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Active Mitigation: Rocket Initiator Thermally Activated (RITA) Insensitive Munitions (IM) Device for the MK22 Mod 4 Rocket Motor

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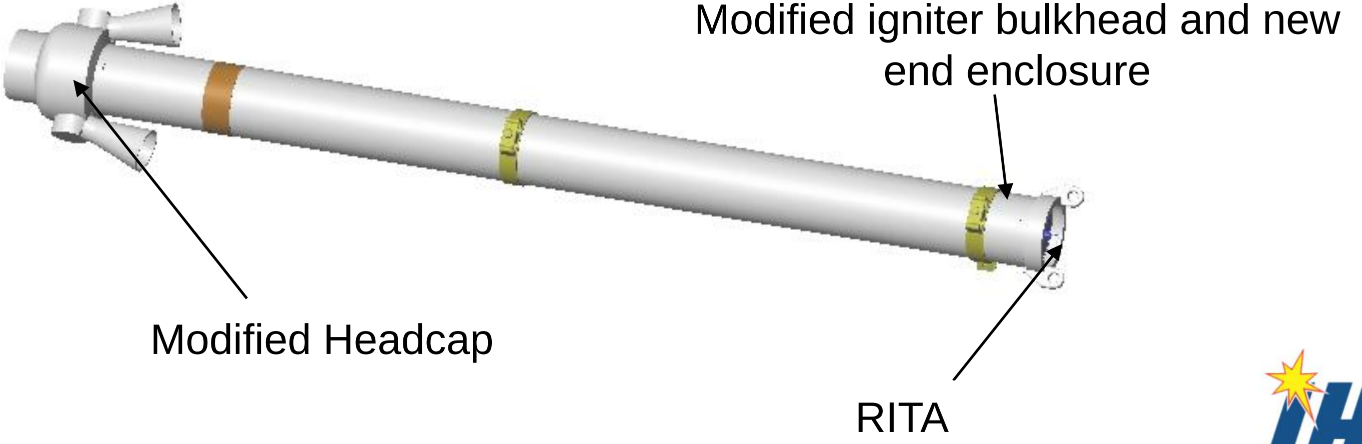
Rocket Motor Improvements

- Proposed Solutions:
  1. Fully vent both ends using a thermally activated shape memory alloy (NiTiNOL) release mechanism
     - 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

Temp.

~210°F Vents Are Released

RITA Functions & Ignites The Motor

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

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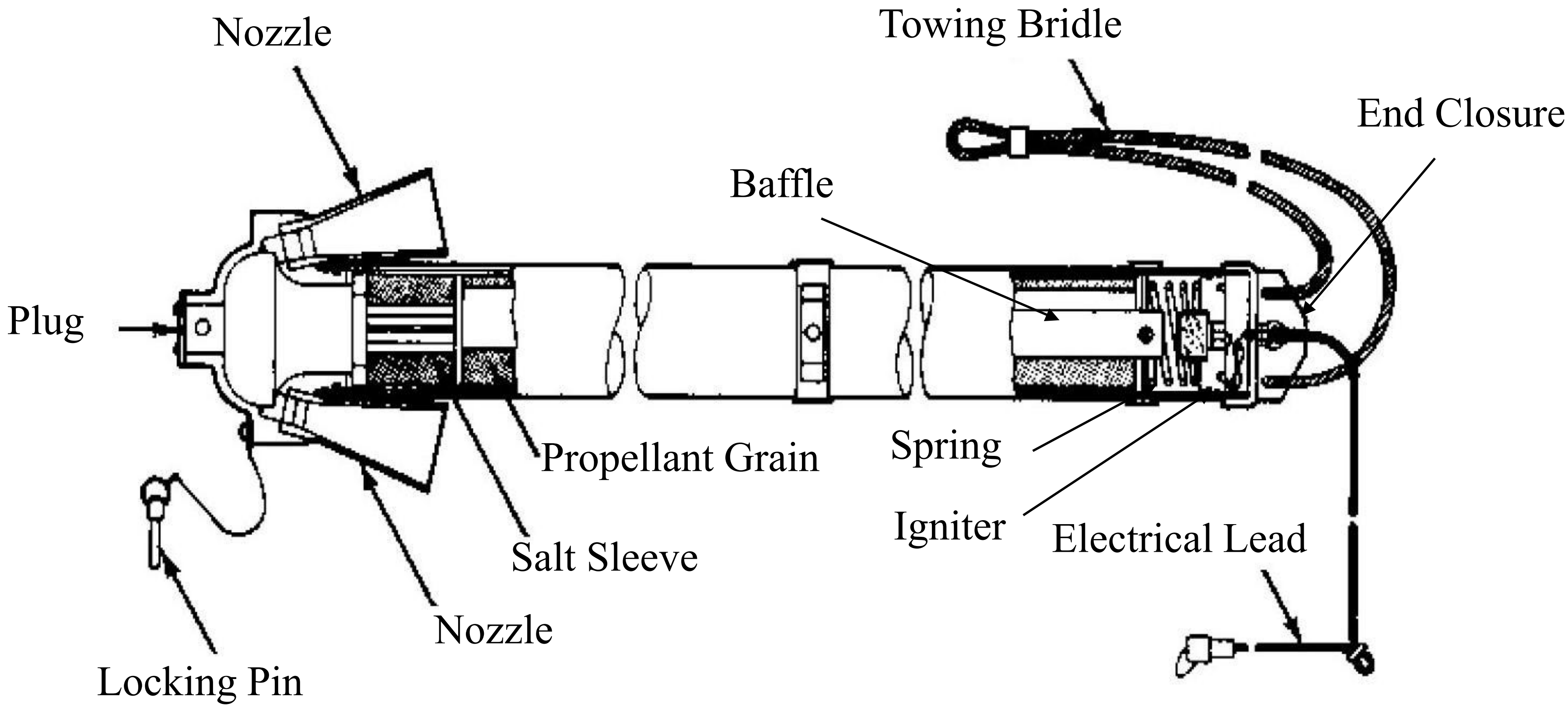
Concept Testing

- 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
- Limited RITA Functionality Tests
  - Showed that the NiTiNOL bar could meet our requirements and that the primer would transfer to the Initiator

High Temperature Ignition Test
(Double Venting)

MK22 Mod 4 Rocket Motor

Current Production Configuration



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

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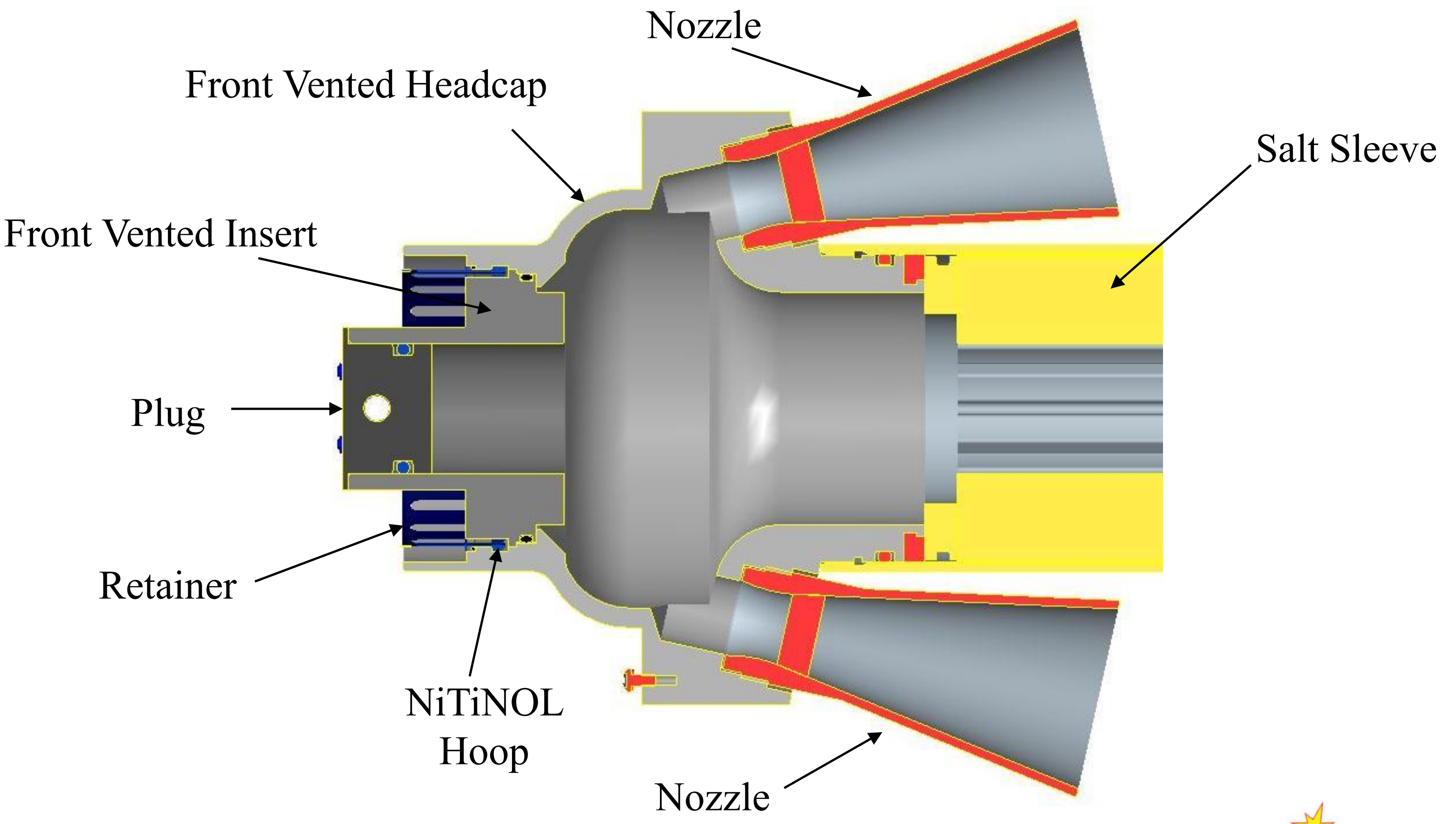
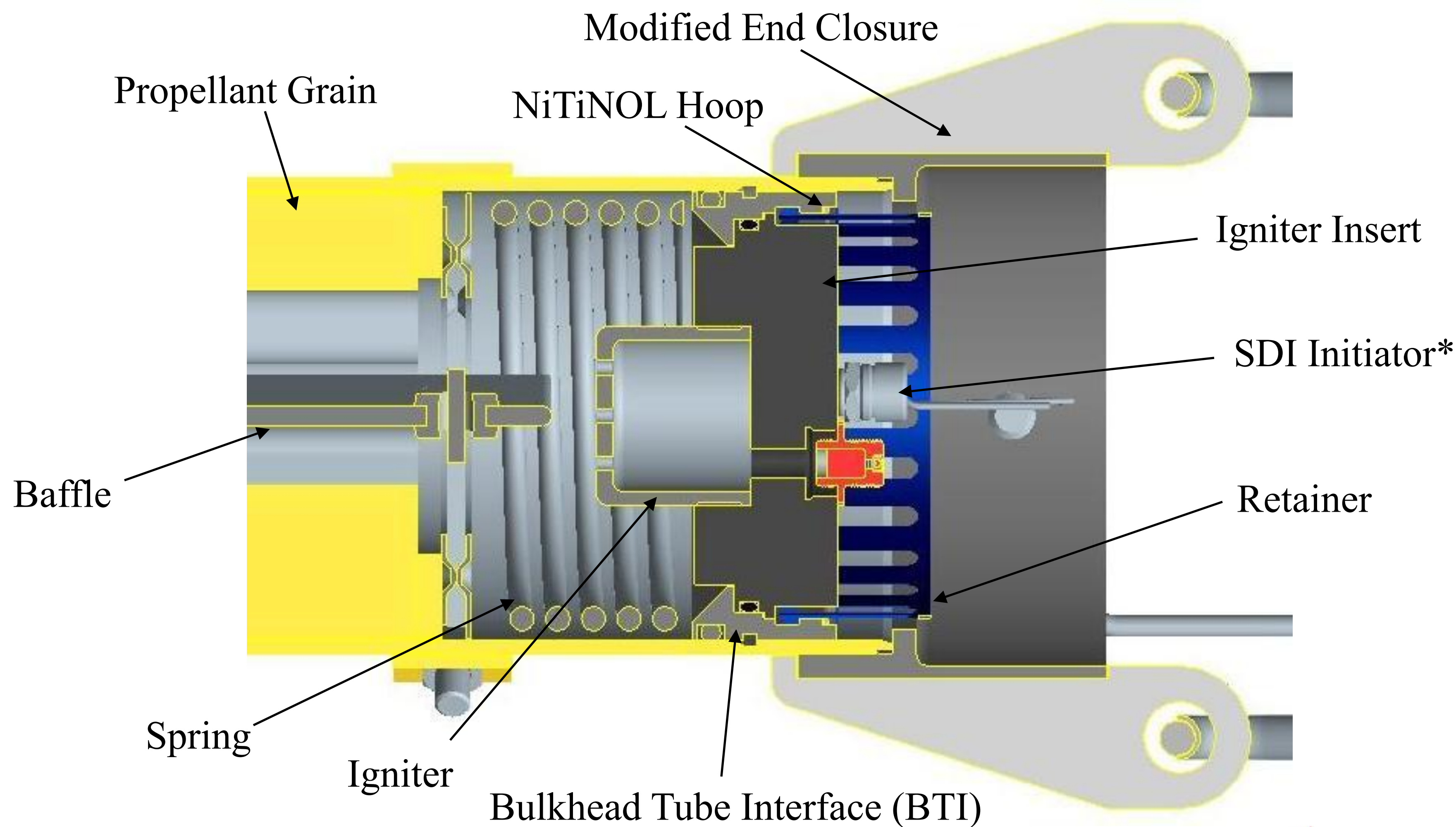
EX 22 Mod 5 – Fwd Vent

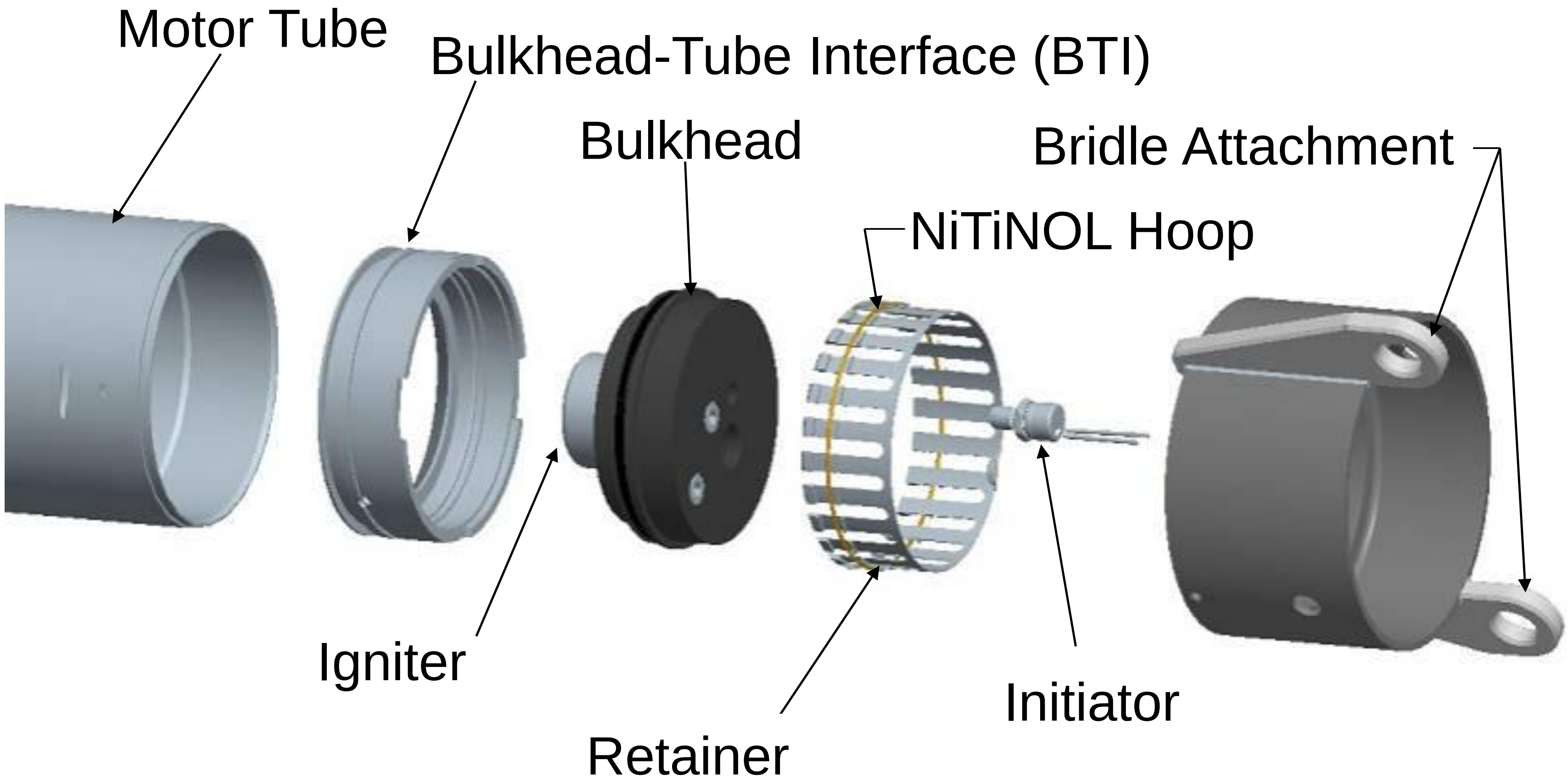


EX 22 Mod 5 – Aft Vent



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

Thermally Venting Bulkhead



***RITA Not Pictured**

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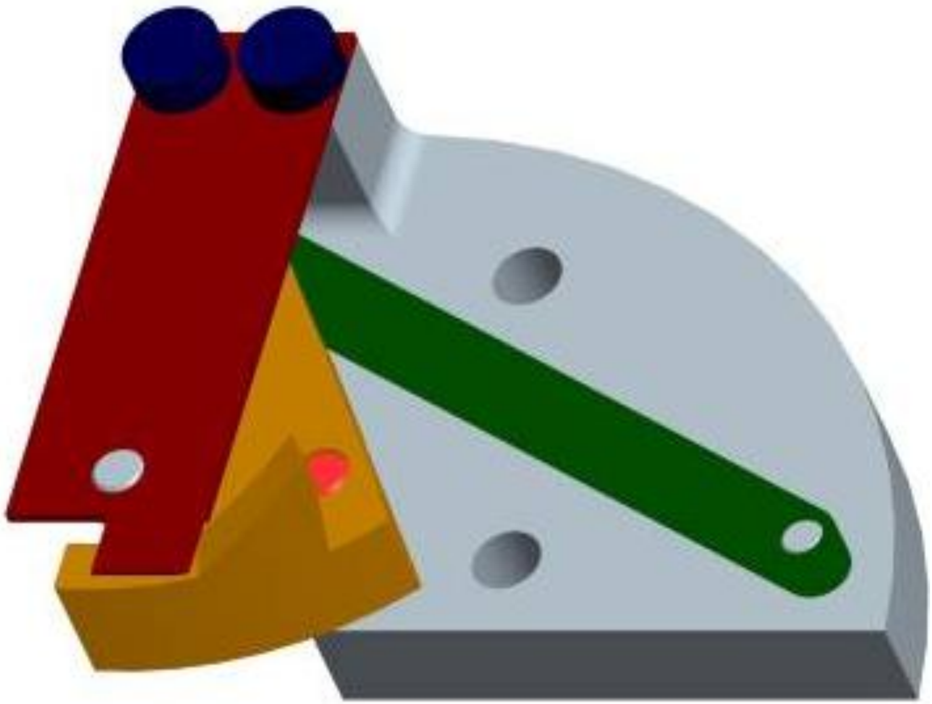
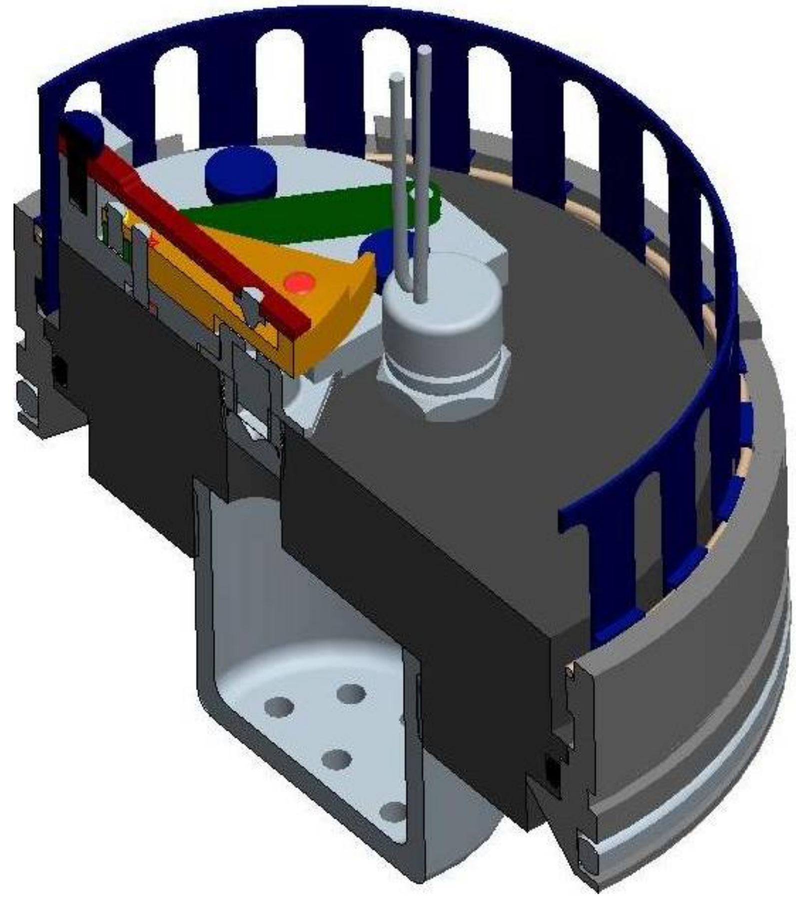
Early Compact RITA Design

- Revised Low-Profile RITA Design





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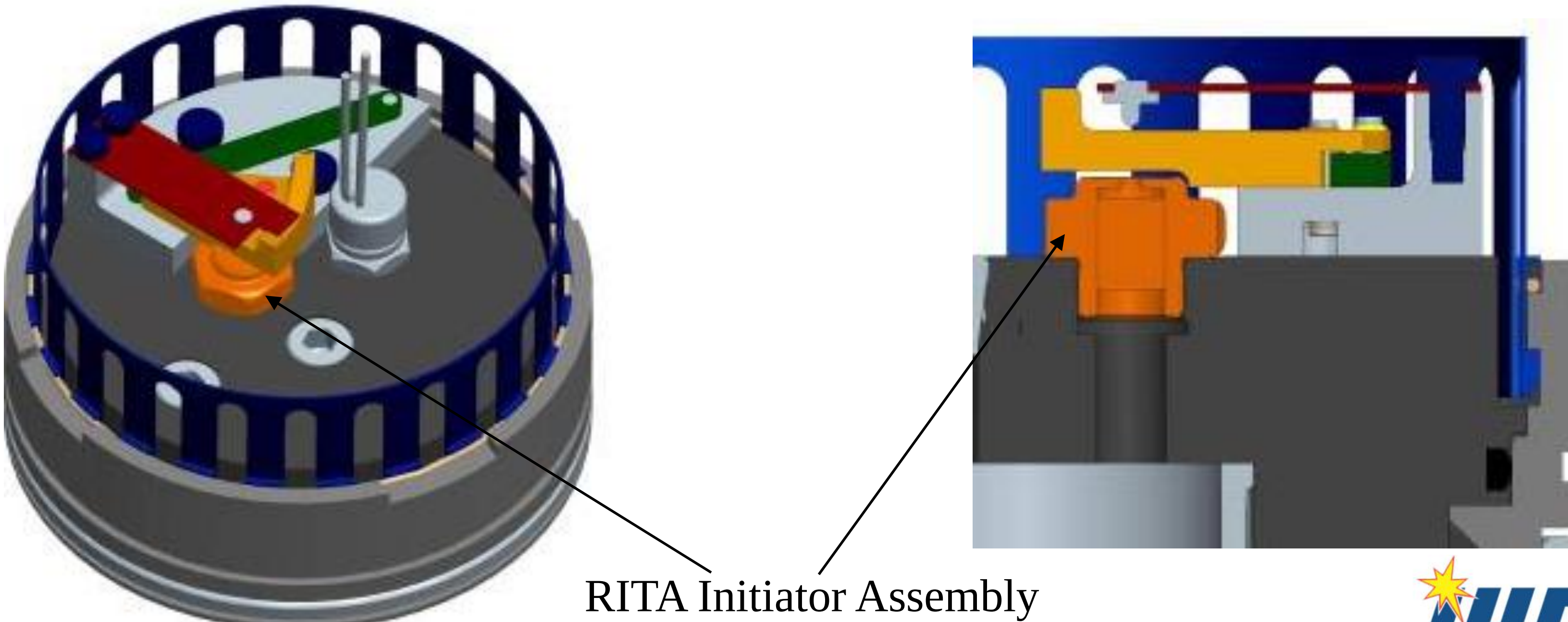
Compact RITA Design

Actuation Process:

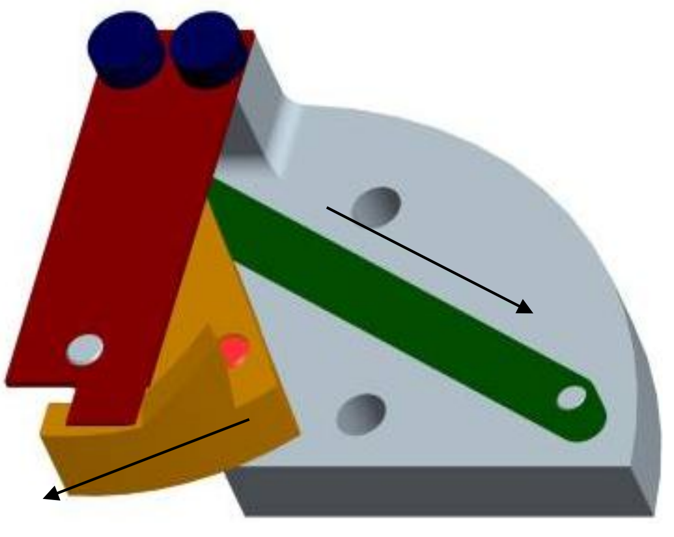
1. RITA In Safe Position
   - Primer Out of Line With Initiator Charge
   - NiTiNOL Bar Is A Structural Member (Device Lock)
   - No Stored Energy

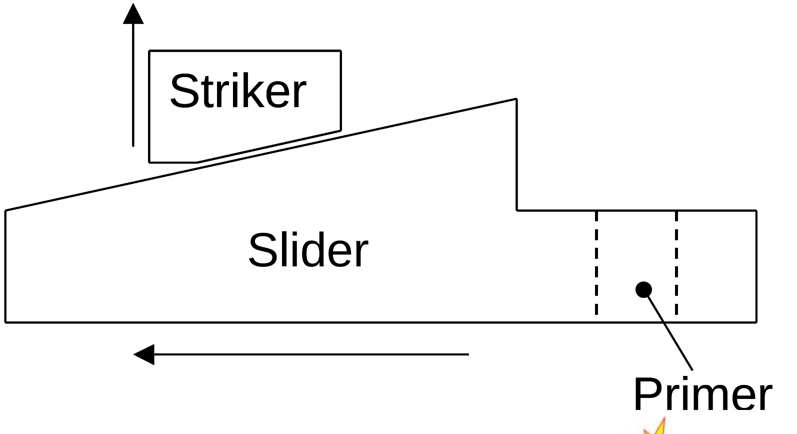


Early Compact RITA Design

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





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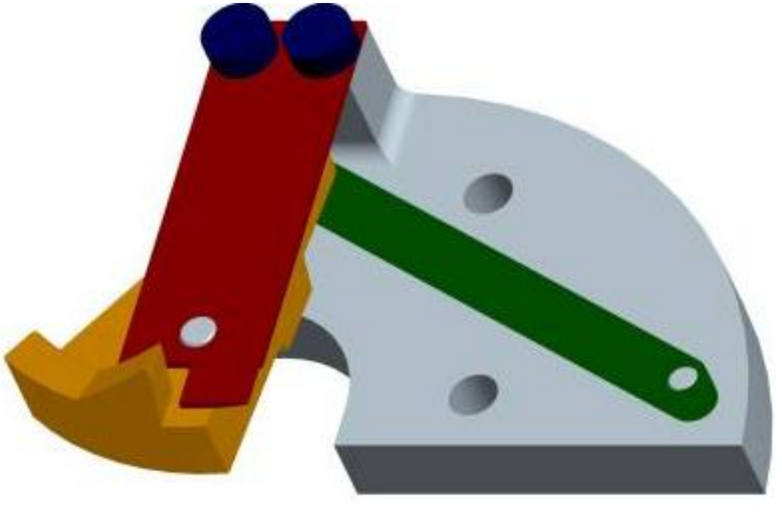
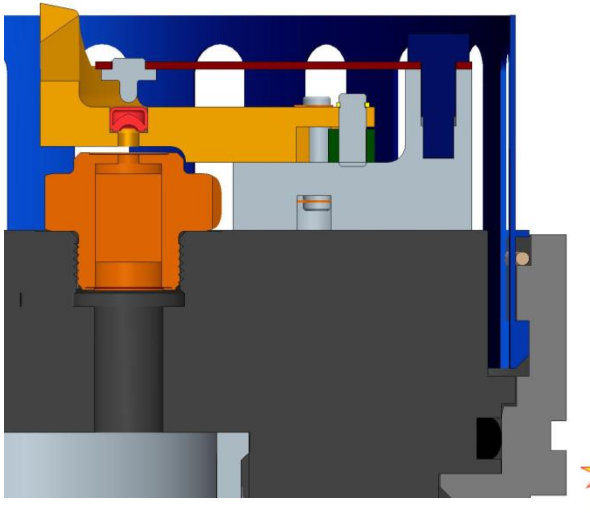
Compact RITA Design

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

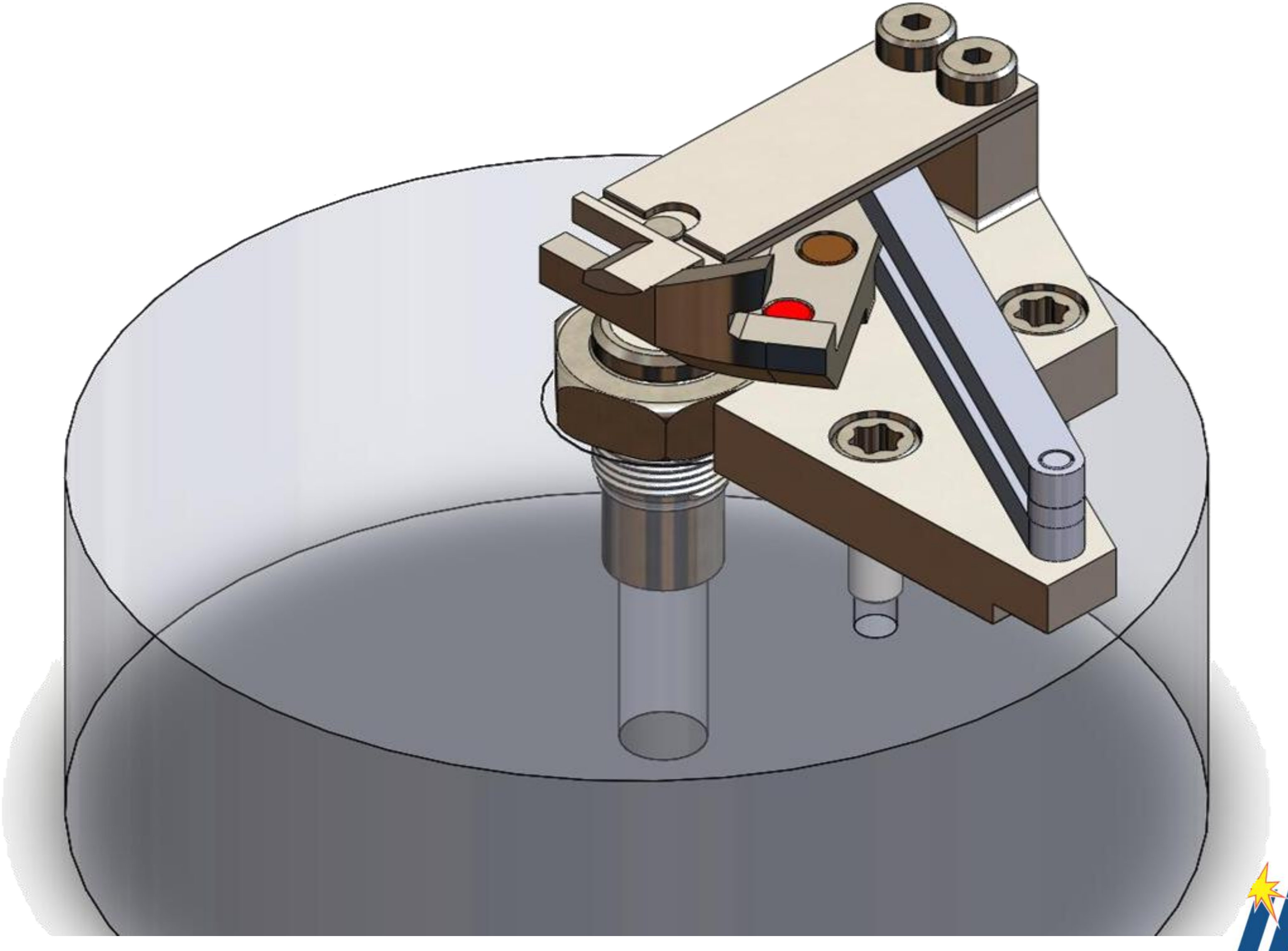




2nd Generation RITA Design Improvements

1. Eliminate pressure loss in BKNO3 to Igniter transfer
2. Increase margins of safety on the striker/ firing pin and NiTiNOL contraction percentage
3. Incorporate a 2nd Safety Feature into the RITA system (FISTRP Requirement)
4. Retest BKNO3/Igniter transfer
5. Follow up with DVT and Qualification Testing of the RM

2nd Generation RITA Design



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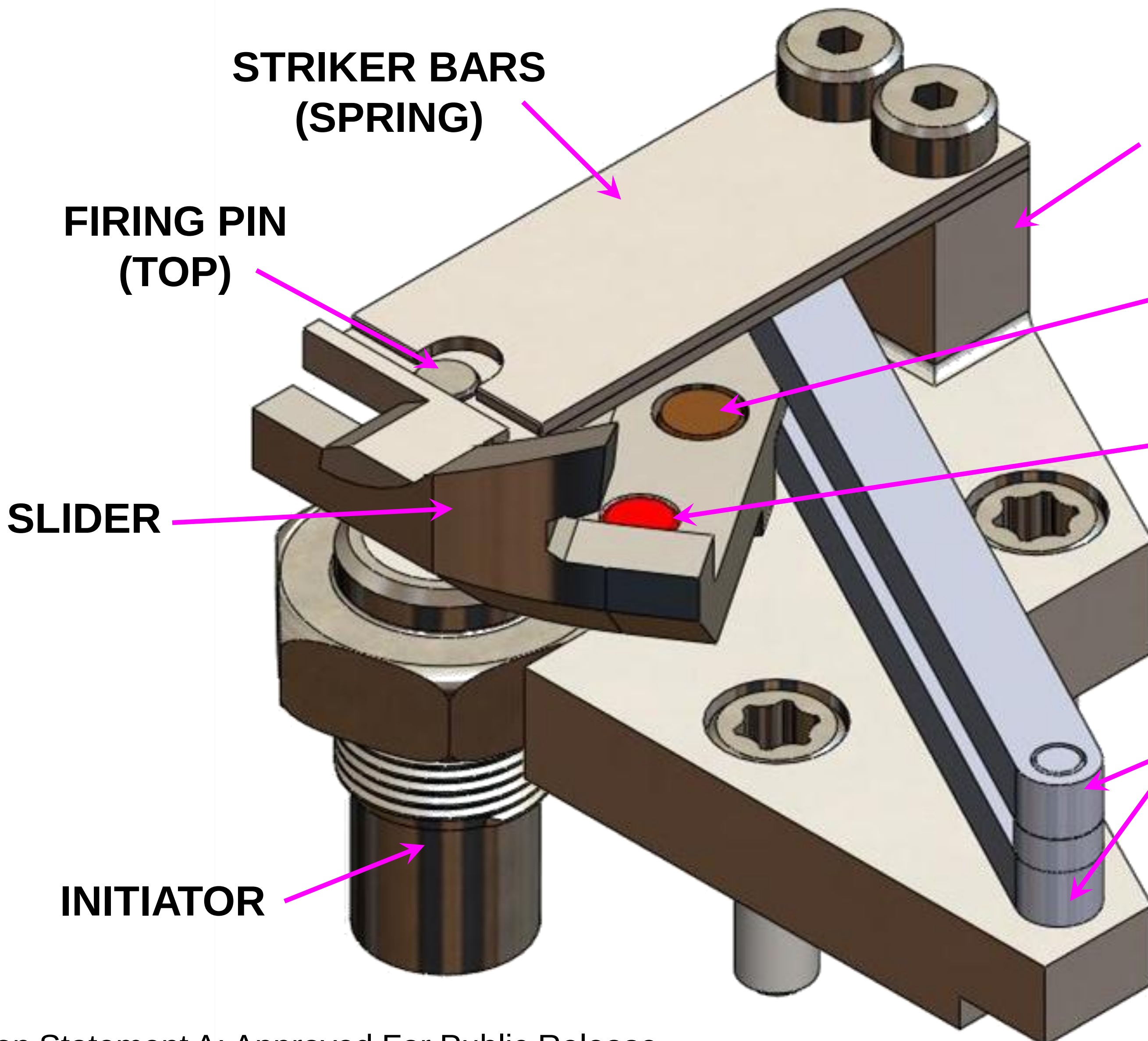
Components



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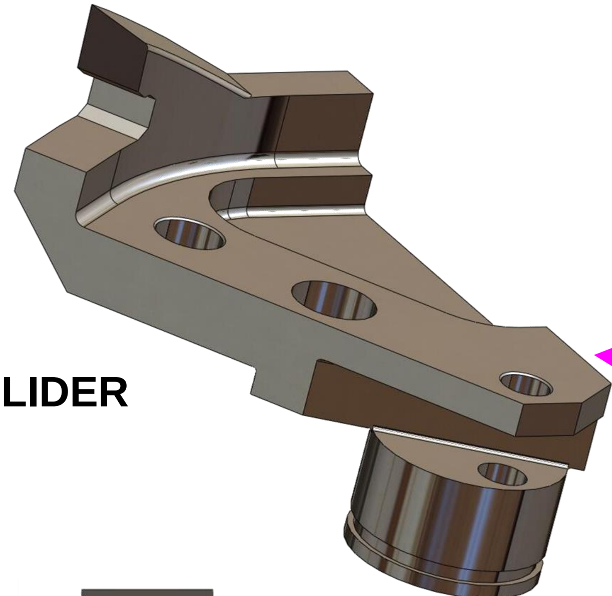
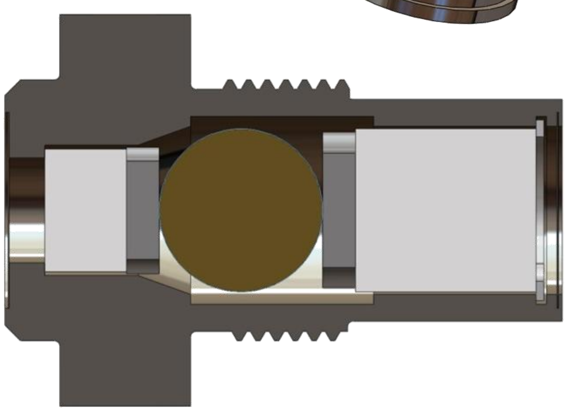
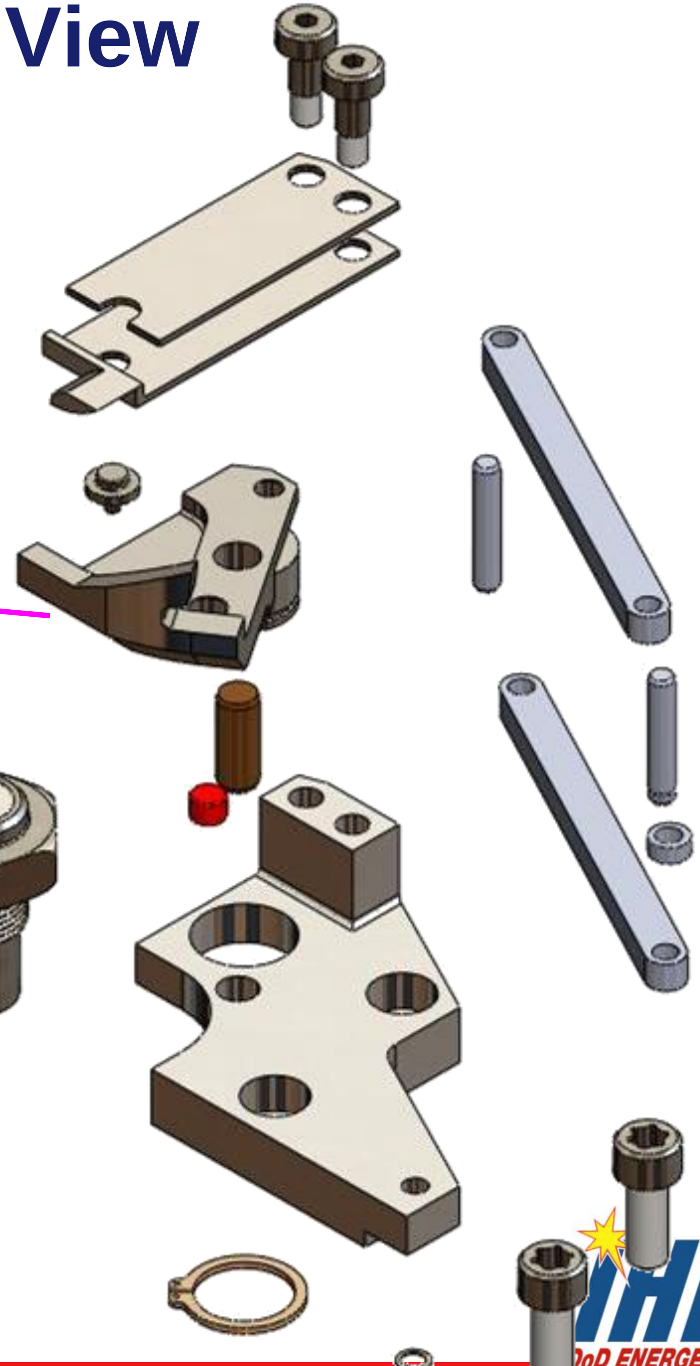
Exploded View



SLIDER



INITIATOR



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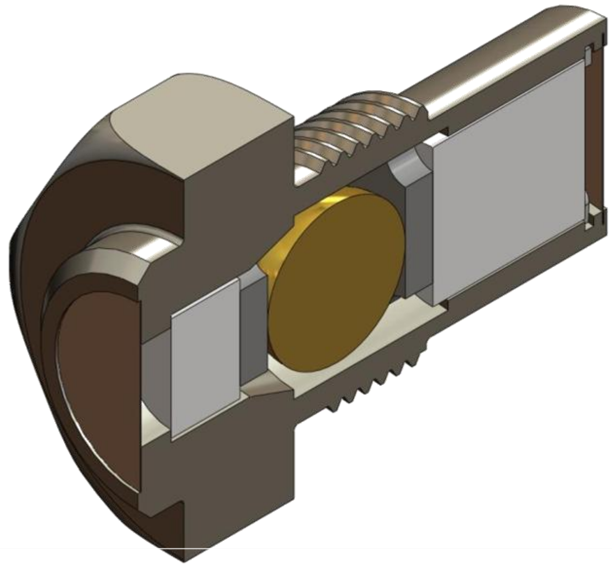
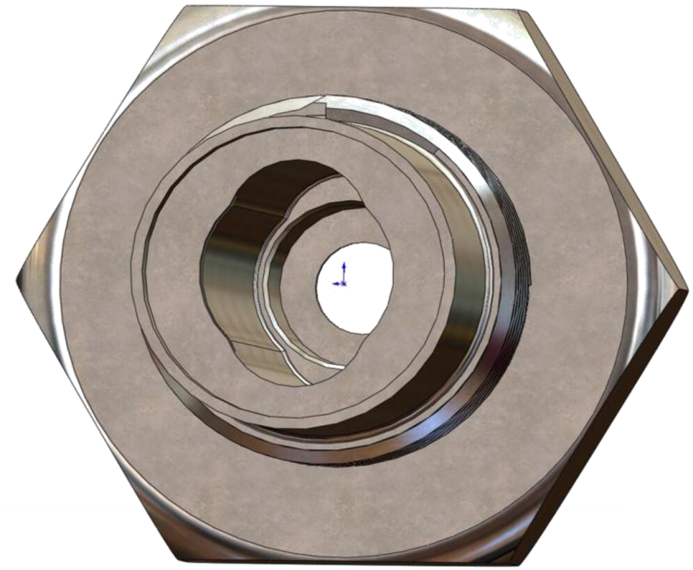
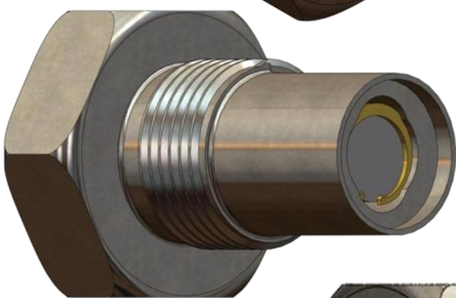
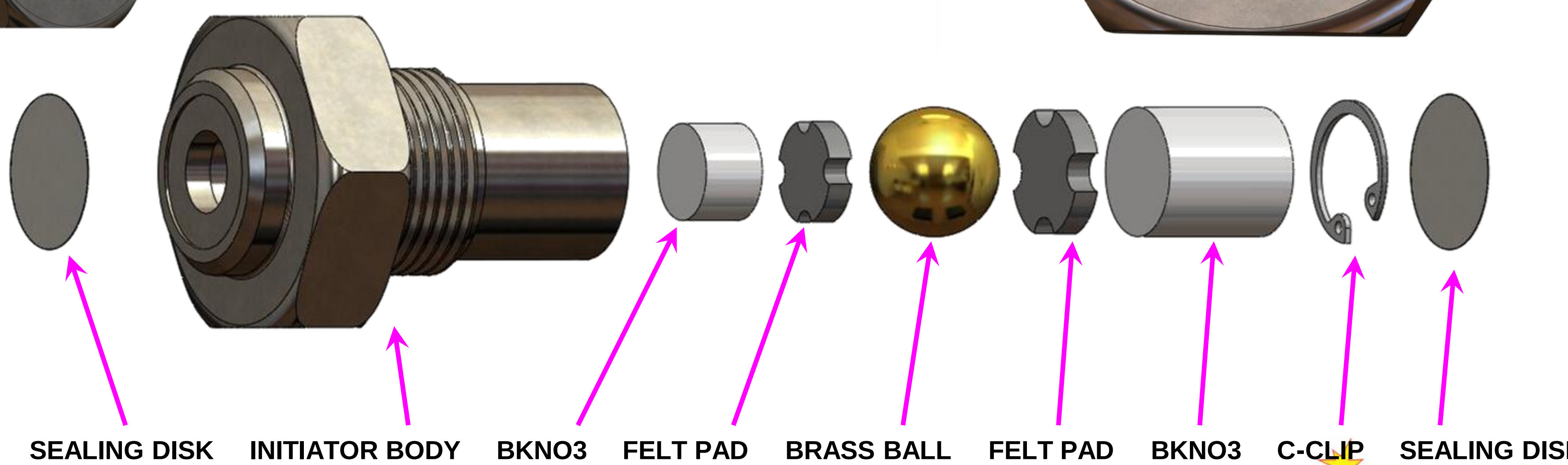
Anti-Blowback Initiator

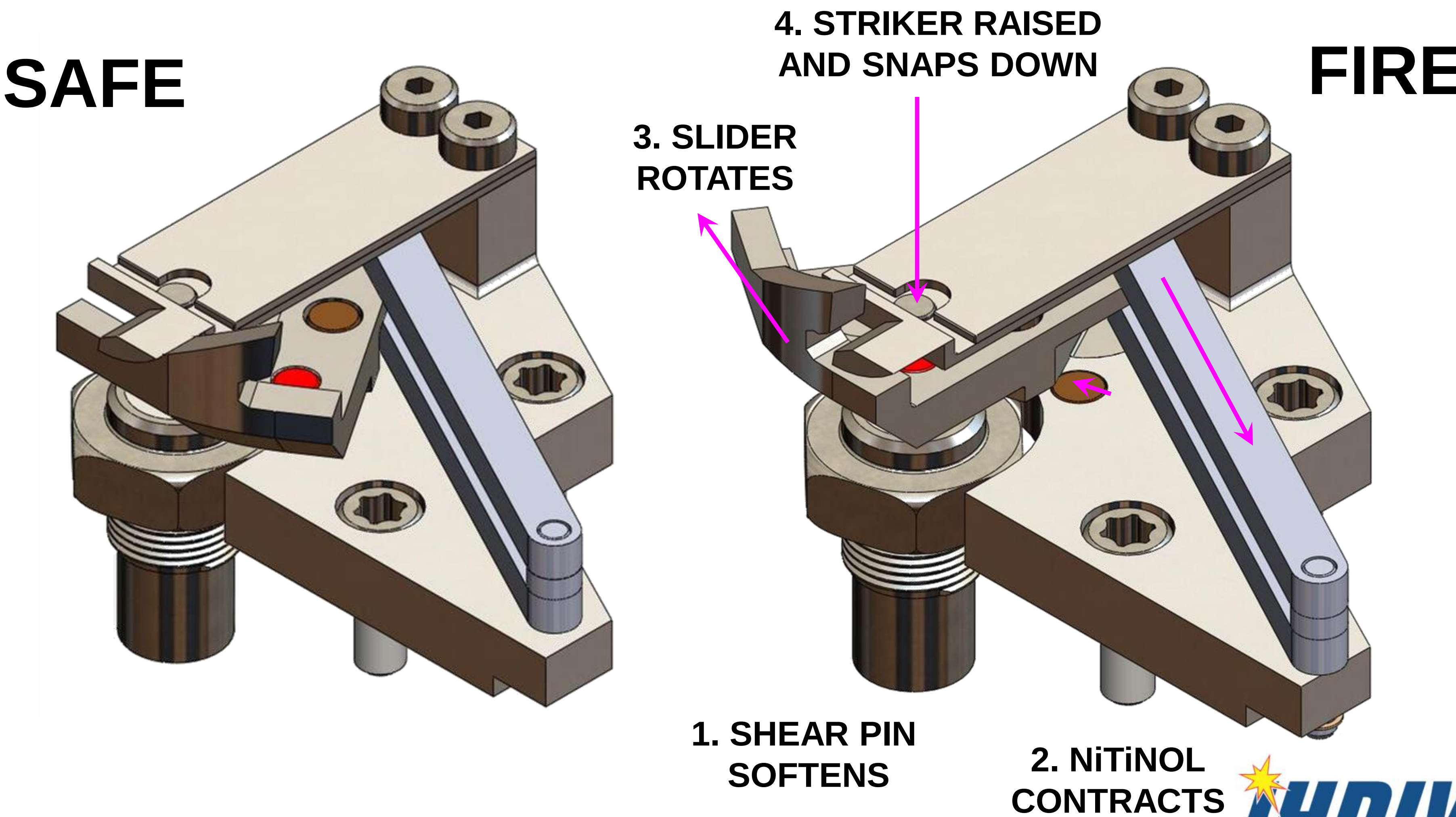






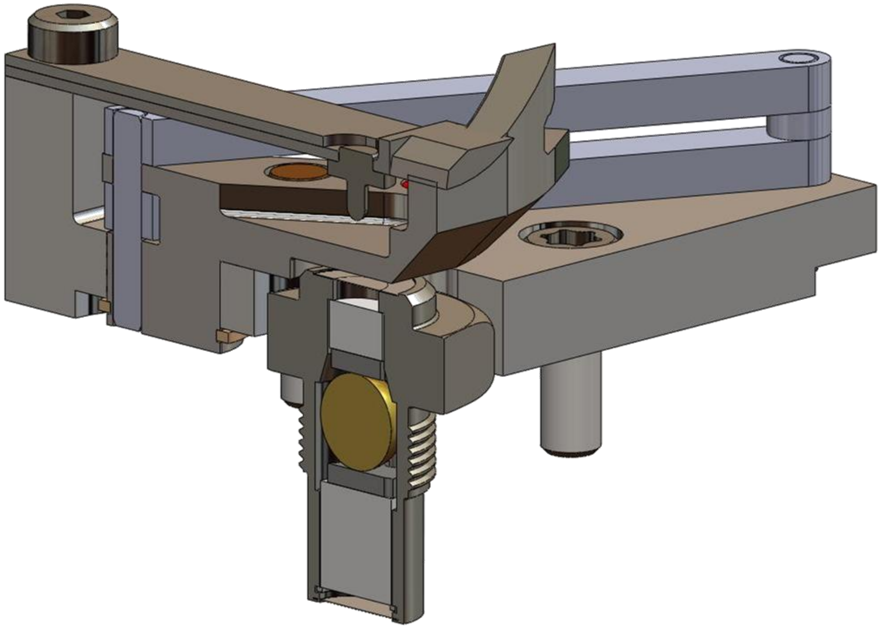


Safe and Fire (4% NiTiNOL Contraction)

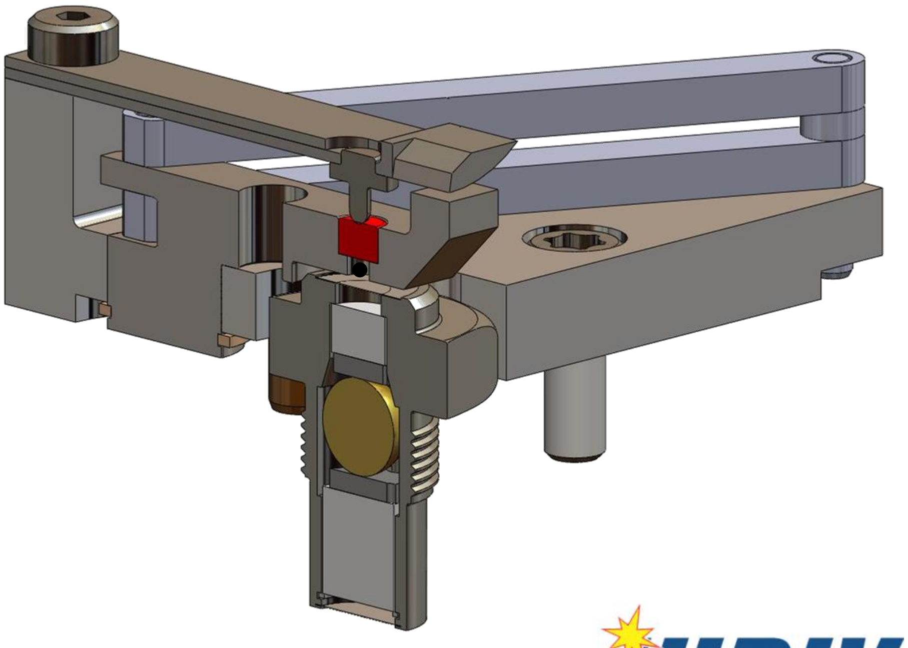


Safe and Fire Cutaways

SAFE POSITION



ARM/FIRE POSITION



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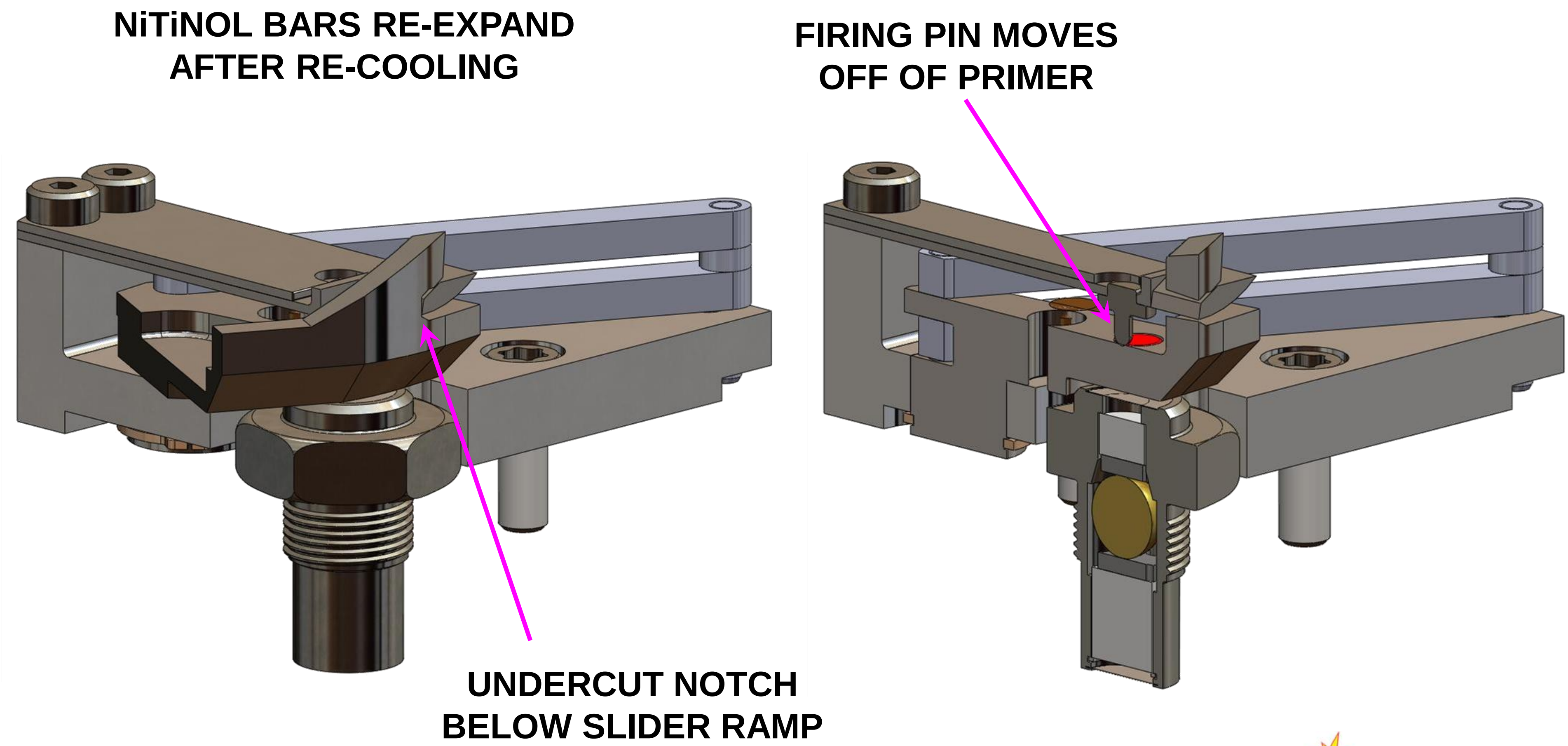
Retracted Position (Misfire)

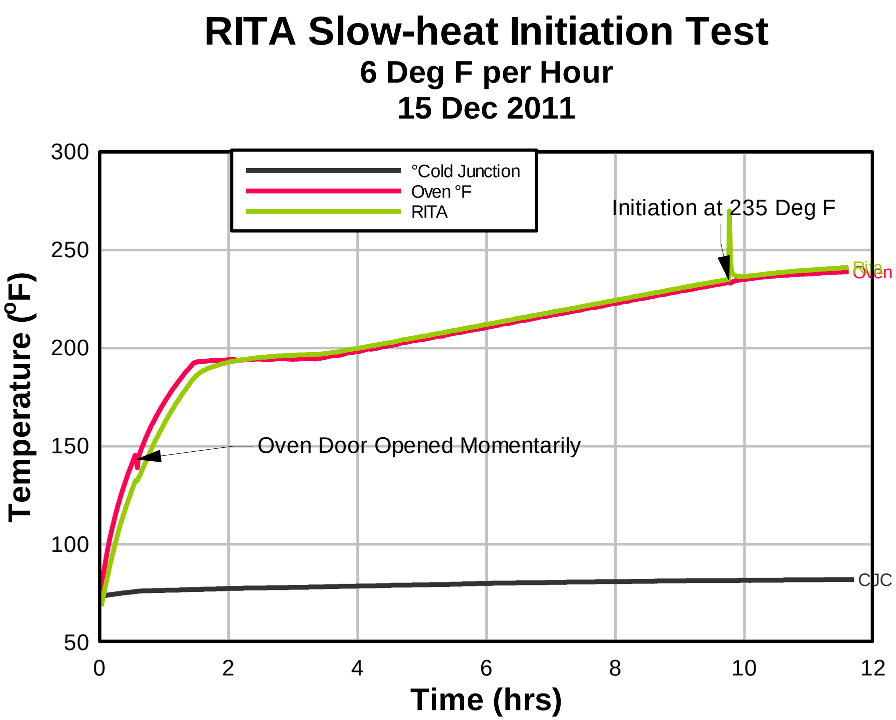


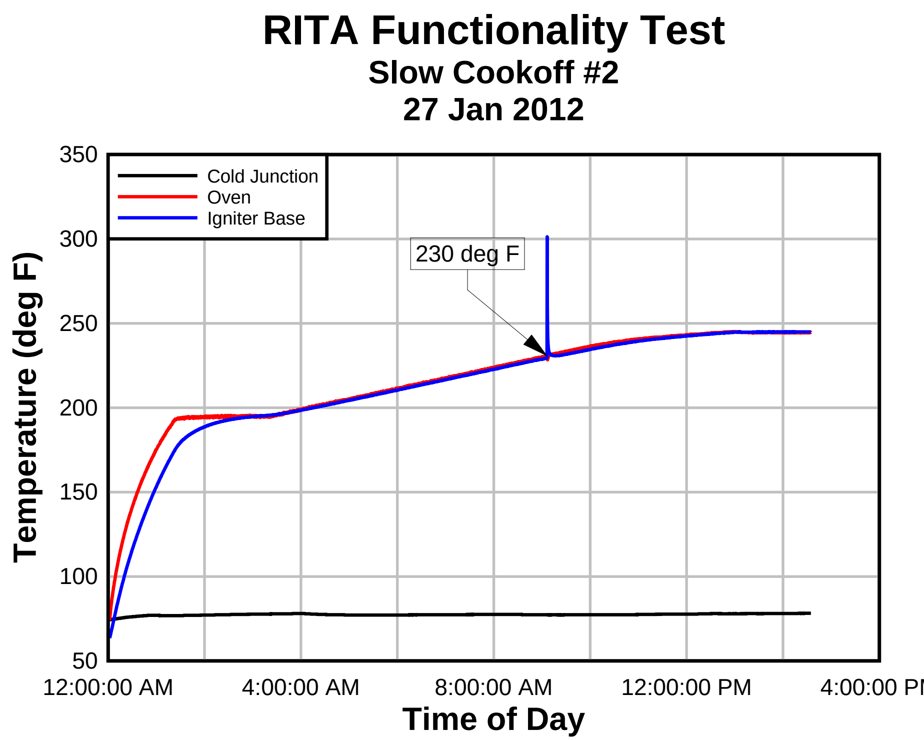
Successful Component Level Testing:

- **Pull-Testing of Springs to Confirm Proper Firing Energy**
- **Pull-Testing of Slider Assembly to Confirm Required Pull Force and Pull Energy Requirements**
- **Pull Testing of Slider and Shear Pin Resistance**
- **Striker Bar, Firing Pin, and Primer Initiation Tests**
- **Various Tensile Tests on NiTiNOL Bars to Confirm Available Pull Force and Pull Energy**
- **Transfer Testing Between Primer and Initiator**
- **Out of Line Safety Tests, Primer to Initiator**
- **Function Testing of Initiator Check Valve**
- **Function Testing of Two Slider Materials**
  - **Electroless Nickel Plated Teflon Impregnated SS Slider**
  - **Teflon Impregnated Hard Annodize on Aluminum Slider**

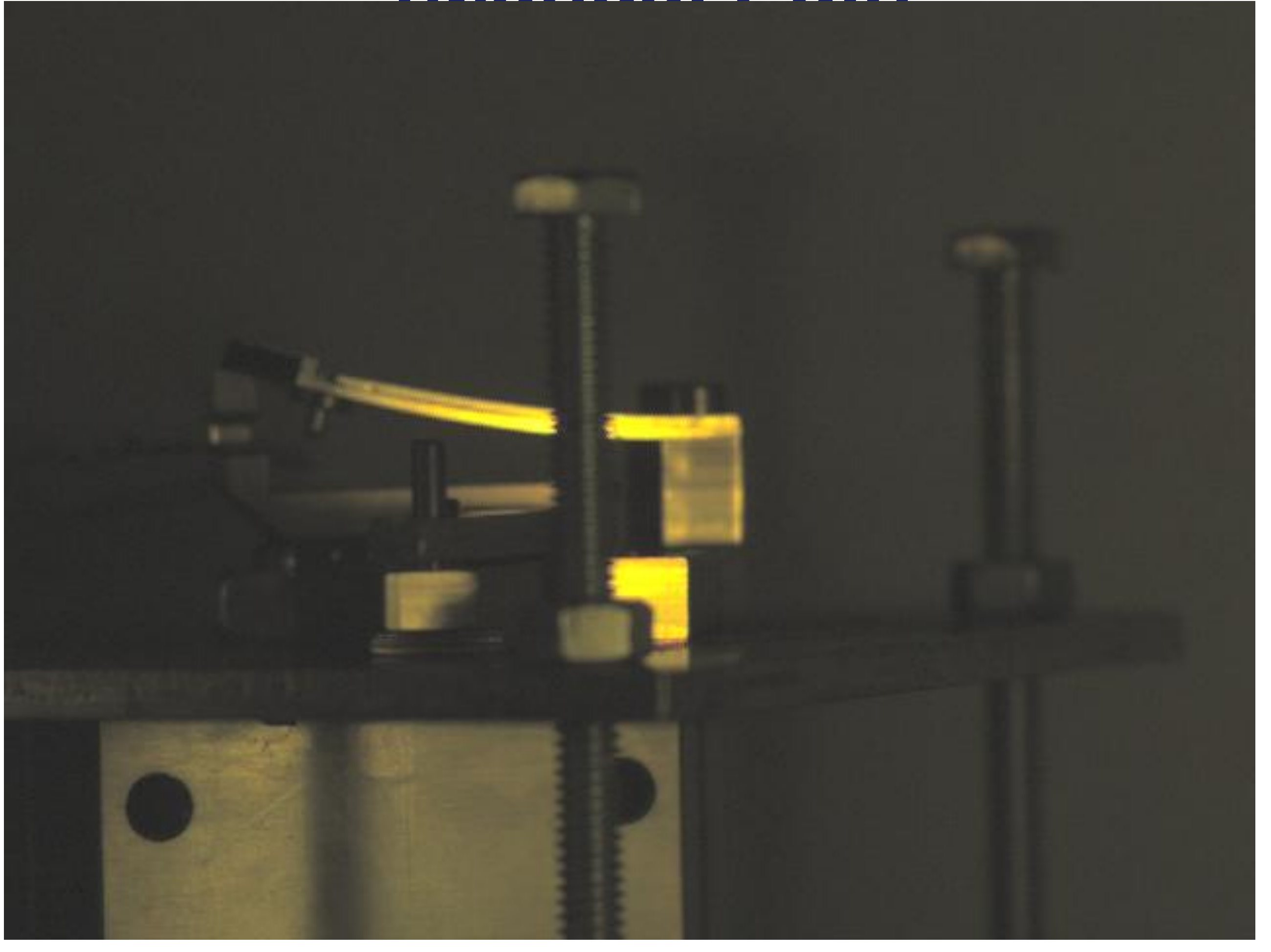
Successful Results of RITA Assembly SCO Tests

A thermocouple "witness" indicator was placed across the output of the check valve initiator.





High-Speed Video of RITA Functioning (Manual Pull)



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Conclusions

- The NiTiNOL based initiation device described here appears to be a viable active mitigation option
- The mechanism described is simple and robust, and appears to be safe and reliable, despite single environment (heat only) activation
- A full set of safety testing (drop, vibration, temperature cycling, etc.) still needs to be done, and likely some minor design refinements based on the test results
- Evolving active mitigation requirements have driven design modifications and features throughout the development of this device

Acknowledgements

- Intrinsic Devices Inc. for NiTiNOL Fabrication and Developing Requirements for the material
- ATR for their Support in Configuration Review
- Tidewater Machine for Drawing and Design Review and Hardware Fabrication
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  - Murthy Bettadapur – Material Selection & Testing Support
  - Ricky Johnson – Hardware Receipt Inspection
  - Danny Bouch – RM Assembly
  - Bob Johnson – RITA/Initiator Fabrication
  - Mike McDonnell & John Lawrence – Inert Component Testing
  - Paul Wallman & Mark Principe – Live Energetic Component Testing

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