

DOSG Science & Technology

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# Developing an Understanding of Variables that Impact on Unknown-to-Detonation Transitions (XDT) in GAP/Nitramine Propellants

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# Overview

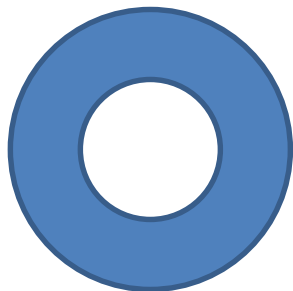
- Introduction
- Trials Hypotheses
- Trials Programme
- Outcomes
- Conclusions
- Further Work
- Questions

# Introduction

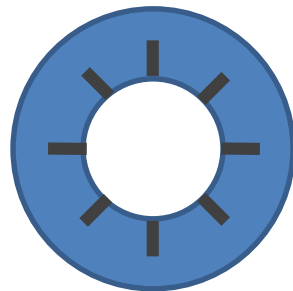
- Following previous work on propellants and booster materials – the UK commissioned work to investigate the XDT effect in Rocket Motor propellants
- Specifically on a GAP/Nitramine Propellant
- Programme put together to investigate whether XDT can be ‘turned off and on’ with minor changes
- Looking at:
  - Bore size
  - Bore geometry

# Trials Hypotheses

- Two main hypotheses to be tested:
- Changing the bore geometry (including slots) will 'turn off' XDT

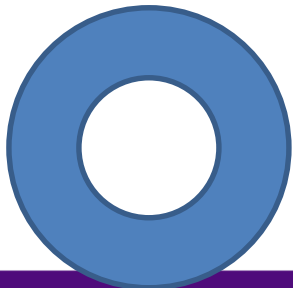


XDT

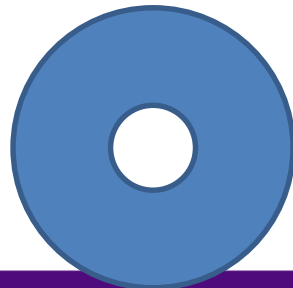


No XDT

- Changing the bore size will 'turn on and off' XDT



XDT

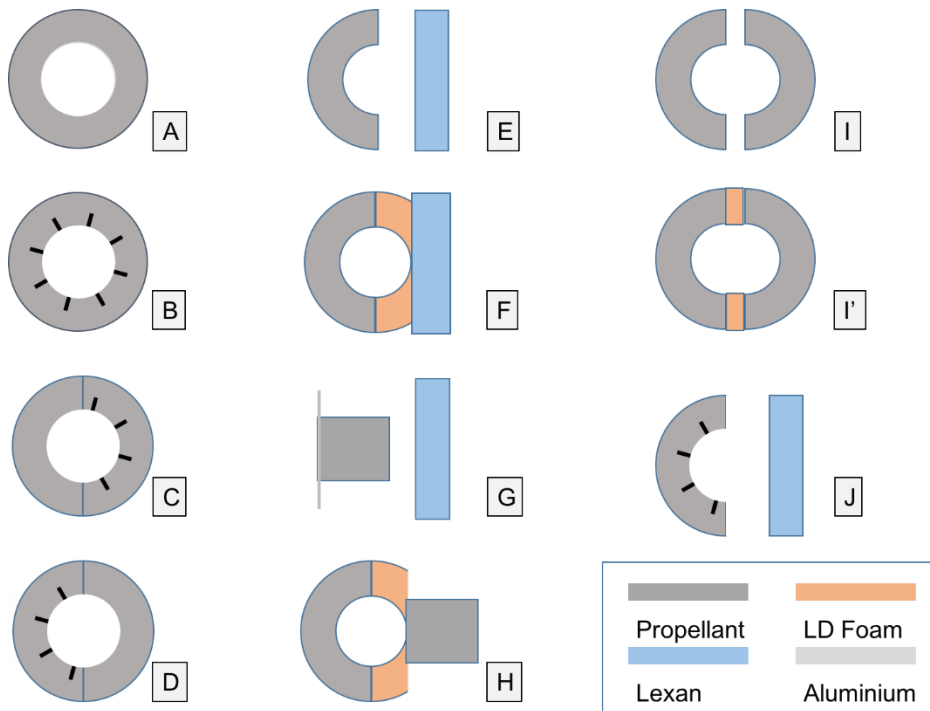


No XDT

Spoiler alert:

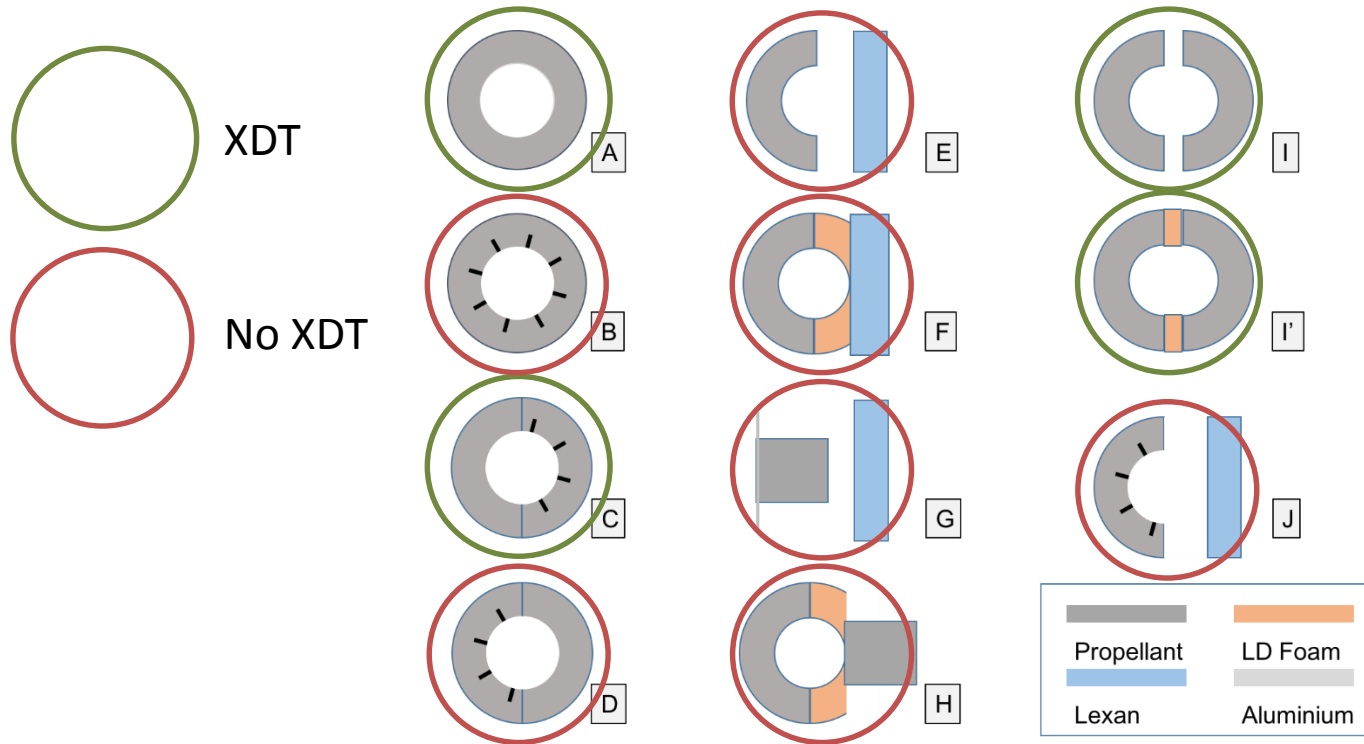
**THESE HYPOTHESES QUICKLY  
WENT OUT OF THE WINDOW**

# Trials Programme

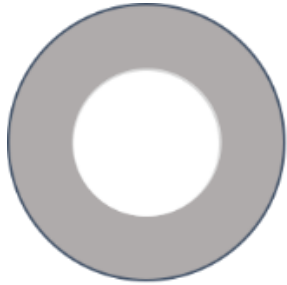


Target Type	Notes
A	Plain smooth-bore motor section, 60 mm long
B	Stellated-bore motor section, 60 mm long
C	Smooth-bore half section at the impact side, and slotted half-section downstream
D	Slotted-bore half-section at the impact side, and smooth half-section downstream
E	Smooth-bore half-section at impact side, and inert Lexan plate downstream. The separation between the Lexan plate and the half-section was 15, 30 and 45 mm
F	Smooth-bore half section at impact face and Lexan back plate. In-fills used to simulate an inert down-stream section of the same bore diameter as the live motor
G	Aluminium cover plate 6 mm thick at impact face, in contact with a solid cylindrical pellet (cylindrical axis in-line with impact direction) and with a Lexan plate downstream. The spacing between the rear face of the pellet and the Lexan plate was 20, 30, 35, 38, 40 and 63 mm
H	Smooth-bore half-section at impact side, with in-fill inert simulated bore, backed by a solid cylindrical pellet
I	Smooth bore half section at impact side, with smooth-bore half section at the downstream side, separated by an air gap of 5 mm
I'	Smooth bore half section at impact side, with smooth-bore half section at the downstream side, separated by a foam in-fill of 5mm thickness
J	Slotted bore half-section at the impact side, and Lexan inert plate downstream. The spacing between the Lexan plate and the impact section was 30, 45 and 60 mm

# Outcomes



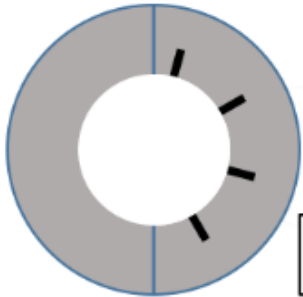
# Configurations that XDT



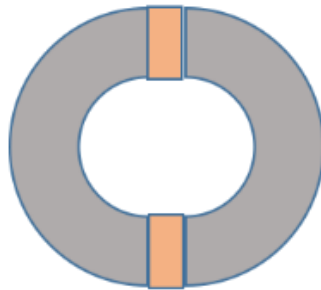
A



I



C



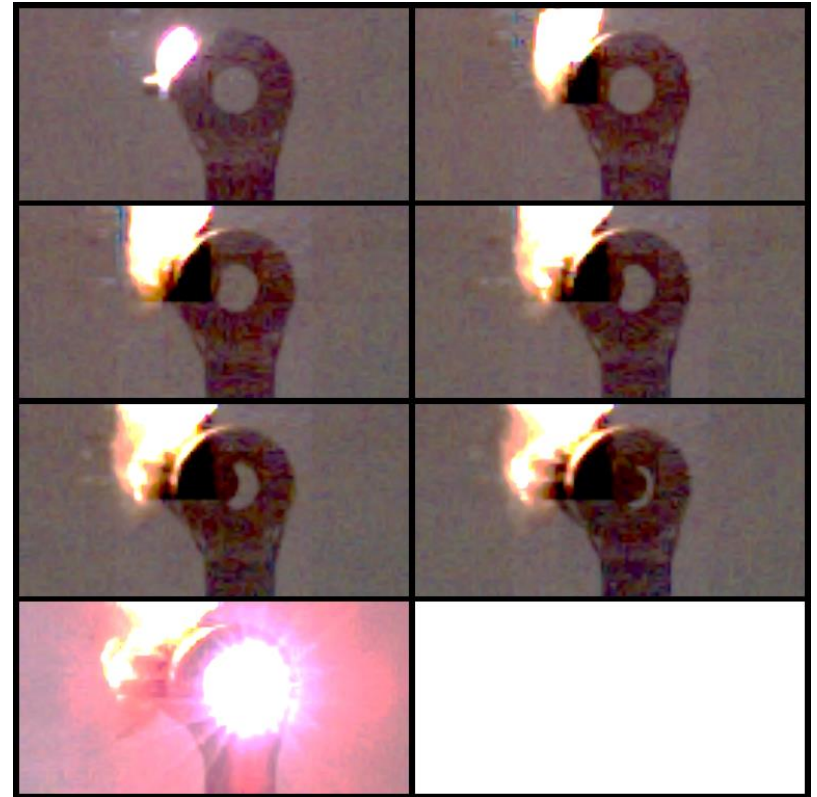
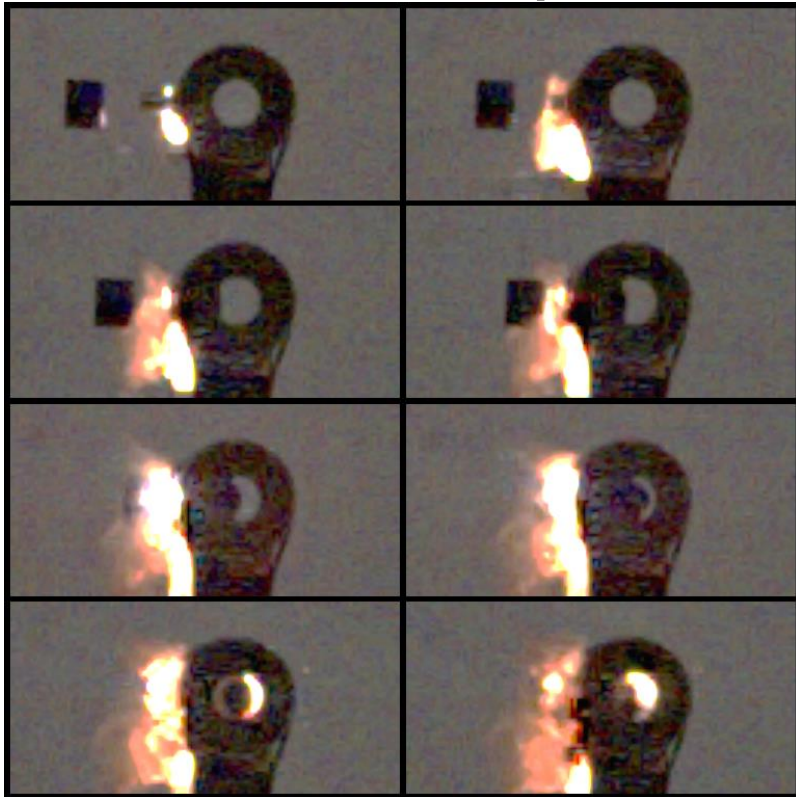
P

What do all of these have in common?

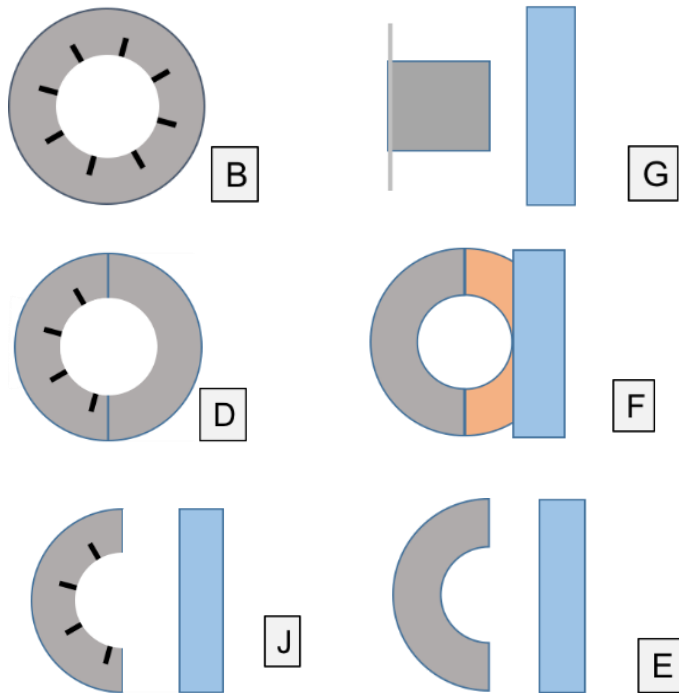
- Smooth bore internal towards when the fragment is striking
- Energetic impact surface



# Examples of Ignition vs. XDT



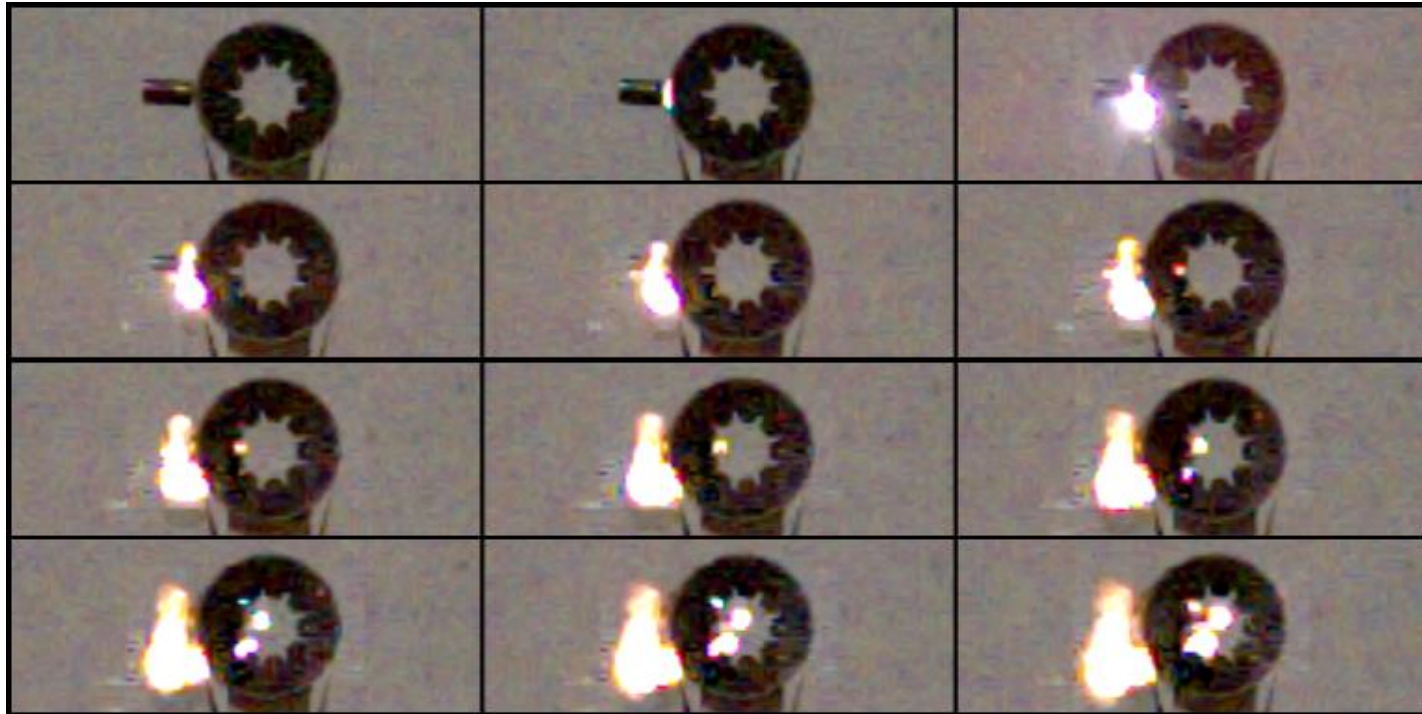
# Configurations that DO NOT XDT



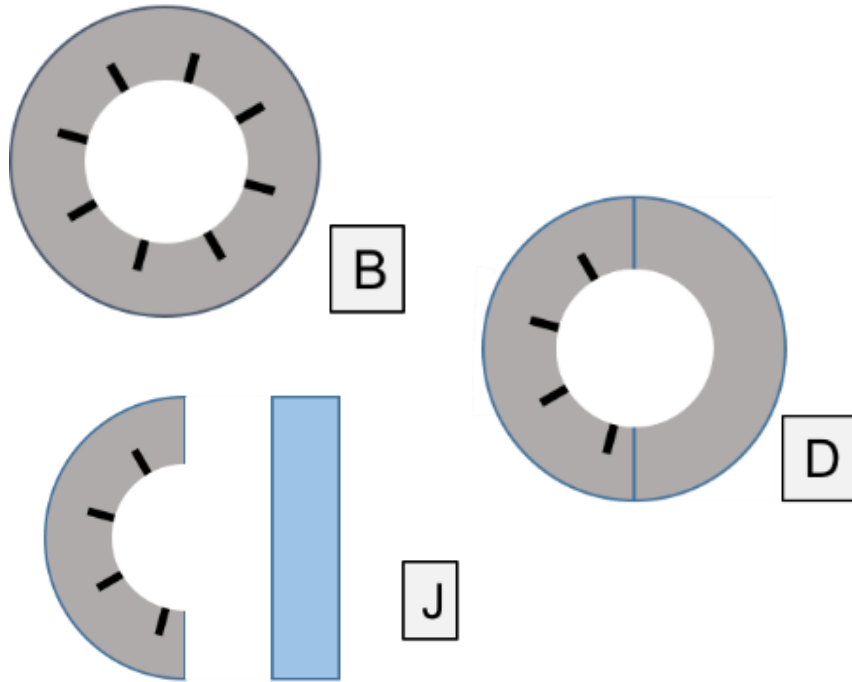
Can broadly fit into two categories:

- Slotted bore internal towards when the fragment is striking
- Inert impact surface

# Example of Slotted Bore

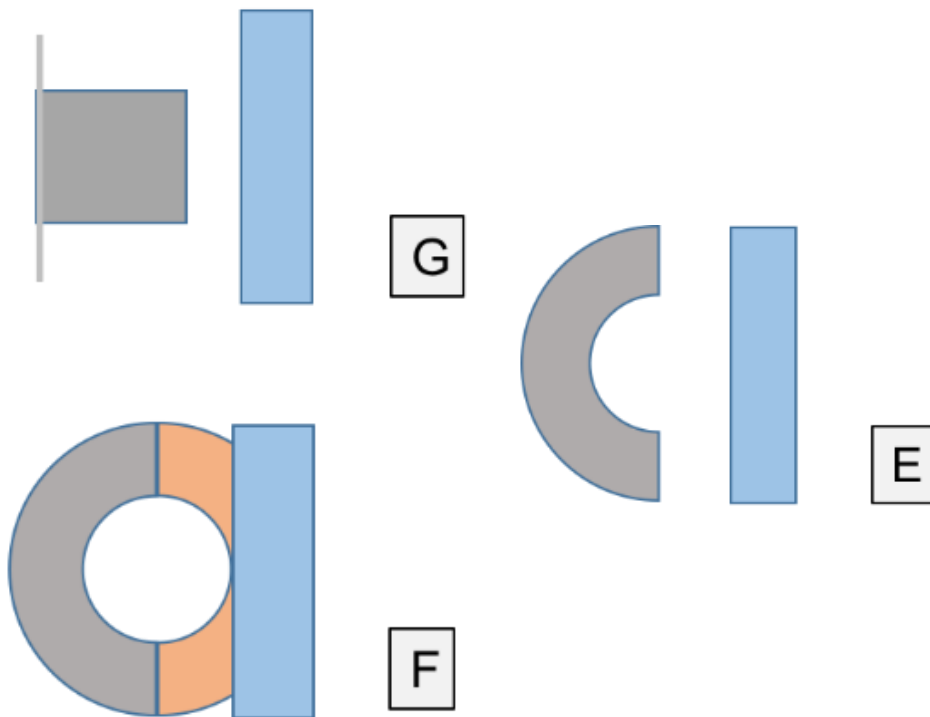


# Slotted Bores



- Slotted bore Rocket Motors do not appear to XDT
- Hypothesis – The jetting effect pre-ignites the ‘XDT cloud’ – meaning it has not developed the correct density for XDT to occur
- Previous work with this work seems to confirm this hypothesis

# Inert Impact Surfaces

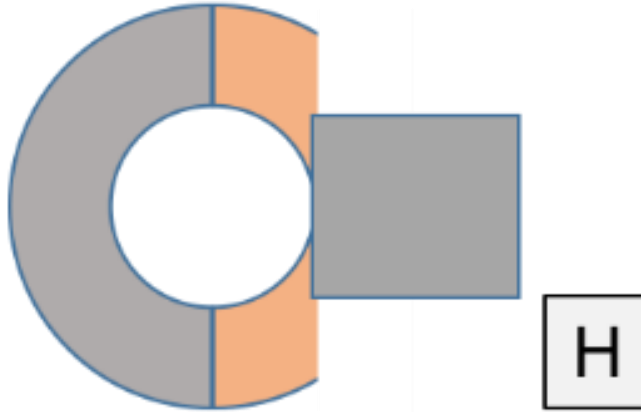


- Hypothesis – XDT requires an energetic secondary surface for XDT to occur
- Previous work **DOES NOT** seem to confirm this hypothesis

# XDT Example Video



# 'Sore Thumb' Result

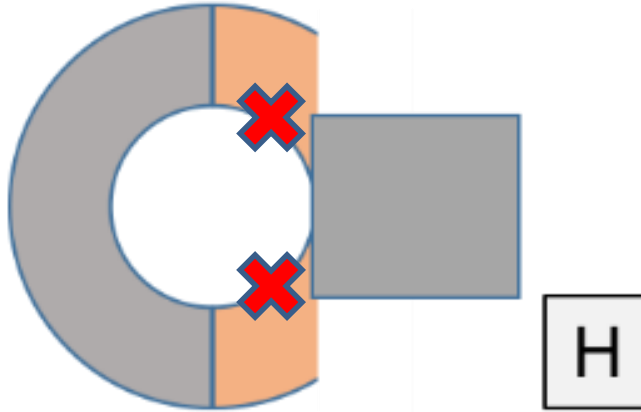


Has the exact same two features seen in the configurations that XDT:

- Smooth bore internal towards when the fragment is striking
- Energetic impact surface

**BUT DOES NOT XDT**

# New Hypotheses



So what could be happening? We have two ideas:

- The nitramine level could have an impact on whether a material with XDT with less material present
- The XDT does not happen directly and the base of the cloud – it could need to happen where the red 'X's are to the left



# Conclusions

- Smooth Bore Rocket Motors have a propensity to XDT
- Slotted Bore Rocket Motors do not have a propensity to XDT
- We have limited ideas as to why the other configurations did not XDT:
  - Low percentages of nitramines in propellants can ‘turn off’ XDT
  - XDT can sometimes occur further round the bore

# Further Work

- Further trials to try to understand what is actually happening
- Other materials to investigate whether the nitramine level has a larger impact than previously thought
- Try to model the phenomena

Thank you for listening.

# QUESTIONS