Report on 8-Inch Isostatic Press Explosion at Site 300

Lawrence Livermore National Laboratory
Livermore, California 94550

This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Livermore, California

Contract No. W-7405-eng-48

REPORT ON 8-INCH ISOSTATIC PRESS EXPLOSION
AT SITE 300

(Title Classification: Unclassified)

April 6, 1960

Classification changed to Unclassified
by authority of D2B2-UCRL-59571

by date 7/24/60

by date 7/25/60
DISTRIBUTION
Series A

UNCLASSIFIED

<table>
<thead>
<tr>
<th>Copy No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8-9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12-13</td>
</tr>
<tr>
<td>14-15</td>
</tr>
<tr>
<td>16-17</td>
</tr>
<tr>
<td>18-19</td>
</tr>
<tr>
<td>20-21</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>23</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>27</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>
CONTENTS

Introduction ................................................. 4
Chronological List of Events Related to the Explosion ........ 4
Cause of the Explosion ........................................ 8
Operational Changes as a Result of the Explosion ............ 10

Appendix

1 – Operational Procedures at the Press Area .................. 12
2 – Physical Damage Caused by the Explosion .................. 26
3 – Fragment Distribution from the 8-Inch Press Explosion .... 37
4 – Chemical Studies on Cause of Accident .................... 38
5 – Financial Statement ......................................... 41

Figure

1 – Map of site of explosion .................................... 5
2 – Component parts of container ................................ 9
3 – Floor plan of Press Building .................................. 27
4 – Distribution of shrapnel ...................................... 28
5 – Cross section of 8-inch isostatic press ...................... 29
6–12 – Views of the site after the explosion .................... 30–36
INTRODUCTION

On 3 March 1960 at 11:30 a.m., a detonation occurred in the 8-inch isostatic press. The press and building were completely destroyed. Operating personnel were protected and no injuries resulted. Adjacent facilities were not affected.

The press was housed in a temporary facility located in the southwest portion of Section 26, Site 300. (See Fig. 1.) The facility was situated approximately 1000 feet west of the main site road, and 1400 feet north of the county road. The press building was of frangible wood construction and was surrounded by an earth barricade. A remote control building, provided with overhead protection, a mechanical equipment room, and a transportainer magazine were located outside the barricaded press building.

CHRONOLOGICAL LIST OF EVENTS RELATED TO THE EXPLOSION

Feb. 18: * Representatives of Physics ("B" Division) and Chemistry (General Chemistry Section) meet to discuss the performance of metal-loaded explosives for the Chickadee program (a high-priority weapons development effort). Some new kinds of data are needed, and it is decided to conduct a two-shot experimental series within the coming month. As a system capable of providing the new information, the following composition (designated PBHNL) is proposed (certain requirements of uniformity, density, and "pressability" are involved):

*All dates in this column refer to 1960.
<table>
<thead>
<tr>
<th>Composition</th>
<th>Wt %</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMX (Holston, 6 material)</td>
<td>47</td>
</tr>
<tr>
<td>Lead (3-micron powder)</td>
<td>47</td>
</tr>
<tr>
<td>Tris-β-chloroethylphosphate</td>
<td>3</td>
</tr>
<tr>
<td>Nitrocellulose (11.8% nitrogen)</td>
<td>3</td>
</tr>
</tbody>
</table>

Feb. 19:  
1. Drop hammer, sparking, and hot block tests are run on 50-50 lead-HMX mixtures. Results are satisfactory. (See Appendix 4.)  
2. An order is placed with Site 300 to prepare 5 pounds of PBHNL by the slurry-coat method.

Feb. 23- Feb. 25: Five pounds of PBHNL are prepared in three 1.7-pound batches at Building 331A. Preparations proceed normally in all respects. The three batches are "V"-blended together, and 50 g of the blend are sent to Livermore, Building 107A, for evaluation.

Feb. 26: To achieve the objective of pressing a rectangular block, 5-3/4 × 4-1/2 × 1-1/2, of PBHNL, two trial pressings, using PBX 9404, are performed. This is done to determine the specific silastic rubber insert configuration required.

Feb. 29:  
1. Five small-scale (1.5 - 4.0 g) pressings of PBHNL are made. The pressings are poor and only 90% theoretical mean density (TMD) is obtained. Samples are set aside for impact-sensitivity and vacuum-stability measurements.  
2. Two additional trial pressings, using 9404, are performed in the 8-inch vessel.  
3. Hazards Control is informed of the status to date. Approval is given to press the desired 5-lb piece of PBHNL.

March 1: Two additional trial pressings, using 9404, are made in the 8-inch vessel. The configuration of the silastic rubber inserts to be used in the PBHNL pressing is determined.

2. Device Engineering places an order to press isostatically a 5-lb billet of PBHNL. The order is verbal. Pressing conditions are to be supplied by Chemistry. Pressing is to be completed, if possible, by March 3.

March 2:  
1. The 5-lb batch of PBHNL is taken from Building 331A to the press area.
March 2:  
(Contd.)  
2. At 4:00 p.m. 5 lb of PBHNL are placed in a stainless-steel tray and positioned in the top shelf of the Stokes oven. Temperature controls are set to heat the material, overnight, to 90°C.

March 3:  
1. At 8:15 a.m. the Stokes oven temperature is observed to be 85°C. This is raised in 3 to 5°C increments, at approximately half-hour intervals, to bring the material to 98°C. This is done to allow for the cooling that will be encountered during the hand-loading of the container.

2. At 8:30 a.m. drop hammer values are determined on PBHNL; the value is 31 centimeters. (Reference: HMX, 30 cm; Comp. B, 53 cm) (The vacuum stability determination was not run prior to the explosion.)

3. At 9:00 a.m. discussions on the possible cancellation of the 5-lb pressing are held because of the low densities obtained in the small-scale pressings. The conclusion is reached that experimental requirements would be met with a 90% TMD pressed billet. The order to press is allowed to stand.

4. Chemistry informs the press facility that the sensitivity of the material is 31 cm and that pressing conditions are to be 90°C, at 20,000 psi, and a 15-minute dwell. (These are arbitrarily chosen conditions, since the small pressings indicate only that the material is difficult to press.)

5. Steam to the 8-inch pressure vessel is turned on. This is done to heat the fluid to 80°C. The container, with silastic and gum rubber inserts, is heated to approximately 65°C to reduce heat losses during pressing and to minimize the possibility of stress cracks in the pressed blank. This is done in a separate oven.

6. At 10:55 a.m. the silastic inserts and container are removed from the oven. Inserts are positioned and the PBHNL is removed from the Stokes oven.

7. The material PBHNL is handpacked to an estimated density of 2 g/cc. All but approximately 150 g of PBHNL is used. A rubber divider is positioned over the silastic inserts, and 9404, at ambient temperature, is added to fill the container to the normal level. Evacuation of the container is completed at 11:13 a.m. The
evacuated container is positioned in the pressure vessel. Figure 2 shows the component parts of the container.

8. There is approximately 20 lb of explosive in the building at this time: 5 lb PBHNL and 4-1/2 lb of 9404 in the 8-inch press, 150 g of excess PBHNL in an oven tray, and 10 lb of 9404 in a container on the north side of the 18-inch press. This 10 lb of 9404 is the excess used as a fill for the particular PBHNL pressing.

9. At 11:18 a.m. the pressing operation is started. A pressure of 20,000 psi is reached at 11:23 a.m. Detonation occurs at 11:30 a.m. after 7 minutes of dwell. [Specified dwell time (item 4, above): 15 minutes.]

10. Firemen, nurse, police, and operations personnel respond to the emergency call. All persons are restricted from entering or viewing the area until approximately 1:00 p.m.

11. Chemistry, Hazards Control, and Operations personnel begin inspecting the explosion site at 1:00 p.m.

CAUSE OF THE EXPLOSION

The explosion was caused by an unsuspected exothermic reaction which occurs between lead, nitrocellulose, and chloroethylphosphate. All three of these reactants are required; combinations of only two of them do not react. HMX plays no part in the reaction. The reaction is not a rapid one, nor is the evolution of heat very large. In small-scale pressings or in loose powder in air, where heat conduction is not a serious problem, no deflagrations occur. In the large-scale pressing, the heat evolved from the closely compacted, evacuated charge had no place to go, and a runaway deflagration which went high order was a natural consequence.

The above is the technical cause of the explosion. The operational cause was associated with the attempt to "scale-up" too rapidly a material whose properties were not well known. Had tests such as vacuum thermal stability or differential thermal analysis (DTA) been completed, the thermal

*This conclusion is based on evidence in which gas evolution is the main criterion of reaction (see Appendix 4 for experimental details). Some experiments conducted immediately after the explosion indicated nitrocellulose and lead alone can react, but closer examination of the data shows that this conclusion is in doubt.*
Fig. 2. Component parts of container in which the PBHNL was handpacked.
instability of PBHNL would certainly have been detected prior to the pressing operation.

OPERATIONAL CHANGES AS A RESULT OF THE EXPLOSION

The nature of the work at a laboratory such as LRL often requires experimentation with explosives that are not well known. Frequently, work must be conducted on short time scales, as in the incident reported herein. The necessity to work with less than well known materials on short time scales makes the responsibility for conducting a safe operation a very heavy one. LRL has attempted to meet this responsibility through a rigorous system of operational procedures and the use of facilities designed to accept the possibility that an explosion might occur.

The design of the facility and the procedures controlling the movements of the press operators adequately protected personnel from the effects of this explosion. It is quite clear, however, that the operational procedures which permitted the scale-up to proceed to a point of danger were not adequate. Key information, which could have alerted those conducting the program to the dangers involved, was not made available on a time scale consistent with the pace of the work.

A basic change in operational procedure has therefore been placed in effect. All explosive materials at LRL have been divided into two broad classifications, designated as follows:

LRL – Standard-1: Materials with certain minimal standards of sensitivity, stability, purity, and operational history.

LRL – Standard-2: All other high-explosive (H.E.) materials.

Included in LRL – Standard-1 are such materials as Composition B, cyclotol, TNT, PBX 9404, and DATB. Representative of LRL – Standard-2 materials are such explosives as pure HMX, RDX, PETN, and all new formulations with little or no previous operational history.

Work involving LRL – Standard-1 materials proceeds according to Site 300 operating procedures which were in effect prior to the explosion. Work with these materials represents perhaps 95% of Site 300's effort.

Work involving LRL – Standard-2 materials continues but under considerably tightened restrictions. Any work with these materials in excess of the laboratory amount of 10 grams is now conducted under a job order system which
requires prior to the commencement of work:

a. Sensitivity evaluation
b. Thermal stability evaluation
c. Stricter review of the proposed work
d. Authorization

This job order system for LRL – Standard-2 materials applies to all fabrication operations (mixing, blending, pressing, machining, etc.) conducted not only at LRL, but also at other installations at the request of LRL. It applies to the firing of assemblies containing LRL – Standard-2 materials; it applies even to the transportation of such materials.

The Laboratory believes the additional operational restrictions imposed on LRL – Standard-2 materials will provide the measure of safety needed to permit the safe handling of the less well-known materials when necessary to the progress of the Laboratory’s programs.

In addition, changes in the operating procedures will specify that explosives will not be used as a fill material when LRL – Standard-2 explosives are pressed.
APPENDIX 1

OPERATIONAL PROCEDURES USED AT THE PRESS AREA

The design of the temporary press facility provided an intraline separation distance for the operation of 1200 lb of explosive: 600 lb in the press building and 600 lb in the adjacent magazine. Actual operations, however, were limited to 350 lb in the press building and 500 lb in the magazine. A second explosives facility, the temporary environmental test area, is located, at its nearest point, 300 ft from the press building. This is the inhabited building distance from the 350 lb permitted in the press building. The Army Ordnance Safety Manual, ORD, M7-224 "quantity distance" specifications were used for these design requirements.

Procedures for the operation of the press facility included the following:

1. Area procedure
2. Press building procedure
3. Specific operations.

A brief description of the pressing operation is as follows: Blended explosive mixes are removed from their shipping containers and spread into suitable oven trays. These are heated to the desired temperature in a Stokes oven. The heated explosive is then loaded into a rubber container, evacuated and positioned in the pressure vessel. The pressure vessel is closed off and the pressurizing system set for remote operation. Personnel retire from the press building to the control room where the pumps and pressure recorder are started. Pressure in the vessel is maintained for the desired dwell time. The vessel is depressurized after the dwell time, and personnel return to the press building. The vessel is opened and the pressed blank packaged for shipment.

Procedures B1 through B6 of the LRL Site 300 Safety/Operational Manual (included in this appendix) describe the details of the operation as it was conducted prior to the explosion. Although not contributing to the explosion, there was one procedural deviation during the PBHNL pressing: 10 lb of PBX 9404 were left in the press building during the operation.
OPERATION OF THE TEMPORARY PRESS & ENVIRONMENTAL AREA

A. ALLOWABLE EXPLOSIVES

1. See Procedure No.'s B-2 and B-8.
2. **Explosive Limits**
   a. **Press Area**
      * 1) 350 lbs. maximum in the Press Building.
      * 2) 500 lbs. maximum in the storage magazines.
   b. **Environmental Area**
      1) 200 lbs. maximum for the total area.
      2) 70 lbs. maximum for a test cell.

B. GENERAL SAFETY AND OPERATION

1. A road barrier and sign will be placed across the road, blocking access to the barricaded area, prior to beginning a remote operation.
2. All persons must receive permission from the Building Supervisor before entering the remote operating area.
3. Personnel entering the area shall leave matches, lighters, and spark producing instruments at the police post.
4. Smoking is permitted only in the police or control buildings. Electric wall lighters and receptacles will be provided in the control buildings for smoking.
5. All personnel shall remain outside of the barricaded area and in no way expose themselves to the open end of the earth barricade during remote operation.
6. After completion of the remote operational phase, the road barricade and sign will be removed.
7. The Building Supervisor or his designated alternate shall have the responsibility of clearing the barricaded area of all personnel and seeing that the barrier and sign is placed across the road before starting remote operation.
8. The Building Supervisors or their designated alternates shall be in complete charge of all operations in their area.

*Rev. (2-23-60)
B. GENERAL SAFETY AND OPERATION – Cont’d

9. Vehicles shall be parked in designated parking area.

*10. If it is necessary for outside contractors to enter the Environmental Area, the Temporary Press facility must be notified as much in advance as possible. This will permit Press to suspend operations, if necessary, depending on the amount of explosives on hand.

APPROVED: (Signed) S. H. Swanson
Site 300 Operations

APPROVED: (Signed) J. S. Dittig
Hazards Control

*Rev. (2-23-60)
LAWRENCE RADIATION LABORATORY – SITE 300

Procedure No. **B-2** (p. 1 of 3)  
Issue Date **4-1-59**

OPERATION OF UTILITY PRESSING BUILDING

A. ALLOWABLE EXPLOSIVES

1. T.N.T.
2. PBX 9401
3. PBX 9404
4. PBX 9406
5. Mock high explosives
6. Comp A-3
7. PBX 9010
8. DATB

Special permission must be obtained from High Explosive Safety Office to press other explosives.

B. EQUIPMENT AND MATERIALS

1. 18" I.D. Pressure Vessel
2. 8" I.D. Pressure Vessel
3. Stokes Oven
4. Small Steam Oven
5. C-60 Pressure Cart
6. Press Building
7. Remote Control Panel
8. Air Compressor
9. C-300 Pressure Cart
10. Floor scales
11. Drying Trays
12. Plug Stand
13. Control Shack
14. Pressure Recorder
15. Temperature Recorder
16. Speedy Electric Steam Generator
17. Shaker Table
18. Gloves and Respirators

C. OPERATION

1. All area regulations as outlined in Procedure B-1 shall be maintained.
2. An up-to-date personnel access list for the area will be maintained at the police post.
3. The only explosives to be in the press building are the minimum amount required to perform operations.
4. There is to be a minimum of two (2) persons in the pressing complex, which consists of the press building control shack and earthen barricade, when explosives operations are being performed. One of the persons must be a qualified operator of the pressing equipment.
5. All tools shall be cleaned and returned to their proper place immediately after use.
6. Each person engaged in work in the pressing complex shall have the responsibility for keeping the work area clean and neat.
C. OPERATION — Cont'd

7. Routine cleanup shall be done at the completion of each day's work and a completed cleanup shall be done once a week or at the direction of the Building Supervisor.

8. All scrap explosives shall be placed in covered scrap high explosives containers and the containers shall be emptied at the completion of the day's work.

9. The floor in the Press Building is to be kept clean and dry as possible during explosives operations.

10. Due to the explosives limits for the Press Area, special effort shall be made to plan the next day's work load so that Stores will deliver the explosives requirements in the afternoon preceding the day it will be used, and, at the same delivery time, the explosives parts pressed during that day will be taken to the magazine or to Building 306 as required.

11. No vehicle will be permitted in the earth barricade except when the processing building has been released for maintenance or is not engaged in explosive pressing.

12. Personnel Limits
   a. Loading Operation (Contact Work)
      Maximum personnel limits inside the earth barricade will be four (4) persons during the pre-pressing operation. A minimum of two (2) persons, one a qualified operator of the processing equipment, must be present.
   b. Pressing Operation (Remote Work)
      No person shall be inside the earth barricade during the remote pressing of explosives.
   c. Personnel
      Personnel limits shall be posted on placards outside and inside the Press Building and are not to be changed without prior approval of Hazards Control and the Building Supervisor.

13. Explosive Limits
   * a. The total poundage and number of items permitted in the Press Building and in-process storage shall not exceed 850 pounds.
   * b. The in-process magazine shall not be opened during remote operations.
   * c. Non-compatible explosives will not be simultaneously processed in the Press Building.

*Rev. (2-23-60)
Procedure No. B-2* (p. 3 of 3)

OPERATION OF UTILITY PRESSING BUILDING – Cont’d

C. OPERATION – Cont’d

13. Explosive Limits – Cont’d

d. Explosives are not permitted in the control shack, or near the air compressor, steam generator and the electrical controls on the back exterior wall of the control shack.

NOTE: To obtain better efficiency for a Monday operation, the following procedure may be used:

1. Secure drying oven Friday afternoon and allow to cool.
2. Place required amount of explosives for Monday morning activities in the cool oven.
3. Set oven controls so that it can be started from the control building.
4. Erect high explosives barricades.
5. Notify Operations, Police, and Hazards Control that explosives are in the area (oven).
6. Schedule with Maintenance Machinists to start oven early Monday A.M., from control building. Oven temperature can be determined by the remote temperature gauge in the control room.

APPROVED: (Signed) S. H. Swanson
Site 300 Operations

APPROVED: (Signed) J. S. Dittig
Hazards Control

*Rev. (2-23-60)
OPERATION OF VACUUM CART

A. ALLOWABLE EXPLOSIVES

1. T.N.T.
2. PBX 9401
3. PBX 9404
4. PBX 9406
5. Mock high explosives
6. Comp A-3
7. PBX 9010
8. DATB

Special permission must be obtained from Hazards Control to process other explosives.

B. EQUIPMENT AND MATERIALS

1. Vacuum pump and distribution system
2. Vacuum cart
3. Cold traps
4. Liquid trap

C. OPERATION

1. Since the vacuum cart is portable, the power lead to the explosion-proof motor must always be connected to the approved explosion-proof wall receptacle when the cart is operated in an explosive area.

2. The cold trap nearest the container must be filled with liquid nitrogen, dry ice, and suitable solvent when the vacuum cart is used to evacuate explosive-filled containers. Cooling of the second cold trap is optional.

3. The liquid trap must be filled only with high-vacuum-type hydraulic oil.

4. The oil level is determined by the vacuum required at the outlets. Roughly, an oil level of 1" above the end of the inlet pipe will give a vacuum of 500 microns at the outlet.

5. Due to the design of the distribution system, the pump must not be turned off when the system is under vacuum.

*6. The cold trap nearest the vacuum outlets should be inspected and cleaned once a week.

7. The oil trap should be cleaned once a week, the oil and residue removed.

8. In cleaning the vacuum cart of explosive powder and residue for any maintenance work, special care must be taken as follows:

*Rev. (9-29-59)
C. OPERATION – Cont’d

8. a. Each vacuum valve must be disassembled, inspected and cleaned.
   b. Each individual filter at the vacuum outlets must be cleaned.
   c. The oil trap and two cold traps must be cleaned.
   d. The polystyrene filter in the Stokes gauge must be inspected and removed if contaminated with explosive powder or residue. The glass unit with the polystyrene filter will be disposed of in the approved manner for explosive-contaminated glass ware.
   e. If any power tool or heat is to be used on the distribution system, it must be disassembled and retained in the explosive area until such time as it can be flame decontaminated and certified free of explosives. If this certification cannot be made, a new distribution system must be built. This is necessary since steam and solvent cleaning can not entirely decontaminate the distribution system.
   f. Even though the vacuum cart is enclosed with metal panels, the design is not dust proof and must be decontaminated with the rest of the system.

APPROVED: (Signed) B. F. Barrows
Site 300 Operations

APPROVED: (Signed) J. O. Vineyard
High Explosive Safety
DRIYING, PREHEATING AND ANNEALING EXPLOSIVES

A. ALLOWABLE EXPLOSIVES

1. T.N.T
2. PBX 9401
3. PBX 9404
4. PBX 9406
5. Mock high explosives
6. Comp A-3
7. PBX 9010
8. DATB

Special permission for other explosives will be obtained from the High Explosive Safety Office when required.

B. EQUIPMENT AND MATERIALS

1. Small Steam Oven, 12" X 12" X 12" internal dimensions (max. explosive poundage - 20 pounds).
2. Stokes Vacuum Ovens, 40" X 24" X 24" (max. explosive poundage - 360 pounds).
3. Steam Oven, 24" X 24" X 24" internal dimensions (max. explosive poundage - 60 pounds).
4. Drying trays (metal).
5. Weighing scales.

C. OPERATION

1. Steam pressure will be regulated between 1 to 30 psig to provide the desired operating temperature level. Maximum steam pressure to be 30 psig.
2. All material to be dried, preheated or annealed shall be placed in the metal drying trays. The elastomer containers shall not be used as drying trays.
3. The metal trays shall not be filled with more than a 3" thickness of explosives.
4. When required, material shall be weighed in trays before loading in oven.
5. The material shall be held at the desired temperature for at least 30 minutes before removing from the oven. The temperature should be determined with a glass thermometer that has been inserted into the material for at least 2 minutes.
C. **OPERATION** — Cont'd

6. In placing and removing the trays in the oven, care should be taken to prevent spillage. Any spillage of explosives must be cleaned up and removed from the oven immediately.

7. Only the metal trays, glass or metal thermometer and the material being dried or annealed shall be in the oven when the oven is in operation overnight.

8. The elastomer containers and caps shall be preheated only when personnel are available to maintain a regular check on the oven.

9. a. Secure drying oven Friday afternoon and allow to cool.
   b. Place required amount of explosives for Monday morning activities in the cool oven.
   c. Set oven controls so that it can be started from the control building.

10. a. Erect high explosive barricades.
    b. Notify Operations, Police, and High Explosive Safety that explosives are in the area (oven).
    c. Schedule with maintenance machinists to start oven early Monday A.M., from control building. Oven temperature can be determined by the remote temperature gauge in the control room.

11. Special attention shall be given to the grounding of the oven and auxiliary equipment. The oven shall be permanently grounded to the building grounding system. The metal trays should be grounded to the building grounding system when transferring the explosives to or from the trays.

12. A minimum air gap of 1/32" should be provided between the oven shelf and the bottom of the metal trays to prevent localized overheating of the explosive material.

**APPROVED:** (Signed) B. F. Barrows  
Site 300 Operations

**APPROVED:** (Signed) J. O. Vineyard  
High Explosive Safety
LOADING OF ELASTOMER CONTAINERS FOR PRESSING

A. ALLOWABLE EXPLOSIVES

1. T.N.T.
2. PBX 9401
3. PBX 9404
4. PBX 9406
5. Mock high explosives
6. Comp A-3
7. PBX 9010
8. DATB

Special permission for other explosives will be obtained from the High Explosive Safety Office when required.

B. SCOPE

This procedure shall be used for loading of elastomer containers for isostatic pressing operations.

C. EQUIPMENT AND MATERIALS

1. Vacuum system
2. Elastomer containers
3. Elastomer or metal closures
4. Scoops, tamps, spatulas, gloves, respirators
5. Vibrating table (shaker table)

D. OPERATION

1. If preheating of the container is required, place the elastomer container in the oven that is maintained at the desired temperature (not to exceed 130°C).
2. Surfaces of the container shall be clean before filling.
3. Pour into the container the pre-determined quantity of material to be pressed. Gloves and respirators are to be worn during all transfer operations or when dust conditions are prevalent. See Procedure B-4 for preparation of pressing materials. The shaker table may or may not be used depending on the bulk density prior to pressing.
4. Transfer of material from drying tray to containers should be performed by either pouring or scooping.
5. All items of equipment are to be grounded during the transfer operations.
D. OPERATION – Cont'd

6. The container shall be loaded as uniformly as possible and the top surface level. If pre-consolidation by tamping is prescribed, this must be performed uniformly. If consolidation by use of the shake table is to be performed, pressure setting on air supply to table regulator should not exceed 60 psi.

7. Insert the top closure into the container opening and, depending on the type of closure, ascertain that seal beads are in groove, slip seals on closure are concentric with container walls, etc.

8. Connect vacuum system outlet to valve outlet on container closure and evacuate to the level specified by operating instructions as indicated by Stokes gauge on the vacuum cart.

9. Close pump valve on top of vacuum cart and determine the container vacuum leak rate by observing pressure increases for a minimum 1-minute period.
   a. The pressure increase rate should not be greater than specified in operating instructions. If the pressure increase rate is greater than specified, check seals, valves, hose clamps, etc., for vacuum leak.
   b. If the specified total vacuum time as indicated by operating instructions is exceeded, the material should be reheated and the evacuation cycle repeated.

10. When vacuum requirements are satisfied, close the valve outlet on container closure and disconnect from vacuum system outlet. The container and charge are then ready for pressing.

APPROVED: (Signed) B. F. Barrows
Site 300 Operations

APPROVED: (Signed) J. O. Vineyard
High Explosive Safety
A. ALLOWABLE EXPLOSIVES

1. T.N.T.
2. PBX 9401
3. PBX 9404
4. PBX 9406
5. Mock High Explosives
6. Comp A-3
7. PBX 9010
8. DATB

Use of other explosives requires approval of High Explosive Safety Office prior to pressing.

B. SCOPE

This procedure shall be used for consolidating explosive charges confined in elastomer containers with flexible or rigid closures.

- Maximum unpressed container dimensions: \(7\frac{1}{2}\)" dia. \(\times\) 14" length
- Maximum pressure: 20,000 psi to 120°C
- 16,000 psi at 150°C
- Maximum charge weight: 40 lbs.

C. EQUIPMENT AND MATERIALS

1. 8 in. isostatic press, Press Building.
2. Auxiliary equipment items, i.e., handling, hand tools, etc.

D. OPERATION

1. Ascertain that vessel and hydraulic system have been checked out prior to pressing explosives.
2. Open pressure vessel by removing top plug and nut using the worm gear hoist and steel bars to unscrew the nut. Place the top plug and nut on the top of the pressure vessel, thereby clearing the opening.
3. Inspect the threads in both the vessel body and nut, and the "O" ring groove for foreign material. Clean if necessary. Then lubricate the threads with molykote and oil.
4. If the press fluid is to be heated, fill the vessel and insert plug and nut to full close position. Turn on steam to external heating coils. Steam pressure to be set according to desired operating temperature.
5. After the elastomer container has been evacuated, load it into the pressure vessel using the handling sling. The container and surfaces should be clean before placing them into the pressure vessel.
Procedure No. B-6 (p. 2 of 2)

OPERATION OF THE 8 IN. I.D. ISOSTATIC PRESS — Cont'd

D. OPERATION — Cont'd

6. Adjust the liquid level to within 1" of the body threads.
7. Lower the top plug and nut into place using the hoist. Screw nut into place until the two match marks are in line. The air bleed-off valve (No. 74) is to be open during the placing of the top plug to relieve any trapped air. After the air is bled off, close valve No. 74.

8. The pressure vessel is now ready for pressurizing. (Procedure B-2 for personnel control.)
9. Pressurize the vessel from the control shack until the desired pressure level is reached.
10. Dwell at the desired pressure for a minimum of 3 minutes.
11. After dwelling, depressurize.
12. Return to the Press Building.
13. Open the pressure vessel and remove the container using the handling sling.
14. Remove any excess fluid from the exterior of the container using compressed air.
15. Release vacuum from the container, remove the closure and the pressed part from the container.
16. Anneal the pressed part in the annealing oven or by wrapping in kim-pack as prescribed in the pressing instructions.
17. Inspect the container and closure for embedded explosives; wash the container and closure with hot water or steam. Container should be thoroughly dried before using again.
18. Cover the vessel opening at the end of the pressing operations. The threads in the body and nut should be inspected, cleaned if necessary and given a coating of molycote and oil if necessary.

APPROVED: (Signed) B. F. Barrows
Site 300 Operations

APPROVED: (Signed) J. O. Vineyard
High Explosive Safety
APPENDIX 2

PHYSICAL DAMAGE CAUSED BY THE EXPLOSION

Figures 6 - 12 show various views of the facility after detonation. The plywood "PortaHouse" frangible building was demolished beyond repair.

The press building housed both the 8-inch and 18-inch isostatic presses. Accessory equipment included a Stokes vacuum oven, shake table, scales, vacuum and pressure carts. See Fig. 3. The 8-inch press was a conventional pressure vessel of single-end construction. (See Fig. 4.) It had an 8-inch inside diameter and a 16-inch-deep pressure chamber. The chamber walls were 3 inches thick. The forging was from SAE4340 steel.

A list of equipment damaged beyond repair is the following:

1. 8-inch pressure vessel
2. Plug stand for 18-inch vessel
3. Stokes vacuum oven
4. Vacuum cart
5. 300 lb weighing scale
6. Steam jacket of 18-inch vessel
7. Stand for 8-inch press
8. Small steam oven
9. Shake table
10. Steam valve - oven control
11. Remarco, hi-pressure control valve
12. Baldwin strain gauge pressure cells
13. Work table
14. Sink

Items only partially damaged were:

1. Air hoist and tractor
2. "A" frame for air hoist
3. Stand for scale
4. Sprague C-300 pressurizing system
5. Sprague C-60 pressurizing system
Fig. 3. Floor plan and equipment layout of Press Building.
Fig. 4. Cross section of 8-inch isostatic press.
Fig. 5. Distribution of shrapnel over the area after the explosion.
Fig. 6. General view - looking south and SE from north edge of west berm.
Fig. 8. Looking north from approx. half way up south berm. Stokes oven, on its side, in center of picture. Overturned pressurizing cart in foreground.
Fig. 9. Looking approx. NE from half way up west berm. 18-inch pressure vessel visible beneath light.
Fig. 10. View looking into Press Building from the NE corner. Note: 1. external coil damage to 18-inch pressure vessel; 2. apparently un-damaged hoist and tractor; 3. caved-in stand which held the 8-inch pressure vessel.
Fig. 11. Looking west from foot of east berm. Note "A" Frame structure and, just to the left, the two largest pieces of the 8-inch pressure vessel.
Fig. 12. Close-up view of the two largest pieces of the 8-inch pressure vessel.
APPENDIX 3

FRAGMENT DISTRIBUTION FROM THE 8-INCH PRESS EXPLOSION

An attempt was made to locate the shrapnel pieces of the 8-inch pressure vessel. Two pieces of the vessel base were found within two feet of the original location of the vessel. The majority of pieces were found buried in the earth barricade. The press plug and nut assembly was found 338 ft NE of the explosion site.

To date, 630 lb of shrapnel from the 1000-lb pressure vessel have been recovered. Figure 5 is a map showing the location of shrapnel pieces.
APPENDIX 4

CHEMICAL STUDIES ON CAUSE OF ACCIDENT

Prior to the explosion, the following drop hammer, hot block, and spark test results were known:

<table>
<thead>
<tr>
<th>Material</th>
<th>Impact sensitivity</th>
<th>Hot block test</th>
<th>Spark test</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-50 lead-HMX</td>
<td>21 cm</td>
<td>No reaction at 255°C</td>
<td>No detonation</td>
</tr>
<tr>
<td>HMX</td>
<td>30 cm</td>
<td>No reaction at 255°C</td>
<td>No detonation</td>
</tr>
<tr>
<td>PETN</td>
<td>12 cm</td>
<td>Rapid decomposition at 190°C</td>
<td>No detonation</td>
</tr>
<tr>
<td>PBHNL</td>
<td>31 cm</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

After the explosion, the vacuum thermal stability of various combinations of lead (Pb), nitrocellulose (NC), tris-β-chloroethylphosphate (CEF), and HMX were investigated. Table I lists the mixtures tested, their composition in weight percent, and the degree of reaction at elevated temperature as measured by the amount of gas evolved.

**TABLE I**

Summary of Thermal Decomposition Experiments

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Weight percent</th>
<th>Measured rate of gas evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb-HMX</td>
<td>50/50</td>
<td>No reaction at 110°C in 45 min or at 140°C in 78 min.</td>
</tr>
<tr>
<td>Pb-CEF</td>
<td>50/50</td>
<td>No reaction at 101°C in 38-3/4 hr.</td>
</tr>
<tr>
<td>Pb-NC</td>
<td>50/50</td>
<td>&lt; 0.1 ml/g/hr at 100°C (see Note 1).</td>
</tr>
<tr>
<td>HMX-CEF-Pb</td>
<td>33/33/34</td>
<td>No reaction at 101°C in 21-1/4 hr.</td>
</tr>
<tr>
<td>HMX-CEF-NC</td>
<td>94/3/3</td>
<td>&lt; 0.1 ml/g/hr at 120°C.</td>
</tr>
<tr>
<td>HMX-NC-Pb</td>
<td>33/33/34</td>
<td>&lt; 0.1 ml/g/hr at 101°C.</td>
</tr>
<tr>
<td>CEF-NC-Pb</td>
<td>33/33/34</td>
<td>0.64 ml/g/hr at 101°C.</td>
</tr>
<tr>
<td>HMX-NC-CEF-Pb</td>
<td>25/25/25/25</td>
<td>0.46 ml/g/hr at 101°C.</td>
</tr>
</tbody>
</table>
TABLE I (Contd.)

Note 1: The total rate of gas actually evolved was ~0.3 ml/g/hr at 100°C. Mass analysis of this gas, however, indicated that it was almost all water. Further work is required to determine if the water is a result of lead-nitrocellulose interaction. The value presented in the table is for the sum of such gases as N₂O, NO, etc., which can only come from the decomposition of nitrocellulose.

Two mixtures, CEF-NC-Pb and HMX-NC-CEF-Pb, evolved considerable gas in 21 hours at 101°C. This gas was analyzed mass spectrometrically, and the results are presented in Table II.

TABLE II

<table>
<thead>
<tr>
<th>Gas</th>
<th>From CEF-NC-Pb mixture (mole %)</th>
<th>From HMX-CEF-NC-Pb mixture (mole %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂O</td>
<td>20.0</td>
<td>20.7</td>
</tr>
<tr>
<td>NO</td>
<td>34.0</td>
<td>26.7</td>
</tr>
<tr>
<td>N₂</td>
<td>9.6</td>
<td>10.3</td>
</tr>
<tr>
<td>CO₂</td>
<td>30.1</td>
<td>32.3</td>
</tr>
<tr>
<td>CO</td>
<td>4.6</td>
<td>5.0</td>
</tr>
<tr>
<td>H₂O</td>
<td>1.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Air</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The above data indicates that the exothermic reaction responsible for the press explosion is one which takes place between lead, nitrocellulose, and CEF. All three ingredients apparently must be present since, when tested in pairs, little or no reaction was observed (see qualifying Note 1 in Table I).
Experimental

The mixtures containing CEF were prepared by first blending the finely divided solid ingredients, placing them in a glass tube and adding the liquid CEF. These mixtures were then sealed in the glass tube under vacuum and heated for varying lengths of time. The amount of gas formed was measured using a manometer after opening the sealed tube on a vacuum line.

Mixtures not containing the slightly volatile CEF were prepared by pressing a blend of the finely divided powders into a pill. These pills were heated under initial vacuum in a vessel directly attached to a manometer. The amount of gas evolved was thus continuously observed. In both cases the decomposition gases were periodically sampled and analyzed on a mass spectrometer.
APPENDIX 5

FINANCIAL STATEMENT

Information on construction, activation, and equipment costs, obtained from the Plant Engineering, Plant Services, and Inventory departments, showed the following:

A. Initial Costs

1. Construction of temporary press facility $13,250
2. Activation costs (crafts) 6,000
3. 8-inch pressure vessel 2,500
4. Ovens, pressure carts, miscellaneous equipment 4,000

$25,750

B. Estimate of Losses

1. Press building $3,000
2. Activation costs 3,500
3. 8-inch pressure vessel 2,500
4. Ovens and miscellaneous equipment 3,500

$12,500

Note: The cost of the 18-inch isostatic pressure vessel ($24,000) is not shown. A visual inspection showed that this vessel, excluding the heating jacket, was not damaged. Tests are presently being performed to determine this.
LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.