OSU AIAA

Oregon State University Chapter of the American Institute of Aeronautics and Astronautics

Team 21: Podium Session

30k SRAD Category

Oregon State University

Design and Validation of the Propulsion System

Notable Project Aspects:

- **Propellant Formulation and Curing**
- **Non-Standard Motor Diameter**
- **Catastrophic Motor Failure**

Propellant Formulation: Curative

- New for OSU
- Ratio of Isocyanate to Hydroxyl compounds
- Verify curing process with Shore-A Durometer
- Refine cure times and propellant hardness
  - Tailor each batch for a launch date
  - Hardness relates to strength and performance

Propellant Formulation

Steve's Orange Sunset (SOS):

- Zinc fuel
- Burn rate inhibitor for slower burn
- Unimodal ammonium perchlorate oxidizer

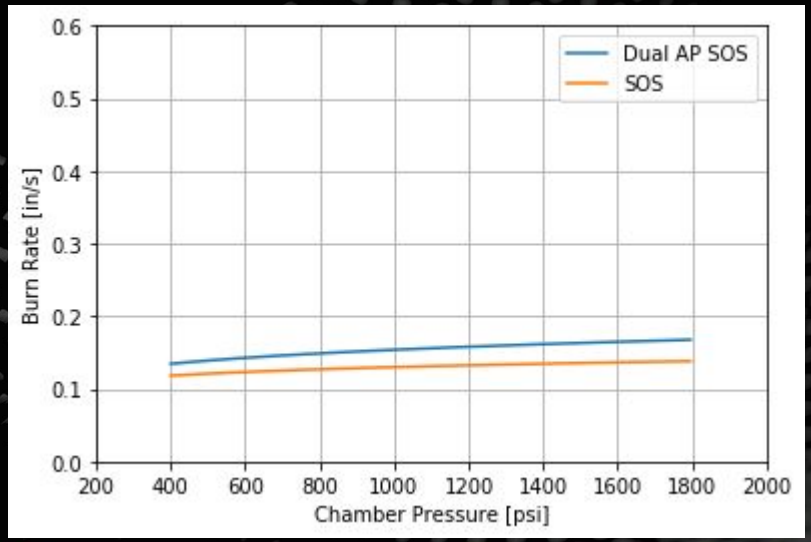
Subscale Testing

- 54 mm motor, two 4”grains
- Varying Nozzle throat diameter to vary chamber pressure

Propellant Formulation

Bimodal SOS:

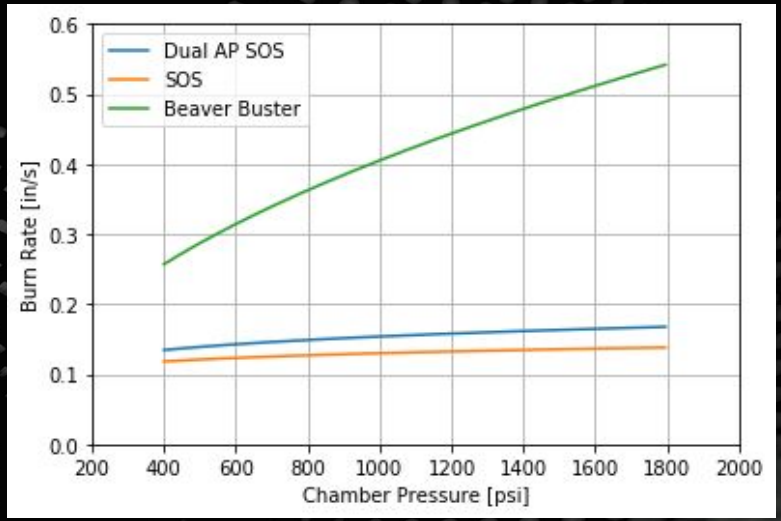
- Bimodal ammonium perchlorate oxidizer
  - Like fitting baseballs between basketballs
  - Faster burn rate
  - More dense



Propellant Formulation

Beaver Buster:

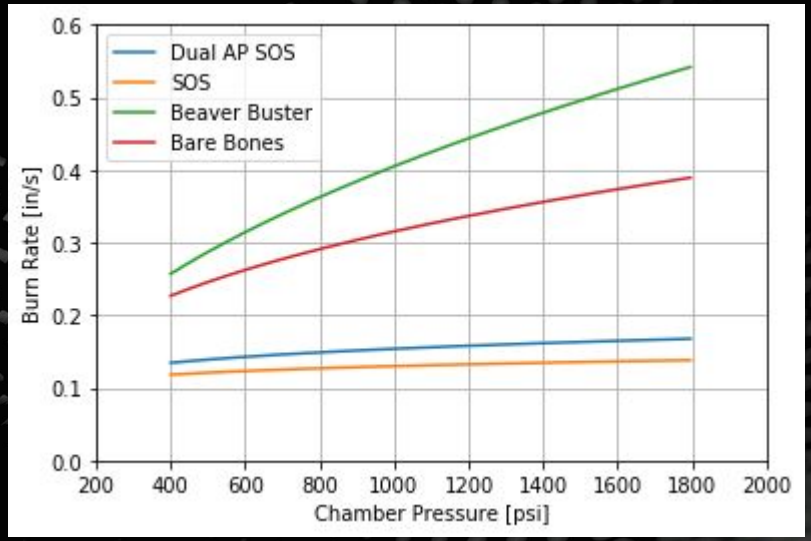
- High solids loading, fuel as a larger percentage
- Aluminum fuel, stronger than Zinc
- Reduced plasticizer and resin
  - Tetra functional polyol binding agent
- Unimodal oxidizer
- Red iron oxide burn catalyst



Propellant Formulation

Bare Bones:

- Similar to Beaver Buster
- No red iron oxide
- No polyol binding agent



Non-Traditional Motor Diameter

Reasons for pursuing 127mm (5”) ID

- Previous years’ issue with length and erosivity
- Conforms with selected airframe diameter
- Reduced cost for material over next size

Top Level Problems

- Sourcing materials for liners and casting tubes
- Manufacturing

Non-Traditional Motor Diameter: Liner

- Standard, available COTS liners
- 38 mm, 54 mm, 75 mm, 98 mm or 152 mm (ARR)
- Considered custom order through Loki Research
- Fiberglass tubing become focus

Settled with Centek Vernatube Exhaust Tubing

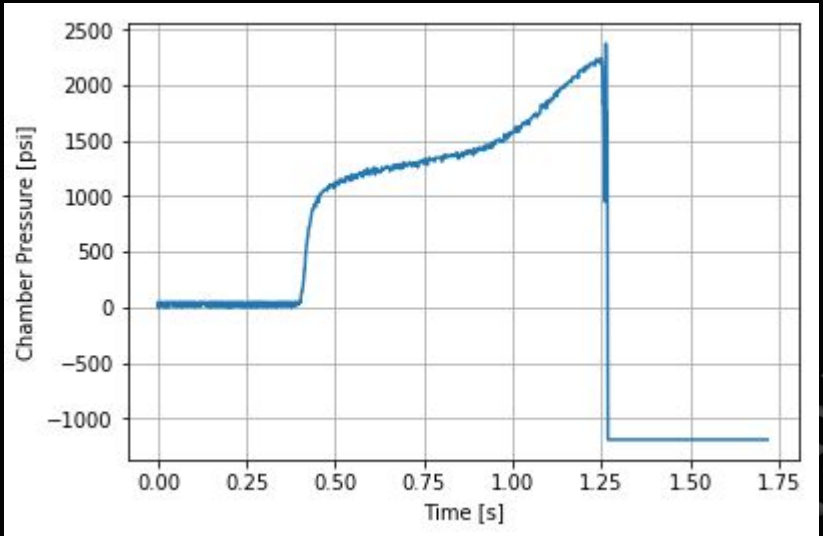
- Filament wound, high temperature, fire retardant

Non-Traditional Motor Diameter: Liner

Non-Traditional Motor Diameter: Casting Tubes

- Standard, available COTS casting tubes
- 38 mm, 54 mm, 75 mm, 98 mm or 152 mm (ARR)
- Considered custom order through Loki Research
- Used custom paper tubes

Full Scale Testing Results #1: March 3rd



Non-Traditional Motor Diameter: Casting Tubes

Version 1

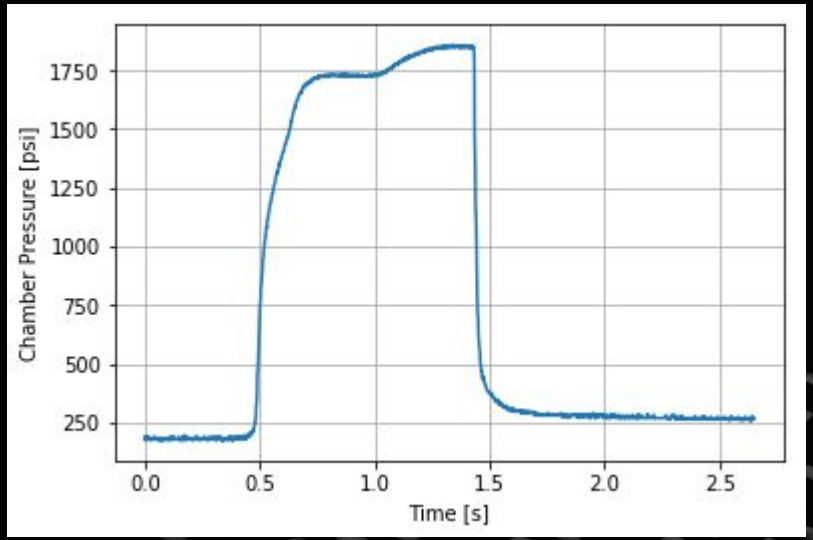
Paper tube

Non-Traditional Motor Diameter: Casting Tubes

Version 2

Rocketpoxy shell

Full Scale Testing Results #2: March 23rd



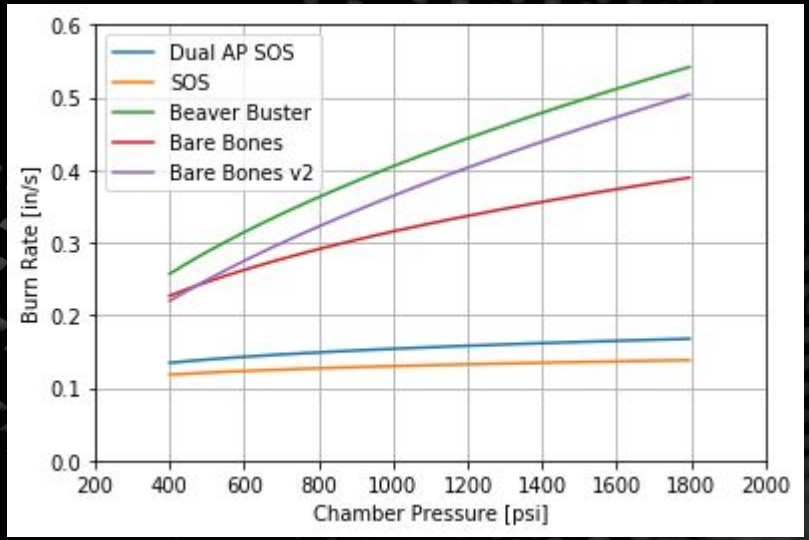
Failure Testing

- Snap ring failure method
  - Similar to industry
- Unable to test thermal and hydrostatic influences together

Propellant Formulation

Retesting Bare Bones with and without polyol bonding agent

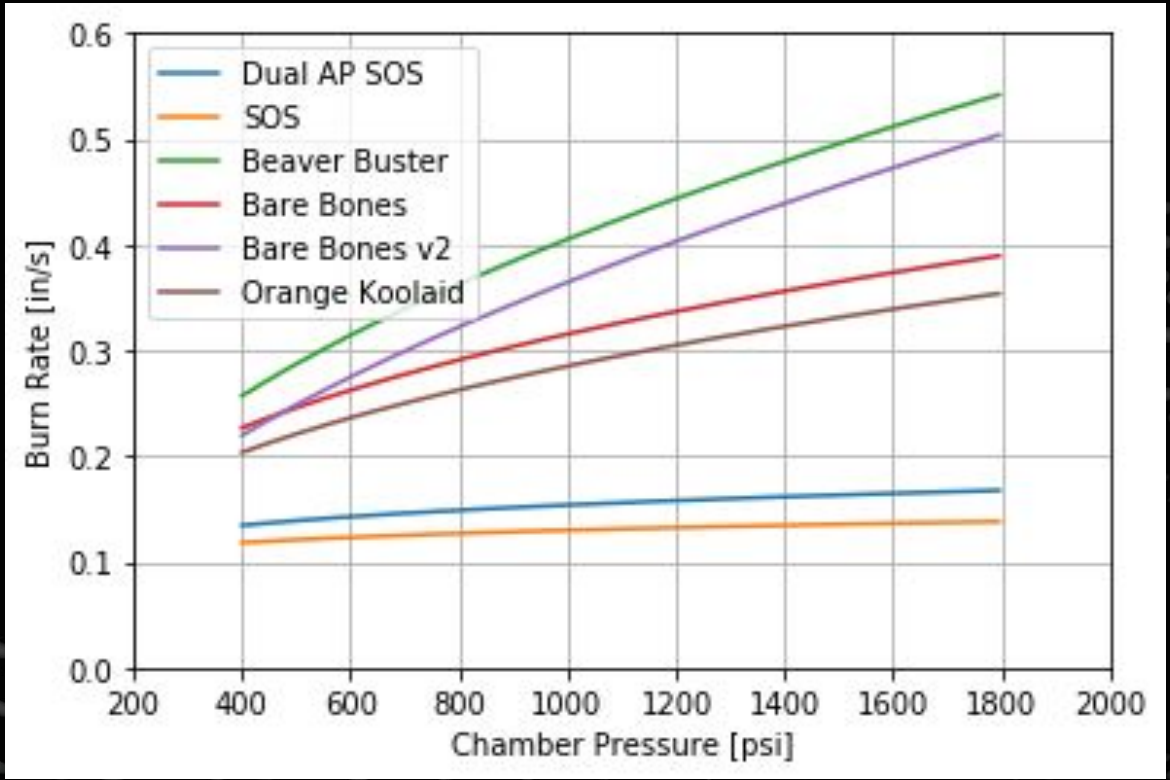
- Resubscale
  - Bare Bones v2 = with binding agent
- Advised no effect on burn rate
- Actually increases burn rate



Propellant Formulation: Orange Koolaid

- Metals: Zinc and Al
- Unimodal AP
- Mix of burn rate inhibitors and catalysts for fast but cooler burn
- Unable to source DOA, use IDP plasticizer
- Cured for several weeks

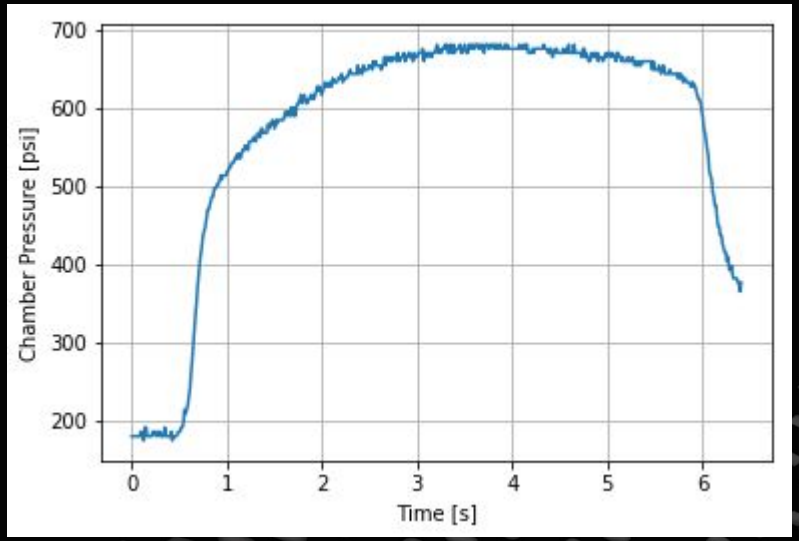
Propellant Formulation: Burn Rate Summary



Non-Traditional Motor Diameter: Casting Tubes

Version 3

Mid Scale Testing Results : April 15th

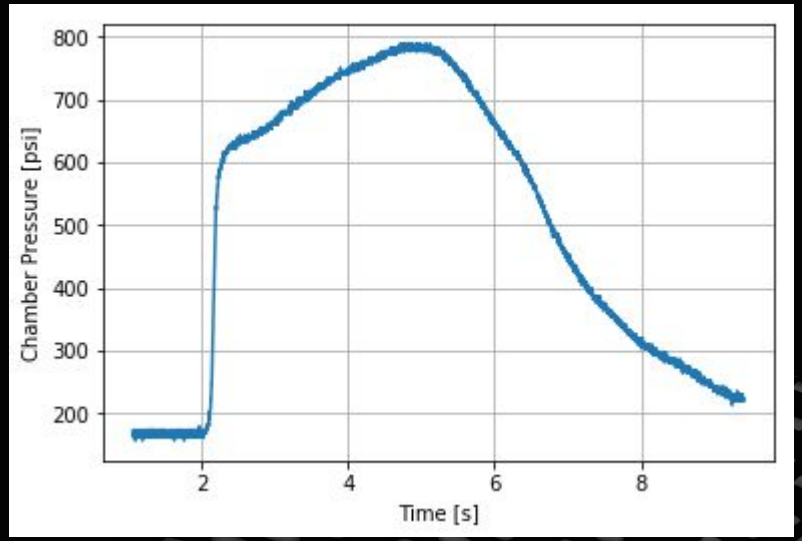


Non-Traditional Motor Diameter: Casting Tubes

Version 4

Version 4 vs Version 1

Full Scale Testing Results #3: May 10th



Full Scale Testing Results #3: May 10th

Solid Rocket Motor Specs:

- 15 kg propellant
- 28,500 Ns
- 5.38 MPa peak pressure
- 7000 N peak thrust
- 6 sec burn time

Flight Test: May 13th

24,200 ft. AGL

Flight Test: May 13th

24,200 ft. AGL

Thank you

Questions?