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A Review: Safe Disposal of Blasting Accessories

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Abstract - Environment and People must be protected from the adverse effects of any parameter or incident that are prevailing in the universe. Efforts should always be there focussing on such issues. Explosives industry manufactures a variety of Explosive substances for different applications. Basically, all these explosive substances are hazardous in nature. In addition to their hazardous properties, they cause certain effects such as noise, heat, light, post detonation products during their intended use, which can affect environment, people etc. adversely. This paper deals with a review of literature for the persons who are authorized to carry out the work related to disposal of blasting explosives and accessories.

Keywords: disposal, blasting explosives, accessories, human errors, explosive substances etc….

INTRODUCTION

Commercial blasting explosives and accessories are designed and considered to be safer during their manufacture, evaluation, storage, transport and usage; when they are handled in line with the procedures laid down by statutory, manufacturer and the user. Despite these precautions, waste materials are generated during the cycle of their production at the manufacturer to their intended consumption by the user industry.

One of the most frequent causes of accidents is human errors, storage of surplus quantity to requirement or limit allowed, disposal by destruction, over-storage resulting in poor condition.

A contributory factor is also the tendency to adopt a somewhat casual attitude towards the operation of disposal. Our efforts should be to mitigate the adverse effects associated with explosive substances at the manufacturer and user of these materials.

This paper deals with a review of literature for the persons who are authorized to carry out the work related to disposal of blasting explosives and accessories.
It supports and should be read in conjunction with all the safety rules that are in vogue.
It does not cover technical information and only provides basic data about the safe disposal of explosives and related requirements.
Various types of Detonators, Shock tube, Detonating cords, Safety fuse and some Explosive substances are covered in this paper.

DETONATORS and DELAY DETONATORS

Great care must be taken while destroying detonators for they contain very sensitive, primary explosives in them, hence are more liable to undergo detonation than any other devices. Since there are reports about detonators having survived large blasts and being scattered considerable distances, it is to be ensured that their destruction is complete.
Detonators can be destroyed by two methods i.e. Detonation and Burning.
While the burning method requires a specific armoured furnace, it suits for a small quantity of detonators, destruction by way of detonation is more preferred.

Detonation methods:
Various techniques can be adopted for destroying detonators by detonation depending on their quantity.
Method1:
Detonators can be destroyed by inserting them into a cap-sensitive explosive charge so that each detonator is completely immersed in the explosive. About ten (10) detonators may be destroyed in this way. The assembly be then primed by an appropriate detonator, then inserted into a shothole as part of a standard blast or fired separately in a shothole specially drilled for the purpose or buried in a hole at least 0.5m deep i.e. the hole should be deep enough that any effects from the explosion of the detonators are negligible at the ground surface. The holes should then be filled with damp sand such that any fragments generated by the explosion are captured. Detonator that is tied for the purpose of firing is then initiated.
Before inserting detonators that are meant for destruction into the explosive cartridges, their lead wires should be cut off. Proper tools (scissors) should be used to cut the lead wires taking all precautions against accidental initiation. No attempts should be made

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to pull the lead wires from the detonators as this can cause serious accidents or even detonations due to possible ignition of fuse head during such actions.

Method-2:

Detonators can also be destroyed in groups of six, arranged with their bases in contact with each other and surrounding a fresh detonator. It is important to restrict the number to six items because this is the maximum number that can be arranged around a detonator without leaving a gap. The arrangement should be buried in a hole that is at least 0.5m deep. The hole should then be filled with damp sand such that any fragments generated by the explosion are captured. Fresh detonator that is meant the purpose of firing is then initiated.

If destruction is carried out in the open then no more than 50 detonators should be destroyed at any one time.

Method-3:

Another method for the destruction of detonators is by bundling them in a cardboard box and then tying the box with a heavy duty detonating cord. One of the ends of the detonating cord is then primed with a fresh detonator. The assembled charge should be buried in a prepared hole, the minimum depth of which should be of the order of 0.6 m i.e. the hole should be deep enough that any effects from the explosion of the detonators are negligible at the ground surface. The hole should then be filled with damp sand such that any fragments generated by the explosion are captured. Detonator that is tied to detonating cord for the purpose of firing is then initiated.

After detonation, the area should be carefully raked and examined for debris or any unfired detonators.

Several such charges may be detonated together, but the distance between buried charges should be such that the initiation of one bundle should not disrupt its neighbours and increase the chances of a misfire.

Method-4 (under the water):

Alternatively the destruction by detonation of electric detonators can be carried out under water. Though it is a very safe method for disposal, special arrangements and procedures shall have to be made depending on the location and circumstances, and suits for destruction of a small number of detonators. However, the lead wires should be separated by cutting them with approved tool, before they are subjected for destruction.

Burning method

Another convenient method for disposing of detonators is by burning at manufacturers premises, in a properly designed and enclosed armoured furnace which will prevent the scattering of unfired detonators and contain any shrapnel effect.

Such specialist furnaces should be loaded remotely.

The burning of detonators and devices should only be carried out by a properly qualified and trained person with the authority of the Factory Manager.

Chemical method:

Though this method is little different from the conventional methods described above, it is safe to do so for small number of detonators if special precautions are taken for handling the chemicals and acids. While this is possible for Aluminium detonators, comprising capsules of primary and secondary explosives, and not suitable for copper or steel detonators.

Method: The Aluminium detonators should be put into dilute Hydrochloric acid (15%) and allowed the metal is completely dissolved. The capsules of primary and secondary explosives are left in the dilute acid and the acid is decanted into a separate container. The capsules are treated with little sodium nitrite and dilute nitric acid to destroy the primary explosive. The PETN capsules are destroyed by way of burning which is a conventionally accepted method.

Special extra ordinary precautions should be taken while handling the acids by wearing the personal protective appliances. Used acids can be recycled for one time and can be disposed by treating and neutralizing.

SHOCKTUBE DETONATORS

Shock tube detonators can also be destroyed by first cutting off the shock tube, at the crimped portion of the detonator. Thereafter, the detonator can be destroyed by the methods described above.

DETONATING CORD

Detonating cords can also be destroyed by two methods i.e. Detonation and Burning.

While the detonation method generates lot of noise, it suits for a very limited quantity only. Hence, Destruction by way of burning is more preferred.

Burning method

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Detonating cords to be disposed of by burning should be cut into short lengths (0.5 m) in order to control the risks of it burning to detonation. It may be necessary to cut detonating cord of heavier core-loads into shorter lengths. This should be determined as part of the process of development of the disposal technique.
By cutting the portions where knots are present or untying the knots will reduce the risks of detonating cord burning to detonation. Removing any crimped on end-caps or detonating-relays will also reduce the risks of detonating cord burning to detonation.

Cutting Technique: Detonating cords should be cut with a sharp and non-sparking knife, placing on a wooden anvil only, or by using approved cutters.
Ends of cut cords should be taped or capped to contain the explosive powder.
Cord should never be subjected to any form of abrasion, blow, shearing or impact from any object for the purpose of cutting for the reason that such actions can detonate the cord.
Never cut cords in magazines.
The cut cord lengths should be burned in 2.5 kilogram heaps separated by a minimum distance of 3 metres in the same way as for blasting explosives.
Note: Under no circumstances should any attempt be made to burn complete reels of detonating cord. They should be unwound and spread on the ground neatly with out any loops and kinks to avoid any type of detonation by burning.
Detonation method
This method is very convenient at user sites i.e. in the mines, by way of placing the cord alongside the charges as they are being lowered into the shothole for normal blasting.
However, this method can only be carried out if downhole initiation is being practised, by a qualified shotfirer and with the approval of the site engineer.

SAFETY FUSE

For the purpose of destruction, Safety fuse should be taken off the reel and ignited in the usual way.
The reels on which the safety fuse is supplied should be disposed of separately by burning as for other explosive waste, because reels can become heavily contaminated.

SHOCKTUBE

Shock tube can be destroyed by open burning in the same way as other explosive materials.
It must always be remembered that the shock tube contains explosive.

BLACKPOWDER / DELAY COMPOSITIONS & DELAY ELEMENTS

The best method for them is by burning. Unconfined powders are easily ignited and burn very quickly. Under certain conditions, pyrotechnic and propellant powders can burn to detonation.
Loose powders may be burned in a pit covered by a heavy duty mesh to prevent any escape of burning propellant.
Care must be taken to ensure that the loose powder does not blow about. It is therefore advisable that a calm day is chosen.

To avoid such situation, loose powder may be dampened with kerosene or other combustible oil.
Before attempting to burn Blackpowder, it must first be removed from its wrapper or container.
Care must be taken to ensure that the powder is spread in a thin layer not exceeding 2 to 5 cm, because the burning phenomenon may give rise to a "fireball" which is to be avoided.
Ignition of blackpowder fire should always be carried out by electrical means so that it can be accomplished remotely. Burning may generate an intense high frequency noise, in which case hearing protection will be required.
Dissolution in water
Black powder can easily be destroyed by treating with copious amounts of water. The wash water must, however, be treated as chemically contaminated effluent.

PETN

Chemical Method:
PETN can be decomposed by Sodium Sulphide.
This method involves addition of hot solution (80 ^{0}C) of aqueous Sodium Sulphide ($Na_2S.9H_2O$) to solution of PETN in acetone.
Rate of addition of SS solution should be such that Acetone does not boil.
Solutions be stirred for 30 minutes for completion of the reaction i.e. decomposition of PETN. Reaction products should be burned.

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PETN can also be decomposed by boiling in ferrous chloride solution.
These techniques can be applied for small quantities of manufacturing waste and also for decomposition of equipment contaminated with PETN, in crevices where PETN melt or PETN spill overs can accumulate. Though the process of decomposition is slow it is advisable to adopt this process wherever the dismantling or digging of the floors are necessary to carry out for certain maintenance works including the pipe lines.

Open Burning:

This method involves burning of PETN and its contaminants in an open area that is designated for such activity.
Procedure shall be in the same manner that is presented for blasting explosives.
The burning ground must be free from hot spots from previous activities and if required dampened with water first.

All sources of ignition in the burning area should have been identified and appropriately controlled prior to commencing any work.
While burning PETN, there can be risk of burning reaction leading to detonation hence measures be taken to minimise the risks and to protect against the effects of a detonation, if it occurs. General rule is to only burn small quantities, at any one time, while avoiding excessive transport movements.
Not more than the authorized quantity of explosive be burned in one lot, at one time
PETN must be placed as a thin layer, in one lot.
Lots thereof should be sufficiently separated to eliminate the risk of a "detonation" that can cause sympathetic detonation of its neighbours.
Each lot should be separated from its neighbour by a distance of at least 3 meters.
The lots should be connected by a "trail" of combustible materials. PETN and trail are well sprinkled with kerosene or diesel or other combustible oil, before ignition**.** "Trail" should be of a sufficient length to allow the operator to retreat to a safe place (Trail length may be 30 feet).
All personnel should be withdrawn from the burning site and in a position of safety before any attempt is made to ignite the train. Cautionary signal to be given by blowing a whistle for three times and ensured no one is there in the vicinity.
The "trail" should always be ignited against the wind to ensure controlled burning
As soon as the trail is ignited the operator must retire immediately to a safe distance from the pile position so that he is in no danger.
Once the fire has been ignited then the burning ground area should be secured and not be approached again until the fire has **COMPLETELY BURNED OUT**.
A minimum safety period should be observed (of at least two hours) after all evidence of burning has ceased before re-entering the area.
Explosives or fuels should never be added to a fire once it is lit and burning. The fire should not be approached during the visible signs of combustion, should be kept under observation until it has burnt out.
Any explosive remaining after the fire must be handled with **EXTREME** care, because the explosive may be in a more sensitive state than usual. Unburnt explosives, if any found, ensure that they are cooled and burned on a fresh bed of wood after liberal application of fuel (kerosene or diesel).

Steps must be taken to ensure that all combustion has taken place **AND THE GROUND COOLED** before a second fire is built.
Ashes from the fire should be collected and disposed of as per the environmental permits or in accordance with best practice.
Any tools used for raking a burnt out fire should be appropriate for use with both the burned residue and any unconsumed explosive. An example of such a tool would be a wooden rather than a steel rake.
Incompatible explosives must not be burned together. If there is any doubt about compatibility of explosives they must be burned separately.
Combustion products contain considerable amount of NO_X fumes.

Incineration technique:

This method is reported in the literature but not in use in our country.

TNT

Chemical Method:

TNT can also be decomposed by Sodium Sulphide.
This method involves addition of TNT to a hot solution (80 ^{0}C) of aqueous Sodium Sulphide ($Na_2S.9H_2O$).

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For one part of TNT, thirty times by weight of SS solution is used.
Solutions be stirred for 30 minutes for completion of the reaction i.e. decomposition of TNT. Reaction products should be burned.
This technique can be applied for small quantities of manufacturing waste and also for decomposition of equipment contaminated with PETN.

Open Burning:

This method involves burning of waste TNT and its contaminants in an open area that is designated for such activity.
Procedure shall be in the same manner that is presented for PETN. Combustion products contain considerable amount of NO_X fumes.

Incineration technique:

This method is reported in the literature but not in use in our country.

CAST BOOSTERS (PETN / TNT)

Chemical Method:

PETN / TNT based cast boosters can also be decomposed by Sodium Sulphide method presented above.

This technique can be applied for small quantities of manufacturing waste and also for decomposition of equipment contaminated with PETN.

Open Burning:

This method involves burning of and its contaminants in an open area that is designated for such activity.
Procedure shall be in the same manner that is presented for PETN. Combustion products contain considerable amount of NO_X fumes.

Incineration technique:

This method is reported in the literature but not in use in our country.
It involves an injection type incinerator equipped with an after burner and scrubber containing caustic soda solution.

RDX (CYCLONITE, HEXOGEN)

RDX be added in small proportions to a 5% solution of sodium hydroxide that is brought to boiling point by injecting steam. After the addition of total quantity of RDX, boiling should be continued and then discharged into a sump.

Open Burning:

This method involves burning of RDX and its contaminants in an open area that is designated for such activity.
Procedure shall be in the same manner that is presented for PETN. Combustion products contain considerable amount of NO_X fumes.

Incineration technique:

This method is reported in the literature but not in use in our country.

HMX (OCTOGEN)

HMX is reactive with alkali. HMX can be decomposed completely with a solution of 1% sodium carbonate at prolonged boiling.

Open Burning:

This method involves burning of HMX and its contaminants in an open area that is designated for such activity.
Procedure shall be in the same manner that is presented for PETN. Combustion products contain considerable amount of NO_X fumes.

Incineration technique:

This method is reported in the literature but not in use in our country.

STYPHNIC ACID

Open Burning method:

Can be burnt by the method described for PETN.

Chemical Method:

Small quantities not exceeding 500 gm shall be taken for destruction in this method.
Acid mixture consisting of 15% H_2SO_4 + 25% HNO_3 to be added in excess to the styphnic acid and care should be taken that the complete styphnic acid is submerged into the acid media. At least 10 parts of the acid mixture shall be added to one part of the styphnic acid.

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Add 300 -500 gm of Iron filings which readily reacts with acid producing Hydrogen gas. Personnel who carry out this job should move away from the site after addition of Iron filings till the destruction process is complete, not to inhale the H_2 fumes. Necessary protective wear shall be worn. H_2 reduces the nitro groups to amino groups.
The supernatant liquid shall be taken into another container, added with hydrated lime slurry till the precipitate become green (pH shall be maintained @ 10 - 11). A glass funnel to be fixed with filter paper no 42 along with some cotton, sand (over the cotton). The sludge shall be filtered through glass funnel and the filtrate should be a clear water. If the water is brown the indication is that the explosive is not destroyed. Some more iron filings to be added to complete the destruction. After the destruction is complete, the solution to be added with sufficient quantity of lime slurry for complete neutralization (as above). The slurry can be filtered through the sand beds and the filtrate can be used for on land irrigation purpose.

NITROCELLULOSE (NC)

Chemical Method:
Small quantities of NC can be decomposed by adding it, slowly and gradually, under stirring, to five times its weight of 10% solution of sodium hydroxide and heating to 70 ^{0}C. Stirring may be continued for ~15 minutes. Cellulose that results be handled by sewage treatment plant.
Burning Method:
NC and its waste be carried to burning pit by placing it in fibreboard or metal drums or cans lined with heavy-gauge, leak-proof liner and covered with water.
At the burning ground, it should be placed on a non-combustible material such as asbestos, water is allowed to drain off.
Procedure shall be in the same manner that is presented for PETN. Combustion products contain considerable amount of NO_X fumes.
Incineration technique:
This method is reported in the literature but not in use in our country.

It involves an induced draft type incinerator equipped with an after burner and scrubber.

LEAD AZIDE (LA)

Lead azide is a primary explosive, extremely sensitive to heat, friction, impact or electric discharge. In view of this, LA and its contaminants should be handled only by experienced personnel.

Lead azide corrodes Copper or Zinc in the presence moisture. With copper, it forms copper azide that is extremely sensitive and dangerous to handle. In view of this, LA is not kept in direct contact with copper or its alloys.

With a view to minimize hazards, LA should be handled as a slurry in water.

Chemical Methods:

Treatment with Nitrite

LA is wetted with 500 times its weight of water. A 25% aqueous solution of sodium nitrite is prepared.

For one part by weight of LA, twelve parts by weight of sodium nitrite solution (25%) is added, stirred and added with 14 parts by weight of 36% nitric acid or glacial acetic acid. After stirring the mixture for ~10 minutes, azide is decomposed. This can be checked by taking an aliquot of reaction mixture and testing with ferric chloride solution, no red colour should form. Red colour indicates presence of azide.

After completion of the reaction, pH of the reaction mixture be adjusted to 6.0 to 9.0 and is diluted to a nitrite / nitrate concentration of less than 45 ppm. Lead gets precipitated in the solution after adjusting pH as said above and should be recovered. NO_X fumes that are liberated during the reaction be removed by scrubbing or destroyed by controlled incineration.

Treatment with Ceric Ammonium Nitrate

LA can also be decomposed by oxidizing the azide moiety to Nitrogen with precipitation of Lead as sulphate.

It involves, use of expensive Ceric salt.

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Electrolytic Method

In this process, LA is converted to metallic Lead and Nitrogen.

LA is made into solution by treatment with sodium hydroxide. For one part by weight of LA, 5 times by weight of 10% sodium hydroxide solution is added and mixed uniformly.

The solution is placed in an electrolytic cell with a lead cathode and stainless steel anode.

In the literature, it is recommended as a satisfactory method and is not in use in our country.

Detonation method

It is reported in literature that Lead azide to be wetted, bagged and transported to the destruction site. All the bags are placed behind a barricade with an over-head protection, which is located at a very safe distance from the firing area.

A bag is carried to the destruction area and Detonator is placed in contact with the bag.

Detonator is initiated from the location of safer distance.

It is reported that the LA would explode even under water.

LEAD STYPHNATE (LS)

Lead styphnate too is a primary explosive, more sensitive than Lead Azide with respect to impact and electric discharge. In view of this, LS and its contaminants should be handled only by experienced personnel.

With a view to minimize hazards, LS also should be handled as a slurry in water.

Chemical Methods:

Treatment with Sodium hydroxide and Aluminium

Lead styphnate is reacted with sodium hydroxide, sodium carbonate and aluminium applying steam as heating source. Reaction products are sodium aluminate, lead carbonate and di sodium salt of amino resorcinol that are non-explosive in nature. As per literature, this is an effective method for the desensitization of styphnate moiety, requiring secondary treatment to destroy amino resorcinol and precipitation of Aluminium.

Detonation method

It is reported in literature that Lead styphnate to be wetted, bagged and transported to the destruction site. All the bags are placed behind a barricade with an over-head protection, which is located at a very safe distance from the firing area.

A bag is carried to the destruction area and Detonator is placed in contact with the bag.

Detonator is initiated from the location of safer distance.

Controlled combustion by Incineration technique:
This method is reported as a promising technique in the literature but not in use in our country.
It involves a rotary kiln incinerator equipped with appropriate scrubbing system

CONTAMINATED WASTE AND PACKING MATERIALS

Packing materials, linings any other material which has been in contact with or has become impregnated with explosives can be conveniently disposed of by using it as combustible base for the fires.
Cotton waste and cleaning material that has been contaminated with explosive during manufacturing operations is best disposed of by using it as combustible base for factory burnings.
Solvents that have been used during the manufacturing process or in clean-up are most conveniently disposed of by soaking on cotton waste or wood meal and burning either separately or as part of a factory burning.
Note: On no account should contaminated solvent be used to fuel the igniting trail.

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