THE IED CLEARANCE GOOD PRACTICE GUIDE:

CHAPTER 5 – "BASIC CHEMISTRY OF EXPLOSIVES AND HAZARDS OF HOME-MADE EXPLOSIVES AND CHEMICAL PRECURSORS"

By Lieutenant Colonel Robert Friedel, GICHD

BACKGROUND

The widespread use of improvised explosive devices (IEDs) has been documented extensively by the mine action (MA) sector over the last decade; accompanying this trend is the use of home-made explosives (HMEs). Although not all IEDs include an HME component, the frequency of their use and the specific operational challenges related to HMEs, as well as their chemical precursors, have highlighted the need to document good practice related to this lesser-known category of explosives.

It is crucial to address HMEs and their associated risks: they pose an explosive as well as a non-explosive threat to both human life and to the environment. There is a significant risk that MA personnel will encounter HMEs in affected countries, whether within IEDs, in abandoned manufacturing or storage sites, or as stockpiles of precursor chemicals used in a variety of industries.

During the development of the IED clearance guide, the GICHD decided that additional efforts should be dedicated to creating a handbook that supports the needs of the humanitarian sector regarding information about improvised explosives and chemicals used to construct IEDs. Due to this focus, as well as the recognised severity of the impact of HMEs and the

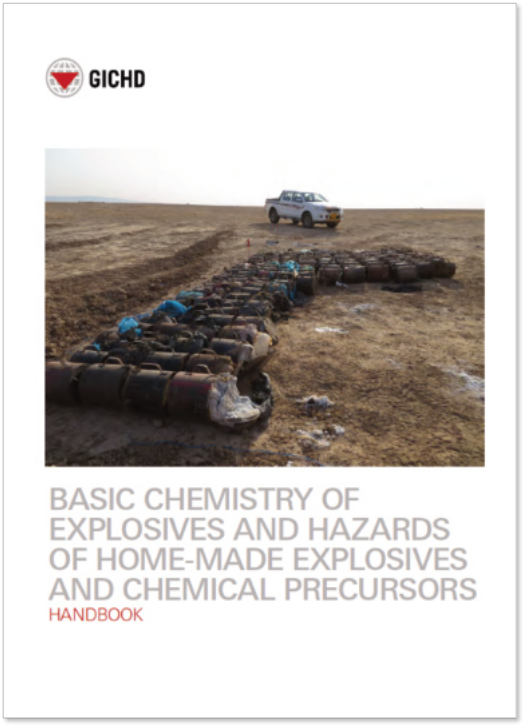

Image 1: Cover of Chapter 5.

(Cover image: Fondation Suisse de Déminage FSD ©)

Image 2: Finding of various canisters and barrels with unknown content next to a former textile factory in Mosul, Iraq; located by an explosive detection dog posing a possible threat to the population and the environment. *(Source: GICHD ©)*

high likelihood of encountering them in certain settings, it was decided that a 5th Chapter to the IED clearance guide should be developed as a handbook that focuses on HMEs.

HMEs AND THEIR PRECURSORS AS A CHALLENGE TO MA OPERATORS AND COMMUNITIES

The IED clearance guide, Chapter 5 – basic chemistry of explosives and hazards of home-made explosives and chemical precursors – is intended for use by MA staff trained in accordance with International Mine Action Standard (IMAS) 09.31 'Improvised Explosive Device Disposal' and IMAS 09.13 'Building Clearance', as well as the newly-approved competency framework for IED Disposal (T&EP 09.31 "Improvised Explosive Device Disposal (IEDD) Competency Standards). It is meant for use by humanitarian IED disposal operators and by MA staff involved in the planning, execution, monitoring, and follow-up of IED clearance operations.

Within the handbook, chemicals and HMEs are presented with a focus on information considered to support the mitigation of risks. The hazard pictograms introduced by the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) are used to classify the specific threats. Given the information available, the content selected to be offered cannot be exhaustive; Key information presented in the handbook includes:

- Name, formula, abbreviation(s) and synonym(s);
- Image and GHS hazard pictogram(s);
- Industrial (legal) and private applications;
- Appearance;
- Chemical behaviour including:
  - Flammability;
  - Promotion of existing fires;
  - Hazard of dust explosion;

- Violent / explosive reactions when in contact with other substances;
- Corrosive or caustic properties;
- Toxic behaviour including:
  - Risks such as irritation, disorder or severe damage to mucous membranes, skin, eyes, lungs, respiratory tract, blood, inner organs or the central nervous system;
- Materials not to be used / to be used for packaging (for instance due to reactions between the matter and the packaging material);
- Means of firefighting not to be used / to be used, such as water, water jet spray, fire extinguishing foams, fire extinguishing powders or carbon dioxide (CO2) fire extinguishing systems and
- Hazard level with regard to water supplies.

Within the handbook, approximately 120 chemicals and HMEs are listed with various depths of detail.

As highlighted, the aim of the handbook is to inform humanitarian aid workers, humanitarian first responders and explosive ordnance risk education practitioners on the development of methodologies, approaches, and tools that are specific to an environment where HMEs and their chemical precursors are present. To increase the value of practical application, warnings, hints, notes on good practice as well as practical examples are emphasized throughout the publication. The examples include guides for the assessment of the labeling of fertilizer packages, explanations regarding the use of safety data sheets and GHS classifications as well as clarifications on the effects of thermal expansion. This visual aid aims to render information that is considered particularly important or supplementary (such as the examples) quickly accessible to users. The methodical approach of presenting key aspects is already practiced in Chapters 1-4 of the series.

WARNING. Acids will burn skin and destroy clothing. If any acid is spilled, it should be washed away with a large quantity of water, and medical attention should be sought as soon as possible. The fumes produced by an acid must not be inhaled.

Image 3: Example – WARNING. *(Source: GICHD ©)*

HINT. Comprehensive information on the transport of ammunition and hazardous goods can be found in the United Nations 'Recommendations on the Transport of Dangerous Goods', the 'Accord européen relatif au transport international des marchandises dangereuses par route' (ADR), and the European Union's agreement concerning the international carriage of dangerous goods by road. IATG 08.10 Annex D provides a summary of these regulations.

Image 4: Example – HINT. (*Source: GICHD ©)*

NOTE. Friction can be introduced during the transport of an improvised explosive. The goal must be to exclude or at least minimise external influences on the HME.

Image 5: Example – NOTE. *(Source: GICHD ©)*

Disclaimer

The handbook is neither a research publication nor a comprehensive technical manual. It rather aims to provide condensed content in an easy-to-read format. The content has been chosen to provide practical knowledge to MA practitioners, based on the most common HME threats that they will encounter. Theoretical knowledge of the very basic chemistry of explosives and their chemical precursors provides the foundation of this document; detailed scientific information, such as complex equations and formulas, has been avoided. Definitions and derivations have also been simplified to provide only the most essential information for end-users. The detail and level of complexity of the terminology used are adapted to fulfil the requirements of this guide and may be simpler than that used in scientific publications.

THE CONTENT OF THE HANDBOOK

The handbook does not contain practical information regarding the manufacturing of HME nor the mixing ratio necessary to achieve a high effectiveness of an improvised explosive. During MA operations, already produced HMEs are encountered; it is, however, considered impossible to identify the specific manufacturing aspects in aged, improvised explosives. For this reason, this information is not added to the manual as its emphasis remains on the protection of personnel and the environment from the effects, whether explosive or non-explosive, of improvised explosives.

The first sections provide considerations regarding explosive matter, a general overview of industrially manufactured explosives and improvised explosives as well as comparative considerations between them, including an emphasis on hazard-related differences. Furthermore, a detailed overview of key technical terms and definitions used to describe energetic materials as well as explosive substances is provided. These sections also offer definitions on physical characteristics such as brisance, stability, strength and oxygen balance in relation to safety or sensitivity.

Starting with Section 4, chemical precursors are listed and explained comprehensively. Based on common practices within the different sectors dealing with HME, the section is organized by acids, oxidants (group of nitrates, group of chlorates, group of perchlorates and other oxidants used), fuels, additives and catalysts; sensitizers and tinder are also presented. For practical reasons, the information accessible on fuels is divided between solid and liquid fuels; metallic fuels are listed separately due to their special features.

Given the vast number of fuels and oxidisers that may be used in HME manufacturing, Section 5 of the handbook focuses on the main types of HME that MA staff may encounter as:

- Chlorate- and perchlorate-based HMEs;
- Nitrate-based HMEs;
- Peroxide-based HMEs;
- Nitromethane-based HMEs and
- Nitrate ester-based HMEs.

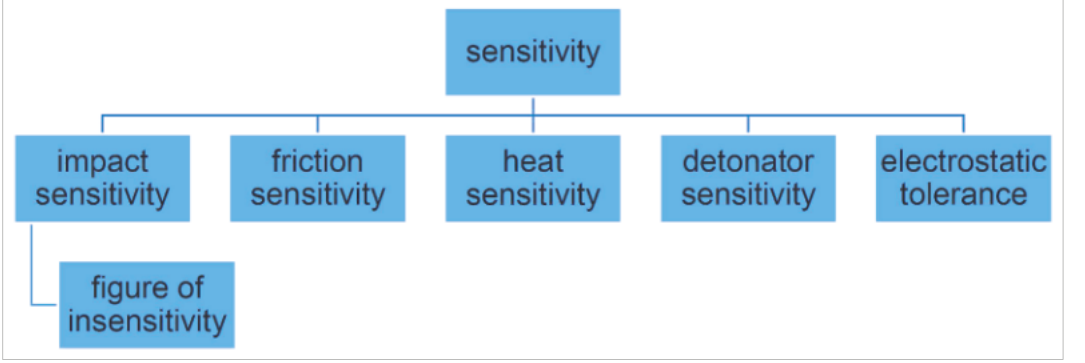

Image 6: Overview of relevant sensitivities used to describe an explosive's behavior within the handbook. *(Source: GICHD ©)*

BENZENE [C_6H_6] OR BENZOL

Image 59. Benzene
(source: Bundeswehr CBRN Defence Command ©)

Benzene is important for the petrochemical industry. It is used in engine fuels, and products from further processing are used to produce paints, plastics, aniline, pesticides, and acetone.

Benzene is a colourless, characteristically aromatic smelling liquid which burns with a strong sooty flame. It is lighter than water and very volatile.

TOXIC BEHAVIOUR

Benzene is carcinogenic and its vapours are toxic. It has a slightly irritant effect on mucous membranes and skin and can lead to central nervous system disorders.

Benzene can be stored in glass or stainless steel. The resistance of plastics must be checked before use.

Suitable extinguishing agents are dry powder, carbon dioxide or alcohol-resistant foam.

Benzene is highly hazardous to water supplies, even in small quantities. Leakage into water, sewerage systems or soil must be prevented.

Image 7: Example of the presentation of chemical precursors, here: benzene. *(Source: GICHD ©)*

The offered content outlines their common characteristics, applications and hazards, considering the limitations in obtaining these data. The previous sections of the handbook provided details on the outward appearance, specific risks and hazards of precursor chemicals, whilst this section provides information on how variables such as particle size, quality of raw materials, and impurities will affect an HME's chemical properties. No safety data sheets are available for most improvised explosives. To emphasize

5.3.3. HEXAMETHYLENE TRIPEROXIDE DIAMINE

Image 169. HMTD
(source: Bundeswehr CBRN Defence Command ©)

Hexamethylene triperoxide diamine ($C_6H_{12}N_2O_6$) or HMTD, is a chemical compound, not a mixture. It has the properties of a powerful primary explosive with a high initiation effect. It has no commercial or military use, due to its sensitivity.

HMTD is a colourless and odourless fine white powder. It does not form large crystals. Because of the amines, old HMTD has a fish-like odour. It is slightly hygroscopic but does not dissolve in water or common organic solvents. It does not evaporate or recrystallise.

HMTD is very highly sensitive to heat, shock and especially friction. It is thermally unstable, will decompose in storage and is very reactive with most metals, even when dry. HMTD's impact sensitivity is 0.6 J. Its friction sensitivity is approx. 0.1 N and is considered to be similar to that of Armstrong's mixture.[56] Confined, it will detonate in small quantities. Aged HMTD loses explosive strength but its sensitivity to electrostatic discharge increases.

Image 8: Example of the presentation of (improvised) explosives, here: HMTD. *(Source: GICHD ©)*

their possible hazards, the GHS classification of their precursor chemicals is added to the enumerations in the sections dealing with improvised explosives.

Based on the intention to provide the most comprehensive information possible, Sections 6-9 contain gas-generating reactions, improvised incendiaries, improvised pyrotechnics and improvised primary explosives.

Section 10 provides an overview of general safety considerations when encountering HMEs, abandoned chemicals (for example, in former industrially used storage sites), abandoned manufacturing sites or

ammunition stockpiles during MA operations. The aim is not to reiterate well-established standards for safeguarding staff from explosive hazards as these are already comprehensively covered by a variety of materials, including IMAS, International Ammunition Technical Guidelines, national mine action standards, as well as standard / standing operating procedures; rather, this section focuses on options to counter the health risks that HMEs or chemicals pose to MA staff. This is done by presenting good practice regarding:

- Basic safety rules and considerations;
- Personal protective equipment and intrinsically safe equipment;
- Temporary storage of HMEs and chemicals and
- Firefighting.

CONCLUSION

The 5th Chapter of the GICHD's IED Clearance Good Practice Guide has been produced to address the immediate need for basic information related to the proliferation of HMEs in environments affected by IEDs. It aims to support on-going efforts to keep MA practitioners (as well as other humanitarian workers and first responders) safe by allowing them to better plan for as well as manage the risks associated with HMEs – both explosive and non-explosive. Knowledge of the physical and chemical properties of HMEs and their chemical precursors plays an important role in strengthening safety measures; this information therefore forms the basis of this handbook.

As the IED clearance guide is intended to be a living document, this notion also applies to its Chapter 5. Its translation into Arabic and French is planned in 2022 to strengthen the support provided to affected regions and programmes. The GICHD welcomes feedback on the Guide and plans to update it as knowledge continues to be acquired on mine action's engagement with IEDs. ■

Link - Basic Chemistry of Explosives and Hazards of Home-Made Explosives and Chemical Precursors[1]

ABOUT GICHD

The Geneva International Centre for Humanitarian Demining (GICHD)[2] works towards reducing risk to communities caused by explosive ordnance, with a focus on landmines, cluster munitions and ammunition stockpiles.

The Centre helps develop and professionalise the sector for the benefits of its partners: National and local authorities, donors, the United Nations, other international and regional organizations, non-governmental organizations, commercial companies and academia. It does so by combining four lines of service: field support focused on advice and training, multilateral work focused on norms and standards, research and development focused on cutting-edge solutions, and facilitating dialogue and cooperation.

REFERENCES

1 https://www.gichd.org/en/our-response/international-and-national-mine-action-standards/improvised-explosive-device-clearance-good-practice-guide/

2 https://www.gichd.org/en/

ABOUT THE AUTHOR

Lieutenant Colonel Robert Friedel joined the GICHD in April 2019, seconded to the GICHD by the German Ministry of Defense. As Advisor on Operational Efficiency and Security Sector Liaison, he is responsible for civil-military cooperation and contributes to the development of standards, outreach activities, the implementation of non-technical survey in relation to Improvised Explosive Devices and the development of support packages to address operational requirements in urban clearance operations. He has served in various functions covering different areas of military engineering including several deployments to Afghanistan.