**Non-Toxic, Non-Incendiary Hexachloroethane (HC) Obscurant Smoke Replacement**

**REQUIREMENTS**

**April 2019**

**PROJECT BACKGROUND**

A high yield smoke compositions such as White Phosphorous (WP), Red Phosphorous (RP) and Hexachloroethane (HC), are extremely toxic with incendiary characteristics. Standard Red phosphorus smoke munitions have excellent obscurant features, and have a much lower adverse health impact when used in training and field maneuvers than HC smoke. However there are some significant maintenance costs and health and safety concerns which have arisen during long term storage of RP obscurant munitions. During long term storage, especially when exposed to atmospheric moisture, RP munitions slowly convert to phosgene and phosphoric oxyacids. These types of chemicals are a severe danger to the personnel that have to monitor transport and maintain these munitions. These chemicals are also corrosive and can impact the security and performance of the munitions canister by corrosion.

Predominantly used obscurant for handheld smoke grenades is based on HC/zinc oxide. Along with granular aluminum this composition burns producing obscurant smoke. Combustion product of such composition are knows to consist of zinc chloride, zinc oxides, aluminum oxides, iron oxides, lead oxides and chlorinated vapors. Primal toxicity of such composition is related to formation of zinc chloride, as a predominant combustion product. The combustion reaction is exothermic, yielding zinc chloride in a hot vapor state. While cooling, zinc chloride tends to nucleates, forming a hygroscopic aerosol that rapidly absorbs water from the surrounding atmosphere. This hydrated form is known to scatter light, thus, providing obscurant effect. Aside zinc chloride, other potentially toxic combustion products have been isolated, but, due to predominant toxicity of zinc chloride, will not be discussed in more details.

Tendencies of recent R&D Projects were focused on defining new low toxicity smoke compositions, mostly based on:

* cinnamic acids, which were volatilized by some low energy pyrotechnic composition,
* aliphatic diacids,
* zinc free compositions based on HX,
* polymer, carbon based, matrix encapsulated chlorine atoms.
* metal powders (Mg, Al, Li, etc.).

**PROJECT OBJECTIVES**

Primary goal for this Project is to develop a non-toxic and non-incendiary pyrotechnic smoke that will meet or exceed the current obscuration performances.

Main requirements new pyrotechnic compositions will need to achieve are:

* **production of low toxicity and environment friendly smokes**,
* **excellent obscuration performances**,
* **ease of ignition** by, what’s considered, usual means of ignition,
* when ignited, pyrotechnic compositions need to be able to sustain **undisrupted combustion process**,
* smoke charge expected **combustion velocity between 3.5 and 5.5 g/s**,
* munitions charged with such pyrotechnic compositions need to be **safe to use**, for both, training and battlefield deployment (reducing inventory costs and training troops in the same smoke environment that would be encountered on the battlefield),
* **acceptable production complexity** (pyrotechnic compositions should be producible under a relatively simple technological conditions, using what’s mostly considered as “standard pyrotechnic production equipment”). Endorsement of more complex technologies/equipment could be justified only by the highest level of excellence in obscuration performances/safety of deployment/maintenance and storage costs.

**We recommend to study the following reports to get an insight about the general problem and work carried out in previous studies**

**Development of Low-Toxicity Obscurant Material, Rutger Webb, TNO Defence, Security and Safety,** **WP-2148**<https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Energetic-Materials-and-Munitions/Pyrotechnics/WP-2148>

**Replacement of HC in Handheld Obscurants**

<https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Energetic-Materials-and-Munitions/Pyrotechnics/WP-2149>

**Surface Modified TiO2 Obscurants for Increased Safety and Performance**

<https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Energetic-Materials-and-Munitions/Pyrotechnics/WP-2150>

**PROJECT MILESTONES**

Work performed under the project should investigate innovative approaches that entail high technical risk and/or have minimal supporting data.

**Table 1.** Project Phases with Key Performance Indicators

|  |  |  |  |
| --- | --- | --- | --- |
| **Milestone No.** | **Milestones** | **Project timeline** | **Milestone Description** |
| 1 | Challenge announcement | Feb-19-2019 | Challenge launch |
| 2 | Team formation & application | July-19-2019 | Teams to be formed and submitting their application |
| 3 | Team selection | Aug-19-2019 | Team will be selected for the next steps |
| 4 | Concept design document preparation | Dec-22-2019 | Team to start working on detailed concept design document |
| 4.1 | Study of related literature | Reference list, report of the state of the art |
| 4.2 | Defining a set of most promising smoke compositions | According to expected toxicity, ecotoxicity and obscuration performance for preparation of proposals and design concepts |
| 4.3 | Detailed concept design document submission | Submission of concept design document |
| 5 | Concept design review & shortlisting | Jan-22-2020 | All concept design documents will be reviewed by the committee and the best 3-4 teams will be shortlisted to proceed with the challenge |
| 6 | Challenge start | Oct-1-2020 | Challenge commencement date |
| 7 | Lab-scale tests | Mar-3-2021 | Pyrotechnic composition characterization (safety, smoke formation, combustion products size distribution and toxicity) |
| 8 | Proof of concept | August-31-2021 | Scaled down, hand-held smoke grenade, grenade, performance testing for selected compositions. |
| 9 | Preparation of reports and other Project related documentation | Feb-5-2022 | Key production documentation with necessary test results reports. |
| 10 | Winner announcement | March-6-2022 | Announcing Winner & Grand Prize Award |

1. **TEAM APPLICATION (Milestone 2)**

Please follow the following guidelines for your team application

**Introduction**

Brief overview about the concept, demonstrating understanding of the requirement.

**Research design and methods**

High-level description of methodology to be applied for the research.

High level estimated resources (equipment, materials, manpower, etc.)

**Team description**

Describe each participant in terms of

* Educational background
* Expertise if any
* Nationalities
* Roles and responsibilities of each team member

**Disclosures**

* Any previous work carried out in fields related to the Contest
* Any commitment towards or restrictions on or affecting the Participant or its participation in the Contest of any government or government owned, funded or directed body in any field related to the Contest

**Contact details**

Provide at least 2 contact details including email and mobile phone

**Questions**

List any questions or queries regarding the challenge

1. **DETAILED CONCEPT DESIGN DOCUMENT   
   (Milestone 4)**

Please follow the following guidelines for your detailed concept design document

**CONCEPT DESIGN LAYOUT**

Please follow the following guidelines for your concept design submission.

**Executive Summary**

Provide a summary of the proposed approach. The summary is meant to serve as a brief overview of the proposal. Please include the project’s long-term objectives and goals, making reference to the project’s relatedness to the state-of-the-art in its field and industry.

* + Should clearly and concisely describe the problem or niche that the project addresses.
  + Addresses potential gaps in evidence/literature of current or similar projects that attempt to fulfill the intended problem/niche
  + How the project will be created/implemented/tested/sustained`0
  + Succinct description of thought process behind the proposal

**Objectives and Goals**

In no more than one (1) page, identify the goals of the proposed research, and list briefly the specific applied objectives of the research proposed,

**Project Personnel**

List any changes in the team participants if any.

**Project Description**

In no more than eight (8) pages, please provide a description of the project. The project description should be written such that it can be understood by a multidisciplinary evaluation committee (i.e., not a discipline-specific committee). Please include the following:

* Background
* Niche/Area of Concern is defined and justified, with the scope and significance of problem being addressed
* Comprehensive and up-to-date review and analysis of existing knowledge
* Critical analysis (feasibility, efficacy, and/or effectiveness, as appropriate) of other programs that have been tested to address the niche
* Conceptual framework or succinct walk through behind research design
* Identification of any potential gaps in current research/literature that might hinder project
* Identifies how the project will improve scientific knowledge and technical capabilities

**Stimulating Research Innovation in Students**

It is anticipated that much of the proposed work should be carried out by UAE researches (i.e. students, Universities), under the direct supervision project lead. Please describe how you want to achieve this aim

**Innovation**

* Describe any novel theoretical concepts, approaches or methodologies, instrumentation or intervention(s) to be developed or used, and any advantage over existing methodologies, instrumentation or intervention(s).

**Proposed Research Design and Methods (with Evaluation Plan)**

* Research design and methods clearly and logically presented
* Proposed project and design methods clearly defined, including setting, resources/inputs (all collaborators, implementers, program material, space), activities/outputs, and expected outcomes/impact
* Clear and justified approach to the evaluation design, sample, measures, data collection procedures (quantitative and/or qualitative), and data analysis, if applicable
* Explains appropriate statistical approach for quantitative/qualitative data, particularly for evaluation of project success, if applicable
* Sample size considerations if applicable
* Any deviations from the stipulates timeline
* Conceptual Models
* The work plan should be structured into work-packages, tasks, milestones, and deliverables (THIS IS MANDATORY)
* Implications of Research with Recommendations and Broader Impact
* Please include the broader impacts resulting from the proposed activities, e.g, how the project will integrate research and education by advancing discovery and understanding; how will the project promote teaching, training, and learning; how the project will enhance the infrastructure for research and/or education, such as facilities, instrumentation, networks, and partnerships; and potential benefits of the proposed activity to society at large.

**Equipment & Materials**

* Itemize any equipment needed specifically for the project
* Materials and Supplies: Itemize materials and supplies for project by major category, e.g., chemicals, glassware, electrical components, etc.
* Software and computers: Itemize any software and computers needed specifically for the project.

**Literature Cited**

* Include a list of cited references. Limit this to a maximum of one (1) page.

**REFERENCES**

1. **DeVaull GE, Dunn WE, Liljegren JC, Policastro AJ.** *Field Measurement and Model*

*Evaluation Program for Assessment of the Environmental Effects of Military Smokes: Analysis*

*Methods and Results of Hexachloroethane Smoke Dispersion Experiments Conducted as Part of*

*Atterbury-87 Field Studies.* Frederick, MD : US Army Medical Research and Development

Command, 1989. AD-A216048.

2. **Cichowicz, J.J.** *Environmental Assessment. Programmatic Life Cycle Environmental*

*Assessment for Smoke/Obscurants. HC Smoke, Vol. 4. .* Edgewood, MD : Chemical Research and

Development Center, U.S. Army Armament, Munitions and Chemical Command, U.S. Army

Aberdeen Proving Ground, 1983. ARCSL-EA-83007.

3. **Agency for Toxic Substances and Disease Registry.** *Toxicological Profile for*

*Hexachloroethane.* Atlanta, GA : vailable: http://www.atsdr.cdc.gov/toxprofiles/tp97.html, 1997. ATSDR 1997.

4. **Holmes, P.S.** *Pneumomediastinum associated with inhalation of white smoke.* s.l. : Milit Med.

1999;164:751–752.

5. **Katz S, Snelson A, Farlow R, Welker R, Mainer S.** *Physical and Chemical*

*Characterization of Fog Oil Smoke and Hexachloroethane Smoke.* Chicago, IL : IIT Research

Institute, 1980. DAMD 17-78-C-8085, AD-A080 936.

6. **H, Cullumbine.** *The toxicity of screening smokes.* s.l. : [PubMed] , J R Army Med Corps.

1957;103:119–122.

7. **Greenfield RA, Brown BR, Hutchins JB, Iandolo JJ, Jackson R, Slater LN, et al.**

*Microbiological, biological, and chemical weapons of warfare and terrorism. .* s.l. : [PubMed],

Am J Med Sci. 2002;323:326-340. .

8. **Hjortso E, Qvist J, Bud MI, Thomsen JL, Andersen JB, Wiberg-Jorgensen F, et al.** *ARDS*

*after accidental inhalation of zinc chloride smoke.* Intens Care Med. 1988;14:17–24.

9. **Loh C, Chang Y, Liou S, Jang J, Cheng H, et. al.** *Case Report: Hexachloroethane Smoke*

*Inhalation: A Rare Cause of Severe Hepatic Injuries.* s.l. : Available:http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1459933/.

10*.* **Bohren, C.F.; Huffman, D.R.** *Absorption and Scattering of Light by Small Particles; Wiley-Interscience: New York, 1983.*

*11.* **Embury, Janon***; Maximizing Infrared Extinction Coefficients for Metal Discs, Rods, and Spheres, ECBC-TR-226, Feb 2002, ADA400404, 77 Page(s)*

*12.* **Clyens, S.; Johnson, W***., The Dynamic Compaction of Powdered Materials, Materials Science and Engineering, 30 (1977), 121-139.*

*13.* **Schwarz, R. B., Kasiraj, P., Vreeland T., Ahrens, T. J., A** *Theory for the Shock-wave Consolidation of Powders, Acta Metall., Vol. 32, pp. 1243-1252.*

*14.* **N. Sordoni, W.Heard, W. Rouse,** *Pyrotechnic Smoke Analysis, Vol I, ERDEC-TR-129, Dec 1993*

*15.* **Toxicity of Military Smokes and Obscurants,** *Vol 1, Committee on Toxicology, Commission on Life Sciences, National Research Council., ISBN 0-3090-56 166-3*