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10 YEARS OF INNOVATION

Thermally Activated Venting System for IM

Mike Fisher
Program Manager,
Propulsion Technology

fishermj@crgrp.com
(937) 320-1877 x 216

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Shape Memory Polymers for Insensitive Munitions

Phase I SBIR effort funded by MDA

March 2006 – September 2006

Technical Monitor

Heather Simko – MDA/QS (Safety, Quality, & Mission Assurance)

Phase II awarded

Initiated 2-year effort in June 2007

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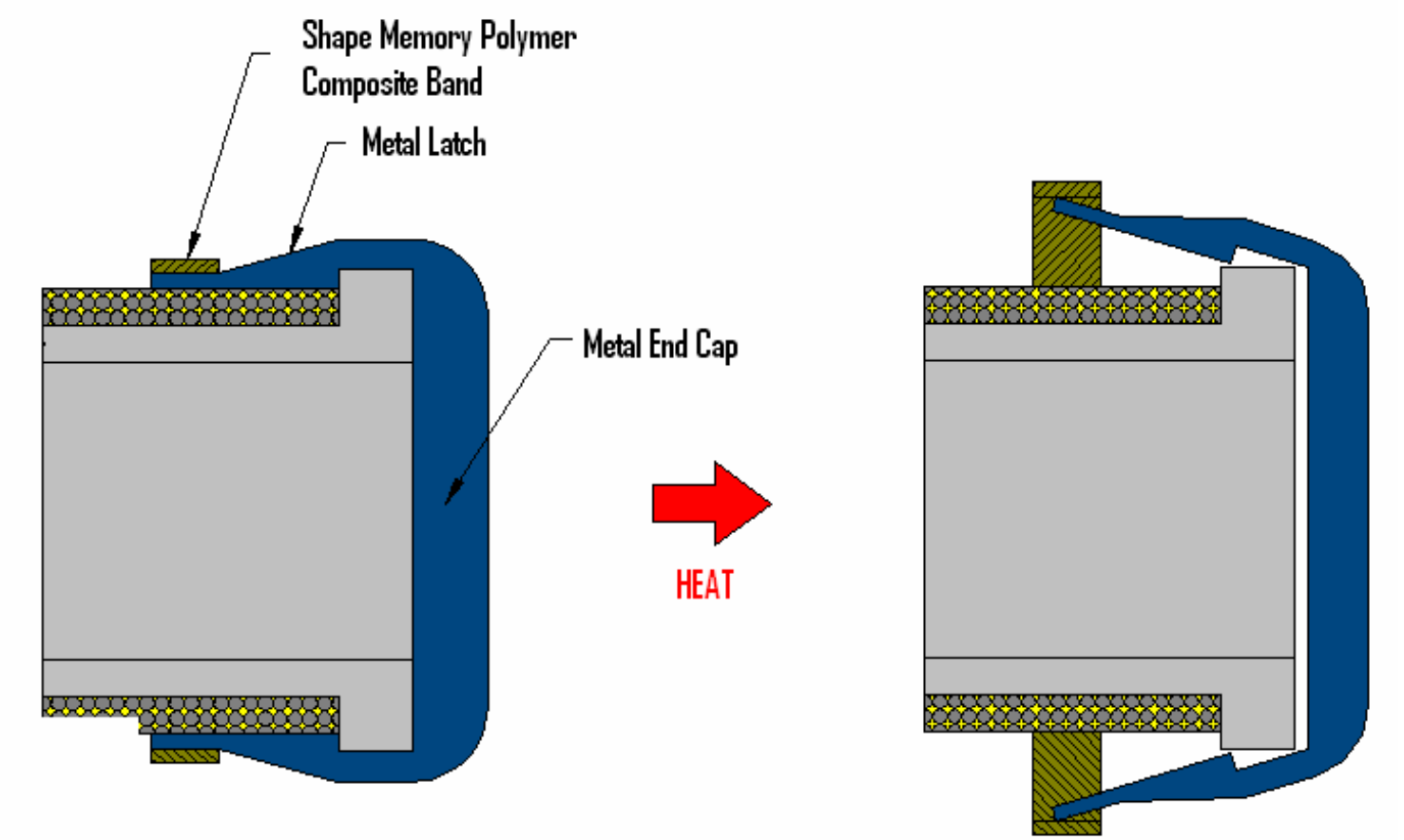
Original IM Technology Concept

Initial Potential Pressure-release Mechanism Design Using Shape Memory Polymer



Phase I Program Goal

Phase I Goal

Demonstrate the feasibility of shape memory polymer actuated venting systems for IM compliant solid rocket motors (SRM)

Phase I Achievements

SMP material compatible with propellant temperatures identified

Designs for SMP venting mechanism options developed

SMP prototype demonstrated

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Determine Design Requirements

Temperature range depending on propellant type

Mechanical requirements

Environmental exposures

- Temperature & Humidity
- Vibration (Transportation Requirements)
- Aging and Creep

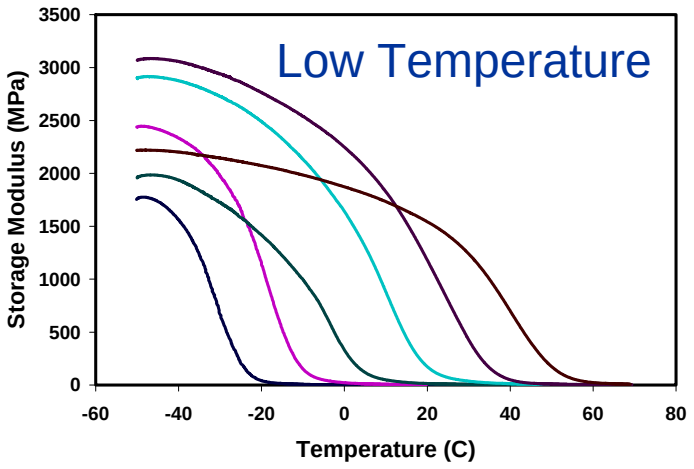
Develop Design Requirement Process

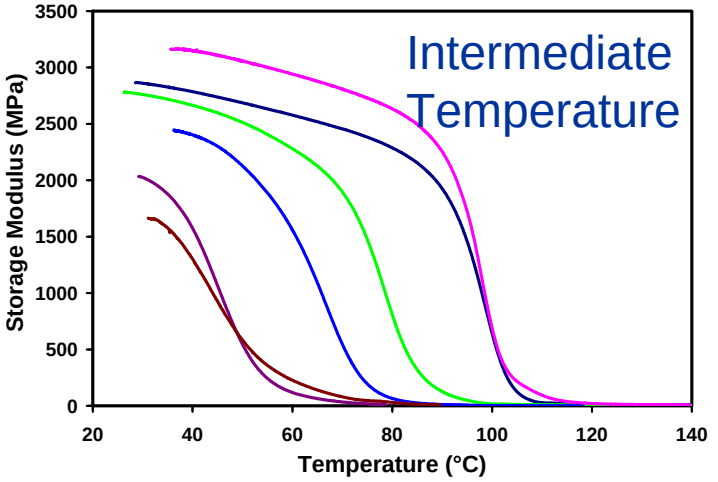
General 3 Step Design Process

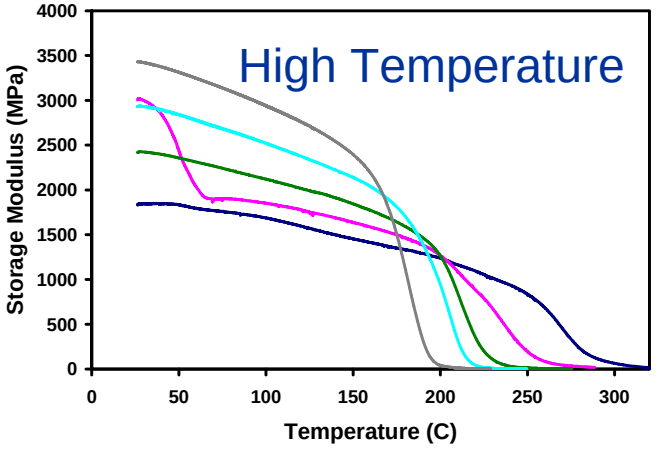
Step in Design Process	Information Needed	Resulting Design Requirement
1. Dimensional design (CRG)	SRM dimensional envelope	Dimensions of SMP mechanism
2. SMP Material selection (CRG)	Propellant type, autoignition temperature	Transition temperature of SMP material
3. Assessment of SRM design impacts (SRM Manufacturer)	Transition temperature of shape memory polymer	Insulator/closure redesign

Identify & Select SMP

CRG can modify SMP materials to have a broad range of transition temperatures depending on the propellant type







Design principle applicable to most classes of polymers

- Acrylate
- Styrene
- Epoxy
- Cyanate Ester
- Maleimide
- Etc...

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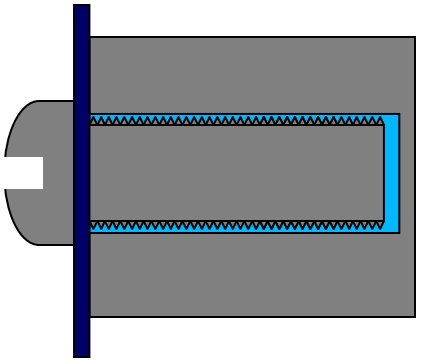
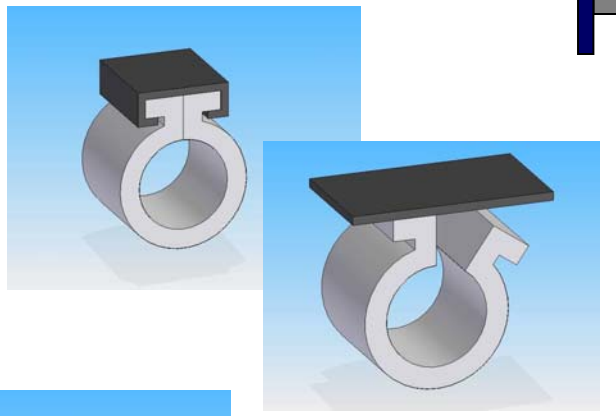
Design Prototype Mechanism

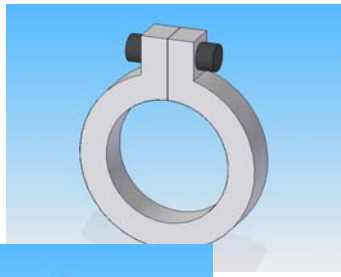
Design prototype mechanism that uses SMP's unique properties for actuation

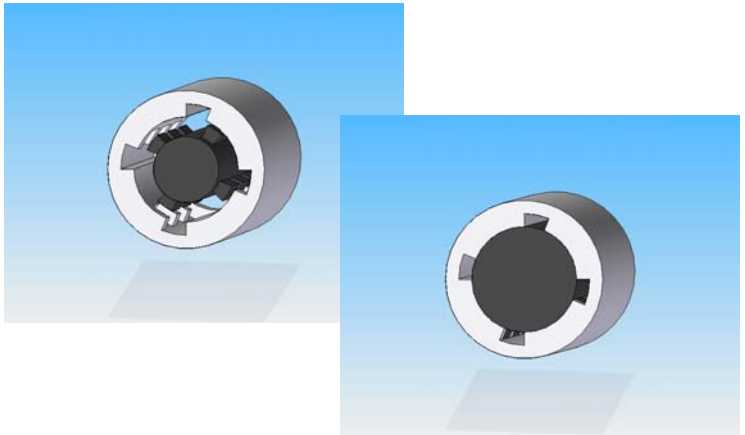
Several preliminary concepts:

- Initial composite band concept
- Reconfigurable thread concept
- C-clamp concept
- Turn and lock concept
- Internal retaining ring concept
- Plug concept
- External retaining ring concept









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Design Prototype Mechanism

CRG Selection Criteria:

Limitation of load seen by shape memory polymer

Significant amount of venting provided by mechanism activation

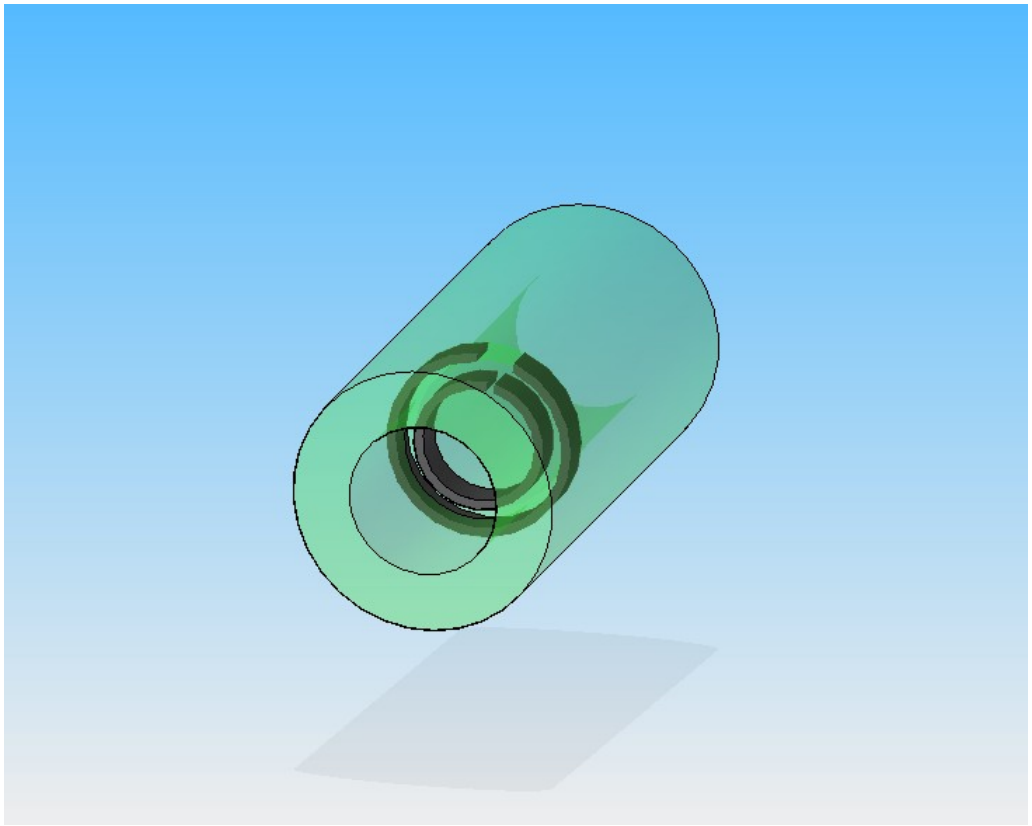
Internal location of mechanism (external volume limited)

Ease of integration into current and future systems

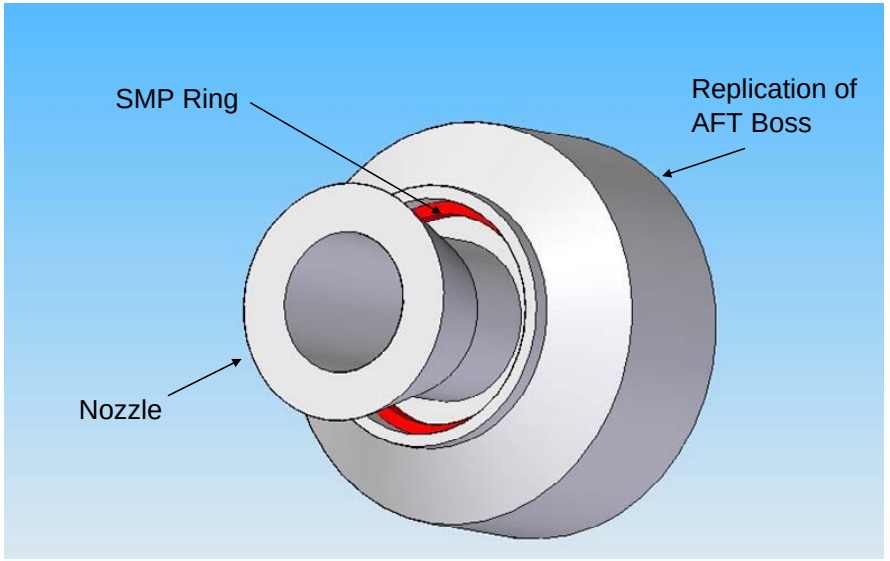
Design Prototype Mechanism

Concept Downselection

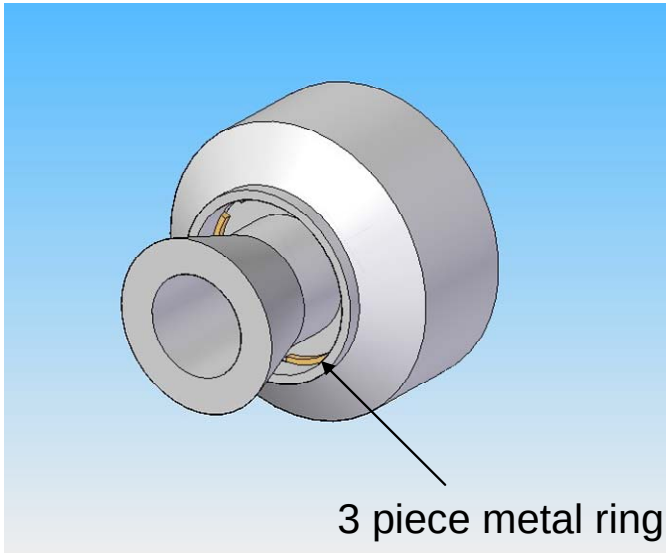
Internal retaining ring concept

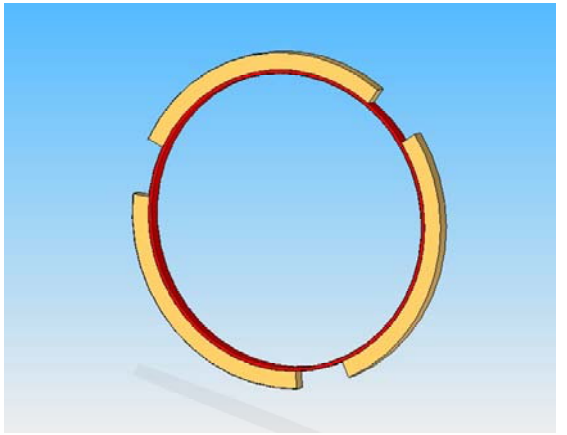


Design Prototype Mechanism



Designed internal retaining ring based on a generic solid rocket motor concept





3 piece metal ring (yellow) with SMP snap ring (red)

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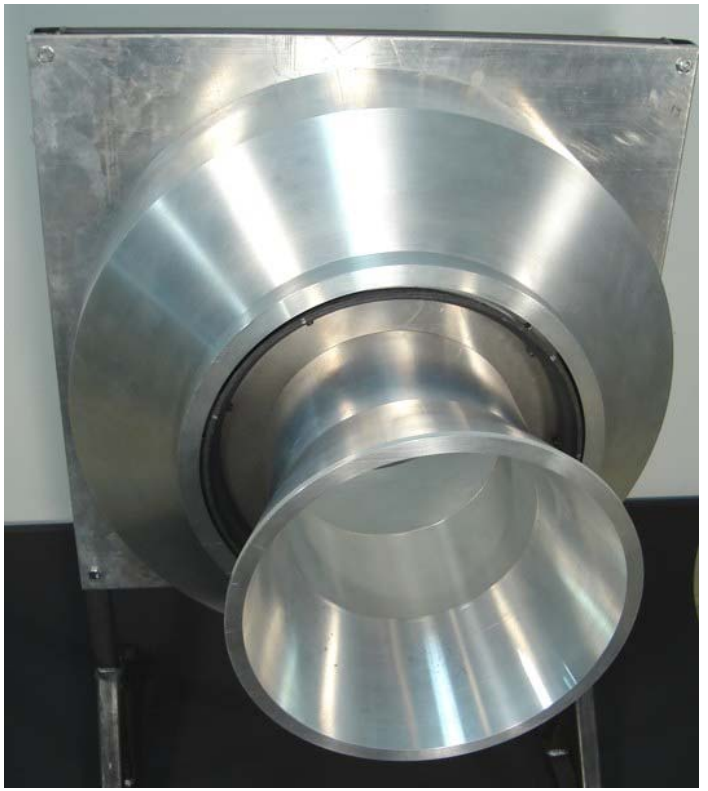
Fabricate Prototype SMP Mechanism

Fabricated prototypes of selected design

- Used CRG's styrene-based resin system for demonstrator
- Basic concept demonstrator for analysis



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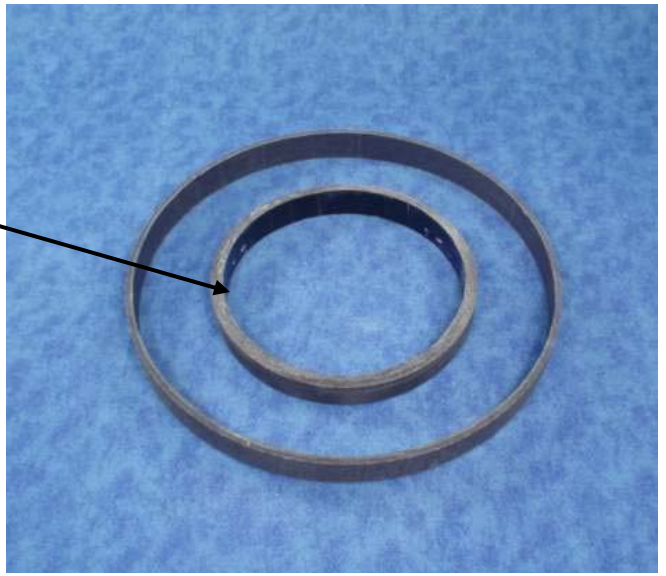
Fabricate Prototype SMP Mechanism



Expanded SMP and attached 3-piece metal ring

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Fabricate Prototype SMP Mechanism

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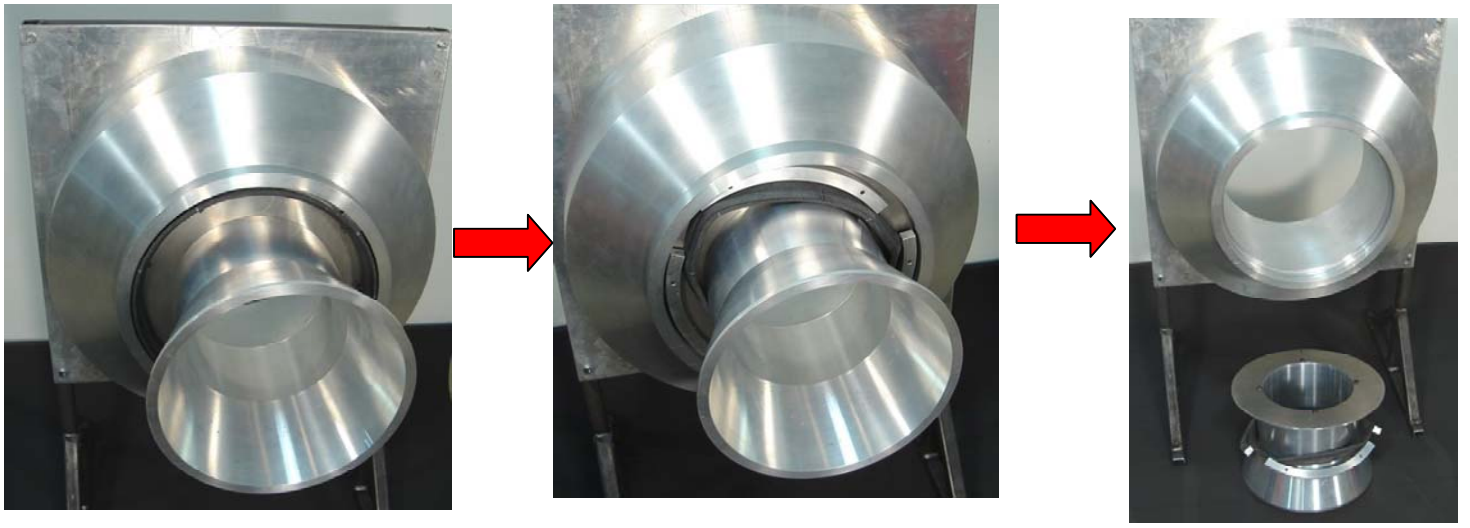
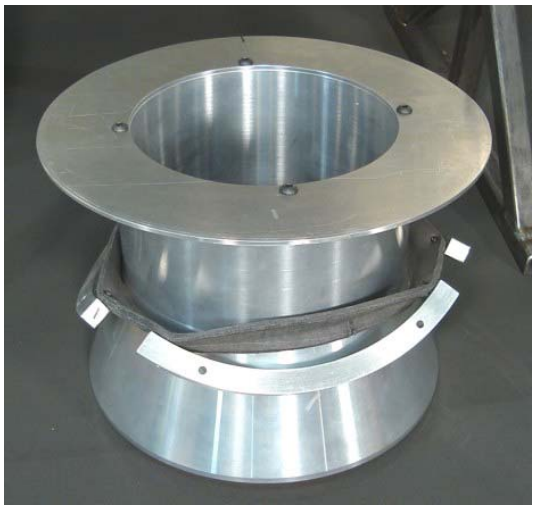
Fabricate Prototype SMP Mechanism

Prototype Demonstrator





Summary

Efforts focused on demonstrating feasibility

- Assessed requirements
- Developed general device mechanism concepts
- Evaluated general concepts
- Selected appropriate SMP materials
- Analyzed motor designs to
  - Identify and analyze potential integration opportunities
  - Downselect to a single concept for prototyping
- Developed specific device design
- Fabricated device prototype
- Characterized prototype and assessed feasibility

SMP Mechanism Benefits

Enables venting for slow cook-off situations

Fail-safe (non-electronic thermal venting system)

Ability to tailor for varying propellants

Simple designs available

Easily adapted to many different solid rocket motor systems

Can also be integrated into ammunition containers

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Future Work – Phase II

Integrate SMP mechanism into an SRM for SCO and pressure testing

Optimize design for a current or future MDA platform integration

Conduct further materials characterization

Look at other applications such as munition containers

Develop system integration documentation

Develop manufacturing plan

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