Explosive Testing of PPE in a Laboratory Accident Scenario

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Introduction

- For small scale laboratory work with novel explosives, protection from the effects of an explosion is vital.

- Existing test standards for civilian PPE do not adequately assess the threat from explosives:
  - See Klapötke et al, Safety Science, **48** (2010), 28 – 34.
  - The main threat is due to fragmentation of the experimental apparatus:
    - Glass or ceramic flasks, funnels etc.
  - Almost no literature data on protection from glass or ceramic fragments.
  - There was therefore no credible evidence to support our existing PPE.

- Need to perform testing of a range of PPE against realistic laboratory explosive threats:
  - Provide evidence, build confidence.

Initial Work

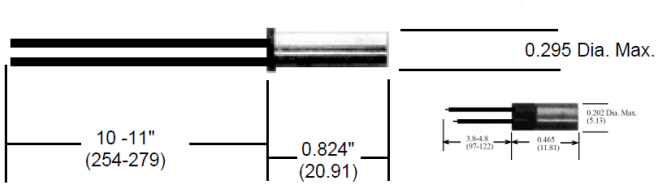
- Carry out explosive testing of PPE with:
  - 0.30 gram
  - 1.00 gram
  - 7.50 grams
- Of explosive inside:
  - Glass Round Bottomed Flasks
  - Ceramic Buchner Funnels
- Against:
  - Four different types of gloves
  - Two types of wrist protectors
  - Two types of face shield
  - One bench shield

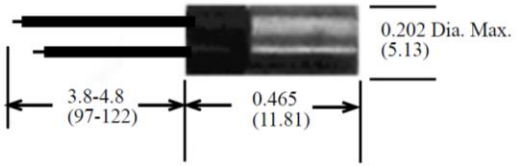
Use of Ballistics Gelatine:

- To simulate human hands and wrists inside the gloves and protectors.

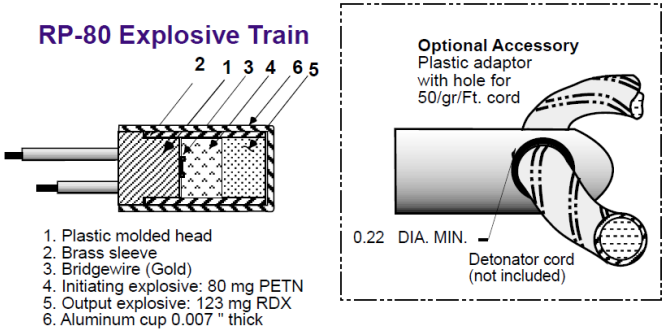
Initiating The Explosive

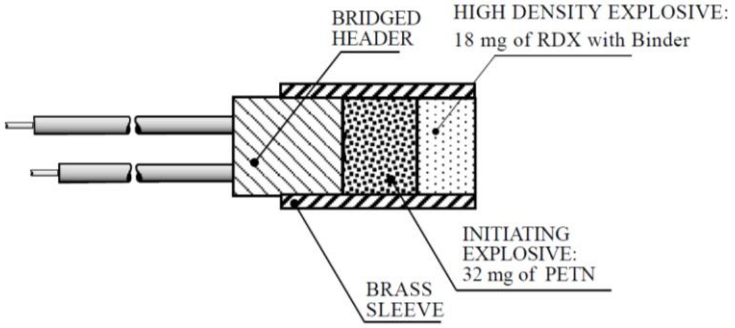
- The smallest charge size of 0.30 gram presented a problem:
  - Using an RP-80 EBW Detonator would almost double the required charge.





RP-2 EXPLOSIVE TRAIN



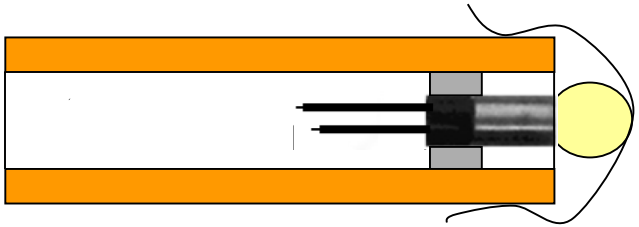


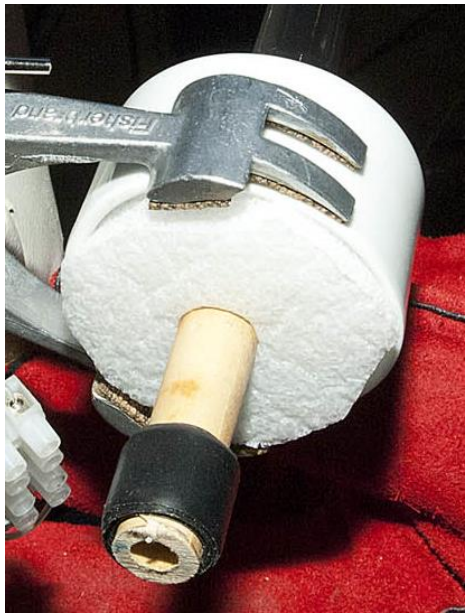
  - Plus the detonator fragmentation would not be representative of an accidental initiation.

RP series detonator images and technical data care of Reynolds Industries.

Initiating The Explosive

- Detonator Fragment Containment:
  - Use of an RP-80 cardboard transport tube:





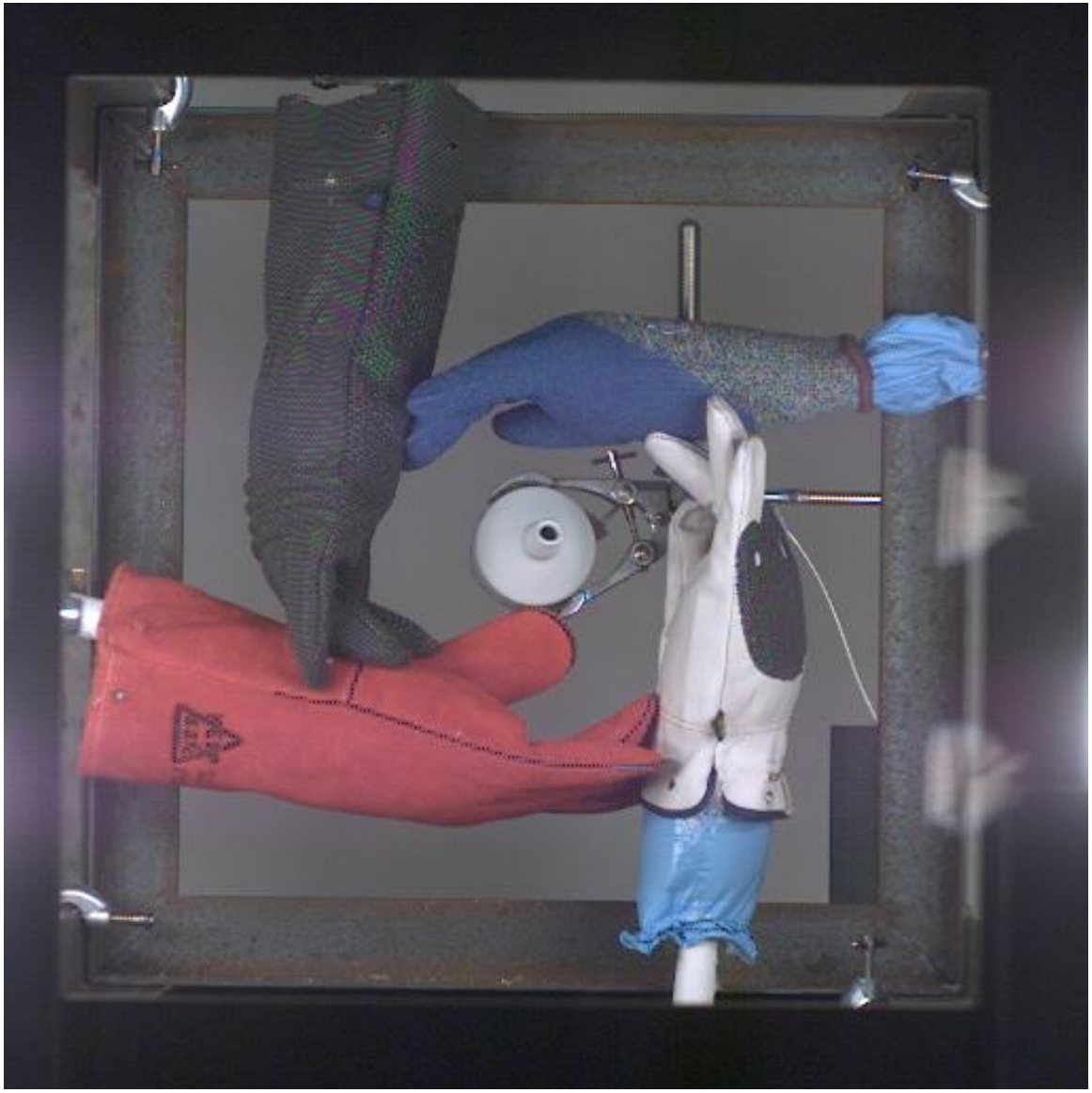
Experimental Set Up:

- Accident Scenario turned through 90 degrees:
  - To allow viewing of fragment flight and impact
  - Recorded via High Speed Video (Phantom Camera at 25,000 fps)
  - Multiple Items of PPE tested with each firing.

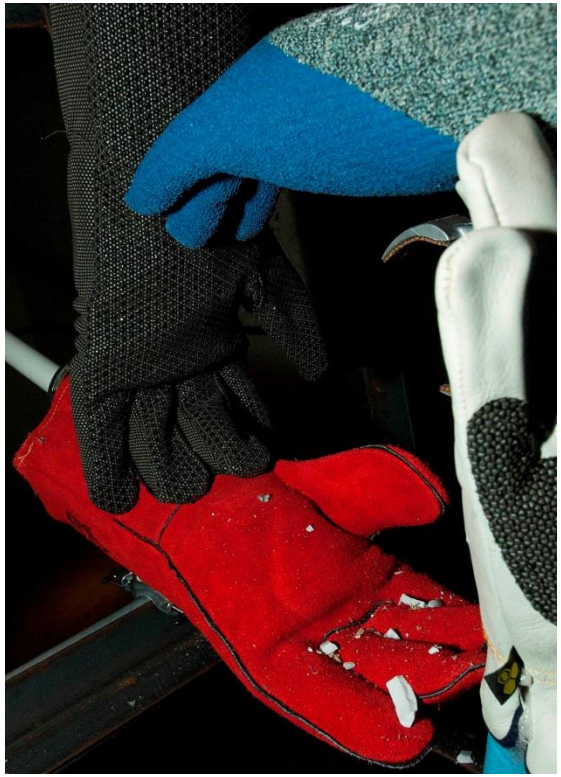
Video Results:

Ceramic Buchner Funnel
with 0.30 gram
Paste Explosive Charge.

Testing of four different
protective glove types.

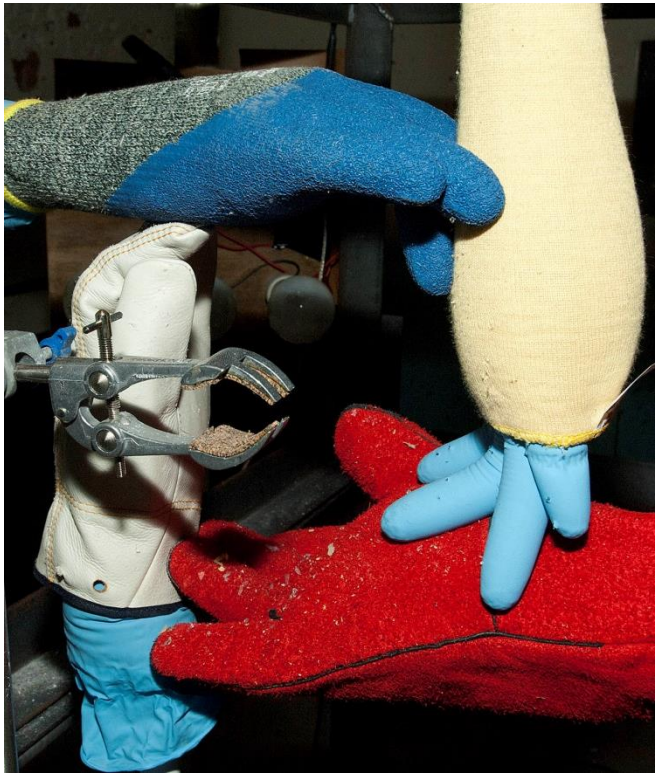


Initial Visible Damage:



Buchner Funnel

0.30 gram

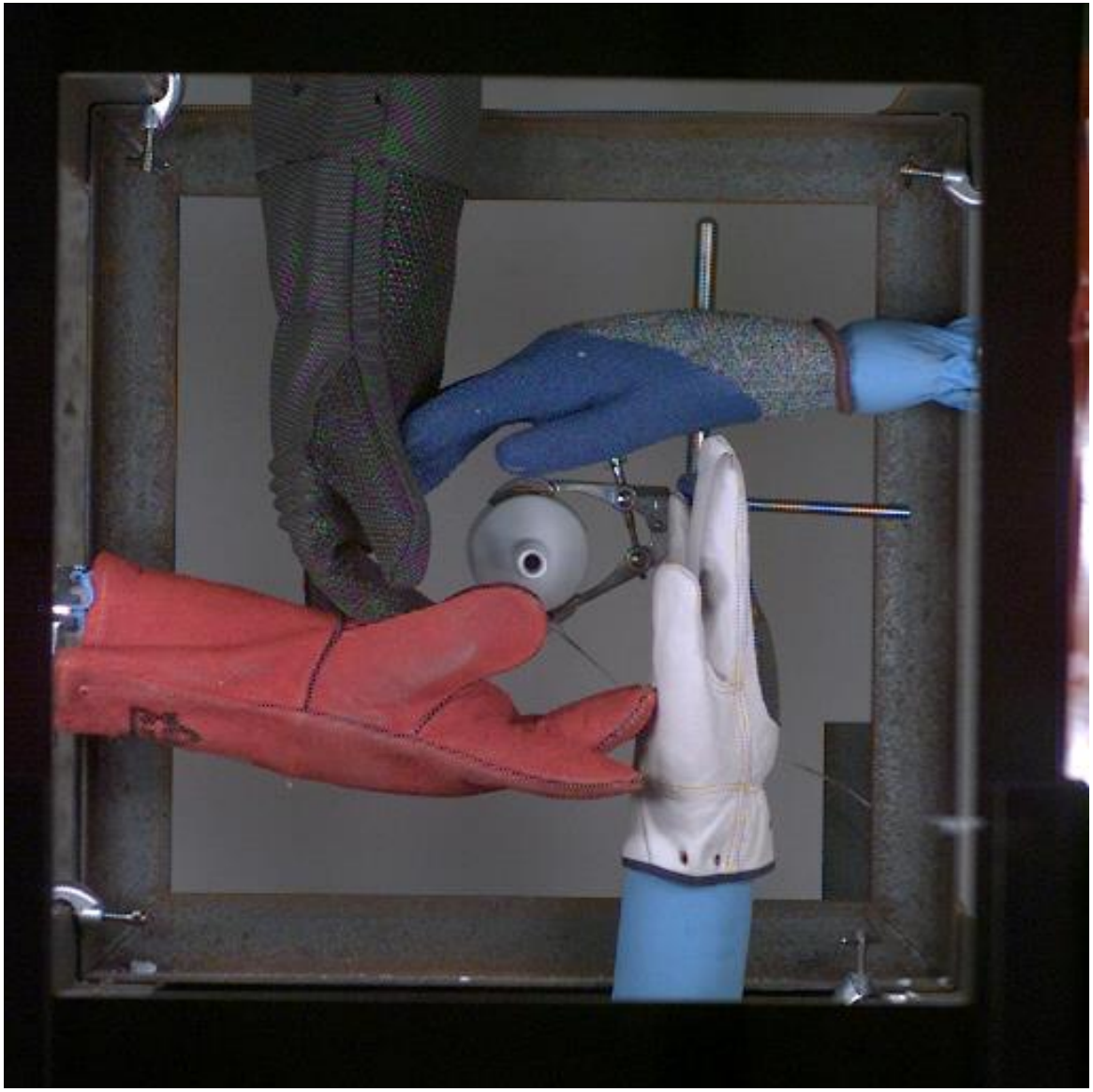


Round Bottomed Flask

Video Results:

Ceramic Buchner Funnel
with 1.00 gram
Paste Explosive Charge.

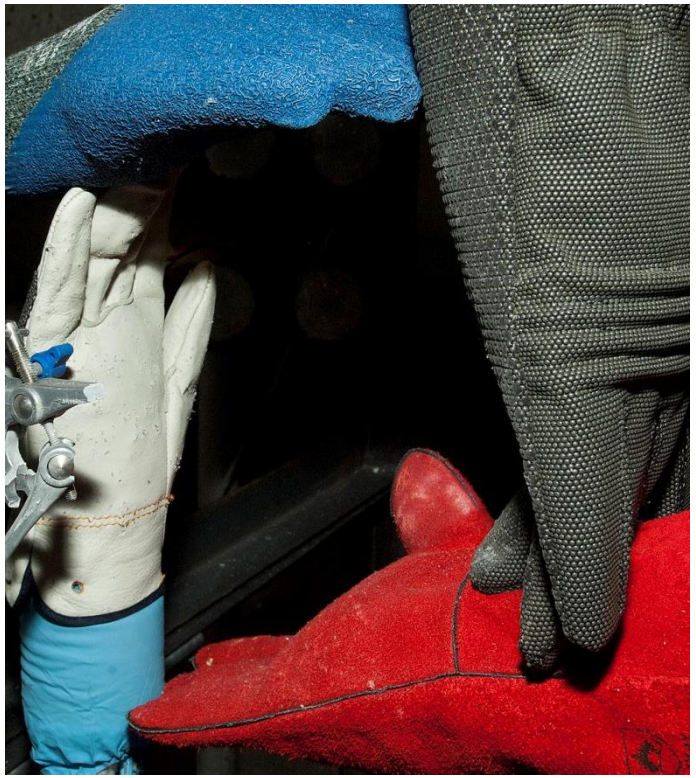
Testing of four different
protective glove types.



Initial Visible Damage:

Buchner Funnel

1.00 gram

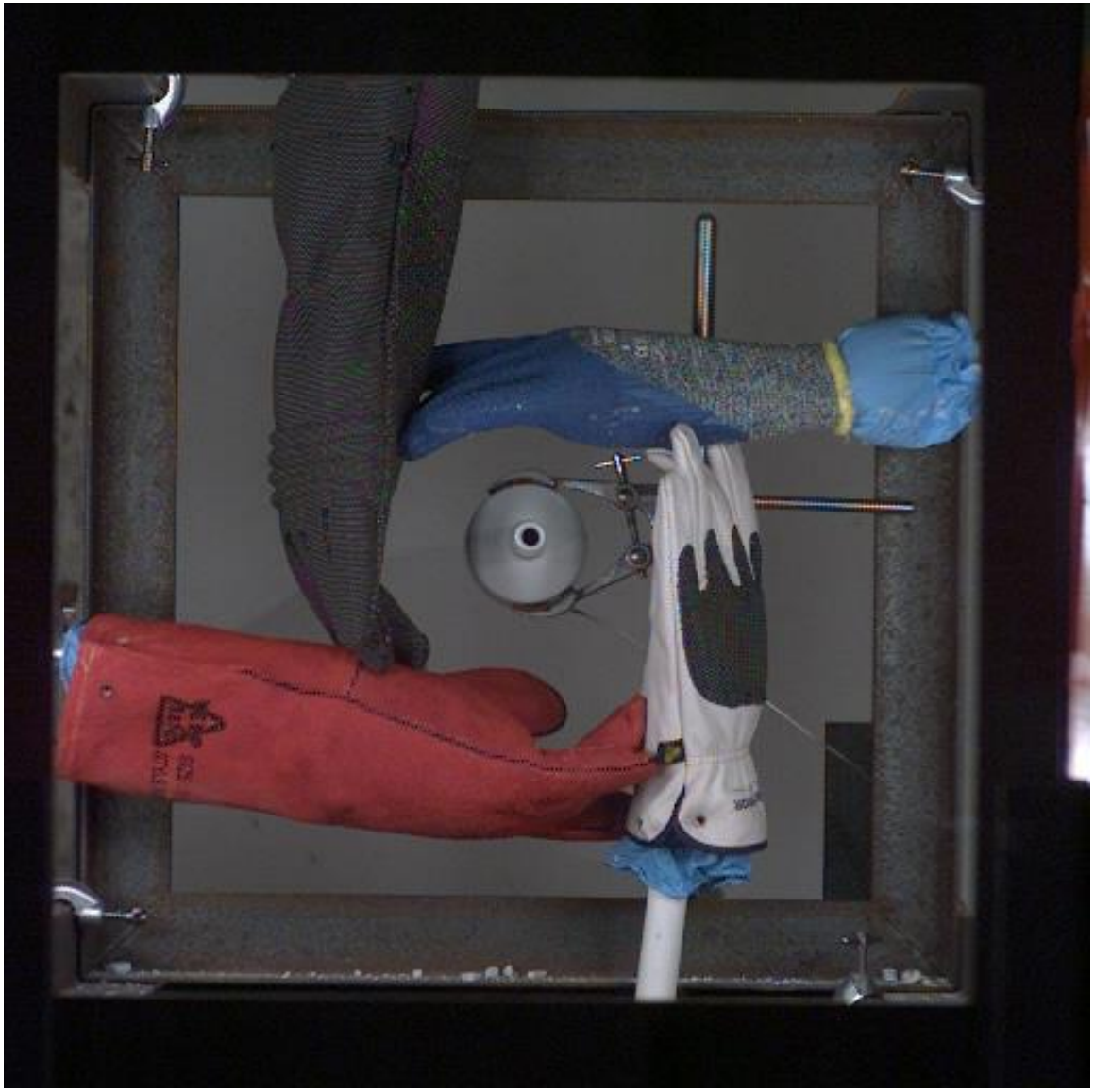


Round Bottomed Flask

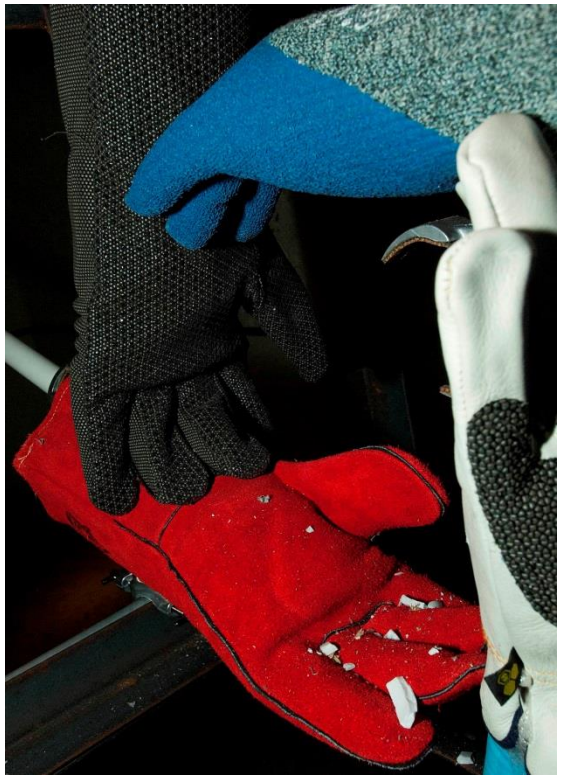
Video Results:

Ceramic Buchner Funnel
with 7.50 gram
Paste Explosive Charge.

Testing of four different
protective glove types.



Initial Visible Damage:



Buchner Funnel

7.50 gram Round Bottomed Flask

Video Results:

Glass Round Bottomed Flask with 7.50 gram Paste Explosive Charge.

Fired in a water filled bath to assess protection provided by aluminium pan.

Video Results:

Glass Round Bottomed Flask with 1.00 gram Paste Explosive Charge.

Fired in a water filled bath to assess protection provided by aluminium pan.

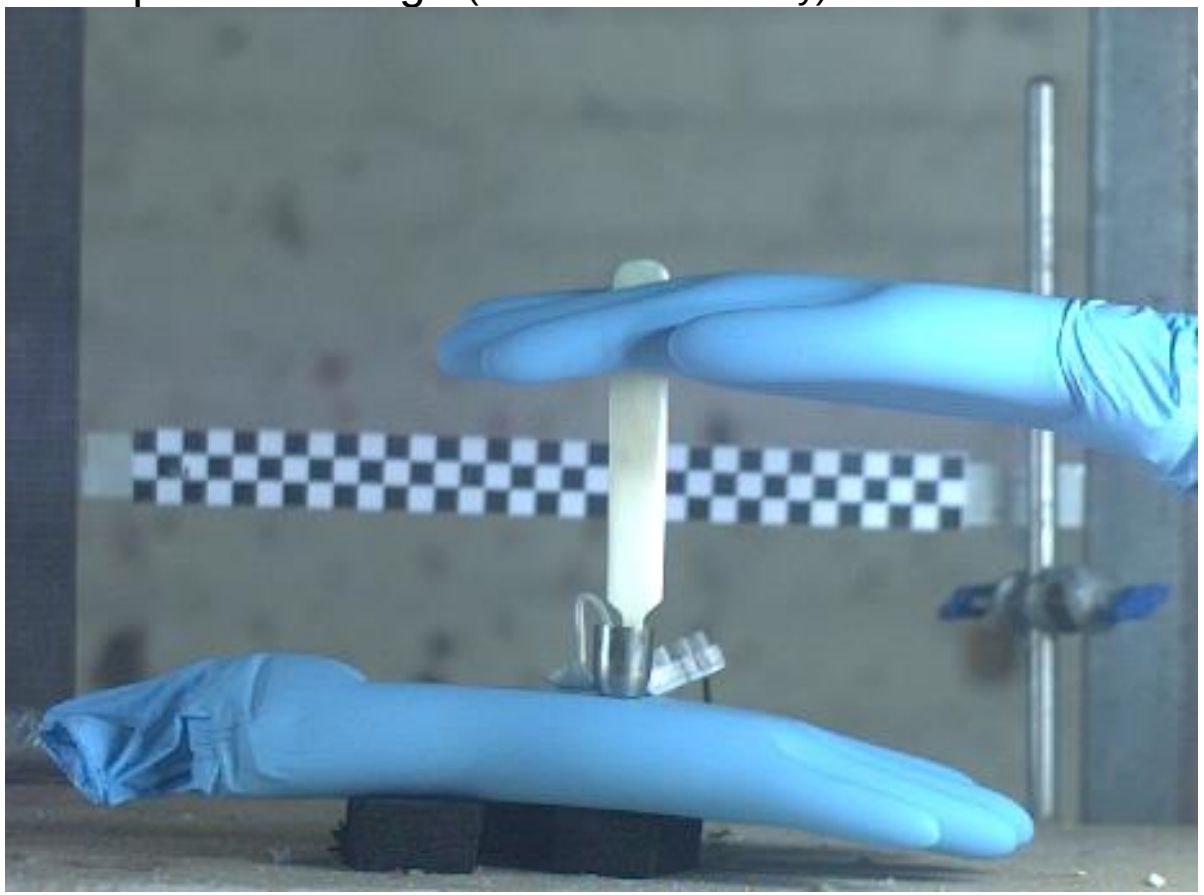
Video Results:

Glass Test Tube
with 5.00 gram Paste
Explosive Charge.

Test of Safety Glasses
and Face Shield
Combination and two
different Bench Shields.

Video Results:

Stainless Steel Crucible with Bone Spatula
with 0.05 gram Explosive Charge (RP-2 Detonator only).



Ballistics Gelatine Results:

Stainless Steel Crucible with Bone Spatula
with 0.05 gram Explosive Charge (RP-2 Detonator only).

Ballistics Gelatine Results:

Glove Surface

Gelatine Penetration

Ballistics Gelatine Results:

Glove Surface

Gelatine Penetration

Conclusions and Future Work

- The trials have given us the evidence to:
  - Evaluate the threat from different scenarios.
  - Select more appropriate PPE:
    - Gloves and grey wrist protector performed very well at 0.30 gram
      - Glove choice at this scale down to dexterity / chemical threat.
    - Face shields performed well at 1.00 gram.
    - All gloves failed at 1.00 gram, however there were large differences; very significant reduction of injury was possible.
    - Standard bench shields good for 1.00 gram, however fragmentation possible with larger quantities.

- Additional trials needed for testing of other items and to allow replication of some shots.

Journal of Chemical Health & Safety
full papers available at:

https://www.sciencedirect.com/science/article/pii/S1871553214000954

https://www.sciencedirect.com/science/article/pii/S1871553214001285

Any Questions?

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Dr Chris Murray and Dr Peter Jenkins - New Materials Team, AWE Aldermaston.

10 yards away from 4 lbs of Ammonium Nitrate Fuel Oil (ANFO)

Knew I Should've Have Had Beans Last Night!