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Practical Notes on the Application of **Thermite Systems** in Mine Action

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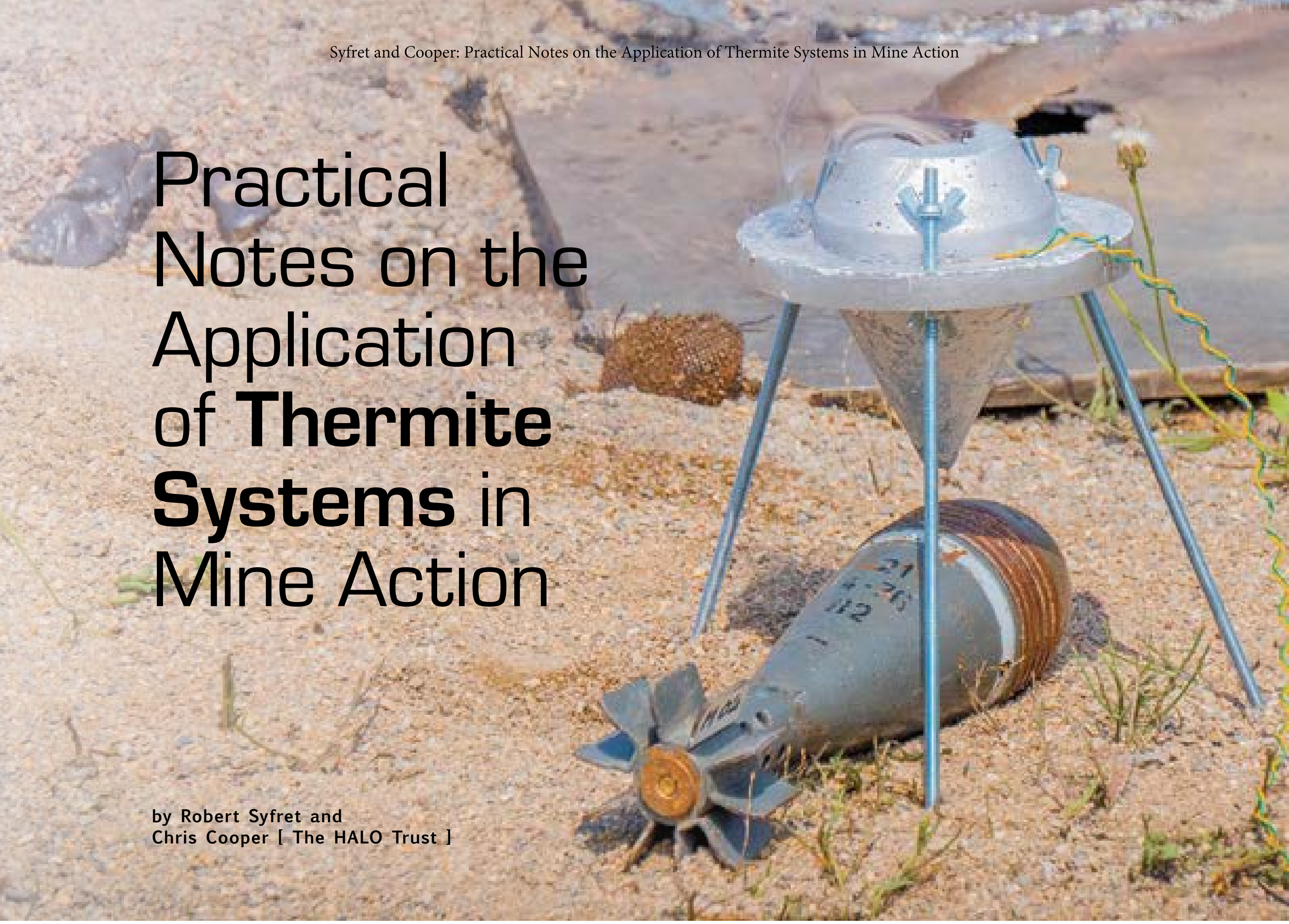

A RendSafe crucible.
Image courtesy of Suzanne Barlow/RendSafe.

There are numerous documents available online relating to the use of thermite systems for explosive ordnance disposal (EOD). However, most of the documents are either scientifically focused or address specific technical questions. This article provides broader practical information for mine action operators at the field and program levels.

Previously employed on a relatively small scale over the last five years, use of thermite as opposed to explosives for the destruction of landmines and explosive remnants of war (ERW) has increased over the last five years. This has been driven by greater engagement across the sector in countries with unstable security situations, and places with more restrictive legislation on the holding and use of explosives by mine action operators. In the past decade, The HALO Trust (HALO) has used thermite throughout the world, from Colombia to the Middle East, learning numerous lessons and best practices. The use of thermite will continue to expand across the sector, improving its cost effectiveness and expanding operator's knowledge of how to best employ the technology.

USE OF THERMITE IN MINE ACTION

In general terms, thermite is a mixture of chemicals that burn at a temperature of approximately 3,500°F/1,927°C, although there can be significant variation.[1] The mixture is typically composed of a fuel, such as aluminum or magnesium, and an oxidizer such as iron oxide. Thermite compositions require an ignition temperature of several thousand degrees, which vary according to the constituent chemicals.[2] Thermite has been used for many years commercially, most commonly to weld together railway tracks. As a non-explosive with minimal military use other than for *low-order* techniques, thermite cannot be used as an homemade explosive (HME).[3] The hazard classification of particular systems may vary according to specifics of manufacture; however, they will typically be Class 4.1 hazardous materials (flammable solids).[4] Some variants are supplied unmixed, in which case the separate chemicals may not even have a hazard classification. It should be noted that the packing group may vary if starter (ignition) systems are built into the item

A T-Jet thermite flare.
Image courtesy of Chris Cooper.

rather than packaged separately and assembled by the operator prior to use (T-Jet systems, for example, are provided as in the latter configuration).

The use of thermite in mine action has grown over the last two decades, and is now used globally in the field. Information from manufacturers shows it has been used in Australia, Cambodia, Colombia, Hong Kong, Iraq, Kosovo, Libya, Mozambique, Palau, Spain, Somalia, Somaliland, South Sudan, Syria, the United Kingdom, and Yemen; this list is not exhaustive. It has not, however, become the industry standard, as there are currently several disadvantages in its employment as an EOD tool when compared to high explosives (HE). These points are noted in the pros and cons paragraph. Having said this, companies producing thermite systems are making rapid advances and show keen interest in customer feedback while addressing previously-raised issues.

TYPES OF THERMITE SYSTEMS AND MANUFACTURERS

There are numerous thermite systems available that are manufactured around the world. They can be broken down into two basic types: molten flowing metals (molten penetrators) and pyrotechnical directional flares (thermite flares). In flare systems, the thermite is packed into a tube with a nozzle at one end. The heat of the flame produced is focused in order to cut the casing and ignite the explosive contents within. Most molten penetrators consist of a crucible placed above the target. The thermite placed in the crucible produces a superheated metal that drips through a hole in the bottom onto the item, burning a hole through the casing and igniting any explosive contents via direct contact. Other versions without crucibles are also available.

It is not possible to give a complete list of available systems here; however, a contact list of manufacturers is provided at the end of this article.

PROS, CONS, AND PRACTICALITIES OF THERMITE

The most important feature for mine action programs is that thermite is not classed as an explosive. This means thermite can be used in places where insecurity or regulatory regimes make HE either illegal or extremely inadvisable. Its storage bears minimal infrastructure burden; and the transport categorization means most systems are suitable for air freight, making logistics chains and planning far easier. The first of these factors is of such significance that it is likely to drive the expansion of use more than any other. The downsides of thermite in comparison to explosives are its cost, the time it takes to carry out the final disposal of an item, and the limitations in its application, for example against more complex ERW such as rocket motors. The following practical lessons have been learned by HALO, and should be of use to programs thinking of introducing thermite in the field:

Security. The closer mine action programs work to the conflict period, the greater the security implications of holding explosives and training staff in their use. In some locations the possession of explosives would place mine action operators at extreme risk of robbery by non-state armed groups or detention by local security services. In these instances, the option of using thermite may be what makes a clearance program possible.

Transportation. As noted previously, most thermite systems are designed to be transportable by air freight; however, different sizes or weights of particular models affect the cost of doing so, which must be accounted for when comparing unit costs to a program of one system over another.

Storage. Storage of thermite is hugely less restrictive, expensive, and logistically challenging than the storage of explosives.

Deflagration of target. Thermite can be used to attempt to target the fuze or booster of an item to produce a *high-order* detonation as soon as possible, or conversely to try and have as much explosive in the item as possible deflagrate prior to the heat causing the detonation of the explosive train. When used against anti-tank mines, it is possible to burn out a large proportion of the explosive prior to detonation, but there is a tendency for the combination of heat and pressure that builds during the burning to result in a "deflagration to detonation" transition of some of the fill. In situations where a munition is in an area where a high order is undesirable, the attempted use of deflagration can be a good option, but it cannot be guaranteed and must not be attempted unless the consequences of a complete detonation can be mitigated to an acceptable degree.

Soak periods. As with normal demolitions, a soak period after the last smoke seen at the target should be scrupulously observed. On many occasions in Syria during the disposal of PTAB 2.5Ms (anti-armor submunitions), a first explosion was followed several minutes later by a second or even third explosion—the longest period between first and last explosions being seven minutes. It is likely that these were caused by different components (nose fuze, base detonator) and the main fill exploding at different times. Given this is unlikely to happen during explosive demolition, the chances of such events are higher with thermite. The extended burning also mean there is an increased likelihood that materials surrounding the target will ignite, meaning a longer delay until the last smoke is seen and the soak period can commence. Thermite is therefore typically less time efficient than high explosive disposal.

Work timings. As a consequence of the long soak period, operations managers must consider cut-off times prior to the end of the working day for beginning a thermite disposal, particularly when teams have to leave a site by a certain time for safety and security reasons, such as driving at night. An hour is a good initial start point.

Protective works. Further consideration must be given when building protective works around thermite demolitions than when building them for use with explosives. With thermite flares, the heat is liable to burn through sandbags. This means it is essential to use some material (e.g., plywood) as a roof above the burning area. If this is not done there is a risk that sand will spill over the flare and put it out before deflagration is complete, giving rise to obvious hazards. Protective works are harder to effectively build around a crucible initiated disposal as the works need to be built up and over the crucible. In comparison, a thermite torch may often be laid flat beside or built into the protective works to attack the target. Usually with explosives, the ERW high orders and all that is left is a crater within the protective works. If the ERW low orders (as sometimes occurs with thermite), exposing the results is more hazardous as the remains of the ERW, which may contain sensitive explosives, are often buried below the protective works.

Rocket motors. Thermite is unsuitable for the disposal of rocket motors in normal circumstances because there is a significant chance of igniting the propellant, thereby causing the rocket to move rapidly in an uncontrolled manner. Programs where rockets are present will need an alternative option.

Cost. Although the relative costs of explosives, detonators, detonator cords, and other items varies among countries, in general, the amount required for a single demolition will be a total of US$2–3, compared with $16 to $90 for a thermite system.[5] A precise calculation for each country would have to include other factors such as the additional storage and management costs for stocks of HE and ancillaries in order to give a true comparison. It should be noted that, typically, the cheaper thermite systems are only suitable for thinner-skinned items such as plastic anti-personnel mines, whereas targets such as artillery shells will require more expensive equipment.

Bulk demolitions. Thermite is highly unsuited to bulk demolitions. The variation in the effects of burning on the nature of the initiation of the explosives in ERW mean that consistent propagation of sympathetic detonation cannot be guaranteed. The results of partially-initiated bulk demolitions are extremely hazardous.

Cluster munition carriers. Although *in extremis,* thermite could be used to attack a cluster munition carrier, there is a higher chance that submunitions will be kicked out and then

This image shows a 25 lb HE shell attacked using a molten penetrator. The conical shape of the entry did not allow sufficient escape of gases during deflagration to completely prevent explosion; however, it is clear that the detonation that did occur lacked the violence of a high-order event.
Image courtesy of Chris Cooper.

have to be dealt with one at a time, after which they may potentially be in a more sensitive state than when in the parent container. Very detailed planning and risk assessment is therefore required.

Multiple items in close proximity. In areas where numerous items are gathered together (for example when gathered by locals), they cannot be targeted simultaneously by thermite as each item would probably initiate at different times, the first initiations potentially disrupting the setup of the remaining disposals. This could be addressed by the use of hook and line, or depending on the proximity and size of the items, by use of individual protective works; however, most of the time explosives are the only means of conducting this operation cleanly.

Cluster munitions and other sensitive ERW (piezo, cocked strikers, etc.). These can be dealt with individually using thermite. The thermite torch lends itself best to this as it is a simple operation to align one next to the target, minimizing the risk of accidental contact during preparation of the operation.

Shaped charges. These are designed to project a plasma jet or slug in a particular direction. They are used to concentrate the explosive effect to penetrate armor. The shape charge is usually a cone or a concave disc. Collapsing the cone or disc during disposal disrupts the formation of the energetic jet or slug and can only be achieved by explosive means. Thermite may still be used but consideration of the direction of travel, protective works, and evacuation are the main means of mitigation. These are still put in place when using explosives that are more likely to prevent the jet or slug forming in the first place. If possible, targeting thermite at the portion of the explosive fill closest to the stand-off will make it much less likely that a high order resulting in the efficient formation of the plasma jet will occur.

Initiation systems. Bridge-wire initiation systems do not work with all variations of exploder. If too much current passes through the wire, it may break without heating the ignition mixture sufficiently. Other ignition systems have not proved 100 percent reliable.

Whenever ordering thermite systems, it is recommended to order an excess of initiators in order to allow for training and to provide spares in the case of operator error or system failure, as the particular starters required are unlikely to be available from other sources in-country, or easily replaced with a self-made alternative.

Identifying evidence of complete deflagration. Thermite systems may burn out an item and leave a hole with evidence of burning. It is difficult to confirm if all the explosive fill/detonator has burned out, requiring it to be attacked a second or third time (or potentially even more). It was also found where bare fuzes are attacked with thermite, the booster may function but the detonator does not, requiring a second attack (if the fuze is unarmed the detonator may well be out of line with the booster and therefore protected from its effect).

Small vs. large items. Generally, items of 57 mm or below high ordered, while larger items deflagrated (unless the fuze or booster were deliberately attacked).

Violent deflagration and low-order detonation. On some munitions, energetic low-order events were observed, resulting in explosive components and filling being dispersed, which required another attack. The results of this event are potentially more dangerous than the state of the ERW as it is initially found, requiring more care to find and expose components. This situation is less likely when using explosives.

PTAB 2.5M. The nose fuze, main filling, and base detonator may react independently with up to three separate explosions heard after one attack. The longest time observed from the first to the last explosion on one event was seven minutes, but the typical period was two to four minutes. They generally low ordered as did most shaped charge munitions.

CONCLUSION

Thermite systems are a useful option for operators. There are plenty of idiosyncrasies to its use, and hopefully the points in this article will allow those using it in the future to improve safety and efficiency issues. In any country, it is probable that there will be circumstances in which thermite is not appropriate. If these issues are identified then development of further non-explosive techniques to deal with such problems will lead to operators relying less on HE. This will, in contexts such as Yemen and Syria, as well as many other places in the future, give significant benefits in terms of operational reach. Further engagement with manufacturers, development of new techniques, and support from donors should increase the effectiveness of the use of thermite.

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Figure courtesy of the authors.

See endnotes page 63

The authors would like to thank Suzanne Richards of Rendsafe and Gary Fenton of Disarmco for providing additional information.

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