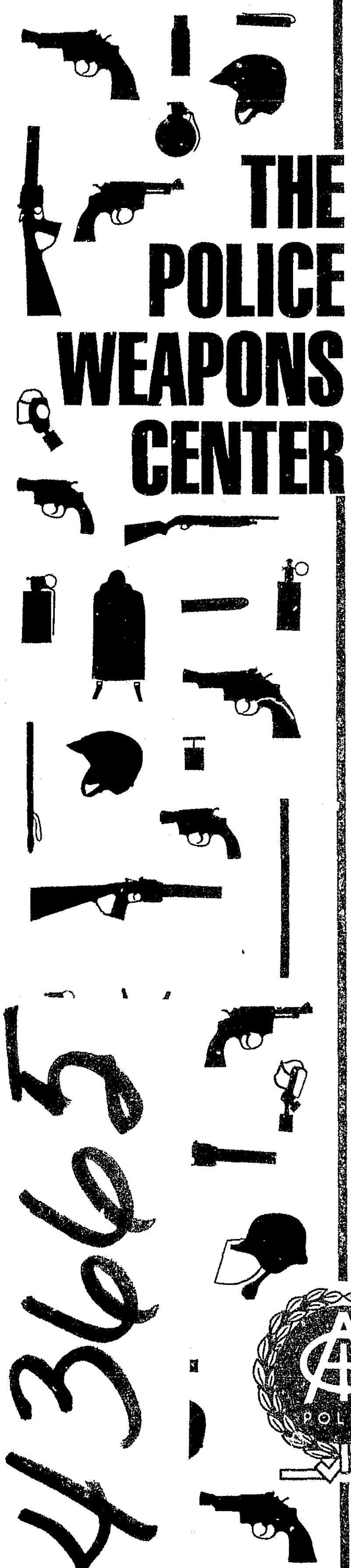
PWC EVALUATION REPORT



EXPERIMENTAL DESIGN AND EVALUATION OF A BOMB DISPOSAL UNIT

INTERNATIONAL ASSOCIATION OF CHIEFS OF POLICE
RESEARCH DIVISION □ POLICE CASUALTY ANALYSIS UNIT
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EXPERIMENTAL DESIGN AND EVALUATION OF A BOMB TRANSPORT UNIT

CONTENTS

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EXPERIMENTAL DESIGN AND EVALUATION OF A BOMB TRANSPORT UNIT

Prepared by

Batelle Memorial Institute

Columbus, Ohio

For

International Association of Chiefs of Police

INTRODUCTION

As a result of a number of discussions with the International Association of Chiefs of Police, a joint program was initated by IACP and Battelle's Columbus Laboratories for the experimental design of a bomb disposal unit. It was anticipated that the design, fabrication, and evaluation of this unit would provide information for the design of a unit that could be utilized by law enforcement groups throughout the United States. Originally it was hoped that such a unit could be built for about $3,000. However, as the program progressed, it became evident that this estimated cost would be low, primarily because of an increase in the cost of industrial prices since the fourth quarter of 1970 and the desire to establish ASME Code qualified procedures for the fabrication of the containment vessel.

An upper safe limit of explosive weight contained in the vessel was not specified because of the lack of valid data on the response of vessels of this type to explosive loading. However, 50 pounds of 60 percent dynamite were set as the desired goal, and design considerations were based on safely containing this amount of explosive.

Views of the complete bomb disposal unit are shown in figures 1 and 2. These pictures were taken at the test site near Athens, Ohio, before the final series of tests.

DESIGN AND CONSTRUCTION

Design of the Containment Vessel

The design of the containment vessel was based upon the most efficient utilization of materials, cost, repairability, and ease of and general availability of fabrication and fabricators throughout the United States. The design based upon these considerations evolved as a welded thin-walled cylindrical container open at the top and closed at the bottom with a dish-flanged head. A replaceable inner liner was mounted within the cylinder so that an annular layer of sand separates the liner from the main vessel. The bottom of the vessel is filled with sand to a height of about 4 inches above the lower end of the liner. The liner serves two purposes: to retain the annular ring of sand in position, and to provide additional protection of the primary load-bearing vessel walls against high velocity fragments.

Sand was selected as a filler because it was a low cost method for increasing the mass of the vessel to alter the response to explosive loading from one controlled by the peak pressure of the blast wave to one controlled by inertial forces.

The approximate dimensions of the vessel, selected on the basis of design calculations, were as follows: Vessel diameter – 6 feet O.D., vessel height – 6 feet, vessel wall thickness – ¾ inch, liner height – 3 feet, liner diameter – 5½ feet, liner thickness – 3/8 inch. Dimensions and details of the vessel are given in the working drawings, figures 3 and 4. The primary vessel was fabricated by the welding of one cylindrical section and two flanged-dished heads.

A flanged-dished head was selected for the bottom of the container because of its increased load carrying ability as compared to a flat bottom. The same shape was utilized for the top of the vessel to retain a greater number of fragments within the container by reduction of the top opening.

Figure 1
VIEW OF BOMB CONTAINMENT UNIT BEFORE
FINAL SERIES OF TESTS

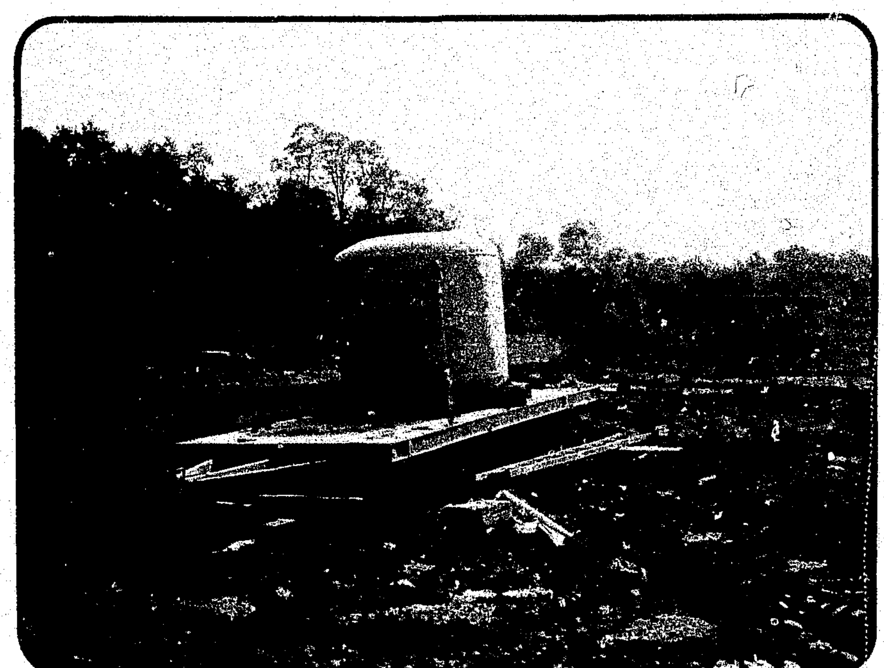


Figure 2
VIEW OF BOMB CONTAINMENT UNIT BEFORE
THE FINAL SERIES OF TESTS

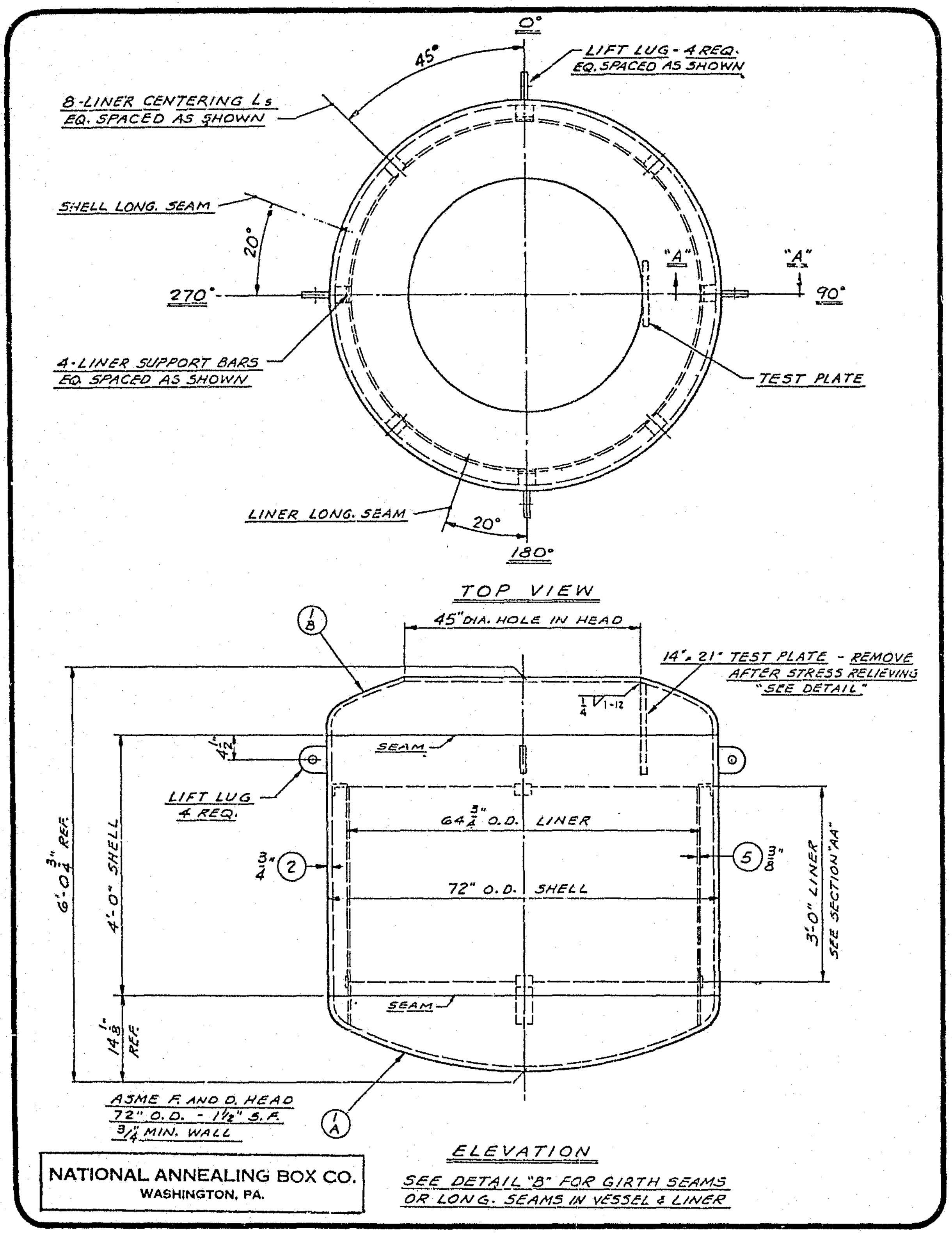


Figure 3
DESIGN SPECIFICATIONS

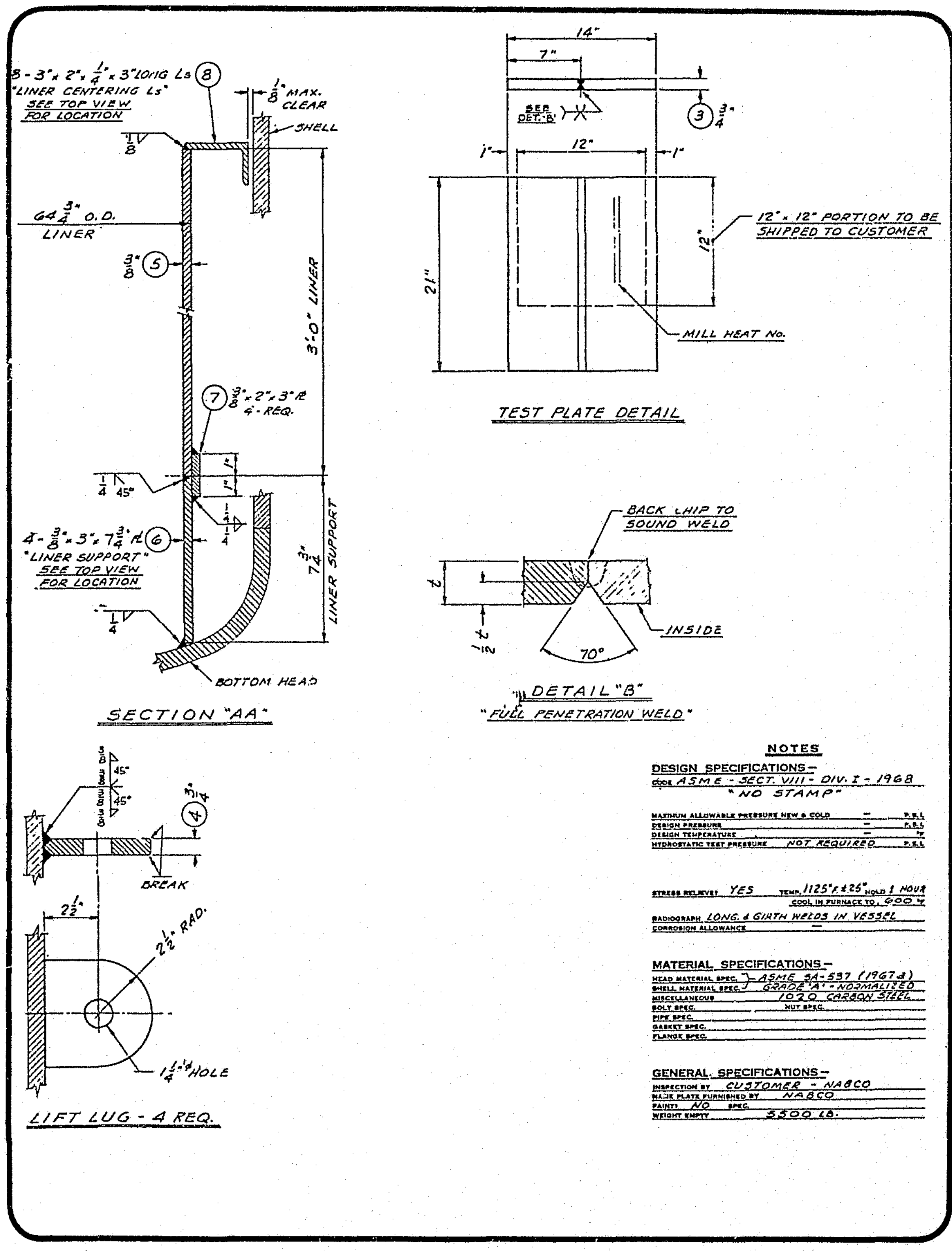


Figure 4
DESIGN SPECIFICATIONS

Flanged-dished heads are standard shapes readily available in the United States. The upper portion could also be produced by the forming and welding of plate.

Material Selection

Steel was selected as the vessel material on the basis of cost, strength, fabricability, and availability. The selection of a specific grade of steel for the primary vessel was based upon five considerations: (1) a high level of toughness, as measured by the Charpy notch-bar impact test, at low ambient temperature, (2) weldability, (3) cost, (4) availability, and (5) the fact that steels with good impact properties at low temperatures must be high-quality steels. This provides additional assurance that deformation of the steels will not be adversely affected by unacceptable defects or improper processing.

The steel grade selected is designated as ASTM A537A or as ASME boiler steel SA-537A. This is a high-quality carbon steel with a nominal composition of 0.15-0.2 percent carbon, 1.2 percent manganese, 0.2 percent silicon, sulfur less than 0.02 percent, and phosphorus less than 0.01. The actual certified analysis and tensile properties of the steel used for the primary vessel are given in Appendix A. This steel, as specified by the American Society for Testing Materials (ASTM) or the American Society for Mechanical Engineers (ASME) boiler code, will have a minimum yield strength of 50,000 psi and elongation in 8 inches of 18 percent. In addition, this steel will have guaranteed minimum Charpy notched-bar impact strength value of 12 foot-pounds at a temperature of -75 Fahrenheit, a temperature far below expected ambient temperatures. Nominal values for impact strength at -75F are about 30 foot-pounds, and at -50F about 55 foot-pounds. This is a steel characterized by high levels of toughness even in the normalized heat-treatment condition that was specified for the vessel. This type of heat treatment was specified because it only requires heating to the specified temperature for the correct length of time and air cooling as compared with the more complicated heat treatments involving heating, quenching, and tempering which yield higher levels of impact strength.

The steel used for the liner was a standard composition low carbon steel, AISI 1020. Since the liner is not a part of the primary structure, its properties and characteristics do not require specification. In fact any grade of low carbon steel available would be satisfactory. It is assumed that the liner would be patched when perforated with fragments, or replaced in whole or part when excessively damaged.

Fabrication

Fabrication of the vessel is as important as the selection of the material. Improper welding practices could readily degrade the excellent basic properties of the steel, and even introduce flaws that would lead to failure well below design levels.

Since one of the major objectives of the program was to develop commercial fabrication procedures, quotations were requested from three firms for the construction of the vessel according to qualified ASME boiler code requirements for pressure vessels. The National Annealing Box Company (NABCO) of Washington, Pennsylvania, won the contract on the basis of price and procedures.

In the development of qualified welding procedures, the fabricator submits procedures for the type of welding process involved and the results of test plates welded by a specific welder following the procedure. The welder who performed those tests is then qualified to weld with the submitted procedure in accordance with ASME Code requirements. The welding procedure includes all of the aspects involved in welding, such as weld joint design, welding machine, welding parameter (voltage, amperage, polarity, welding speed), the number of welding passes, type of welding (machine or manual), type of electrode and flux, preheat, and post-heat. The detailed qualified procedures submitted by NABCO and accepted by us for two welding processes, submerged arc welding and shield arc welding, are given in Appendix B. These procedures can be used for the welding of other containers.*

The Trailer

The trailer used for this experimental bomb disposal unit was supplied by the Fayette Manufacturing Company of Fayette, Ohio – Grand Island, Nebraska, and Americus, Georgia. The trailer selected was a Model 10212, double axle with 12,000 pounds capacity. This is a standard trailer and was not modified. This trailer, equipped with electric brakes, retails for about $1,000. A schematic sketch of the trailer is shown in figure 5. As will be discussed subsequently, a stronger trailer will be required, such as another model of the Fayette line with modification that will withstand the impulsive short-time-duration load generated by the detonating explosive.

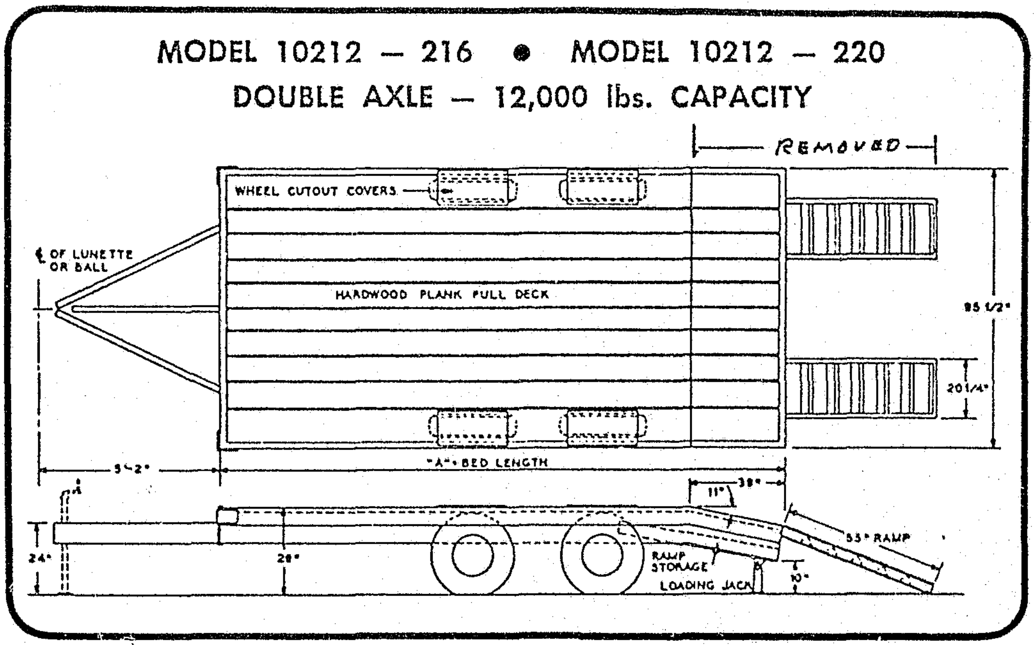


Figure 5
SCHEMATIC SKETCH OF THE TRAILER USED IN THE EXPERIMENTAL BOMB DISPOSAL UNIT

*It should be mentioned that if a fabricator is given the task of fabricating the vessel from a specified steel grade including the ordering of the steel, the fabricator is obliged to handle any discrepancies in the material with the steel supplier. If the fabricator is supplied the steel, the persons who purchased the steel are responsible for any negotiations with the steel supplier.

TEST AND EVALUATION

Two series of tests were conducted on the bomb disposal unit (container and trailer) using 60 percent dynamite as an explosive. In addition, two pipe bombs (2 inches in diameter and 10 inches total length) containing 60 percent dynamite were detonated in the bomb disposal unit.

In the first series of tests, four charges were detonated in the unit in 5-pound increments: 5, 10, 15, and 20. Measurement of the container showed no change in dimensions – no plastic (permanent) deformation. The liner, however, showed some plastic deformation at charges of 15 and 20 pounds at a position about parallel with the explosive charge. (The explosive charges were set on end on the sand in the center of the container.) Deformation of the liner increased as the charge was increased. At 15 pounds the liner was bulged outward about 3/8 inch over a distance of about 7 inches quite uniformly around the circumference of the liner. At 20 pounds the liner was bulged about 1 to 1¼ inches uniformly. The initial thickness of sand between the liner and the outer container was originally about 3 inches. After the tests, the thickness of sand at this portion of the container was only about 1¾ to 2 inches.

The trailer began to show significant effects of the blast load at 15 pounds of dynamite. At this point the trailer platform was striking the axles, and at 20 pounds, deformation of the axles and bending of the cross-members was evident.

The tests with 5 through 20-pound charges were run in Battelle's explosive facility at West Jefferson, Ohio. The detonation of larger amounts of explosive necessitated moving to the remote site near Athens, Ohio. Figure 4 shows the unit after the detonation of the first 50-pound charge. Note the bending of the trailer frame and the position of the trailer.

In the second series of tests, two pipe bombs and two 50-pound charges of 60 percent dynamite were detonated. The persons involved in these tests were Thompson Crockett and C.R. Newhouser of IACP, Thomas Brodie of the Dade County Department of Public Safety; and Joseph Dunleavy, Dr. Dale Trott, and Vernon Petry of the Columbus Laboratories. The results of the tests are as follows.

(1) **Pipe bomb, 1 pound of 60 percent dynamite.** Pipe 2-inch O.D. Total length 10 inches. Approximately 60 percent of the bomb was recovered within the bomb container (these were pieces large enough to be readily recognized). There was evidence that the restricted opening at the top of the container was responsible for the retention of some of the fragments in the container. This was particularly apparent with respect to fragments that had ricocheted off the sloping top of the container and remained on the annular sand ring between the liner and the container shell. Several deep indentations were made in the liner, some of these reaching a depth about ¼ of an inch or about 2/3 of the liner thickness. This type of fragment damage is one of the basic reasons for an internal repairable or replaceable liner which will absorb fragment impact and protect the principal container walls.

(2) **Pipe bomb** – a duplication of the first bomb. Motion pictures taken of these tests may give some indication of fragment pattern.

After both tests (1) and (2), no measurable change was noted in the container. The liner was also unaffected by the blast wave (no additional bulging).

(3) **Fifty-pound charge of 60 percent dynamite.** The detonation of this charge expanded the liner a total distance of 2 inches from the vertical, leaving about 1 inch of sand between the liner and the container wall. The container wall underwent plastic deformation at this point of about 0.57±0.04 percent and at a distance of about 9-10 inches above the bottom weld of the container, as shown in figure 6. At a distance of 24 inches above the bottom weld, the strain was about 0.1±0.04 percent, and at a distance of 39 inches above the bottom of the weld, there was no measurable strain.

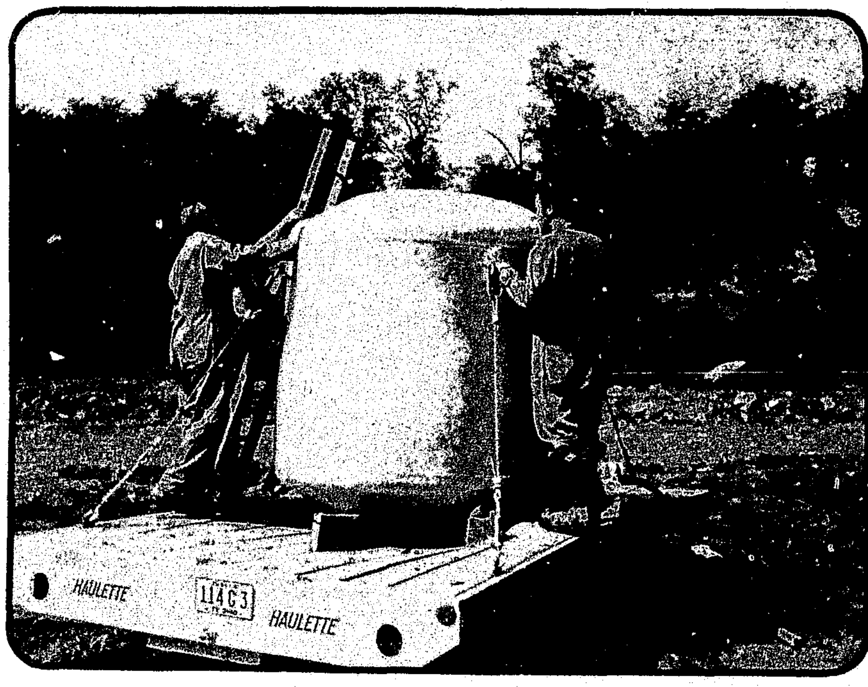


Figure 6
BOMB CONTAINMENT UNIT AFTER DETONATION OF THE FIRST 50-POUND CHARGE

The trailer was badly damaged: axles and main supporting members under the container were bowed.

(4) **The second 50-pound charge of 60 percent dynamite.** Detonation of this charge split the liner in two places for a length of about 10-14 inches. Fracture of the liner occurred at the point of previous bulging about 9-10 inches above the bottom weld seam of the container. The entire liner was bulged in this area to the extent that less than 1 inch of sand remained between the liner and the container wall. The plastic strain at the bottom, middle, and top positions is 1.67±0.04, 0.3±0.04 percent, and no measurable strain respectively. Measurements of the flanged-dished bottom section showed no significant change in dimension. The trailer was completely incapacitated by this detonation. Axles were down to within 1 or 2 inches of the ground. Main supporting members were badly bent.

Figures 7, 8, 9, and 10 are views of the container and trailer after the detonation of the second 50-pound charge. The fracture of the inner liner and the bulge (plastic deformation) of the container are clearly shown; however, the container shows no evidence of fracture.

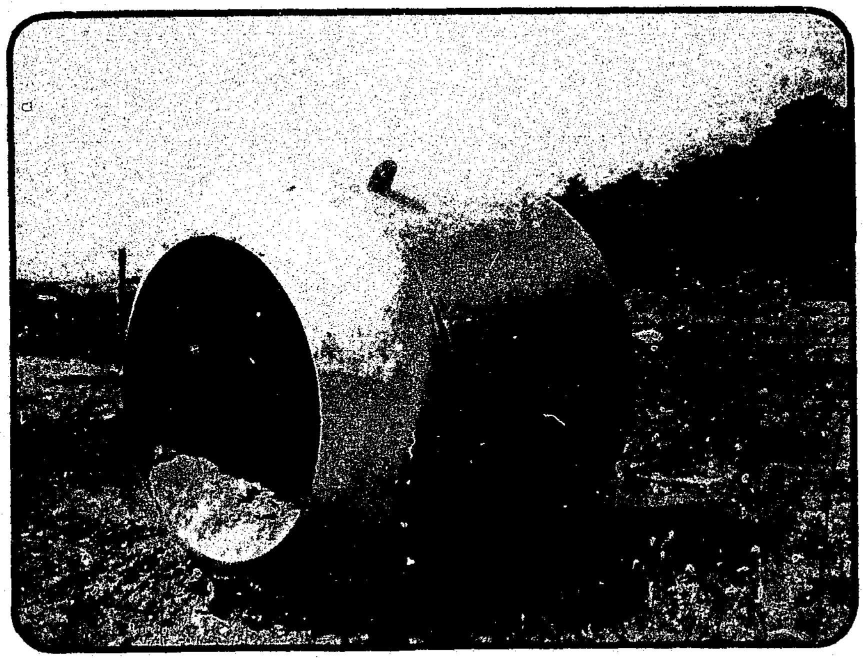


Figure 7
FRONT VIEW OF THE CONTAINER AFTER DETONATION
OF SECOND 50-POUND CHARGE

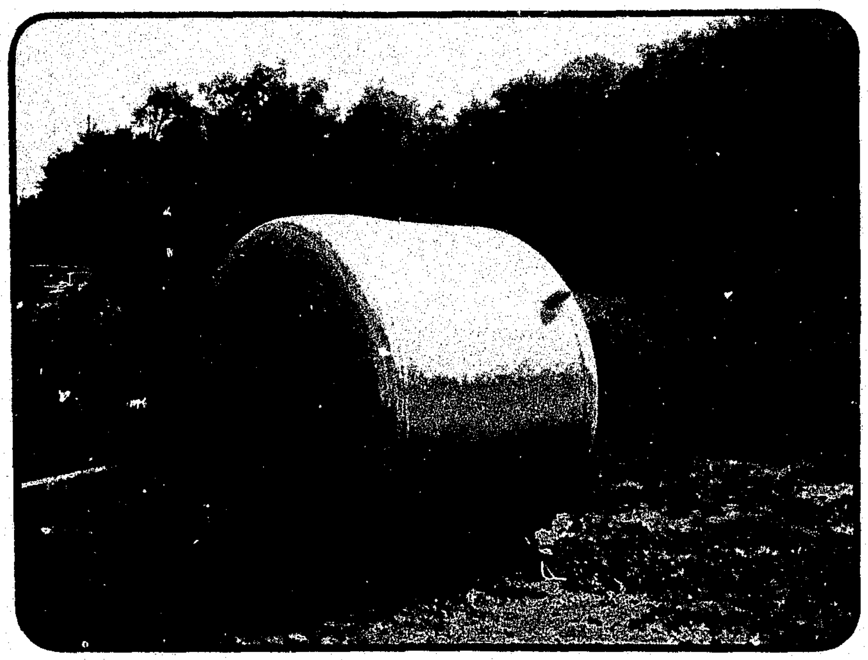


Figure 8
REAR VIEW OF THE CONTAINER AFTER DETONATION
OF THE SECOND 50-POUND CHARGE

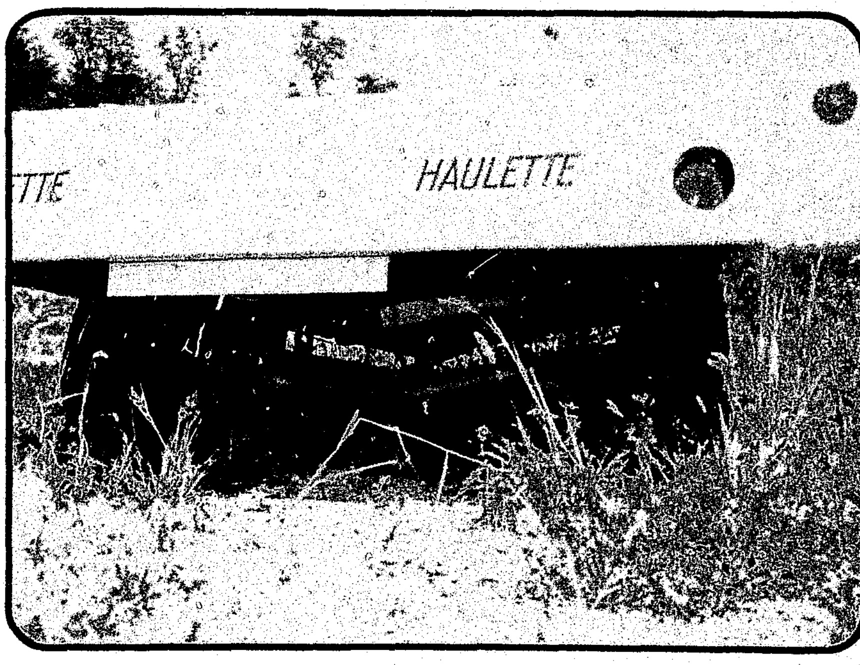


Figure 9
REAR VIEW OF THE TRAILER AFTER DETONATION
OF THE SECOND 50-POUND CHARGE

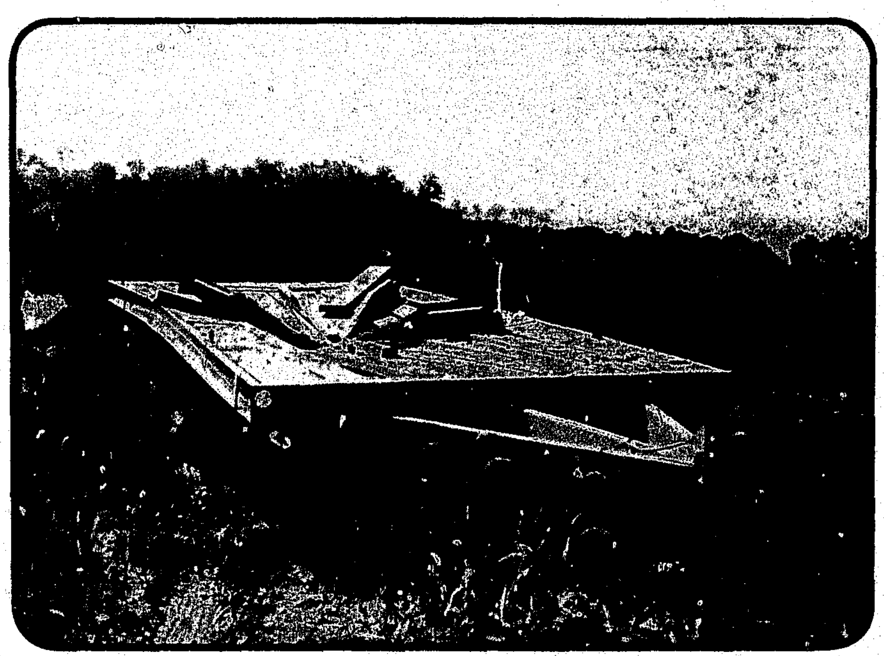


Figure 10
FRONT VIEW OF THE TRAILER AFTER DETONATION
OF THE SECOND 50-POUND CHARGE

DISCUSSION

The evaluation of the bomb disposal unit showed that the container safe limit is *at least* 50 pounds of 60 percent dynamite. If the liner had been replaced prior to detonation of the 50-pound charges it appears that very little, if any, deformation of the container shell would have occurred. With a new liner, deformation of the shell at the point of maximum load, approximately 9 inches above the bottom weld of the vessel, would have been less than the deformation at the middle measurement position (24 inches above the bottom weld) – less than 0.1 percent strain. Nevertheless, the 50-pound tests were conducted under these severe conditions so that significant plastic strain would occur, and the integrity of the container could be assessed. After a plastic strain of 1.67 percent, the container showed no evidence of cracking or fracture. Deformation that occurred was ductile in nature and uniform over the area of maximum load. With a new liner, this vessel could be safely used for charges up to 50 pounds. Inspection of the container would be necessary, however, after each detonation of this magnitude to determine whether plastic deformation was continuing. At this point it appears that the limit of this container, before fracture would occur, would probably be in the range of 75 to 100 pounds of 60 percent dynamite.

The trailer used in this bomb containment unit was definitely inadequate. It appears from the approximate amount of deflection noted during detonations, 8 to 10 inches with the 50-pound charges, that significant strengthening of the structure under the container, springs, and axles is required. The results of the tests were transmitted to Fayette Manufacturing Company, and quite probably they will have recommendations for improvement.

The following discussion comments were prepared by C.R. Newhouser of the NBDC staff and were not a part of the original Battelle research report.

- During the testing phase of the bomb transporter, it was decided to develop and employ less than ideal conditions in relation to the type of sand employed, its moisture content, and the degree of compactness which would be allowed. This was done to determine if the bomb transporter could survive under less than ideal conditions which might inadvertently occur during heavy work load periods and under adverse weather conditions. Consequently, ordinary fine gravel sand was employed with no attempt made to control its moisture condition. After the damp sand was placed inside the bomb transporter, no attempt was made to prevent its compacting under the force of the test detonations. No breakup of compacted sand was performed after the detonation of 5, 10, 15, and 20 pounds of 60 percent strength dynamite. During the movement of the bomb transporter from West Jefferson, Ohio, to Athens, Ohio (approximately 100 miles), some shifting and settling of sand was noted due to normal road shock and air passage across the sand through the uncovered vent opening.

- The detonation of the two dynamite-filled pipe bombs may have caused some breakup of the packed sand in the bomb transporter, but during the fragment recovery operation, it was noted that the sand was hard packed at a depth of approximately 2 inches.

- Detonation of the first and second 50-pound charges of 60 percent dynamite produced additional compacting of the sand to produce an almost solid sandstone-like aggregate. At the completion of the tests, the tank was pulled from the damaged trailer with a bulldozer and tumbled and almost turned upside down upon impact with the ground. Inspection of the inside of the tank revealed that approximately 2/3 of the sand was still packed in position on the bottom of the tank after this tumbling action, indicating that a high degree of sand compacting was present during testing. In spite of these adverse conditions, the tank survived the test explosions and was deemed fit to contain additional detonations of similar magnitude.

- In operational bomb transporters, silicon sand should be employed as the shock absorbing medium inside the tank body. Silicon sand has excellent free flow and moisture resistant qualities. In addition, steps should be taken to protect the sand from exposure to rain or moisture by providing a lightweight removable rain cover for the vent opening of the bomb transporter.

- After any detonation occurs in the bomb transporter, the entire sand load should be dug through and turned to ensure that all compacted portions are restored to a free flow condition. If this is not accomplished, the shock absorption qualities of the sand may be almost totally lost and the blast pressure will be transmitted through the packed or caked sand directly to the outer container walls. This increases the possibility of plastic deformation of the outer body.

- Prior to detonation of the second charge of 50 pounds of 60 percent dynamite, Mr. Brodie, Mr. Donleavy, and Mr. Newhouser positioned themselves in the open at a distance of 100 feet from the bomb transporter and remained in that position during the test detonation.

- They reported that the shock wave was minimal at that position due to the highly directional and columnar venting of the exploding force in an upward direction.

- When detonation of an explosive charge in the bomb transporter occurs, a loud eerie rushing and whistling sound is produced (noticable after the sound of the detonation diminishes) which is heard for 5 seconds or longer. This sound is accompanied by a visible smoke ring which is rapidly projected upwards in a vertical line from the open end of the bomb transporter, and indicates that the vented gases and shock waves are being projected in a narrow column from the mouth of the tank. It is this feature, shown in figure 11, which provides a margin of safety in employment of the bomb transporter in congested high rise building areas. The majority of the explosive force is columnated and does not, therefore, tend to create structural or glass damage to the surrounding buildings.

Figure 11
VIEW OF THE CONTAINER AT THE MOMENT OF DETONATION OF FIFTY POUNDS OF 60 PERCENT DYNAMITE

APPENDIX A

CERTIFICATION OF MATERIAL

PURCHASER:

4 National Annealing Box Co.
Pur. Dept., Pur. Agent

LUKENS STEEL COMPANY

COATESVILLE, PA. 19320

TEST CERTIFICATE

MILL ORDER NO.	CUSTOMER PO.	
48612-1	50918	MP 51471 LK

DATE: 5-20-71 FILE NO. 5536-01-01

CONSIGNEE:

SPECIFICATIONS:
SA-537-67A Gr. A

BEND TEST O.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	
A7999	18	1.22	008	017		20								F.G.P.

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ENLOG IN 8"	%R.A.	BHN	IMPACTS		DESCRIPTION
A7999	5A	526	742	24					2-72 OD x 3/4" Min. Ga.

Heads and tests norm.

APPROVED
MAY 27, 1971
By

Affirmed and subscribed before me this day of May 20, 1971

Phillip A. Romandino Jr.
Notary Public
My Commission Expires April 1, 1972

We hereby certify the above figures are correct as contained in the records of the company.

SUPERVISOR-TESTING

PURCHASER:

4. National Annealing Box Co.
Pur. Dept., Pur. Agent

LUKENS STEEL COMPANY

COATESVILLE, PA 19320

TEST CERTIFICATE

DATE: 5-20-71

FILE NO. 5536-01-01

CONSIGNEE:

MILL ORDER NO.	CUSTOMER P.O.	
48612-2	50918	MP 51471 LR

SPECIFICATIONS:
SA-537-67A Gr. A

BEND TEST O.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	
A7999	18	1.22	008	017		20								F.G.P.

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG IN 8"	% R.A.	BHN	IMPACTS				DESCRIPTION
A7999	4A	543	751	34							(1-225-1/2 x 48-1/2 x 3/4" (1-42 x 7 x 3/4"

Plates and tests norm. 1650°F., ±25°F., held 3/4 hr. per inch min. and air cooled

APPROVED

MAY 27, 1971

By

Affirmed and subscribed before me this day of MAY 20, 1971

Phillip A. Romandino Jr.

Notary Public

My Commission Expires April 1, 1972

We hereby certify the above figures are correct as contained in the records of the company.

SUPERVISOR-TESTING

APPENDIX B

WELDING PROCEDURES

NATIONAL ANNEALING BOX CO. WASHINGTON, PA.		WELDING PROCEDURE SPECIFICATION PQT-6704	Base Material P-1
			Process SMA
ISSUED 3-28-67	REV. 5-9-67 REV. 7-14-67 8-18-67		Page 1 of 2 Pages

Base Material			Filler Metal: Electrode Group		Filler Metal: Deposit Analysis Group		Welding Process	
Carbon Steels	(P1)	☒	F1	☐	A1	☒	Shielded Metal Arc (SMA)	☒
Low Alloys	(P3)	☐	F2	☐	A2	☐	Submerged Arc (SA)	☐
Low Alloys	(P4)	☐	F4	☒	A3	☐	Metal Inert Gas (MIG)	
Medium Alloys	(P5)	☐	F5	☐	A4	☐	Flux Cored Wire	☐
High Alloys	(P8)	☐	F7	☐	A7	☐	Spray Arc	☐
	(P)	☐	F	☐	A8	☐	Short Arc	☐
Special		☐	Special	☐	Analysis Not Reqd.	☐		
							Tungsten Inert Gas (TIG)	☐
							Manual	☒
							Semi-Automatic	☐
							Full Automatic	☐

Preparation of Base Material: The edges or surfaces of the parts to be joined by welding shall be prepared by the method shown below to the contours as shown on the attached sketches. The edges or surfaces of the parts to be joined by welding shall be cleaned of all oil or grease and excessive amounts of scale or rust.

Smearing	☐	Gas Cutting	☒	Powder Burning	☐
Machining	☒	Air Arcing	☒	Plasma Cutting	☒
Grinding	☒				

Appearance of Welding Layers: The welding current and manner of depositing the weld metal shall be such that there shall be practically no undercutting on the side walls of the welding groove or the adjoining base material.

Cleaning: All slag or flux remaining on any bead of welding shall be removed before laying down the next successive bead.

Defects: Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding, or gouging before depositing the next successive bead of welding.

Peening: Peening of welds shall not be allowed.

Repairs: Any repair welding will follow procedures of original welding or of another qualified procedure covering proper base material.

Treatment of Underside of Welding Groove: Double-welded butt joints shall have second side of welding prepared using applicable processes allowed above under "Preparation of Base Material". Such preparation shall include penetration of first side welding to clean, sound and fused weld metal. Dye penetrant testing may or may not be used as an added safeguard. Single welded butt joints, qualified under double welded tests, must utilize a backing strip or else be separately qualified.

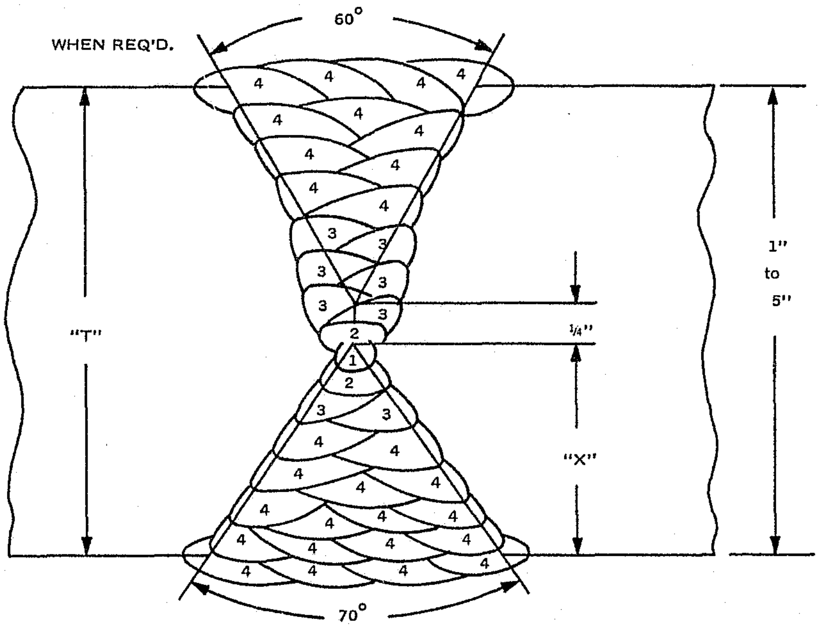
Miscellaneous: This procedure is qualified to meet Section III and Section VIII ASME Code.

NATIONAL ANNEALING BOX CO. WASHINGTON, PA.	WELDING PROCEDURE SPECIFICATION PQT-6704	PQT-6704 Sketches
ISSUED 3-28-67 / REV. 5-9-67 / REV. 7-14-67 / 8-18-67		Page 2 of 2 Pages

Qualification Base Material A-516 Gr. 70 to A-300
Qualification Filler Metal A-316-64T E-8018-C3
Qualification Tks. 3½" Tks. Range Qualified 3/16" to 5"
Flux ☐ or Inert Gas ☐ used Gas Rate CFH —
Welding Position Flat
Preheat Range 200°F. Min. Max. Interpass Temp. 300°F.
Heat Treatment 1125°±25°F Hold 26 Hrs. Hold 4 Hrs. Also as Welded ☐
Radiographic Examination Per Par. N-624 Section III ASME Code And/Or Cust. Spec.
Magnetic Particle Examination Per Par. N-626 Section III And/Or Cust. Specs.

JOINT DESIGN AND WELDING PROCEDURE

Ultrasonic Test — Per Par. N-625 Section III And/Or Customer Specs.



"T"	"X"
1"-1-1/4"	3/8"
1-1/4"-1-1/2"	1/2"
1-1/2"-1-3/4"	5/8"
1-3/4"-2"	3/4"
2"-2-1/4"	7/8"
2-1/4"-2-1/2"	1"
2-1/2"-2-3/4"	1-1/8"
2-3/4"-3"	1-1/4"
3" -3-1/4"	1-3/8"
3-1/4"-3-1/2"	1-1/2"
3-1/2"-3-3/4"	1-5/8"
3-3/4"-4"	1-3/4"
4" - 4-1/4"	1-7/8"
4-1/4"-4-1/2"	2"
4-1/2"-4-3/4"	2-1/8"
4-3/4"-5"	2-1/4"

Pass Numbers	Elec. Dia.	Amperage Range	Voltage Range	Speed or Technique	Elec. Char.	Miscellaneous
1 & 2	5/32"	150-220	22-25	Stringer Bead	DC-RP	
3	3/16"	240-300	23-26	Stringer Bead	DC-RP	
4	1/4"	320-400	24-27	Stringer Bead	DC-RP	
Stringer Bead Technique Required for Improved Charpy Impacts Results.						

26 Hr. Stress Relief Sect. 111

RECOMMENDED FORM Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. P.Q.T. 6704
Date 10-5-67
Welding Process Shielded Metal Arc
Manual or Machine Manual
Material Specification A-516 Gr-70 to A-516 Gr 70 of P-No. 1 to P-No. 1
Thickness (if pipe, diameter and wall thickness) 3½"
Thickness Range this test qualifies 3/16" to 5"
Filler Metal Group No. F-4
Weld Metal Analysis No. A-1
Describe Filler Metal if not included in Table Q-11.2 or QN-11.2

For oxyacetylene welding–State if Filler Metal is silicon or aluminum killed.

Flux or Atmosphere
Flux Trade Name or Composition –
Inert Gas Composition –
Trade Name - Flow Rate –
Is Backing Strip Used? No

Preheat Temperature Range 200°F

Welding Procedure

Single or Multiple Pass Multiple
Single or Multiple Arc Single
Position of Groove Flat
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

Postheat Treatment 1150°F±25°F Hold 26 Hrs.

(See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)

For Information Only

Filler Wire–Diameter 5/32" – 3/16" – 1/4"
Trade Name Atom Arc 8018-C3
Type of Backing Double Welded
Forehand or Backhand Backhand

Welding Techniques
Joint Dimensions Accord with P.Q.T. 6704

amps 150-400 volts 22-27 inches per min. Manual

Round Tensils Test (Fig. QN-6(c))

Specimen No.	Dimensions		Area	Ultimate Total Load, lb.	Ultimate unit Stress, psi	Character of Failure and Location
		Diameter				
1	–	.502	.198	14,800	74,750	Base Metal
2	–	.504	.199	15,000	75,375	Base Metal
3	–	.500	.196	15,000	76,530	Base Metal
4	–	.501	.198	15,200	76,770	Base Metal

Guided Bend Tests (Figs. Q-7.1)

Type and Figure No.	Result	Type and Figure No.	Result
Side Bend No. 1	No Defects	Side Bend No. 3	No Defects
Side Bend No. 1A	No Defects	Side Bend No. 3A	No Defects
Side Bend No. 2	No Defects	Side Bend No. 4	No Defects
Side Bend No. 2A	No Defects	Side Bend No. 4A	No Defects

Welder's Name G. Ward Clock No. 52 Stamp No. Af

Who by virtue of these tests meets welder performance requirements.

Test Conducted by NABCO
per W. Porter

Laboratory-Test No. (SO. 8694-8) (PQT. 6704-1)

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

Signed: National Annealing Box Company
Manufacturer
By: J.S. Loughrian, Welding Engr.

Date 10-5-67
Charpy Impact – "V" Notch @ + 10°F (PTL43591)
Weld Metal 135 – 146 – 128
Heat Affected Zone – 49– 44 – 55

NATIONAL ANNEALING BOX CO. WASHINGTON, PA.		WELDING PROCEDURE SPECIFICATION PQT-7006	Base Material P-1
			Process SA
ISSUED	REV. REV.		Page of Pages

Base Material			Filler material: Electrode Group		Deposit Analysis Group		Welding Process	
Carbon Steels	(P1)	☒	F1	☐	A1	☐	Shielded Metal Arc (SMA)	☐
Low Alloys	(P3)	☐	F2	☐	A2	☒	Submerged Arc (SA)	☒
Low Alloys	(P4)	☐	F4	☐	A3	☐	Metal Inert Gas (MIG)	☐
Medium Alloys	(P5)	☐	F5	☐	A4	☐	Flux Cored Wire	☐
High Alloys	(P8)	☐	F7	☐	A7	☐	Spray Arc	☐
	(P)	☐	F	☐	A8	☐	Short Arc	☐
Special		☐	Special	☒	Analysis Not Reqd.	☐		
							Tungsten Inert Gas (TIG)	☐
							Manual	☐
							Semi-Automatic	☐
							Full-Automatic	☒

Preparation of Base Material: The edges or surfaces of the parts to be joined by welding shall be prepared by the methods shown below to the contours as shown on the attached sketches. The edges or surfaces of the parts to be joined by welding shall be cleaned of all oil, grease, scale, rust and all foreign materials.

Shearing	☐	Gas Cutting	☒	Powder Burning	☒
Machining	☒	Air Arcing	☒	Plasma Cutting	☐
Grinding	☒				

Appearance of Welding Layers: The welding current and manner of depositing the weld metal shall be such that there shall be no undercutting on the side walls of the welding groove or the adjoining base material.

Cleaning: All slag or flux remaining on any bead of welding shall be removed before laying down the next successive bead.

Defects: Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding, or gouging before depositing the next successive bead of welding.

Peening: Peening of welds shall not be allowed.

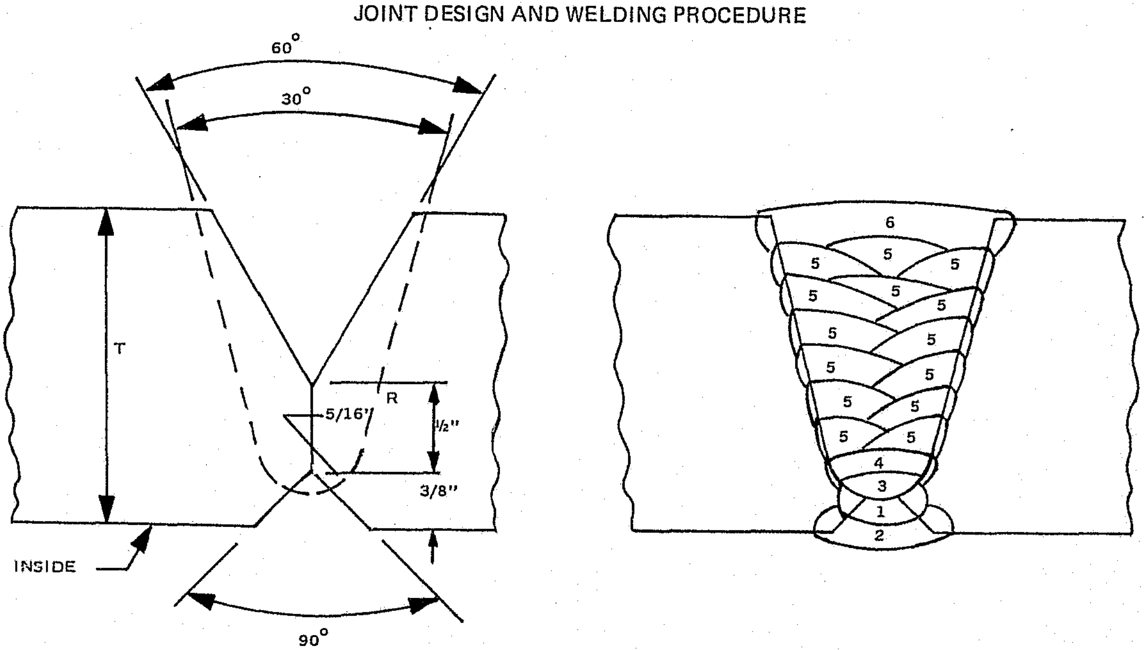
Repairs: Any repair welding will follow procedures of original welding or of another qualified procedure covering proper base material and process.

Remarks:

NATIONAL ANNEALING BOX CO' WASHINGTON, PA		WELDING PROCEDURE SPECIFICATION PQT-7006	PQT-7006 Sketches
ISSUED 3-9-70	REV.		
	REV.		Page 2 of 2 Pages

Qualification Base Material ASTM A-515 GRADE 70
Qualification Filler Metal LINDE 40B
Qualification Tks. 1-11/16" Tks. Range Qualified 3/16" to 2-11/32"
Flux x or Inert Gas used LINDE GR 80 (12 x 65) Gas Rate CFH –
Welding Position FLAT
Preheat Range 60°F Max. Interpass Temp. 500°F
Heat Treatment 1125°F±25°F HOLD 1 HR/IN. Also as Welded
Radiographic Examination PER PAR UW-51 ASME CODE SECTION VIII
Dye Penetrant Examination BACKCHIP AND FINAL WELD SURFACES

JOINT DESIGN AND WELDING PROCEDURE



Pass Numbers	Elec. Dia.	Amperage Range	Voltage Range	Speed or Technique	Elec. Char.	Miscellaneous
1	3/32"Ø	400-450	31-33	14-16 1PM	DC-RP	Inside Weld
2	3/32"Ø	400-450	31-33	6-8 1PM	DC-RP	Inside Weld
3	5/32"Ø	375-425	30-32	19-21 1PM	DC-RP	Outside Weld
4	5/32"Ø	475-525	31-33	16-18 1 PM	DC-RP	Outside Weld
5	5/32"Ø	600-650	33-35	14-16 1PM	DC-RP	Outside Weld
6	5/32"Ø	400-500	31-33	5-7 1PM	DC-RP	Oscillation Pass

RECOMMENDED FORM Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. PQT-7006 Date 3-9-70
Welding Process Submerged Arc Manual or Machine Machine
Material Specification SA-515 Gr. 70 to SA-515 Gr. 70 of P-No. 1 to P-No. 1
Thickness (if pipe, diameter and wall thickness) 1-25/64"
Thickness Range this test qualifies 3/16" TO 2-25/32"

Filler Metal Group No. F-
Weld Metal Analysis No. A-2
Describe Filler Metal if not included in Table Q-11.2 or QN-11.2 Linde 40B

For oxyacetylene welding–State if Filler Metal is silicon or aluminum killed

Flux or Atmosphere
Flux Trade Name or Composition Linde Gr-801 (12 x 65)
Inert Gas Composition –
Trade Name – Flow Rate –
Is Backing Strip Used? No

Preheat Temperature Range 60°F

Welding Procedure

Single or Multiple Pass Multiple
Single or Multiple Arc. Single
Position of Groove Flat
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

Postheat Treatment 1125°±25°F Hold 1 Hr/In.
(See Pars. & Figs. Q-2, & Q-3, or QN-2 & QN-3)

For Information Only

Filler Wire–Diameter 3/32" & 5/32" Ø
Trade Name Linde 40B
Type of Backing Double Welded
Forehand or Backhand Backhand

Welding Techniques
Joint Dimensions Accord with PQT-7006
amps 375-500 volts 30-35 inches per min. 5-21 1 PM

Reduced Section Tensile Test (Fig. Q-6 and QN-6)

Specimen No.	Dimensions		Area	Ultimate Total Load, lb.	Ultimate unit Stress, psi	Character of Failure and Location
	Width	Thickness				
1	.745	1.340	.998	78000	78160	Base Metal
2	.745	1.332	.992	78000	78630	Base Metal

Guided Bend Tests (Figs. Q-7.1, Q-7.2, QN-7.1, QN-7.2, QN-7.3)

Type and Figure No.	Result	Type and Figure No.	Result
Side Bend No. 1	No Defects	Side Bend No. 3	No Defects
Side Bend No. 2	No Defects	Side Bend No. 4	No Defects

Welder's Name D. Welling Clock No. 518 Stamp No. BM
Who by virtue of these tests meets welder performance requirements.

Test Conducted by NABCO Laboratory-Test No. (R-0208A) (PQT 7006)
per J. Manion

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

Signed: National Annealing Box Company
(Manufacturer)
Date: 4-28-70 By: J. Loughran, Welding Engineer

ROUND TENSILE TEST (ALL WELDS)

No.	DIA.	AREA	YIELD(LOAD)	YIELD(PSI)	TENSILE(LOAD)	TENSILE(PSI)	ELONG.	RED. OF AREA
1	.504	.199	12900	64820	15700	78940	30%	40%
2	.503	.199	12500	62810	15700	78895	28%	40%

END