Author Phil D Djali, BAE Systems, Land Systems Munitions, Glascoed, Usk, Gwent, NP15 1XL e mail phil.djali@baesystems.com

The Design, Installation and Commissioning of High Volume PBX Facilities at BAE Systems, Land Systems Munitions, Glascoed

Introduction

In 2001, BAE Systems (Land Systems Munitions) at Glascoed, near Usk in Gwent, decided to invest in new facilities for volume production of artillery shells, driven by the need to re-equip ageing facilities, and to upgrade the company product portfolio. The conventional plant used to produce TNT and RDX\TNT filled shells had been in use since the 1960s, and the buildings were pre 2nd World War vintage, hence the need for investment was clear, but the direction was less so. However, a key objective agreed was 'to achieve IM compliant shell designs with the same or better performance than conventional shells and with a minimal increase in unit production costs'. A detailed review of the alternatives was conducted before the final decision was made to invest in facilities for filling shells with a cast-cure PBX, as this was assessed as the best route to achieve IM performance together with good lethality. The selected explosive was Rowanex 1100 (RX1100), an RDX based composition developed in house (which has now been fully qualified), and which has been shown to be capable of integration into shell designs to achieve the required performance levels.

The investment required was significant, £10M for the main plant and construction, with a further £5M on additional infrastructure, and as both the need and route were clear, a final key supporting factor became the IM Policy promulgated by our main customer, MoD, which supported IM compliant in favour of non IM compliant products.

With this level of investment and the importance to the business, it was decided to reduce risk by first building a Low Volume Filling Facility, and also by applying formal project management to the scheme. The Low Volume facility was officially opened in April 2004, and has been used to develop knowledge of the materials used, the processes, the throughput and the shell designs. The application of formal project management has allowed the creation of a facility development team, led to a managed implementation of the facilities on the Glascoed site, enabled Stakeholders to have an input, and the funds to be directed and controlled.

Process Design

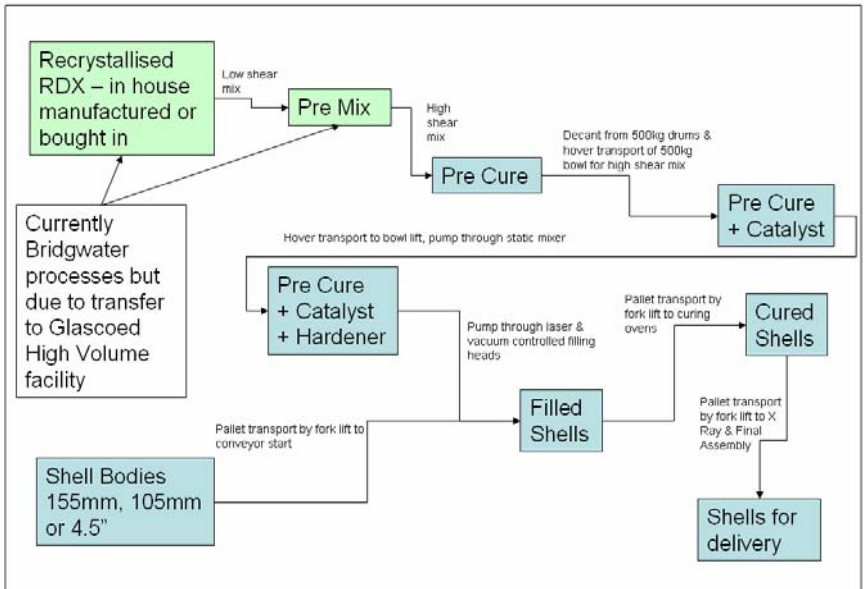

Figure 1 Schematic Process Flow for High Volume PBX Facility

The basic process design was based on delivery of the explosive, from the Munitions Bridgwater site, in a pre-cure form – that is, with all the ingredients added apart from catalyst and hardener. The process then required a remix (to overcome any ingredient separation) together with addition

of catalyst, prior to the pumped delivery of explosive to the filling heads, via an in line (static) mixer to add the hardener. An outline of the process is given at Figure 1.

The initial process design set up for the Low Volume facility focussed on the efficient delivery of explosive from the mixing bowl to the shell bodies. The main areas that were developed included the design and process parameters for the pre cure material, for the static mixer, for the control of filled height, and for the curing of shells.

The process design for the High Volume facility added improvements to the efficiency with which the pre-cure was made available for dispense, and in the way in which palleted shells moved through the filling facility. The design at the filling heads was exactly the same for both facilities, but the difference in throughput as a result of these changes alone was 4Te explosive per day for the High Volume facility as opposed to 4Te per week for the Low Volume facility. This translates into numbers of shells filled as shown in Figure 2, for a double shift 5 day week.

Low Volume 780 kg per double shift (46 weeks)

	Daily Shell	Weekly Shell	Annual Shell	
155mm	66	297	13,662	or
105mm	240	1,080	49,680	or
4.5 inch	240	1,080	49,680	or
81mm mortar	1600	6400	294,400	

High Volume 2Te per shift = 4Te per double shift (46 weeks)

	Daily Shell	Weekly Shell	Annual Shell	
155mm	317	1,428	65,688	or
155mm Trg	502	2,258	103,868	or
105mm	1,333	6,000	276,000	or
4.5 inch	1,280	5,760	264,960	

NB capacity can be increased by up to 30% on above

Figure 2 Low & High Volume PBX Facility capacities

The High Volume process was also modelled using Lanner's Witness software, in order to establish the flow rates through the facility for a variety of different scenarios and shell types. The scenarios covered operative numbers, shift patterns, equipment quantities, plus materials and plant availability. From this modelling a number of refinements were made to the process prior to installation, and the numbers (hence cost) of items such as explosive drums, pallets and filling heads were defined.

The process design has not only influenced the plant and equipment, but also the civil design of the facility, as this has been developed in parallel. As a result the High Volume facility contains a number of unique features in both areas, such as the integration of three identical unit risked drum decant stations with a remote mixing facility, all enclosed by heavy reinforced concrete structures designed to TM5-1300. Other features include a hover transport system for moving bowls containing 500kg of explosive, purpose designed cleaning facilities for bowls, pallets and drums, and sophisticated control

Figure 3 Derelict site area, inherited by facility team in Oct 03

systems for ensuring safe and controlled delivery of the explosive through the filling heads into the shell bodies. In addition, it was reasoned that IM materials and designs must achieve a level of insensitivity at some point in the manufacturing process. Evidence from fuel fire and slow heating trials, plus that from small scale testing, led to the conclusion that the shells during curing could be designated as Hazard Type 3 – this gave a major advantage in construction as a much lighter concrete construction than that required by TM5-1300 was then sufficient to unit risk the curing oven facility.

Plant Installation & Facility Construction

The funding for the High Volume facility was approved in October 2003, when the facility team inherited a derelict area of the site (Figure 3) for the project.

The area selected was situated within the existing shell filling area, in order to take advantage of the existing infrastructure for shell body preparation and final assembly, and because the long term plan was to cease conventional shell manufacture.

Figure 4 Beginning of construction of curing oven facility

The capability to design, construct and install plant in such a facility lay well beyond that available in Munitions, hence the early stages of the project concentrated on building a team involving civil contractors and plant suppliers. E Turner and Sons were appointed as the Principal Contractor and the area was fenced off and put under their control for the duration of the construction phase.

Figure 5 Ovens in place in completed curing facility

The derelict area was first demolished to create a brown field site and then construction of the curing oven facility began in earnest. Figure 4 shows the portal frame being constructed around the concrete cruciform and Figure 5 shows the completed area with the ovens in place; in both, the relatively light reinforced concrete structure used in this area due to the designated reduced hazard of the shells during curing can be seen.

Figure 6 Scale of reinforced concrete used in the drum decant and mixer areas

The need for integration of the plant and civil work was apparent from the start as, due to the size of some of the plant (eg. The 500kg mixer from IKA), it

was necessary to complete to building work after plant installation.

The scale of reinforced concrete construction in the drum decant and mixer building can be seen during construction as shown in Figure 6, and the completed area with the mixer in place is shown in Figure 7.

It was decided to refurbish an existing building to house the main filling line, and within this is now situated the filling conveyor and filling heads (Figure 8), plus the control room and a bowl cleaning station. A further building was refurbished in order to house a drum and pallet wash facility, essentially a large dishwasher with appropriate filtration to take out explosive.

Figure 7 The 500kg IKA Mixer in place

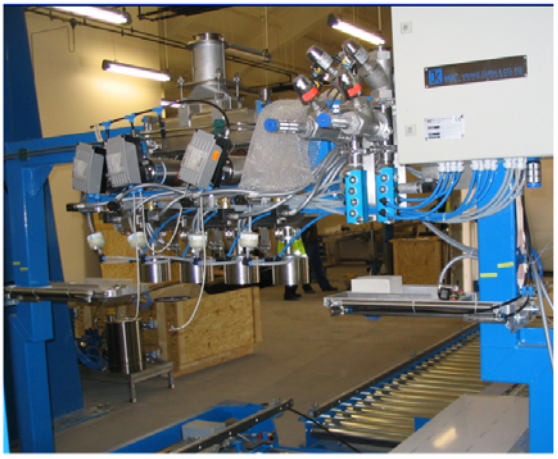

Figure 8 The pallet conveyor and the 4 head filling system

One change that has arisen during the project, which will modify the early stages of the explosive manufacture process, is the pending closure of the Munitions Bridgwater site. The plan is to procure recrystallised RDX and then to process this into pre-cure on the Glascoed site. No changes to the High Volume process are required as the input will still be 500kg drums of pre-cure.

Key Learning Points

Many learning points have been set down during the construction of the High Volume facility, and a few of the key ones have been listed here.

Design of the process prior to the start of construction was identified early on, but even so, many details were determined later, leading at times to alterations to the civil construction with consequent cost and time extensions.

Initially, the materials knowledge was limited to the start materials, eg RDX and pre-cure and the finished material, cured RX1100. As a Basis of Safety has been established for the facility it has become clear that knowledge of the intermediate materials (shown in Figure 1) is equally necessary for safe operation of the manufacturing processes.

The logic for doing anything needs to be properly explored, for example the original curing oven concept was actually found to be flawed. It was mentioned earlier that the concrete in the curing oven building was of a much lighter construction than in

the mixer area due to the reduced Hazard that could be designated to shells during cooling. However, reducing to Hazard Type 3 actually became essential, in order to allow sufficient stacked pallets of shells to be loaded into the ovens, and therefore to avoid this becoming the rate controlling process.

The risk is always with the new technology, however simple it appears at first sight, especially as this facility is essentially a manufacturing system, and a change to any one part can have a knock on effect to the whole of it.

And finally, allow time for protected species to be re housed! The High Volume facility construction was actually delayed for a while due to the residence of bats in some of the old buildings, and work could not then proceed until a Bat License had been received and a bat expert had been contracted.

2006 – A Big Year

The High Volume facility is now nearing completion with (at the time of writing) the inert commissioning phase about to start. This will be followed by live commissioning before facility handover to Operations for start on the main production order for 105mm shells. It is unique in being a volume production facility for filling cast cure explosives into artillery shells, and the Munitions business is proud to own this world class IM Technology capability.

Also the Low Volume facility requires recommissioning due to a fire that occurred there in late 2005. Together with the transferred BW processes, and a new R&D facility for Low Vulnerability (LOVA) gun propellants, it is intended that the Munitions Glascoed site will become the centre of IM excellence in the UK. Longer term, there is a plan to move all products towards IM compliance, giving the advantages of safer and more environmentally friendly manufacture as well as the more publicised benefits of safety in use and logistic benefits.