IM Design Constraints for the LRLAP Warhead

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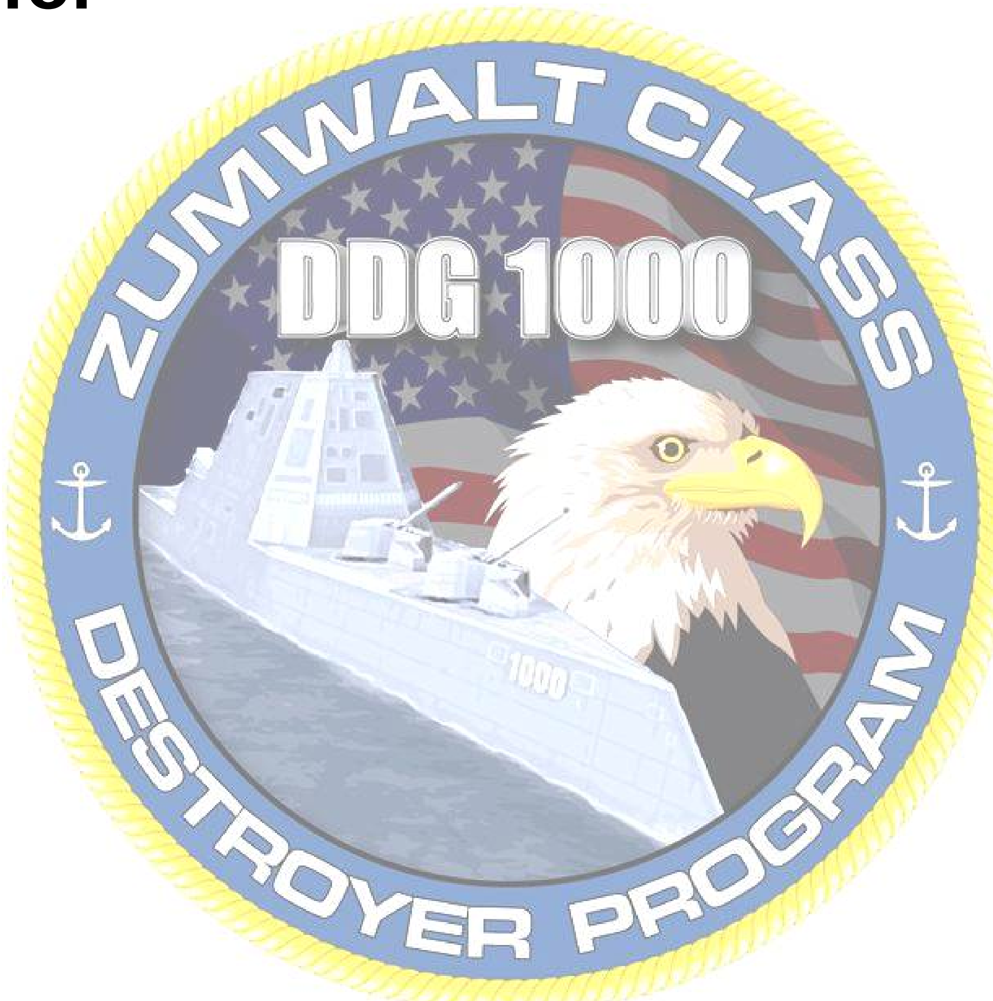
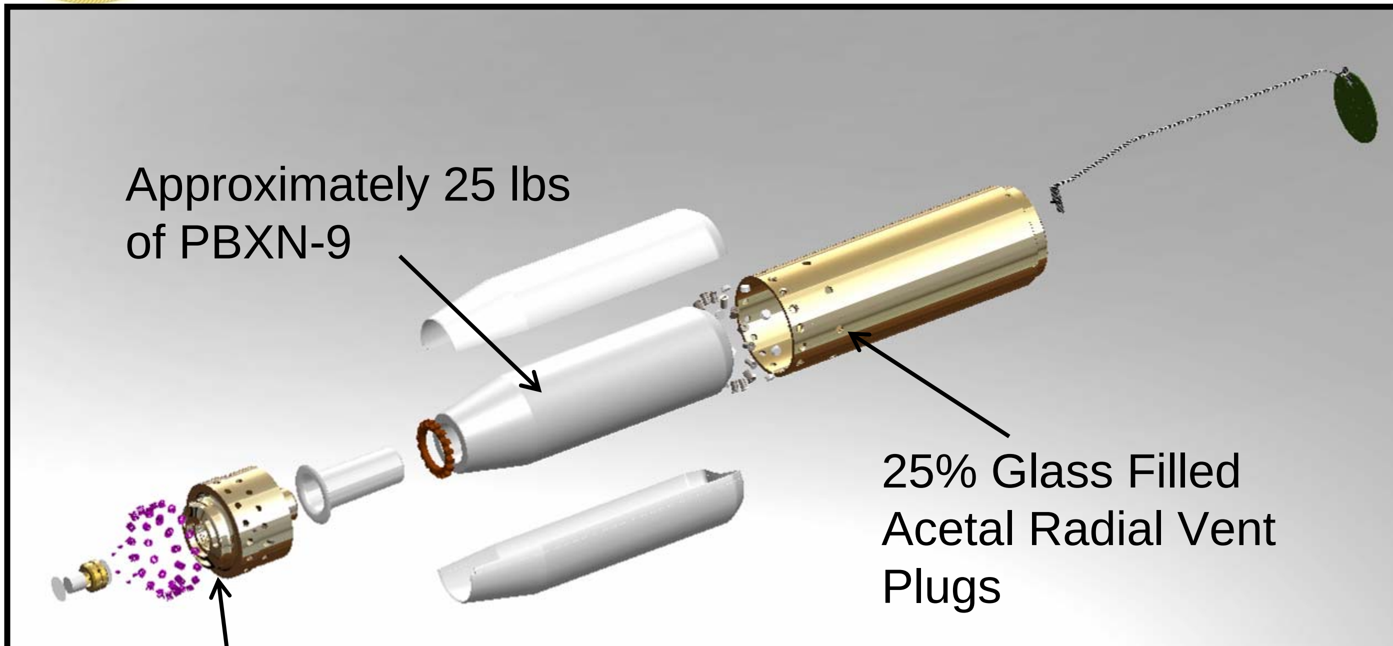


Overview

- Design Overview
  - Thermal Requirements
- LRLAP Warhead Design Evolution
- Thermal Analyses
- IM Tests

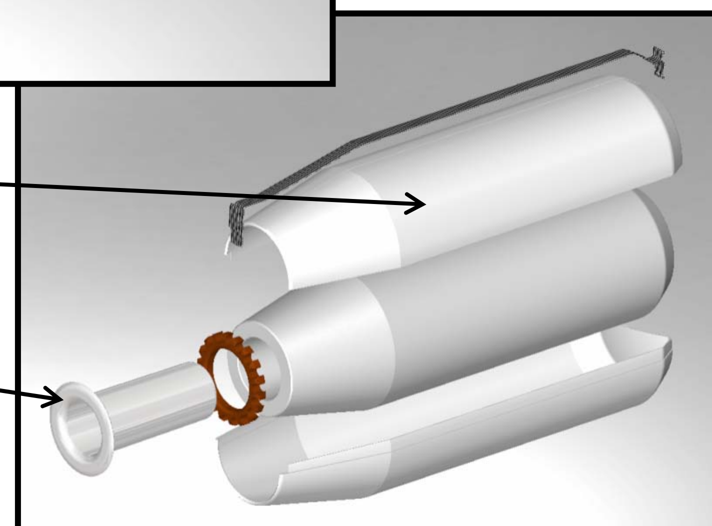
LRLAP Warhead Design



Venting Slots in Forward Closure

Two Piece Acetal Liner

High Density Polyethylene Top

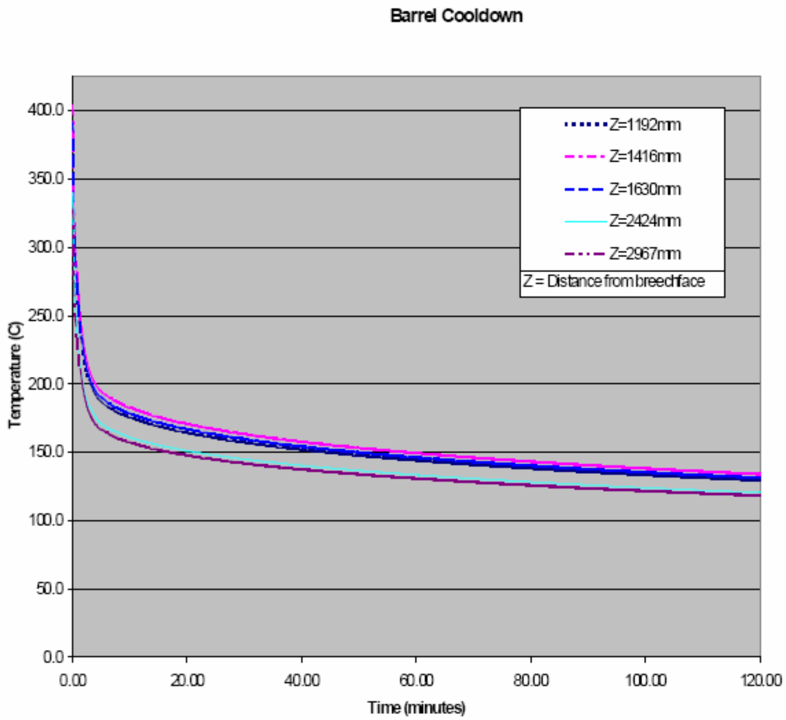


IM Design Evolution

- Preliminary Warhead Design
  - Problem Statement
    - Bounding the problem
  - Four piece liner design, HDPE and PEEK
  - Hot Gun Analysis
  - Hot Gun Test
  - Fast and Slow Cook-off Tests
- IM Design Changes
  - Hot Gun Analysis
  - Fast and Slow Cook-off Tests

Thermal Requirements

- Gun Launched Projectile subject to gun barrel cooling curve for time duration during firing



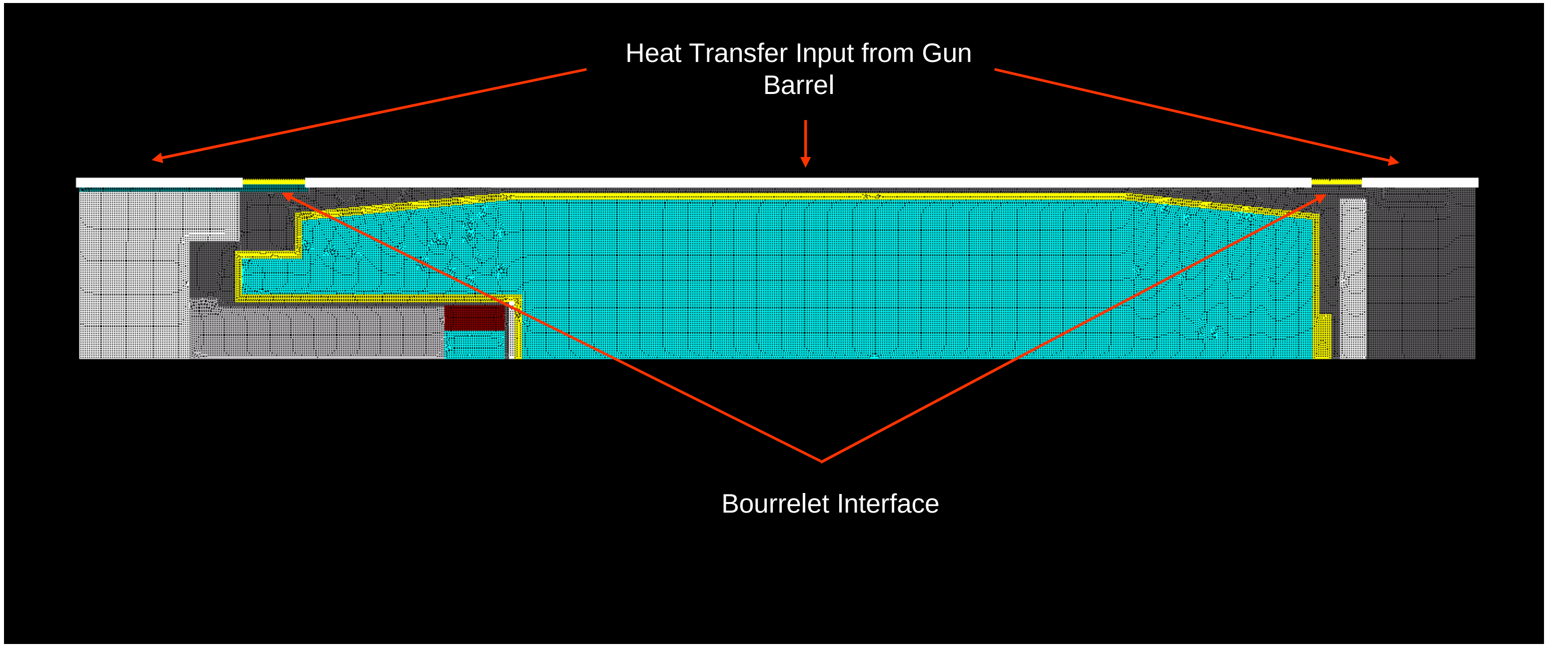
- Must have a Type V reaction for fast cook-off and slow cook-off (6°F/hr heat rate)

IM Problem Statement

- The LRLAP warhead needed to be design in order to meet two conflicting design requirements
  - An insensitive munitions liner was needed that would melt during a thermal event, such as fast and slow cook-off
  - The warhead needed to insulate the explosive such that sitting inside of a hot gun barrel for a two hour duration would not cause an adverse reaction
- How do we design an IM feature that melts for fast and slow cook-off but is thermally stable throughout the long duration Hot Gun environment?

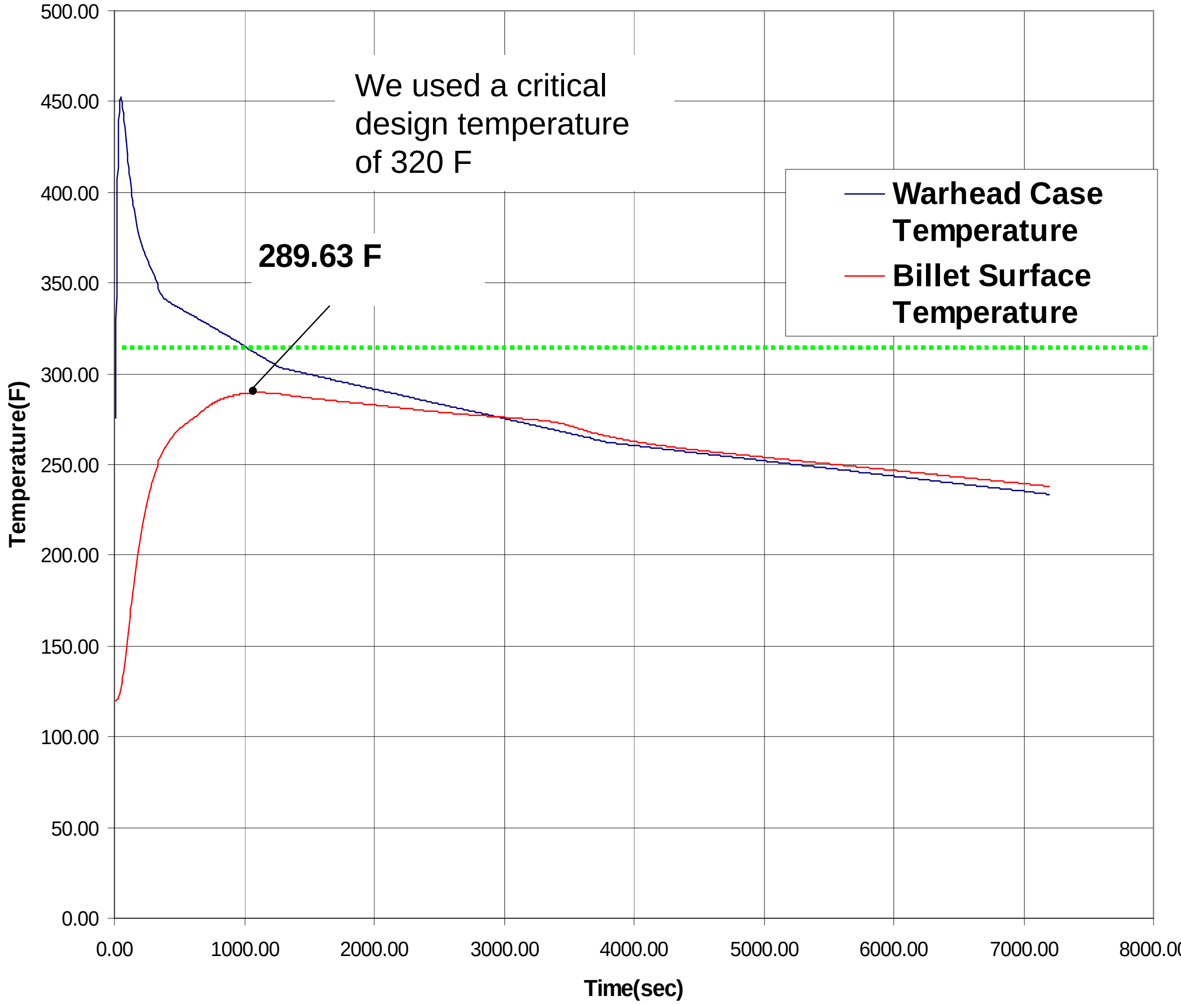
Preliminary Hot Gun Analysis

- Element plot shows different material properties used in analysis
- Boundary conditions used were convection and radiation
- High convection used at Bourrellets rather than conduction to simulate a more accurate boundary condition.



Preliminary Hot Gun Analysis

The temperature was recorded at the inner surface of the warhead case and the outer surface of the billet at nodes in the center of the warhead.

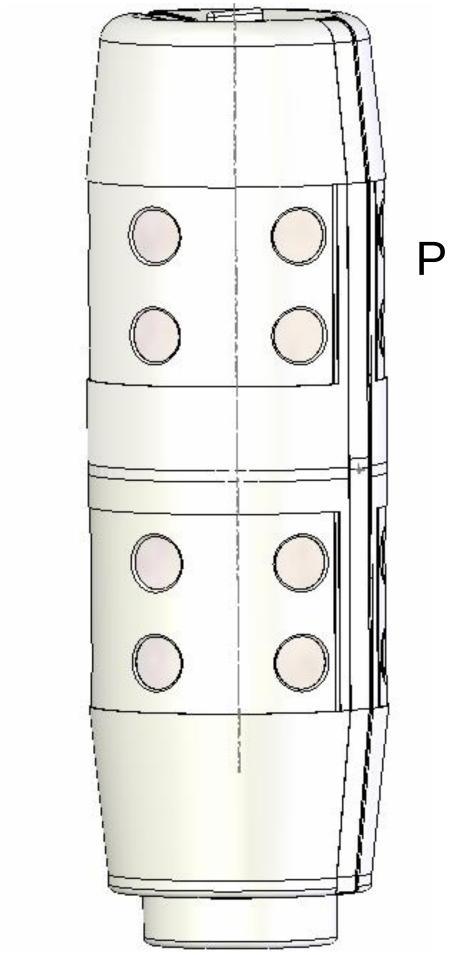


AGS Long Duratiuon Hot Gun Analysis With Grooved Thermal Shield Concept

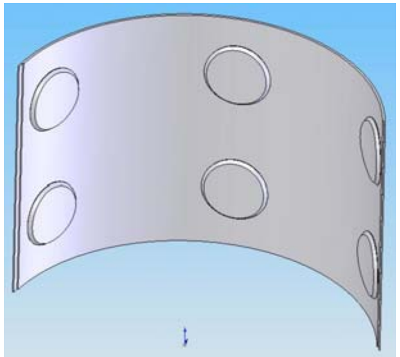
Thermal Analysis

- Analysis showed that the billet needed to be kept at a constant distance from the wall of the warhead case to minimize heat transfer to the explosive
- A high temperature plastic sleeve was designed to give the explosive a constant standoff
- In high production, HDPE could be injection molded around upper and lower sleeve so that billet will be held at a constant distance from the case wall

Two Piece High Density Polyethylene Liner

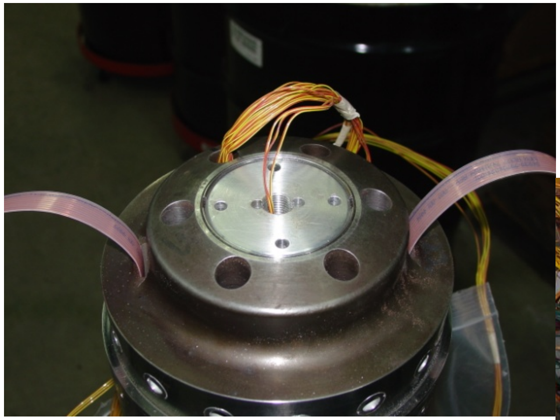


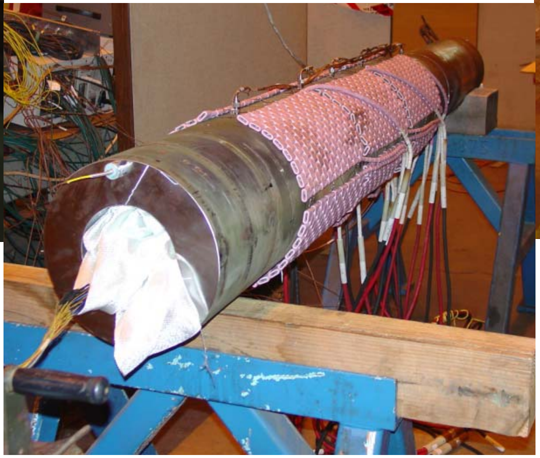
Polyaryletheretherketone (PEEK) Sleeves

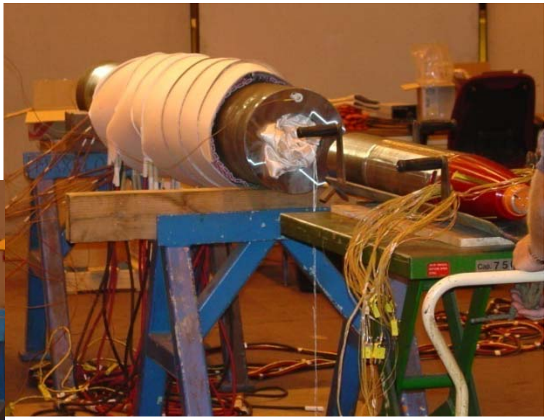


Hot Gun Test

- Hot Gun Test conducted in September 2004
  - Goal was to simulate the Hot Gun Environment
  - Inert warhead was instrumented with 24 thermocouples and placed inside 9 ft section of a M199 155 mm gun barrel
    - Thermal blankets used to control heat rate of barrel

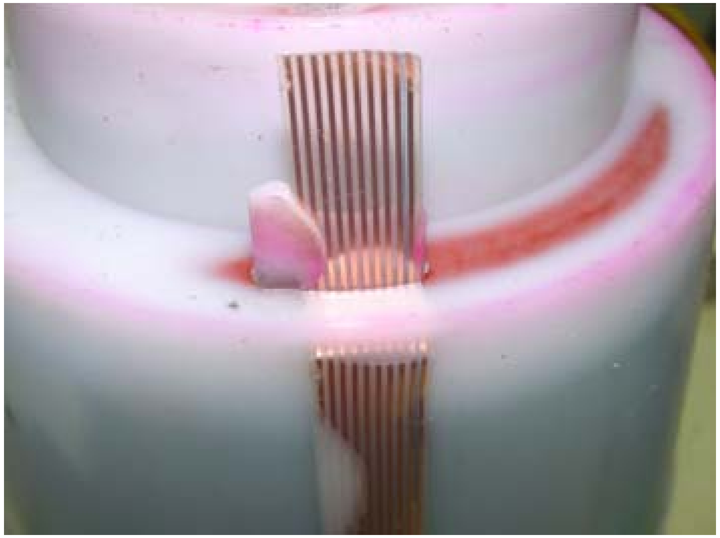


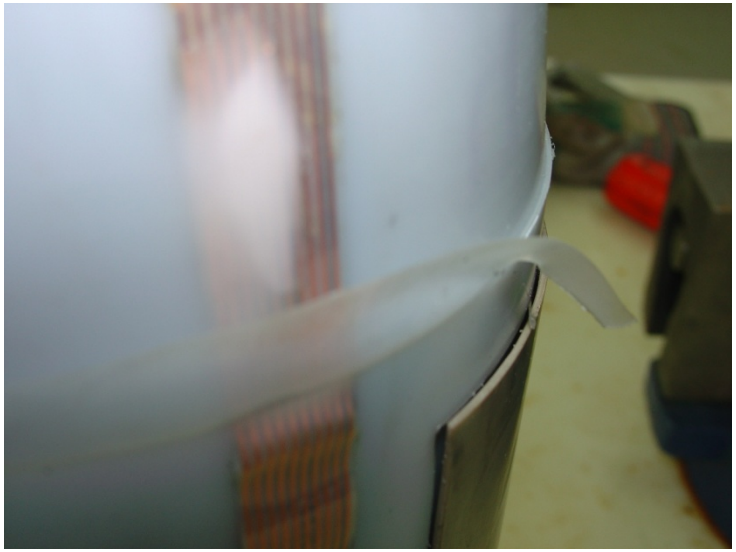




Hot Gun Post Test

- Billet temperature remained below its reaction temperature
  - PEEK sleeves maintained uniform spacing between billet and warhead case
- However, other warhead components became entrapped in melted plastic. This was potential for damage to occur during gun lauch

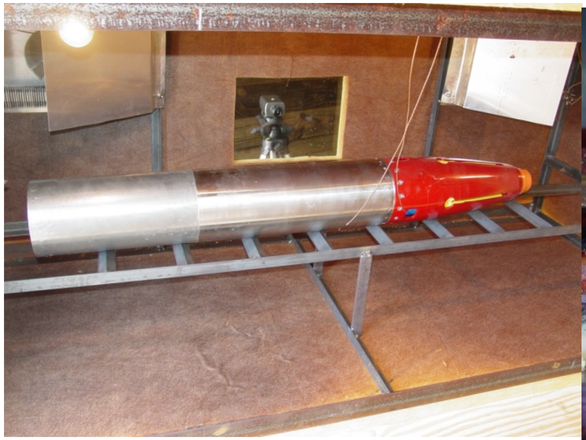


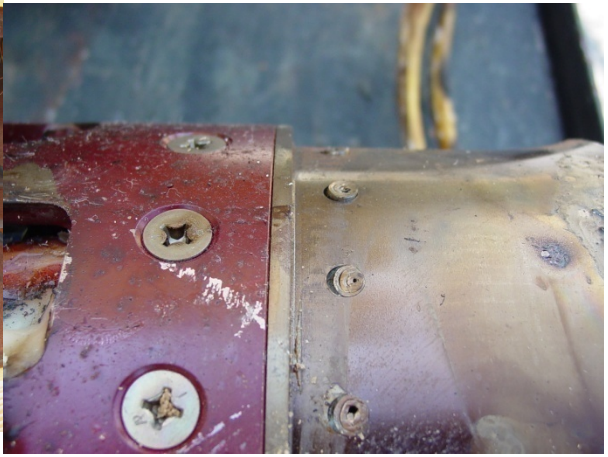


Cook-off Tests

- Fast Cook-off
  - Pressure build up caused pins to shear and free venting to occur
  - Type IV or V reaction

- Slow Cook-off
  - Again pressure caused joint to separate and venting to occur
  - Type IV or V reaction



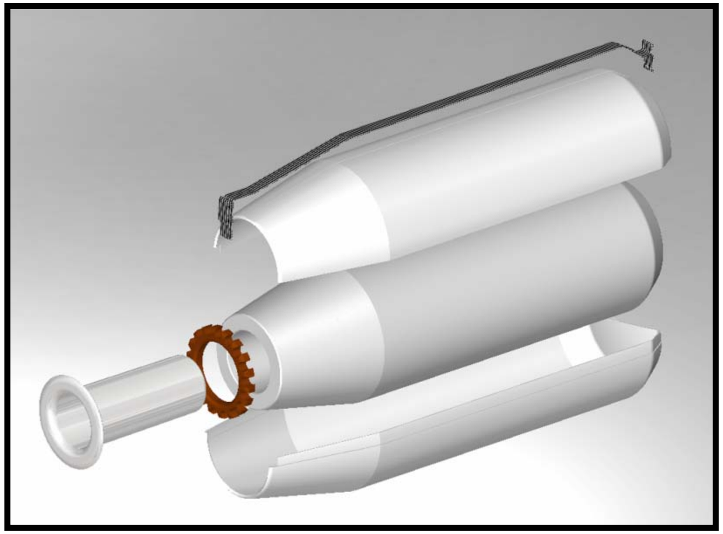


Redesign

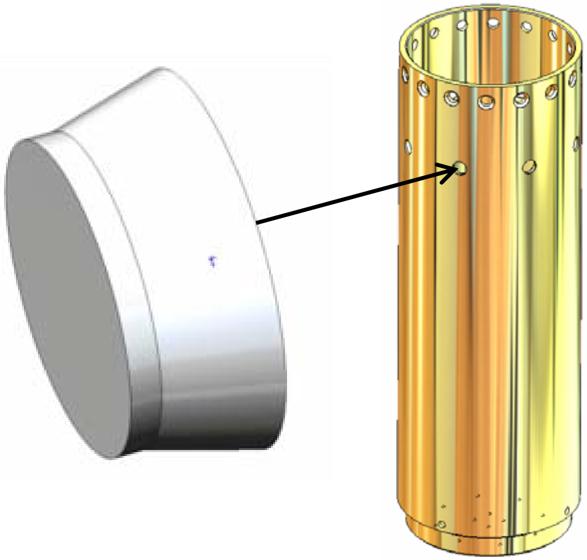
- IM liner was a known design flaw
  - Melting during a Hot Gun environment would not be permissible regardless of keeping explosive temperature low
- Adding to design difficulty, system level design maturity revealed that coiled pin joint design did not provide enough stiffness for flight
  - Threaded fastener joint must be used
    - Would not allow joint shearing to occur during cook-off
    - Needed to add more vent area to reduce pressure

Design Changes

- Solution to Hot Gun Issues
  - IM liner material change
    - – Acetal with a 330°F melt temperature

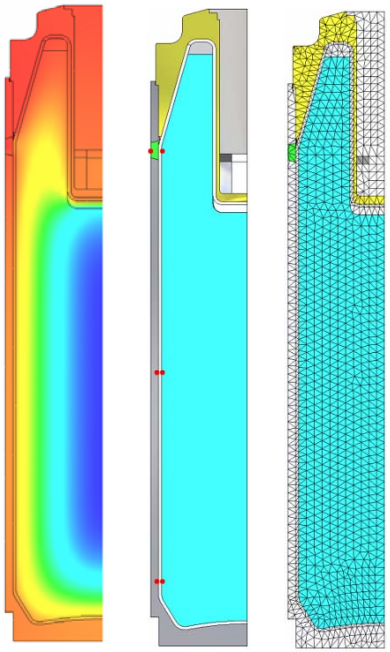


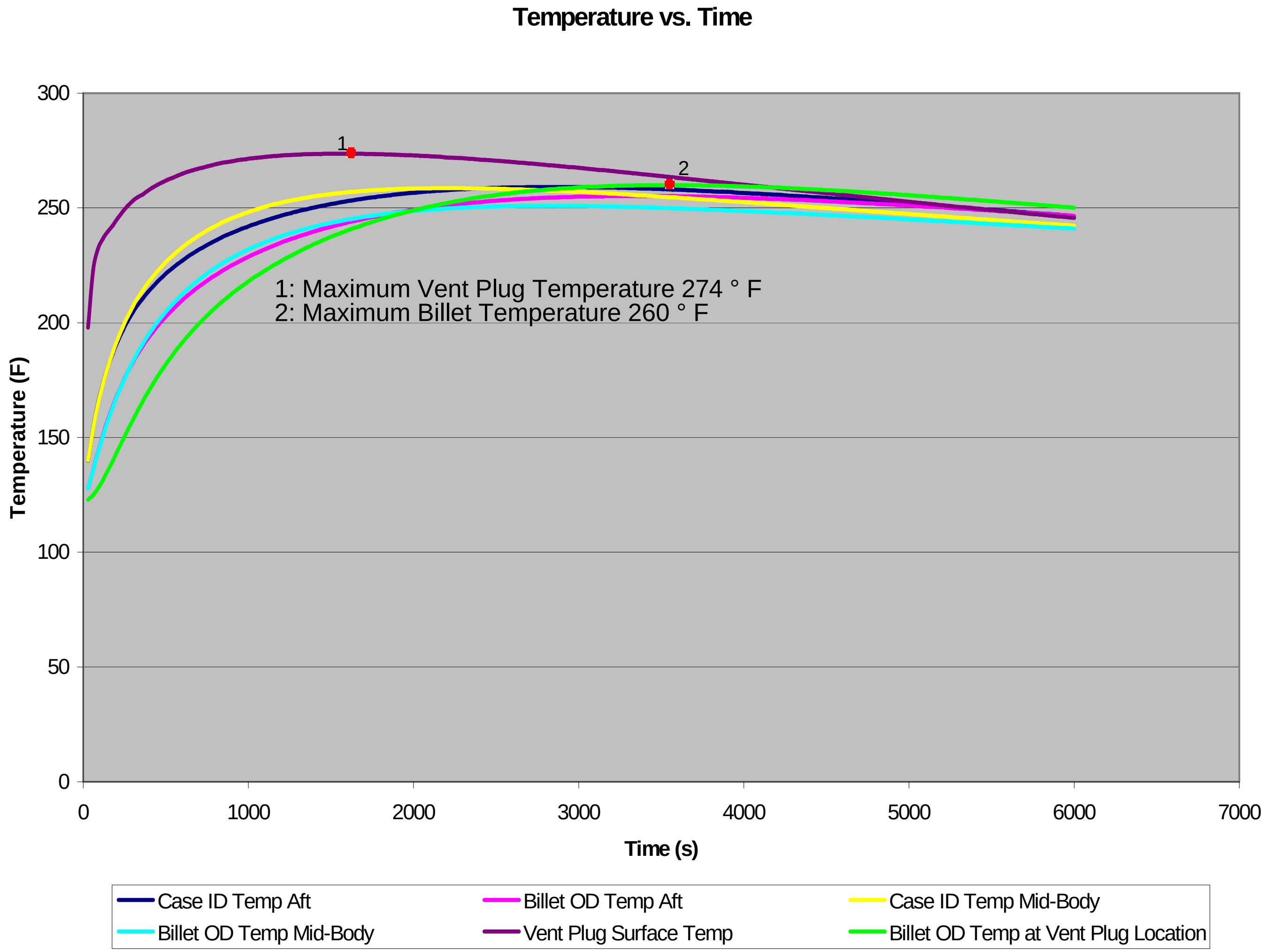
- Solution to Fast and Slow Cook-off Issues
  - Incorporate radial vents into design
    - – Vent plugs made from 25% glass filled acetal (glass provides structural rigidity for gun launch)



Hot Gun Analysis- New Design

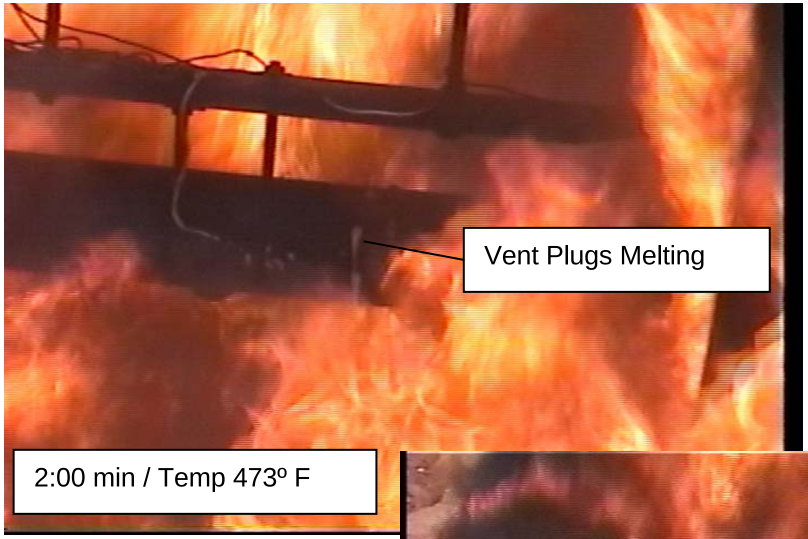
- Billet remains well below cook-off temperature
- Vent plugs and liner remain below melt temperature

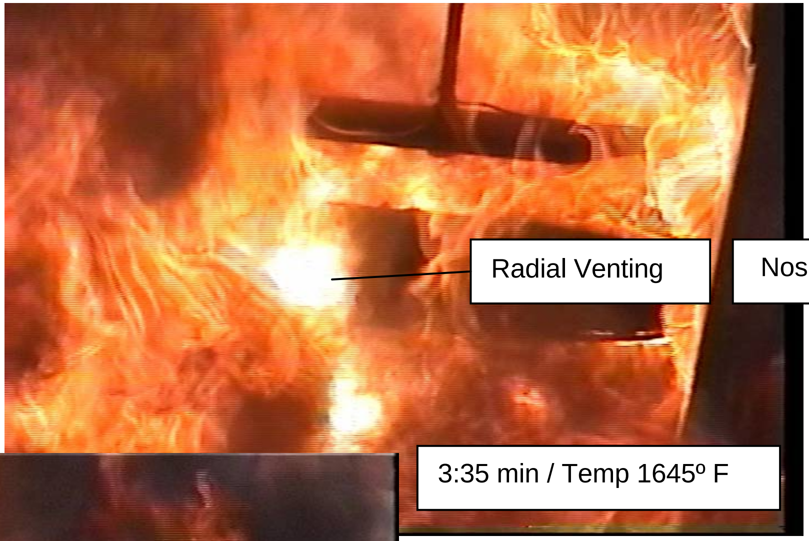


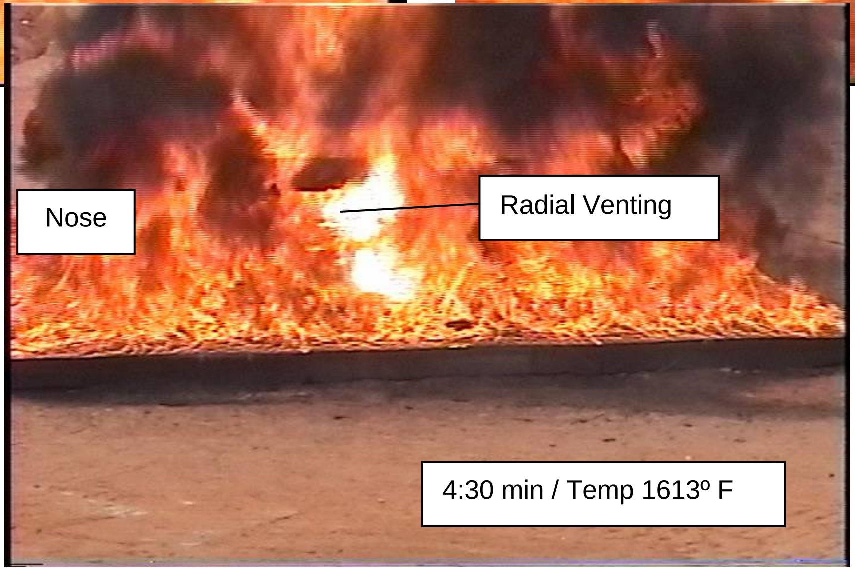


Fast Cook-off Test- New Design

Video Clips



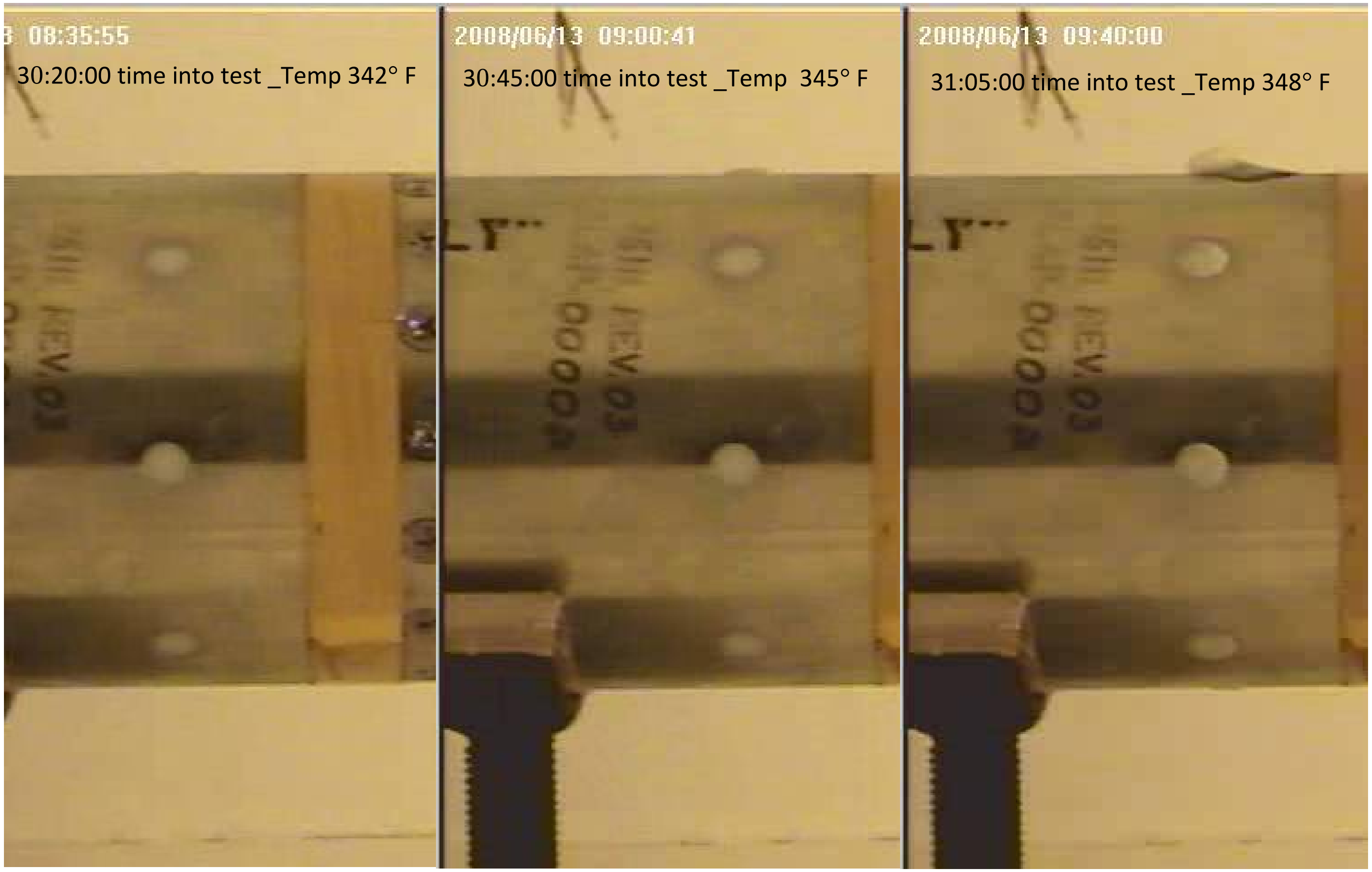




Reaction Considered Type V

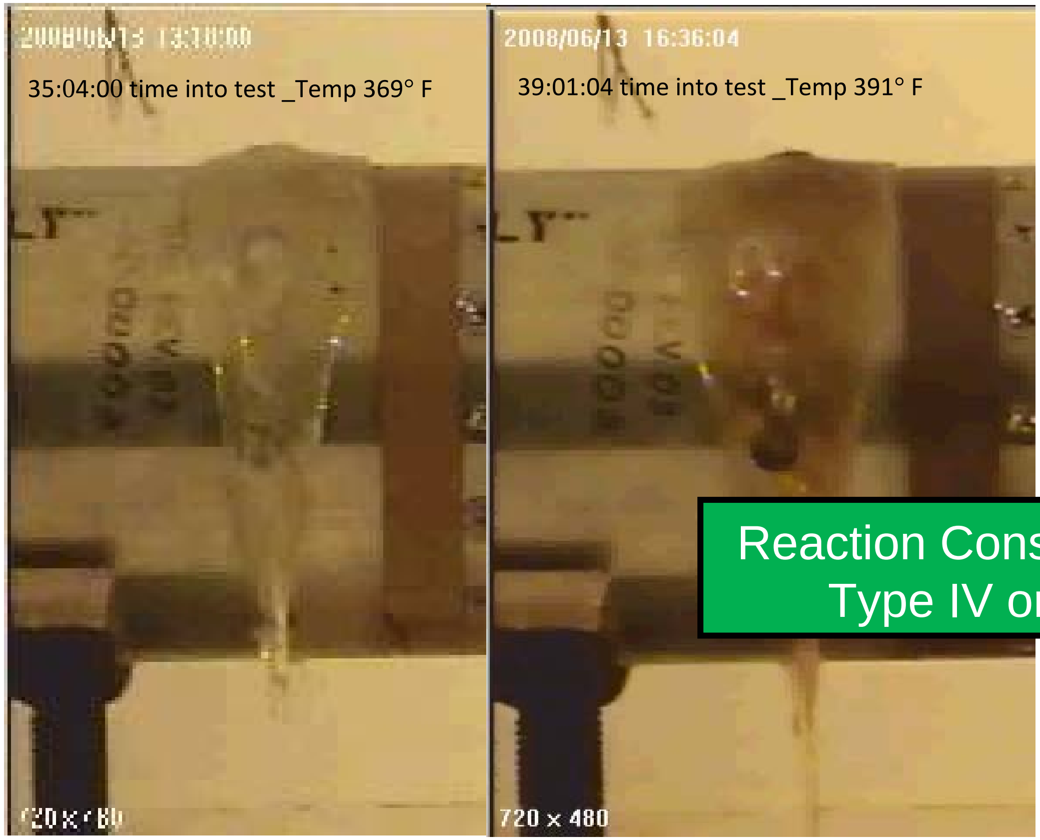
Slow Cook-off Test- New Design

Timeline

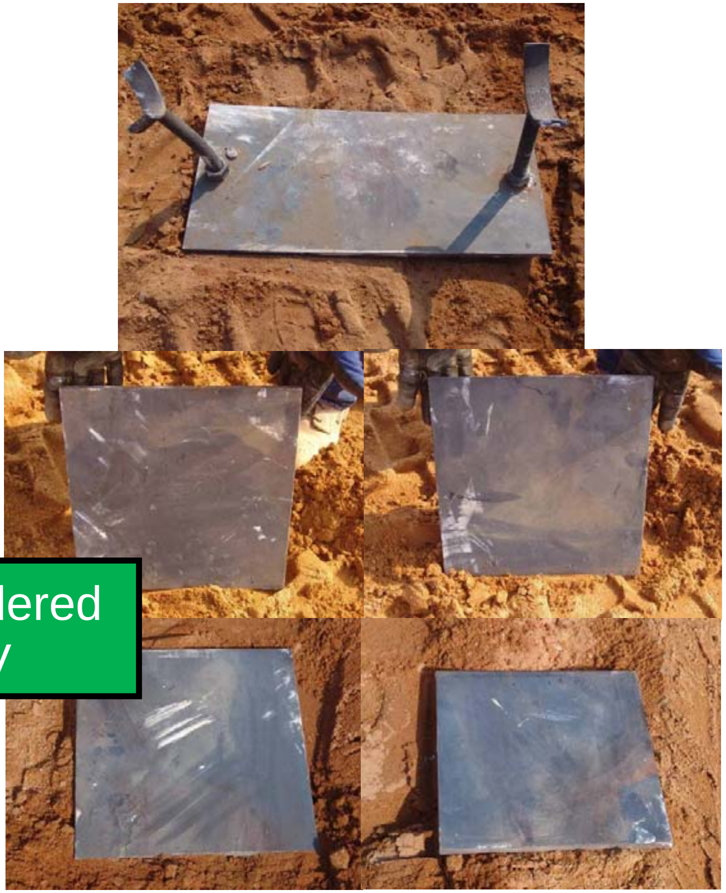


Slow Cook-off Test- New Design (Cont'd)

Timeline



Reaction Considered
Type IV or V



Shows the possible decomposition of
the PBXN-9 elements.

Conclusions

- Initial design was successful at maintaining a constant spacing between warhead billet and case
  - Resulted in thermally stable billet in Hot Gun environment
  - Was not successful at keeping internal components from being encapsulated in the melted IM liner
  - ✓ Solution: Analysis of new liner material indicates that melt temperature will not be reached, thus internal components will survive
- Change to threaded fasteners would no longer allow joint to shear and vent area to increase as pressure increased
  - ✓ Solution: Fast and Slow Cook-off tests reveal Type IV or V reaction is achieved with radial vents