Audax Engineering

Improved Army Exhaust Brake

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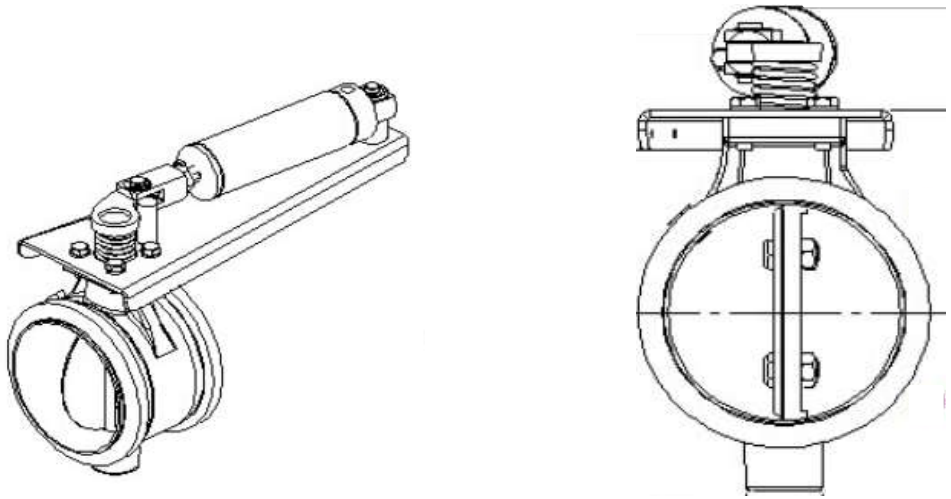
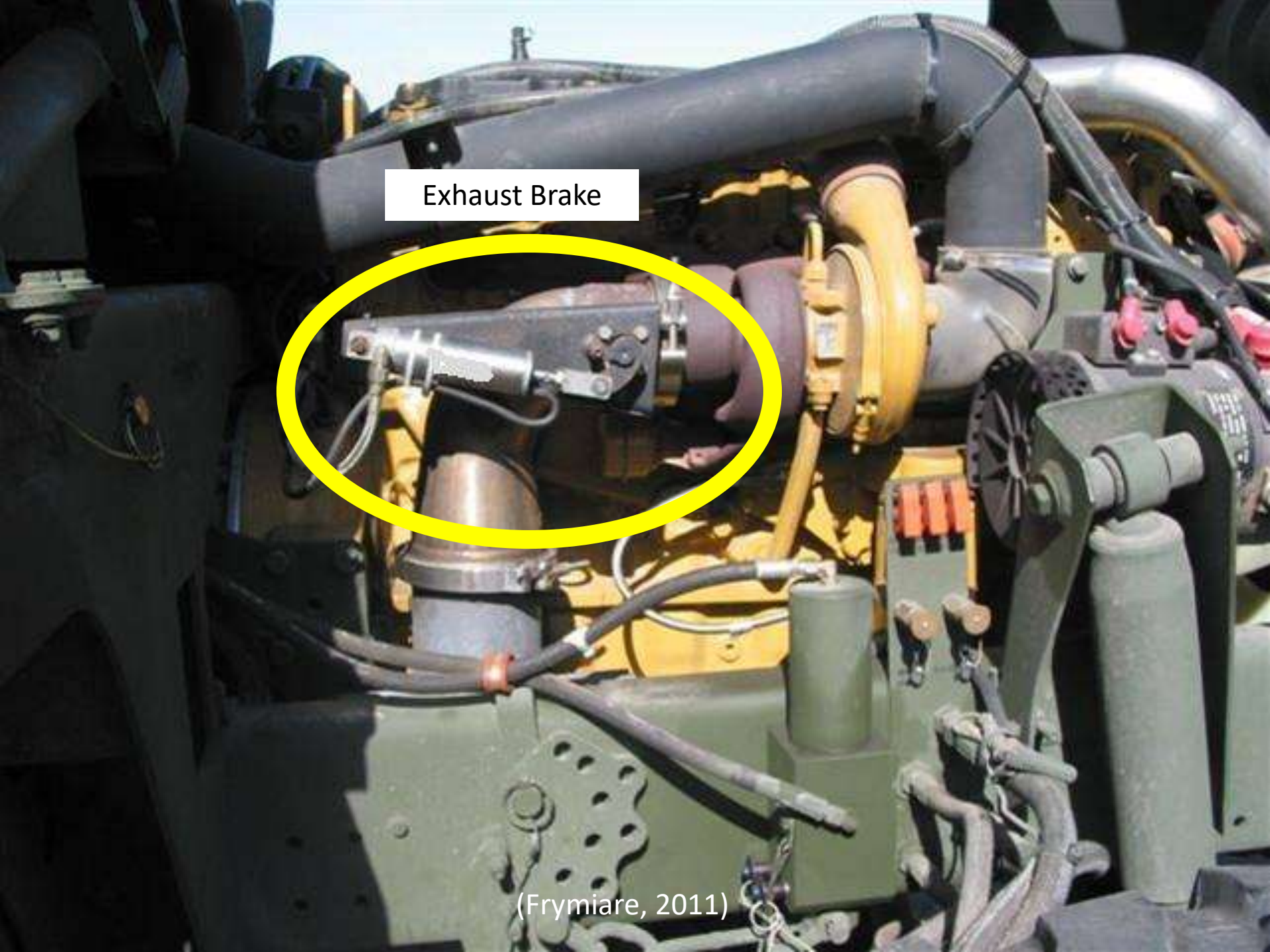
Introduction

Army Materiel Systems Analysis Activity:

AMSAA 2011-2012 Senior Project - Army Exhaust Brake



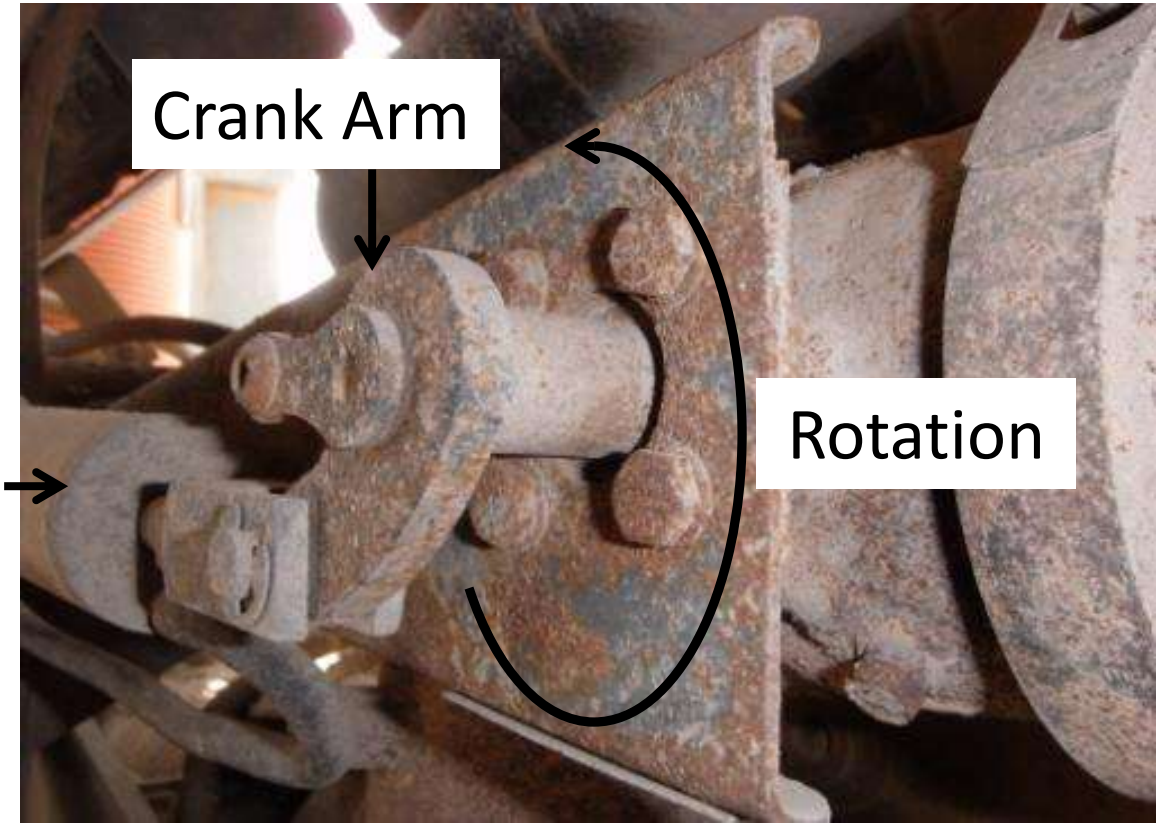
(Frymiare, 2011)



(Frymiare, 2011)

Background

Corrosion is the primary failure mode of the current exhaust brake design.



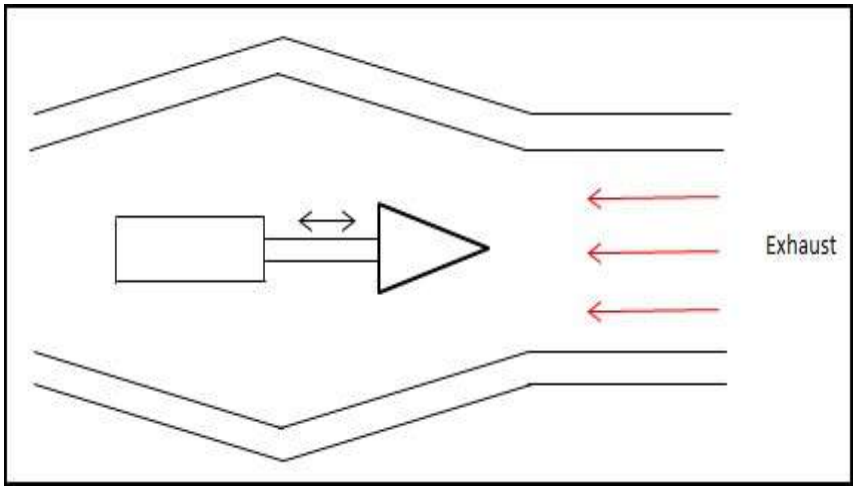
(Frymiare, 2011)

Design Specifications

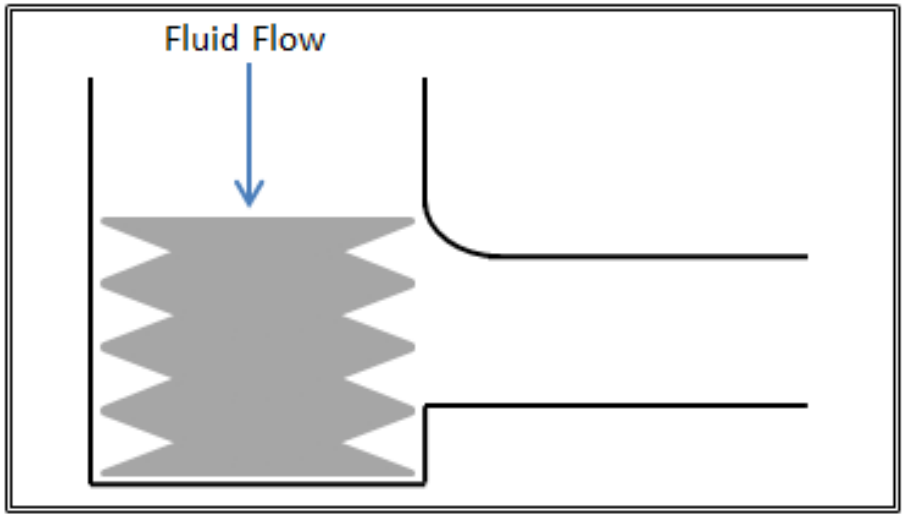
- **Lifetime:** 1 million miles (40,000 hours of engine operation)
- **Maintenance:** minimal to none
- **Exhaust gas temperature**: 1200˚F
- **Ambient temperatures**: -60˚F to 130˚F
- **Thermal shock:** operating temperature → 33˚F water
- **Environment:** dust, sand, mud, snow, ice, and water
- **Backpressure:** ≤ 40 psi
- **Vibrations:** shock of 20 g
- **Budget:** $2,500

Morphology

- Alternative Valve
  - Cup and cone
  - Bellows



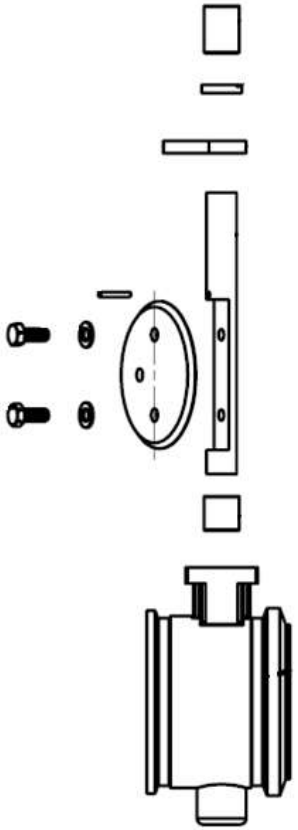
- Alternative Materials
  - Silicon nitride
  - Stainless Steel



Modeling

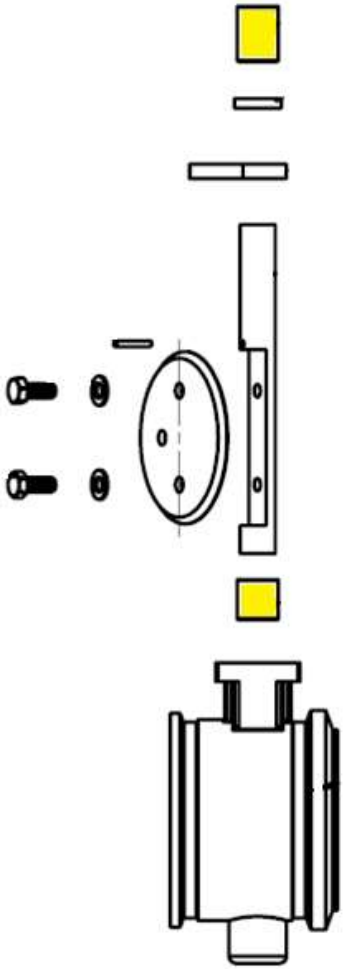
- Thermal Shock: $R_t = \frac{\sigma_o(1-\nu)}{\propto E}$
- Predicted Corrosion Rate: $\frac{r_2}{r_1} = e^{-\frac{Q}{R}\left(\frac{1}{T_2}-\frac{1}{T_1}\right)}$
- Stress: Singularity Functions
- Heat Transfer: 2D Finite Difference Method
- Fatigue: Marin Equation

Final Design



Replace critical components with corrosion resistant Stainless Steels

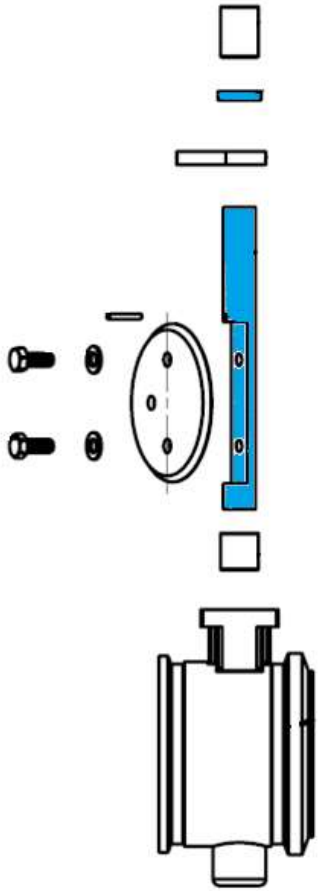
Final Design



410 Stainless Steel:

Shrink-Fit Bushings

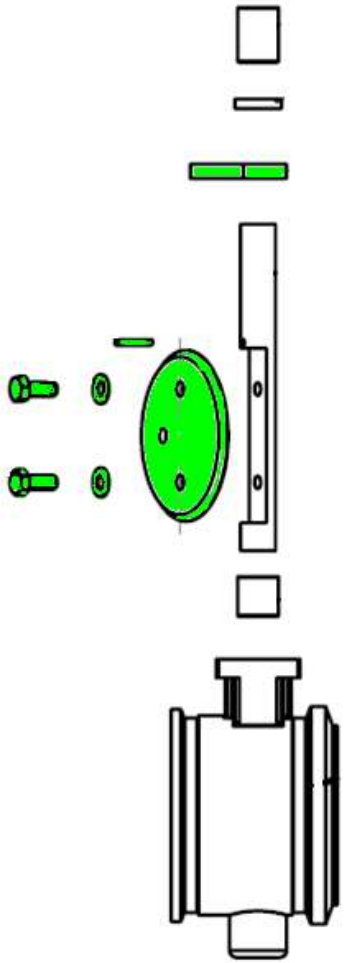
Final Design



Nitronic 60:

Shaft and Lock Washer

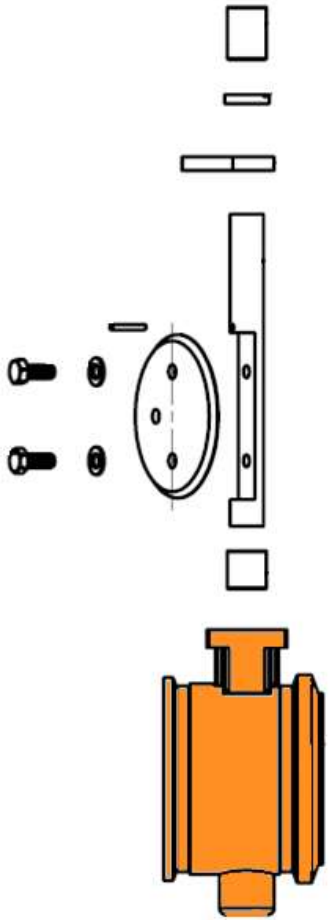
Final Design



304 Stainless Steel:

Disk, Crank Arm, Misc. Small Components

Final Design



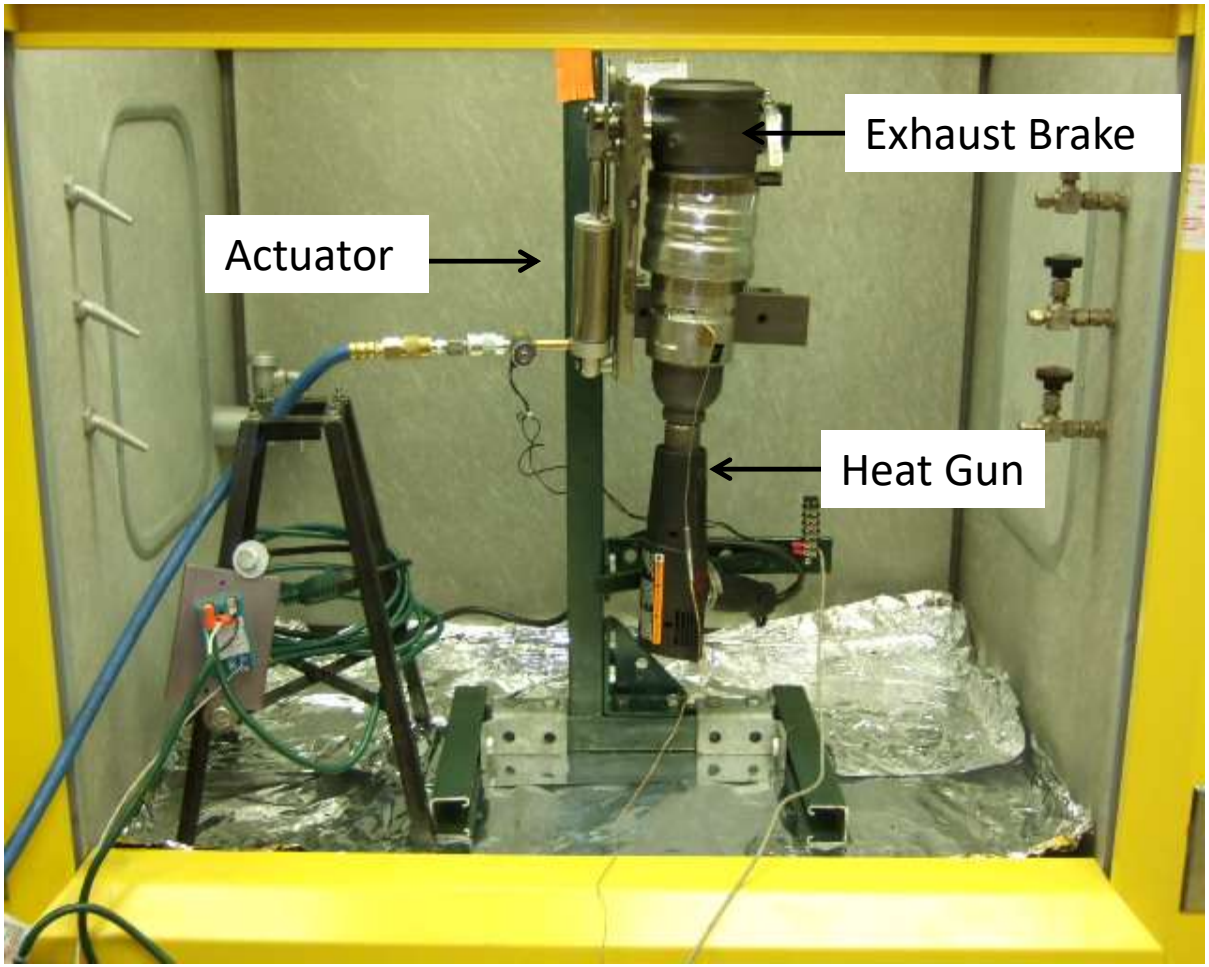
65-45-12 Ductile Iron:

Housing

Compliance Testing

- Cyclic Test
- Bearing Clearance Test
- Thermal Shock Test
- Mechanical Load Test
- Corrosion Test

Cyclic Test



Cyclic Test Cont.

- First test lead to galling failure

2nd Cyclic Test

- Second cyclic test
  - No failure in over 1500 actuations
  - Minor galling
  - 2D finite difference model verified

Desired Life Comparison

40,000 hrs of engine operation ⇨ 800 hrs of brake operation ⇨ 3200 Actuations

For 2% use

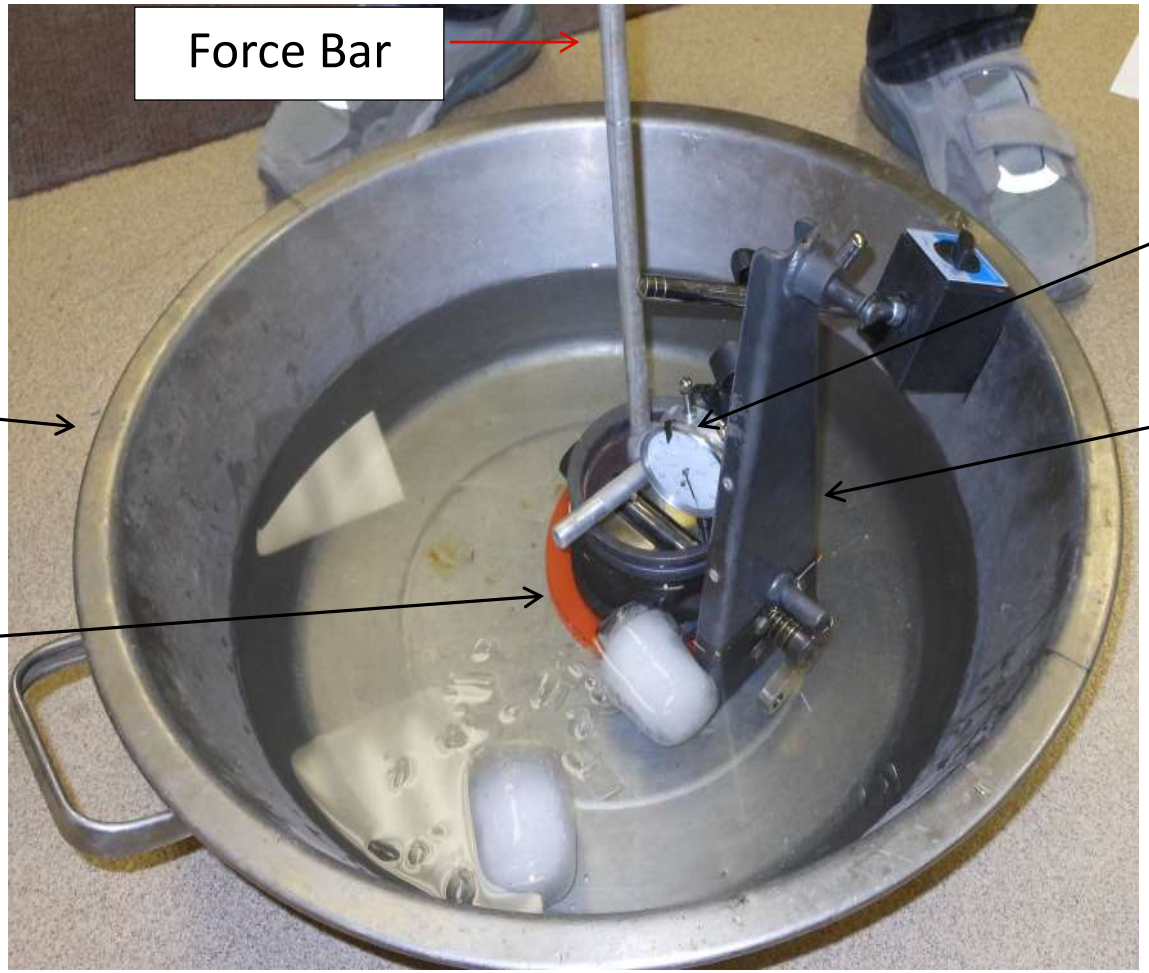
For 15 mins actuation time

Bearing Clearance Test

Dial Indicator

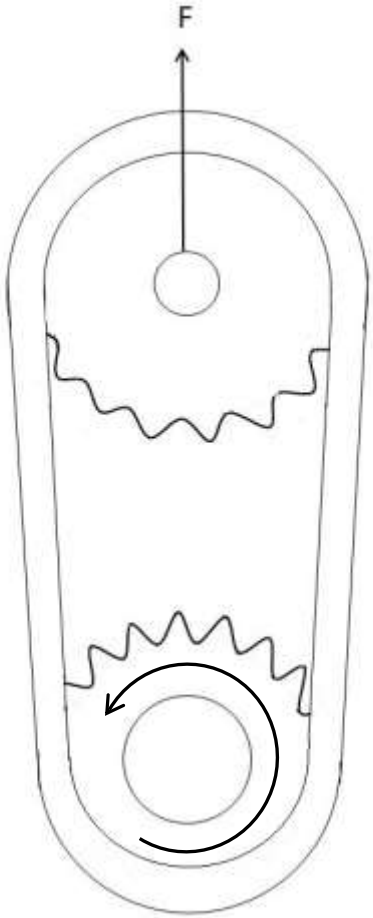
Radial Clearance measurement

Thermal Shock Test

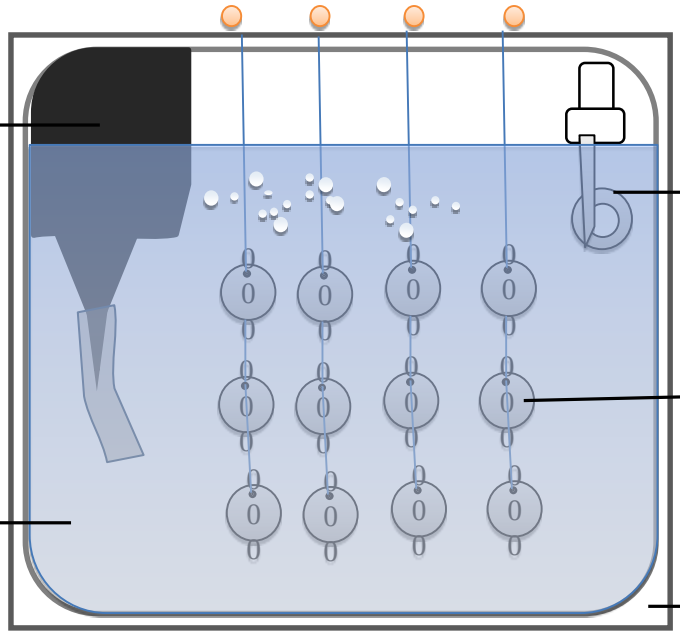


Mechanical Load Test

- No observed Galling
- No determined permanent deformation
- Successful Test



Corrosion Testing



Corrosion Testing

- Primary and secondary mode of failure in original brake negated

Material	Corrosion Rate (mm/year)
Nitronic 60	0
304	370
410	155
1018	14075

$$corrosion\ rate = \frac{W}{A \times T \times D}$$

Where:

A=Surface Area (cm^2)

D=Density (g/cm^3)

T=Time of Exposure (hours)

W= Mass Loss (g)

Conclusions

- Design specifications tested have been met
- Ready for full-scale field test by AMSAA
- I learned much about engineering as well as being team leader

Acknowledgments

- AMSAA
  - Mr. Brian Frymiare
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  - Mr. Mike Schilt
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Questions

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For further questions, please contact:

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