

**REPORT**

**DEVELOPMENT OF A PAX-21 LOADING  
PROCESS FOR THE 60MM M720E1 HE MORTAR PROJECTILE**

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## INTRODUCTION

The Program Manager for Mortars (PM Mortars) has initiated efforts to develop high explosive (HE) mortar cartridges having Insensitive Munition (IM) characteristics. PAX-21 is a new melt pour IM explosive recently developed through a joint effort between the US Army Armament Research, Development and Engineering Center (ARDEC) and Thiokol Propulsion to replace Composition B, the current HE fill for mortar cartridges. A process development program was conducted in Building 810, TACOM-ARDEC, Picatinny Arsenal, NJ to establish a melt pour process for loading 60mm M720E1 HE mortar projectiles with PAX-21. Experiments were conducted and an initial melt pour loading process developed to provide loaded projectiles for Type Classification (TC) testing, IM testing and process information to support future production development efforts. A total of 923 each 60mm mortar projectiles were loaded in a series of 20 experimental runs. The results from radiograph x-ray inspection of the 923 mortar projectiles demonstrated that acceptable explosive casts can be produced using the initial melt pour process parameters. It can be suggested that based on the results of this initial effort to load PAX-21 and with additional development, a high probability of an efficient, cost effective and safe production PAX-21 melt pour loading process can be achieved. The 60mm M720E1 is scheduled to go into full production in FY01. Plans to scale-up from the pilot plant facility will be presented, which will include prove-out of the melt pour and the controlled cooling processes.

## BACKGROUND

The 60mm M720E1 HE mortar cartridge (figure 1) was developed by PM Mortars in an effort to field an HE mortar cartridge that meets IM requirements. To accomplish this, the M720E1 was designed to incorporate a new plastic fuze adapter, an improved M734A1 Multi-Option Fuze with a new booster explosive (PBXN-5), a new melt-cast explosive fill with reduced shock sensitivity and an HF1 steel projectile body to maintain the effectiveness/lethality. Recent IM and performance testing has shown that the combination of these design features have proven to be effective and that the potential to meet IM requirements for the 60mm M720E1 HE mortar cartridges is high. The purpose of this paper is to discuss the melt cast loading process used to load PAX-21 into 60mm HE mortar projectiles.

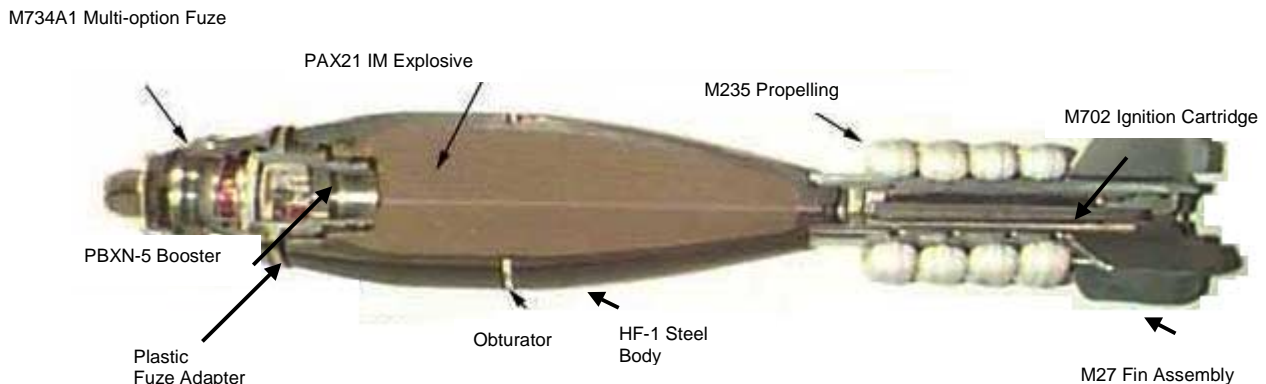


Figure 1 - 60mm M720E1 HE Mortar Projectile

In order to TC the M720E1, PM Mortars required approximately 900 projectiles loaded with PAX-21 to conduct IM, Production Qualification Testing (PQT) and Final Hazards Classification (FHC) tests. To accomplish this, Thiokol Propulsion, located in Brigham City, UT, was contracted to manufacture 2,000 pounds of PAX-21. The 2,000 pounds of PAX-21 was shipped to ARDEC, Picatinny Arsenal, NJ for development of a melt cast loading process at the explosive loading pilot facility located in Bldg. 810. In addition, a minimum of 900 loaded and x-ray acceptable projectiles were to be provided to support TC testing. PAX-21 is a new melt pour IM explosive manufactured from the following materials:

- RDX
- 2,4 Dinitroanisole
- Ammonium perchlorate
- n-methyl nitroaniline

PAX-21 performance is comparable to Composition B, but provides higher thermal stability, lower shock sensitivity and reduced shrinkage. Since PAX-21 is a melt cast explosive with a melting point of approximately 188 degrees Fahrenheit, it was decided to utilize a loading process and equipment similar to the process already established for Composition B loaded projectiles. The requirements for cast quality are the same for 60mm HE projectiles loaded with Composition B and are those sited in MIL-C-48368A. This military specification does not contain a requirement for porosity however, a requirement for porosity was added for the development of the M720E1 projectile in an effort to obtain additional information regarding the loading characteristics of PAX-21. The requirement for porosity

was established based on the 81 mm HE mortar projectile specification. Below are the acceptance criteria used:

General. Cavities having a maximum (max) projected dimension of 3/32 inch or less shall be disregarded provided that they are separated by 1/2 inch or more of solid explosive.

Porous areas. Porous areas shall be treated as cavities and shall be subject to the restrictions placed upon the cavities, except that 80 percent of the projected length and 80 percent of the projected area shall be considered.

Cracked charges and annular rings. Not more than four transverse cracks shall be permitted in any charge. The cracks shall be no wider than 1/32 inch. Longitudinal cracks shall be disregarded. The presence of annular rings with a projected width of 1/16 inch max. and extended from the shell wall 1/4 inch max. into the charge shall not be cause for rejection.

Maximum projected areas and dimensions of cavities. The aggregate of the projected area of all cavities shall not exceed 1 square inch and no individual cavity shall exceed 1/2 square inch. Cavities located in the area of the charge which extends from the base of the fuze well to 2.5 inches below the base of the fuze well shall not exceed 3/4 inch in any direction and their aggregate projected area shall not exceed 5/8 square inch.

Piping cavity. A piping cavity on the longitudinal axis of the projectile shall be permitted provided that its projected length does not exceed 1 1/2 inches and its width does not exceed 1/4 inch. The projected area of such a cavity shall not be included when determining cavity area in the charge.

Base separation. The separation between the base of the projectile and the explosive charge shall not be greater than 1/32 inch.

## **PAX-21 EXPLOSIVE MELT POUR LOADING PROCESS DEVELOPMENT**

### **PROCESS AND EQUIPMENT DESCRIPTION**

Melt pour loading of 60mm M720E1 projectiles was conducted in building 810 at Picatinny Arsenal, NJ. Except for the addition of a four nozzle pouring manifold (described below), the loading was conducted utilizing existing melt pour equipment developed for previous efforts. The melt pour process and equipment consisted of the following:

Projectile/Pouring Funnel Preparation – The inside of the projectile metal part is inspected utilizing a probe flashlight to ensure that no foreign material is present. In addition, any surface irregularities to the interior coating of the projectile are noted. If the pouring funnel and projectile body are to be conditioned to the same temperature, the body is loaded onto a pouring buggy and the funnel is

inserted into the projectile nose. The 60mm funnel (figure 2) was designed and fabricated at ARDEC. For the initial process, explosive capacity of the funnel is approximately one pound, while the 60mm M720E1 contains 0.8 Lbs of PAX-21.



Figure 2 – 60mm HE Mortar & Funnel Assembly

Metal Part Preheat – The completed buggy is inserted into a metal parts preheat oven where a specified temperature is maintained for a length of time sufficient to ensure that the interior wall of the projectile body reaches that temperature. The funnels were preheated to a different temperature than the projectile metal parts, and therefore the conditioning of the funnels and projectiles are performed in separate ovens. The first oven, manufactured by Quincy Oven, Company (Serial No. 868-1/ID No. 4430-00240) is used to condition the buggy and projectile metal parts. It has interior dimensions (l x w x h) of 70 in. by 57 ¼ in. by 60 ½ in. This oven utilizes four (4) individual forced hot air heaters capable of supplying a maximum temperature of 350 °F. Temperature control is achieved by use of an Omron Controller (Model E5AJ) and two (2) J Type thermocouples located on the inside walls. The second oven, manufactured by Gruenberg, Company (Model No. C35H450/Serial No. 26131), is used to preheat the funnels if the temperature is different than that of the projectile bodies. This oven measures (l x w x h) 36 in. by 36 in. by 60 in. and contains adjustable shelves. Forced hot air is utilized and the maximum temperature is 350 °F. Temperature control is achieved with a Watflow Temperature Controller (Series 965).

Explosive Preparation – PAX-21 is received in Velostat bags within a 55 gallon drum (60 pounds per bag/10 bags per drum). The bags are opened and the explosive is screened to ensure that no foreign matter is present. The explosive is manually scooped into a 25-gallon melt kettle (figure 3). The kettle consists of:

- A stainless steel mixing bowl, jacketed for steam or hot water containing a single outlet, and a temperature sensor.
- A stainless steel, jacketed kettle lid with ports for product inlet, ventilation and operator inspection.
- A steam heated anchor agitator mounted at a 25 degree angle relative to the kettle lid and extending into the mixing bowl. The agitator is driven by an explosion proof electrical motor/gear reduced drive system.



Figure 3 – 25 Gallon Explosive Melt Kettle

Initially, 15 psi steam is utilized in the bowl jacket and anchor agitator until all explosive is melted and brought up to a minimum temperature of 200 °F. Steam control is maintained using Foxboro valves (Model No. E69P-B11S). The explosive is agitated at this temperature for 30 minutes minimum to ensure complete melting and mixing of the PAX-21 explosive. Upon completion of this melting/mixing cycle, the steam is replaced with hot water in the mixing bowl jacket to bring the explosive temperature to the desired pour temperature. The following process parameters are controlled on the 25 gallon melt kettle utilizing an Allen Bradley SLC 500 Programmable Logic Controller:

- Explosive temperature
- Agitator Speed
- Inlet and outlet hot water temperatures

Projectile Loading – PAX-21 explosive was gravity fed from the 25-gallon melt kettle to a four nozzle manifold as shown in figure 4. The explosive downcomer pipe and manifold are water jacketed for temperature control. Each nozzle was manually operated via a diaphragm valve. This method was utilized for the 20 sets of pours.



Figure 4 – Four Nozzle Explosive Pour Manifold

Controlled Cooling – The loaded projectiles were placed into a temperature controlled oven. The oven utilized (figure 5) measures 96 in. by 28 in. by 36 - 1/2 in. (l x w x h). A steam heated rectangular panel runs along the top of the oven and one steam heated panel runs along each side of the oven. Each panel is zoned for 15 psi steam. The top panel is 24 in. wide and the two side panels are 8 in. wide.



Figure 5 – Controlled Cooling Oven (front door removed)

X-ray – Upon completion of the cooling cycle, the funnels were knocked off and the projectiles were packed for shipment to building 908. X-ray of projectiles was performed in building 908 utilizing a 25 Mev Betatron unit.

**KEY PROCESS PARAMETERS**

The following are nominal values of the initial process parameters utilized:

Kettle Agitator Speed (rpm).....	20
Explosive Pour Temperature (°F).....	205
Projectile Preheat Temperature (°F).....	185
Funnel Preheat Temperature (°F).....	205
Explosive Draw-off Line Temperature (°F).....	213
Explosive Pour Manifold Temperature (°F).....	213
Controlled Cooling Oven Panel Temperatures (°F).....	220
Total Time in Conditioning Oven (hrs).....	3
Time Steam to Oven Panels (min).....	Top - 60 Sides - 15

**RESULTS**

**Final Loading Statistics**

TOTAL RUNS	GOOD ROUNDS	LOADED ROUNDS	SUCCESS RATE	REJECT RATE
20	811	923	87.9%	12.1%



## **CONCLUSIONS**

60 mm M720E1 mortar projectiles were successfully loaded with PAX-21. An overall reject rate of approximately 12 percent was achieved utilizing the equipment set-up, controls and process described in this report. While this reject rate is acceptable considering this was the first attempt to load PAX-21, further enhancements and process development is required to improve the process and reduce the reject to an acceptable level for full scale production. In addition, it was learned that the probability of loading PAX-21 with traditional melt pour equipment is high and that it melts and pours in a manner similar to Composition B.