

U.S. Army Research, Development and Engineering Command



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Suppressor Blowback Measurement NDIA Armament Systems Forum 28 April 2016

Adam Jacob – U.S. Army ARDEC

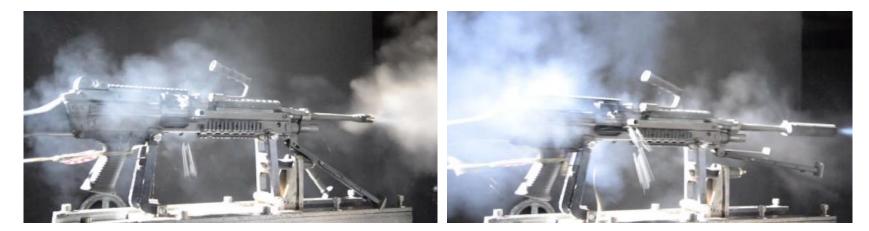
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Develop a Method to Measure and Quantify Blowback From Small Arms Systems

- Blowback Refers to the tendency of a small arms system to blow gases back through the chamber and toward the Operator after the bolt opens
- Although there has been work done in the area, there is no standard or accepted method to measure this phenomena with respect to the gases experienced by the Operator in a repeatable manner





Unsuppressed M249

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Suppressed M249

*Photos courtesy of AAI/Textron.



Background





Unsuppressed M249



Matcolm Baldrige National Quality Award 2007 Award Recipient

Suppressed M249

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- Many Operators report increased blowback when a suppressor is added to a small arms system – we also have some qualitative laboratory evidence of this
- Different suppressor designs result in different amounts of blowback
- Why is this a problem?
 - Operational impact
- How is it currently measured and assessed?
- Why do we need to measure it?
 - Comparison of suppressors
 - Predict operational impact
 - Generation of requirements

*Photos courtesy of AAI/Textron.



Small Arms Toxic Gas Testing – Toxins



Toxins in Small Arms Exhaust Gases

- Ammonia (NH₃)
- Carbon Dioxide (CO₂)
- Carbon Monoxide (CO)
- Hydrogen Cyanide (HCN)
- Methane (CH₄)
- Nitric Oxide (NO)
- Nitrogen Dioxide (NO₂)
- Sulfur Dioxide (SO_2)





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UNCLASSIFIED Current Small Arms Toxic Gas Testing



- TOP 2-2-614
 - Purpose of Current Testing Health Hazard Assessments (HHA)
 - Section 4.2 Weapons Systems Tests
 - "Open air toxic fumes testing... not normally conducted..."
 - Typically done inside the vehicle from which they may be fired (combat vehicle, etc.) in order to create a realistic scenario
- Other Methods IAW TOP 2-2-614
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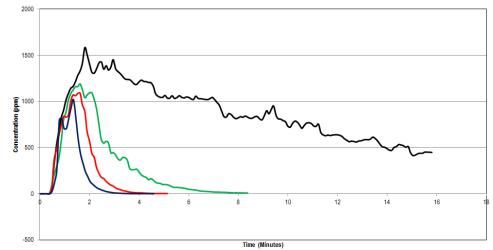
U.S. Army MOUT Chamber











Mateom Baldrige National Quality Award 2007 Award Recipient

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RDECON 2005 U.S. Army Blowback Test









*Photos from 2005 ATC report, "Comparison of Toxic Gas Results for the M249 SAW, (Squad Automatic Weapon) Weapons Firing Testing Using Various Suppressors".



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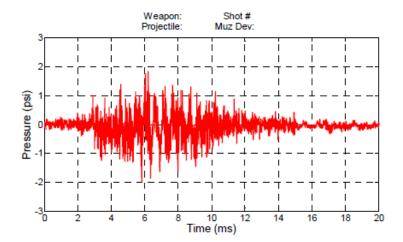


Optimization of Signature and Sound Suppression (OSASS) Developmental Method





Test Setup



Sample Data



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Path Forward



Where do we go from here?

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UNCLASSIFIED Challenges for Blowback Testing



- Gas concentrations are most important
- Need to look specifically at the added blowback resultant of a suppressor (or, potentially, any design feature)
- Must address the gases that are blown back to the User's face (versus all blown back)
- Must be repeatable
 - Eliminate wind, etc.
 - Common set up
- Must represent an operational scenario
- Test setup must be feasible for all potential users
- Must be affordable for all potential users





Path Forward



- 1. Preliminary proof of concept test at Army Research Lab (ARL) Aerodynamics Range (18-22 April, 2016)
 - Test blowback using a wide variety of different methods
 - Multiple weapons and suppressors from high blowback, to low
- 2. Analyze data
 - Assess the ability of each method to measure blowback differences at the Operator's location
 - Determine which methods have the best results, both in ability to measure differences from system to system, as well as repeatability of measurements
 - Overall cost of method will also be considered
- 3. Write standardized test method
- 4. Validate standardized method in live fire test





Methods Assessed



Handheld Gas Analyzer – MultiRAE Pro

- CO, NH3, HCN
- Tested as both a chamber assessment, and a real-time assessment at the Operator's face
- Test full weapon, as well as chamber gases only

Pros

- Less expensive
- More readily available
- Easy to use

Cons

- Slow Reaction Time
- Does not analyze all gases, must pick and choose







Methods Assessed



High Sensitivity Microphones at Various Locations (Similar to OSASS)

- Highly sensitive piezo electric microphones
 located at Operator's face
- Measures pressure wave which can be compared from system to system

Pros

- Concept proven in OSASS
- Able to measure small differences in pressure

Cons

- Difficult to shield muzzle blast from blowback
- Pressures may be too low at Operator location





http://www.pcb.com/products.aspx?m=106B



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Methods Assessed



Shadowgraph / High Speed Video

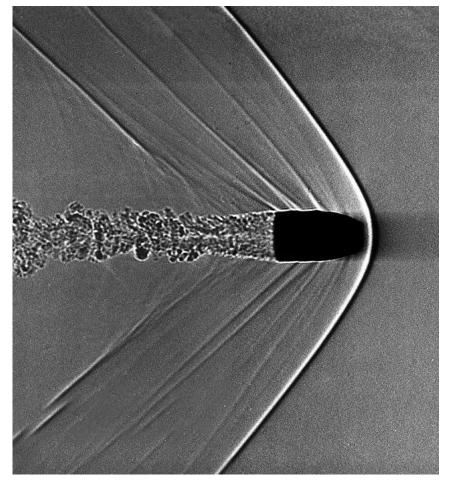
- Often used to look at projectile aerodynamics
- Provides qualitative data regarding pressure waves throughout the air

Pros

- Proven technology
- High likelihood of providing good qualitative data

Cons

- May be difficult to quantify data
- May be cost prohibitive for contractors, NATO partners



https://en.wikipedia.org/wiki/File:Supersonic_Bullet_Shadowgraph.jpg



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Methods Assessed



Planar Doppler Velocimetry (PDV)

- Uses laser/Doppler methods to track particle velocity through a plane
- Particles in propellant gas could potentially be tracked

Pros

High probability of providing accurate and repeatable
measurements of velocities at the Operator location

Cons

- Not readily available
- Could be cost prohibitive to industry and/or NATO partners
- Doesn't tell you anything about gas concentrations, just velocities





Methods Assessed



Bag Collection Method

- Vacuum pump is used to pull air into a collection bag at a given flow rate
- Collected air is sent to a laboratory for analysis

Pros

- Input can be positioned at Operator face location
- Adjustable flow rate
- Laboratory can assess for wide variety of gases
- Inexpensive and portable

Cons

- Very flow rate dependent
- Parameters must be applicable to all weapons
- Repeatability could be an issue



http://www.restek.com/catalog/view/11097







- 1. The addition of a suppressor to a small arms system has the potential to increase the amount of toxic gases blown back toward the User during weapon operation.
- 2. These gases can result in an operational impact by causing a User to experience burning/watering eyes, difficulty breathing, and potential burns which could cause him to momentarily and immediately become ineffective in firing the weapon.
- 3. Although there has been work done in the area, there is no standardized method to measure and assess blowback.
- 4. This is currently being addressed through the development of a measurement methodology that is intended to eventually be both a NATO and MIL standard.





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Questions/Discussion





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Equipment Overview – FTIR



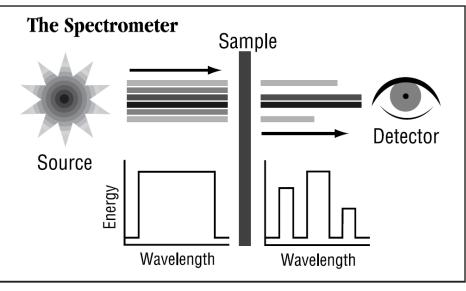
How Does It Work?

- An infrared (IR) radiation beam is generated and passed through an Interferometer
- Interferometer manipulates the beam (this is done to enable all frequencies to be measured simultaneously)
- The manipulated beam is passed through a sample, where some IR is absorbed, and some passes through (transmitted)
- Detector measures the signal

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RDECOM)

- Resulting spectrum represents the total absorption and transmission for all frequencies
- Fourier Transformation is used to calculate individual frequencies





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Open Air vs. Chamber



Open Air Testing

Advantages	Limitations
Simulates specific operational conditions	Introduces variables such as wind, etc., that will affect results
Can be compared to exposure limits to analyze impact to health or function	Sampling too slow to catch "peaks" – may result in artificially low readings
Air inlet can be placed directly at the position of interest (User's face)	Not a "worst case" condition

Chamber Testing

Advantages	Limitations
Ensures that all gases of interest are captured	Not operationally relevant unless the chamber size and ventilation reflect specific operational firing scenarios
Eliminates issue of slower sampling rates	Generates artificially high concentrations
Good for comparing emission data for different weapon systems, ammunition, or configurations of weapon or ammunition	Cannot be compared to exposure limits to analyze impact to health or function, unless the conditions reflect specific scenario that you are interested in
A chamber would be a worse case than open air	Cannot zero in on specific location (User's face)





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Summary of Test Attributes



Current Testing (TOP 2-2-614)	Proposed Blowback Testing
Measures toxic gas concentrations	Measures toxic gas concentrations
Measures total gas concentrations resultant from firing a weapon system (including muzzle gases)	Measures concentrations only of the gas blown back at User (muzzle gases not included)
Does not measure temperature or pressure	Could measure temperature and pressure at selected areas of interest
Purpose is to quantify toxic gases in order to assess health risk for HHA	Purpose is to quantify only the gases that are blown back toward the User to assess risk of immediate operational impact
Largely independent of weapon design, and mostly dependent on combustion products of ammunition	Very dependent on weapon and suppressor design due to increased backpressure
	Quantify the increase in blowback in a weapon system as a result of the addition of a suppressor, perhaps as a percentage
	Assess risk of operational impact due to blowback (this is not required, but would be ideal)



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