Giovanni Begue, Lionel Aufauvre (lionel.aufauvre@ineris.fr)

INERIS, Business Development and Certification Division,
Parc Technologique Alata, BP 2, F-60550 VERNEUIL EN HALATTE, FRANCE

Explosive and pyrotechnic wastes management practices

Abstract

In the life cycle of explosives and pyrotechnics, disposal operations are not to be forgotten. This is most critical when one needs to get rid of large amounts of materials or articles due to overrun of shelf life. It can be the case when non-conform products are generated without possibilities of reprocessing or more frequently in situation of decommissioning unused explosives which will be considered as wastes. Due to the nature of these wastes thorough regulations as well as various technical processes have been developed for their control and elimination with high safety considerations. In this frame, the disposal operations are not only limited to the destruction itself but could usually cover other operations like transportation, collection, sorting, neutralization or residues and effluents treatment.

In this work, we illustrate some operations and give examples of different techniques for the disposal of mining or military explosives, fireworks, pyrotechnic articles for vehicles or for marine distress signals. Several practices in place are also described and their advantages and drawbacks are commented.

Introduction

As manufactured products, explosives and pyrotechnics no longer escape from waste treatment, disposal and recycling operations. This is true for the whole product life cycle from research activities to final disposal or decommissioning passing through qualification, manufacturing, testing, use. In the following, we mainly cover the cases of disposal of explosives and pyrotechnics at their end of life mostly by expiry of shelf life.

Explosives for Civil Uses

Explosives for civil uses are not manufactured in view of being stored and kept for long period of time. In contrary, it is usually most profitable for an explosive manufacturer to smartly manage its stocks to distribute its products in due time to the final users. The larger quantity of explosives for civil uses is found for quarry and mining industries. These products are mostly detonators, detonating cords, explosives in cartridge or bulk explosives. There the explosives are consumed usually shortly after their delivery when not immediately in the case of on-site manufacturing. There is an economical reason to avoid at the maximum situations where an explosive will be found to be too old or degraded to be used. A product can be considered too old when it reaches the end of its shelf life, and a product is generally degraded when it has not been stored and / or transported under adequate conditions which lead to alter its performances.

An unexpired or undegraded explosive normally operates according to its known nominal characteristics. However, if the product is aged or has undergone various stresses (shock, crystallization, contact with water, ...), evolutions of its chemical composition or modifications of its physical properties may have taken place resulting in increasing or decreasing its instability and / or rendering it sensitive to external stimulus. The hazards associated with this type of too old or degraded products are linked to a poor knowledge of their current characteristics and associated behavior.

We encountered such a situation in an inactive storage with a forgotten box of degraded dynamites that presented a significant exudation. These dynamite cartridges have been stored there for several years and have been forgotten. Dynamite has a shelf life of about 1 year; it is also very sensitive to shock and friction which can make handling difficult when it is outdated or degraded. At the end this box was in so bad conditions that it had to be taken in charge by a bomb squad for safe disposal.

Picture of degraded dynamite cartridges with presence of exudate

This shows the importance of the identification and traceability of explosive products in order to identify if explosives have reached their end of life. It also shows the necessity to record them precisely (date of manufacture, place of storage, ...) and to make regular checks at explosive storage.

Military Explosives

For military explosives the situation is the opposite as these explosives are manufactured and stored usually in view of never being used in a peaceful world. That creates large stockpiles of materials in different countries throughout the world but as storage capacities are not extensible and maintaining them as a cost, it is necessary for obsolete or unserviceable materials to be demilitarized after some years. The demilitarization becomes even more critical when storage capacities are reduced for economic reasons.

Fortunately, demilitarization by dumping ammunition in deep sea or lakes or underground burial is far behind us. Open burning and open detonation are also becoming less and less popular not only because the privileges granted to the military sector tend to be reduced but also due to environmental considerations and the fact that a very limited number of facilities would allow such practices at large scale nowadays. In all case open burning and open detonation shall be use as very last choice or for safety reasons. Since many years now, that gave perspectives for the development of multiple processes for demilitarization.

For military explosives and weapons manufacturers, offering to their customers the full life cycle management of their products from conception to disposal became during the last years an important aspect of their proposed activities. As example, the Company MBDA announced in a press released (November 14, 2012) the start of work on a demilitarization facility, which when operational would be capable of dismantling annually 2,500 tons of various type of sensitive munitions, notably missiles. It will also permit the recuperation of waste products which will be sorted, re-used or recycled in full accordance with French and European standards. Only those waste elements comprising energetic material will be incinerated in the thermic treatment unit.

Military explosives are qualified to be operational on a long period of time and they tend to be less affected by harsh conditions compared to explosives for civil uses. When they are properly stored, they normally reach their end of life in a good shape and can be demilitarized by adequately design industrial

processes. These industrial processes being more complex than open burning or open detonation are obviously more expansive to put in place and require a significant initial investment. In the example of the Company MBDA above, the figures given for the investment are about 12 million euros. Cost to operate such demilitarization facilities shall also be considered and cost reductions achieved by finding a market for recycled materials are of importance based on the R3 (Reduce, Recycle and Reuse) principle. However, this must be legally permitted, and some restrictions may apply for critical components pushing each country to implement its own demilitarization facility to protect the confidentiality of its strategic explosive products and weapons.

Fireworks

Most fireworks are manufactured in China and are exported all around the world. The fireworks sector is an economical sector somehow like the civil explosives sector as the products are made to be consumed. Fireworks are stored for a short period of time before they are used in exhibitions, festivals or display shows for celebration (e.g. July 4th, Guy Fawkes Night, New Year Eve…) which obey to a seasonal cycle. These are occasions to generate quantity of products that may be considered as waste (unwanted/unused products, customer returns, faulty products, illegal/counterfeit products seized…). Also, fireworks must comply for safety reasons with regional approvals or regulations to be use (e.g. CE marking for the European market) and it happens sometime that batches of imported products are found non-conform. The cost to restore the conformity is most of the time too high compare to the cost of the products and then these non-conforming fireworks must be disposed.

The establishment and application of procedures should allow, depending on the type of articles, to identify the possible causes of the anomalies, the measures to be taken if necessary, to secure the device and the suitable method for disposal. But it is often difficult for the customer to comply with the recommendations on the labels of an article that indicates returning the products to the manufacturer or importer in accordance with the regulations on the transport of dangerous goods. The general public often has only a very limited knowledge of this regulation and / or do not want to assume the costs related to the packaging and the return of the products. It should be easier when this is directly handled by the manufacturer or importer of the fireworks but lack of adequate facilities and practices to properly dispose these articles creates unsafe situations. This can be illustrated by the explosion that occurred on April 8, 2011 in Waipahu, Hawaii where the Donaldson Enterprises, Inc. an unexploded ordnance remediation company was storing and disposing seized fireworks. This explosion results in five fatalities and one injury.

Still today, destruction by open burning of fireworks is used by the fireworks industry, to treat waste from damaged products, missed shots, residues and non-conforming products. It is also sometime the case by authorities when they need to get rid of illegal or seized articles, which is not without generating costs often difficult to support by public authorities. If disposal of fireworks by burning method seems indeed to be the best suited, it must however be done under safe and acceptable environmental conditions. These conditions shall include at least protections for the furnace/incinerator, full or partial treatment of fumes and washing water and ashes recovery. It should be also considered that in the case of fireworks, when burning the active components (mainly inorganic substances) generate more solid residues than gaseous residues (reverse effect for burning secondary explosives) and that the presence of roughly 75% of the gross weight is made of inactive components (cardboard, paper, earth (clay) and sometimes plastic…).

Maritime Distress Signals

Distress flares for pleasure-boating are made to be use in emergency situations and for that they shall operate without failure before their use-by-date. It is a reason why regulations impose a fix shelf life for them (typically 3 years) and require periodic replacement. That leads to the consequence of generating continuous flux of distress flares to be disposed. Therefore, management of obsolete or damaged distress signals is an issue that must be taken into account by the public authorities and the world of pleasure-boating for many years. The particularity for these articles is that they are dispersed in the hand of the boat sailors. It is then necessary to proceed first to their collection, grouping and sorting before their disposal. The collection is eased by allowing free return of outdated signals when buying new ones at selling points. Outdated signals are then temporary stored at the chandlers' places before transporting them for destruction in adequate facilities. To realize that, many countries put in place dedicated channels which cover the whole process. If the status of the expired signals is similar to that of the unexpired signals (no signs of deterioration or degradation) and if these signals have expired for a short time, these expired signals may be considered to present relatively similar risks than those of the same signals not expired. They can *a priori* be transported in their original transport packaging (if they are still available). If the expired signals to be treated have suffered damage due for example to a water intake or a tearing in this case, a specific study of the risks relating to these deteriorated signals must be carried out in order to determine the method of treatment to determine the most appropriate packaging for their transport from their place of collection to their place of destruction.

Illustration of damaged maritime distress flares

For example, in France the Eco-organism APER-Pyro (www.aper-pyro.fr) was selected and appointed by the national authority to oversee the whole process and channel of disposal. This channel can be broken down into 4 main stages: the expired maritime signals are left to an authorized reseller; the products are collected, sorted and stored in packaging for transport; the products are transported to the destruction site; the products are destroyed by a heat treatment unit. APER-Pyro collects yearly almost 300 000 articles (smokes, hand-held flares and parachute flares) through 500 collecting points mostly distributed on the sea shores. Special collecting campaign are carried out in order to drain sleeping stockpiles. It is estimated that 10 to 17% of the articles collected are degraded and that this rate can goes up to 30% old stocks. APER-Pyro developed a specific packaging that allows transportation in safe condition while limiting handling operations. This packaging also plays an important role in the process until the end by mitigating the effect of hazardous debris during the final burning in a large incinerator. In this context APER-Pyro is committed to promoting this dedicated disposal channel in organizing a specific communication and events towards leisure sailors.

It should also be noted here that similar initiatives aimed at setting up channels for the collection and destruction of maritime signals were introduced in other countries. The UK has since April 2010 established a network of 18 sites of official collecting points distributed around the UK using the Maritime Coastguard Agency (MCA). In each site was set up with specific containers for temporary storage of products. Collection staffs are also trained to identify and sort products that do not present an increased

hazard (compared to new products) and degraded products that need to be treated more carefully. These latter products are thus stored in different containers according to their state. The products are then routinely sent to destruction centers from the collecting centers.

Automotive Pyrotechnics

In Europe and throughout the world millions of vehicles are scrapped every year and each of these vehicles contains several airbags, seatbelt pretensioners or other pyrotechnic actuators. The European regulation on End of Life Vehicles (see the Directive 2000/53/EC) sets minimum targets for reuse, recycling and recovery of materials. According to recommendations of automotive suppliers, automotive pyrotechnics are not reused as spare parts from wrecks. They are either activated on the car at the demolishers place to be sale with the car frame to grinders of automotive residues. Or they are dismounted from the car frame and are treated in armored oven for auto-ignition. This latter method has the advantage of containing the effects of deployment (smoke, solid residues) and allow treating the fumes generated.

Illustration of the variety of explosive article present in vehicles

Explosives Disposal Methods

There are several methods for the disposal of explosives, we can mention apart from reuse or recycle, functioning, burning, detonating, dilution/dissolution and chemical destruction/digestion, each has its own advantages and drawbacks. Functioning is very straightforward but is possible only if the explosive in not damaged and will operate as design and it may be difficult to deal with the residues if not done in close a chamber. Burning is a way that will ultimately suppress all explosive properties of the waste, it is applicable to a wide range of products and fumes can be treated. But controlling the progression of the reaction may be difficult and risky. Detonation works well with secondary explosives, the input of an additional donor charge may be necessary in some cases, and it requires heavy facilities such as closed blast chamber in addition to equipment to handle the fumes. It is also noted that rest of undetonated material might be present in the residues. Dilution/dissolution is applicable in a limited number of cases and shall not be seen as a final solution for wastes. It is more a conversion of an explosive waste into a less hazardous waste (or presenting a different hazard) often by generating larger quantities of wastes for example by dissolving a water-soluble explosive in water. As for the chemical destruction/digestion, although it can give good result (for example with nitroglycerine) its application is limited and usually require careful studies on a case by case.

Conclusions

As all industries, the explosive sector generates wastes that need to be disposed. During many years for these wastes, environmental considerations were secondary to safety. But the respect of the environment shall no more be overlooked and due care about safety must still be taken. There are unfortunately numerous examples of accidents involving explosives wastes and indeed explosive disposal is for the explosive sector one of the most hazardous of its activities. To limit the hazards associated with the explosive wastes, they shall be correctly identified and sorted from other explosive products. Their origin shall be well known, they shall be disposed promptly, or periodic verification shall be made if they must be stored for some time prior to destruction.