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BUILDINGS AND EQUIPMENT CONTAMINATED WITH EXPLOSIVES

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DOD is closing more bases and releasing more property than at any time since after World War 2. Some of this property contains buildings and equipment used for munitions manufacturing, maintenance, or demilitarization. These buildings, and any equipment remaining in them, may harbor residual explosives.

Such buildings and equipment can present explosion hazards if subjected to operations such as cutting, drilling, sawing, welding, or demolition. These buildings and equipment must be inspected to determine if explosion hazards exist. If found, hazards must be eliminated before the buildings are released or demolished.

This paper will address these questions:

What causes explosives residues to become deposited?

Where should you look for explosives residues?

How do you detect explosives residues?

How do you remove explosives residues?

What causes explosives residues to become deposited? There are several mechanisms.

<u>Explosives dusts</u> can be generated in operations involving high speed automated handling of explosives. One example of such an operation is the high speed automated pressing of explosives into munitions casings. Hundreds of millions of detonators, small projectiles, and submunitions have been press loaded. These operations generate explosives dusts. A second example is high speed automated loading of propelling charges. Loading artillery charge bags or large cartridge cases involves moving a lot of propellant. A third such operation is machining or drilling explosives. For example, cast rocket motor grains are outside turned on a lathe to give them the exact diameter needed to fit into the rocket motor body.

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Once airborne, explosives dusts can easily settle in out of the way, inaccessible places. Although routine equipment washdowns take care of dust in obvious places, these less obvious places are sometimes overlooked.

In general, explosives dusts are much more sensitive to initiation than solid explosive material. Very low levels of energy from friction, flame, or static discharge are often enough to set off a dust layer.

Explosives vapors are generated by some operations. The two best examples are melt pour and washout.

Melt-pour refers to the cast loading of projectile and bomb bodies using molten explosive. For melt pour, the explosives TNT, or TNT mixed with RDX, ammonium nitrate, or aluminum powder, are usually used. Because large quantities of molten explosive are exposed to the air during melt-pour, some explosive becomes airborne vapor. These vapors, like dusts, can travel to out-of-the way or inaccessible places and evade routine equipment washdowns. The vapors can condense on any available surface, forming crystalline deposits of explosives on equipment, walls, floors, ceilings, or any other part of the building interior.

Washout refers to a process by which hot water is used to wash out the explosives from projectile and bomb bodies. Most of the explosives are then removed from the washwater and recycled. Washout operations also generate explosives vapors, but not as much as melt pour.

Equipment washdowns are yet another way explosives become deposited inside and outside buildings. Explosives-contaminated production equipment is washed down periodically, and the explosives-bearing washwater simply spills onto the floor in many cases. From there, it goes down a drain to a sump. In some cases, it continues on to a settling lagoon. [1] Therefore, drains, sumps, pipes, and lagoons all become explosives laden. If there are cracks in the floor near the equipment, explosives washwater leaks into the cracks. This deposits explosives in the cracks and also possibly beneath them. Explosive “nuggets” of considerable size have been found under cracks beneath the foundations slabs of some facilities.

Spills can produce gross amounts of explosives in a hurry, but are normally cleaned up quickly. However, cleanups often involve washwater, which was discussed above.

Unauthorized disposal: At one time, it was fairly common practice to throw small quantities of unwanted explosives out the doors of the munitions facility. Minor spills were often disposed of in this way. Although the concentrations of explosives in the soil outside building entrances is normally well below the explosive level, such areas deserve a check from an environmental protection standpoint.

Where should you look for explosives contamination? The first thing you need to do is classify the operation(s) that occurred in the building as “clean” or “dirty”.

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[1] In a few cases, the washwater is disposed into storm drains. Of course, these are past practices no longer permitted at operating DOD munitions factories today.

“Clean” ammunition operations produce no explosives dusts, vapors, or liquid migration. Explosives may be present, but are either totally contained - or because of the explosive’s physical makeup or because of the nature of operations conducted in the bay, the explosives did not produce any appreciable dusts, vapors, or liquid migration.

To illustrate what we mean by “clean” operations, here are two examples. The first is assembly or disassembly of complete rounds of ammunition wherein the propelling charge is manually inserted or removed. Although the propelling charges are exposed during these operations, the charges are not being subjected to rapid movement in mass quantities. The generation of explosives dusts which could migrate behind walls and into other hidden areas and porous surfaces is not a credible event.

A second example of a clean operation is surveillance inspection of mortar rounds. Although the mortar rounds have exposed propelling charges, the charges are not being subjected to rapid movement in mass quantities. The generation of explosives dusts which could migrate into hidden surfaces is not a credible event.

“Dirty” ammunition operations, on the other hand, involve generation of explosives dusts, vapors, or migration of liquids containing explosives. Dirty operations usually involve energetic mixing, rapid movement of exposed explosives, vaporizing of molten explosives, or the presence of large quantities of easily dispersed explosives.

Many operations in munitions factories are considered “dirty”. As discussed, a few examples include automated high speed explosives pressing, automated propellant loading, and cast loading. In contrast to munitions factories, most operations at ammunition depots are considered “clean”. However, some operations are also “dirty”, such as ammunition washout and vacuum collection of propellent (in this example, only the vacuum system gets “dirty”).

Now, back to our question - where should you look for explosives contamination?

For clean operations, you need only to visually inspect readily accessible surfaces. About the only explosives you’d expect to find are small amounts that may have been dropped. Such explosives are normally removed in routing cleaning operations. Typical buildings used for “clean” operations are packaging and shipping buildings, inspection buildings, and storage magazines.

For dirty operations, your inspection must be much more thorough. Here are some typical “hiding places” that can harbor explosives residues:

Behind wall panels. Ideally, the operation took place in a concrete walled bay. But if wall panels exist, they should be removed to allow inspection behind them.

In cracks or recesses in buildings and equipment.

Embedded in porous surfaces. A classic example of this is the wood framing members of certain old propellant manufacturing plants. In these plants, nitric acid is mixed in vats with cellulose to produce nitrocellulose. Some of the nitric acid fumes during this operation. Some of the fumes come into contact with the wood framing. This nitrates the cellulose in the wooden framing. The result is framing partially converted to low grade propellant!

Inside process piping. For example, a plant used to manufacture high explosives may still have installed piping which was used to transport explosive or reactive compounds. Another example is pipes used for explosives bearing-waste water.

Inside process equipment. Usually, most of the equipment, such as mixers, blenders, presses, etc., will have already been removed. If not, it is all suspect - inside and out.

Inside open-nozzle, dry-pipe sprinkler systems. If a sprinkler line ends in a dirty area, and the nozzle is open (i.e., no blow out baffle), then the pipe could be filled with explosives. This actually happened at one production plant. The sprinkler pipe was so choked with explosive that it could carry only a fraction of the amount of water it was supposed to carry.

Inside explosive dust collection ductwork. Explosives dust collection systems are quite common at munitions plants. Some systems are portable, so they are shipped off elsewhere for storage or reuse after the installation closes. Other systems use installed ductwork and collection boxes, and these are the ones to watch out for.

In drain pipes, floor drains, sumps, sewer lines, lagoons, and piping leading to lagoons. As discussed, washwater and wastewater disposal can leave explosives in these areas. Obviously, it is difficult to look inside a pipe or floor drain for explosives. Unless one has detailed knowledge of which pipes were used to carry explosives mixtures and which weren't, the safest bet is to assume all pipes, floor drains, and sumps are potentially contaminated. Explosives in these areas can be dangerous. For example, a sump blew up at an Army Ammunition Plant several years ago. The explosive sediment in the sump dried up because the production line it supported was inactivated. In this case, the explosives were highly sensitive priming compositions. Although relatively safe when wet, priming compositions are quite easily initiated when dry. What actually initiated the compositions in the sump remains a mystery.

Under concrete slabs. An 80 lb nugget of TNT was found beneath the concrete slab of a washout plant. The nugget was created when TNT-bearing washwater leaked through a crack in the concrete floor. Over the years, repeated equipment washdowns had deposited so much TNT down the crack that a large nugget had formed beneath it. To inspect beneath a crack, several approaches are possible. One is to carefully drill through the slab adjacent to the crack to sample the soil beneath the crack. Such drilling should be done remotely, using a slow drill speed and plenty of coolant to avoid an explosion. Another method is to use explosive shaped charges to open the crack. These charges must be detonated from a safe distance, since the charge can detonate any TNT lying beneath the slab.

How do you detect explosives contamination? The three methods, in order of preference, are visual inspection, color reagents/field test kits, and lab analysis.

<u>Visual inspection.</u> With the lone exception of nitroglycerin, explosives residues that pose explosion hazards are visible to the naked eye. Therefore, if you can visually inspect all surfaces where explosives may have migrated and you find nothing, you can safely assume the building is safe to release with no restrictions and no treatment required for explosives safety purposes. On the other hand, if foreign material is identified, you either visually identify it as an explosive if you have the expertise, or you use a field test kit to identify it.

<u>Color reagents and field test kits.</u> Color reagents can be prepared by a lab for your use. To obtain recipes that labs can use to prepare different reagents for different types of explosives, contact the author of this paper. Color reagents are cheap and will detect explosives below the levels at which they present explosion hazards. Field test kits are basically more sophisticated versions of color reagents, although some test kits use immunoassay instead of color reagents. Most kits will tell you the concentration of explosives. This can be useful information. For example, if explosive is mixed with sediment in a sump, not all concentrations are explosive. As a general rule, explosives constituting 10 percent of more by weight of a mix cause the mix itself to be an explosive. The 10 percent rule only applies to secondary explosives; it does not apply to primary explosives. For further information on field test kits and threshold concentrations, contact Mr. Wayne Sisk, Army Environmental Center, 410-612-6851, or the author.

<u>Laboratory analysis of samples.</u> This method isn't normally needed to determine if you have a substance presenting explosion hazards. Lab analysis is very sensitive and accurate in that it can detect in the parts per billion range with repeatable results. Lab analysis is usually only needed if environmental regulators are concerned about trace residuals which don't pose an explosion hazard but pose an unknown hazard to human health or the environment. Lab analysis is done using SW 846 Method 8330.

How do you remove explosives residuals? There are many methods, and each has its own limitations.

<u>Burn in place.</u> The traditional approach is to burn the entire building and its equipment in place. The building is stoked with wood and burned. This method is simple, effective, and still in use. However, if the building contains asbestos or lead-based paint, regulators may require that these substances be removed before burning. This can greatly increase costs. A open burning permit may also be required by some states. These can be difficult to obtain.

<u>Open flash flaming of process equipment.</u> Several recent projects to treat buildings and equipment have involved the physical removal of the equipment from the building and subsequent open flash flaming in a separate area. Again, flame treatment is most effective compared to other methods. A "certipak" has been developed to verify that the flash flaming effectively removes the explosives from the equipment. A certipak contains a porous ceramic bead. The bead is impregnated with explosive. The bead is then wrapped in a stainless steel envelope, and the envelope is tethered by a wire. The certipaks are placed throughout the stack of equipment to be

flashed. After flashing, the tethers are used to retrieve the certipaks, and the ceramic cores are tested for explosives. Further information on certipaks is available from Michael Nelson, P.E., U.S. Army Corps of Engineers, Seattle District, (206) 764-3458 or Wendy Oresik, P.E., Woodward-Clyde Federal Services, (206) 343-7933. One precaution: there are hazards involved in disassembling explosives-laden equipment. For example, disassembly of threaded junctures involves friction, so penetrating oil is used to reduce the sensitivity of explosives that may be in the threads. Cutting via torch is prohibited. Mechanical cutting or drilling is permitted if done on a component known to be clean. If mechanical cutting or drilling is desired for a suspected dirty component, then the cutting should be done as slowly as possible, using coolant. The cutting operation should be performed remotely. Pipes and equipment can also be remotely cut using explosive shaped charges.

Incineration. As an alternative to open flash flaming, incineration (such as in a rotary kiln furnace) can be used if the feedstock is small enough. For example, TNT-contaminated wooden pipeline at a site in Missouri is being shredded, then fed into an incinerator. Prior to shredding, the pipe is thoroughly wetted to reduce the sensitivity of the TNT. The shredding operation is done remotely.

Hot gas decontamination. This is a method of thermal treatment using lower temperatures than flash flaming or incineration. Hot air is circulated through the equipment containing the explosives. The air temperature is high enough to volatilize or decompose the explosives, but low enough so as not to alter the mechanical properties of the metal being treated. Hot gas decontamination is most applicable to active munitions plants, where equipment must be decontaminated for maintenence and then put back into service. However, the process has been used experimentally to remove residual toxic chemical agent from an agent production plant building. For more information, contact the Army Environmental Center, 410-671-2466.

Chemical neutralization. Various chemicals can neutralize explosives (eliminate their explosive properties). Both AMCP 706 -177 and TM 9-1300-214 contain guidance on this.

Steam cleaning, hot water washing, flushing, etc. These methods are very effective in removing almost all explosives from visible, accessible surfaces. Any trace amounts remaining on visible accessible surfaces do not pose an explosion hazard. Regarding piping: no amount of flushing can positively remove explosives from pipes such that the pipes no longer present explosion hazards. Flushing of pipes is therefore usually a pretreatment to reduce risks in pipe disassembly to allow flash flaming.

Explosive charges. This is a treatment applicable to concrete slabs with cracks suspected of harboring explosives from daily washdowns. Shaped charges are placed over the cracks to explosively open them. Personnel, of course, are located a safe distance away. If explosive is present in the crack or beneath it, the charges will usually detonate them. If they do not detonate, they will be exposed and another charge can be placed on them. Shaped charges can also be used to remotely section piping and equipment. This was done on piping leading from a washout plant to a settling lagoon at an Army Ammunition Depot.

This paper has hopefully given you an overview of approaches to explosives residues in buildings and equipment. Each project has its unique conditions, and the safety of workers and the public is paramount.

Obviously, to address explosives residues in a building, you must know the building's history you must know and understand what types of munitions operations occurred. Only then can you can draw up an inspection plan, do the inspection, remove explosives as needed, and document the process. If the building will be released from DOD control, the documentation should be part of the title transfer papers, along with any precautions or restrictions on use of the building.