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DECONTAMINATION OF EXPLOSIVES BUILDINGS AND PLANT AT RO/XD BRIDGWATER*

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Summary

Guidance notes detailing the procedures given in this paper are issued to all Heads of Section who may have to deal with major structural change in explosive buildings. The point is stressed, however, that each case will have its own special features and must be assessed on its own merits. For work to proceed safely constant vigilance and attention to detail must be exercised at all times.

Introduction

RO/XD Bridgwater is an explosives manufacturing plant dedicated to the production of high explosives and composite propellants.

This paper outlines the systematic approach which is followed by RO/XD Bridgwater when major work involving the demolition of building structures and floors, or the repair of large items of equipment, takes place in areas where explosives have been manufactured or handled. Some examples of special techniques which have been used are also described in Appendixes A, B and C.

The procedures consist essentially of 6 steps:

1. Acquiring preliminary information about the area where the work is to be done.
2. Conducting a work survey.
3. Deciding what preliminary precautions are required.
4. Deciding what precautions must be taken whilst the work is in progress.
5. Preparing the paperwork.
6. Doing the work and recording how it was done.

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1. Preliminary information

The previous history of production work carried out in the area is researched as far as possible so that the nature of potential hazards can be adequately determined. For example, a number of buildings on the Composite Propellant Section were originally used for tetryl manufacture and this explosive still manifests itself today even though some 40 years have passed since production ceased. Explosives made nowadays at Bridgwater include RDX, HMX, TNT, HNS and compositions involving some or all of these materials.

From this review of the previous history of the building the possible explosive hazards which might be encountered can be assessed and listed.

2. Work survey

A thorough survey is made of the area where the work is to be done. This is carried out by the Head of Section in conjunction with representatives from the Engineering and Safety departments and any other personnel he judges can contribute suitable expertise relating to the job or area in question.

The main purpose of the survey is to examine the area in order to decide exactly how the work is to be done, who is going to do it and what safety features must be incorporated. Matters such as remote control of certain operations or the use of other special techniques are considered at this stage.

If production operations have been performed under wet conditions, the most likely areas where explosives could have accumulated would be at or near floor level. Drains and gullies are examined very closely and particular note is taken whenever faults such as cracks in brick, mortar, tiles or asphalted areas are evident.

In "dry" buildings, particular attention is paid to the possibility of explosive dust accumulations. Meticulous examination of all crevices, cracks, girders, stairways and ledges is made at all levels within the building, from floor to ceiling.

3. Preliminary precautions

In the light of the information obtained from the previous history review and the work survey, the Head of Section then decides what preliminary precautions must be taken. These might include:

a. Thorough cleaning by water and/or steaming, with scrubbing, followed by close inspection by a chemist. The entire building and equipment should be scrupulously checked for freedom from visible signs of explosive.

b. Chemical, thermal or other treatment. For example, arrangements might be made to flood the area to be worked on for some hours beforehand using sandbags or other devices to retain the water.

c. Testing for the presence of explosives. This may be done on site, or samples and swabs can be checked in the laboratory.

d. The use of compatible paint strippers. Structures which have been painted merit special attention, particularly where it can be seen that nuts and bolts have been painted over.

When considering these matters, the Head of Section may wish to seek advice or information from people who have previously dealt with similar situations, either at Bridgwater or elsewhere. He could make use of library facilities to consult reports covering demolition and decontamination procedures. He might also consider whether there may be a case for heat treatment in situ — an example of this will be given later.

4. Precautions to be taken whilst work is in progress

Particular attention is paid to the supervision and personal protection of those doing the work.

The concept of the stand-by or stand-over is used at Bridgwater. When a person is instructed to stand-by, he is required to be present in the building at all times the work is proceeding. To stand-over means that the job demands especially close attention and that there are no circumstances in which it can be left at any time while work is in progress. A person can stand-over only one job at a time.

A production worker who is appointed to stand-by or over work must have satisfactorily completed a formal training course. On each occasion that he is selected to act as a stand-by he is issued with written general instructions defining his responsibilities. He is also given in writing any instructions specific to the job in hand. He must not permit work to start unless a fully authorised precautions certificate is present in the work areas. He must ensure that all tradesmen, contractors and other personnel involved are fully aware of the precautions stipulated on the certificate and that these precautions are fully observed at all times. He also has full authority to stop the work if at any time he is not satisfied that it can proceed safely.

Heads of Section must consider carefully the level of stand-by appointed in relation to the work to be done. For work involving major demolition operations it will almost certainly be necessary to appoint a Foreman or Chemist to stand-by, or even stand-over, certain activities.

The protective clothing and equipment to be worn, including boots, goggles and visor, helmet, gloves, masks, ear defenders etc, are detailed precisely. If there is considered to be any danger of flying masonry becoming a hazard the wearing of additional body protection such as a flak-jacket is specified and complete protection of the head and eyes will be mandatory. Wherever possible, protective barriers are also employed. The stand-by must wear the same level of protection specified for the personnel actually carrying out the work.

The number of people present in the work area is kept to an absolute minimum at all times. No other work of any sort is permitted to take place when demolition is in progress.

Whenever possible non-ferrous tools are used. Ferrous tools are permitted only if absolutely essential and their use is strictly controlled.

All items, structures and materials within areas which are concerned in the manufacture or handling of explosives are considered to be contaminated until *proved* otherwise. (Proved means that the items have been raised to a temperature in excess of that necessary to ensure complete destruction of the explosive concerned.) This assumption is made no matter how thorough the cleaning has been and even if negative results have been obtained on samples or swabs tested in the laboratory. Under these circumstances whenever drills, chisels or similar tools are being used a continuous stream of water is directed on to the area where the tool is being applied. It is *not* considered sufficient simply to wet the area prior to work commencing or to state on the precautions certificate that running water is to be at hand — the work area must be continuously soaked.

Consideration must be given to carrying out demolition work in stages. A sequence such as cleaning—inspection—testing—part demolition—further cleaning—inspection—testing—further part demolition may well be appropriate.

The use of paint strippers has been mentioned previously, particularly on nuts and bolts which have been painted. Threaded areas are always treated with caution and subjected to thorough cleaning. When undoing nuts and bolts the use of excessive force is avoided and such work is always done under running water.

The adoption of good-housekeeping procedures with frequent removal of rubble away from the work area is always highly desirable. Debris must be considered as contaminated with explosive and arrangements made to treat it on an open fire.

5. Paperwork

Precautions certificates, special tool passes, fire permits and other necessary paperwork are prepared, authorised and displayed in accordance with the Director's instructions. Particular care is taken to ensure that the work to be done is defined clearly and precisely and that the precautions stipulated are comprehensive and unambiguous.

6. Record of details for future reference

A record is kept of procedural details of major demolition work with particular emphasis being given to the precautionary measures adopted. Wherever possible, photographs are included in the record. This information is published as a Bridgwater Technical Note and thus becomes available for reference by those who will be faced with similar work in the future. All sections retain for immediate consultation a loose leaf folder containing such reports.

Appendix A

Explosive demolition techniques

Introduction

In early 1983, during the demolition by conventional means of a glazed brick partition wall in a process building, a small detonation occurred injuring a contractor. The building had been used for many years as an RDX boiling, oiling and waxing house and, although the surface of the wall had been cleaned, checked and wetted, it is suspected that a small amount of RDX had penetrated the mortar between the bricks.

It was, therefore, decided to find out whether the demolition of the wall could be completed using explosives engineering methods. The Royal Armament Research and Development Establishment was asked for advice and their Explosives Ordnance Branch visited the factory. They reported that explosive demolition was a suitable method to complete the work and they agreed to undertake it and in addition to train a number of the Bridgwater staff in the technique.

Preparation on site

The remains of the partition wall were thoroughly hosed and then submerged in water held by sand-bags for 48 h. The wall was of single thickness of glazed brick and extended 4½ bricks deep into the building, being 2 bricks high for half its length and single brick high for the remainder. Three samples of mortar scrapings were taken from exposed surfaces and these were checked in the laboratory for RDX content — only a minute trace was indicated (Fig. A-1).

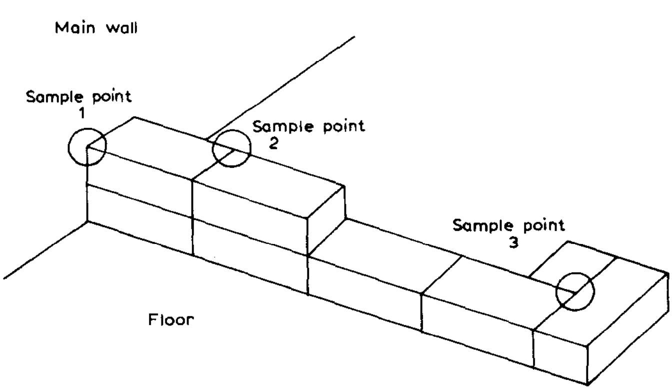

Fig. A-1. Remains of partition wall before final demolition showing sample points.

The following precautions were taken to prevent extraneous damage:
a. To prevent damage from propelled debris a barricade of sand-bags was positioned around the remains of the partition wall.
b. Adjacent surfaces were protected from surface damage by covering with a double layer of hardboard.
c. All windows and doors were opened to reduce over-pressure. Panes of glass from a window immediately above the work site were removed.
d. Consideration was also given to removing some light fittings but it was finally decided to leave them. The nearest was 10 m from the work site.

Explosive engineering procedures

1. Safety procedure

a. The number of persons directly involved in the charge laying operation was kept to a minimum.
b. A prohibited area within 80 m of the work site was designated. Security of this area was maintained by the Factory Fire Brigade.
c. The firing post was situated about 75 m from the work site. The Firing Officer was solely in charge of operations.
d. Factory personnel were warned generally of explosions within the factory due to demolition work by announcements over the public address system. Additionally, before each individual firing a warning in the immediate work area was given by sounding the 2-tone siren of the Fire Brigade control vehicle stationed on the prohibited area perimeter.

2. Charges, detonators and firing system

The charges used were made up from $\frac{1}{8}''$ thick strips of SX2 cut from sheets made in the factory. The strips were laid on $\frac{5}{8}''$ aluminium angle in the general configuration shown in Fig. A-2. The individual weights and length of charge varied according to the break-up of brickwork the Firing Officer considered it was advisable to produce at each firing.

The detonator used for each charge was an L2A1. Generally this was

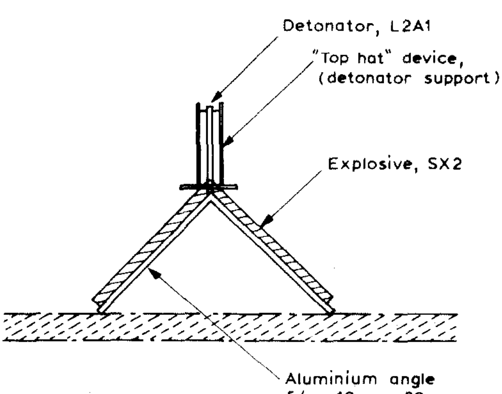

Fig. A-2. Cross section of explosive charge and detonator.

placed on the apex of the charge and held in position by a plastic top hat device shown in Fig. A-2.

Firing was carried out using "Shrike" electronic ignition equipment sited 75 m from the firing area and connected to the detonator by firing cable.

3. Method of laying charges

Charges were laid by the Firing Officer where required to give the desired effect. Direct contact with the brickwork or indirect contact using a wooden stand-off were utilised according to circumstances. The charge was attached to the firing site by adhesive tape.

4. Demolition of partition wall

The requirement was to remove the remains of the partition wall and provide a rebate of about 25 mm below the floor surface. The method employed was to use a number of small charges and remove the wall incrementally. Small charges were used to avoid over-pressure in the building.

Debris was retained by the sand-bag enclosure, although a small amount of dust and small fragments were noted up to about 8 m from the work site. After each firing, debris was removed and the area was brushed and hosed. A sample taken after the first firing was checked for RDX content — a figure of less than 0.01% RDX was reported. While removing portions of brick the charge was generally in direct contact; when providing the rebate into the floor the charge was stood off using wooden blocks. A total of 15 charges was used to complete the work.

Assessment of finished results

The work was satisfactorily completed. It was noted that following the firing of one incremental charge during the cutting of the recess into the flooring, the Firing Officer reported that the damage pattern produced by that charge was greater than expected. The damage to the concrete substrata was probably caused by shock waves from earlier firings but it does not rule out the possibility that additional trapped explosives had been detonated during that firing.

Acknowledgement

Grateful acknowledgement is made to RARDE EM1/EOD Branch for their technical and practical expertise in carrying out this work.

Appendix B

Heat treatment of the TNT nitration unit prior to repairs involving grinding and welding

Introduction

After completion of a production run in April 1982, inspection of the TNT Nitration Unit revealed a hole at one end of the vessel and also defects in some welds in the area.

Because of the large size of this unit (it measures 9.6 m long × 1.3 m wide × 1.4 m high and weighs about 3.75 tonnes) its removal from the building for heat treatment in the proving oven (the normal Bridgwater procedure) was considered impracticable. It was, therefore, decided that heat treatment of the relevant areas of the unit in situ was the only alternative. At first it was envisaged that this would be achieved by heating all welds in the area to be repaired to a temperature of at least 400°C (indicated by temperature sensitive paint) using a remotely operated oxyacetylene torch.

It soon became apparent, however, that there would be major problems in this approach — possible local overheating of welds leading to structural changes in the steel and also the drawback that only the welds (a small proportion of the total compartment area) would have been proved. A better method of heat treatment was sought.

In 1980 a firm had been employed to stress relieve a welding repair to the manhole of an ammonia storage vessel by subjecting it to an accurately programmed heating/cooling cycle with the aid of electrically heated pads. The firm was contacted again and after inspecting drawings of the TNT unit, agreed to carry out heat treatment of the area requiring repair.

Procedure

a. Preliminary preparations

All steam pipes, delivery pipes, handrails, a stirrer and coil and the drowning flap mechanism were removed from the area, which was then thoroughly cleaned by a combination of steaming, hot water washing and scrubbing until free of TNT as detected by test solution.

Other areas in the region of the TNT unit were cleared free of visible explosive and all vessels including the other compartments of the unit were filled with water.

b. Description of heat treatment system used

A vertical bulkhead consisting of a wire grid covered with mineral wool insulation material ("Rock Wool") was installed in the unit to isolate the main section of the vessel from the area to be treated.

Six electric heaters were positioned as shown in Fig. B-1 and spaced from the unit by firebricks. The heaters were secured in position by steel wire or, in the case of the 2 heaters under the floor of the unit, supported by scaffolding poles. The heaters were rated for a maximum of 13.2 kV A (13.2 kW) each (55 amp at 240 volt) and were wired in a "star" configuration, 2 heaters being connected in series to each phase of the 3 phase supply.

Five thermocouples were positioned on the basis of their proximity to the areas which were to be repaired. Another thermocouple was placed to measure the temperature of the area which, if any, would be the coolest of the region under treatment, achievement of the specified temperature at this position being an assurance that all areas had attained or exceeded this temperature.

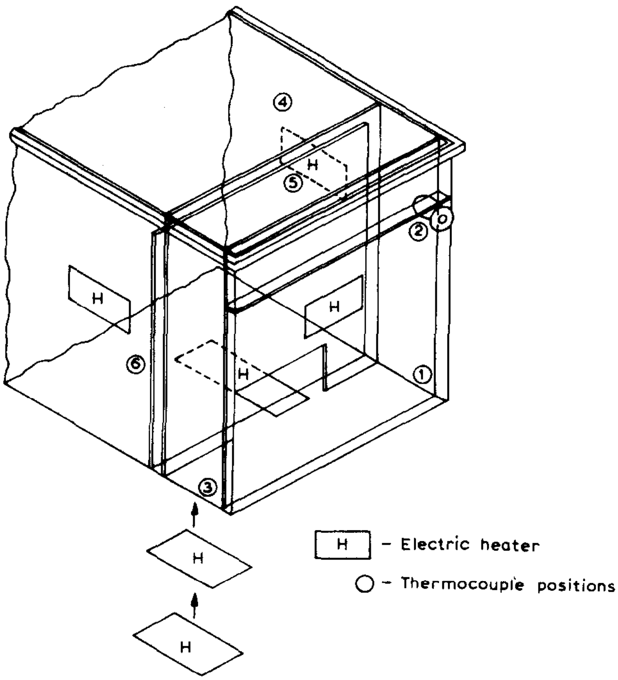

Fig. B-1. Arrangement of electric heaters (two heaters are placed underneath the floor of N8/T9).

The thermocouples were spot welded to steel plates which were then placed in contact with the unit itself. (For maximum accuracy, the preferred technique is to weld the thermocouples direct to the unit but this was considered to be too hazardous.)

As a further check on the whole region, surfaces and welds were spotted with a temperature sensitive paint which changes from green to pink after 10 min heating at 410°C and tablets having a melting point of 399°C were placed randomly in the area.

When all the heaters, thermocouples and associated wires and cables were positioned, the sides, top and bottom of the unit were covered with "Rock Wool". In addition 2 heavy insulation mats were placed on top of the unit.

c. Heat treatment

The required programme was to allow the temperature to rise to 300°C uncontrolled and then to increase the temperature at a rate of 150°C per hour to the range 425°C to 450°C. The temperature was maintained in this range for 2 h after which the heaters were switched off and the unit allowed to cool in still air.

All heating controls and temperature recording equipment were positioned outside the mound of the building and nobody was permitted within the building whilst the work was in progress.

Assessment

The recording chart showed that the required temperature programme had been met. Inspection of the unit revealed the spots of temperature sensitive paint had all changed colour. All tablets placed in the treated region had fused.

Apart from the inevitable heat staining there was no damage to the unit as a result of this heat treatment.

Repairs were carried out successfully.

Appendix C

Demolition of building 3/48A on the RDX section

Introduction

Building 3/48A had previously been used for 2 major activities; shell breakdown in the immediate post war years and RDX/TNT cracking and packing for the past 30 years. The refurbished building was required for an RDX/TNT mixing and pelleting plant.

Preliminary techniques

1. Test solution

A test solution of sodium hydroxide in methanol and acetone was used to determine the extent of contamination. The test solution develops a red colour in contact with TNT. Contamination was found in the paint layers and at many points where dust had settled.

The whole building was thoroughly hosed by the Fire Brigade to remove dust.

2. Paint remover

Pipework on the drench system, ducting on the air removal system and nuts and bolts were contaminated. These areas were treated with an approved paint remover before dismantling with non-ferrous tools.

3. Dust under the asphalt floor

There was evidence to suggest that explosive dust had penetrated between the asphalt floor and the concrete base. The floor area was segregated, sandbagged and flooded with water. The asphalt was lifted with a non-ferrous pick before being removed to the burning ground for disposal.

Major demolition

1. Clerestory concreted roof beam

Breaking out the concrete from the RSJ (rolled steel joist) girder was commenced using non-ferrous tools under running water. This proved expensive in terms of both tooling and time. Repeated tests did not indicate the presence of explosive contamination so the tooling was changed to steel although retaining the running water. No problems were encountered thereafter and this part of the demolition was completed on time.

2. Girders

When the concrete cladding had been removed from the girders they were cut up using an oxy-acetylene torch. The following precautions were taken

a. The girders were thoroughly hosed down and cleaned.

b. The area on the beams where cutting was to occur was test solution checked.

c. The floor was sand-bagged and flooded to quench the sparks from cutting.

The cutting was completed without problems.

3. Floor over the underground ducts

Underground ducts had been fitted to supply ventilation air to the building. The relatively thin duct covering was broken out using steel tooling on hand-held compressed air jack hammers with running water applied to the tool tip and with the duct flooded.

4. Main floor

The technique here was to use a remotely controlled large hydraulic hammer with steel tooling and copious running water.

The operator sits in a protected cab some 3 to 5 m remote from the hammer point, a safer option than the traditional handheld jack hammer. The procedure dealt with 0.38 m thickness of concrete and an area of 40 square metres was cleared in 6 h.

5. Walls

It had been intended to retain most of the walls and re-use them in the new building. However, it was eventually established that the building had no piled foundations and the decision was taken to demolish and rebuild. The walls were pulled inwards by the back actor shovel, drenched with water and broken up before removal.