GD-OTS/RWM NON-TOXIC LESS INCENDIARY SMOKE PROJECTILE

Guns & Missiles Conference
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Obscuration

What is the purpose of Obscuration?
- To Hide
- To Mask
- To Delay
- To Confuse

What better way to do that than inflicting our adversaries with.....
General Dynamics – Ordnance and Tactical Systems (GD-OTS), partnered with Rheinmetall Waffe Munitions (RWM), offers a unique solution that re-uses existing M483 DPICM projectiles (after demilitarization, recovery, and refurbishment) as a carrier for the deployment of non-toxic, very-low incendiary canister technologies with the DM1560 smoke canisters.
M483-Based Smoke Projectile

8 ea DM1560 Smoke Canisters

Reutilized M483 Carrier

Expulsion System

Phase Description
1. Projectile on trajectory
2. Expulsion of smoke canisters
3. Ignited smoke canisters in flight
4. Smoke pattern
M483-Based Smoke Projectile

- Diameter and height of the smoke canister payload stack are designed to fit into the M483A1 shell with minimum modification.
- Weight of the smoke canisters is designed to replicate the current M42/M46 DPICM grenade payload.
- Payload will interface with the current keyway in the body to insure a firm lock into the carrier to prevent any relative payload motion during flight.
- Expulsion/pusher plate system will be used to ensure both proper ignition of the smoke canisters and complete cargo expulsion.
DM1560 Smoke Canister

- Burning time in excess of 3.5 min
Features

• The M483 projectile is currently being demilitarized by the US Army
• The RWM DM1560 is a NATO-qualified canister currently employed in the DM125 projectile
• RWM smoke compound based on Micro-Encapsulated Red Phosphorous offers significantly reduced phosphine split rates over conventional RP
• Low incendiary risk due to contained combustion
• No toxic effects on environment and human beings in compliance with STANAG 4588
Burning of Red Phosphorous generates $\text{H}_3\text{PO}_4$ which is phosphoric acid.  

The phosphoric acid is highly hygroscopic and adds water from the ambient air.  

Together with $\text{H}_2\text{O}$ the $\text{H}_3\text{PO}_4$ forms droplets which can be seen as smoke in the visual band. The smoke is also IR-effective.
Red Phosphorous Smoke Design

Mass extinction coefficients are such that RP has the same demonstrated IR masking capabilities as WP, better than HC

\[ \tau(\lambda) = e^{-\alpha c x} \]

\( \tau(\lambda) \) = Transmission
\( \alpha \) = Mass extinction coefficient
\( c \) = Aerosol concentration
\( x \) = optical length through smoke

<table>
<thead>
<tr>
<th>Material</th>
<th>visual 0.4 - 0.7 µm [m²/g]</th>
<th>near IR 1.06 µm [m²/g]</th>
<th>mid IR 3 - 5 µm [m²/g]</th>
<th>far IR 8 - 14 µm [m²/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP</td>
<td>2.9</td>
<td>1.4</td>
<td>0.27</td>
<td>0.32</td>
</tr>
<tr>
<td>RP</td>
<td>2.9</td>
<td>1.4</td>
<td>0.27</td>
<td>0.32</td>
</tr>
<tr>
<td>HC</td>
<td>2.1</td>
<td>0.7</td>
<td>0.18</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Red Phosphorous Smoke Design

Reaction:

\[
\begin{align*}
4P & + 5O_2 & \rightarrow & 2P_2O_5 + \text{heat} \\
P_2O_5 & + 3H_2O & \rightarrow & 2H_3PO_4 + \text{heat} \\
H_3PO_4 & + nH_2O & \rightarrow & H_3PO_4 \cdot nH_2O
\end{align*}
\]

(Combustion)

(Chemisorption)

(Condensation and Hydration)

Yield-Factor:

\[
Y_F = \frac{m_{\text{Aerosol}}}{m_{\text{RP}}}
\]

The ratio of burned smoke compound to generated smoke aerosol mass by the water add is called Yield Factor.
DM1560 Red Phosphorous Smoke

\[ \tau(\lambda) = e^{(-\alpha c x)} \]

- \( \tau(\lambda) \): Transmission
- \( \alpha \): Mass extinction coefficient
- \( c \): Aerosol concentration
- \( x \): Optical length through smoke

- Smoke Performance is dependent on humidity & temperature

\[ C = \frac{m_{\text{Aerosol}}}{V} \]

\[ C = \frac{m_{\text{RP}} \cdot \text{Y.F.}}{V} \]

\[ \text{Y.F.} = \frac{m_{\text{Aerosol}}}{m_{\text{RP}}} \]
Multi Spectral

- The output of the DM1560 is such that sufficient obscuration can be produced to cover the VIS and IR spectrum.
- Effective against all electro-optical equipment like Thermal Imagers, Laser Range Finders, and Laser Designators
Red Phosphorous Smoke Design

Current Rheinmetall Smoke Round

Target View without smoke

Visual

Infrared 8 - 12 µm
Red Phosphorous Smoke Design

Current Rheinmetall Smoke Round

Target View with 3 Rounds (24 canisters)

Visual

Infrared 8 - 12 µm
Toxicity

- RWM has developed a Hexachloroethane (HC) – free, non-toxic obscurant
- RWM RP is more compatible than existing smoke compositions for environmental and human toxicology
- The RWM RP smoke compound was successfully tested in accordance with STANAG 4588
- Toxicologically harmless to humans and the environment
- Does not exceed pollution limits when used in training
- No restrictions for use in training or tactical missions
- No restrictions in storage and shipping
Stability

- Phosphine split rate reduced by a factor of 1:100,000 compared to uncoated RP
- Production is environmental eco-friendly by using water based binders
- Storage life of 10 years minimum
- No toxic effects from Phosphine PH$_3$ during storage
- No auto-ignition based on PH$_3$ – split (no disproportion reaction $2 \text{P}_4 + 12 \text{H}_2\text{O} \rightarrow 5 \text{PH}_3 + 3 \text{H}_3\text{PO}_4$)
- Long-term stability of RP in the smoke compound is supported by a smooth and water based production process at RWM branch

Split rates of RWM RP, development on the last 20 years on RP coating

RP used for the RWM Smoke Compounds
Conclusions

• Low cost re-use of existing payload hardware after demilitarization, recovery and refurbishment.

• Concept exists for replacing the original DPICM grenade cargo with a low-incendiary, non-toxic, RP obscurant.

• DM1560 canisters currently undergoing US smoke characterization trials.

• Partnership to fully utilize US manufacturing base.
# Points of Contact

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<thead>
<tr>
<th><strong>GD-OTS</strong></th>
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BACKUP SLIDES
The droplets in the smoke screen have the size in the order of the wavelength of visual and IR wavelength, so that absorption and scattering effects occur in the smoke cloud.
Red Phosphorous Smoke Design

Law of Lambert and Beer:

\[ \tau(\lambda) = e^{(-\alpha c x)} \]

- \( \alpha = \) Mass extinction coefficient
- \( c = \) Aerosol concentration
- \( x = \) optical length through smoke

The intensity of transmitted light can be described by the law of Lambert and Beer.
Red Phosphorous Smoke Design

Mass extinction coefficients

\[ \tau(\lambda) = e^{(-\alpha c x)} \]

\[ \tau(\lambda) = \text{Transmission} \]
\[ \alpha = \text{Mass extinction coefficient} \]
\[ c = \text{Aerosol concentration} \]
\[ x = \text{optical length through smoke} \]

• The mass extinction coefficient in \([m^2/g]\) defines the amount of mass which is able to be efficient in the observed wavelength. Mass extinction coefficients are material specific values.

This means effectiveness in a defined wave length is depending on:

• The chosen smoke compound material.

• The concentration of smoke compound in the target area.
Toxicity

Toxicological Evaluation

• The toxicological and ecotoxicological evaluation according STANAG 4588 were performed by independent german institutes:
  
  • Fraunhoferinstitut für Umwelt und Chemische Technologien, Schmallenberg
  • Fraunhoferinstitut für Toxikologie und Aerosole, Hannover

• The final assessment was carried out by:
  
  • Bundeswehr Research Institute for Protective Technologies and NBC Protection (WIS)
Toxicity

Humantoxicological results
• No relevant toxicological findings.
• The RP Aerosol showed no genotoxic effects.
• In “28 Days Inhalation Toxicity Study“ there were found typical symptoms for phosphoric acid / phosphorus oxide with 1 mg/m³ (“Reversible Irritation Effect”)

Ecotoxicological results:
• RP Smoke compound showed no toxicological effects.
• RP Aerosol showed no soil toxicity (no negative influence to soil due to dilution and buffer effects). Only a slight aquatic toxicity due to a slight pH-displacement was observed. Consequently no negative results for environment were expected.
• Burning Residues showed moderate aquatic toxicity and no toxicity as far as soil is concerned (no negative results for environment when dumping of substances is prevented)
RP Technology already qualified in the US

With the qualification of the **Grenade, 66 mm, Smoke Screening IR, Vehicle Launched, MK1 mod.0** the RWM RP smoke compound is fully qualified in the US.

The RP composition is the same as DM125, only slight % changes of ingredients.