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2009 INSENSITIVE MUNITIONS & ENERGETIC MATERIALS TECHNOLOGY SYMPOSIUM

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Loews Ventana Canyon Resort, Tucson AZ

Insensitive Munitions (IM) Improvement MK22 Mod 4 Rocket Motor (#7963)

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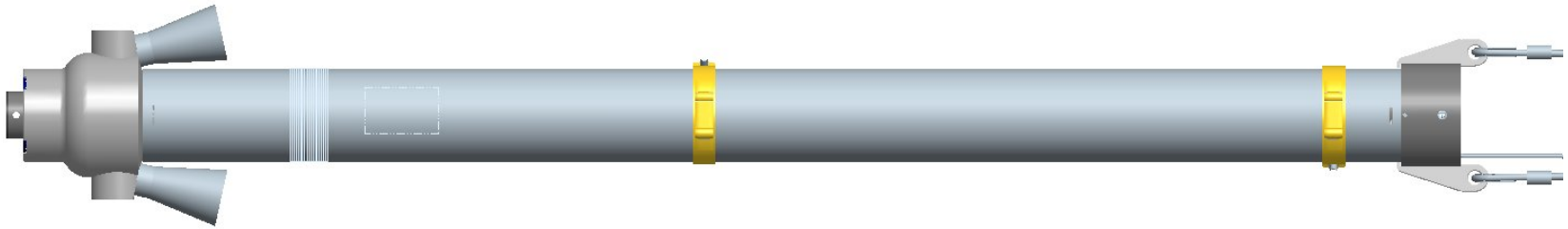
Outline

- Background
- Program Objectives
- Design Approach
- Vents
- Rocket Initiator Thermally Actuated (RITA)
- Concept Testing
- Future Efforts



Mine Clearance System Description

- Mine-clearing device used to clear a path for tanks, vehicles and personnel through minefields or other obstacles
- System clears a path 350 ft long by 46 ft wide
- Deployment Platforms
  - Mk 1 Mod 0:
    - 3 line charges deployed from inside an AAV, uses the Mk 154 Hydraulic Launcher
  - Mk 2 Mod 0:
    - 1 line charge deployed from the ABV or M353 Trailer towed behind any armored/tracked vehicle, uses the Mk155 Hydraulic Launcher
- Uses Rocket Motor for towing the line charge over obstacles or minefields for breaching, training or test applications
- Effective against single-impulse, pressure-type, non-blast hardened anti-tank mines and mechanically actuated anti-personnel mines

Objectives: RM Program

SYSTEM	FCO	SCO	BI	FI	SD	SCJ
Current Performance MK 22 MOD 4[1]	(IV)	III	V	III	Pass	Unknown
Expected IM Improved Performance EX 22 MOD 5	(V-IV)	(V-IV)	V	(V-IV)	Pass	Unknown

- **Design, Build, and Prove Out an Improved IM MK 22 Rocket Motor for Procurement in FY 09/10**
  - Primary:
    - Slow Cook-Off (SCO) Performance Improvement
      - **Goal: Type V Reaction (Burning)**
    - No Performance Change
      - No Change in Deployment of Linear Demolition Charge
  - Secondary:
    - Minimization of Cost
    - Rapid Retrofit of Current Inventory

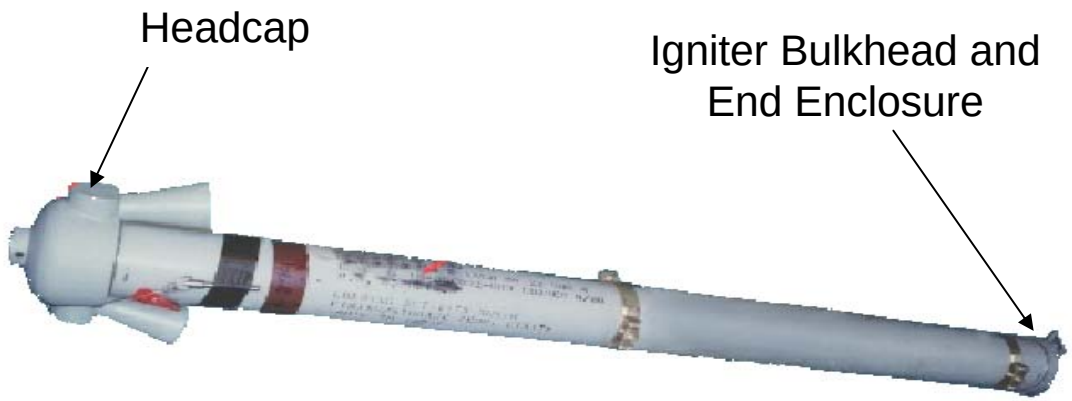
Slow Cook-Off Criteria

- **MIL-STD-2105 Type V (Burning Reaction)**
- **Test Configuration**
  - In the Shipping Container based on THA, SSHA, and IMO inputs
- **Munitions Behavior**
  - Energetic Materials: Combustion
  - Case: Benign split, smooth gas release/end separation
- **Effects**
  - Projection of Materials < 50 ft

Rocket Motor Improvements

- Seeking IM improvement in MK 22 RM
  - Performance across temperatures eliminates composite propellants from consideration
  - Application mandates an inexpensive, rugged design
    - Eliminates composite case, making strip laminate case undesirable
  - Venting possible solution
    - Data suggests venting alone will not cure the problem

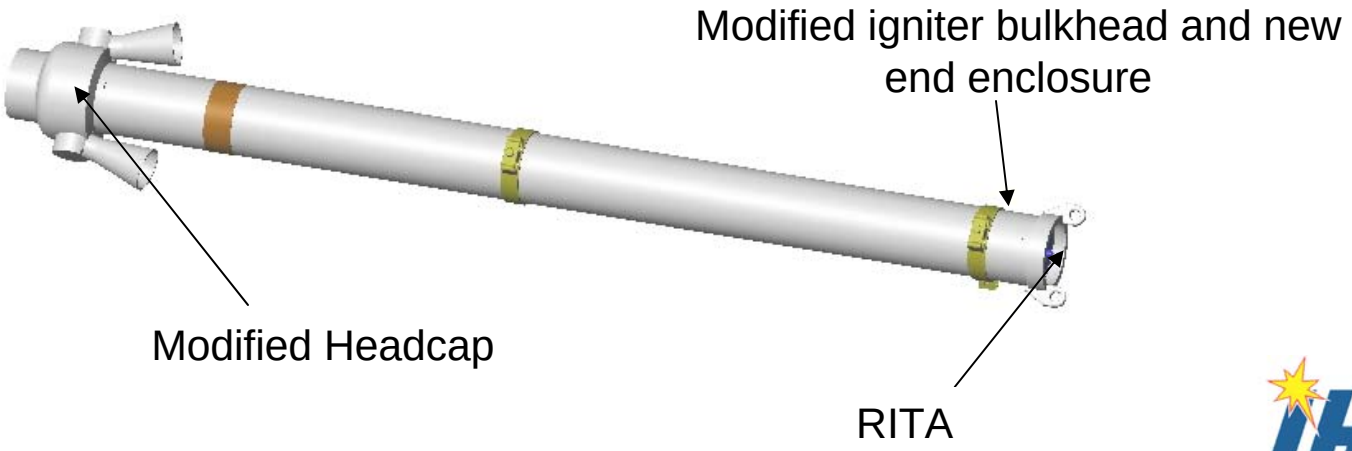
MK 22 Mod 4



Rocket Motor Improvements

- Proposed Solution:
  1. Fully vent both ends using a thermally activated shape memory alloy (NiTiNOL) release mechanisms
     - Modify headcap
     - Modify igniter bulkhead
     - New end enclosure
  2. Ignite surface of propellant prior to auto-ignition using an Active Mitigation Device (AMD)
     - Rocket Initiator Thermally Actuated (RITA)

<u>EX 22 Mod 5</u>



RM IM Improvement Approach

- Design approach temperature timeline to allow safe, controlled venting (SCO Profile):

Current MK22 RM

Grain Auto-Ignites

~255°F

0°F

Temp.

*IM Improved MK22 RM**

0°F

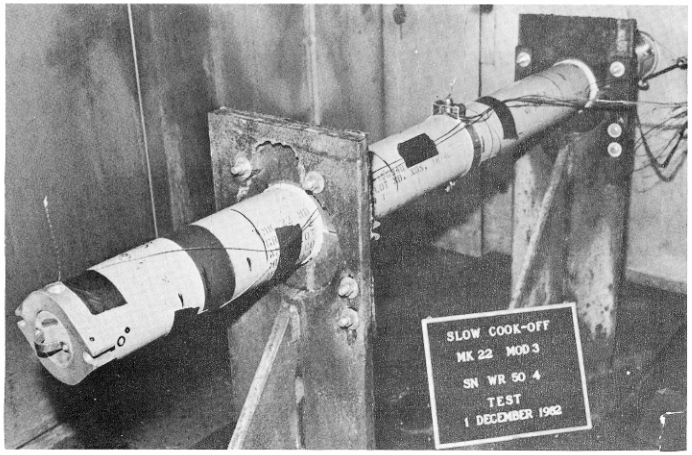
~210°F Vents Are Released

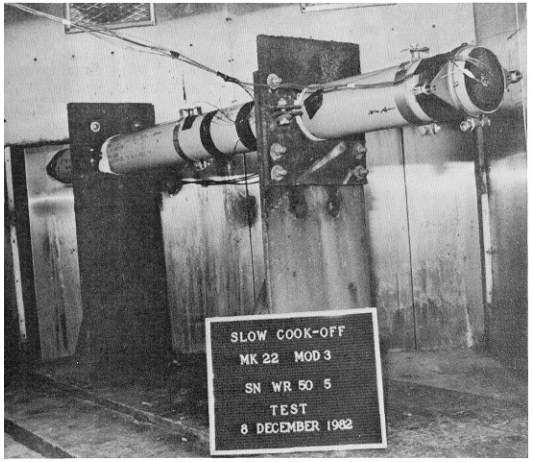
RITA Functions & Ignites The Motor

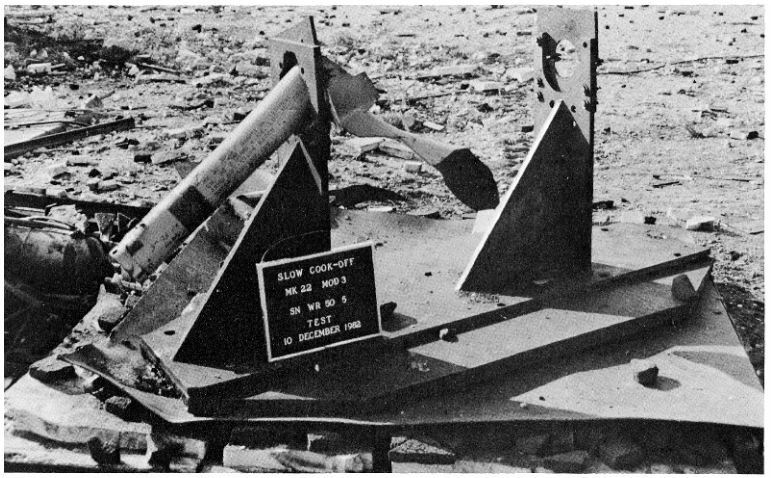
Temp.

*All Proposed IM Mitigation Events Will Occur Prior To Grain Auto-Ignition

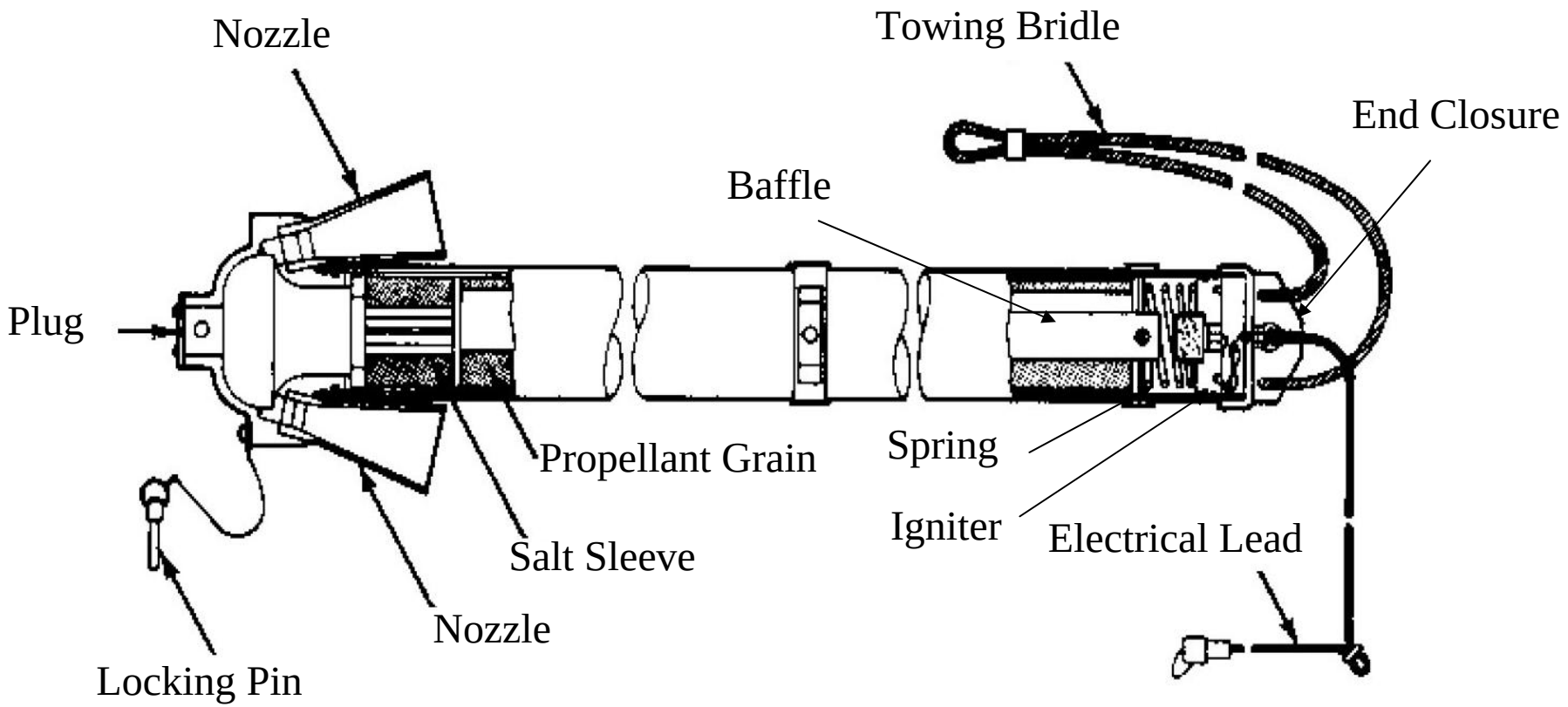
Background: Mk 22 Mod 3 Slow Cook-Off History





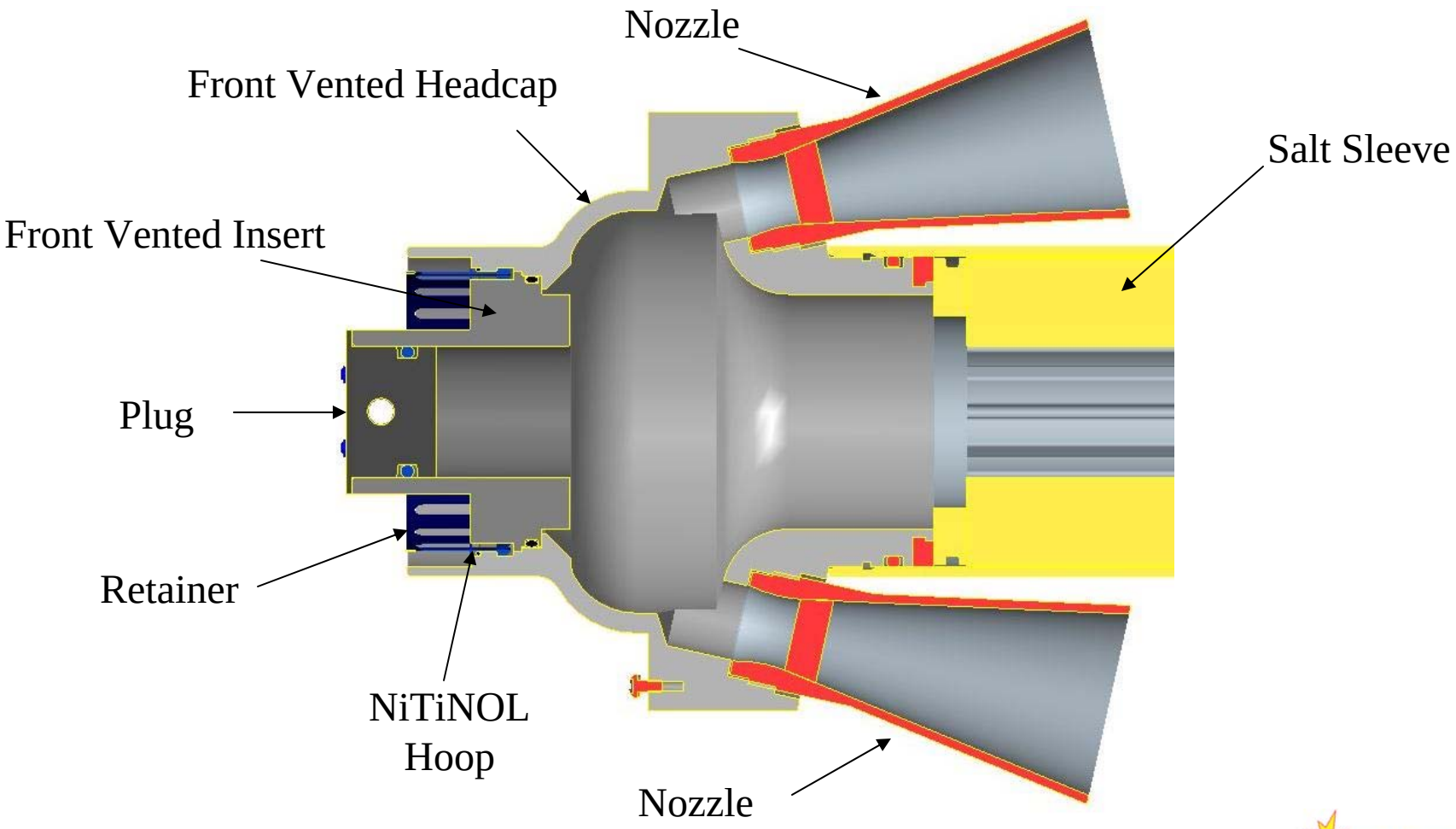


MK22 Mod 4 Rocket Motor
Current Production Configuration

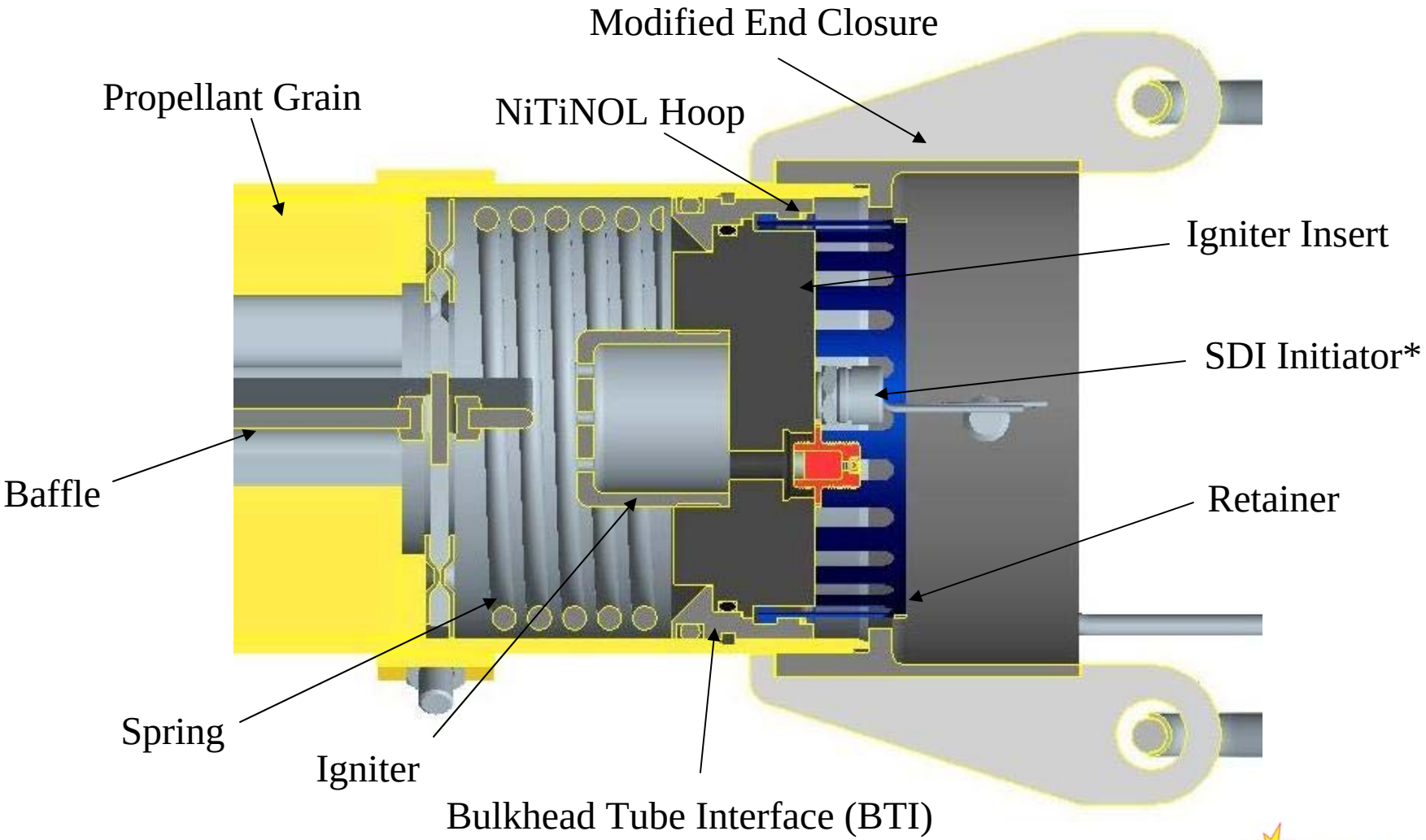


N-5 Double Base Propellant Autoignition Temperature ~255°F

EX 22 Mod 5 – Fwd Vent

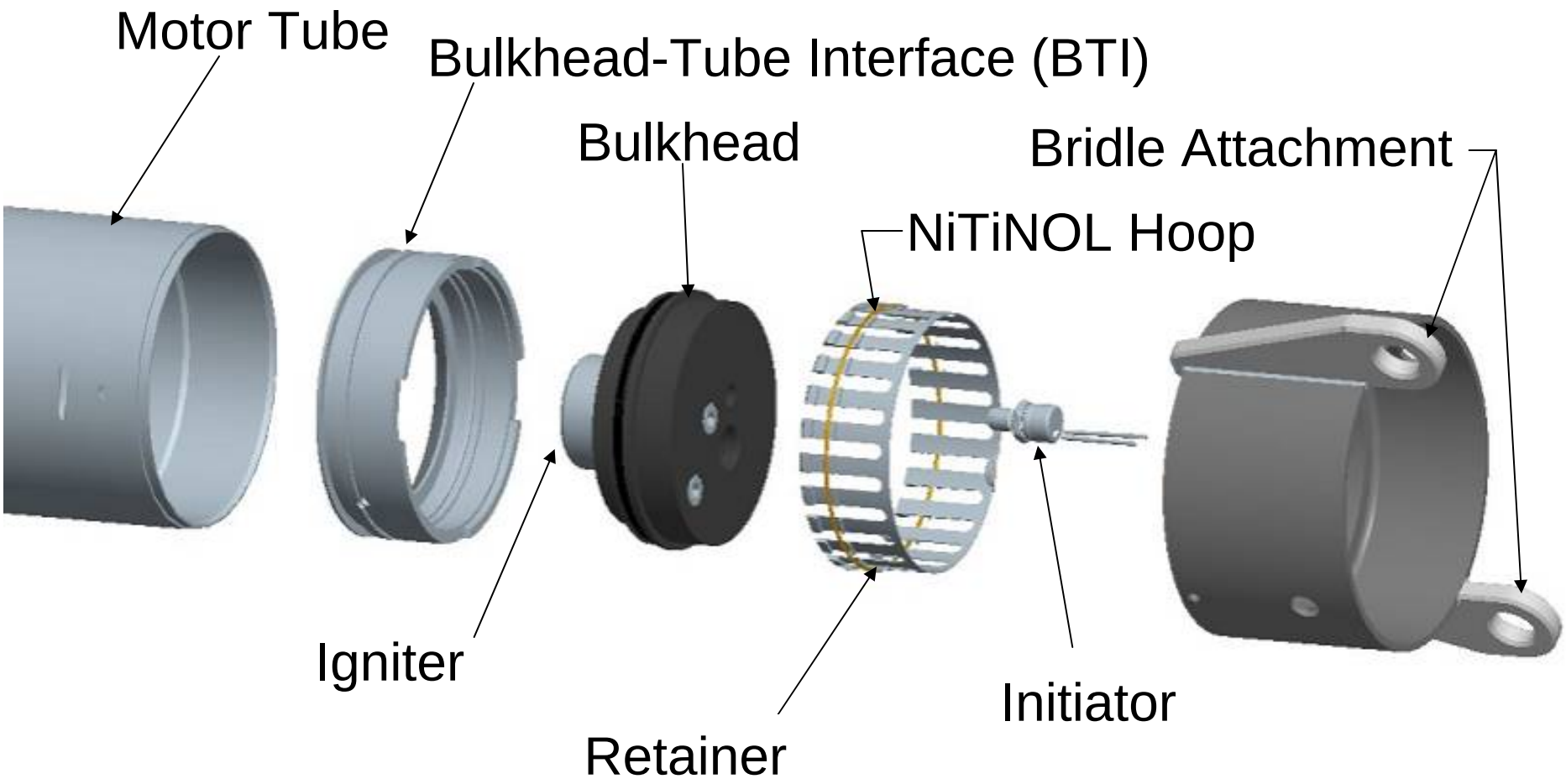


EX 22 Mod 5 – Aft Vent



*Maintaining Current In-Line Initiator (Prior to MIL-STD-1901)

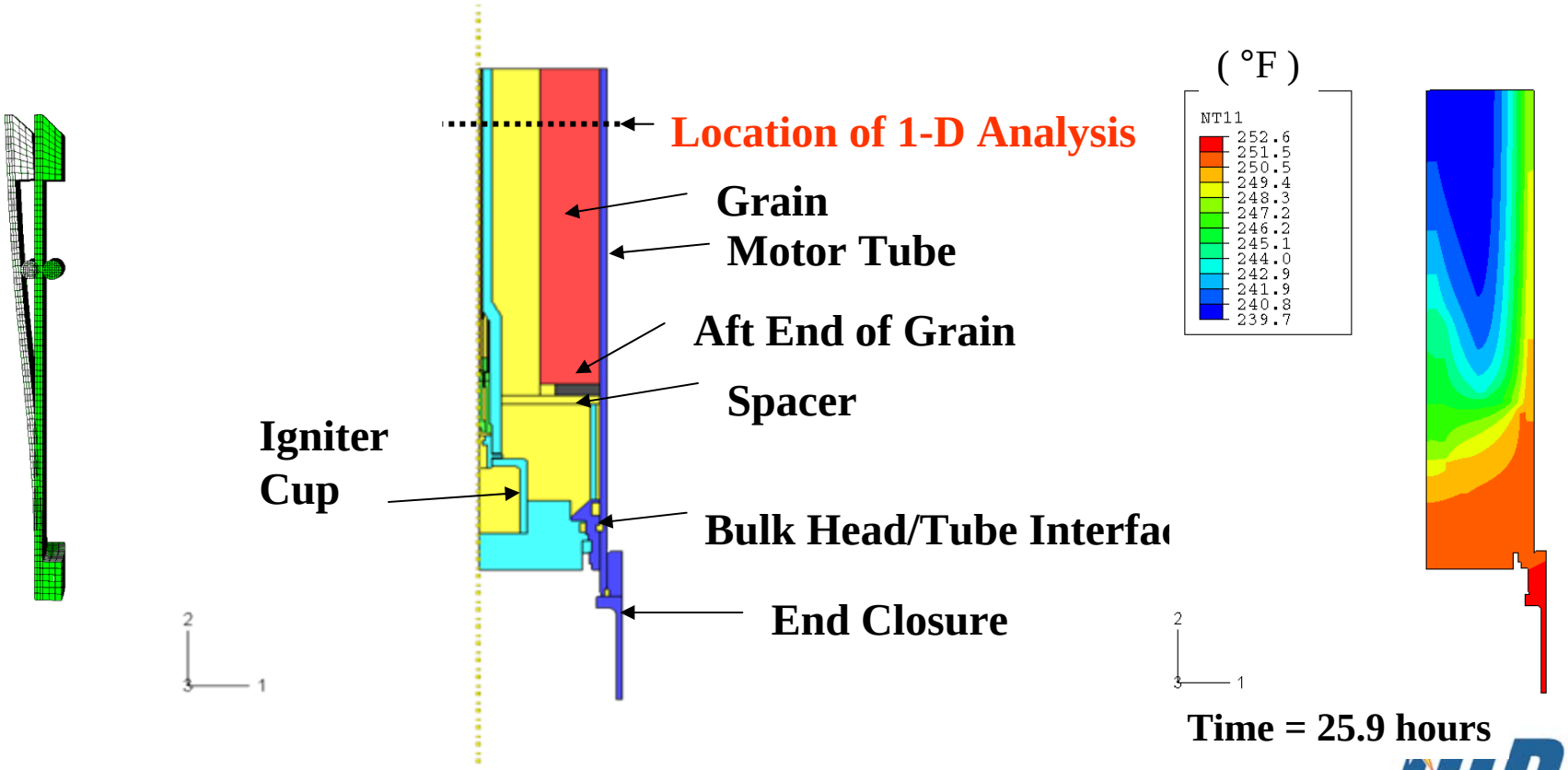
Thermally Venting Bulkhead



***RITA Not Pictured**

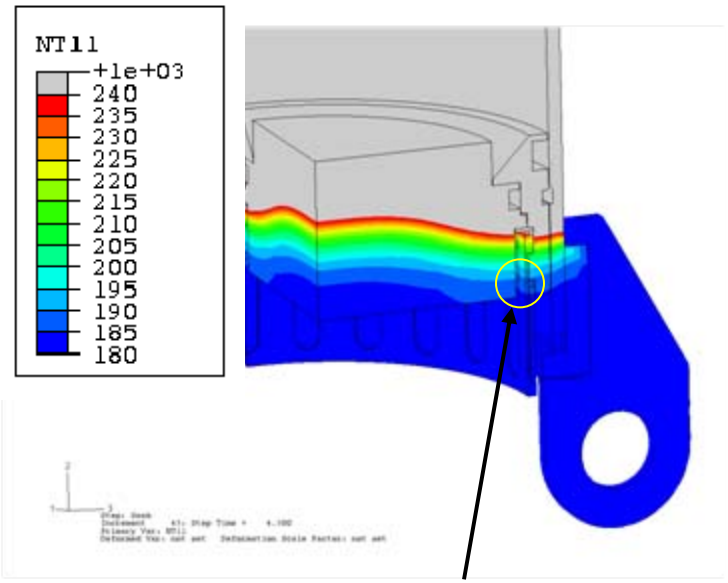
Vent Thermal & Structural Analysis

- Thermal Analysis
  - Slow Cook-Off Analysis – Predicts Venting Mechanism Function & Verified Heating Profile of Motor

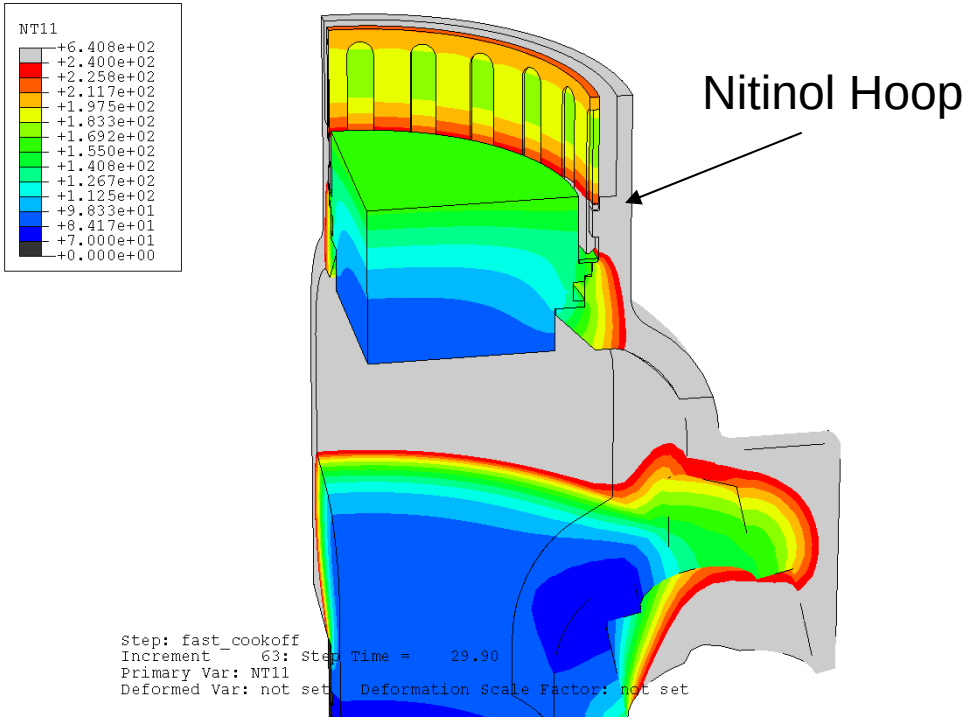


Vent Thermal & Structural Analysis

- Thermal Analysis
  - Hot Motor Firing – Predicts Venting Mechanism Retained
  - Fast Cook-Off Analysis – Predicts Venting Mechanism Function



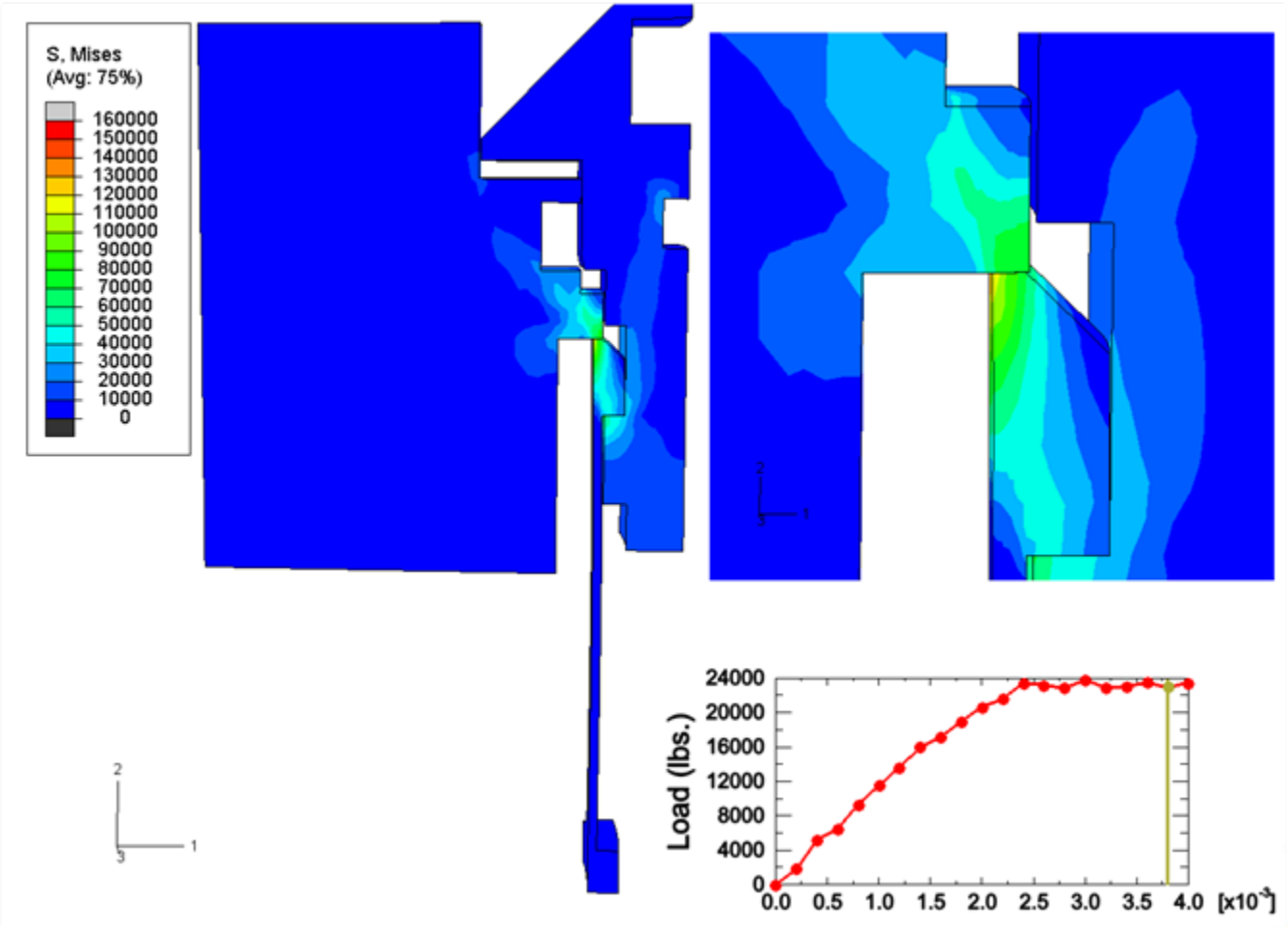
Hot Motor Firing (Aft End)



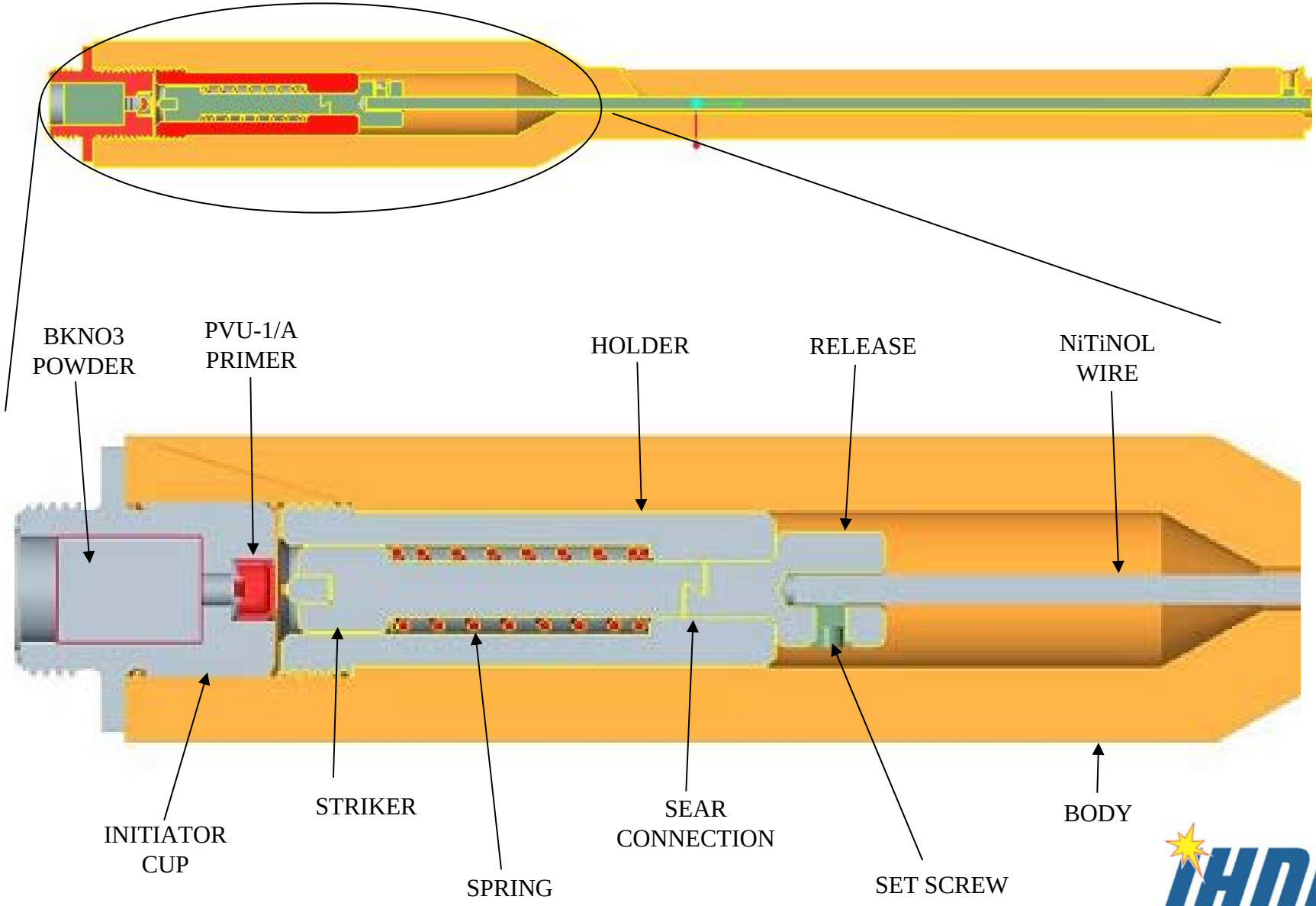
Fast Cook-off (Headcap)

Vent Thermal & Structural Analysis

- Structural Analysis
  - Firing Loads – Retainer Expected To Hold At Maximum Firing Loads



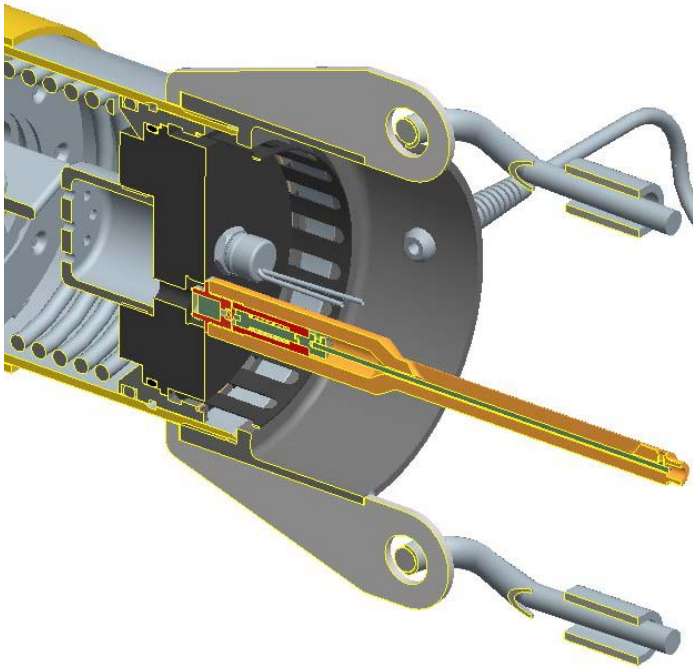
RITA Design (Preliminary Configuration)

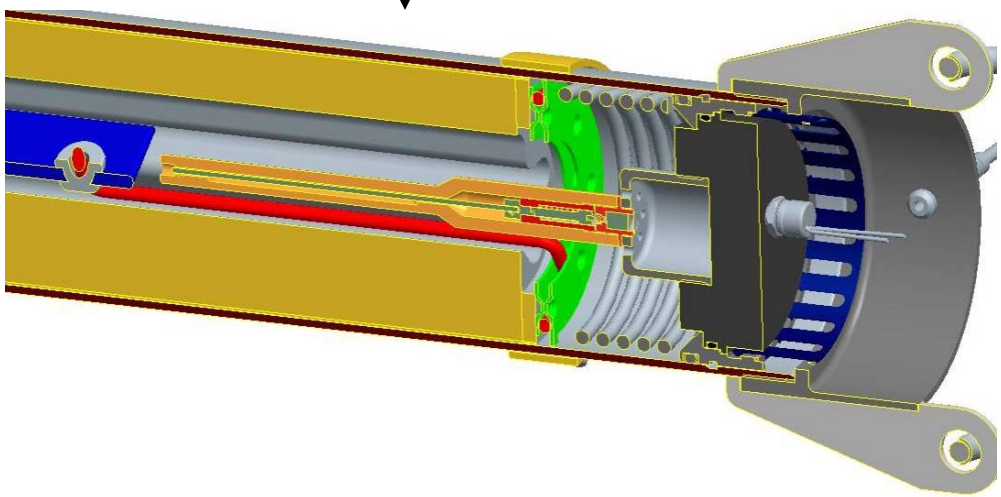


RITA Design (Preliminary Configuration)

Possible Mounting Configurations

- **External (Igniter Bulkhead)**
- **Internal (Igniter Cup)**





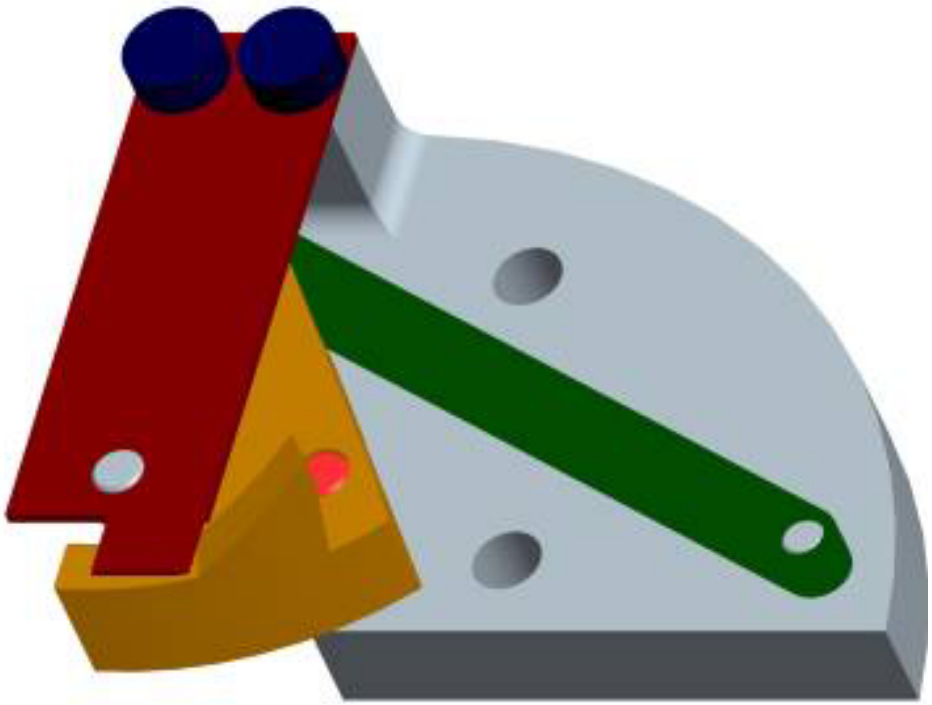
RITA Design (Preliminary Configuration)

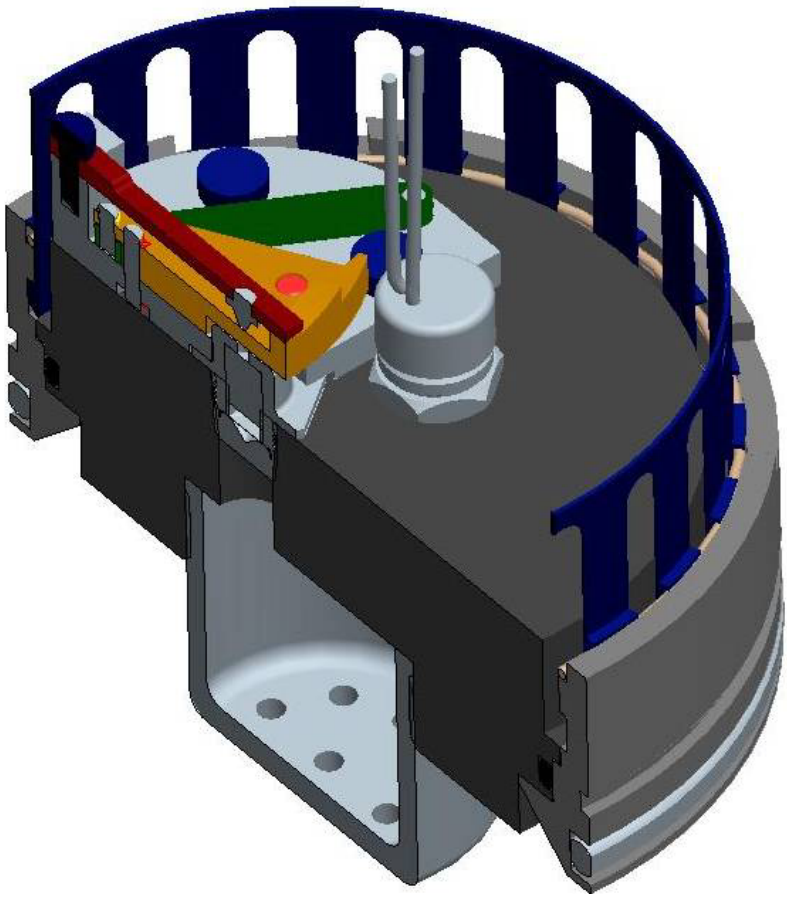
Design Deficiencies:

- Striker/Primer/Initiator Charge In-Line
- Possible Inadvertent Actuation Due to Shock
- Mounting Issues:
  - Internal
    - Structural Integrity
    - Flow Impact (Baffle)
    - Temperature Exposure
  - External
    - Length Limitations
    - Possible Use As A Handle

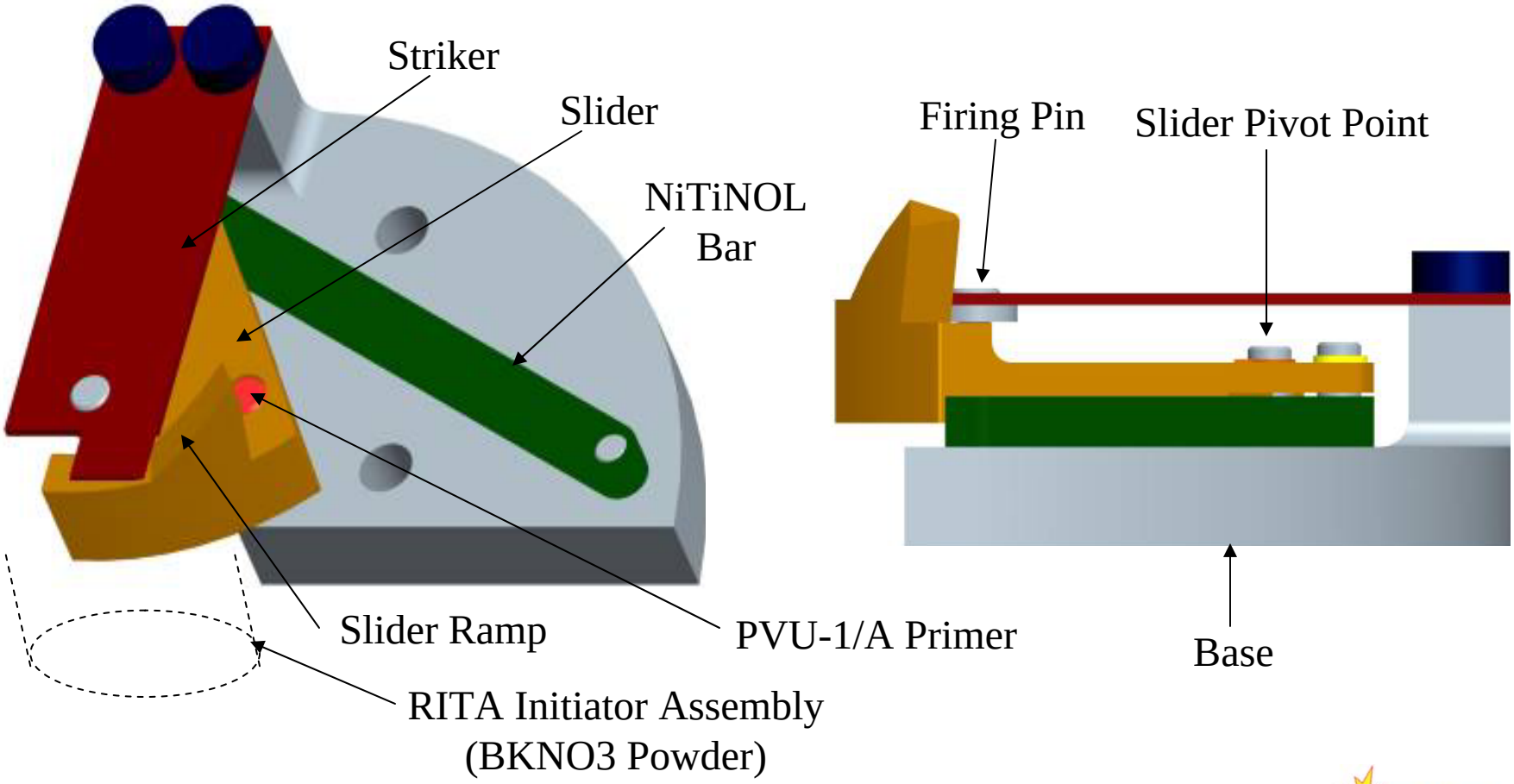
RITA Design (Revised Design)

- Revised Low-Profile RITA Design:





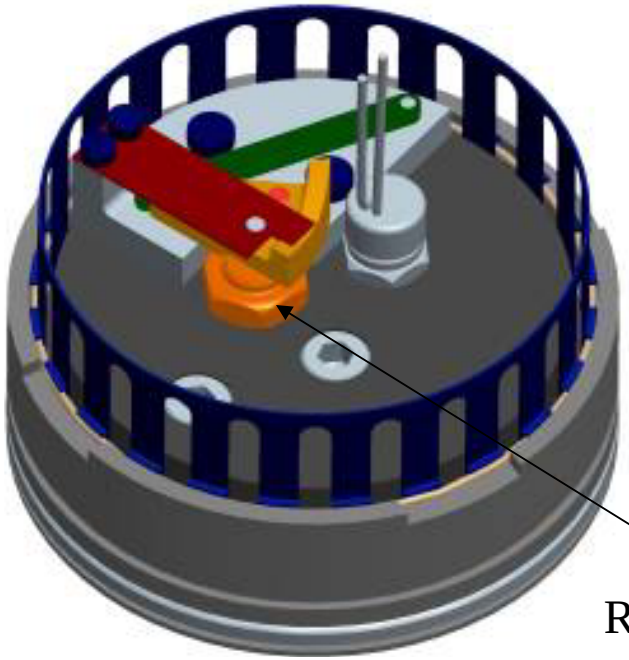
RITA Design (Revised Design)
Safe Position

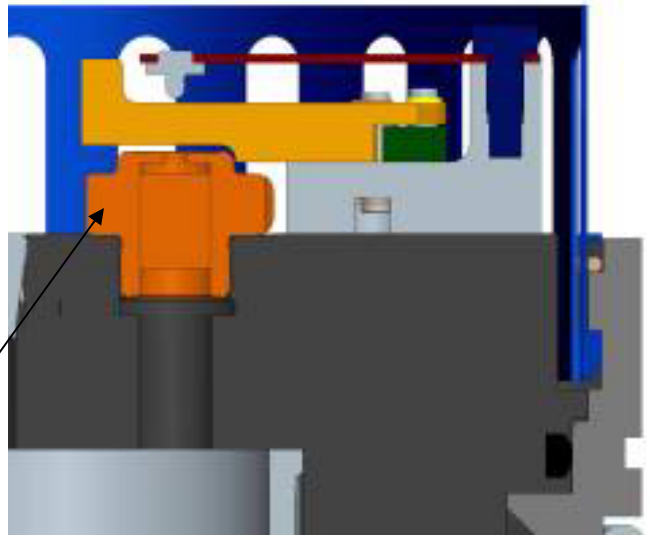


RITA Design (Revised Design)

Actuation Process:

1. RITA In Safe Position
   - Primer Out of Line With Initiator Charge
   - NiTiNOL Bar Is A Structural Member (Device Lock)
   - No Stored Energy



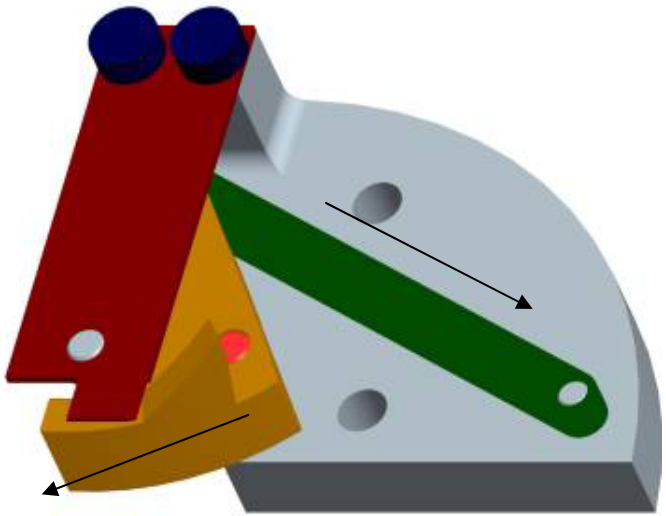


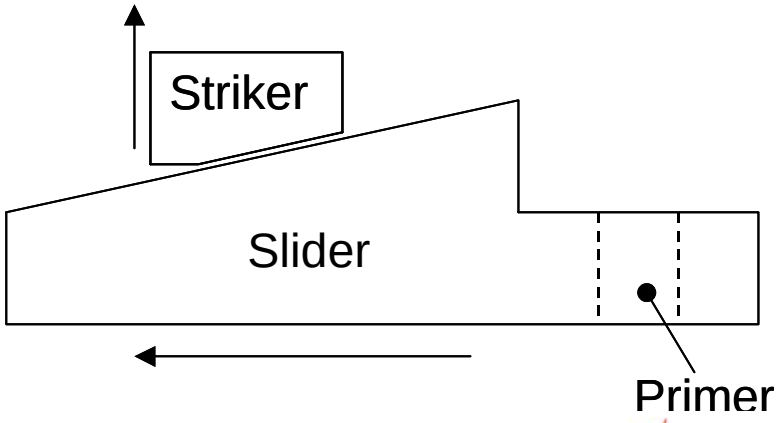
RITA Initiator Assembly

RITA Design (Revised Design)

Actuation Process Cont'd:

2. RM (RITA) Exposed To Cook-off Environment (SCO or FCO)
   - NiTiNOL Bar Begins To Contract
   - Slider Begins To Pivot
   - Striker Begins Moving Along Slider Ramp

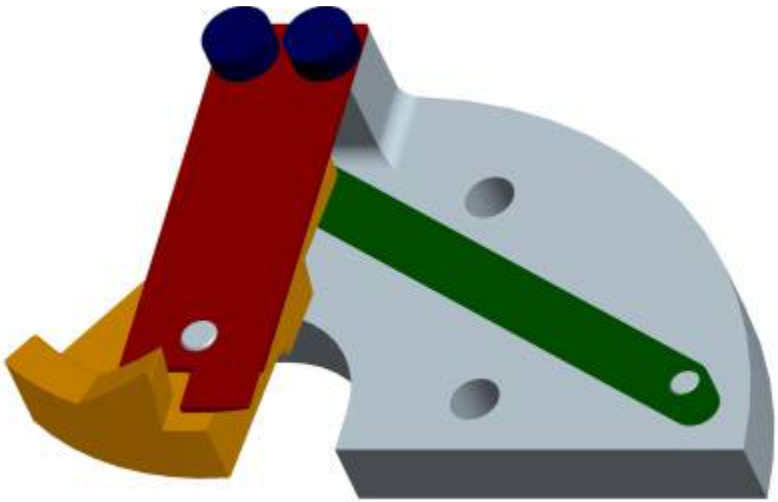


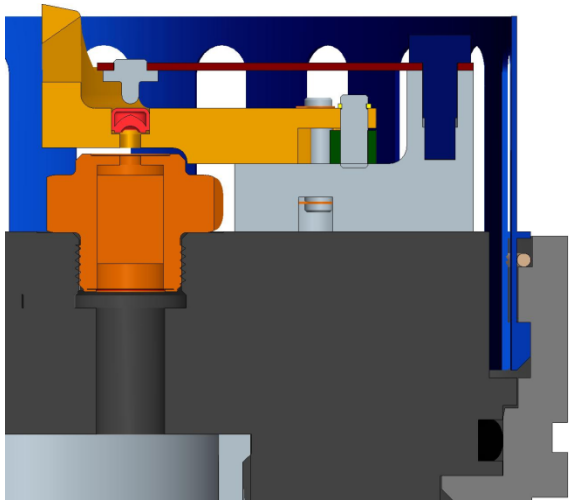


RITA Design (Revised Design)

Actuation Process Cont'd:

3. RITA Fully Actuates (Armed Position)
   - NiTiNOL Bar Completes Contraction
   - Slider Completes Pivot Motion
   - Striker Reaches the Apex of Slider Ramp And Releases
     - Firing Pin Impacts Primer
     - Begins Ignition of Initiator Charge / Igniter / RM

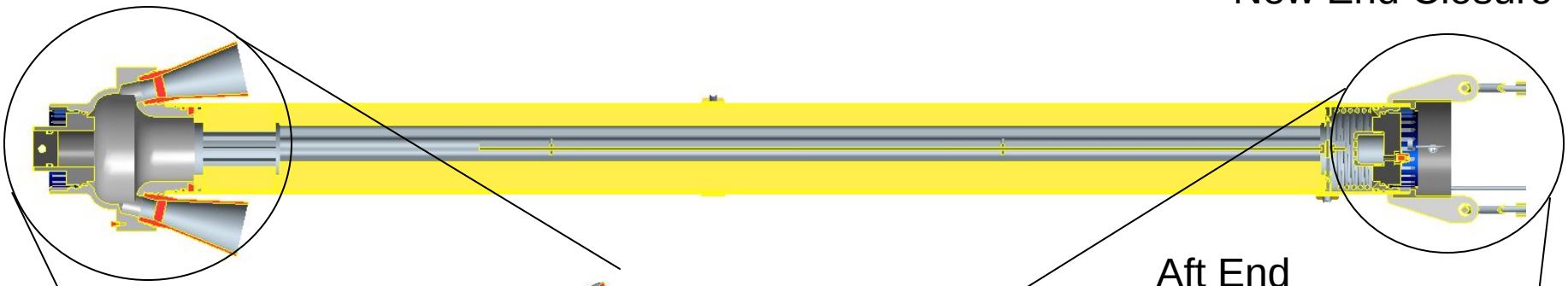




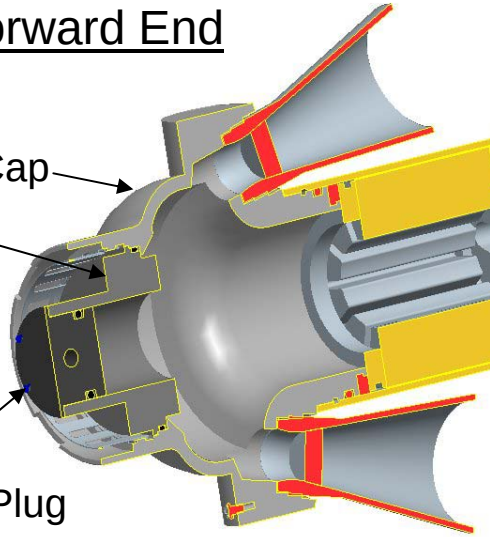
EX 22 Mod 5 with RITA

Modified Head Cap

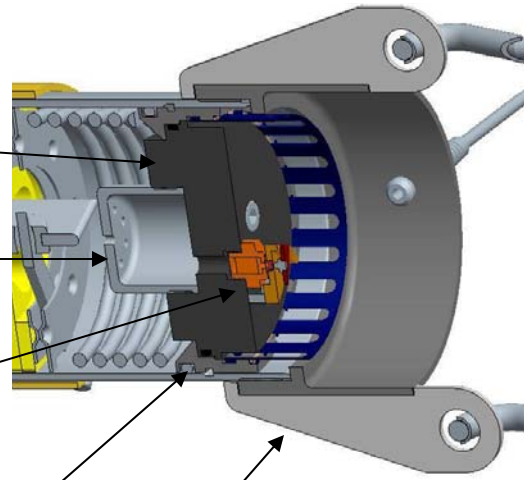
Modified Igniter Bulkhead & New End Closure



Forward End



Aft End



Rocket Motor Explosive Information

EX 22 Mod 5 Energetic Materials		
Component	Explosive	Weight
Propellant	N-5, Double Based	42.00 lbs.
Electrical Initiator	Bridgewire Composition 500486 (ZrKClO4)	65 mg
	Initiator (BKNO3)	220 mg
Igniter	Igniter Charge (MTV)	48 g
RITA	Primer PVU-1/A (Lead Styphnate)	21 mg
	BKNO3	220 mg

Only New Energetic Materials

Concept Testing

- Slab Motor Tests
  - Determined Propellant Could be Safely Ignited At Elevated Temperatures
- High Temperature Vented Test
  - Proved Active Mitigation Device Required
- High Temperature Ignition Test
  - High Temperature Ignition Viable
- Previous RITA Design Performance Tests
  - Verified Primer & Initiator Charge Sufficient In Igniting RM

High Temperature Ignition Test (Double Venting)

RITA Future Efforts

RITA Functionality Test Series:

1. NiTiNOL Performance Validation
   - % Reduction Verification
   - Tensile & Compression Strength
   - Force Generated When Activated
2. Initiator Performance Characterization
   - Firing Pin to Primer Performance*
   - Primer / Initiator Gap Analysis
   - Primer to BKNO3 Transfer*
   - BKNO3 to Igniter Transfer*
   - Primer / Initiator Offset (Progressive Arming)
3. Full-up RITA Performance Demonstration
   - Full-up RITA In SCO environment
4. EX22 Mod 5 SCO Demonstration
   - Venting & RITA
5. RM / RITA Qualification

*Building Off of Previous RITA Testing

Acknowledgements

- Intrinsic Devices Inc. for their Support in Developing Requirements for the NiTiNOL
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  - Eric Hampton – Effort Coordination Support/Project Management
  - Peter Lewis – Effort Coordination Support
  - Bernadette Wackerle - Effort Coordination Support
  - Fred Borrell – Design Support
  - Murthy Bettadapur – Material Selection & Testing Support
  - Ricky Johnson – Hardware Receipt Inspection
  - Danny Bouch – RM Production
  - Bob Johnson – RITA Production
  - Diptiman Sengupta – Igniter Production
  - Wesley Shaw – NiTiNOL Testing
  - K C Elliot – RITA Testing
  - Eric Meyer – RM Static Firing Test Lead
  - Tony Kee – RM Static Firing Support

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