DETERMINING THE EXPOSURE OF PERSONNEL WHEN USING AMMUNITION

Monique van Hulst, Rob Groeneveld and Jan Langenberg

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PROCUREMENT OF AMMUNITION / SMOKE (S3*)

The best munition for the intended purpose and with the weapon of choice

Choice based on:

- Functionality of the ammunition → Functionality:
  - E.g. Muzzle velocity and “point of impact”
  - E.g. Smoke density and duration
- Life-time
- Costs
- Law and legislation
  - REACH (EU)
  - Occupational health → Occupational health: exposure formed emission products during firing/use
  - Environment
- Etc.

*S3 = Safe and Suitable for Service

INFLUENCE ON EMISSION PRODUCTS

- Configuration of the material burned
- Temperature of the combustion
- Availability of oxygen
- Composition of the burned mixture
- Weapon configuration
- ...

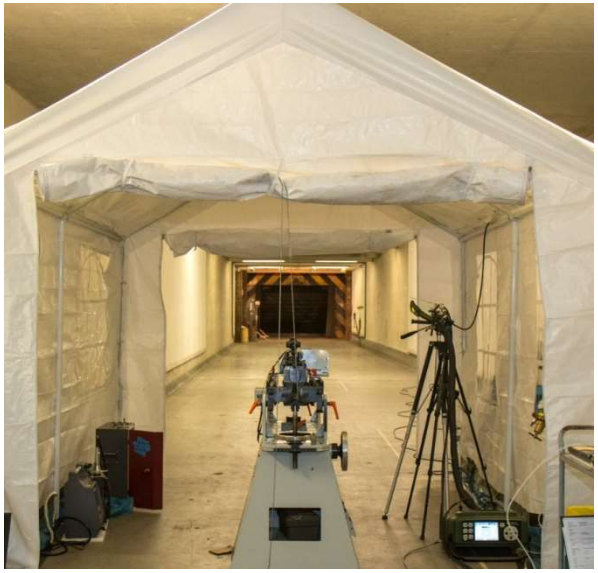
HOW TO DETERMINE THE EMISSIONS

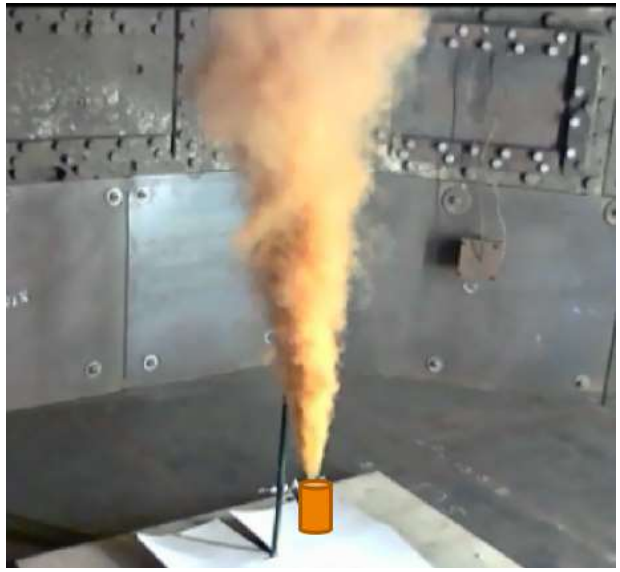
- Experimental setup
  - Volume of chamber or shooting range (degree of dilution)
  - Location/position of measuring (distance to the source)
  - What and how to measure/sample (diversity of the emission products)

- Influence of environmental conditions
  - Humidity
  - Temperature
  - Air flow (speed and direction)

- Number of rounds and frequency of firing

EXAMPLES EXPERIMENT AREAS / VOLUMES





LOCATION OF MEASURING

- Distance to the source – end of the barrel
  - Pressure wave influence
  - Further away reaction and cooling of emission products

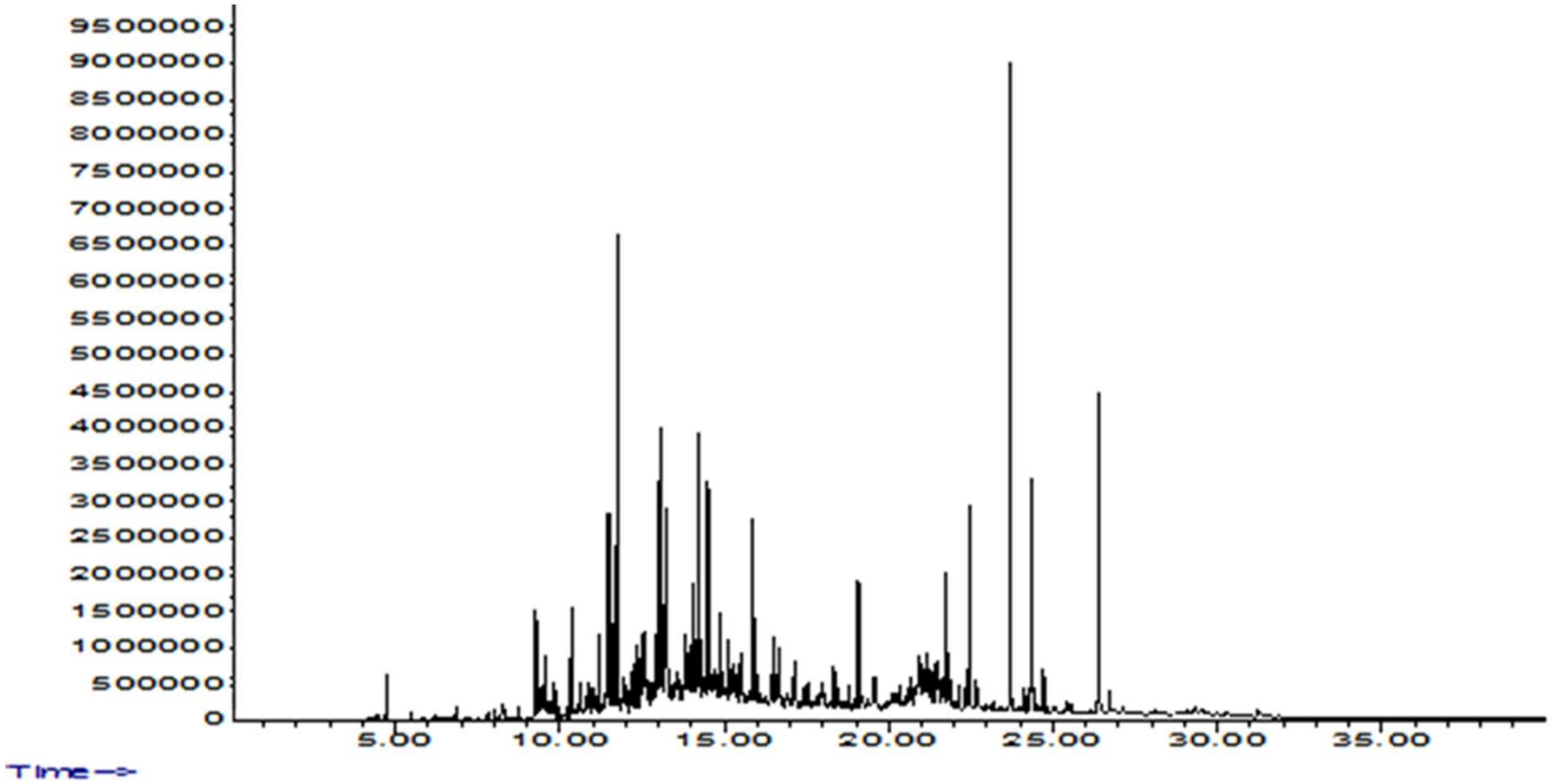
- Personal monitoring
  - Influence of different sampling flow rates
  - Not practical for all weapon types.
    (Like shoulder mounted weapons)

https://www.stuff.co.nz/national/105882611/the-battle-over-semiautomatics-police-frustrated-by-the-law-firearm-owners-frustrated-by-police

WHAT AND HOW TO SAMPLE

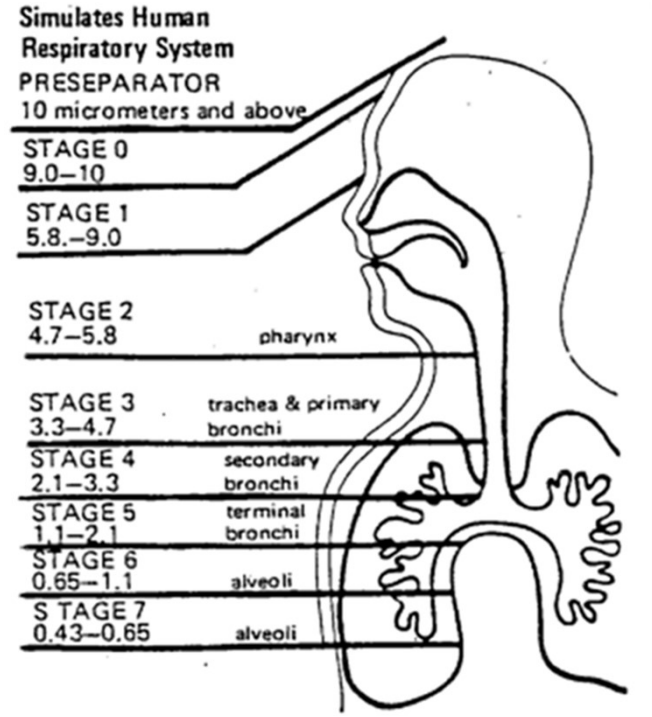
- Hundreds of components are emitted

  E.g. (semi-) Volatile Organic components with GC-MS



WHAT TO MEASURE

- Analyses of:
  - Gases; CO, CO_2, NO, NO_2, NH_3, HCN, HCl, …
  - Inorganics elements; metal/salts
  - (Semi-) volatiles organics; Benzene, Acetic Acid, Naphtalene, …
  - Total dust
  - Particles size distribution



SAMPLING AND MONITORING

- Concentration and sensitivity of the sensor/monitors/analysis systems
- Reactivity and degradation of the components during sampling and storage
- Desorption of components and representative concentrations

INFLUENCE ON TEMPERATURE

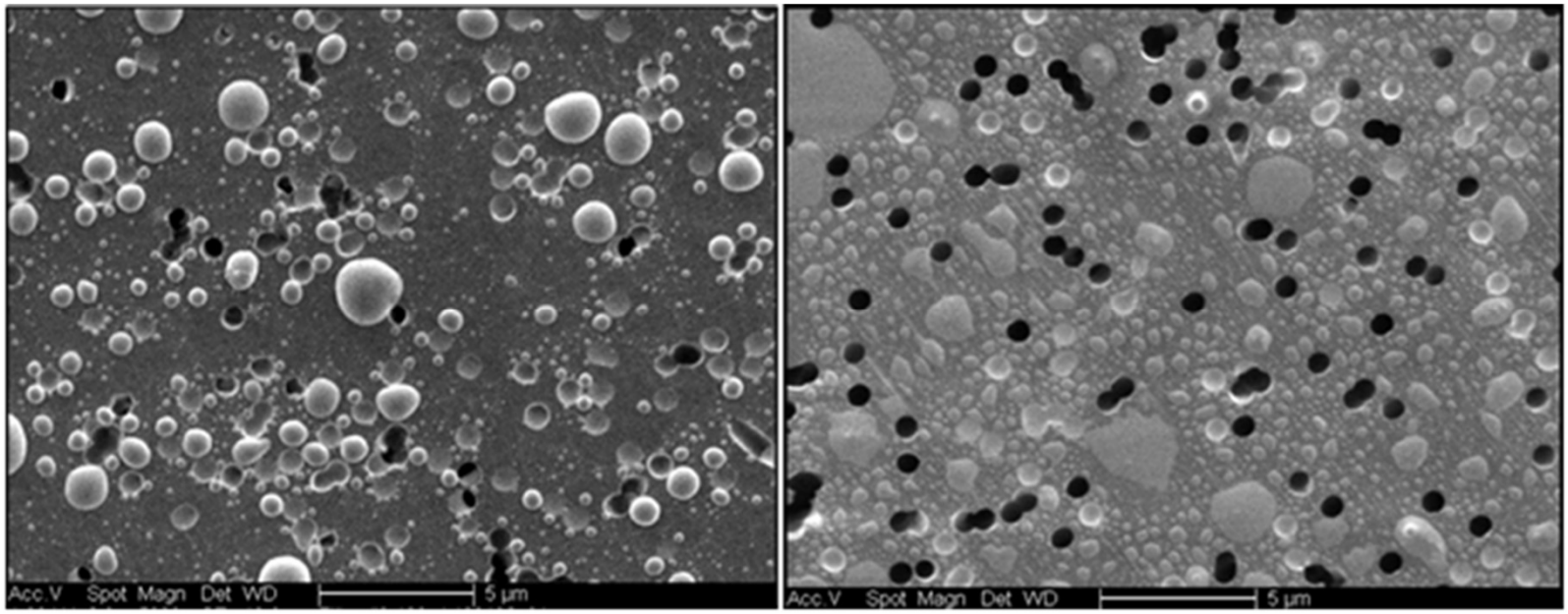
Allied Environmental Conditions and Test Publications (AECTP) 300

- **Cold Temperatures**
  - Liquid to solid (e.g. lubricant)
  - Change in viscosity and/or change in modulus, strength, elongation
  - Possible reduction of burning rates of explosives and propellants
- **Hot Temperatures**
  - Components can melt
  - Increasing the rate of diffusion
  - Increasing the rate of ageing reactions
  - Possible increase of burn rates of explosives and propellants

https://warriorpublications.wordpress.com/2017/01/04/pdf-small-unit-leaders-guide-to-mountain-warfare-operations/

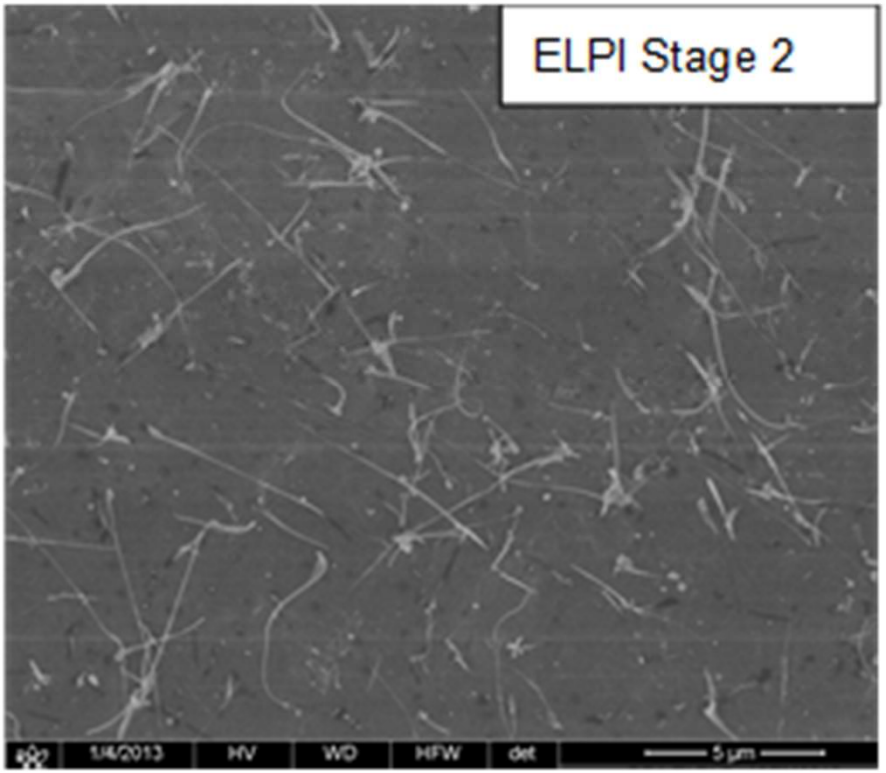
INFLUENCE OF HUMIDITY

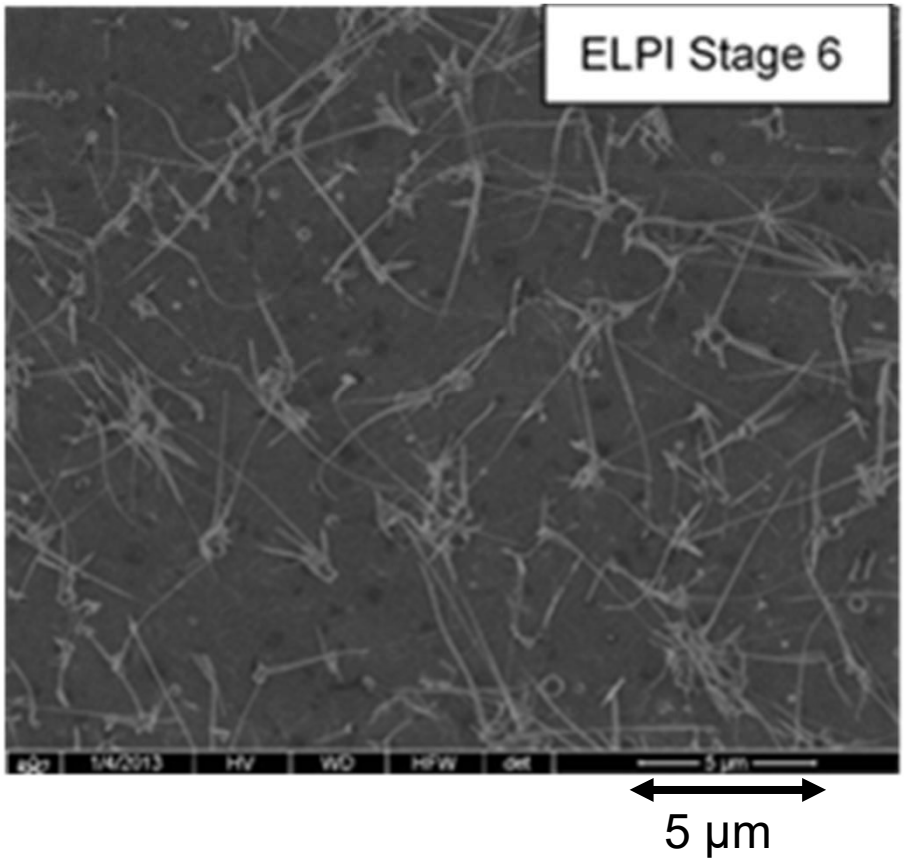
- Reaction of components with moisture in the air (sample collected)



AFTER REACTIONS

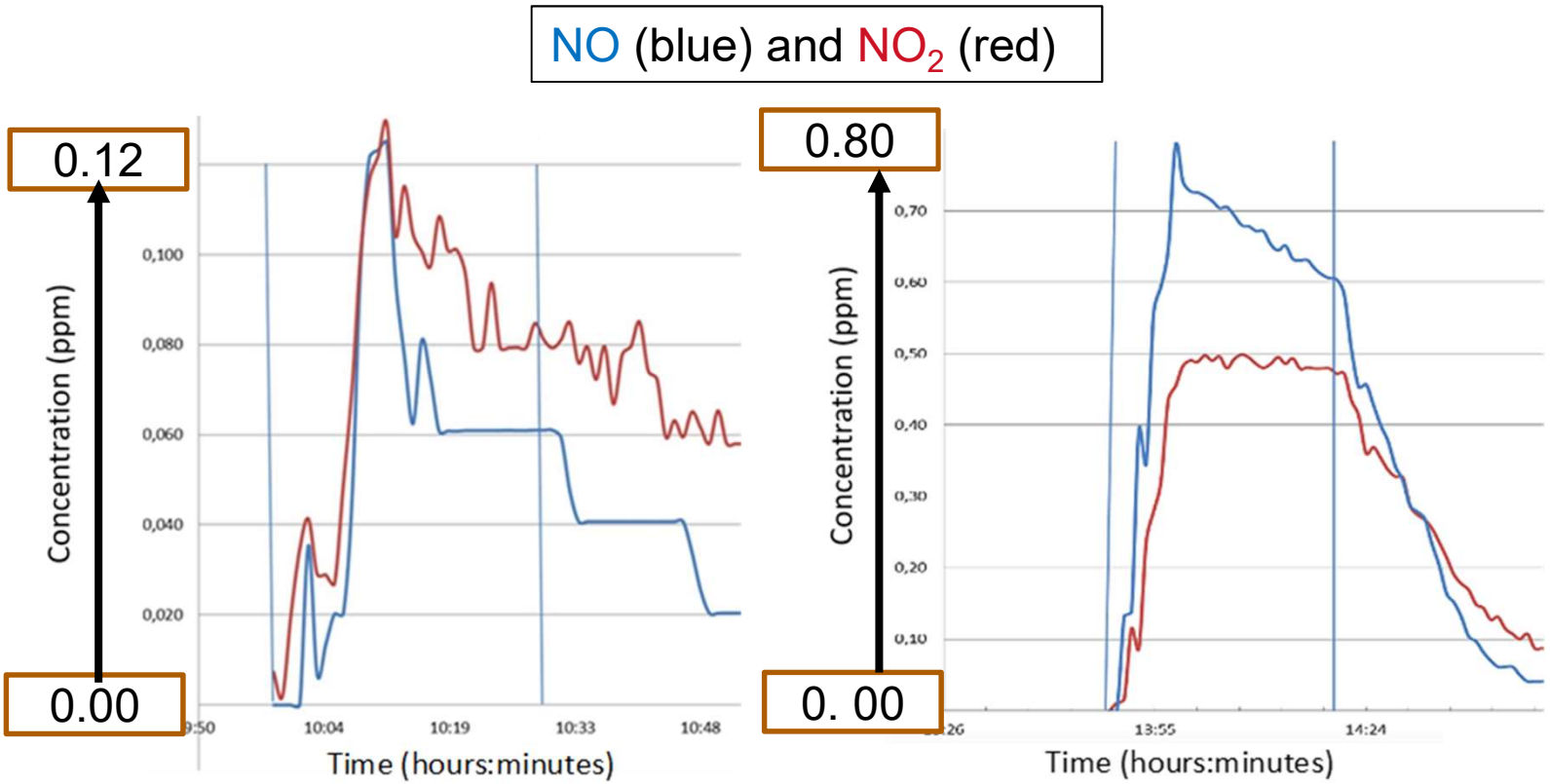
- Stage 2 has a cut-off diameter off 0.056 µm and stage 6 of 0.383 µm.





FREQUENCY AND NUMBER OF AMMUNITION FIRED

- 15 versus 150 rounds; same setup, same frequency of firing



TOXICITY ASSESSMENT

- Toxicity values – often only occupational health levels, >15 minute exposures
- Military Exposure Guidelines – Military specific, >15 minute exposures
- Combination of components – possible increased toxicity effects
- Correlation between components - e.g. particle size of a metal on toxicity
- …

CONCLUSIONS

- Every sampling and analysis approach and every experimental setup has it pros and cons

- Adjust setup to the question needed to be answered
  - Comparing munition-weapon combinations
  - Exposure / emissions

- Can not qualify and quantify all products; need to compose a list

- Assessing hazards is difficult due to;
  - no <15-min limits
  - exposure to complex mixtures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