DOSG Science & Technology

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

Ben Keefe – Benjamin.Keefe100@mod.gov.uk
Dr Jocelyn Peach – Jocelyn.Peach108@mod.gov.uk
DOSG Science & Technology – Energetics Vulnerability
Insensitive Munitions and Energetic Materials Symposium – Seville, 2019

Overview

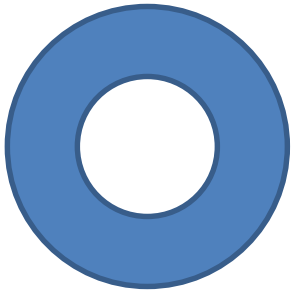
- Introduction
- Trials Hypotheses
- Trials Programme
- Outcomes
- Conclusions
- Further Work
- Questions

Introduction

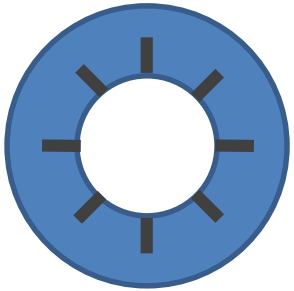
- Following previous work on propellants and booster materials – the UK commissioned work to investigate the XDT effect in Rocket Motor propellants
- Specifically on a GAP/Nitramine Propellant
- Programme put together to investigate whether XDT can be ‘turned off and on’ with minor changes
- Looking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

Trials Hypotheses

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

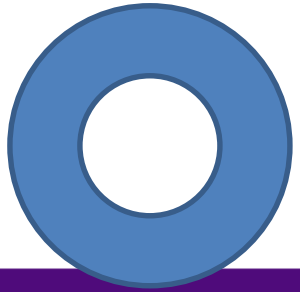


XDT

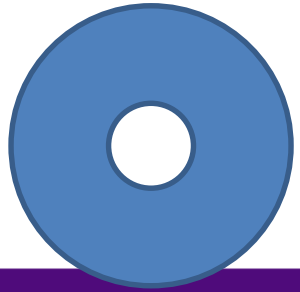


No XDT

- Changing the bore size will ‘turn on and off’ XDT



XDT

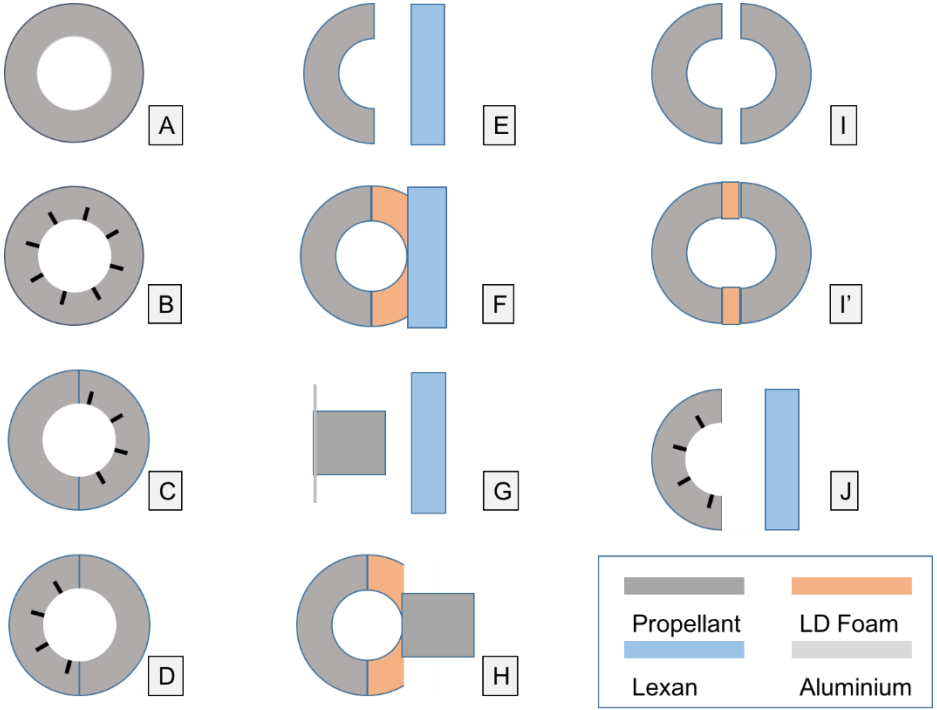


No XDT

Spoiler alert:

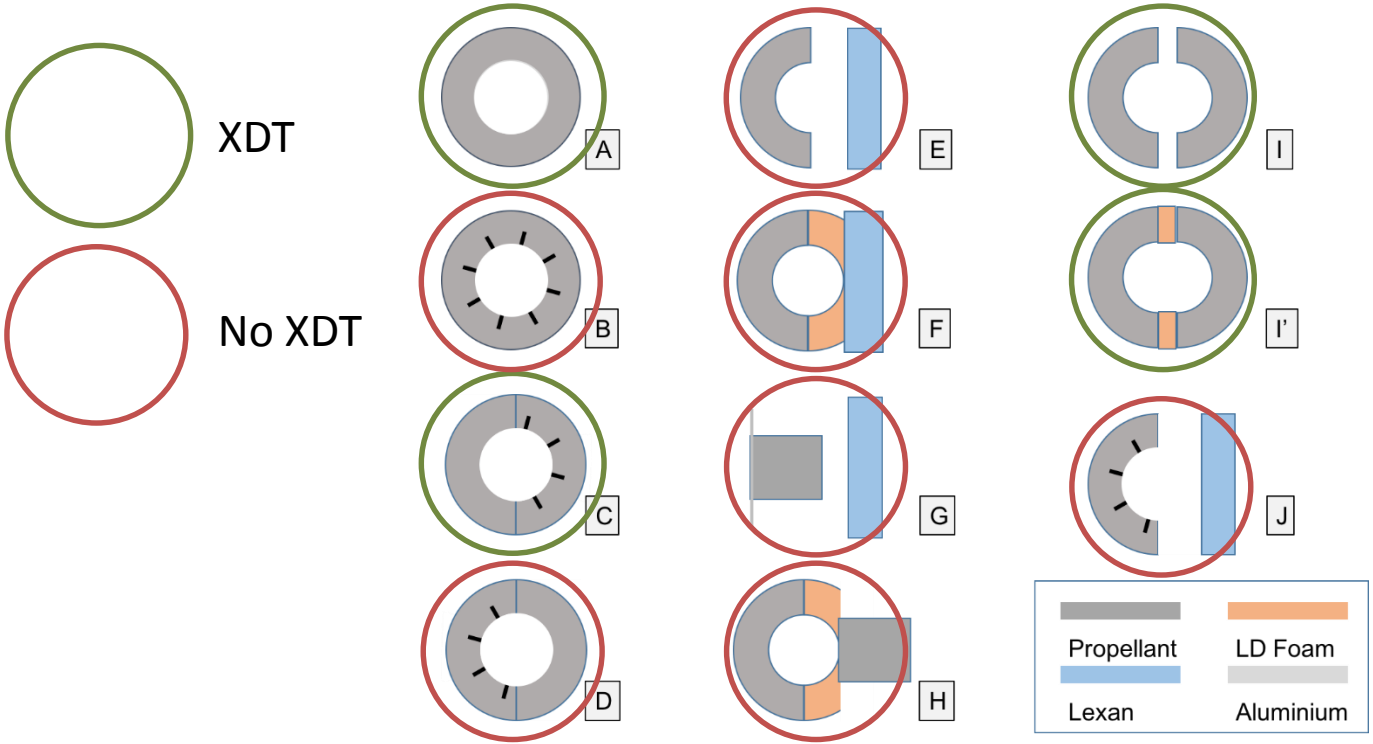
THESE HYPOTHESES QUICKLY WENT OUT OF THE WINDOW

Trials Programme

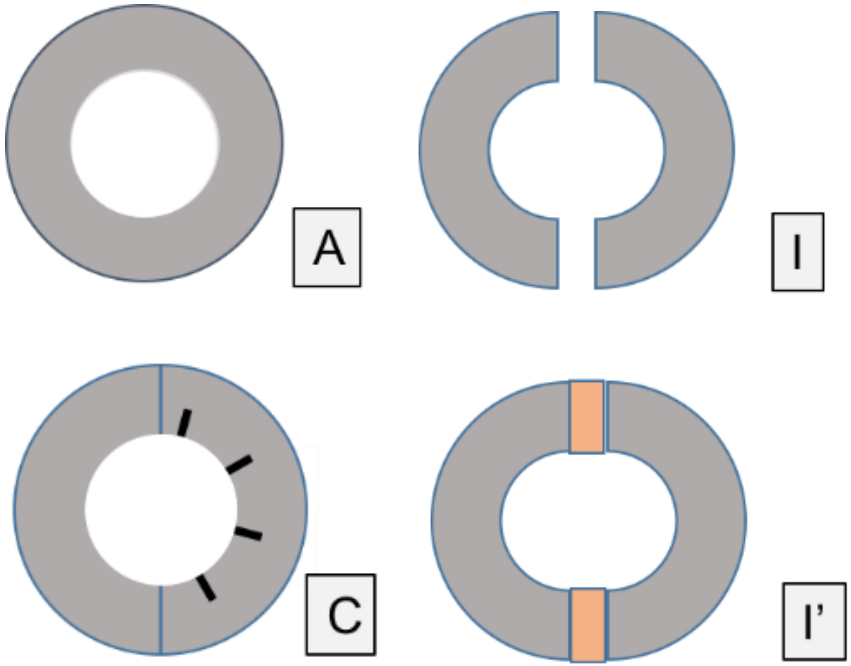


Target Type	Notes
A	Plain smooth-bore motor section, 60 mm long
B	Stellated-bore motor section, 60 mm long
C	Smooth-bore half section at the impact side, and slotted half-section downstream
D	Slotted-bore half-section at the impact side, and smooth half-section downstream
E	Smooth-bore half-section at 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



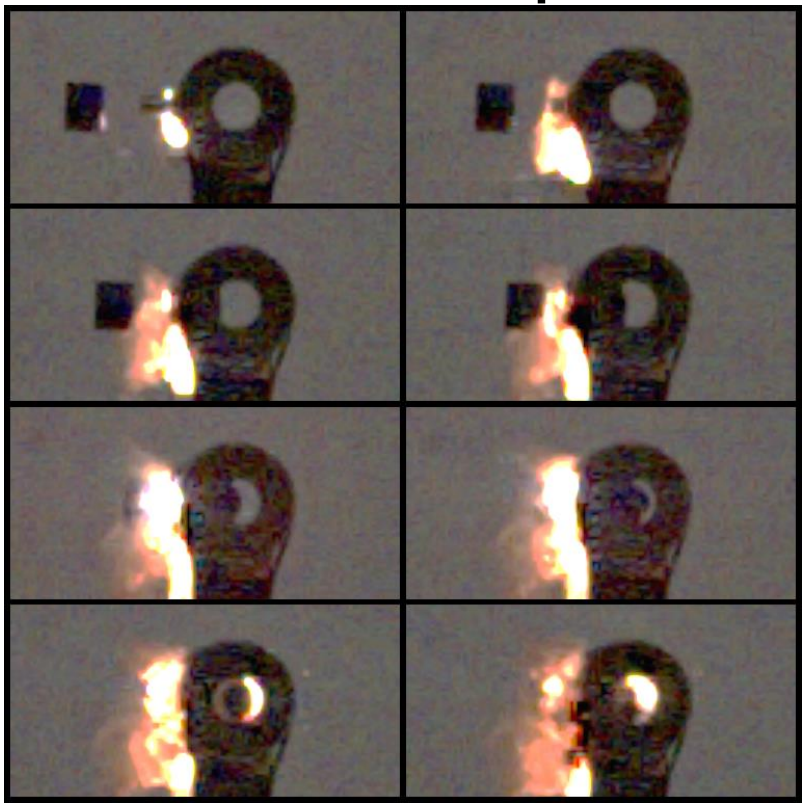
Configurations that XDT

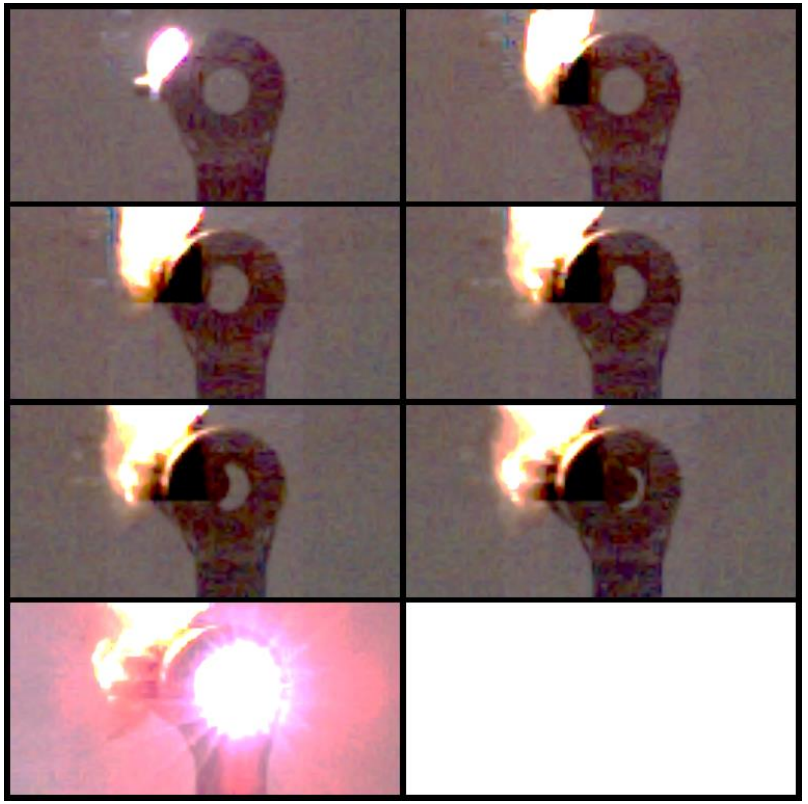


What do all of these have in common?

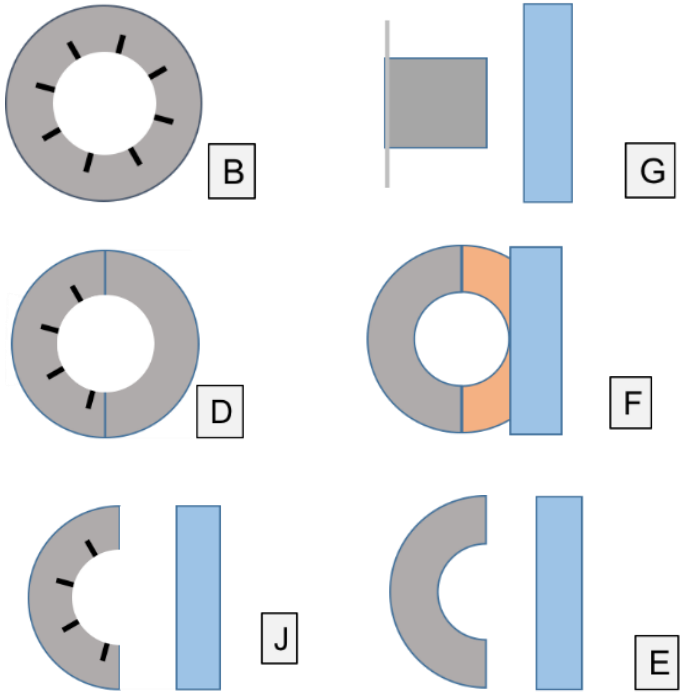
- Smooth bore internal towards when the fragment is striking
- Energetic impact surface

Examples of Ignition vs. XDT





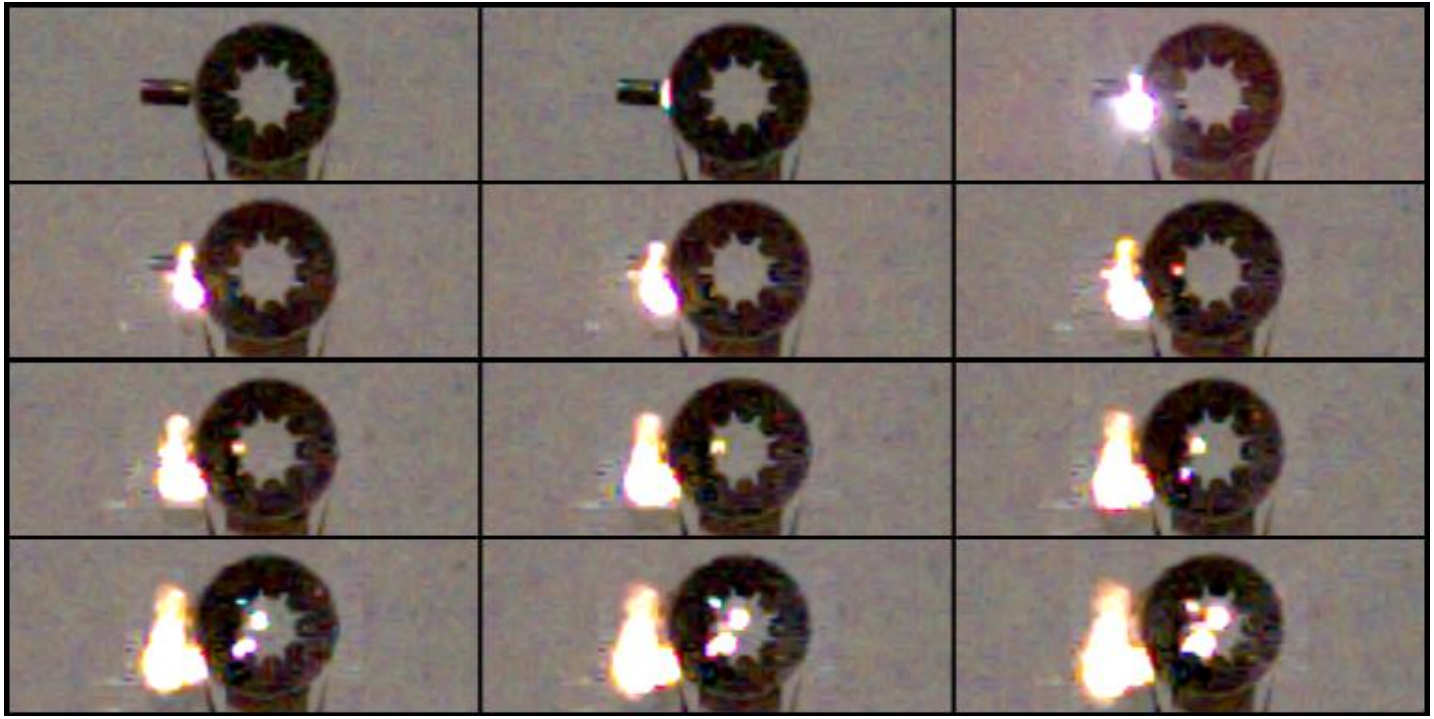
Configurations that DO NOT XDT



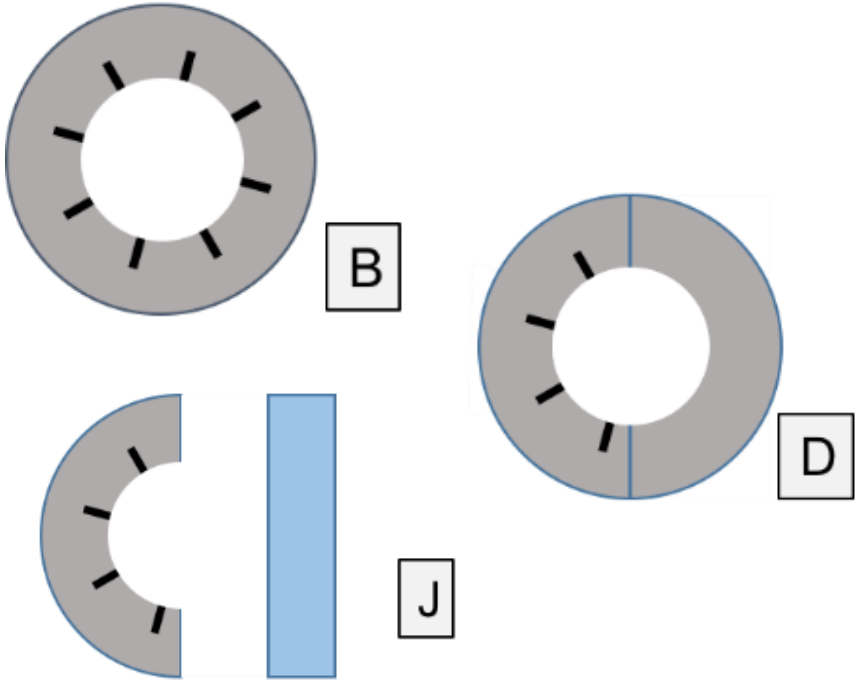
Can broadly fit into two categories:

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

Example of Slotted Bore

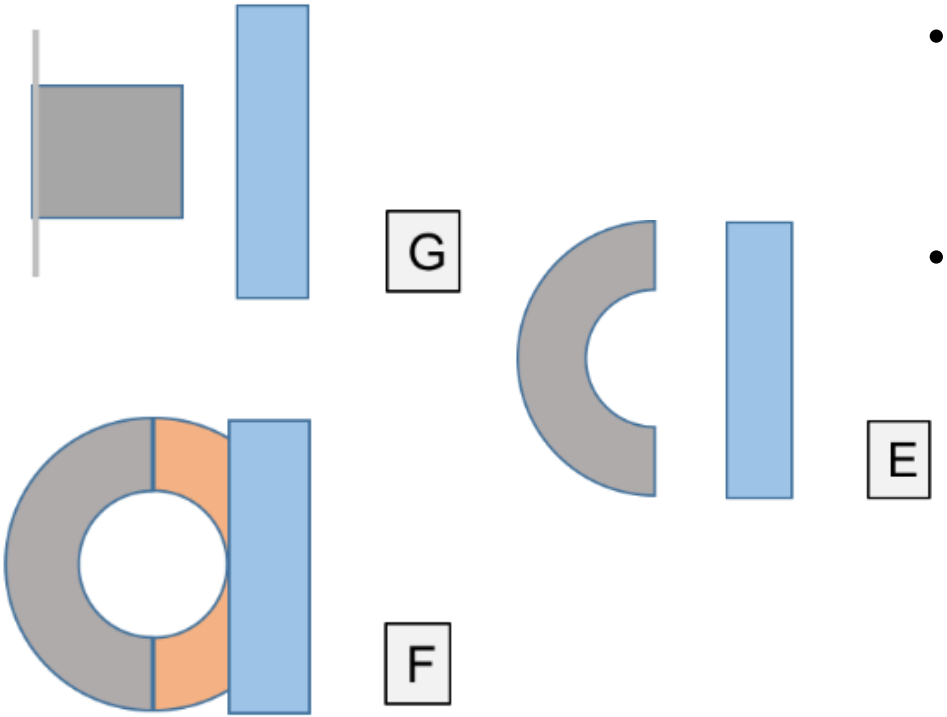


Slotted Bores



- 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

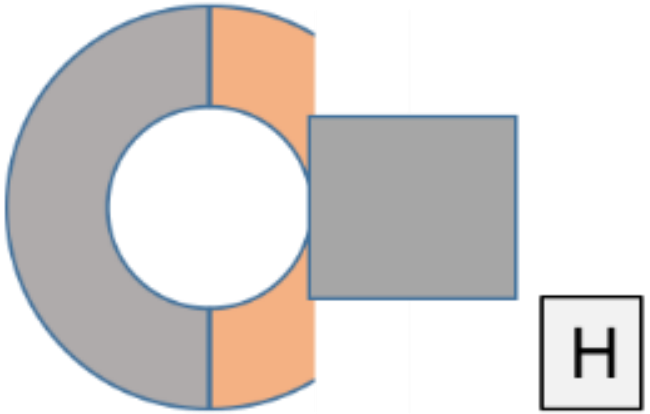
Inert Impact Surfaces



- 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

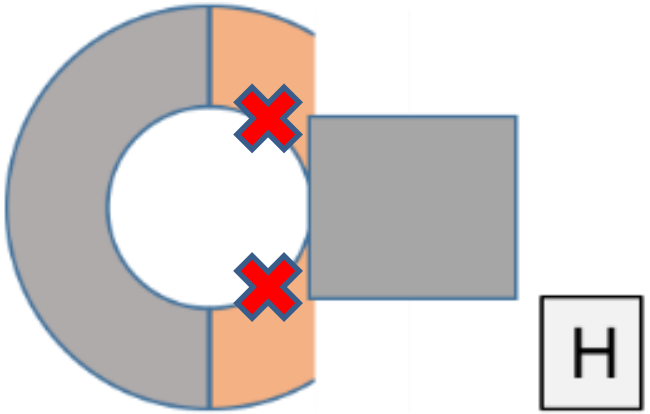


Has the exact same two features seen in the configurations that XDT:

- 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 though
- Try to model the phenomena

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Thank you for listening.

QUESTIONS