Small-scale Tests for Identifying Explosivity

Jimmie C. Oxley; James L. Smith; Patrick R. Bowden; Ryan Rettinger
University of Rhode Island; 401-874-2103 joxley@chm.uri.edu

THINK BIG WE DO℠

Abstract

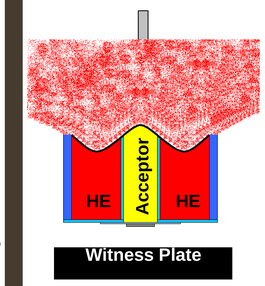
Many homemade explosives (HMEs), e.g. ANFO, don't release all their energy promptly at the detonation front. In these, loss of energy at edges becomes so significant that it is necessary to use large charges to achieve detonation, i.e. large critical diameter. This does not stop terrorists; they use them in VBIED's. For the researcher it means he may not observe detonability without using large amounts of material—expensive, time-consuming, & hazardous. A small-scale test is being developed to overcome edge effects so that detonability or lack thereof can be observed without regard to critical diameter. Target materials are those which fail to detonate at the scale of DoT testing but may be threats at large scale, i.e. tons.

Relevance

With active confinement provided by a detonating annular booster, a convergent, overdriving shock wave is driven into the test material. If it is detonable, the test material will detonate regardless of its critical diameter because the shock is being driven from the edges, not lost at the edges. The goal of this research is to develop a test to observe detonability without requiring large amounts of material. By creating a small test we save time and money and make it possible to test large numbers of potential explosives or industrial hazards with significantly less hazard to the researcher. Hazard to the researcher is reduced because this detonability test uses less material and because less material need be synthesized.

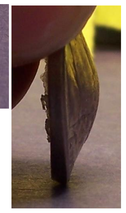
Technical Approach

Test Series 1: Flyer Plate



a "no go"

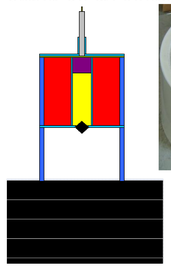
a "go"

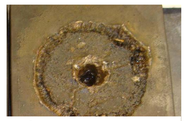


Lessons Learned:
Stand-off requirement
Booster requirement
Decipher Go/No Go

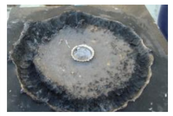
Test Series 2 &3 : Flyer Ball

Major Changes: Flyer ball replaced nickel; varied stand-off & Annular Booster NM/Sens vs. HP/EtOH





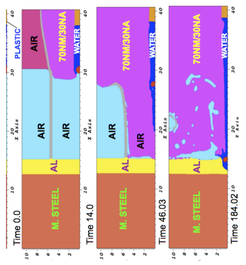
Brine Acceptor



NM/NA Acceptor

2 dents

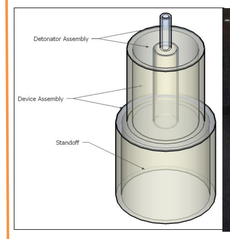
Inverted Results:
Detonation gave shallowest dents
Non-detonations deepest dents
Problem with multiple dents. ALE3D explained results

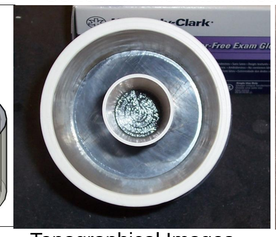


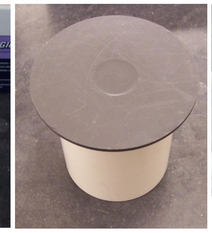
Test Series 4: No Flyer

- Device size reduced: 3"dia x 4"
- 1" booster: mass halved (~1lb)
- No flyer; observed jet or not
- Annular booster: NM/NA, NM/DETA, HP, EtOH
- 2" Al witness plate top of 5 1" x 6" x 6" steel plates
- Varied stand-off: 1", 2" to 10" (in 2" increments)
- Solid acceptors without detonation interrupter

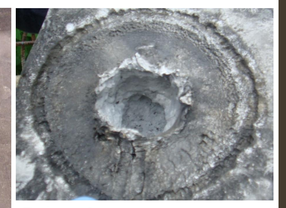
Initial Observation: Differentiates detonable & non-detonable
Concern: Mountain/Moat effect



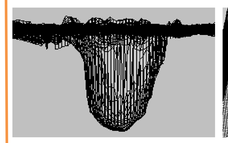


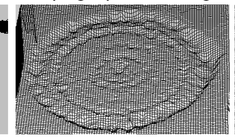


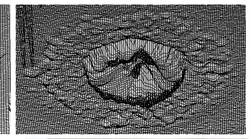
Topographical Images



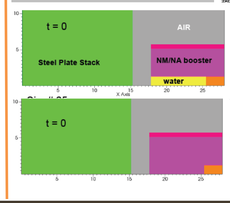
Brine Acceptor

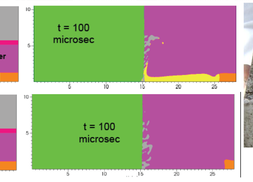






Detonable Acceptor





Moountain/Moat

Accomplishments Through Current Year

Liquid Inner Materials 8" standoff	Booster 3" x 4" OD	Dent Depth (mm)	Dent Volume (mL)
70/30 NM/NA - No Det. Int.	70/30 NM/NA	-2	0
70/30 NM/NA	50/50 NM/NA	-4	0
80/20 NM/NA	70/30 NM/NA	-4	0
70/30 NM/NA	80/20 NM/NA	-5	0
70/30 NM/NA	98/2 NM/DETA	-5	0
70/30 NM/NA	70/30 NM/NA	-5	0
70% HP/ 13% EtOH	98/2 NM/DETA	-11	9
90/10 NM/NA	70/30 NM/NA	-11	8
95/5 NM/NA	70/30 NM/NA	-11	4
99.5/0.5 NM/DETA	70/30 NM/NA	-12	13
NM	98/2 NM/DETA	-12	10
50/50 NM/NA	70/30 NM/NA	-13	8
NM	70/30 NM/NA	-13	10
80/20 NM/EtOH	70/30 NM/NA	-13	6
80/20 NM/Acetone	70/30 NM/NA	-16	7
90/10 NM/Acetone	70/30 NM/NA	-16	11
30/70 NM/NA	70/30 NM/NA	-16	10
70/30 NM/Acetone	70/30 NM/NA	-17	5
70/13 HP/EtOH	70/30 NM/NA	-19	7
50/10 HP/EtOH	70/30 NM/NA	-26	17
50/30 HP/EtOH	70/30 NM/NA	-28	12
50/5 HP/EtOH - No Det. Int	70/30 NM/NA	-37	25
50/5 HP/EtOH	70/30 NM/NA	-39	23
Acetone	70/30 NM/NA	-24	12
Turpentine	70/30 NM/NA	-29	22
70% HP	70/30 NM/NA	-33	24
70% wt NA	70/30 NM/NA	-43	23
Brine	70/30 NM/NA	-51	26

Detonable
Questionable
Non-detonable

Solid Acceptors			
Inner Mix	Dent Depth (mm)	Volume (mL)	Acceptor Amount (g)
MagnaFrac	-14	4	84
DNT	-16	5	81
87/13 AN/IS	-17	6	82
70/30 KN/IS	-18	8	100
AN	-20	11	82
PMMA	-33	12	54

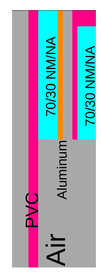
Test series 4 involved 42 shots using ~1lb (450g) of booster and 40-100g of acceptor material. The results indicate clear separation of detonable materials from inert materials of both liquids and solids. Intermediate results have not been completely elucidated. Simulations of these tests have agreed with field-test results. The model is now being used to design the next test series.

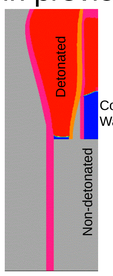
Opportunities for Transition to Customer

This research is aimed at determining detonability of substances. Once threats are assessed, regulations can be tailored to fit these materials and emerging threats. The application of this test is not limited to identifying potential terrorist threats. Chemical processing plants will benefit from a test they can afford, in terms of dollars, time, and material. We anticipate it may become a standard hazard test in plant design.

Future Work

Instead of having booster & acceptor separated by a PVC pipe, an annular aluminum pipe will be used as a flyer across a small air gap. The "flyer pipe" will create a higher input pressure into acceptor materials than previous devices. This will cause detonable samples to have a more prompt detonation vs run-up to detonation as in previous designs.





Publications Acknowledging DHS Support

Oxley, J.C., Smith, J.L., and Bowden, P.R. "Assessing the Detonability of Substances", in Prep

This material is based upon work supported by the U.S. Department of Homeland Security under Award Number 2008-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied of the U.S. Department of Homeland Security.