



Research at Explosions Test Facility University of Kentucky Mining Department

Kentucky Professional Engineers in Mining Seminar

Projects sponsored by: ALPHA FOUNDATION, NIOSH,
UKERT

September 06, 2019
University of Kentucky



UNIVERSITY OF KENTUCKY EXPLOSIVES RESEARCH TEAM



Explosion tests Facilities in the USA (Industrial Application)

National Technical Services (NTS) <https://www.nts.com/about/history/>



It All Started with Breaking a Few Windows ...

At NTS, we perform mechanical shock testing using the following methods:

- › **Acceleration testing**
- › **Acoustic noise testing**
- › **Impact testing**
- › **Corrosion testing**
- › **Vibration testing**
- › **Shock testing**
- › **Drop testing**

- › **Pyrotechnics to simulate pyro-shock** — **Pyro-shocks are often encountered in spacecraft flight** when rocket booster stages are separating and in military applications when weapons are being fired or ordnances are being detonated.
- › **Drop Testing** — this occurs up to 80ft (24m) for testing the resilience of items against mishaps that could happen during transportation, handling, and expected use.
- › **Drop towers to induce mechanical shock** — Our drop towers are able to deliver peak acceleration in excess of 20,000g (196,000 m/s²).
- › **Air gun generated hydroshock** — In this type of test, an air gun fires a blast of air into a volume of water to generate shock waves within that volume of water.
- › **Free-fall and variable force test techniques** — These techniques produce shocks up to 15,000g (147,000 m/s²).
- › **Shipboard shock testing** to MIL-DTL-901E.
- › Simulated catapult launch/arrested landing per MIL-STD-331.

Welcome to NTS Camden: The National Ordnance and Ballistic Test Center



Located within the original 68,000-acre Shumaker Naval Ammunition Depot and a portion of Highland Industrial Park is our National Ordnance and Ballistic Test Center. It's equipped to safely conduct a wide array of severe and dangerous tests on weapon systems, ordnance, rocket motors, hazardous materials and commercial products.

Explosion tests Facilities in the USA (Industrial Applications)

Fike Corporation <https://www.fike.com/services/testing-capabilities/remote-testing-facility/>



Explosion tests Facilities in the USA (Military Applications)

<https://www.sandia.gov/vqsec/index.html>



Industrial Applications

Fires and Explosions →
Pharmaceuticals
Food processing plants
Chemical industries
Metal working industries
Mining

Causes:

1. Combustible dust, Imperial sugar 2008 (Georgia, US)
2. Hot work (Industrial fires)
3. Flammable liquids and gasses
4. Faulty equipment
5. Electrical hazards

University of Kentucky Explosives Research Team UKERT



Research and teaching in Explosives & Explosions

Explosives:

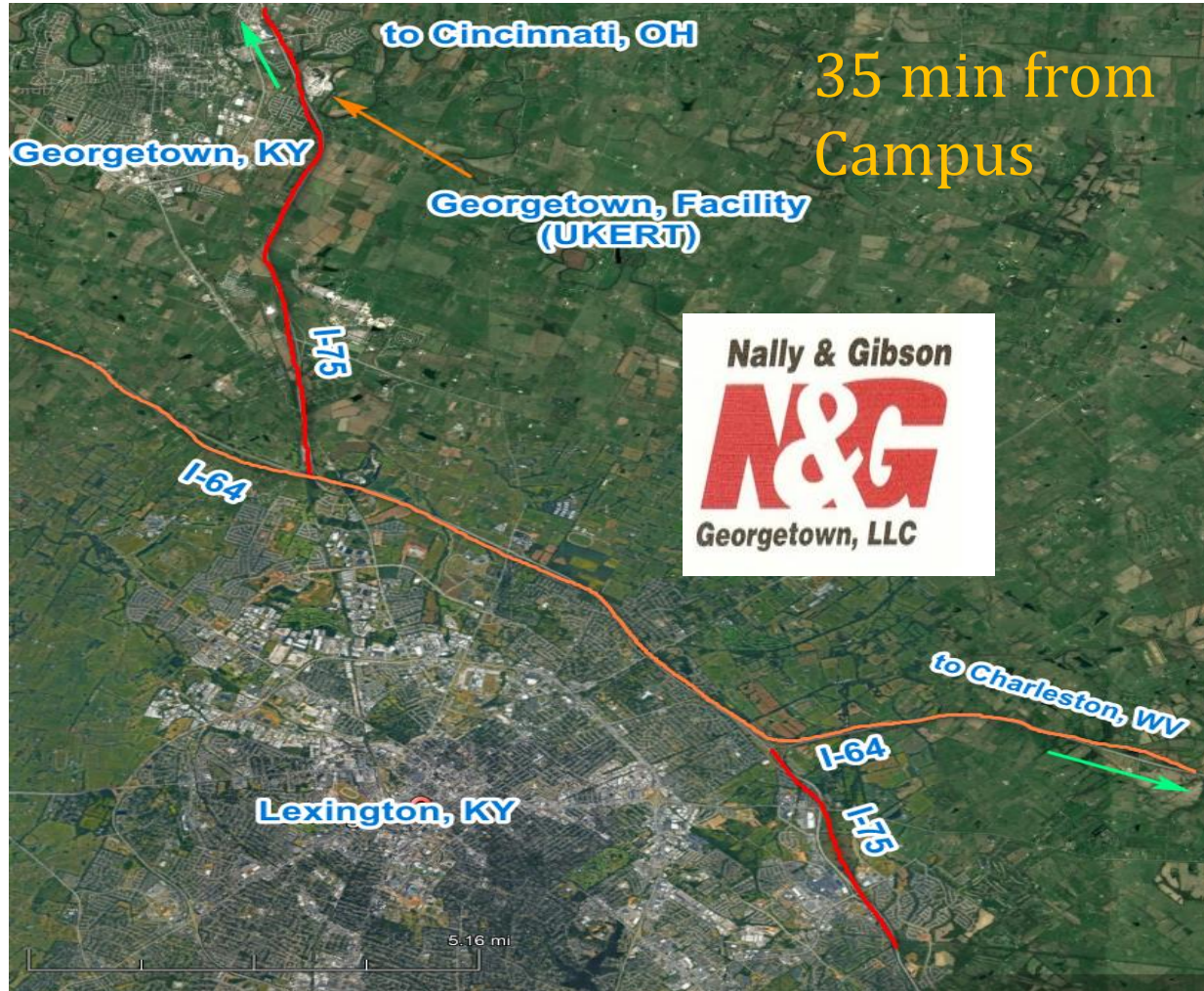
Rock Fragmentation, ground vibrations, surface, underground blasting.

Explosions:

Methane, coal dust explosions, impact. Mining safety.

UKERT

Facilities hosted by Nally & Gibson (Quarry)



Underground



Surface



Explosives Research at UKERT

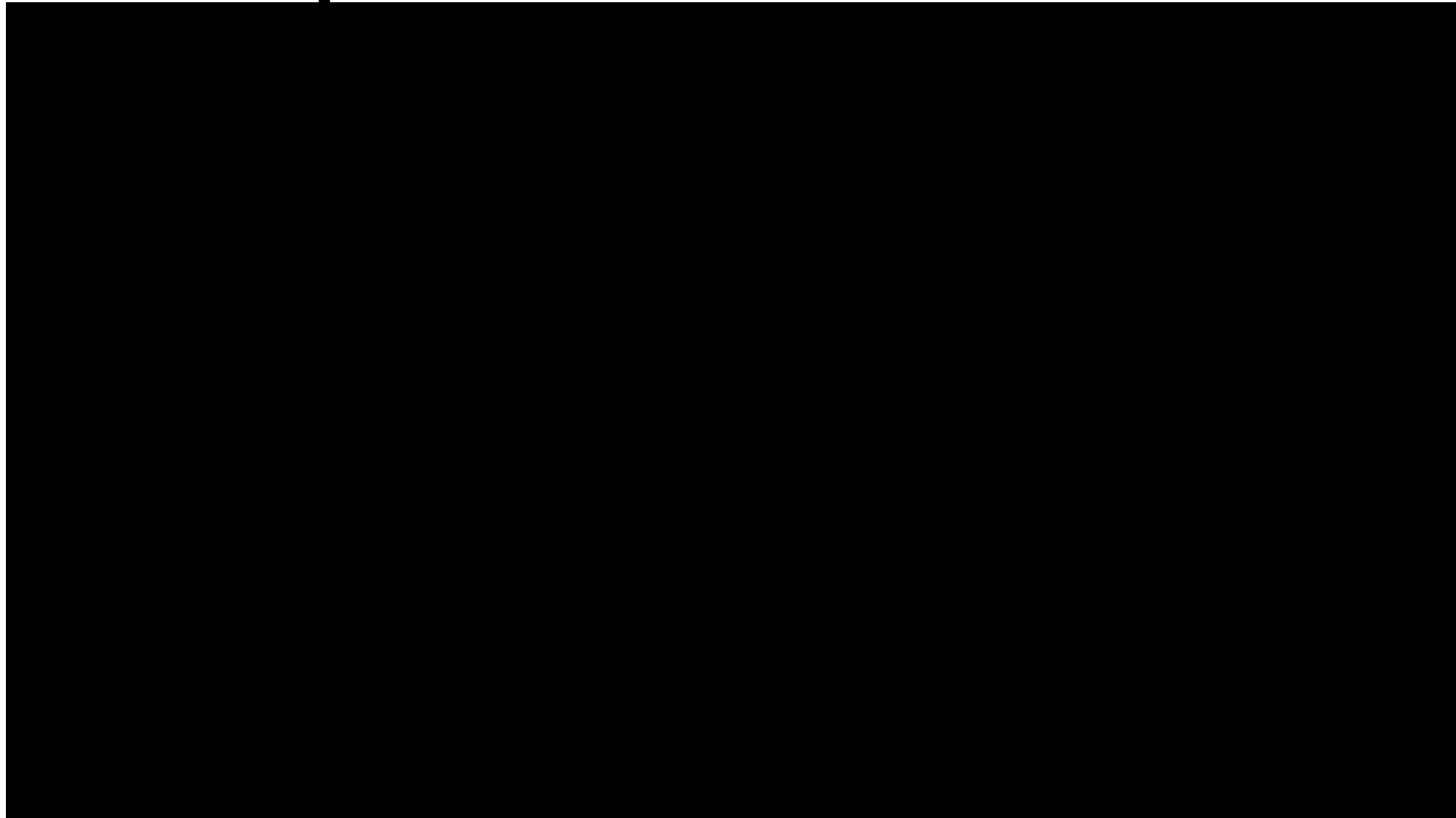
Three research topics: (UKERT – Funded Projects)

1. Fragmentation,
2. Displacement of muck pile (Cast blast)
3. Fracture extension – Fracture propagation

Explosives Research at UKERT



Explosives Research at UKERT

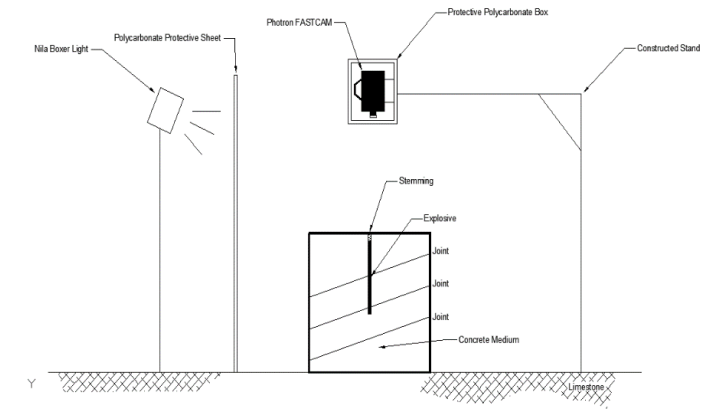
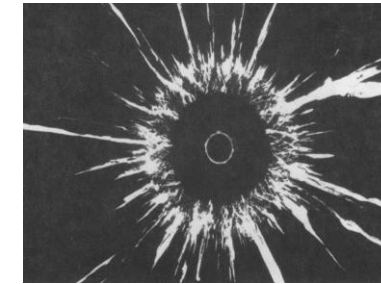
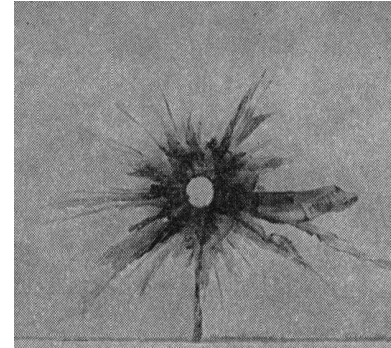
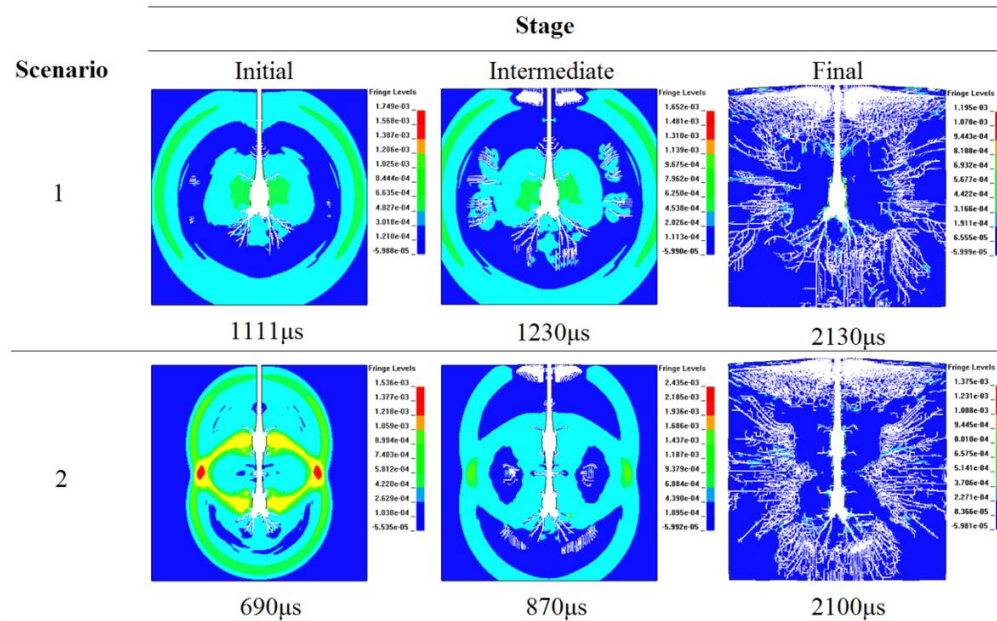


Explosives Research at UKERT



Explosives Research at UKERT

Fracture extension – Fracture Propagation



Explosion Research at UKERT

Focuses on Methane and methane coal/dust explosions

The mining industry lack of explosive – explosion research facilities after the closure of the Lake Lynn Experimental Mine (LLEM).

Closed in 2013, after 30 years of use.

Some of the developments at LLEM:

- Necessary level of incombustible material in order to keep coal dust incombustible,
- Development of a coal dust explosibility meter,
- Testing the strength of various seals

Explosion Research at UKERT

UKERT built at the surface of N&G quarry a 40 ft long and 8 x 8 ft cross section shocktube for methane/coal dust explosion tests.



Designed by a structural design company specialized in dynamic and blast resistant structures. The design loads were triangular type loads of 50 psi @ 200 ms and 250 psi @ 5 ms.

Explosion Research Projects at UKERT

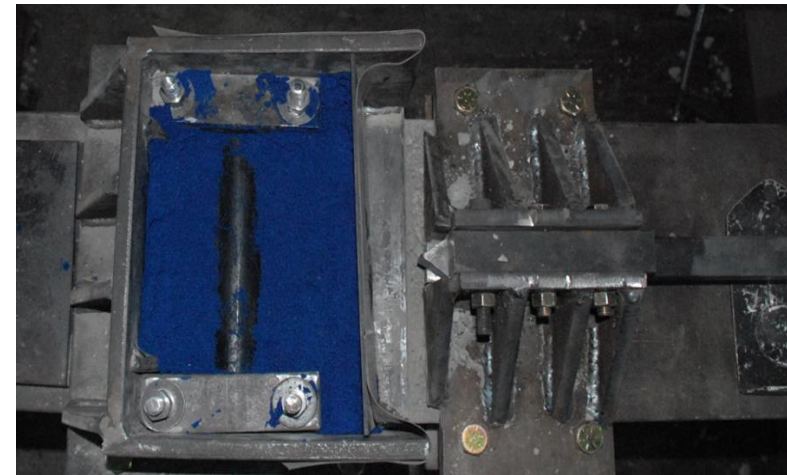
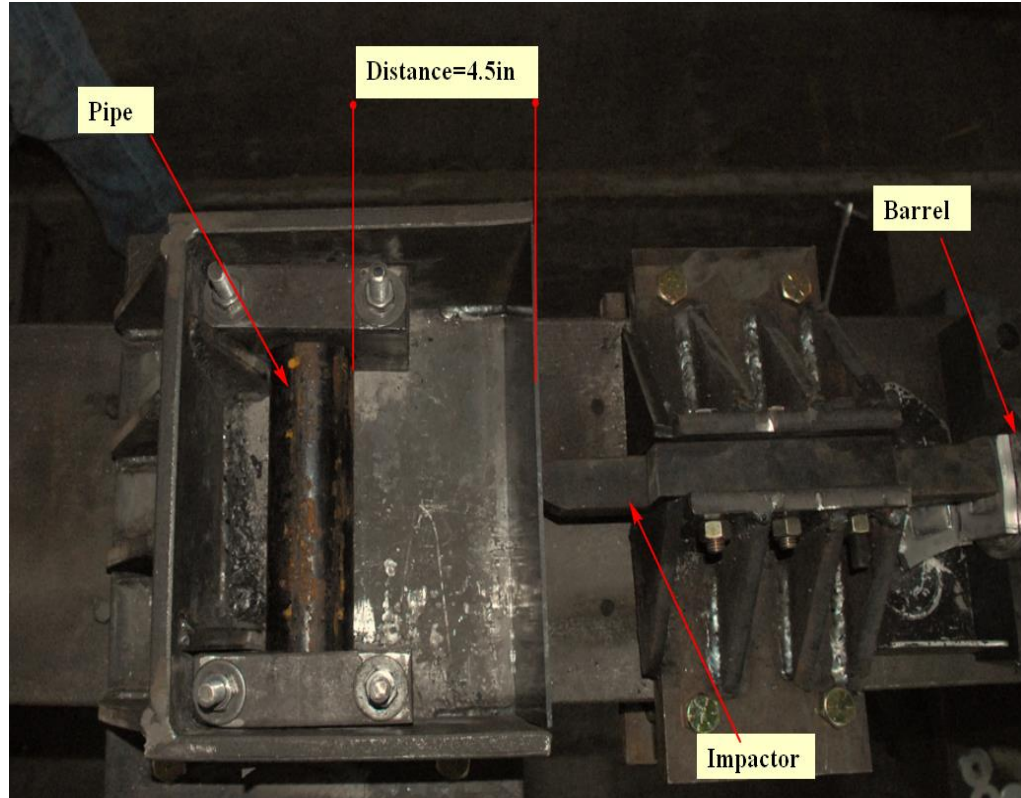
Agencies – Funded Projects

1. **NIOSH** “Protection of compress air lines against explosions” Breathable air (RAs)
2. **Alpha Foundation** “Experimental Testing and Design of Protective Measures for Communications and Tracking Systems Subjected to Catastrophic Events in Underground Coal Mines”.
Final Report **04/30/2019**
3. **NIOSH 01** “Evaluation, Scale Testing, and Testing Design of Active Explosion Barrier Systems for the US Underground Coal Mines” **Final Report** **09/15/2019**
4. **NIOSH 02** “Evaluation and Testing of Pressure Relief Valves for Refuge Alternatives Subjected to Explosive Forces”.
Final Report **08/30/2020**

Compressed Air Lines – Impact Tests



Compressed Air Lines – Impact Tests



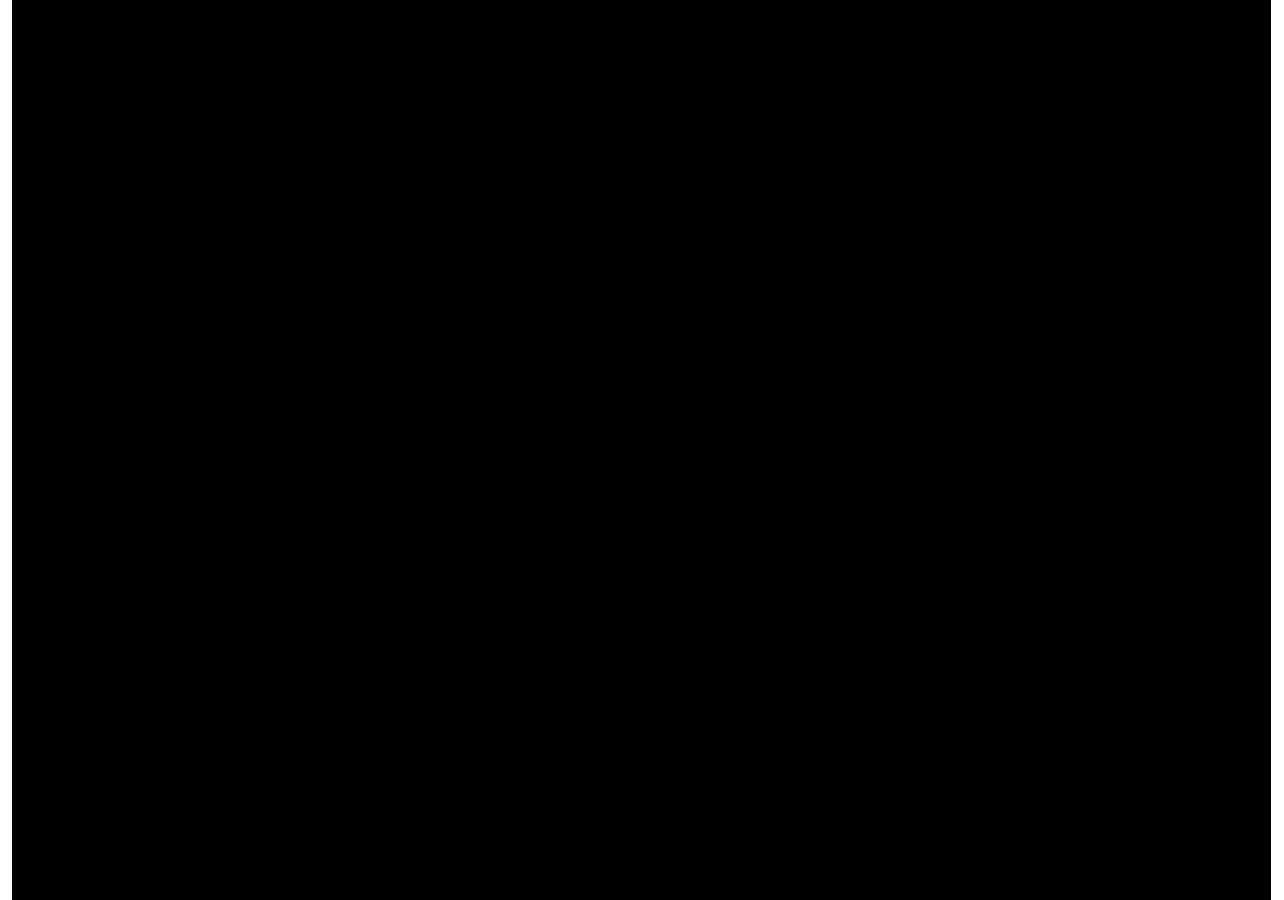
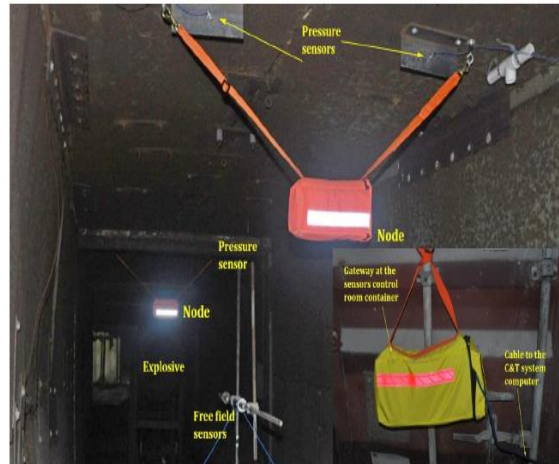
Compressed Air Lines – Impact Tests



Communication Systems

Define critical emergency operations and determine pre-event operations reliability and coverage
Determine system survivability

Tests using C4



Communication Systems

2. Define critical emergency operations and determine pre-event operations reliability and coverage
3. Determine system survivability

Tests using Methane



Communication Systems



Tests using Methane





Communication Systems

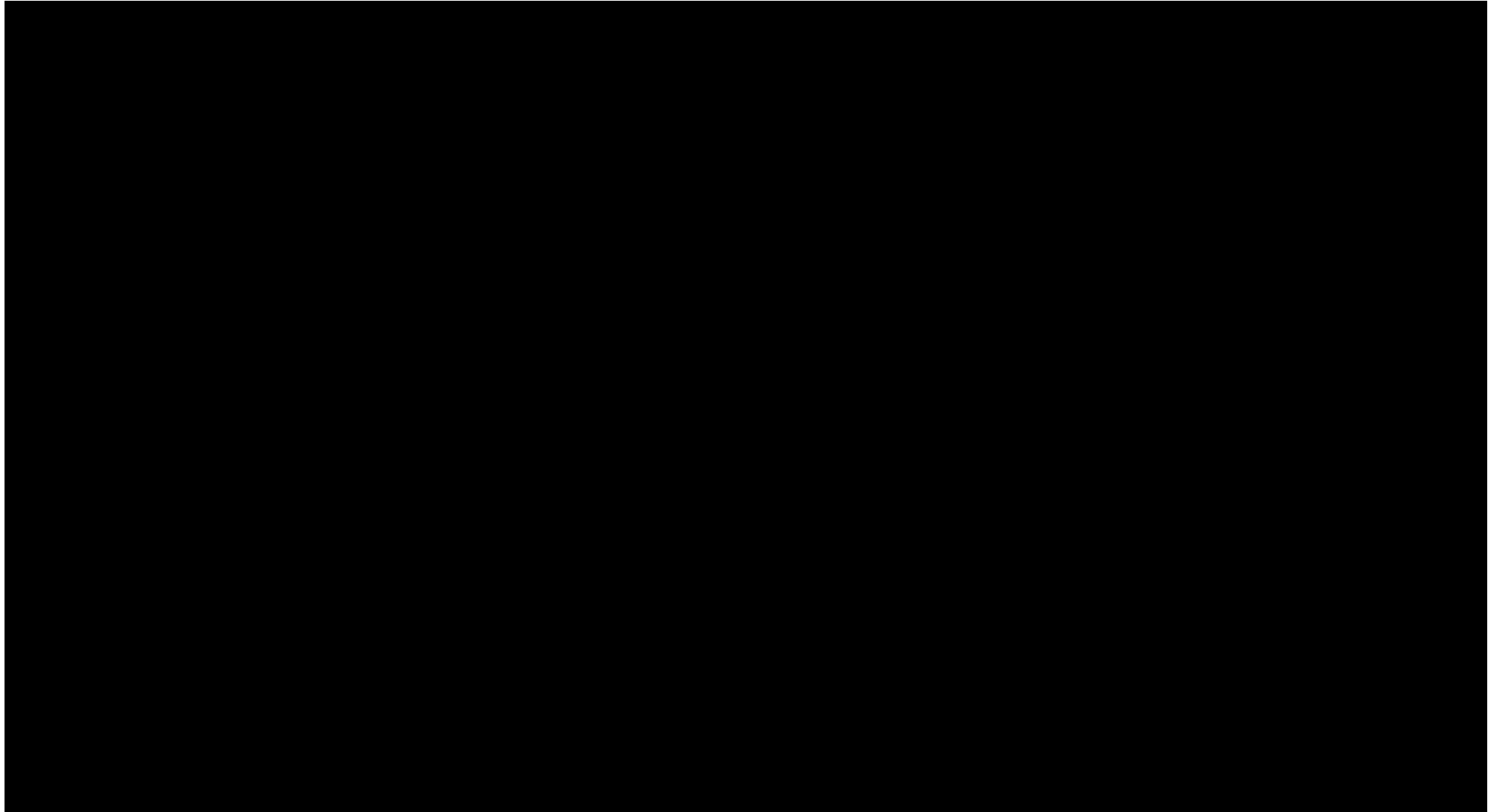
Results for the pressures generated by the explosions



The antennas were displaced onto the floor of the shock tube, however, none of them suffer severe damage.

Communication Systems

Impact tests



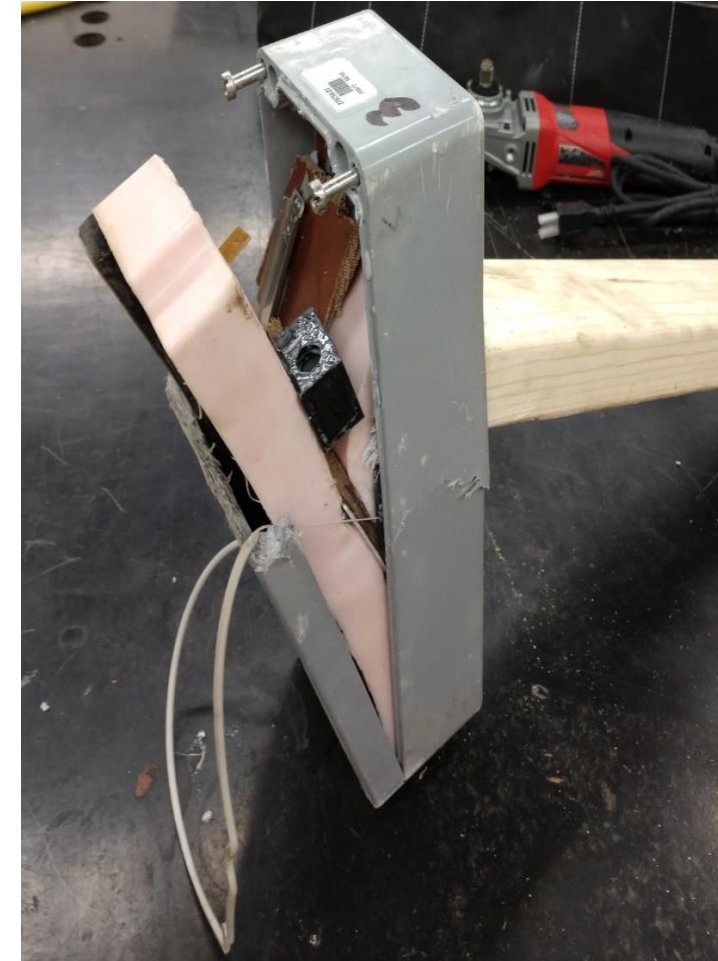
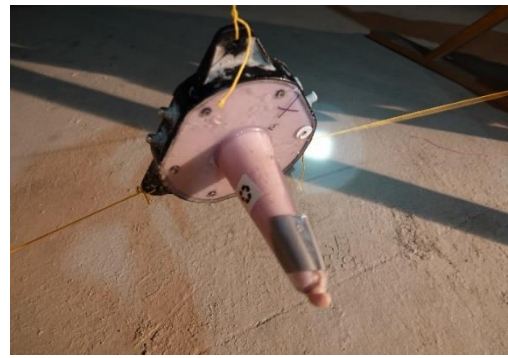
Communication Systems

Impact tests
Hardening



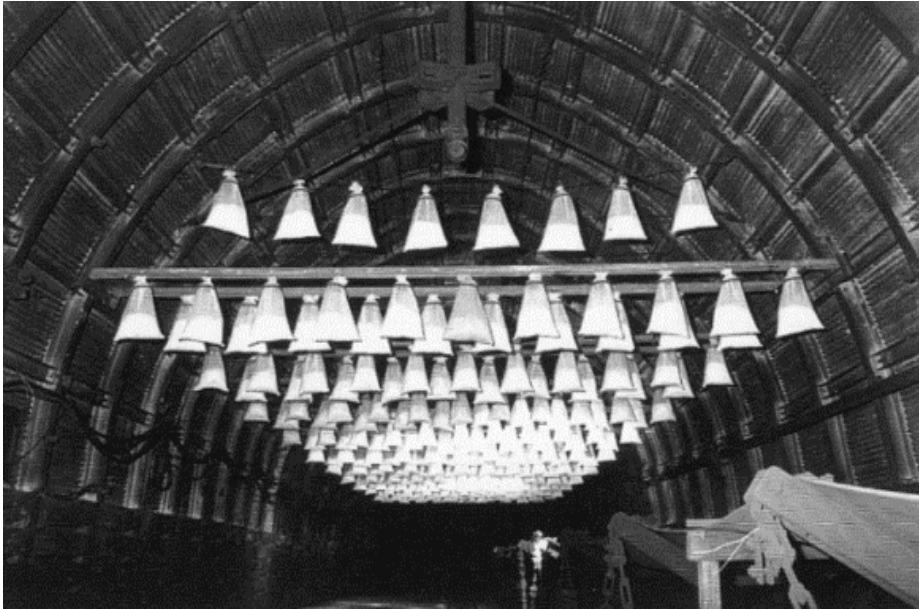
Auxetic
Materials

Polyurethane

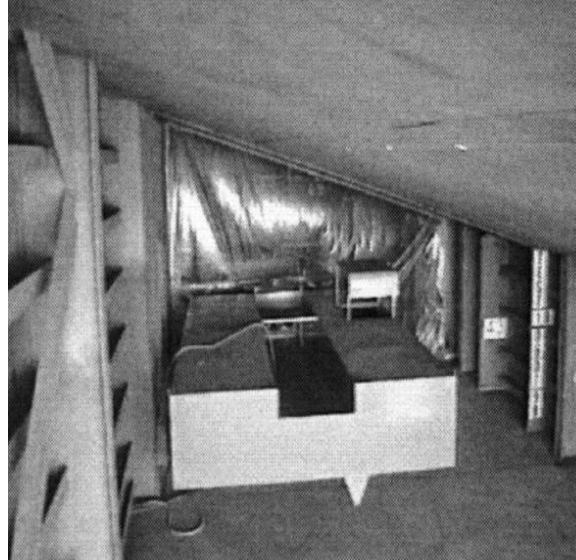


Active Explosion Barrier Systems

Systems to mitigate an explosion in addition to other preventive measures



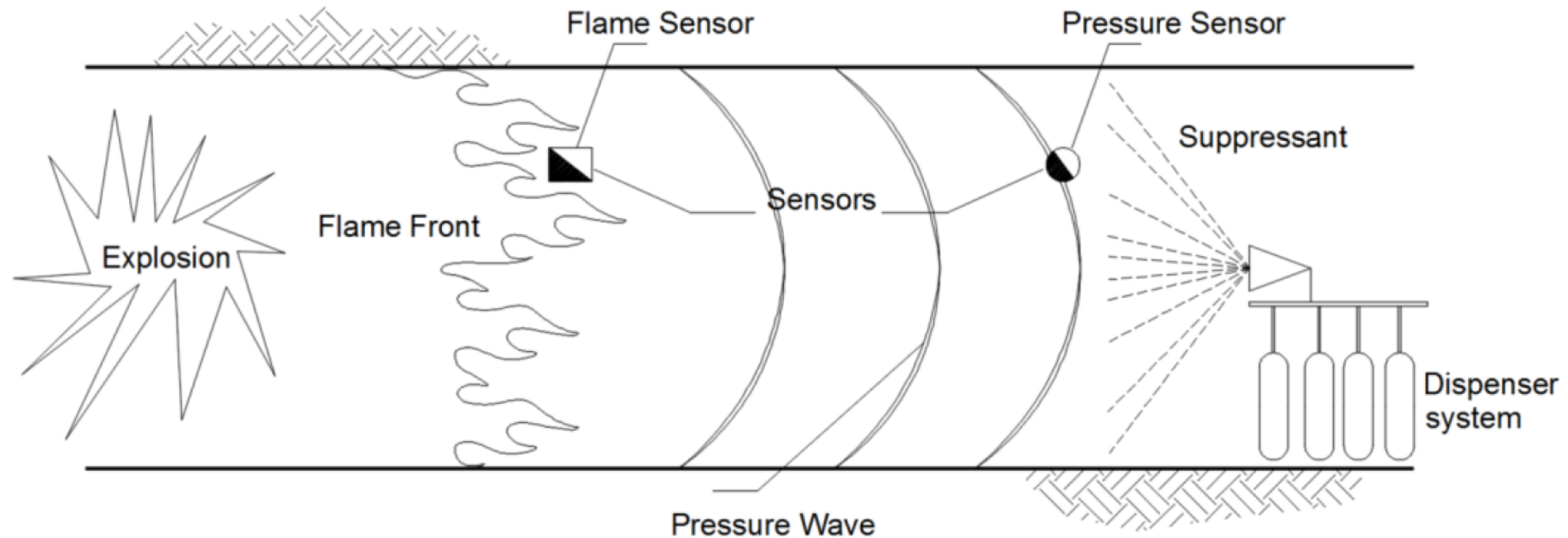
Passive Systems



Machine Mounted Systems

Active Explosion Barrier Systems

Systems to mitigate an explosion in addition to other preventive measures



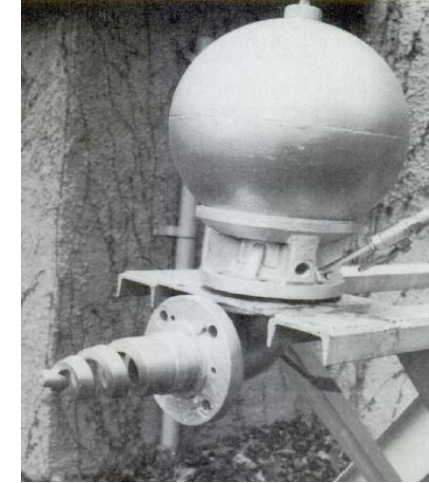
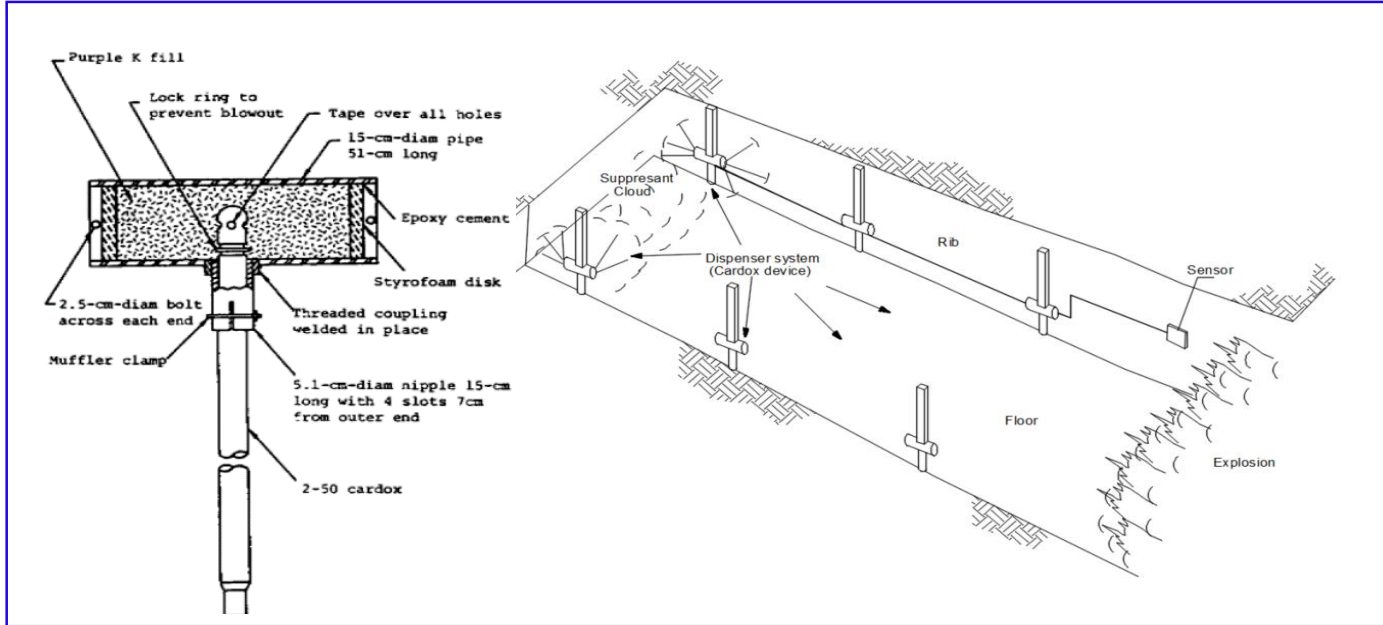
Active barrier systems (Concept)

Active Explosion Barrier Systems



Simulated Methane Gas Explosion
Continuous Miner without protection
Kloppersbos, South Africa

Active Explosion Barrier Systems



0 time



25 msec



50 msec

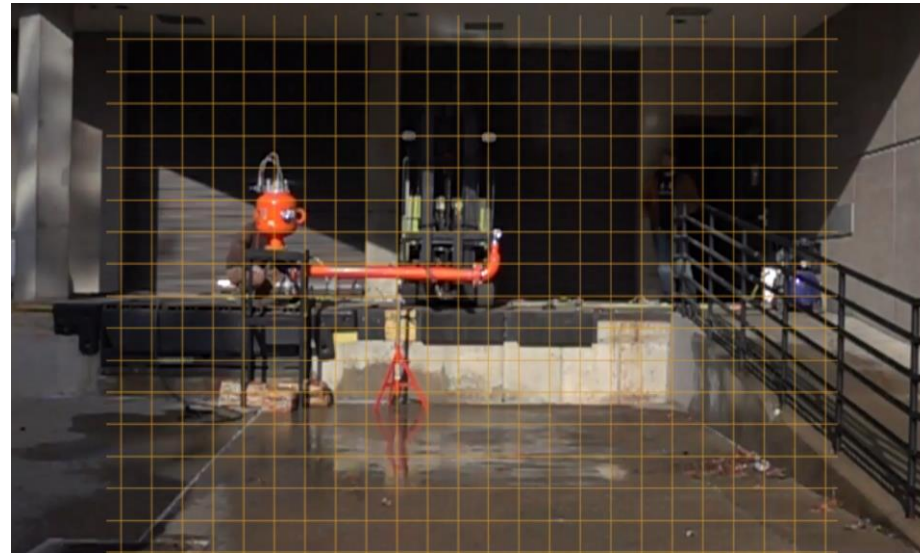
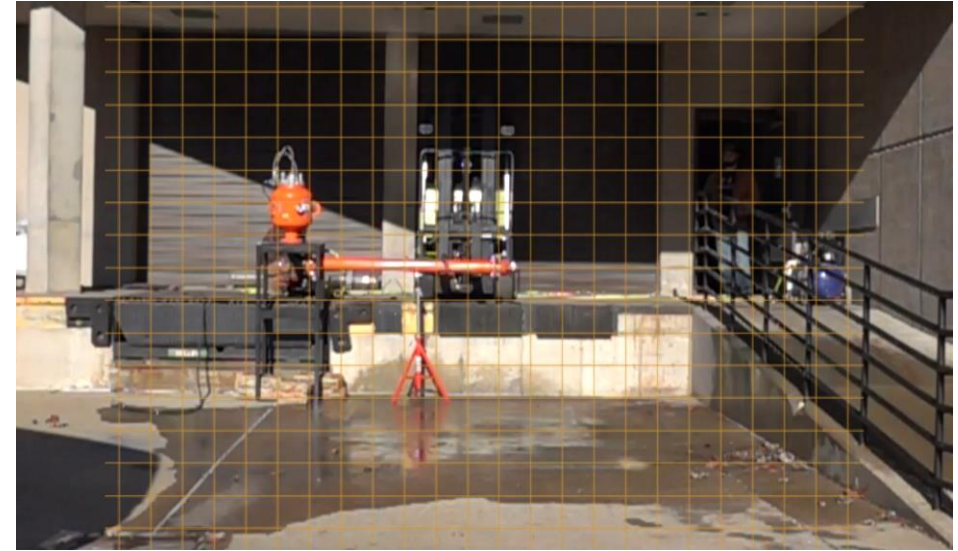
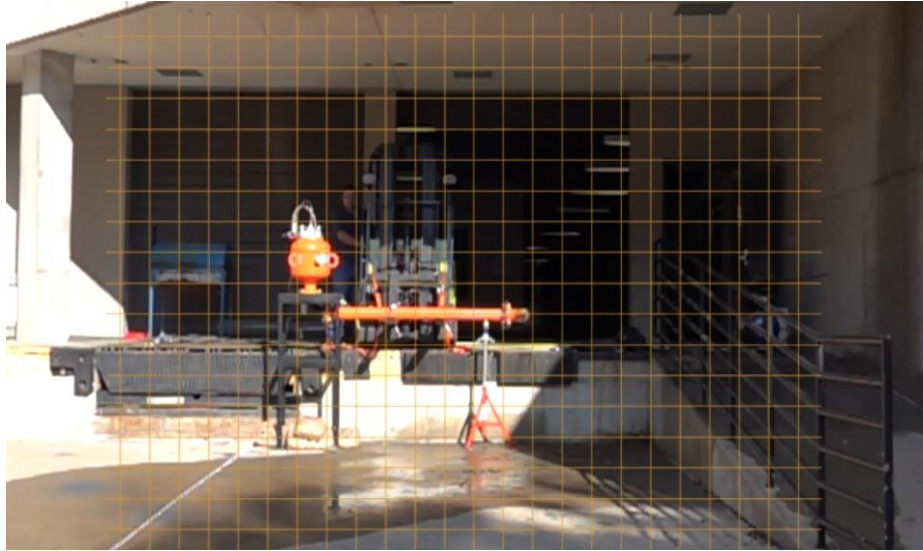
Active Explosion Barrier Systems

UKERT Active Barrier System

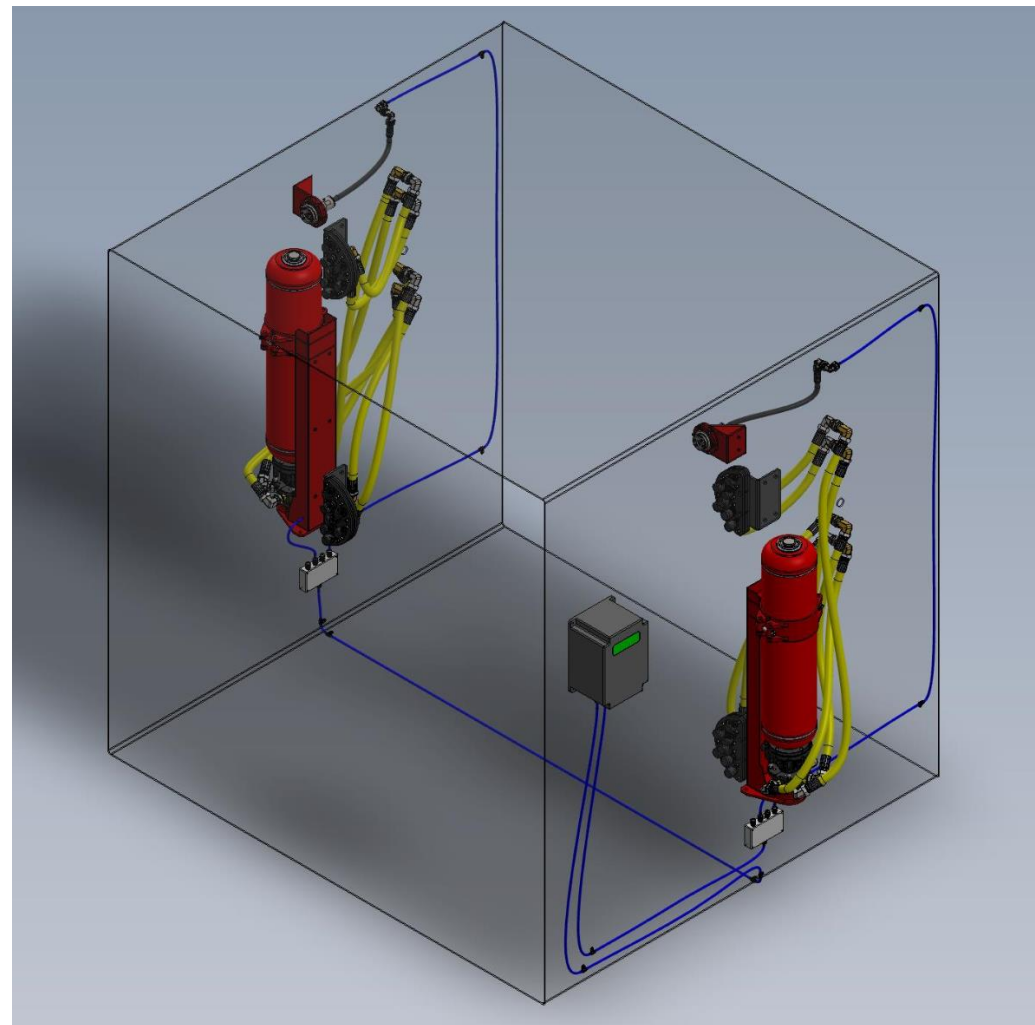
Includes a 35 L high pressure Martin air tank, two solenoid valves, two elbows, a 14.8 L water tank capacity, and three different nozzle heads



Active Explosion Barrier Systems

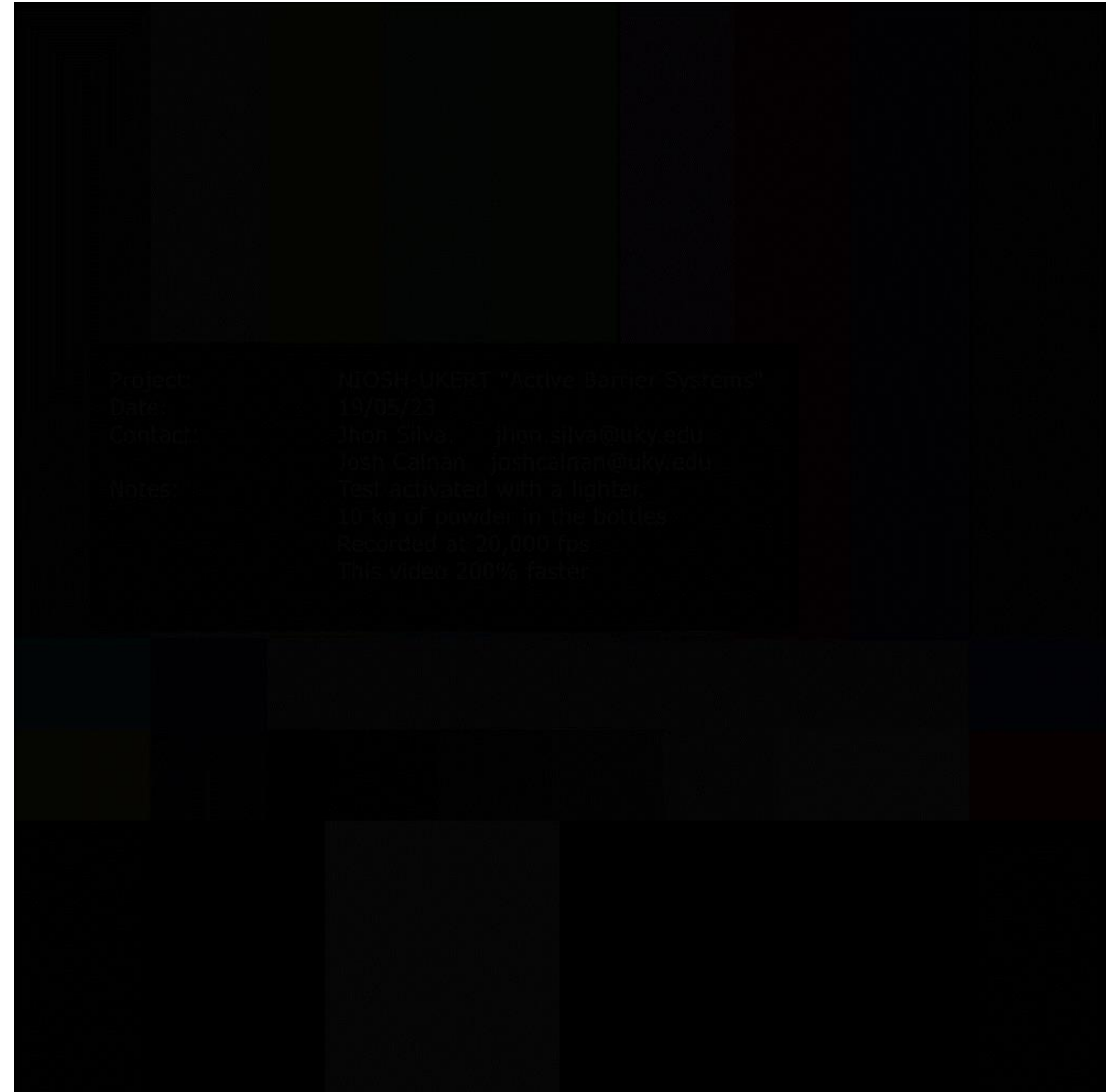


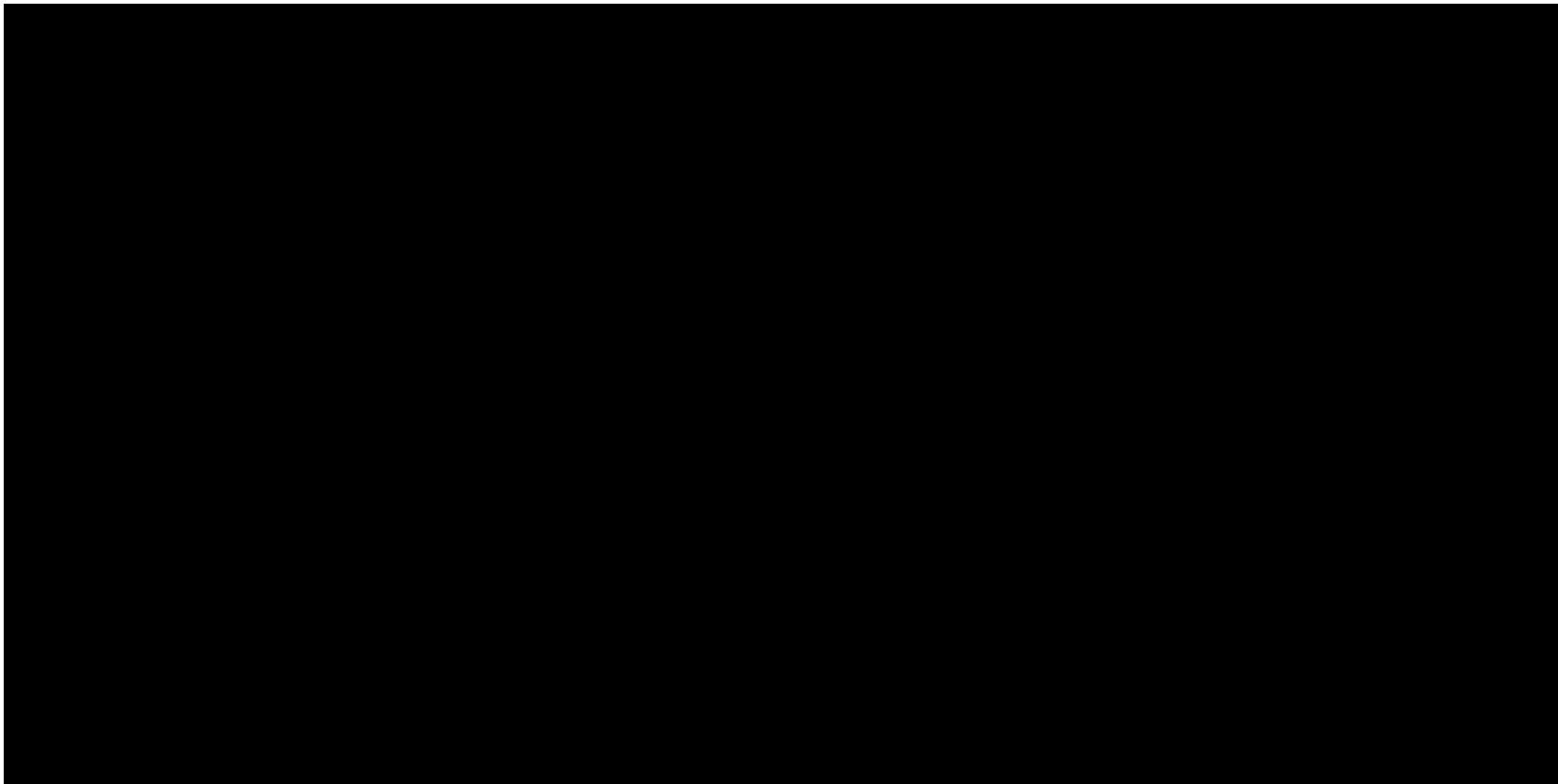
Active Explosion Barrier Systems



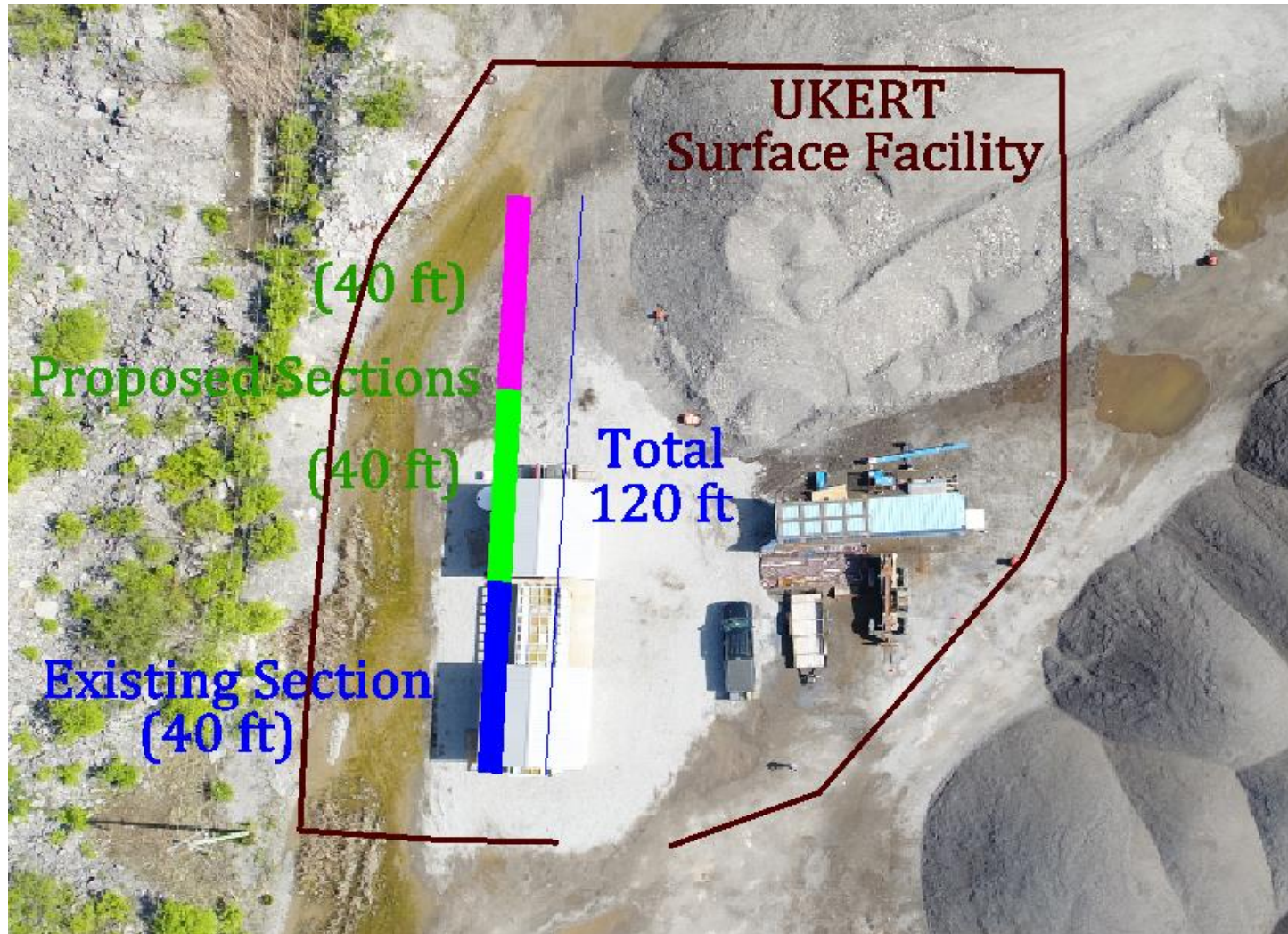
Active Explosion Barrier Systems

- Initial test 10 kg of powder per bottle (fully charged is 27 kg/bottle)
- Pressure (Nitrogen) 1450 psi





Active Explosion Barrier Systems



Academic Projects/Activities

2018- MEC Organization Recognition Award. The award recognizes a group for exceptional efforts of involvement with MEC. "UKERT, through outreach events both on campus and at their underground research facilities, is dedicated to educating and inspiring others about the importance of mining."

Online Blasting Certificate

MNG 331
Explosives and Blasting

Fall Semester

MNG 625
Environmental Aspects of Blasting

Division of Mine Reclamation and Enforcement
DMRE - Blasting Branch will recognize 12months
of training towards blasting license. (24 months
are required)

MNG 631
Advanced Blast Design

Spring Semester

MNG 621
Instrumentation for Blasting

Approved starting Spring 2020

Overview of Explosives and Explosion Research

Acknowledgments/Thanks

