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Life Cycle Demilitarization Considerations for IM Development

Gary Mescavage,
Chief Engineer (Acting),
Product Manager for Demilitarization

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Demilitarization in the Life Cycle

Demilitarization is the end stage of the life cycle of military materiel. Acquisition policy states that "at the end of its useful life, a system will be demilitarized and disposed of …." (DoD Instruction 5000.02 5.d.(14)(b)2, 7 Jan 2015) This requirement includes "conventional ammunition." "Conventional ammunition" is defined in DoDD 5160.65 as: "An end item, complete round, or materiel component charged with explosives, propellants, pyrotechnics, or initiating composition for use in connection with defense or offense (including demolitions) as well as ammunition used for training, ceremonial, or non-operational purposes. This includes inert devices that replicate live ammunition, commonly referred to as dummy ammunition, which contain no explosive materials." Examples of conventional ammunition are identified in DoDD 5160.65 and shown in Table 1 below. Tactical missiles (not strategic missiles) are included and sometimes classified separately from other conventional ammunition. Conventional ammunition does not include nuclear, chemical, or biological munitions.

• Small arms, mortar, automatic cannon, artillery, and ship gun ammunition. • Bombs (cluster, fuel air explosive, general purpose, and incendiary) • Unguided rockets, projectiles, and submunitions • Chemical ammunition filled incendiary, riot control, smoke, burster igniters, peptizers and thickeners for flame fuel (but not chemical agent) • Land mines (ground-to-ground and air-to-ground delivered)	• Demolition materiel • Grenades • Flares and pyrotechnics • Guided projectiles, rockets, missiles, and submunitions • Naval mines, torpedoes, and depth charges • Cartridge and propellant-actuated devices • Chaff and chaff Dispensers • Guidance kits for bombs and other ammunition • Swimmer weapons

Table 1. Examples of Conventional Ammunition

Both "demilitarization" and "disposal" are accomplished as part of the final stage of the life cycle as required in DoD Instruction 5000.02. These terms are defined in the Defense Materiel Disposition Manual (DoD 4160.21-M, Aug 1997) as follows.

- Demilitarization – The act of ***destroying the military offensive or defensive advantages*** … ***to prevent the further use*** of this equipment and material for its originally intended military or lethal purpose …"
- Disposal – The process of reutilizing, transferring, donating, selling, destroying, or other ***ultimate disposition*** of personal property.

Conventional ammunition is designated for demilitarization by each Service when it is determine to be obsolete, unserviceable, or excess or is unsafe for continue storage.

Aside from being a requirement, demilitarization is significant from a number of life cycle perspectives. Demilitarization, or "demil" for short, is recognized as a notable portion of overall life cycle cost, generically estimated at 10%, though this value differs with munition type. In addition, there are significant safety and environmental liabilities associated with demil and disposal since Government employees interact with live munitions during demil operations and waste streams are generated that potentially have negative environmental impacts. Finally, demil is important from a readiness perspective. Since demil stocks are co-mingled with go to war stocks, the elimination of the no longer needed ammunition frees storage space for current ammunition storage and streamlines outload of ammunition to the warfighter.

Demil Stockpile, Mission, and Methods

The "demil stockpile" of ammunition identified as obsolete, unserviceable or excess is significant, comprising about one third of covered storage space at depots. It is large and varied, totaling approximately 414,000 short tons (as of Feb 2018) and consisting of over 7,000 unique Department of Defense Identification Codes (DODICs). This ammunition represents a liability of approximately $1.15B using current average demil costs. And new munitions are continually being added as Services identify additional ammunition that is no longer needed.

The mission for performing demilitarization of conventional ammunition and managing the demil stockpile falls to the Product Director for Demilitarization, located at Picatinny Arsenal, NJ. Under the Single Manager for Conventional Ammunition (SMCA), certain logistics responsibilities have been consolidated within the Army and under the Program Executive Officer for Ammunition as the SMCA Executor. PEO Ammo has delegated the responsibility for demilitarization in particular down through the Project Director for Joint Services to PD Demil. PD Demil is supported by a variety of organizations, principally those identified below, that perform different aspects of the demil mission.

- Joint Munitions Command, Rock Island Arsenal, IL (conventional ammunition stockpile management and execution)
- Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ (conventional ammunition research and development)
- Aviation and Missile Command, Redstone Arsenal, AL (missile execution)
- Aviation and Missile Research, Development and Engineering Center, Picatinny Arsenal, NJ (missile research and development)

Approximately half of demil (by cost) is accomplished at a number Army depots, identified below.

- McAlester Army Depot, McAlester (MCAAP), OK
- Crane Army Ammunition Activity (CAAA), Crane, IN

- Hawthorne Army Depot (HWAD), Hawthorne, NV
- Tooele Army Depot (TEAD), Tooele, UT
- Blue Grass Army Depot (BGAD), Richmond, KY
- Letterkenny Munitions Center (LEMC), Chambersburg, PA
- Anniston Munitions Center (ANMC), Anniston, AL

The other half of demil is accomplished by a variety of commercial firms under Government contract.

Historically, munitions were demilitarized by being open burned or open detonated (OB/OD). This involved detonating munitions using “donor charges” or burning munitions on burn pans in open air. This method is still used today for a considerable number of munitions and is an environmentally permitted process. However, its use is not allowed for some munitions that present specific environmental concerns and in general its use has declined in favor of “closed disposal” process that contain and treat all by-products of the process before release. Due to the variety of different types of conventional ammunition, a suite of different closed disposal demil capabilities are required to perform demilitarization on the stockpile. These can generically be divided into disassembly, explosives removal, and thermal treatment process. Some examples of existing closed disposal demil processes located at Government depots are shown in Table 2 below. These capabilities are augmented through contracts with commercial entities, who also use a suite of different processes. Approximately one fourth of the demil stockpile (by weight) is demilitarized through commercial contracts. Demil capabilities are tailored to a munitions type and fill and can be complex and costly involving multiple thermal, chemical, and/or mechanical process steps including manual and automated operations.

	ANMC	BGAD	CAAA	HWAD	LEMC	MCAAP	TEAD
Incineration APE 1236 Rotary Kiln Incinerator or Equivalent			X	X		X	X
Autoclave (APE 1401) or Equivalent				X		X	
High Pressure Water Washout		X		X			
Steam Out				X			
Base Hydrolysis CADS/PADS							X
Hot Water Wash Out		X					
White Phosphorous Recovery			X				
Navy Gun Explosive D Conversion to Picric Acid			X				
MLRS Demil	X						
D563 155mm DPICM Demil			X	X		X	
Hot Gas Decon				X			

Table 2. Closed Disposal Demil Capabilities

Insensitive Munitions Challenges

Munitions with larger energetic fills such as mortars, 105/155MM projectiles, and bombs are typically demilitarized by removing the explosive fill. This removal can be accomplished in a number of ways including autoclave (applying steam heat to the outside of a projectile), water wash out (high pressure or hot water), and sectioning. Autoclave is preferred where possible as it does not contaminate the explosive with water and allows it to be reconstituted and reused.

Removal and reuse of explosives is performed when possible as it provides valuable economic return to the Government. In some cases, significant quantities of explosives have been recovered and reused in new production, resulting in significant cost avoidance to the production program. In other cases, recovered material is used as donor charges in OD operations again resulting in cost avoidance by providing “free” donor material precluding the need to procure donor explosives.

The traditional method of explosives removal relies on the melt properties of the energetic material to allow re-melting and removal. Steam is applied to the outer shell of projectiles with the explosive melting into a system that captures, cools, flakes and boxes the material. However, cast-cured insensitive munitions (IM) fills in particular cannot be remelted. Since the existing demil infrastructure for larger munitions is based on remelting energetic material, it cannot be used in the demil of cast-cured IM munitions with larger energetic fills. This presents a number of cost impacts. First, the cost avoidance value of the recovered explosive is lost and is replaced with an additional cost burden of needing to process the energetic material for its destruction. This represents on ongoing issue associated with demil operations. In addition, new infrastructure will be needed to establish facilities to perform the demilitarization of the cast-cured fills. These facilities involve industrial type processes and the cost to construct and commission them is significant. This represents a one-time capital investment requirement for each new facility. As another consideration, in cases were munitions could historically have been demilitarized by OD, they will now need more expensive closed disposal processes. OD is typically a lower cost demil method. In general, IM filled munitions cannot be OD due to their insensitive nature and large amount of donor required to initiate the munition. Where munitions can be detonated an incomplete destruction of the munitions typically occurs leaving residual large pieces of explosive. All of these factors will increase the life cycle cost for cast-cured IM filled munitions.

In addition to cost issues, environmental and occupational health impacts are also a consideration due to some of the materials that comprise the IM fills. One example is ammonium perchlorate (AP), which is widely used in IM fills. Early investigations of methods to demil cast-cured IM fills indicate that high pressure water wash out is one method to remove the material. However, the AP enters the waste water and is sent to the depot’s water treatment system, which are not currently equipped to handle AP contamination. This will require upgrades to water treatment facilities. As another example, 2,4-Dinitroanisole (DNAN) presents toxicology concerns for humans and will require special handling during the demil process to protect workers.

One specific example of IM challenges is in the demil of the M795 155MM projectile. This round is filled with IMX-101, which actually is melt cast and can be remelted during demil. However, the melt dynamics are different than traditional explosives and required some adjustments to the autoclave process to achieve an acceptable melt out rate. This improvement was made on a pilot scale autoclave and the same modification will be required across the existing production systems. Another example is the XM1112 projectile, also filled with IMX-101. Demil of this round was also tested in a pilot autoclave facility. A tar layer in the projectile melted along with the energetic material causing significant contamination and clogging of the process lines. This contamination is a safety hazard and the equipment had to be disassembled and thorough cleaned. Consequentially, these rounds cannot be processed using existing autoclaves.

Another specific example of IM challenges is the BLU-109C/B round filed with AFX-757. These bombs are in production and while demil of stockpiled ammunition has not been attempted, there has been a need to remove explosives from production rejects, which provides good

indication of future demil operations. After applying heat to the shell body, a slug of explosive is removed that is then sectioned and open burned. This procedure might inform an eventual demil method, though in the future OB is not expected to be acceptable. Currently, no closed disposal demil facility exists for this munition.

Design Considerations

Systems engineering is the DoD's approach to munitions development and involves incorporation of all life cycle considerations into the up-front design process. Demil is clearly a life cycle consideration that warrants inclusion. While not necessarily a design driver, proper inclusion in the systems engineering process will ensure low cost options for mitigating risk and cost during demil are not overlooked.

As a general principal, energetics present the greatest challenge during demil operations. And facilitating the removal of energetics through design features should significantly improve demil operations. This involves the ability to readily disassemble and access energetics or otherwise enabling their removal and segregation. Factoring this need into the design process can result in munitions that can be more easily and economically demilitarized. In addition to removal, reuse is an important consideration. To the degree explosive fills can be formulated to allow reuse, value will be added to the life cycle rather than increasing the life cycle cost burden. Environmental and occupational exposure impacts should also be considered to minimize risk and streamline the demil process. Finally, innovative approaches can be used to facilitate end of life cycle demil operations. One example is early research currently being considered in the area of "depolymerizable thermosets." This involves a cast-curable polymer that can be "liquitized" on demand for removal. While in the early research phase, it represents the type of innovative thinking that could ensure compliance with IM requirements while at the same time significantly facilitating demil operations and minimizing overall life cycle cost and risk.

Inclusion of demil during up front design, or "Design for Demil," is an initiative that is supported by the Office of the Undersecretary of Defense. A Design for Demil handbook has been developed and is available from the Office of the Product Manager for Demilitarization at Picatinny Arsenal, NJ.

Conclusion

Demilitarization is a life cycle function that is an acquisition requirement and is important to sustaining warfighter readiness by improving stockpile management. The demil stockpile is significant and represents a very large cost, safety, and environmental liability to the DoD that is largely created and defined during the up-front munitions design process. In particular, cast-cured IM fills present unique challenges in that they cannot be demilitarized using existing infrastructure and result in lost value due to the inability to reuse the energetic material. Efforts at incorporating demil considerations into the systems engineering of conventional ammunition, and IM munitions in particular, early in the life cycle will yield real life cycle benefits. These benefits can be accomplished with design features that facilitate explosives removal and reuse. In addition, innovative thinking at the early research level has the potential to ensure IM requirements are met while greatly simplifying demilitarization operations resulting in significant life cycle benefit.