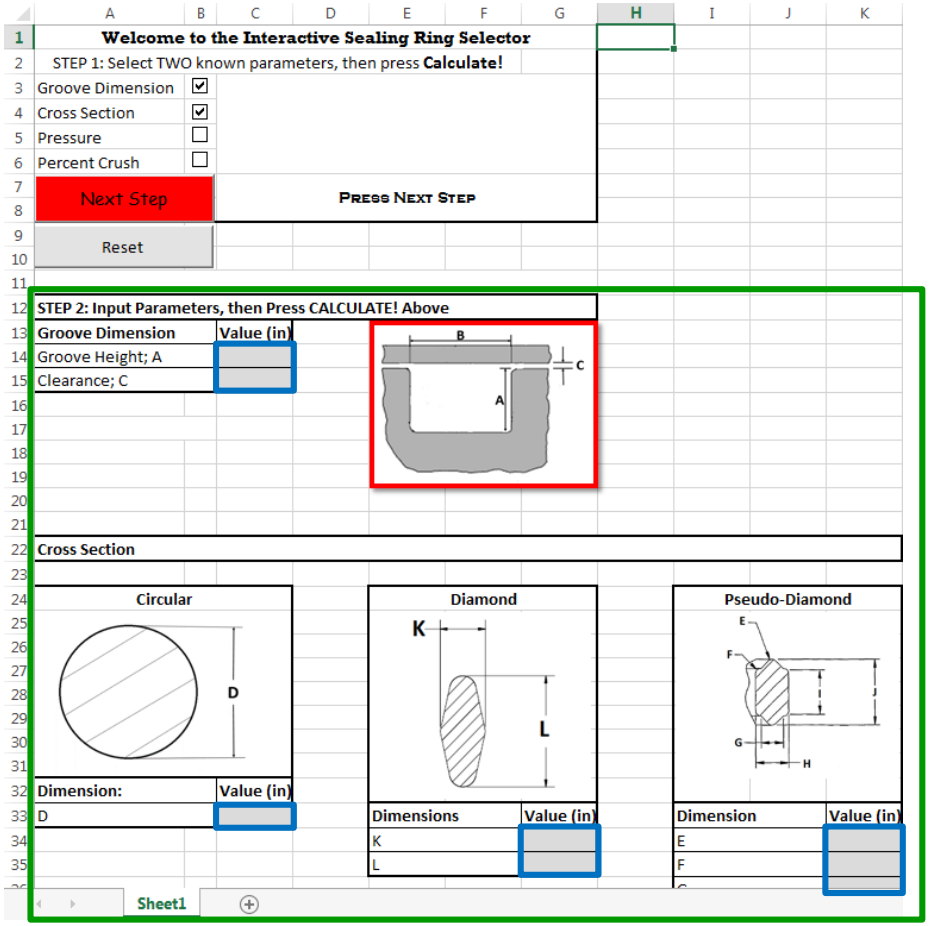


User Interface: How It Works

	A	B	C	D	E	F	G
1	**Welcome to the Interactive Sealing Ring Selector**						
2	STEP 1: Select TWO known parameters, then press **Calculate!**						
3	Groove Dimension	☐					
4	Cross Section	☐					
5	Pressure	☐					
6	Percent Crush	☐					
7	Next Step		NEED TWO PARAMETERS				
8							
9	Reset						
10							

Press Next Step

User Interface: How It Works

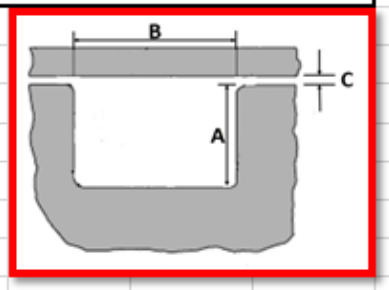


Insert Known Parameters

User Interface: How It Works

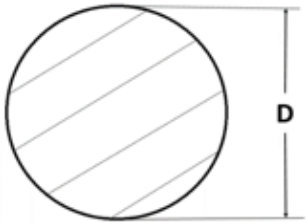
STEP 2: Input Parameters, then Press CALCULATE! Above

Groove Dimension	Value (in)
Groove Height; A	0.5
Clearance; C	0



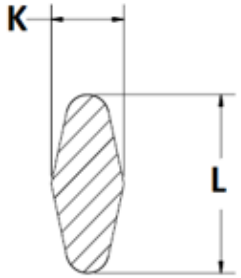
Cross Section

Circular



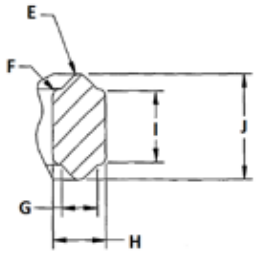
Dimension:	Value (in)
D	0.75

Diamond



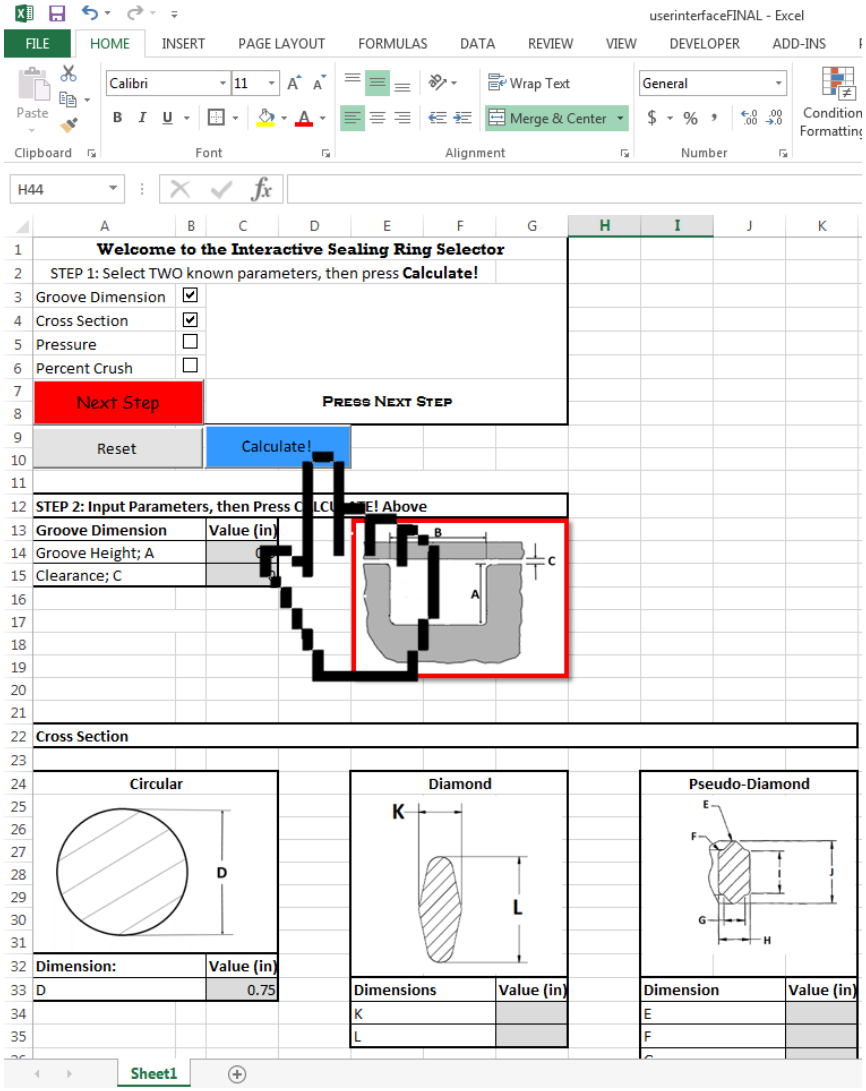
Dimensions	Value (in)
K	
L	

Pseudo-Diamond

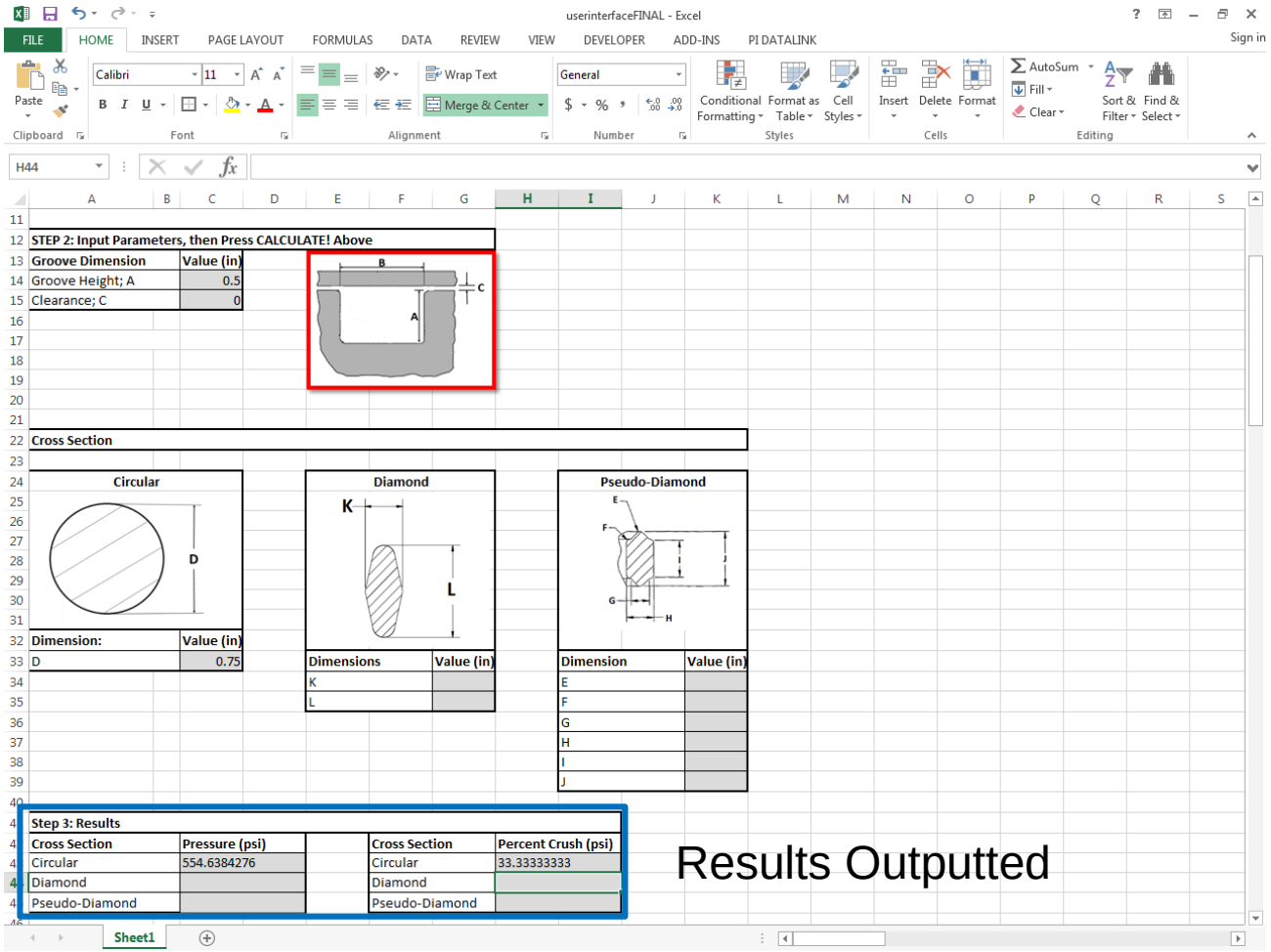


Dimension	Value (in)
E	
F	

User Interface: How It Works



User Interface: How It Works



Results Outputted

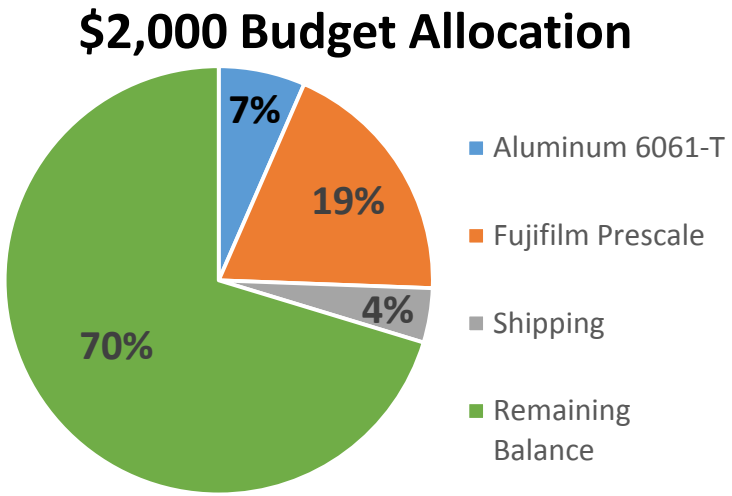
User Interface: How It Works

Step 3: Results				
Cross Section	**Pressure (psi)**		**Cross Section**	**Percent Crush (%)**
Circular	554.6384276		Circular	33.33333333
Diamond			Diamond	
Pseudo-Diamond			Pseudo-Diamond	

Project Management

Material Purchases

- Aluminum 6061-T6511
  - Test Fixture and Groove Plates
- Fujifilm Prescale
  - Low sensitivity
  - Super Low sensitivity
  - Ultra Low sensitivity



Item	Cost ($)	Remaining ($)
Fixture Material	130.71	
Fujifilm	380.99	
Shipping	82.17	
Total	593.87	1406.13

What We Learned

- Project planning
  - The importance of proper scheduling and work planning
- Constant communication
  - Staying in touch with team members
- Job delegation
  - Utilizing the strengths of team members

Summary

- We were unable to find a “universal” equation that relates the pressure-percent crush relationship between different cross-section geometries.

- The pressure-percent crush relationship is the same among sealing rings with the same cross-section geometry and independent of cross-section scale.
  - Ex. Circular sealing rings with diameters of 1in and 2 in display the same pressure-percent crush relationship. The same is true for diamond seals with different dimensions.

- Sealing ring pressure values are dependent on the deformation of the contact area with percent crush. Contact area deformation differs significantly between different shaped sealing rings.

Future Work

- Research programs to help with Fujifilm scan analysis
  - Currently very tedious, visual analysis
- Expand sealing ring database to include more cross-sectional geometries
- Research more parameters to monitor sealing ring deformation

QUESTIONS? COMMENTS?

REFERENCES

1. “Overview”. *Cummins,* Inc. Web. 12 Feb. 2015. <http://www.cummins.com/about-us/overview>.

2. "Sterling Seal: O Ring Supplier, Kalrez Orings, Bonded Washers & Dowty Seals." *Sterling Seal: O Ring Supplier, Kalrez Orings, Bonded Washers & Dowty Seals*. Web. 9 Apr. 2015. <http://eorings.com/>.