Technical notes for mine action

TNMA

Technical Note 09.30 /04

Version 1.0

Amendment 1, July 2013

Fuel Air Explosive (FAE) systems

Warning

This document is distributed for use by the mine action community, review and comment. Although in a similar format to the International Mine Action Standards (IMAS) it is not part of the IMAS Series. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation. Comments should be sent to mineaction@un.org with a copy to imas@gichd.org.

The contents of this document have been drawn from a range of open source information, and have been technically validated as far as reasonably possible. Users should be aware of this limitation when utilising the information contained within this document. **They should always remember that this is an advisory document only; it is not an authoritative directive.**

Contents

Contents iii
Foreword v
Introduction vi
Fuel Air Explosive (FAE) systems 1
1. Scope 1
2. References 1
3. Terms and definitions 1
4. Background 1
5. Reasons for FAE system hazard clearance 1
6. Current systems 2
6.1. Development 2
6.2. Enhanced Blast Munitions (EBM) and Thermobaric muntions 2
6.3. Weaponisation 2
6.4. FAE systems 3
7. Fuel Air Explosives (FAE) 4
7.1. Introduction 4
7.2. Performance of FAE systems 4
7.3. TNT equivalence 5
7.4. Blast effects 5
7.5. Upper and Lower Explosive Limits (UEL and LEL) 5
7.6. Initiation 6
7.6.1. Explosive initiation 6
7.7. Chemical initiation 6
7.8. Cloud formation and dispersion 6
8. Hazards 6
8.1. EOD hazards 6
8.2. Advice and International Responsibilities 7
9. Guidance on Render Safe Procedures (RSP) 8
9.1. Shaped charge attack 8
9.2. Ballistic Disc attack 8
9.3. Destruction by detonation 8
9.4. Other options 9
10. Equipment 9
10.1. Personal Protective Equipment (PPE) 9
10.2. Respirator 9
11. Safety brief 9
12. Recommendations 10
12.1. National mine action authority 10

12.2. Demining organisations 10

12.3. Demining personnel 10

Annex A (Normative) References 11

Annex B (Informative) Enhanced Blast and Thermobaric munitions 12

Annex C (Informative) Hazard data sheets - common fuels 13

Amendment record 14

Foreword

Management practices and operational procedures for humanitarian mine action are constantly evolving. Improvements are made, and changes are required, to enhance safety and productivity. Changes may come from the introduction of new technology, in response to a new mine or UXO threat, and from field experience and lessons learned in other mine action projects and programmes. This experience and lessons learned should be shared in a timely manner.

Technical Notes provide a forum to share experience and lessons learned by collecting, collating and publishing technical information on important, topical themes, particularly those relating to safety and productivity. Technical Notes complement the broader issues and principles addressed in International Mine Action Standards (IMAS).

Technical Notes are not formally staffed prior to publication. They draw on practical experience and publicly-available information. Over time, some Technical Notes may be 'promoted' to become full IMAS standards, while others may be withdrawn if no longer relevant or if superseded by more up-to-date information.

Technical Notes are neither legal documents nor IMAS. There is no legal requirement to accept the advice provided in a Technical Note. They are purely advisory and are designed solely to supplement technical knowledge or to provide further guidance on the application of IMAS.

Technical Notes are compiled by the Geneva International Centre for Humanitarian Demining (GICHD) at the request of the United Nations Mine Action Service (UNMAS) in support of the international mine action community. They are published on the IMAS website (www.mineactionstandards.org).

Introduction

There have been occasions in Kuwait involving a requirement to render safe, or certify as safe to move, Fuel Air Explosive (FAE) systems. In addition, there is evidence to suggest that such systems have been deployed and used more recently in Chechyna.

This Technical Note has been written, as an advisory document, to remind, or inform, mine action managers and field staff of the major hazards of FAE systems. The Technical Note provides guidance on the establishment of safe operating environments and procedures. It also provides guidance, (developed from first principles), for the formulation of a render safe procedure, but the appropriate technical advice should always be taken.

The clearance of FAE systems should only be undertaken by appropriately qualified EOD personnel or other qualified staff; they are not a task for basic deminers or other field staff.

Fuel Air Explosive (FAE[1]) systems

1. Scope

This Technical Note provides guidance on the identification of hazards, and establishment of safe operating environments and procedures for Fuel Air Explosive (FAE) systems that may be encountered during demining operations in a permissive post conflict environment.

2. References

A list of normative references is given in Annex A. Normative references are important documents to which reference is made in this Technical Note and which form part of the provisions of this Technical Note.

3. Terms and definitions

A complete glossary of all the terms, definitions and abbreviations used in the IMAS series and Technical Notes is given in IMAS 04.10.

In the Technical Notes series, the words 'should' and 'may' are used to indicate the intended degree of compliance. This use is consistent with the language used in International Mine Action Standards (IMAS) and guides.

a) 'should' is used to indicate the preferred requirements, methods or specifications.

b) 'may' is used to indicate a possible method or course of action.

4. Background

Recent conflict has seen the use of FAE systems by armed forces to destroy concentrations of ground forces. The legacy of the use of these munitions remains, and could be a clearance task for demining organisations in Kuwait and Vietnam[2] (it has been confirmed that FAE munitions were not used in Afghanistan during 2001). Although there are almost certainly such systems deployed in many other operational areas.

Figure 1: SUU-19/B Dispenser from US CBU-72B
(Courtesy of http://www.fas.org/man/dod-101/sys/dumb/cbu-72.htm).

5. Reasons for FAE system hazard clearance

There are numerous reasons why the clearance of FAE system hazards may be desirable in a post conflict situation. These include:

[1] Sometimes abbreviated as FAX.

[2] They may also have been used in Laos.

a) to reduce risk to human health;

b) to allow destruction of unserviceable or unstable ammunition;

c) to safeguard the environment; or

d) to permit environmental clearance of the area.

6. Current systems

6.1. Development

Fuel Air Explosive weapons represent a relatively recent development in the weapons field. The technology of FAE weapons was primarily developed at the US Naval Weapons Centre (NWC) at China Lake, California, and this work led to the standardisation of the first real operational FAE weapon, the Cluster Bomb Unit (CBU) 55/B, which saw extensive use in Vietnam. This programme was prompted by the first operational use of FAE in Vietnam consisting of canisters of Ethylene Oxide for minefield clearance, used by the US Marine Corps in 1967. (For a short example film of FAE munition effectiveness go to www.nawcwpns.navy.mil/clmf/faeseq.html.

6.2. Enhanced Blast Munitions (EBM) and Thermobaric muntions

There is occasionally confusion between FAE systems and other systems with similar effects. The differences are explained at Annex C.

6.3. Weaponisation

The design and manufacture of a FAE weapon is dominated by the challenge of achieving the correct fuel / air mixture and then initiating it at the correct time. A typical FAE munition could be a circular cylinder, two or three diameters long, filled with fuel and designed to burst at an optimum height above the ground. A bursting charge of 1 to 2% of the fuel weight is located in a tube along the central axis of the bomb. The mass of the burster charge to fuel ratio has little effect on resultant cloud dimensions once the ratio exceeds 1:40. The purpose of this burster is to break open the fuel container and distribute the fuel in a cloud with sufficient volume to contain enough oxygen for complete initiation. This volume is determined by the quantity and reaction chemistry of the fuel.

If the FAE munition contains a liquid fuel, then the burster charge will also distribute the liquid in aerosol form so that it can be detonated. This is a critical function as particle size and distribution influences the detonability of the fuel.

The fuel is ideally detonated when the cloud reaches the correct diameter for the optimum stoichiometric ratio. Then a second detonator that has been projected into the cloud will initiate the explosion. This explosion is not initiated by the functioning of the first detonator, as the fuel is not in a detonable aerosol form whilst contained in the weapon body; this has advantages for EOD render safe procedures. The delay time between dispersion and initiation is of the order of 150 ms, and therefore local meteorological conditions have little effect on the cloud formation.

The expansion of the cloud after initiation is affected by aerodynamic forces acting on the droplets, which are progressively broken up until the cloud expansion ceases, and a distinctive “pancake” shaped cloud has been formed. The vaporisation of these droplets primarily takes place when they have been heated by the arrival of the shock wave or the flame front after initiation.

Safety is an important issue in the weaponisation of FAE. Factors such as the toxicity, corrosiveness, stability, flammability and explosiveness of the fuel all need to be considered. Fuel selection is inevitably a trade-off of factors, and the following table illustrates some of the safety issues to be considered for FAE fuels:

SER	FUEL	CORROSIVE	INFLAMMABLE	EXPLOSIVE	TOXIC
(a)	(b)	(c)	(d)	(e)	(f)
1	Aluminium Powder	No	No	No	No

SER	FUEL	CORROSIVE	INFLAMMABLE	EXPLOSIVE	TOXIC
(a)	(b)	(c)	(d)	(e)	(f)
2	Decane	No	Yes	No	No
3	Ethylene Oxide	No	Yes	No (Liquid)	Yes
4	Kerosene	No	Yes	No	No
5	Propylene Oxide	No	Yes	No	No

Table 1: Safety Considerations for Potential FAE Fuels

6.4. FAE systems

Examples of FAE systems, together with their current operational status, are summarised below [3]:

SER	SYSTEM	COUNTRY	DELIVERY MEANS	REMARKS
(a)	(b)	(c)	(d)	(e)
1	CBU-55/B	USA	Air dropped	Operational. Contains 3 x BLU-55/B ?
2	CBU-72	USA	Air dropped	Operational Contains 3 x BLU-73/B Ethylene Oxide filled.
3	BLU-64/B	USA	Air dropped	Hydrocarbon fuel
4	BLU-72/B		Air dropped	Pave Pat - Propane filled Pave Pat 2 - Ethylene oxide filled
5	BLU-73/B	USA	Bomblet	Ethylene oxide filled
6	BLU-95/B	USA	Air dropped	500 lb Propylene oxide filled
7	BLU-96/B	USA	Air dropped	2000 lb Propylene oxide filled
8	FAACB Fuel/Air Aero Cargo Bomb	China	Air dropped	Operational. Similar design to Serial 1.
10	KAB-500KrOD	Russia	Air dropped	TV guided
11	ODAB-500PM	Russia	Air dropped	
12	ODS-OD BLU Dispenser	Russia	Air dropped	Contains 8 x CBU
13	S-8D (S-8DM) 80mm Rocket	Russia	Air delivered	
14	S-13D 122mm Rocket	Russia	Air delivered	
15	AS 11 Rocket	Russia	Air delivered	Unconfirmed
16	AS 12 Rocket	Russia	Air delivered	Unconfirmed
17	SPLAV 220mm BM 9P140 Uragan MLRS	Russia	Multiple Launch Rocket System	May be also be known as TOS-1 220mm MLRS?
18	NORINCO 305mm FAE Minesweeping MLRS	China	Multiple Launch Rocket System	Operational.
19	SLUFAE Surface Launched Unit FAE	USA	Multiple Launch Rocket System	Trials only, now stillborn.
20	SHTURM ATGM	Russia	Helicopter launched	ATGM
21	KORNET-E LRATGM	Russia	Ground launched	
22	CATFAE Catapult Launched FAE	USA	Catapult	Trials and Development. Operational status undefined.

Table 2: Summary and Operational Status of FAE Weapons

[3] Sources include; 1) Jane's Defence; 2) http://www.hrw.org/press/2000/02/chech0215b.htm; and 3) http://www.fas.org/man/dod-101/sys/dumb/fae.htm.

Figure 2: Russian ODAB-500PM FAE Bomb
(Courtesy © Janes EOD, 2001)

7. Fuel Air Explosives (FAE) [4]

7.1. Introduction

FAE are different from conventional condensed explosives in that they contain fuel elements only and do not carry their own oxygen. To initiate explosion, the fuel is mixed with the ambient atmospheric air, often using a condensed explosive burster charge, and when mixing is complete, initiation is achieved by a delayed ignition or explosion.

There are many possible fuels for FAE, but practical considerations such as safety quickly reduce the list of options. The unclassified list of FAE fuels is not large, and hydrocarbons are the most numerous. The following table lists some of the possible FAE fuels that have been experimentally demonstrated to work, and compares their energy output with that of TNT [5]:

SER	FUEL	ENERGY/UNIT MASS (kcal/g)	ENERGY/UNIT VOLUME (kcal/cm^3)	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Decane	11.3	8.5	
2	Kerosene	10.2	8.2	
3	**Propylene Oxide**	**7.9**	**6.6**	**CONFIRMED USE**
4	Aluminium	7.4	11.0	Aluminium Powder
5	**Ethylene Oxide**	**6.9**	**6.0**	**CONFIRMED USE**
6	TNT	1.1	1.6	

Table 3: Comparison of Energy/Unit Mass of FAE versus TNT

From Table 2 it is apparent that FAE, such as Propylene or Ethylene Oxide can release over 400% more energy that TNT, although the period of energy release is much quicker in the case of TNT.

7.2. Performance of FAE systems

The absence of an oxidiser means that a much greater proportion of the payload of the weapon can be devoted to the fuel. Therefore a greater release of energy can theoretically be achieved at a target for a munition of a given payload.

Due to the high Heats of Explosion of potential fuels, the energy advantage can be as high as ten times that of TNT in ideal conditions. However, the fact that air only contains 21% oxygen, means that the explosive efficiency of FAE systems is less than 40%. The nitrogen in the air dilutes the system and absorbs heat and an even concentration of fuel in the atmosphere is difficult to achieve operationally. This can be illustrated by comparing the Heats of Explosion of potential fuels against that of TNT [6]:

SER	FUEL	HEAT OF EXPLOSION (MJ/kg)	EASE OF INITIATION
(a)	**(b)**	**(c)**	**(d)**
1	Propane	38.0	80 Moderate
2	Ethylene (Acetylene 3)	5.0	13 Easy
3	Oxirane	21.0	2 Easy
4	Gasoline (Aerosol)	37.0	30 Moderate
5	Aluminium (Dust)	16.0	2000 Difficult
6	TNT	4.2	

[4] This section developed from UK RMCS Cranfield, Ammunition and Explosive Systems Department course notes.

[5] Fuel Air Explosives, Weapons and Effects, *L Lavoie*, Military Technology, September 1989.

[6] JSP 333, Services Textbook of Explosives, Chapter 11, *UK MOD*, October 1990 (Amendment 6).

Table 4: Comparison of Heats of Explosion of FAE versus TNT

7.3. TNT equivalence

The explosive potential of a FAE system can be expressed in terms of its TNT weight equivalent (W_{TNT}):

$$W_{TNT} = (K \times W_F \times \Delta H_F) / \Delta H_{TNT}$$

Where,

K = Efficiency of the explosion
W_F = Weight of Fuel
ΔH_F = Heat of Explosion of Fuel
ΔH_{TNT} = Heat of Explosion of TNT

7.4. Blast effects

The initial detonation pressures and velocities of FAE are much less than those for an equivalent weight of conventional explosive.

SER	TYPE	DETONATION PRESSURE (Bar)	VELOCITY OF DETONATION ($m.s^{-1}$)
(a)	(b)	(c)	(d)
1	TNT	190,000	6950
2	FAE	19	1800

Table 5: TNT v FAE, Detonation Pressure and Velocity of Detonation

Therefore FAE have little brissance or shattering effect. Notwithstanding that they do have other advantages in the propagation of the air blast. Condensed explosive detonates as a “point source” and the blast overpressure falls rapidly with increasing distance from the charge. In contrast, the source for a FAE explosion is a large cloud, (which for a 33Kg charge can be up to 30m in diameter). This can not be regarded as a point source, and therefore the decay in peak overpressure falls much less rapidly with distance from the edge of the cloud than is the case for condensed explosive:

SER	ETHENE (1 TONNE) / AIR EXPLOSION	
	DISTANCE FROM CLOUD EDGE (m)	OVERPRESSURE (% OF TNT EQUIVALENCE)
(a)	(b)	(c)
1	10	50
2	20	139
3	50	374

Table 6: Over-pressure from FAE Cloud Edge

Furthermore, the duration of the blast wave from FAE is greater than that from condensed explosive, so the Impulse of FAE will be even greater. This gives it the potential to do more work on the surrounding environment.

Although on first sight the lower over-pressure performance of FAE against TNT would seem to be a disadvantage, trials and operational use have proved its effectiveness against personnel[7], soft skinned vehicles, parked aircraft and antennae arrays.

7.5. Upper and Lower Explosive Limits (UEL and LEL)

Fuel-air explosions can only occur when the fuel concentration in the atmosphere lies within certain limits. For explosion by deflagration these are the Upper and Lower Explosion Limits (UEL and LEL); within this range lies the narrower Upper and Lower Detonation Limits (UDL and LDL). This has advantages for render safe by detonation, which will be covered later.

[7] The Threshold Limit for eardrum rupture is approximately 2 Bar, FAE produces a detonation pressure of approximately 10 times that!

Most FAE fuels are dispersed by a central explosive burster charge, producing a cloud of droplets and vapour that mix with the surrounding air. The cloud is then detonated after between 0.1 to 5 seconds depending on the system. During this time there is some evaporation of the droplets and further mixing as the cloud expands. This leads to large variations in concentration within the cloud, thereby further reducing efficiency. For this reason only fuels with a wide range of UEL and LEL are used:

SER	FUEL	EXPLOSIVE LIMITS (% Volume in Air)	
		LEL	UEL
(a)	(b)	(c)	(d)
1	Ethyne	2	100
2	Oxirane	3	80
3	Ethene	3	34
4	Methane	5	14
5	Propane	2	10
6	Gasoline	2	8

Table 7: Explosive Limits for Potential FAE Fuels (Initiation Energy = 10J @ STP)

If the fuel concentration lies within the detonation limits then a transition from deflagration to detonation may occur if the FAE cloud is large enough. However, most systems rely on a high explosive booster to induce detonation.

7.6. Initiation

7.6.1. Explosive initiation

Present FAE systems are fitted with a two stage fuze. The first to fire the burster charge and the second to initiate the resultant fuel-air cloud by shockwave effect.

7.7. Chemical initiation

The advantage of chemical initiation is that a single event could be used to disperse and initiate the fuel. In this case chemicals that react with one another or the fuel are dispersed with the fuel. Heat from the reaction is then sufficient to initiate the cloud.

a) the **hypergolic** approach uses bromine trifluoride or choline trifluoride that are able to react with the fuel. Perfluorohydrazine[8] is the interacting two component initiator.

b) **pyrophoric** initiation has been tried using boron and aluminium alkyls, but is not known to have been deployed on an operational system.

7.8. Cloud formation and dispersion

The delay time between cloud formation and initiation is so short (150 ms for the CBU-55B) that local meteorological conditions have no effect on the operational use of the weapon.

> **WARNING 1: Meteoroloicigal conditions should be considered during render safe procedures in the event that they do not go to plan. Any cloud formation will quickly lead to a downwind vapour hazard area of fuel. Whilst it will by then be outside the LEL, it still presents a potential toxic risk.**

8. Hazards

8.1. EOD hazards

An unexploded FAE munition will present some, or all, of the following hazards:

[8] This is a derivative of the hydrazine family. (See Technical Note 09.20 for details on the hazards of hydrazine). The level of PPE recommended by Technical Note 09.20 is not required if an RSP by detonation has fully destroyed the munition.

a) the presence of the burster and booster charges linked to the fuze means that any explosive attack against only the fuze may well initiate the munition. Although full cloud formation will not occur because of contact with the ground, enough could disperse to cause a nasty surprise!

> **WARNING 2: Do NOT explosively attack the fuze as the first stage of a render safe procedure.**

b) FAE munitions are thin cased and are therefore prone to rupture. Although any leakage from a damaged UXO is unlikely to reach the LEL, there is still a potential toxic hazard;

c) the meteorological conditions may result in another hazard. The boiling point of Oxirane is +13.5^{0}C, whilst that of Methyl Oxirane is +34.0^{0}C. This means that the liquid content could be boiling lead to gradual pressure build-up. Although this is unlikely to rupture an undamaged case, EOD technicians should be aware of the hazard; and

d) some FAE munitions rely on the expulsion of a coiled probe from the munition. This probe is thought to be tipped with a piezo-electric element to trigger the booster charge when it contacts the ground. This ensures initiation at the optimum height. Should the probe have not deployed, then the EOD technician should be aware that it deploys with great force!

> **WARNING 3: Do NOT approach the munition along its longitudinal axis, always approach from the side.**

> **WARNING 4: Apply a danger area of 800m [9] along the longitudinal axis of the weapon. The remaining danger area should be calculated in accordance with the guidance provided in TNMA 10.20/01 Estimation of Explosion Danger Areas.**

8.2. Advice and International Responsibilities

Advice on safety and on the disposal of chemical waste can be obtained from either:

United Nations Environmental Programme (UNEP)
Emergency Response Unit
United Nations Avenue, Gigiri
PO Box 30552,
Nairobi
Kenya

Tel: (254-2) 621234
Fax: (254-2) 624489/90
Email: **UNEP Webmaster**

http://www.unep.org/PolicyDivision/emergency_response.html

World Health Organisation (WHO)
Avenue Appia 20
1211 Geneva 27
Switzerland

Tel: (+41) (22) 791 2599
Fax: (+41) (22) 791 3111
E-Mail: inf@who.int
http://www.who.int/m/healthtopics-a-z/en/index.html

[9] This distance is based on the fact that a shaped charge can travel approximately 1800m in free air. There is NO publicly available scientific evidence to back up this distance and the EOD technician adopts it at his/her own risk!

9. Guidance on Render Safe Procedures (RSP)

WARNING 5: There are NO publicly available render safe procedures for FAE munitions. The following guidance has been derived from first principles and a limited knowledge of the possible munition design. These RSPs should only be attempted by appropriately qualified EOD technicians.

WARNING 6: Always consider the possibility of leakage of unreacted toxic fuel and apply an appropriate downwind hazard danger area.

9.1. Shaped charge attack

The munition could be attacked using a shaped charge along its longitudinal axis [10]. Great care should be taken to ensure that the shaped charge jet does not initiate the booster, burster or fuze. The aim is to induce deflagration of the fuel content of the munition without initiating the high explosive content.

Then consider conducting a second manual approach to destroy the high explosive contents by detonation. (Remember that there will be liquid contamination as it is unlikely that 100% of the fuel will have burnt).

Risks of this destruction method include:

a) the shaped charge fails to initiate the fuel content. The munition is now leaking slightly and at this stage destruction by HE remains the only real option; and

b) complete detonation.

9.2. Ballistic Disc attack

Consider attacking the munition using two diagonally opposed ballistic discs. The aim is to induce a shear force across the munition casing, thereby splitting it open, when the residual heat energy should then ignite the fuel. Great care should be taken to ensure that the ballistic discs do not initiate the high explosive components of the munition.

Then consider conducting a second manual approach to destroy the high explosive contents by detonation. (Remember that there will be liquid contamination as it is unlikely that 100% of the fuel will have burnt).

Risks of this destruction method include:

a) the ballistic disc fails to initiate the fuel. The munition should now be cracked open and at this stage the munition could be left until all of the fuel has evaporated. However it may be possible to conduct a downwind manual approach wearing appropriate PPE to deploy a destructor incendiary to initiate the fuel; and

b) complete detonation.

9.3. Destruction by detonation

Attack the munition using high explosive charges against the fuze and main body.

WARNING 7: Ensure that the charges are; 1) either linked with double detonating cord; or 2) are initiated in series. It is highly undesirable for the charge attacking the fuze to initiate at a different time to the charge on the main body. A single event on the fuze may result in the designed initiation of the munition.

[10] See Warning 3. Approach the munition from the side and minimise bodily exposure to the rear of the munition when placing the charge.

9.4. Other options

One option includes a manual approach to attempt to unscrew the filling bung. This should only be attempted when there is not other option as, arguably, it involves an unnecessary manual approach. Due to the limited information on the munition design, this option should only be attempted after X-Ray diagnostics.

Another possible option is the use of Hydro Abrasive Cutting systems (HAC) to remove the fuze and then gain access to the body. The filling can then be destroyed using destructor incendiary. This is perhaps the safest possible option but relies on the deployment of HAC equipment to mine action programmes; to date[11], only UXO Laos has immediate access to this sort of equipment.

10. Equipment

10.1. Personal Protective Equipment (PPE)[12]

The following PPE should ideally be used by the EOD technician or qualified staff member until any leakage from the munition can be positively discounted:

a) inner cotton gloves;

b) outer heavy PVC gloves of industrial quality; and

c) respirator.

The aim of the PPE should be to provide complete overall protection from inhaled or skin-contact vapour, and cuts from sharp fragments. Managers unable to obtain military equipment should use the best materials, and ingenuity, to achieve this requirement.

10.2. Respirator

The eyes are particularly sensitive to chemical attack and the presence of any toxic or irritant vapours, fumes or mists will necessitate adequate eye protection being available. There are many commercial personal respirators on the market that provide adequate protection against particulate contamination, BUT may well not be suitable for protection against vapours, fumes and mists.

11. Safety brief

Demining organisations should ensure that all of their managerial, demining, administrative and support staff are briefed as to the hazards of FAE systems if they have to move in a potentially hazardous environment. (Their EOD or specially qualified personnel should already be trained in the hazards of liquid fuels).

The following safety brief should be made available to such personnel:

You should be aware that it will not be possible, without special instruments, to detect whether a damaged FAE system is leaking. The following precautions should be taken.

a) *do not enter the immediate area of the damaged FAE system, or loiter within 50 metres, unless you are working in co-operation with an EOD technician;*

b) *if your work requires you to work within 50 metres, wear a facemask and gloves, and roll your sleeves down. Cover any cuts and abrasions with waterproof dressings. Spend as little time as practicable on the task;*

[11] 16 November 2001.

[12] This PPE is additional to the PPE requirements contained within IMAS 10.30.

c) *do not eat, drink or smoke near the damaged FAE system. After completing your task, wash and shower as soon as practicable. Remove your outer clothing and, if feasible, replace it. Otherwise, have it laundered. Do not eat, drink or smoke until you have done so; and*

d) *if you suspect you have been exposed to the fuel, inform your medical support team.*

12. Recommendations

12.1. National mine action authority

The National Mine Action Authority is responsible for identifying and warning all mine action agencies of any history of the use of FAE systems. The Authority should be aware of these Technical Notes, and make copies available, through the National Mine Action Centre, to all mine action agencies, including those involved in Mine Risk Education.

12.2. Demining organisations

The manager of any mine action team should also be aware of these notes, and if the use of FAE systems is suspected or proved, should include the recommendations of these notes in SOPs. The manager is also responsible for ensuring the presence of a trained EOD staff member, or for sending a staff member for specific training in FAE system hazards. Where a National Mine Action Authority of Mine Action Centre have not been established, managers are responsible for establishing amongst themselves a code of practice to ensure the safety of mine action staff and locals.

12.3. Demining personnel

All mine action staff working in areas of potential fuel contamination, should make every effort to keep themselves free from the hazard by conscientious use of protective equipment, and strict observation to SOPs and the dictates of common sense.

Annex A
(Normative)
References

The following documents when referred to in the text of this Technical Note, form part of the provisions of this guide.

a) IMAS 04.10. Glossary of demining terms.

The latest version/edition of these references should be used. GICHD hold copies of all references used in this Technical Note. A register of the latest version/edition of the IMAS standards, guides and references is maintained by GICHD, and can be found on the IMAS website (www.mineactionstandards.org). National Mine Action Authorities, employers and other interested bodies and organisations should obtain copies before commencing mine action programmes.

The latest version/edition of the Technical Notes can be accessed via the IMAS website (www.mineactionstandards.org).

Annex B
(Informative)
Enhanced Blast and Thermobaric munitions

B.1 Enhanced Blast Munitions (EBM)

In parallel to the development of FAE was the development of Enhanced Blast Munitions (EBM). An EBM is little more than an improved efficiency high explosive, obtained by the addition of metal powders that release energy when they oxidise in the high temperatures of the explosion. The result of these improvements can be significant in terms of energy release, but problems of safely deploying them in weapon systems precludes their use in all but the most limited of circumstances. One known example in operational service is the US Bomb Live Unit (BLU) 82 “Daisy Cutter” which consists of a 15,000 lb bomb filled with an aqueous mixture of ammonium nitrate, aluminium powder and polystyrene soap. It should also be noted that FAE are now beginning to be grouped with EBM by some sources. EBM are not covered in this TNMA, but are known to have been used operationally in Afghanistan, Kuwait/Iraq and Vietnam.

B.2 Thermobaric munitions

The thermobaric weapon works by propelling a warhead that scatters an aerosol explosive on or before impact with the target and then immediately igniting this to create a high-pressure blast wave. The effect is a much more rapidly expanding blast than a conventional explosion.

Compared with a fuel-air explosive, the thermobaric weapon has a much higher expanding concussion effect and lacks the degree of vacuum implosion produced by fuel air weapons. Primarily, this is because fuel air weapons take time to distribute the aerosol explosive widely before ignition.

Russia is currently the world leader in thermobaric weapons, and has already used them in action, for example to clearing Mujahideen from caves in Afghanistan and more recently Chechen guerrillas from buildings in Grozny. The Russian RPG-7 thermobaric warhead, fired from a manportable rocket-launcher, is said to produce effects comparable to the detonation 2kg of TNT, while the effects of the Russian RPO-A Shmel rocket-propelled incendiary/blast projectile are reportedly similar to those produced by a 122mm howitzer projectile. Russian variants of this latter weapon include one that combines a thermobaric warhead with a small hollow charge, which is designed to penetrate structures prior to detonation of the main warhead, thus considerably enhancing its effects.

Annex C
(Informative)
Hazard data sheets - common fuels

C.1 Ethylene Oxide

http://www.osha-slc.gov/OshStd_data/1910_1047_APP_A.html

http://hazmat.dot.gov/erg2000/g119.pdf

C.2 Propylene Oxide

http://www.osha-slc.gov/dts/chemicalsampling/data/CH_265000.html

http://hazmat.dot.gov/erg2000/g127.pdf

C.3 Isopropyl Nitrate (IPN)

http://www.cdc.gov/NIOSH/idlh/627134.html

http://hazmat.dot.gov/erg2000/g130.pdf

Amendment record

Management of Technical Notes amendments

Technical Notes (TN) are subject to review on an 'as required' basis. As amendments are made to this TN they will be given a number, and the date and general details of the amendment shown in the table below. The amendment will also be shown on the cover page of the TN by the inclusion under the version date of the phrase *'incorporating amendment number(s) 1 etc.'*

As reviews of TN are made new versions may be issued. Amendments up to the date of the new version will be incorporated into the new version and the amendment record table cleared. Recording of amendments will then start again until a further version is produced.

The most recently amended TN will be the versions that are posted on the IMAS website at www.mineactionstandards.org.

Number	**Date**	**Amendment Details**
01	01 Jul 2013	1. Inclusion of amendment No, date in the title and header. 2. Updated links and email addresses. 3. Removal of Annex B. 4. Inclusion of amendment record. 5. Minor text changes in fifth paragraph of foreword. 6. Annexes B and C, relabelled.