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ARMAMENTS

Measurement and Quantification of Suppressor Blowback

Presented at:

NDIA Armament Systems Forum

Fredericksburg, VA

03 May 2017

UNPARALLELED

COMMITMENT

& SOLUTIONS

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Agenda

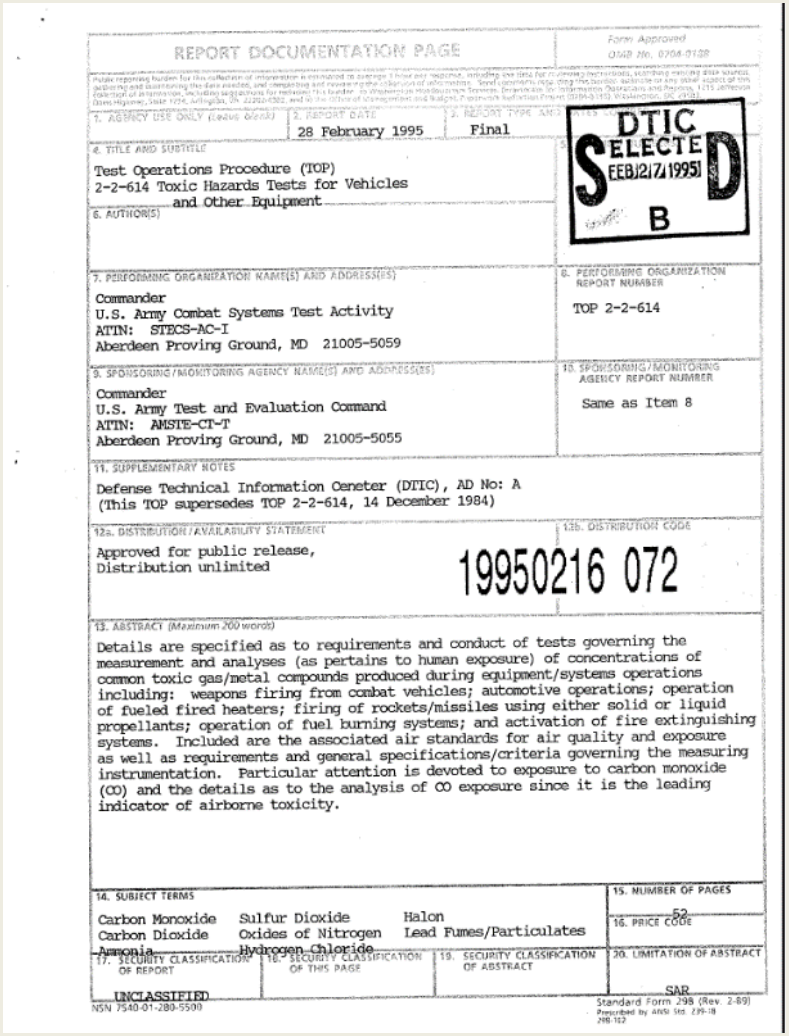
- Background and Purpose
- Background of Toxicity Testing
- Spring 2016 Test
  - Overview
  - Results
- December 2016 Test
  - Overview
  - Results
- Alternate/Additional Methods
- Path Forward
- Questions

Background and Purpose

- Background
  - Suppressor use becoming more common across general Users (non-specialized)
  - One negative side effect of suppressors use is the toxic gas blown back to the User
  - No current standard method to measure and quantify blowback
- Purpose
  - *The purpose of the project is to develop, test, and validate an Army and NATO standardized method to measure and quantify suppressor blowback in small arms systems.*

Background of Blowback Testing

- U.S. Test Operations Procedure (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
  - Military Operations in Urban Terrain (MOUT) situations
  - This testing is still aimed at Health and Safety, rather than operational impact



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13. ABSTRACT (Maximum 200 words)
Details are specified as to requirements and conduct of tests governing the measurement and analyses (as pertains to human exposure) of concentrations of common toxic gas/metal compounds produced during equipment/systems operations including: weapons firing from combat vehicles; automotive operations; operation of fueled fired heaters; firing of rockets/missiles using either solid or liquid propellants; operation of fuel burning systems; and activation of fire extinguishing systems. Included are the associated air standards for air quality and exposure as well as requirements and general specifications/criteria governing the measuring instrumentation. Particular attention is devoted to exposure to carbon monoxide (CO) and the details as to the analysis of CO exposure since it is the leading indicator of airborne toxicity.

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MEASUREMENT AND QUANTIFICATION OF SUPPRESSOR BLOWBACK

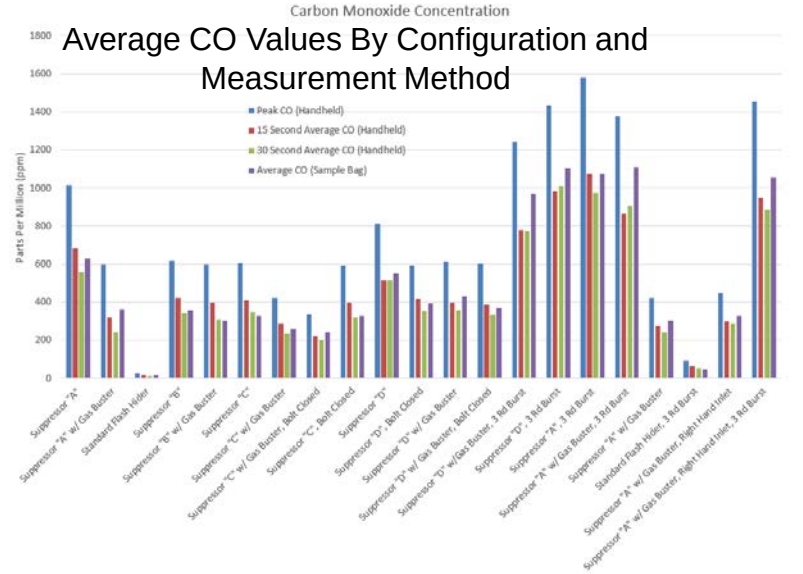
Preliminary Proof of Concept Test
U.S. Army Research Lab (ARL) Aerodynamics Range
18-22 April, 2016

- Test blowback using several different methods
  - High speed video shadowgraph
  - Piezo electric pressure at User's face
  - Gas sampling bags
  - Handheld gas analyzer

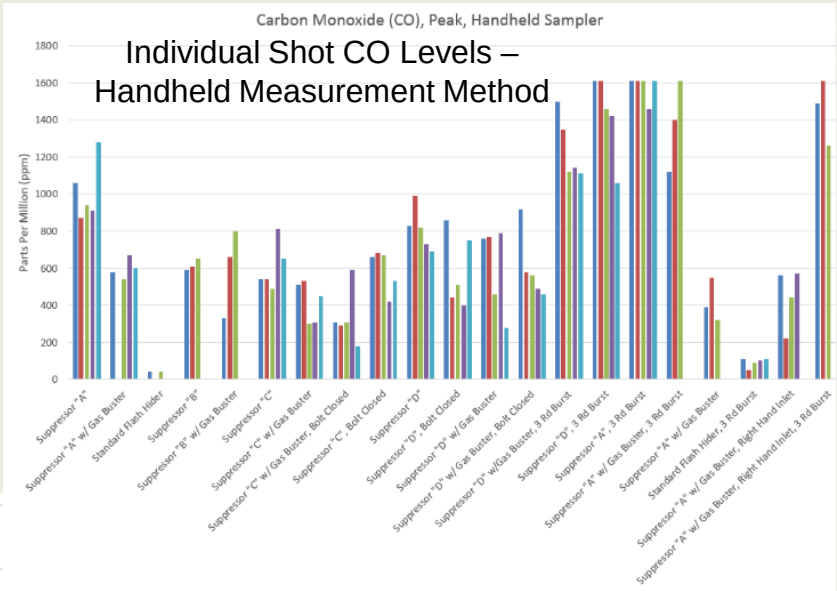
- Multiple configurations to represent wide range of blowback
  - M4 used as base weapon
  - Unsuppressed (standard flash hider)
  - 4 different suppressors
  - Standard and "gas buster" charging handles
  - Single and 3 round burst
  - Open and closed bolt after shot

Results Summary – Preliminary Proof of Concept Test – 18-22 April 2016

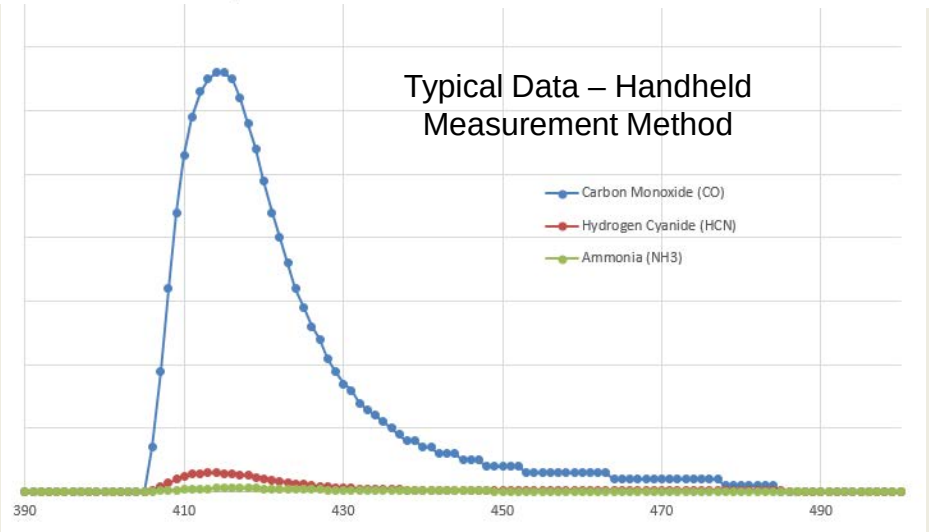
Average CO Values By Configuration and Measurement Method



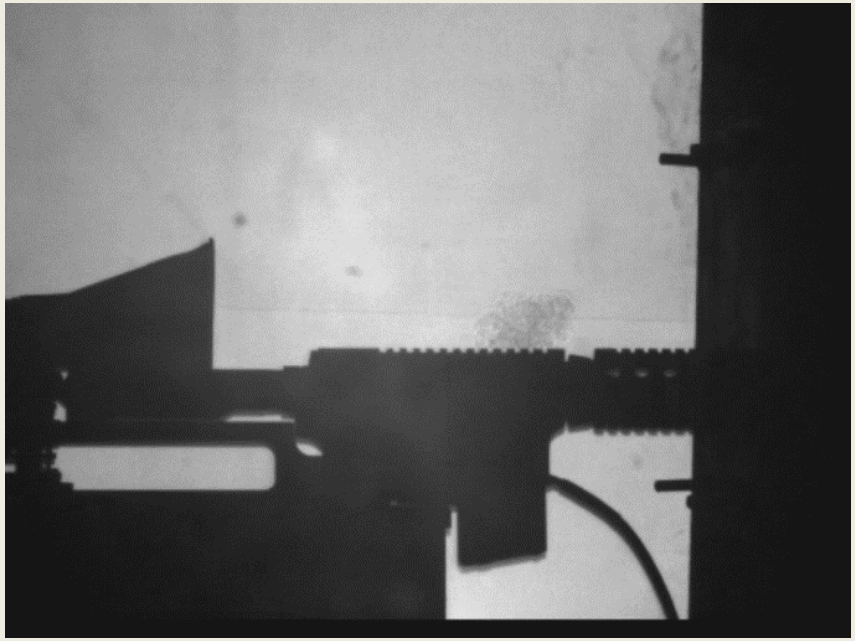
Individual Shot CO Levels – Handheld Measurement Method

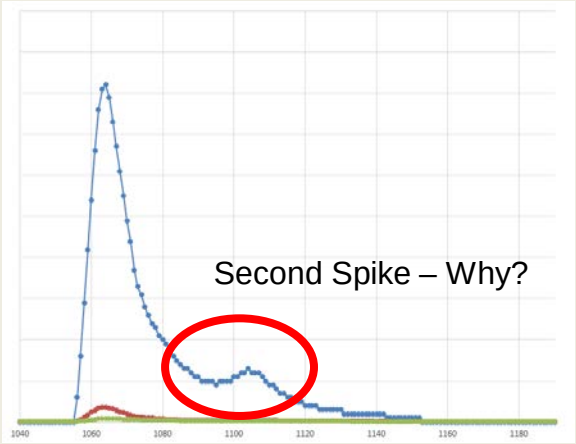


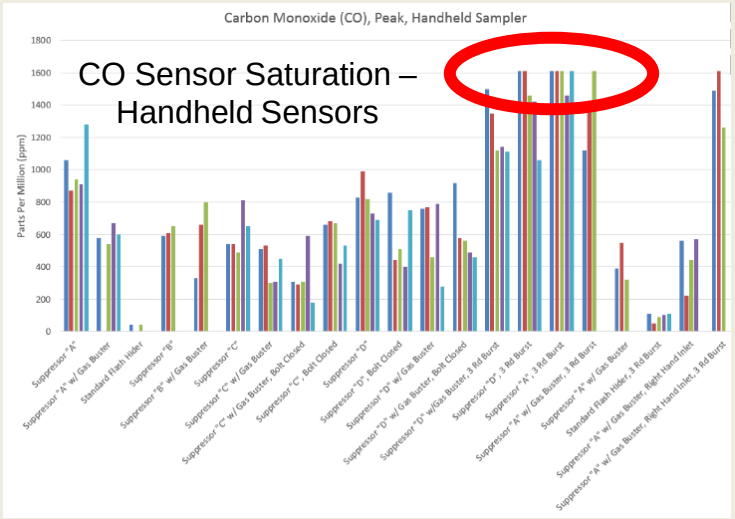
Typical Data – Handheld Measurement Method



Results Summary – Preliminary Proof of Concept Test – 18-22 April 2016







Conclusions – Preliminary Proof of Concept Test – 18-22 April 2016

Handheld Sampling – RAE Systems MultiRAE

- Sensor reaction time appears to be sufficient.
- CO, HCN sensors not sufficient for concentrations measured.
- 15, 30 second time weighted averages are good comparison to bag sampling data.

Bag Sampling – RESTEK Vacuum Sampling Unit

- Bags filled to somewhat different levels, may be due to accuracy of flow rate control.
- 15 seconds may not be enough sampling time due to the length of the event.

Shadowgraph / High Speed Video

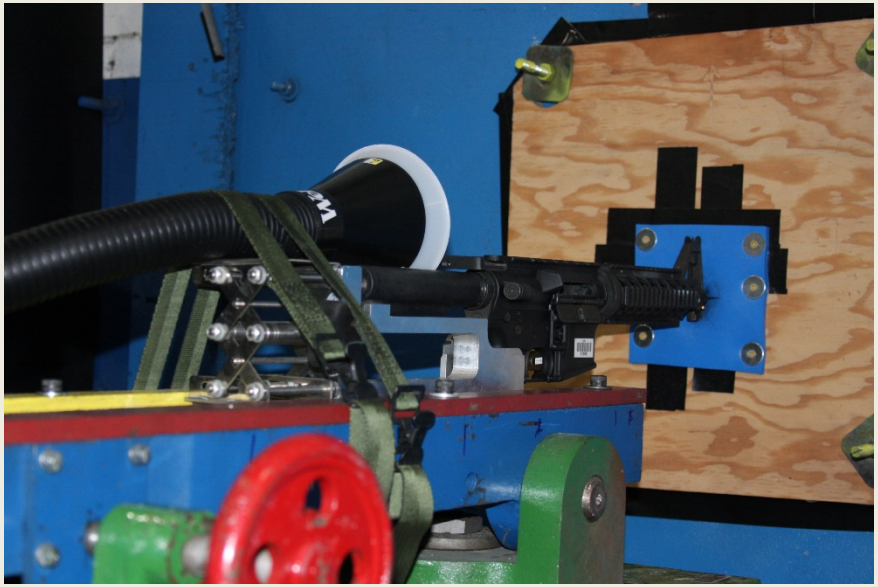
- Good visual representation, but may get better results with regular HSV, dark background.

General Conclusions

- Exhaust fans should be left off for a longer period of time after each shot, due to second spike in handheld data
- Anomalies (either high or low flyers) tend to be anomalies in both methods (Handheld, Vacuum Sampler), and typically are anomalies for all gases. This indicates that differences in concentration from shot to shot are real.
- While the magnitudes are different, the trends are consistent when comparing peak, 15 sec average, and 30 sec average using the handheld unit.
- HCN, NH3 percent of CO are not in agreement for handheld sampler versus vacuum sampling. Could be due to reaction of gases, could be other reasons. Still, it may be acceptable to use CO as an indicator gas, but more research is needed to fully validate that assumption.
- Shot to shot data is highly variable – larger sampling size for each configuration (more shots) is needed for more statistically valid results.
- Different CO sensor needed to measure concentrations above 1600 PPM, HCN sensor above 50 PPM
- Additional handheld unit (different manufacturer) needed to ensure that results are comparable.

MEASUREMENT AND QUANTIFICATION OF SUPPRESSOR BLOWBACK

Follow-On Test – 12-16 December 2016



OBJECTIVES

- Improve methods from spring test
- Assess data consistency
- Test additional sensors, compare data
- Test additional suppressors
- Test measurement sensitivity to other “blowback reduction” technologies

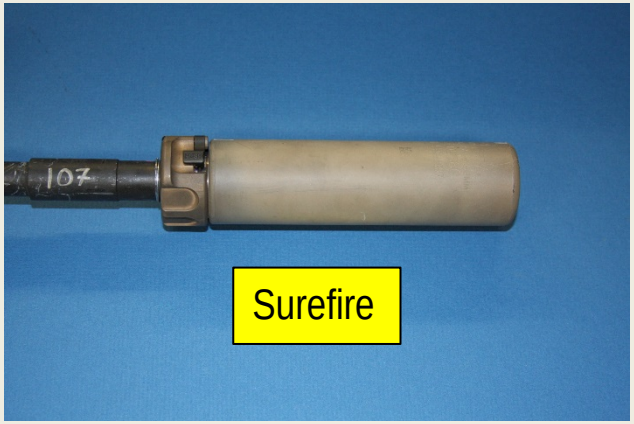
Measurement Methods/Sensors

- High Speed Video – standard with dark background
- Gas Sampling Bags – 45 second sampling time
- Handheld Gas Analyzers
  - RAE Systems MultiRAE Pro
  - Draeger XAM5000 (Higher PPM CO and HCN)
- Additional time with range exhaust turned off between shots
- Additional shots with each configuration (at least 10)
- Each configuration tested with left and right inlet
- Single and 3 round burst for each configuration

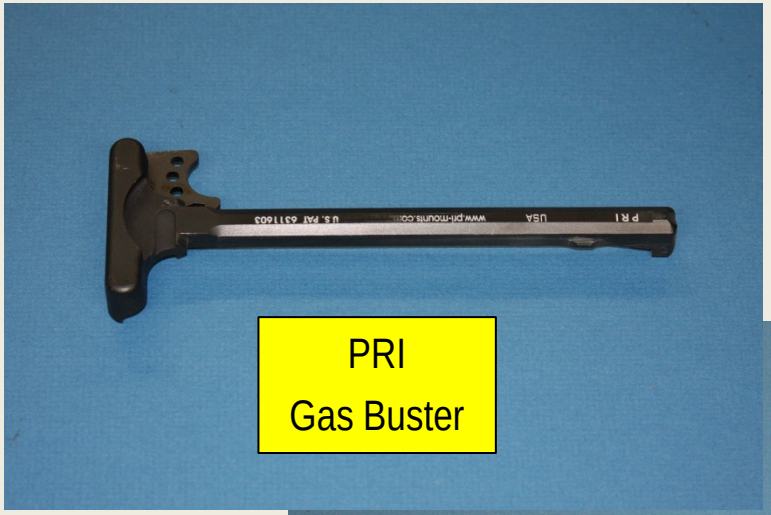
Weapon Configurations

- 4 different muzzle devices tested (flash hider plus 3 suppressors) for wide range of blowback
- 4 different charging handles used (standard charging handle and 3 different handles marketed to reduce blowback)

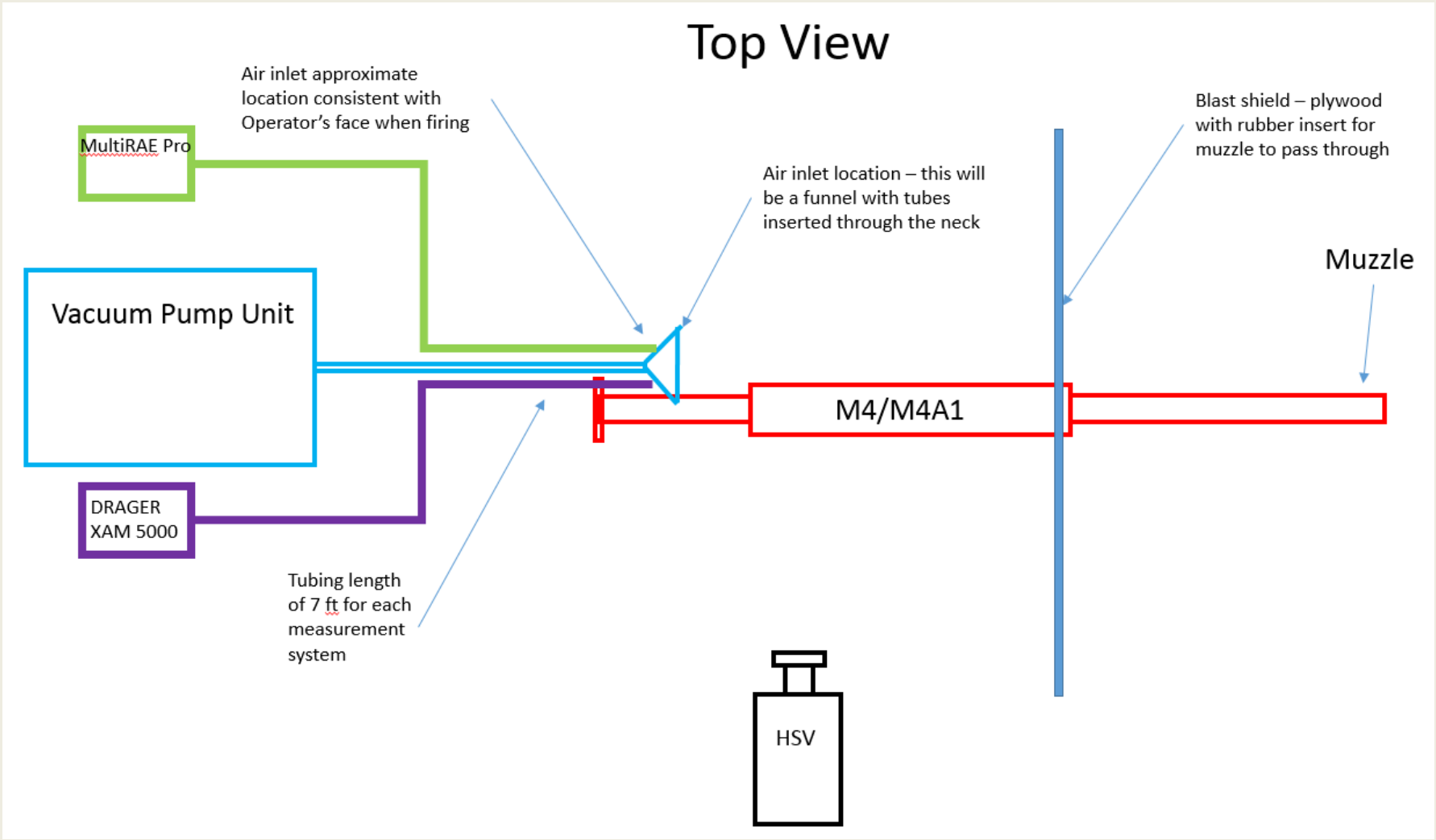
Suppressors Tested



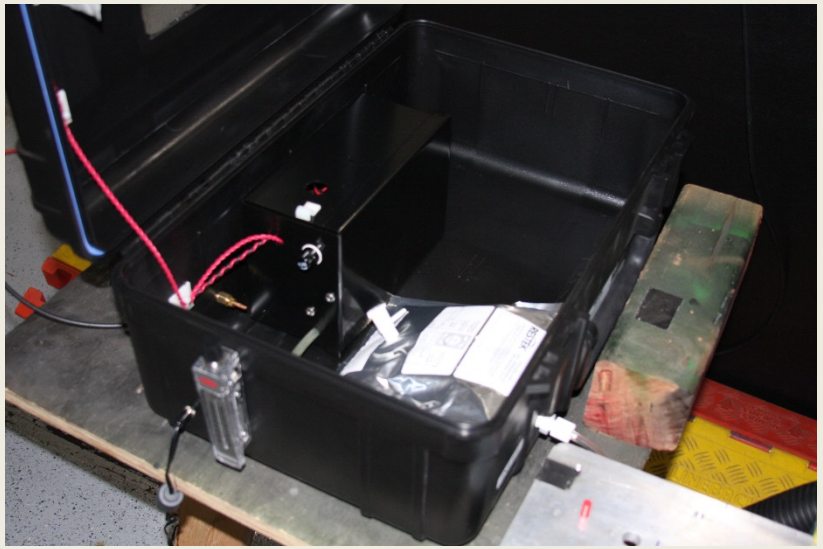
Charging Handles Tested



Test Set-Up



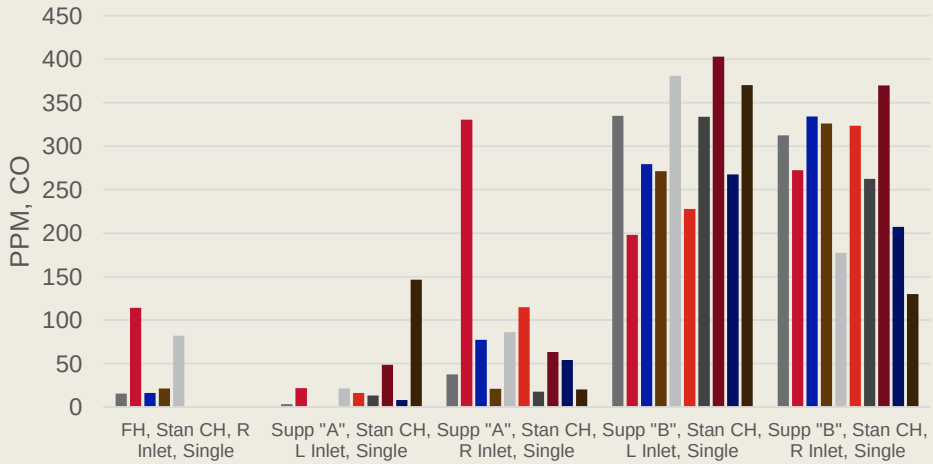
Test Site Pictures



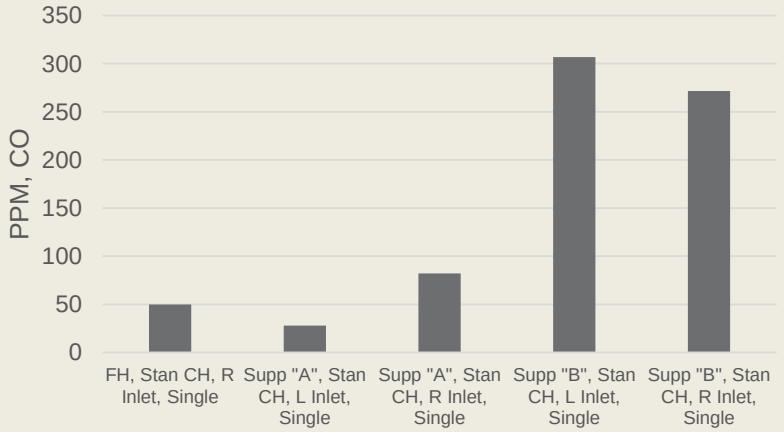
Preliminary Results – MultiRAE vs. Draeger Data

Preliminary Results – Suppressor Comparison

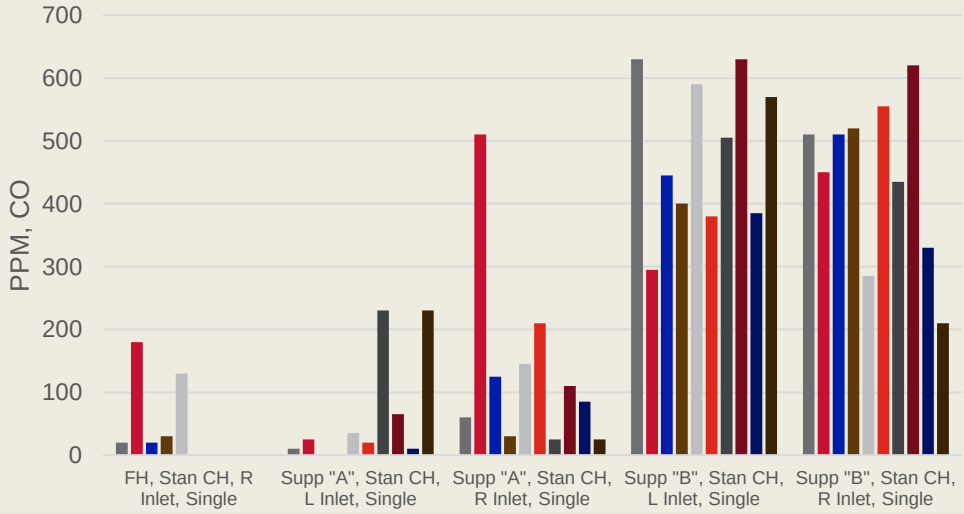
30 Second Average, Individual Shot Data



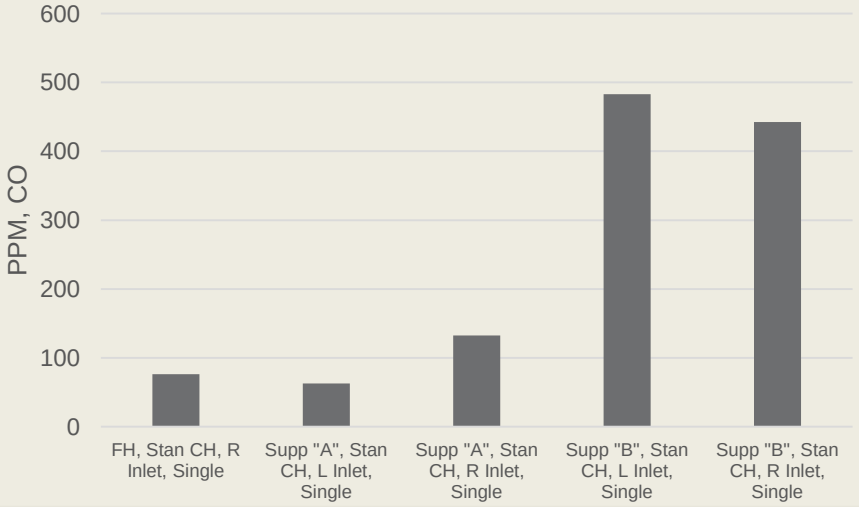
30 Second Average, Configuration Averages



Peak CO, Individual Shot Data

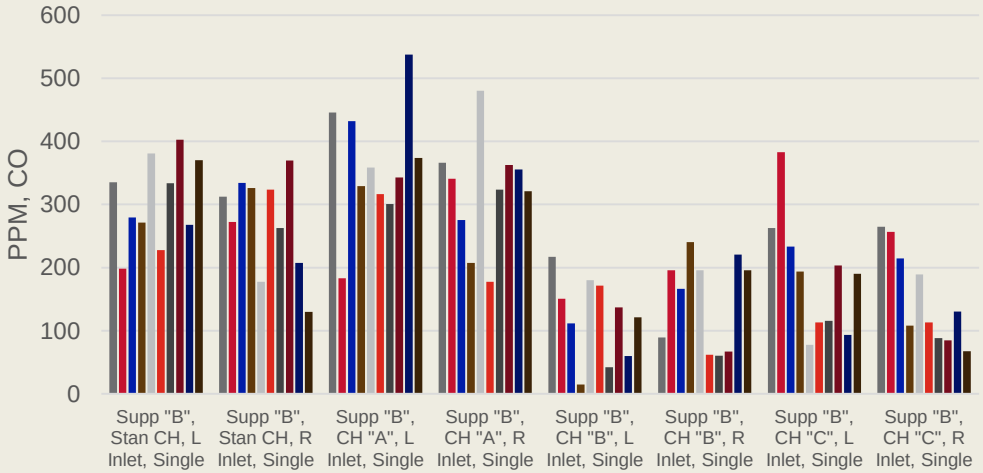


Peak CO, Configuration Averages

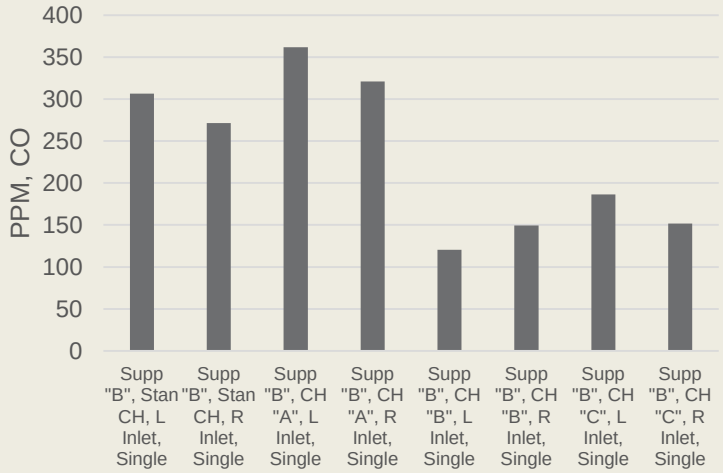


Preliminary Results – Charging Handle Comparison

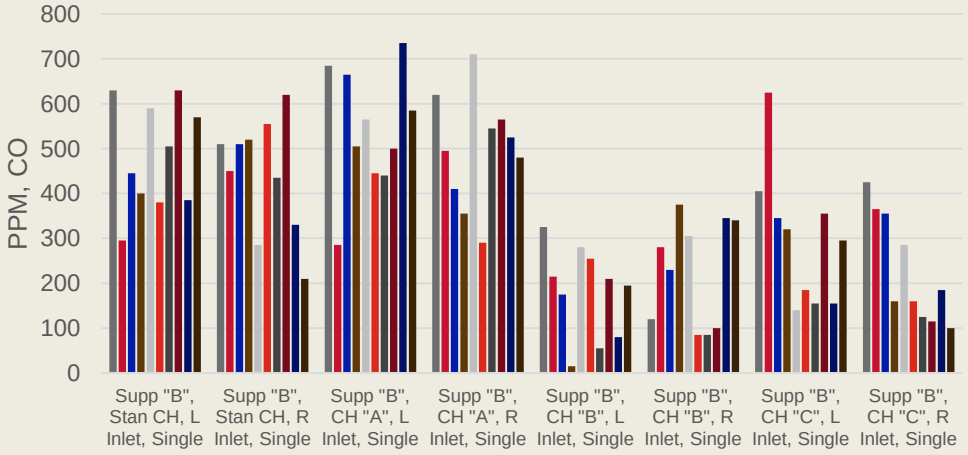
30 Second Average, Individual Shot Data, Charging Handle Comparison



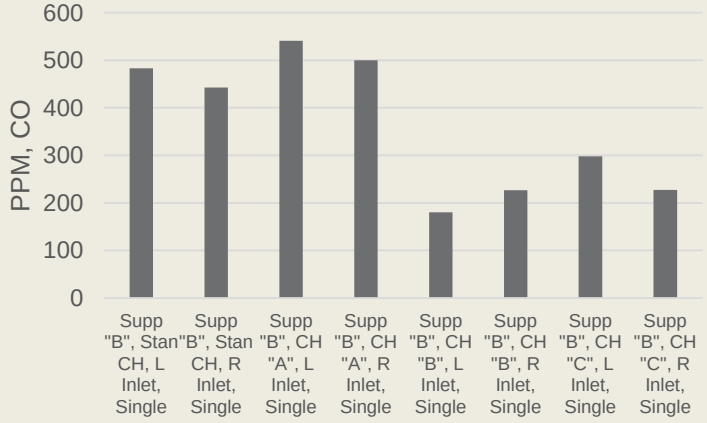
30 Second Average, Configuration Averages, Charging Handle Comparison



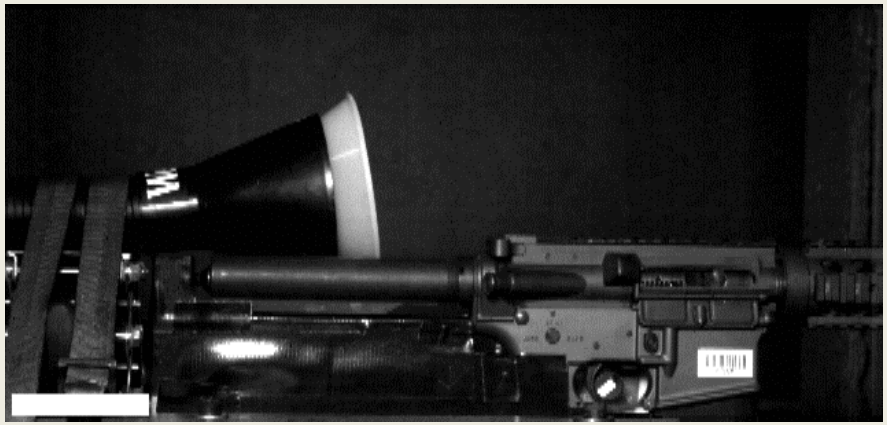
Peak CO, Individual Shot Data, Charging Handle Comparison



Peak CO, Configuration Averages, Charging Handle Comparison



High Speed Video



Suppressed (Shot 41217)

Unsuppressed (Shot 41155)

Conclusions on Methodology and Test Equipment

- MultiRAE and Draeger XAM500 appear to measure within 10% of each other when measuring within sensor limits.
- Draeger XAM5000 sensors do not appear to saturate like the MultiRAE sensors did in prior testing.
- 15, 30 second time weighted averages provide additional insight.
- Exhaust fans left off for 1 minute after firing – still can see additional “hump” in concentrations, but the event is mostly over at that point. Must make sure only the first 60 seconds of data are analyzed in order to prevent errors.
- There is considerable variation in shot to shot CO concentration over a given 10 shot group. Possible causes for “high” outliers could be related to random flash incidents / ignitions.
- Comparison of methods shows that the shot to shot variation is real.
- Statisticians may need to be consulted to verify statistical methods. May need to eliminate outliers in shot to shot data to get more realistic averages. May need more than 10 shots per configuration.
- 45 second bag sampling time at lower flow rate appears reasonable (still awaiting data from lab).
- Data shows that the method can measure differences in blowback from different suppressors
- Data shows that the method can measure differences in concentration *at the Operator’s face* resultant of the use of blowback reducing charging handles which redirect the gas. This is groundbreaking because these devices do not change total blowback, and only change the amount that reaches the operator. This shows that the method can assess directionality, which plays a role in operational impact.
- Left inlet and right inlet do not appear to have a significant effect on the concentration of gas measured. Still, left and right inlet should probably be included in order to assess effect on both right and left handed Operators.
- High Speed Video shows that a significant amount of gas blows out of the weapon’s ejection port, on the right side of the gun.

Discussion on Alternate Method (Chamber Test)

Advantages

- Simpler test.
- Not reliant on Human Factors considerations.
- May be able to use facilities and equipment from weapon toxicity test with little to no modification.
- Methodology is largely proven out.

Disadvantages

- Does NOT account for directionality or how much gas goes to operator.
- Does not take into account the system level effects (i.e. effects of charging handle configurations, etc.)

Schedule / Path Forward

- March/April 2017
  - Complete detailed data analysis from December Test.
- April/May 2017
  - Generate formal DRAFT methodology, present to JSSAP/NATO and SOCOM customers.
  - Generate/present NDIA briefing and technical report.
- June/July 2017
  - Plan and perform final verification/validation test (working with Canada on this, joint test at DRDC Valcartier).
- August/September 2017
  - Finalize methodology and present to NATO working group.

Questions