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DAVID W. TAYLOR NAVAL SHIP
RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

[illegible] OF PRESSURE TANK USING HY-[illegible] STEEL

by

[illegible]

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STRUCTURES DEPARTMENT
RESEARCH AND DEVELOPMENT REPORT

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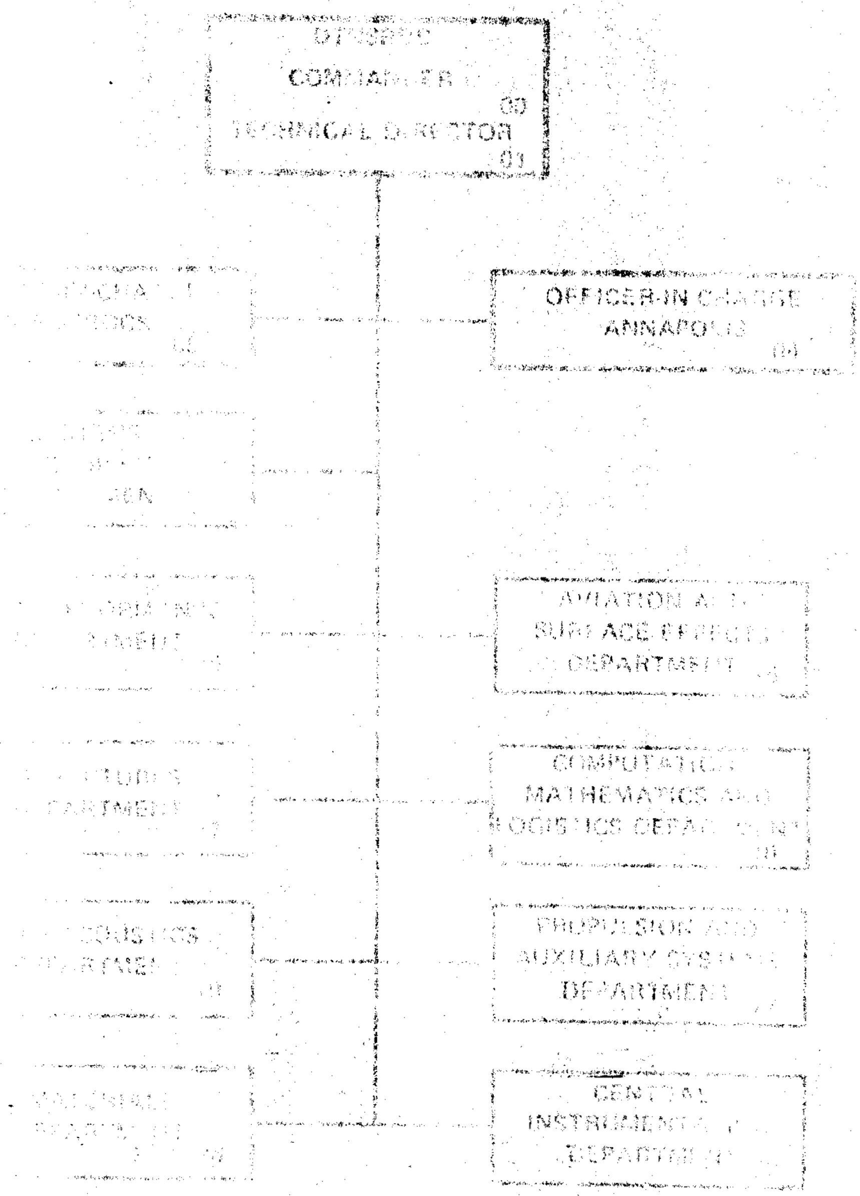

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A large pressure tank, fabricated of HY-100 steel, was constructed for the David W. Taylor Naval Ship Research and Development Center (DTNSRDC). During construction careful documentation was kept concerning materials, construction practices, inspection, and certification. This report publishes that information. It is prepared to help others who may need to construct items from HY-100 steel.

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ABSTRACT

A large pressure tank, fabricated of HY-100 steel, was constructed for the David W. Taylor Naval Ship Research and Development Center (DTNSRDC). During construction careful documentation was kept concerning materials, construction practices, inspection, and certification. This report publishes that information. It is prepared to help others who may need to construct items from HY-100 steel.

ADMINISTRATIVE INFORMATION

The pressure tank was built by Hahn and Clay of Houston, Texas, for the Navy under contract N00600-73-C-0706. Funds for the construction were provided by Naval Material Command 6.5 money and Naval Sea Systems Command 6.2 money. The contract was administered by the Navy Regional Procurement Office through Defense Contract Administration Services, Houston, Texas.

INTRODUCTION

The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) has a number of pressure tanks at its Carderock site. The first of these to be installed was a 12-foot diameter tank. It was put in service in the early 1950's. A routine inspection late in the 1960's revealed a large number of fatigue cracks and at that point plans were begun to replace the tank.

The replacement tank is 13 feet in diameter, 40 feet long and operates at a pressure of 3,000 pound per square inch. The tank, which was constructed by Hahn and Clay, Houston, Texas, is a multilayer tank, made of HY-100 steel. The advantage of multilayer as well as a description of multilayer construction is contained in a paper by R. Pechacek published by ASME. Mr. Pechacek states:

> "The ever increasing demand for higher service pressures in pressure vessels is pushing today's material and fabrication technology to its limit.
>
> "Improved material properties, enhanced by sophisticated alloying, vacuum degassing, electroslag remelting, multiple heat treatment, etc., have provided some relief. However, today's high

pressures require metal thicknesses that do not lend themselves to uniform heat treatment. High physical properties are difficult to achieve at the mid-point of thick sections. Therefore, when high mid-point properties are required, the total single wall thickness becomes restrictive.

"Increased design stresses, supported by high quality control standards, exhaustive nondestructive testing (NDT), advanced analytical and experimental stress analysis, etc., are being used to extend the limit of today's metal technology. In many cases, that limit also has been reached.

"Large, thick, single wall vessels present complex material, fabrication, post-weld heat treatment (PWHT), and NDT problems that sometimes defy solution. Layered vessels offer an alternative design approach.

THE LAYERED VESSEL

"The layered vessel consists of a pressure tight inner shell, surrounded by multiple layers which are vented to the atmosphere.

"The inner shell is usually made of a material selected to resist corrosion, erosion, embrittlement, etc., of the internal liquids and/or gases. The inner shell may or may not be considered load bearing. Its prime function is to seal the contents.

"The layer material is chosen for its load bearing characteristics. That is, it resists the stresses generated by the internal vessel pressure and the temperature imposed on the structure. The number of layers is dictated by loads imposed on the vessel (pressure, temperature, wind, earthquake, etc.).

"Since the layer material is thin, usually less than 1/2 in. (12.7 mm thick), very high strength and toughness properties can be achieved by cross rolling, quenching and tempering."

During construction careful documentation was maintained concerning material, fabrication procedures, inspection, etc. The purpose of this report is to present that data to the engineering community so that future HY-100 structures may benefit from the project.

GENERAL

The 13-foot tank was built under contract N00600-73-C-0706. It was built in five major parts, these are the upper and lower hemispherical heads and the three main cylinders.

The assembly was as follows. The middle and lower cylinders were assembled and welded together. The lower head was assembled and welded to the lower cylinder, see Figure 1. A forging was welded to the upper cylinder and another forging was welded to the upper head. (The upper head forging is a layered forging made from two ring forgings.) These forgings, shown in Figure 2, have interlocking fingers. The two forgings were assembled and tapered holes were machined for closure pins as shown in Figure 3. Finally the upper cylinder was welded to the lower assembly to form the complete tank, see Figure 4. Several nozzles made from HY-100 forgings were fabricated and installed during construction as will be described later.

MATERIAL

The major part of the tank was made of HY-100 steel plate material supplied by Lukins Steel, Coatsville, Pa. The plate was nominal HY-100 with some modifications to the sulphur, phosphorous, and vanadium limits to improve weldability. The plates varied in thickness from 5/16 to 1 inch.

All plates were required to meet the chemical, mechanical, toughness and nondestructive examination requirements of military specification MIL-S-16216H(1). In addition the phosphorous, and sulphur contents were limited to 0.015 percent and vanadium was limited to 0.02 percent. The ultimate tensile strength was at least 115,000 pound per square inch. It was required that the steel be vacuum degassed while in the molten state.

Charpy impact specimens were taken from each plate at 1/4 thickness. These had to exhibit at least 50 foot pound at -120 degree Fahrenheit. The failure planes had to be 100 percent fibrous fracture in appearance at 0 degree Fahrenheit.

Table 1 lists the mechanical and impact properties of each plate. Table 2 lists the actual chemistry of each plate.

The forgings were also made of HY-100 steel. The forging properties were required to conform to military specification MIL-S-23009A. Once again the phosphorous and sulphur contents were limited to a maximum of 0.015 percent, the vanadium to 0.02 percent, and the minimum ultimate strength was 115,000 pound per square inch. Vacuum degassing was again required. Charpy v notch specimens were taken both axially and transversely at mid thickness. These specimens were required to have 100 percent fibrous fracture appearance and an average Charpy value of 50 foot pound at 32 degree Fahrenheit. A minimum tempering temperature of 1,050 degree was required.

The forgings were supplied by Muroran Plant of Japan Steel Works, as no U.S. company would guarantee the required properties. Table 3 shows the chemistry of the forgings. This table includes the large forgings for the closure rings and the small ones for the nozzles. Table 4 lists the mechanical properties of all forgings. Charpy specimens from the two thickest ring forgings were not quite 100 percent fibrous. To determine the ductility of these, dynamic tear tests were run. The results indicated nil ductility temperature of -120 degree Fahrenheit and good tear resistance at 32 degree Fahrenheit. Therefore, the forgings were accepted even though they did not meet the 100 percent fibrous fracture requirement of the original contract specification.

To assure good quality material both the plates and the forgings were inspected using ultrasonic (UT), magnetic particle (MT), and liquid penetration (PT) techniques. The requirements were as follows: (a) the forgings were inspected with each method using 100 percent coverage. If a surface crack of 1/8 inch was found by either PT or MT, or a discontinuity greater than 20 percent of normal back reflection was found by UT, the forging was rejected, (b) the plates were inspected in accordance with MIL-S-16216H.

Both Lukens Steel and Japan Steel were required to provide Quality Assurance Standards. These standards provided such data as who inspected the material, what their qualifications were, what equipment was used, how and when it was last calibrated, etc. These documents are on file.

The welding rod used on the tank was also carefully controlled. The 11018 rod, used to join HY-100 to HY-100, was required to exhibit Charpy values of 20 foot pound at -60 degree Fahrenheit and 40 foot pound at 32 degree Fahrenheit. Chemical and mechanical property tests, impact, and side bend tests were required for each heat, lot, or batch of electrodes. Tests were done in accordance with Military Specifications MIL-E-22200/1C and MIL-STD-00418B. Test data for both (11018 and $NiCu_2$) rods used are on file. Since this data would be bulky to include, only one set of data is presented. Table 5 contains typical data available for the 11018 rod used to weld HY-100 to HY-100 and Table 6 contains typical data for the $NiCu_2$ rod used to weld monel liners and to overlay monel deposits.

Finally, the taper pins used to hold the tank closed were manufactured from E 4340H steel. The properties of this material are listed in Table 7.

FABRICATION

THE UPPER HEAD

The head is made of 8 layers. The inner layer is 3/4-inch thick and the other 7 layers are all 0.392-inch thick. This makes the finished thickness approximately 3 1/2 inch. Each layer is made up of a circular plate at the center called a dollar plate, a row of eight wedge-shaped plates called gore plates and a second row of 16 gore plates, see Figure 5.

The first row of 16 gore plates were stamped to the approximate spherical shape and layered up on the frame shown in Figure 6. The edges of the plate were prepared as shown in Figure 7 and the bevels were inspected with magnetic particle (MT). The gore plates were then heated to 200 degree Fahrenheit and manually welded from the inside using temper beads. Next the joint was back gouged outside to sound metal and ground smooth. The root pass was MT inspected. Then the outside was welded manually just as before and ground smooth. The weld was MT inspected and 100 percent radiographed (RT). In nearly all cases the radiographs used gamma rays from iridium, Ir 192, rather than X-rays.

The above process was used for all seams on the inner layer. This includes the vertical welds, welding one gore plate to another, and the two horizontal welds; one between the dollar plate and the upper ring of gore plates and the other between the two gore plate rings (see Figure 5).

Once the inner layer was completed, a gore-applying fixture was set up. This is basically a hydraulic jacking arrangement which presses the gore piece against the head, see Figure 8. The gore pieces were again stamped to the appropriate shape of the sphere. This time, however, a number of vent holes were drilled into the plates as shown in Figure 9. The prime purpose of these is to vent the welding gages. It also allows the layer tightness to be measured. Finally, the vent holes are a safety device since any leak that developes in the inner shell is vented to the outside thus preventing a catastrophic failure. Each gore plate was pressed over the inner skin to the desired tightness, heated to 200 degree Fahrenheit, and tack welded. The ends of the tack weld were ground smooth. Care was taken to be sure alternate layer welds were staggered.

This process was repeated for the next gore. The fitup of the 0.392-inch gore plates is shown in Figure 10. This fitup is used for all joints in the layer. Once the plates were fitted they were manually welded with the 11018 rod at a 200 degree preheat. All but the first and last pass were lightly peened. Finally the welds were ground smooth and MT inspected. The plates were checked for tightness.

If a plate was found to be loose, the plate was lanced. This involved machining a groove in the plate nearly its entire thickness and filling the groove with weld to shrink the plate. Welding procedures and inspection for this operation are the same as for other joints. This procedure was repeated until all layers were attached.

The next process was to install four nozzles. Prior to installing these, monel liners were put on the nozzles and a monel plate was added to the inside. To do this the nozzles were machined as shown in Figure 11. The liner was then installed and welded all around using a 200 degree Fahrenheit preheat and $NiCu_2$ electrodes. Care was taken to remove all contaminants before heating. The initial weld was ground smooth and dye checked. Next the remaining areas were overlayed using the same welding procedures. These were also ground smooth and dye checked. The nozzles were then machined to final dimensions. Finally the monel plate was manually welded to the inside surface of each nozzle. Where the plate was welded to a monel overlay, a preheat of 70 to 150 degree was used and where the plate was welded to HY-100 a 250 degree preheat was used. Once again $NiCu_2$ electrodes were used. The welds were ground smooth and checked with dye penetrant. No peening of welds was allowed.

As soon as the nozzle was lined it was installed in the head. First a hole was machined in the head at the correct location and the nozzle was installed. A backup ring was welded on as shown in Figure 12. The assembly was heated to 200 degree and the nozzle was manually welded from the inside with the 11018 electrode. Light peening was used on all passes except the first and last. Temper beads were used on the last pass. The backup ring was removed by arc gouging and the outside was arc gouged to sound metal which was ground smooth. The root was then magnafluxed. The outside was welded as above peening all but the final pass which used temper beads. Welds on both sides were contour ground, MT inspected, and 100 percent radiographed.

The large nozzle in the center of the head also received a monel overlay as shown in Figure 13. First a one-eighth inch recess was machined over the nozzle face. All contaminants were removed and the nozzle was heated to 200 degree. The overlay was manually added with $NiCu_2$ rod and ground smooth. No peening was allowed. The nozzle was dye checked and machined to the final dimensions.

A hole was machined through the head and ground smooth. The bevel was MT inspected. After fitup a backing bar was installed on the outside. This nozzle was welded using the same procedure as the others, except that all passes except the first and last were thoroughly peened.

Three support lugs were installed in the head to be used during tests to hang models. Since the head is layered, the layers were joined at the lugs to transfer load to all layers of the head instead of just the inside one. To do this a hole was burned in each layer (except the inside one) over each of the three lugs. The holes were ground smooth and beveled to 15 degree. Each hole was manually filled with weld as that layer was assembled using 200 degree preheat, 11018 electrodes, light peening of each pass and temper beads. Each hole was ground flush, and MT inspected before the next layer was applied. The holes in one layer overlap the holes in the next layer. The lugs were cut to size, ground smooth, and the bevels MT inspected. They were next fitted and welded using the same procedure as above, except that each pass was thoroughly peened. The root side was back gouged to sound metal, ground smooth, and MT inspected; then finish welded just as before, ground smooth, and inspected.

The final major assembly was installing the forging to the head. The design of this forging required a finished thickness of 12 inch. This was too thick to forge as one piece; therefore, two thinner forgings were used. These were 6 1/4 and 6 3/4-inch thick. First the finger grooves and outside dimensions were rough machined. Next the mating surfaces were carefully machined. This included machining the weld groove shown in Figure 14 on the inner forging. The two forgings were shrunk-fit together by heating the outside forging and cooling the inside forging before assembling them together, see Figure 2. Once the two forgings were shrunk-fit together the CS-F1 weld (Figure 14) was made. It was done at a 200 degree preheat, with the 11018 rod. All passes were thoroughly peened except the first and last and temper beads were used on the last layer. The weld was ground smooth and completely inspected with MT. Finally the finished forging was machined to fit the head, and the head and closure forging were machined to clean up each side of the weld groove.

The closure forging was next fitted to the head and a backup bar tack welded on the inside only. The seam was then welded using 200 degree preheat, the 11018 rod, and temper beads on the last pass. All passes were thoroughly peened except the first and last. Next the backup bar was removed and the root arc gouged to sound metal, ground smooth, and MT inspected. The weld was then finished off, thoroughly peening all layers except the last, ground smooth, MT inspected, and then 100 percent radiographed.

Following this the lifting lugs were attached as outlined in Figure 15.

An overlay of monel was deposited on the inner finger of the inner forging in the sealing area, see Figures 2 and 16. The finger was machined and preheated to 200 degree, welded with $NiCu_2$ electrodes (no peening allowed), ground smooth enough to inspect, PT inspected, and machined to final size.

This completed fabrication of the upper head except for final machining the closure forging. This had to be done in conjunction with the same task for the tank body so that they would fit together.

THE LOWER HEAD

The lower head was manufactured exactly the same as the upper head except it had one more layer which was 3/8-inch thick and was added as a corrosion allowance. Fitup of this extra plate was approximately the same as that shown in Figure 10 for the 5/16-inch plate. This head has no nozzles or lifting pads. It was welded directly to the lower cylinder of the tank so no forging was necessary. The welding process will be described in the next section.

THE CYLINDERS

The cylindrical portion of the tank was made up of three cylindrical cans welded together. The three cylinders were wrapped or formed identically. Welding details were different for each cylinder depending on its various attachments.

The wrapping operation for the three cylinders or cans will be described first. Before actual construction of the cans began, a mandrel, shown in Figure 17, was constructed. Its outside diameter corresponded to the inner diameter of the tank and it was slightly shorter than the cans.

Two 1-inch plates the length of the first can were rolled to approximately the inner diameter of the tank and were then laid up on the mandrel shown in Figure 17. The plates were pulled up tightly to conform to the mandrel, with hydraulically operated "belly bands." Once fitted they were welded together to form the inner shell or wrap. The welding procedure was as follows. The bevel shown in Figure 7 was burned and ground to bright metal. The seam was heated to 200 degree and manually welded inside with the 11018 electrode. Moderate peening was used for all but the first and last pass. Preheat was kept constant throughout the operation and interpass temperatures were limited to 300 degree. Temper beads were used on the final pass.

The root pass was back gouged to sound metal, ground smooth, and inspected with MT. The seam was then welded manually using the same procedure as outlined above. The weld was then MT inspected, allowed to cool, and 100 percent radiographed.

As soon as the inner shell was inspected the next layer was added. This consisted of a 1/2-inch thick layer made of four segments. The segments were rolled to the approximately correct diameter, put on the mandrel, fitted as shown in Figure 10, pulled tight with the belly band, tack welded using 200 degree preheat, and ground smooth of the tacks at the ends. After the entire layer was in place it was welded manually (downhand) using 200 degree preheat, 11018 electrodes, and light peening on all but first and last pass. Once the welding was completed the welds were ground flush and MT inspected. The layer was then checked for tightness with feeler gauges in the vent holes and for sound using a light hammer. If the layer was not tight it was lanced (for description of lancing see upper head fabrication procedure) and rewelded.

This procedure was repeated until each can had a 1-inch inner shell, ten 1/2-inch intermediate layers and two 5/16-inch outer layers. Care was taken to stagger the weld seams from layer to layer. The upper can was 7-foot long, the middle can was 10-foot long, and the lower can was 9-foot, 11 9/16-inches long. All layers in the upper can were 7-foot long and all layers in the middle can were 10-foot long. However, the outside layers in the lower can were somewhat shortened at the bottom end to account for the difference in thickness between the head and the cylinder, see Figure 18.

Once the lower can was completed it was fitted with four small nozzles and one large one. Prior to installing the nozzles they were fitted with monel liners and a monel plate was added to the inside. To do this the small nozzles were machined as shown in Figure 11 and the large nozzle was machined as shown in Figure 19. Welding and inspection procedures were the same for these five nozzles as for the nozzles in the head.

The nozzles were welded into the cylinder as shown in Figure 20. The procedure was the same for both the big and small nozzles. A hole was machined in the cylinder, the nozzle inserted, and a backing bar installed. The material was heated to 200 degree and manually welded from inside with the 11018 rod. Light peening was used on all but the first and last passes. Temper beads were used on the last pass. The final layer was ground flush with the inside shell and no weld touched the monel plate. A deposit of monel was then added using a $NiCu_2$ electrode, see Figure 20. After grinding smooth, the weld was MT inspected. The backup bar was removed by arc gouging and this was continued to sound metal. After grinding smooth the root was MT inspected. The outside weld was then completed using 200 degree preheat, an 11018 rod, and light peening on all but the last pass; temper beads were used on the last pass.

Finally the weld was contour ground smooth inside, MT inspected outside, PT inspected inside, and 100 percent radiographed.

Five small nozzles were also installed in the upper can. These were prepared and installed in exactly the same manner as were the small nozzles on the lower can.

A monel overlay was added to support the sealing ring, see Figures 2 and 21. The upper can was machined as shown and the overlay was manually inserted using a $NiCu_2$ rod and a preheat of 200 degree Fahrenheit. (The bolt holes were welded before the entire overlay was added.) The overlay was ground smooth enough to PT inspect and then machined to final size.

The welding of the upper can to the upper forging was accomplished as follows. The can and forging were machined as shown in Figure 22. After fitting, the inside was tack welded and the outside welded completely using 200 degree preheat, an 11018 electrode, light peening on all but first and last pass, and temper beads on the final layer. After welding outside, the inside was back gouged to sound metal ground, and the root inspected with MT. Then the inside weld was finished using the same procedure. Finally both ends were ground smooth, MT inspected, and 100 percent radiographed.

FINAL ASSEMBLY

The lower portion of the tank was assembled first. The lower end of the middle can and the upper end of the lower can were prepared, fitted as shown in Figure 22, and welded using the procedure described for putting the upper forging on the upper can.

The lower head was fitted to the lower can as shown in Figure 23 and welded using the same procedure as outlined above. This completed lower assembly is shown in Figure 1.

The fingers were machined on the head and tank forgings as shown in Figure 2 and the taper pin holes were bored, see also Figure 3. The head and upper cylinder were disassembled and the upper cylinder was welded to the lower assembly using the procedure followed for welding the middle and lower cans together. This completed the assembly of the tank.

WELDING AND WELDING REPAIR

Throughout the fabrication section reference was made to welding techniques. Such items as electrode, minimum preheat and amount of peening were covered. Quality welds require much more than careful weld parameters. First is the welder. Each welder used during the construction of this tank was certified for HY-100 steel. This means he has welded specimens made of the material to be used. These are made with the equipment to be used in the position to be certified. The specimens are then sent to an independent company for evaluation. A report similar to that shown in Figure 24 is on file for each welder and qualification combination.

The specific qualification requires each welder to pass an eye test. He must then weld two plates, one a single bevel and one a double bevel. These welds are then radiographed and must meet requirements established in NAVSHIPS 0900-600-9010 and MIL-STD-00418B. The plates are cut up into six side bend test specimens. These are tested and if any specimen opens greater than 1/8 inch or any three openings more than 1/16 inch, the welder is disqualified.

In addition to qualifying welders each welding procedure is also qualified according to NAVSHIPS 0900-600-9010 whether it is a repair or a first time weld. This test requires everything the welder qualification test requires plus a tension test. In this reduced section tension test the specimen must fail outside the weld and heat affected zone to be acceptable or if it fails in these areas it is acceptable if the stresses equal the minimum specified HY-100 physical properties.

After both the welder and the process are qualified each weld is carefully monitored and inspected. Appendix A shows the welding history of Long Seam Number 2. This was picked as an example since it was typical of the procedure and because it did have a defect.

INSPECTION

Various components of the tank were nondestructively examined during and after construction. The requirements are as follows:

a. Forgings - The forgings required 100 percent surface inspection with both PT and MT, and 100 percent coverage with UT.

b. Plates - Only UT was required and then only on plates thicker than 1/2 inch. The scanning grid was on 2-foot centers.

c. Welds - All weld inspection conformed to Part AF of Section VIII of ASME Boiler and Pressure Vessel Code, Division 2. In general full penetration, full thickness welds required 100 percent gamma radiation inspection. Full penetration welds at reinforced openings required radiography if possible. Liquid penetrant or magnetic particle may be used if radiography is not feasible. This examination is required for each shell layer. Full penetration welds of individual layers shall be inspected using MT or PT. Cladding is examined with PT only.

Once again specifications are only as good as the people and equipment used to implement them. In this case both people and equipment are governed by industry standards established by the American Society of Nondestructive Testing and implemented by individual company certification programs, an example of which is shown in Appendix B. An example of an inspection report is shown in Figure 25.

SUMMARY

It is well within the state-of-the-art to build a high grade pressure tank of HY-100 steel. To do so however requires careful control of material, fabrication, welding, inspection techniques, procedures, and personnel.

ACKNOWLEDGMENT

The author wishes to thank Hahn and Clay for all their assistance in providing both fabrication data and information concerning final fitups. Many of the figures in this report were taken directly from the Hahn and Clay fabrication manual. This is typical of the industry-government cooperation which existed throughout this very difficult project.

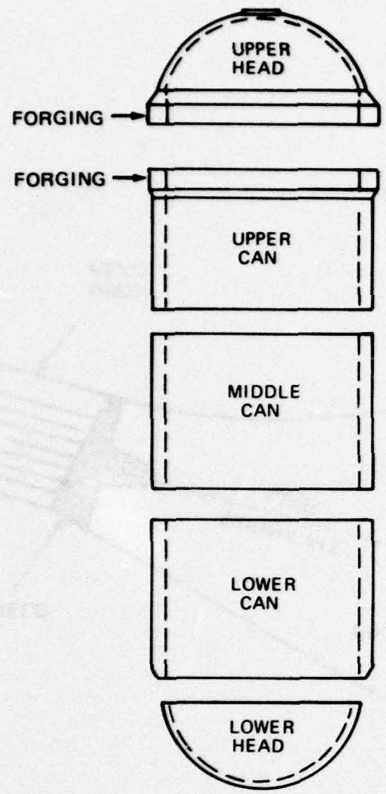


Figure 1a - Assembly

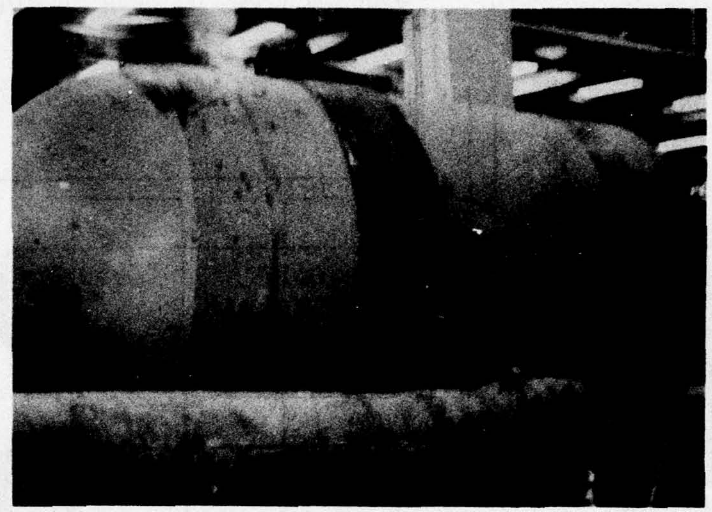


Figure 1b - Photograph of Lower Head Welded to Lower and Middle Cans

Figure 1 - Assembly of Tank

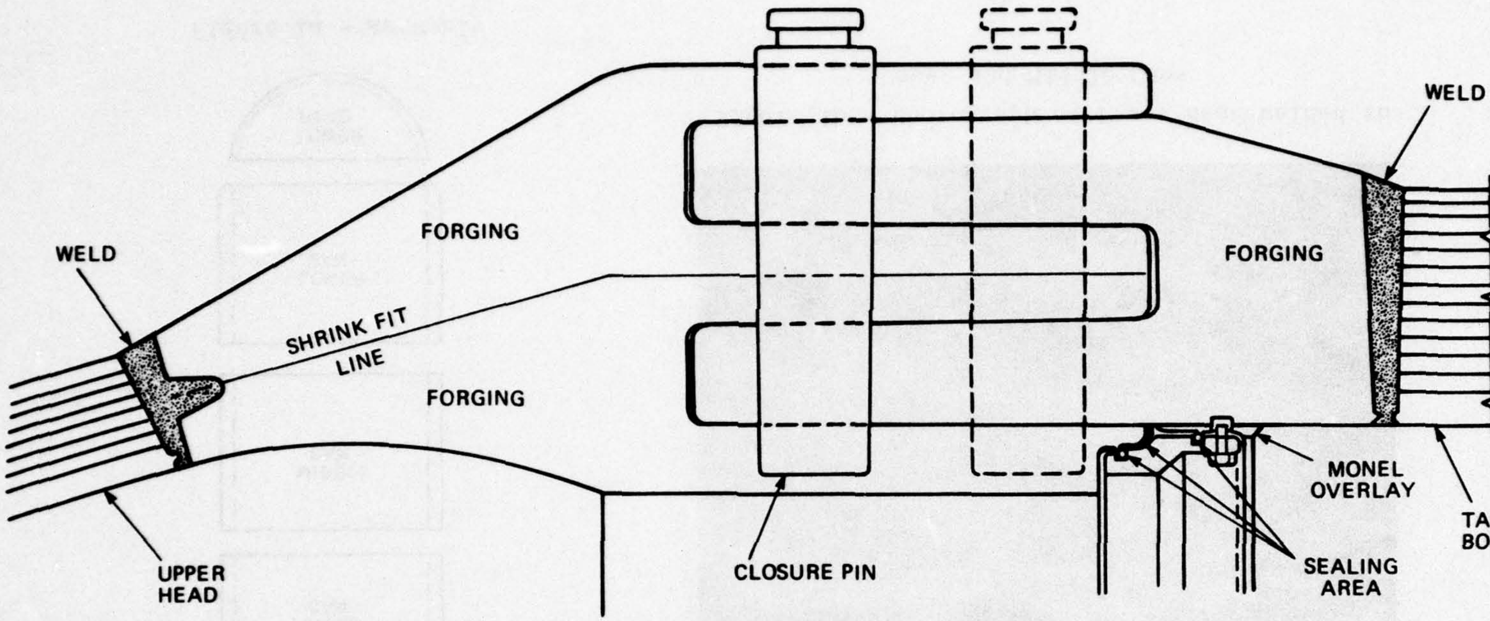


Figure 2 - Assembly of Head to Shell Closure

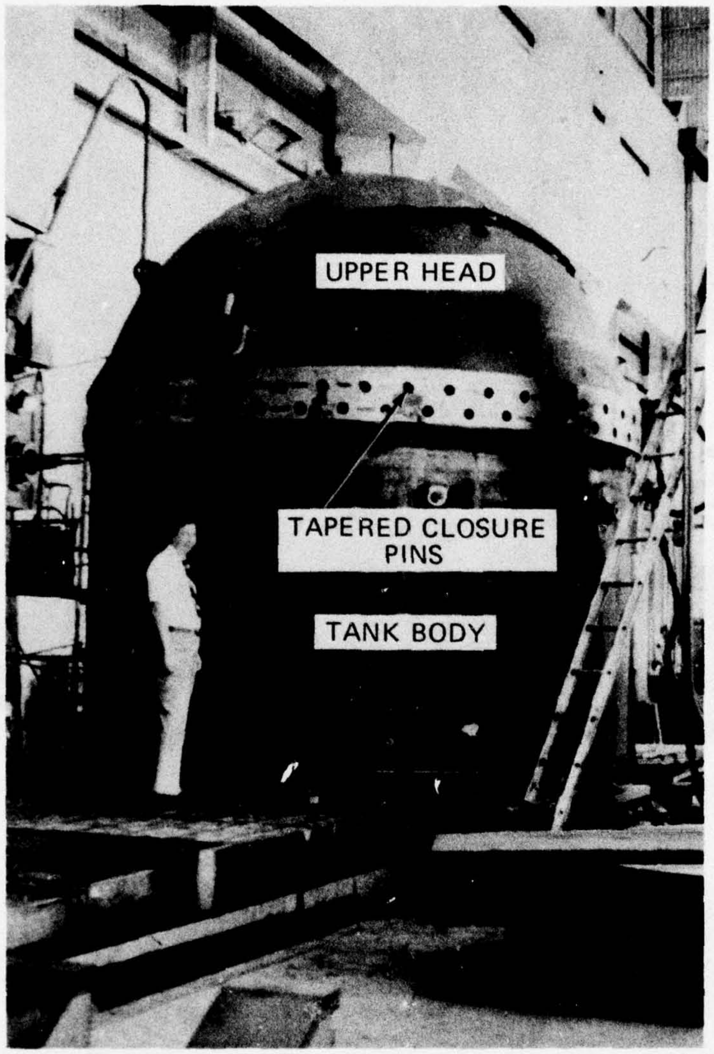


Figure 3 - Final Machining of Pin Holes in Forgings

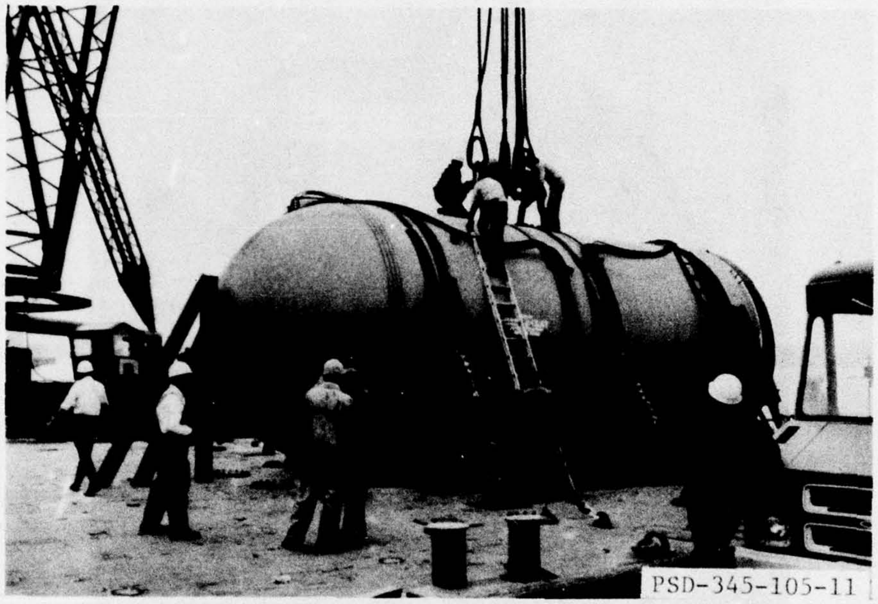


Figure 4 - Tank Being Offloaded in Baltimore

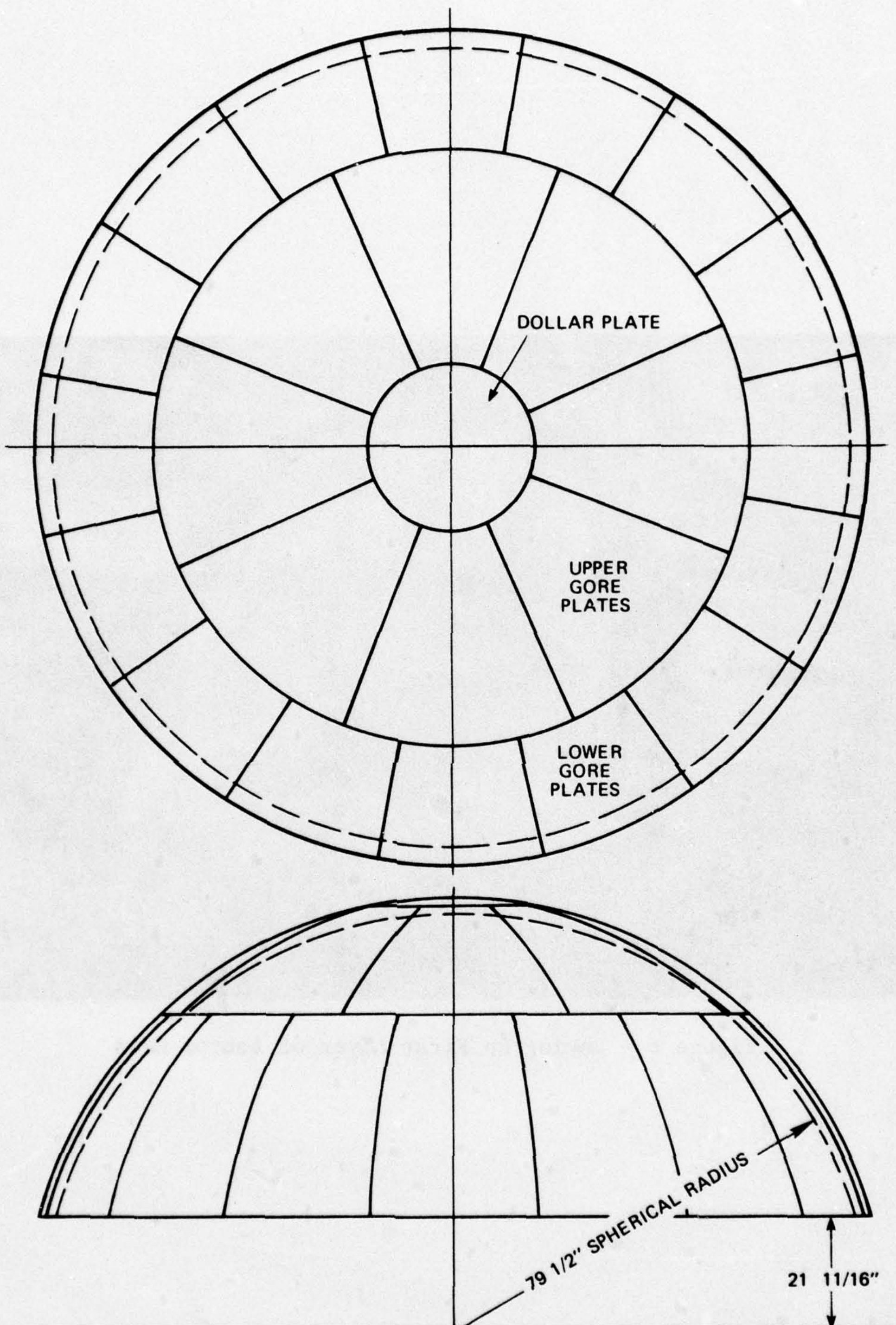


Figure 5 - Layout of Segments for Hemispherical Heads

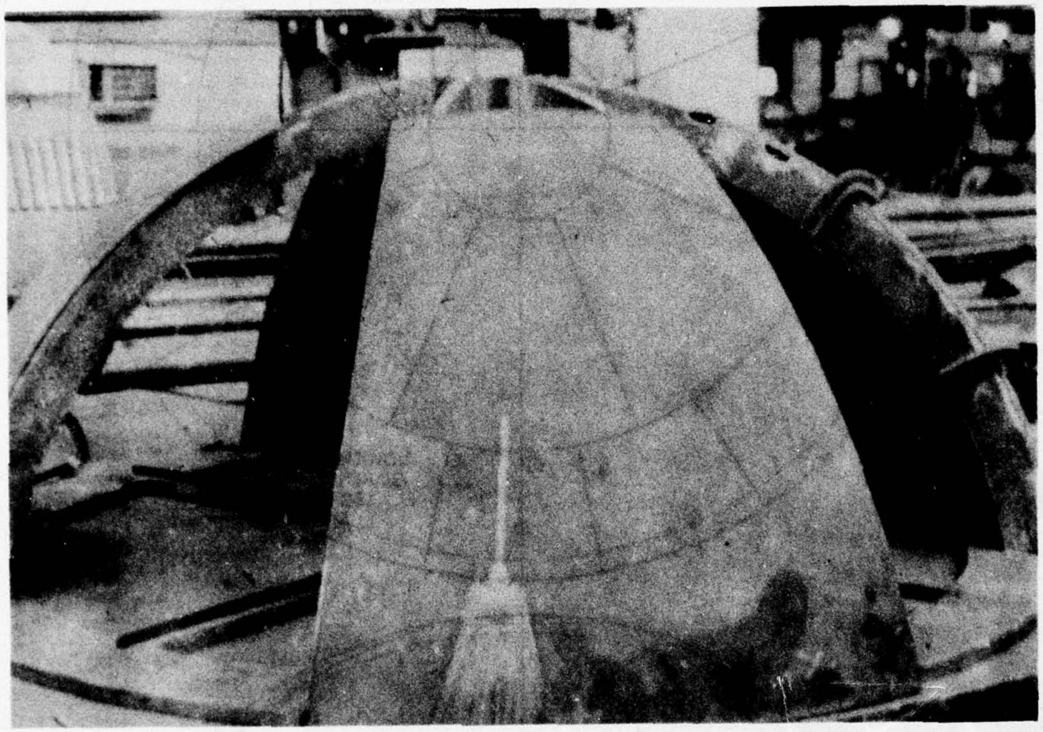


Figure 6 - Laying Up First Layer of Bottom Head

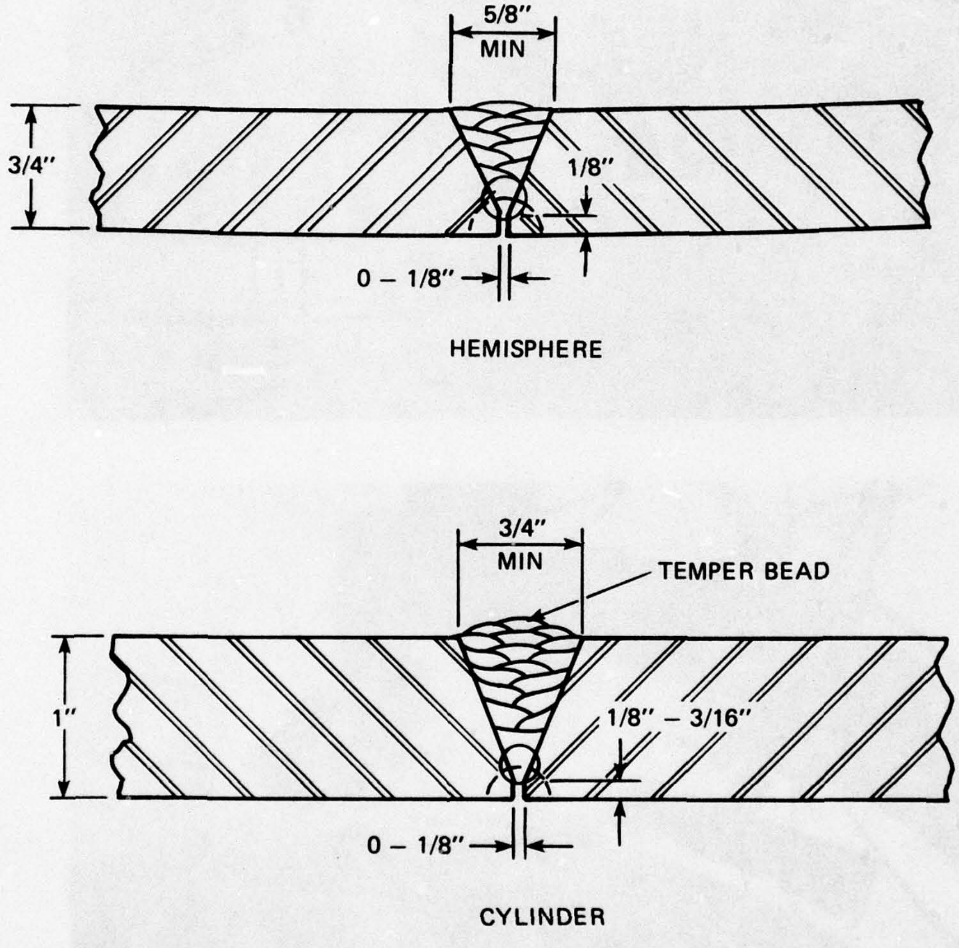


Figure 7 - Welding Fitup for Inner Layers of Heads and Cans

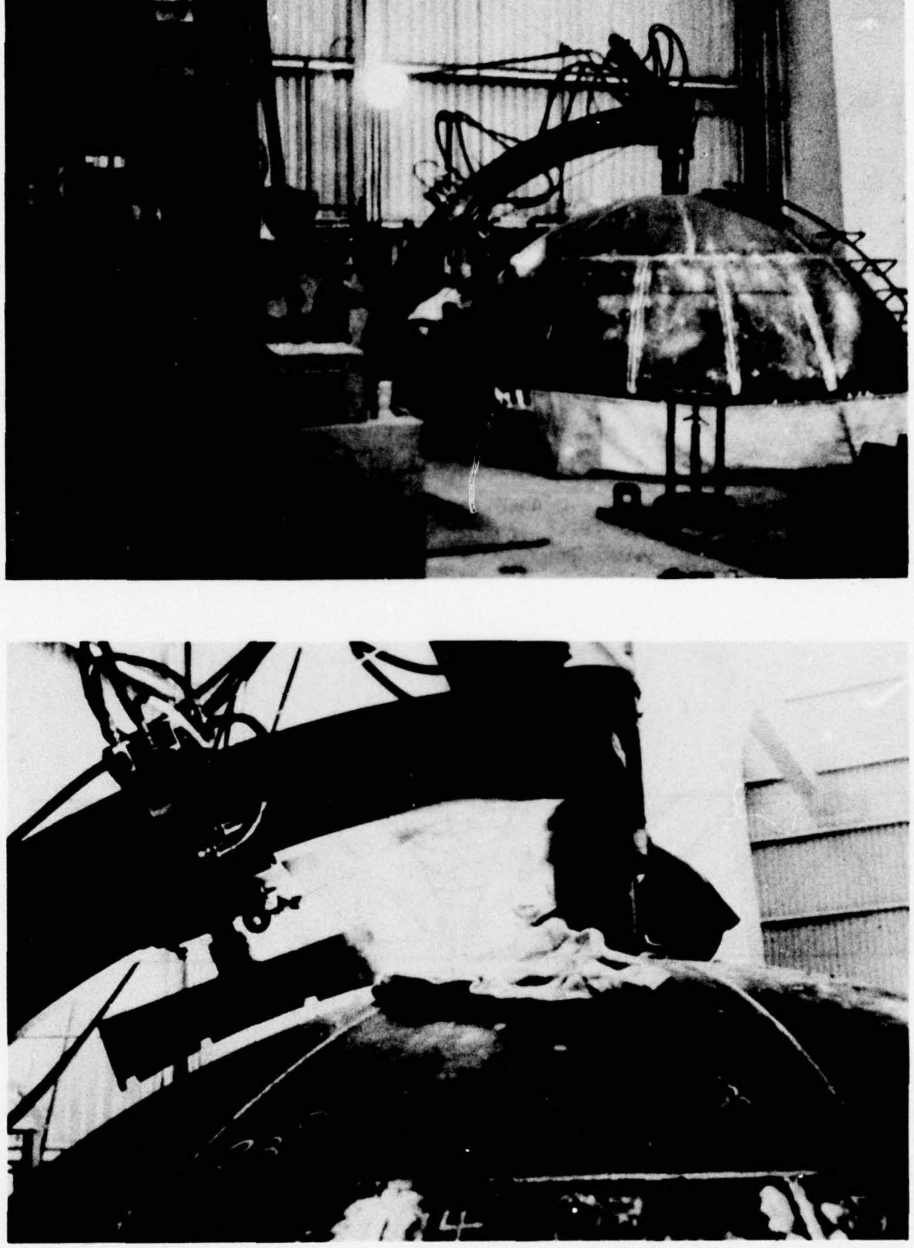


Figure 8 - Assembling a Head

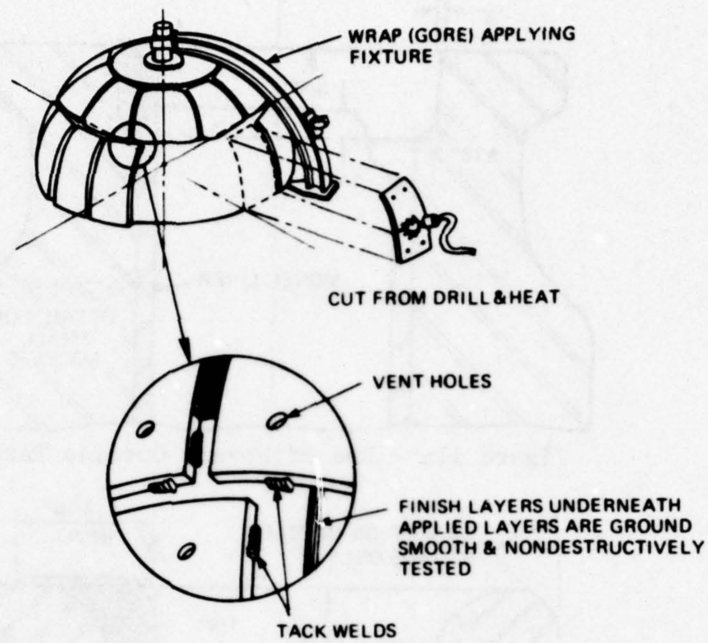


Figure 9 - Layered Hemispherical Head Fabrication Procedure

(Note: *This figure taken from ASME* Paper 76-PET-77 by R. Pechacek)

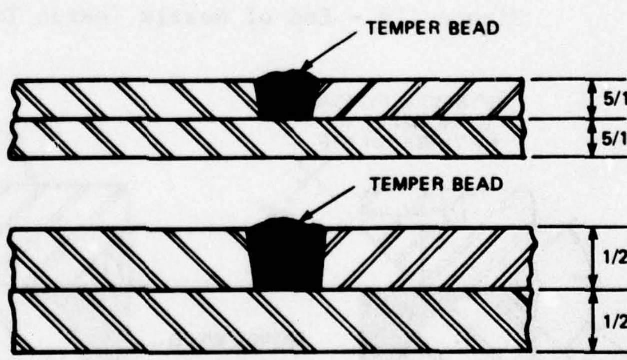


Figure 10a - Typical Layer Long Seams

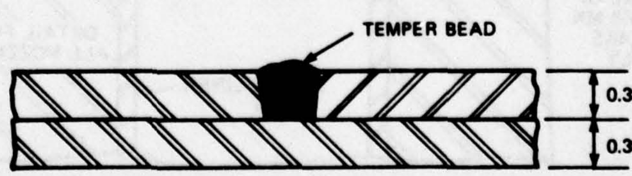


Figure 10b - Typical Bottom Head-Gore Seams

Figure 10 - Welding Fitup for Intermediate Layers of Heads and Cans

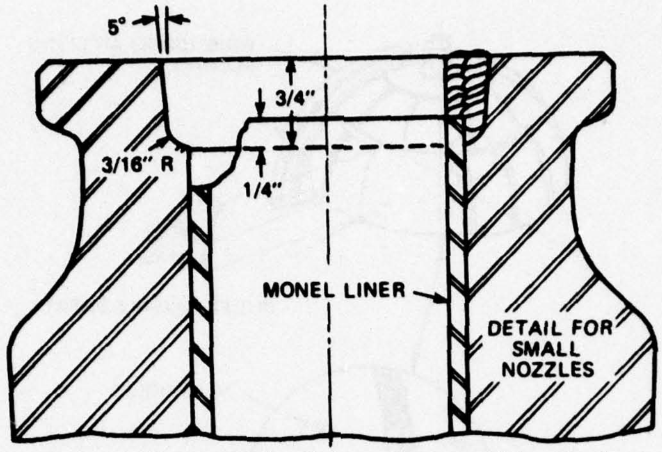


Figure 11a - End of Nozzle Outside Tank

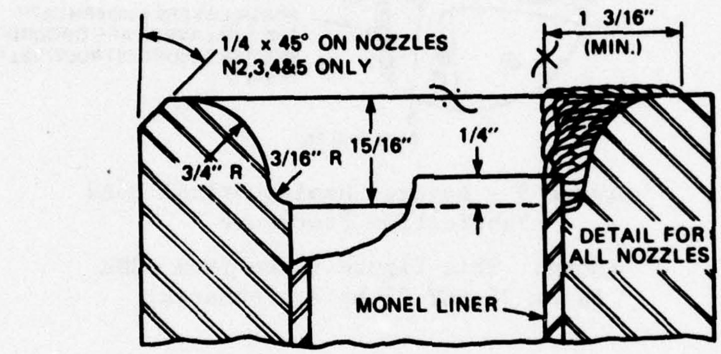


Figure 11b - End of Nozzle Inside Tank

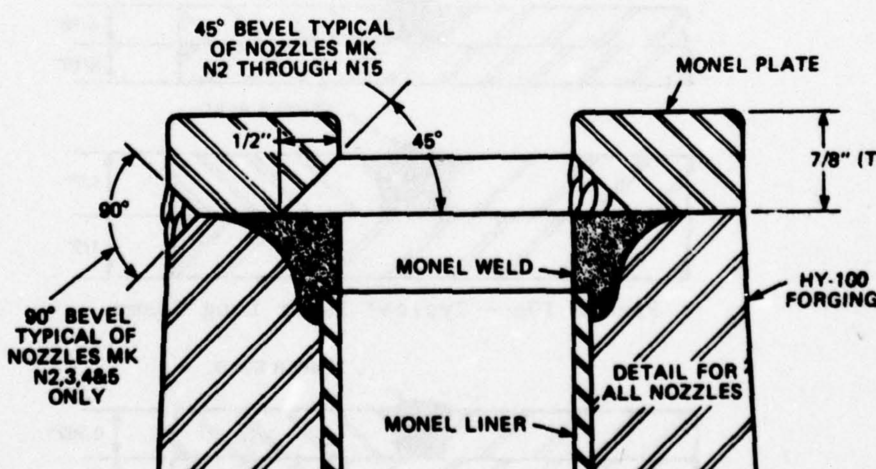


Figure 11c - Plate Welded to Nozzle

Figure 11 - Welding Details for Lining Small Nozzles

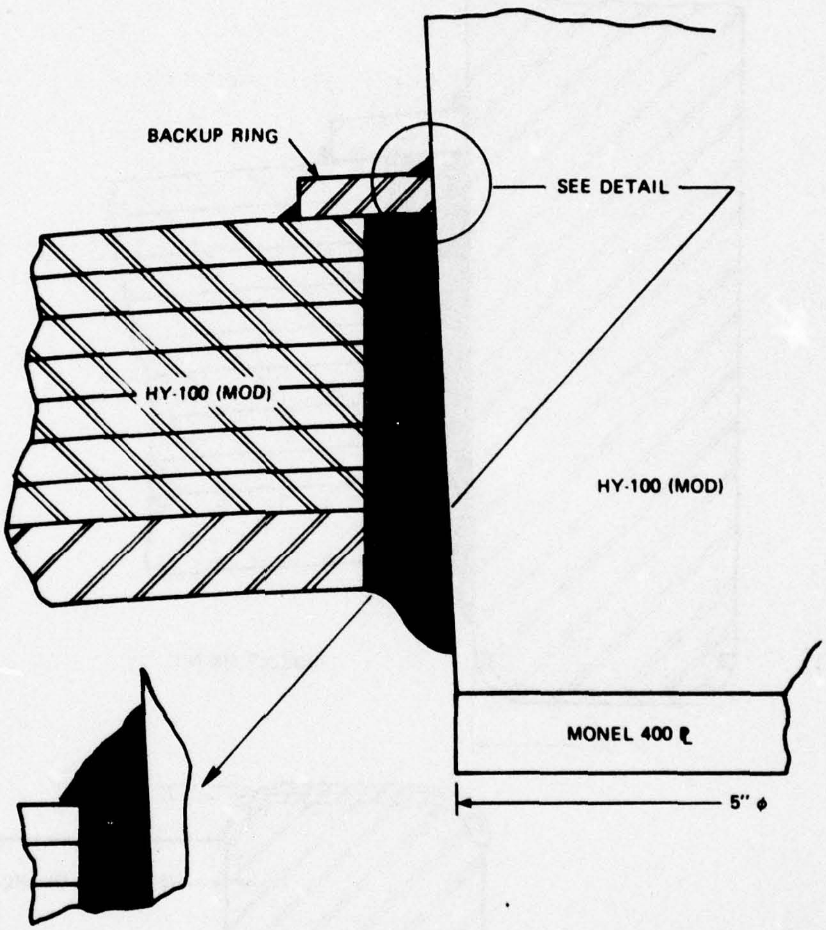


Figure 12 - Welding Details for Welding Small Nozzles in Head

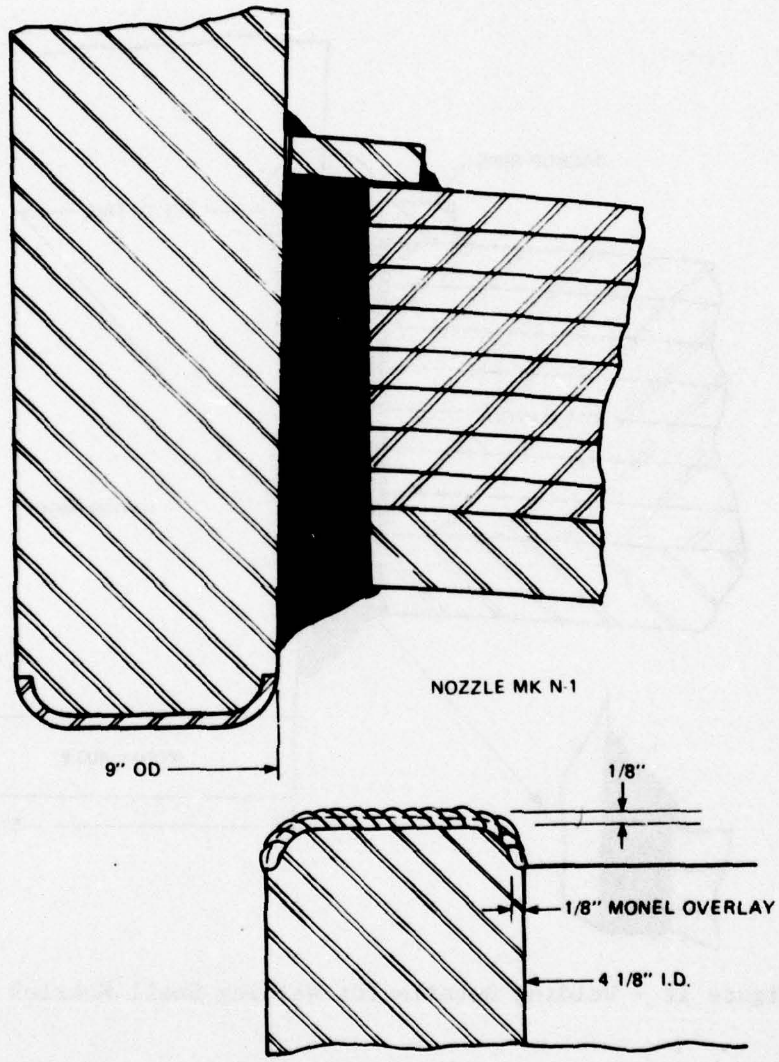


Figure 13 - Welding Details for Feed Through Nozzle

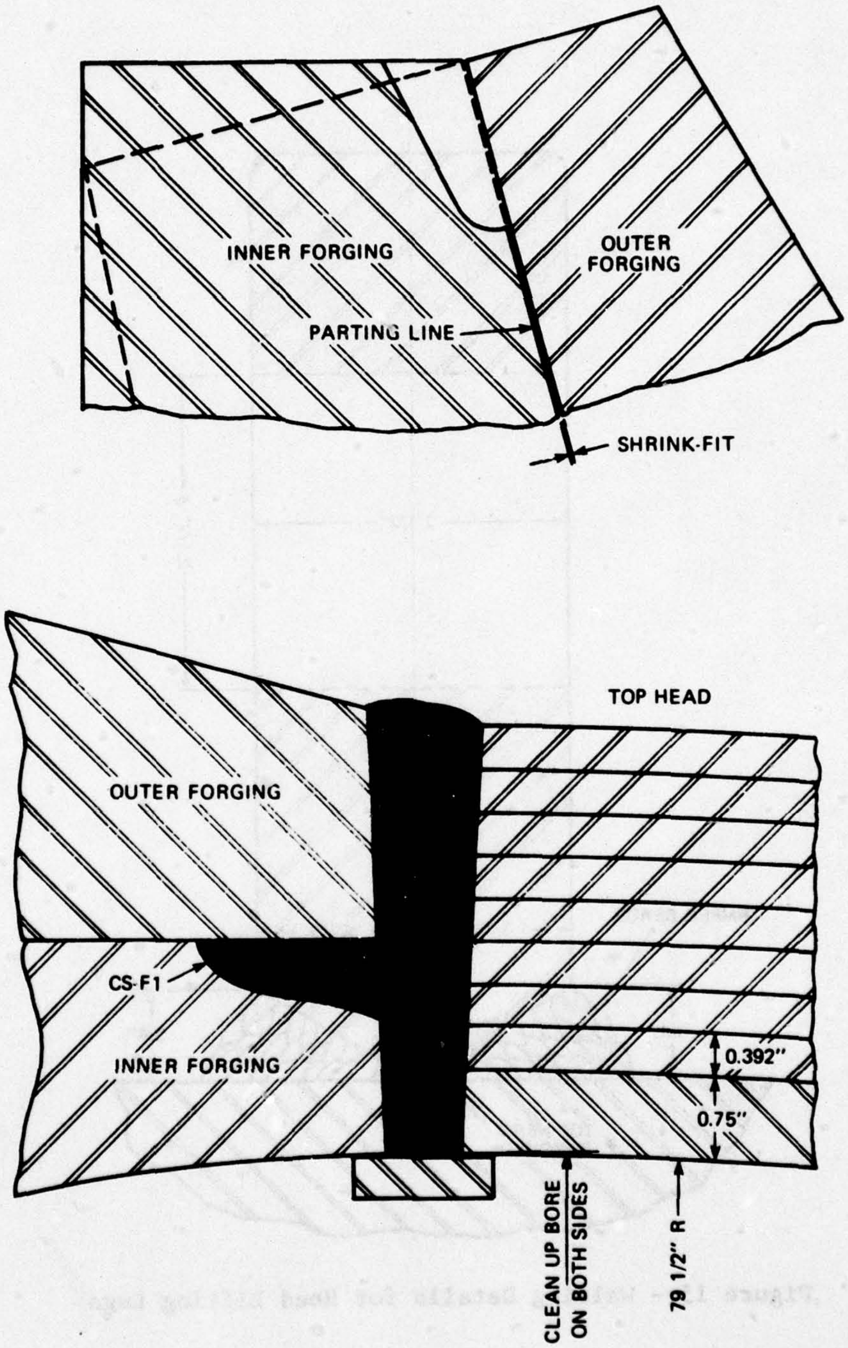


Figure 14 - Welding Forgings to Upper Head

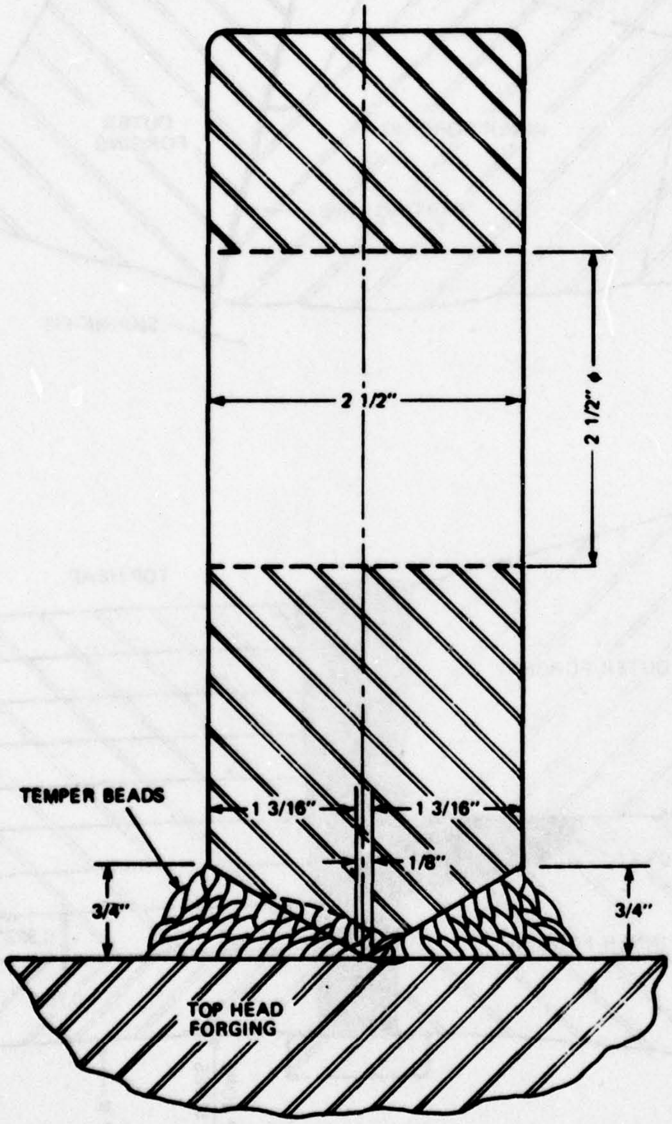


Figure 15 - Welding Details for Head Lifting Lugs

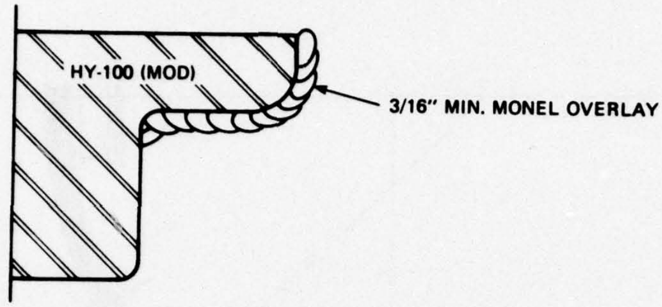


Figure 16 - Finger Inlay Details

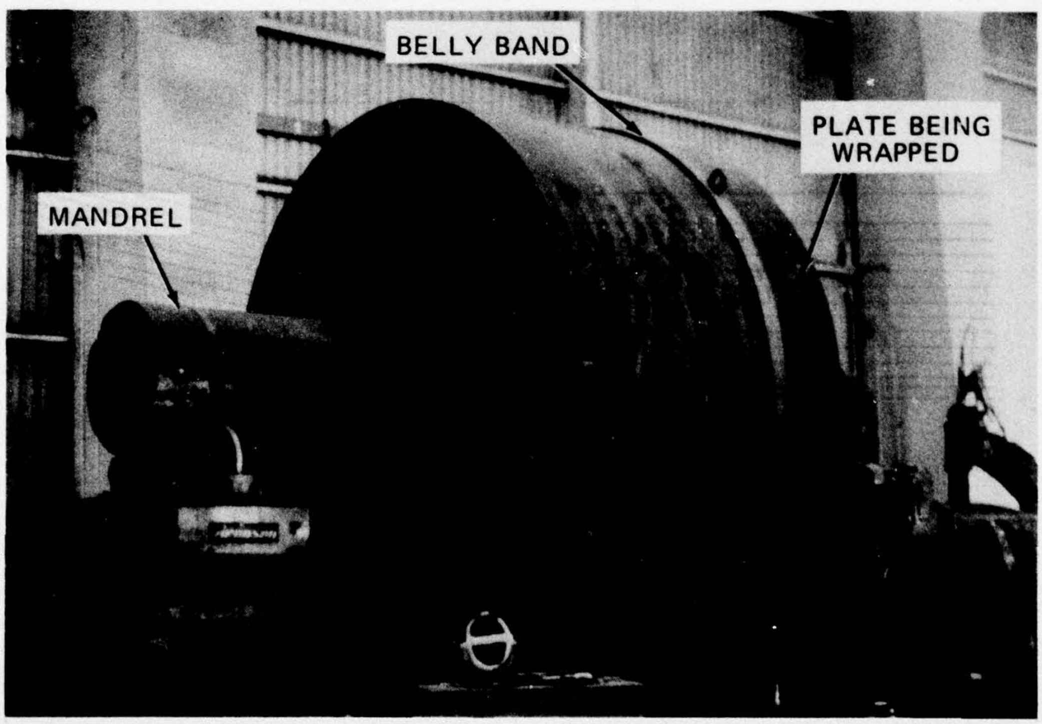


Figure 17 - Rolling a Can on Mandrel

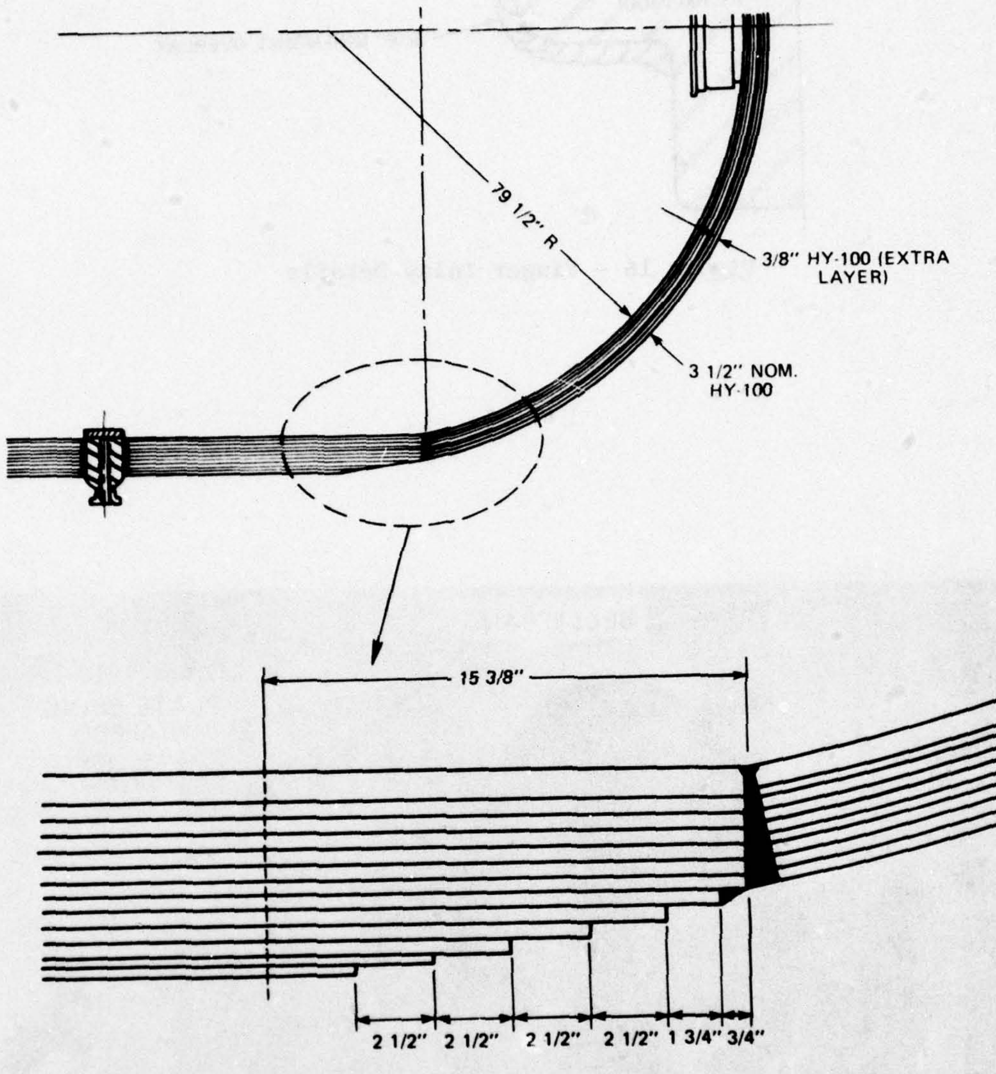


Figure 18 - Fairing Lower Can Into Lower Head

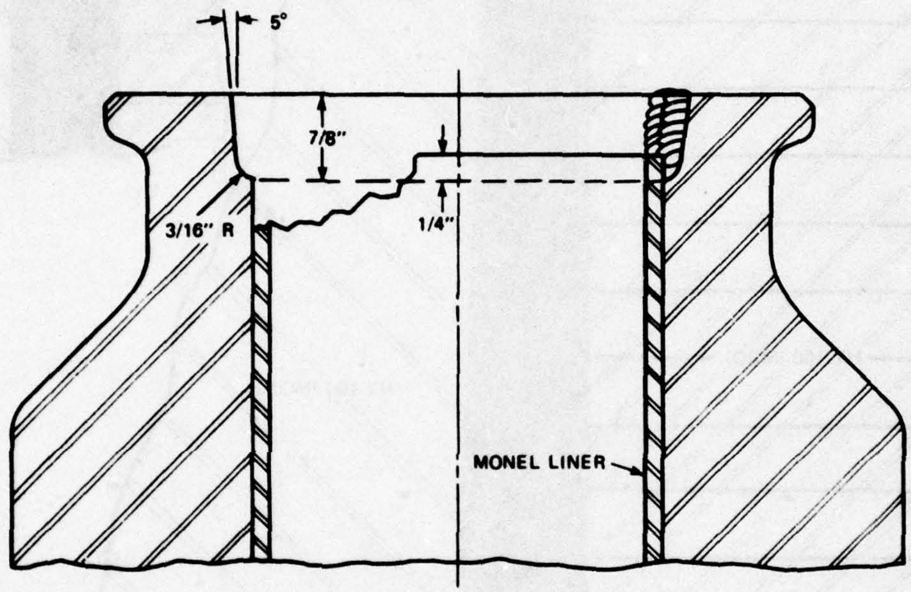


Figure 19 - Welding Details for Lining Large Nozzle

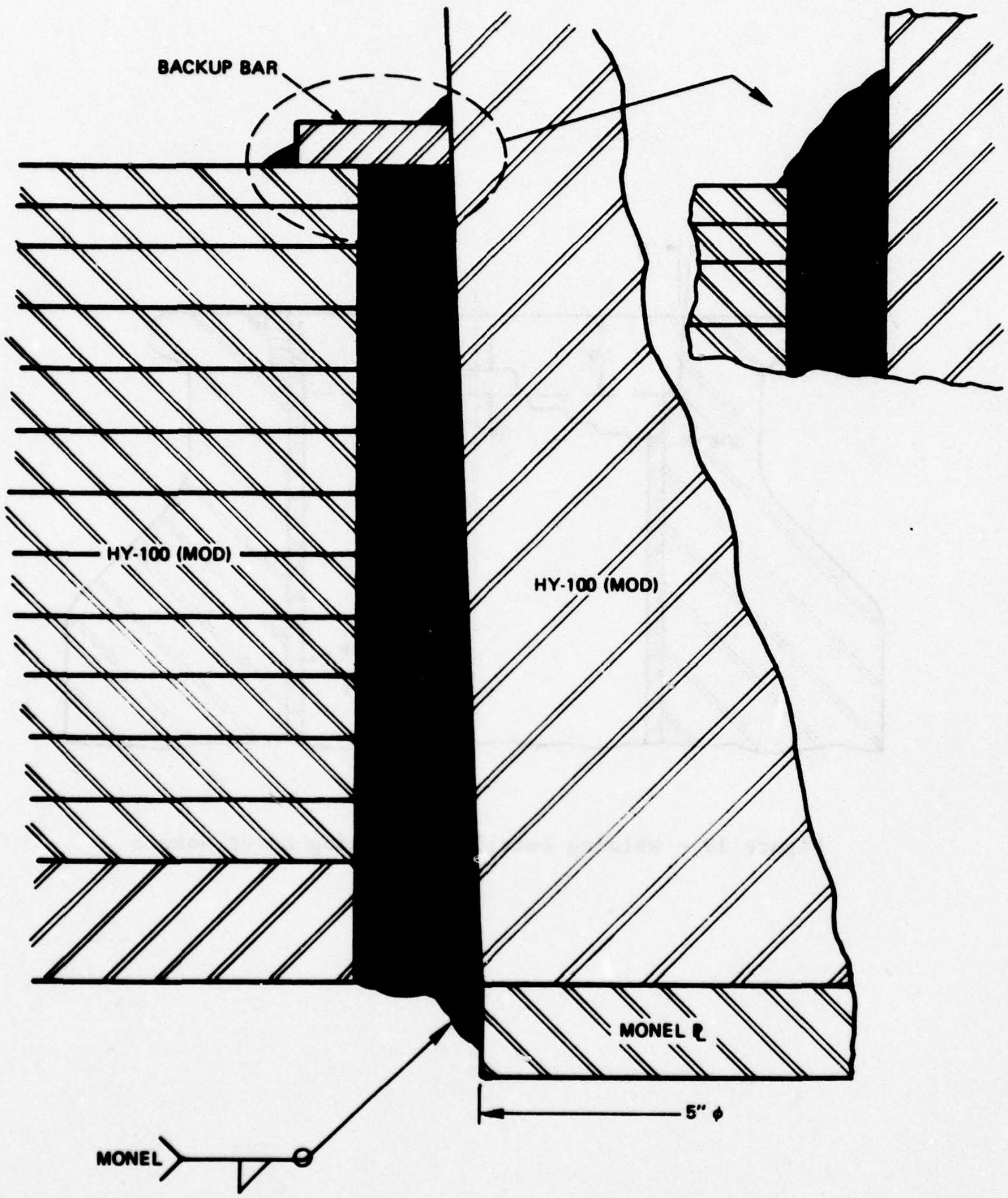


Figure 20 - Welding Details for Securing Nozzles in Cylinders

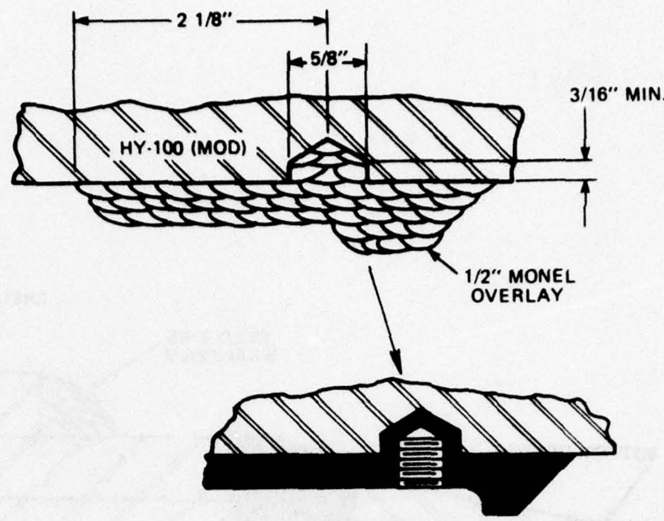


Figure 21 - Sealing Ring Overlay Details

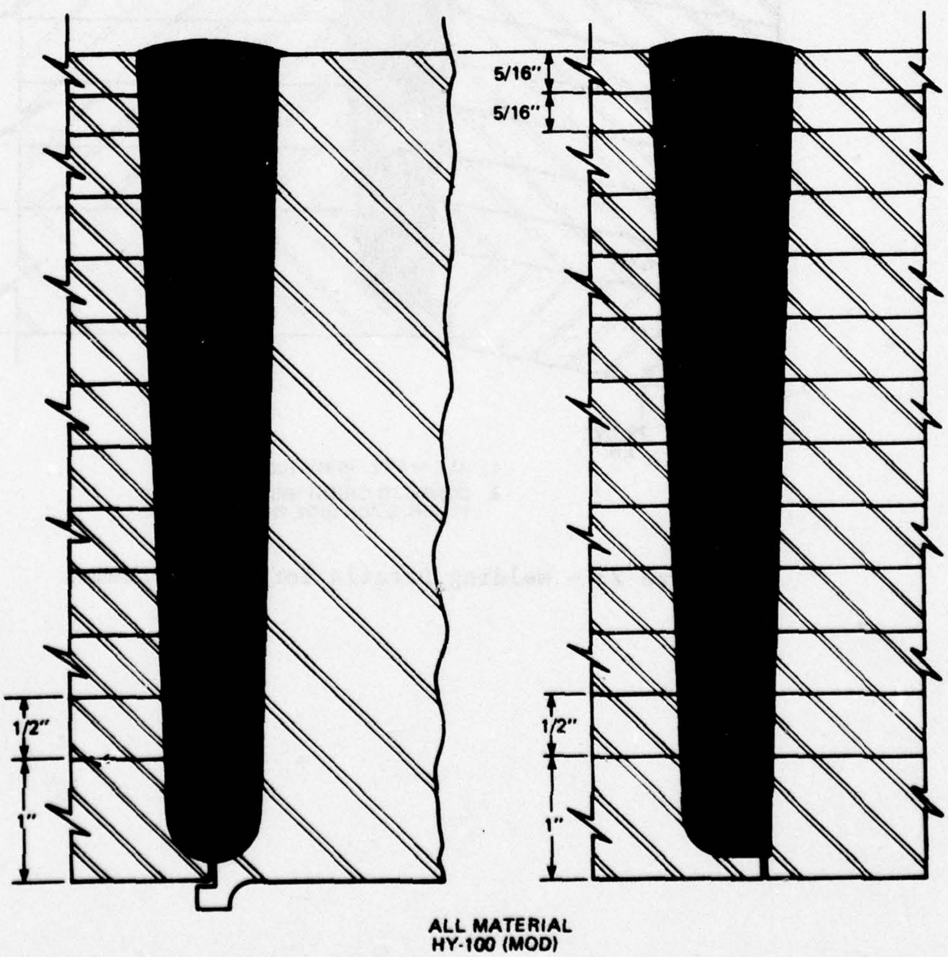
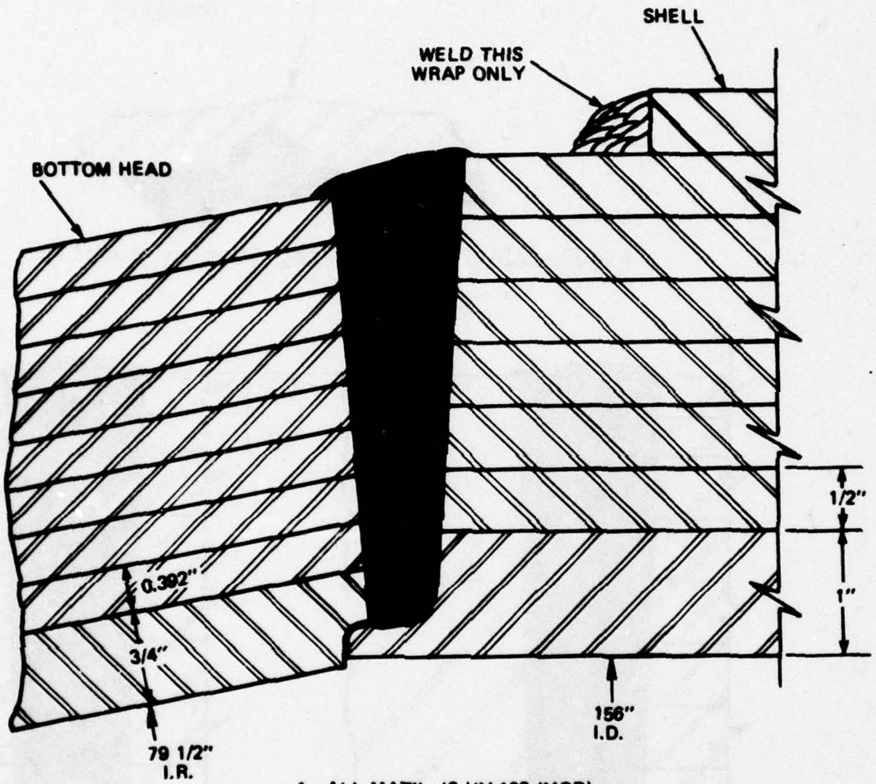


Figure 22 - Welding Details for Circle Seams 2, 3, and 4



1. ALL MAT'L. IS HY-100 (MOD).
2. CONTOUR GRIND INSIDE, 1" MIN. EACH SIDE OF WELD.

Figure 23 - Welding Details for Circle Seam 1

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

Specification No. 2187-A-1 Date July 22, 1965

Welding Process Electric Shielded Arc Manual or Machine Manual

Material Specification MIL-S-16216G HY-100 of P-No. to P-No.

Thickness (if pipe, diameter and wall thickness) .625"

Thickness Range this test qualifies 1.250"

Filler Metal Group No. F-4

Weld Metal Analysis No. A-4

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

Postheat Treatment none

Position of Groove 45° Angle from flat (See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

For Information Only

Filler Wire—Diameter 1/8", 5/32"

Trade Name Arcos Ductilend 110

Type of Backing none

Forehand or Backhand

WELDING TECHNIQUES

Joint Dimensions Accord with 2187 Sec. IV Page 19 Fig. 1

amps volts inches per min.

REDUCED SECTION TENSILE TEST (Fig. Q-6 and QN-6)

Specimen No.	Dimensions: Width	Dimensions: Thickness	Area	Ultimate Total Load, lb.	Yield Stress, psi	Character of Failure and Location
5			.604		104,305	Parent metal
11			.586		110,068	" "

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 1	Passed, no tears	Side 16	Passed, 1/64" and 3/32 corner crack
Side 7	Passed, no tears		

Welder's Name E. F. Jones Clock No. 87 Stamp No. 87

Who by virtue of these tests meets welder performance requirements.

Test Conducted by ROBERT CLARK ANDERSON Laboratory—Test No.

per

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 HAHN & CLAY (Manufacturer)

Date July 22, 1965 By

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code. Recommended Form Q-1 is available for purchase at ASME Headquarters.)
Note: Any essential variables in addition to those above shall be recorded.

Test Results (Standard Charpy 10mm x 10mm Vee Notch)

Specimen No.	Temp.	Ft. Lbs.	Specimen No.	Temp.	Ft. Lbs.
3	32°F	60.5	12	-60°F	33.0
4	32°F	61.5	14	-60°F	33.5
8	32°F	56.5	15	-60°F	35.0

Figure 24 - Welder Qualifications

Name of Client MITSUI & Co. Ltd/HAHN & CLAY

Order Number 19835

Job Number 99400

Number

Work Number FG3-0117

Charge Number 48D 1011-1-1

RECORD OF INSPECTION

(ULTRASONIC TESTING)

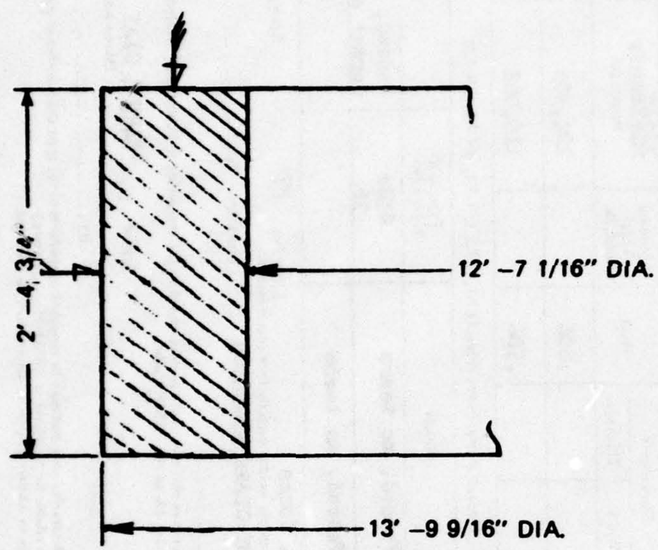
INSPECTED AS Rough Machined CONDITION

MURORAN PLANT.
THE JAPAN TEEL WORKS, LTD

Date of Issue Nov. 24, 1973

for Chief of Inspection Section

Item FORGED RING (2)



Specification : HAHN & CLAY's Spec. No. 6-A-132

Test Condition

Equipment : UM-721, Sperry Type made by TOKYO KEIKI

Test method : Straight Beam

Frequency : 2.25 MHz

Transducer : 1 1/8 in. dia. (1.10236") 28mm

Sensitivity : B1 = 80% of full screen height

Couplant : Machine Oil

Date of Test : Nov. 24, 1973

Test Result : Good.

Note :

Witnessed by

NOTE: ITEM 2 HAD (12) DEFECT AREAS CAUSED BY SCALE IN THE END OPPOSITE THE PROLONGATION END. INDICATIONS VARIED FROM 1/4" -2" LONG. MAXIMUM DEPTH WHEN REMOVED BY GRINDING 17MM (0.669") FINISH MACHINING WILL ELIMINATE ALL OF THESE DEFECTS.

SEE NSRDC AUDIT FINDING 3

Figure 25 - Forging Inspection Report

TABLE 1 - MECHANICAL AND IMPACT PROPERTIES OF PLATES USED FOR CONSTRUCTION OF THE TANK

Item	Quan.	Plate Description: Thickness x Width x Length	Heat No. (Melt No.)	Slab No.	Mechanical Properties: Yield Strength (< 3/4" Thick 100,000 to 120,000 psi; > 3/4" Thick 100,000 to 115,000 psi)	Tensile Strength (115,000 Minimum)	% Elongation (< 3/4" Thick 17%; > 3/4" Thick 18%)	% Reduction in Area (< 3/4" Thick No Req't.; > 3/4" Thick 45%)	Impact Properties – Tests at Low Temperature: C_V Specimen Ident. (If Req'd.)	Test Temp. −120° F ± 3° F	Charpy Values (Average > 50 Ft-Lb, No Single Value Below 45 Ft-Lb) 1	2	3	Tests for Fracture Appearance: C_V Specimen Ident. (If Req'd.)	Test Temp. 0° F ±3° F	Charpy Values (Average > 50 Ft-Lb, No Single Value Below 45 Ft-Lb) 1	2	3	C_V Specimen Fracture Appearance (100% Fibrous Fracture, No Crystalline or Bright Facets Permitted)
1		Canceled																	
2	1	1/2 x 126 5/8 x 325 5/8	B4766	6A	112.0	120.0	27%	NA	8215	−120° F	122	115	123	8214	0° F	130	133	117	Normal
	2		B6766	6B	115.0	121.0	28%		8271	−120° F	119	122	130	8270	0° F	140	142	141	Normal
	3		B6766	4A	114.0	122.0	28%		387	−120° F	149	136	136	386	0° F	146	143	146	Normal
	4		B6766	4B	111.0	120.0	26%		2633	−120° F	121	126	130	2634	0° F	133	130	126	
3	1	1/2 x 127 1/2 x 325 5/8	A1607	10B	113.0	121.0	27%	NA	9015	−120° F	118	118	118	4014	0° F	126	134	129	Normal
	2		B6940	4A	116.0	123.0	25%		8133	−120° F	103	103	104	8132	0° F	100	105	104	Normal
	3		A1607	10A	103.0	118.0	24%		1786	−120° F	116	113	115	1787	0° F	126	121	121	Normal
	4		B6940	4B	114.0	124.0	21%		5305	−120° F	99	103	103	5304	0° F	106	103	109	Normal
4	1	1/2 x 128 3/8 x 325 5/8	B6766	7A	107.0	116.0	27%	NA	8389	−120° F	130	133	133	8388	0° F	130	139	138	Normal
	2		B6766	8B	106.0	117.0	28%		7806	−120° F	131	128	129	7805	0° F	136	138	138	Normal
	3		B6766	7B	115.0	121.0	26%		8213	−120° F	120	122	125	8212	0° F	136	125	136	Normal
	4		B6766	8A	107.0	119.0	24%		8269	−120° F	102	82	101	8268	0° F	109	106	107	
5	1	1/2 x 129 1/4 x 325 5/8	A1607	1B	111.0	120.0	26%	NA	2856	−120° F	100	108	107	2853	0° F	108	116	117	Normal
	2		A1607	1A	110.0	119.0	23%		9019	−120° F	118	118	118	9018	0° F	126	134	129	Normal
	3		A1607	2A	113.0	122.0	29%		9017	−120° F	102	99	109	9016	0° F	111	117	109	Normal
	4		A1607	2B	113.0	120.0	26%		8209	−120° F	97	106	109	8208	0° F	122	120	119	Normal
6	1	1/2 x 130 7/8 x 325 5/8	A1607	3A	109.0	118.0	29%	NA	7173	−120° F	116	112	110	7172	0° F	114	114	113	Normal
	2		A1607	3B	112.0	119.0	28%		8137	−120° F	109	100	101	8136	0° F	125	106	120	Normal
	3		B6766	3A	110.0	119.0	30%		5826	−120° F	131	130	130	5827	0° F	142	142	143	Normal
	4		B6766	3B	106.0	116.0	24%		5206	−120° F	131	128	131	5207	0° F	134	134	133	
7	1	1/2 x 130 7/8 x 325 5/8	B6755	6A	115.0	123.0	26%	NA	9628	−120° F	101	104	107	9629	0° F	104	96	110	Normal
	2		B6940	5A	114.0	121.0	24%		120	−120° F	120	95	102	119	0° F	102	110	98	Normal
	3		B6755	6B	124.0	130.0	25%		672	−120° F	120	82	101	673	0° F	109	106	107	Normal
	4		B6940	5B	113.0	121.0	25%		7462	−120° F	100	110	104	7461	0° F	116	116	116	Normal

Table 1 (Continued)

Item	Quan.	Plate Description: Thickness	Plate Description: Width	Plate Description: Length	Heat No. (Melt No.)	Slab No.	Mechanical Properties: Yield Strength (< 3/4" Thick 100,000 to 120,000 psi; > 3/4" Thick 100,000 to 115,000 psi)	Mechanical Properties: Tensile Strength (115,000 Minimum)	Mechanical Properties: % Elongation (< 3/4" Thick 17%; > 3/4" Thick 18%)	Mechanical Properties: % Reduction in Area (< 3/4" Thick No Req't.; > 3/4" Thick 45%)	Impact Properties, Tests at Low Temperature: C_V Specimen Ident. (If Req'd.)	Tests at Low Temperature: Test Temp. −120° F ± 3° F	Tests at Low Temperature: Charpy Values (Average > 50 Ft-Lb, No Single Value Below 45 Ft-Lb) 1	2	3	Tests for Fracture Appearance: C_V Specimen Ident. (If Req'd.)	Tests for Fracture Appearance: Test Temp. 0° F ±3° F	Tests for Fracture Appearance: Charpy Values (Average > 50 Ft-Lb, No Single Value Below 45 Ft-Lb) 1	2	3	C_V Specimen Fracture Appearance (100% Fibrous Fracture, No Crystalline or Bright Facets Permitted)
8	1	1/2 x	131 3/4 x	325 5/8	B6755	8A	106.0	116.0	30%	NA	674	−120° F	110	111	110	675	0° F	106	111	103	Normal
	2				B7319	3B	108.0	119.0	25%		6464	−120° F	130	132	122	6463	0° F	141	141	142	Normal
	3				A2076	2A	111.0	118.0	29%		6460	−120° F	131	124	131	6455	0° F	133	133	140	Normal
	4				B6755	7A	125.0	130.0	23%		3492	−120° F	86	85	90	3493	0° F	103	94	106	Normal
9	1	1/2 x	132 1/2 x	325 5/8	A1607	8A	111.0	120.0	29%	NA	576	−120° F	104	110	105	577	0° F	121	121	123	Normal
	2				A1607	7B	109.0	118.0	31%		8211	−120° F	107	104	100	8210	0° F	116	110	114	Normal
	3				B7319	3A	108.0	119.0	24%		6462	−120° F	122	120	124	6461	0° F	122	132	121	Normal
	4				A2014	2A	106.7	118.6	21%		9080	−120° F	132	132	138	9079	0° F	147	145	140	Normal
10	1	1/2 x	133 3/8 x	325 5/8	A1607	4A	110.0	119.0	30%	NA	8205	−120° F	115	115	104	8204	0° F	120	122	116	Normal
	2				A1607	4B	104.0	118.0	25%		7382	−120° F	124	114	132	7381	0° F	122	125	129	Normal
	3				A1607	9A	110.0	118.0	30%		8207	−120° F	112	112	116	8206	0° F	116	117	124	Normal
	4				A1607	9B	114.0	121.0	30%		8135	−120° F	87	85	88	8134	0° F	101	102	101	Normal
11	1	1/2 x	134 1/4 x	325 5/8	A1607	6B	107.0	117.0	28%	NA	7175	−120° F	126	126	130	7174	0° F	131	134	127	Normal
	2				A1607	5B	109.0	117.0	24%		574	−120° F	121	120	106	575	0° F	126	133	116	Normal
	3				A1607	5A	109.0	121.0	30%		1788	−120° F	119	119	122	1789	0° F	126	132	131	Normal
	4				A1607	6A	112.0	122.0	21%		1881	−120° F	141	138	142	1882	0° F	146	140	144	Normal
12	1	5/16 x	91 5/8 x	325 5/8	A1588	5B	104.0	116.0	21%	NA	8672	−120° F	44	44	44	8673	0° F	48	48	46	Normal
	2				A1588	5A	111.0	121.0	27%		7384	−120° F	30	31	29	7383	0° F	32	32	32	Normal
	3				A1588	6A	103.0	116.0	20%		4780	−120° F	45	46	46	4779	0° F	48	47	49	Normal
	4				A1588	6B	103.0	116.0	20%		4846	−120° F	43	43	43	4845	0° F	45	44	45	Normal
	5				A1588	7A	106.0	117.0	20%		5281	−120° F	48	47	46	4963	0° F	40	42	46	Normal
	6				A1588	7B	103.0	116.0	20%		4850	−120° F	44	42	43	4849	0° F	45	44	44	Normal
13	1	5/16 x	91 1/2 x	325 5/8	A1588	18A	112.0	120.0	29%	NA	7386	−120° F	45	46	45	7385	0° F	48	48	49	Normal
	2				A1588	19A	106.0	121.0	19%		8381	−120° F	44	44	46	8380	0° F	48	47	50	Normal
	3		91		A1588	20A	107.0	118.0	19%		6602	−120° F	47	44	46	6603	0° F	46	48	48	Normal
	4				A1588	18B	108.0	119.0	22%		5282	−120° F	44	44	44	4883	0° F	43	43	43	Normal
	5				A1588	19B	109.0	119.0	20%		4840	−120° F	43	44	43	4839	0° F	45	45	45	Normal
	6				A1588	20B	105.0	118.0	22%		4842	−120° F	43	43	43	4841	0° F	44	44	46	Normal

Table 1 (Continued)

Item	Quan.	Plate Description	Heat No. (Melt No.)	Slab No.	Mechanical Properties: Yield Strength < 3/4" Thick 100,000 to 120,000 psi / > 3/4" Thick 100,000 to 115,000 psi	Mechanical Properties: Tensile Strength 115,000 Minimum	Mechanical Properties: % Elongation < 3/4" Thick 17% / ≥ 3/4" Thick 18%	Mechanical Properties: % Reduction < 3/4" Thick No Req't. / ≥ 3/4" Thick 45%	Impact Properties, Tests at Low Temperature: C_V Specimen Ident. (If Req'd.)	Tests at Low Temperature: Test Temp. −120° F ±3° F	Tests at Low Temperature: Charpy Values Average > 50 Ft-Lb No Single Value Below 45 Ft-Lb: 1	2	3	Tests for Fracture Appearance: C_V Specimen Ident. (If Req'd.)	Tests for Fracture Appearance: Test Temp. −120° F ±3° F	Tests for Fracture Appearance: Charpy Values Average > 50 Ft-Lb No Single Value Below 45 Ft-Lb: 1	2	3	C_V Specimen Fracture Appearance 100% Fibrous Fracture No Crystalline or Bright Facets Permitted
14	1	3/4 x 81 x 428	B6766	10	112.0	122.0	20%	67%	7171	−120° F	139	139	134	7170	0° F	134	137	138	Normal
	2		B8840	6	110.0	120.0	22%	64%	1880	−120° F	122	120	128	1879	0° F	130	134	124	Normal
15	1	3/4 x 70 x 140	B8840	6A	121.0	128.0	20%	65%	9102	−120° F	121	122	125	9101	0° F	122	129	134	Normal
16	1	0.382' x 103' x 410'	A1598	11A	104.0	117.0	22%	NA	4676	−120° F	44	43	42	4675	0° F	46	46	46	Normal
	2		A1598	12B	106.0	117.0	24%		6504	−120° F	30	30	32	6505	0° F	43	46	48	Normal
	3		A1598	13A	105.0	117.0	23%		4680	−120° F	43	44	44	4679	0° F	44	44	46	Normal
	4		A1598	13B	107.0	118.0	23%		6500	−120° F	45	46	44	6501	0° F	44	46	46	Normal
	5		A1598	14A	106.0	117.0	21%		4672	−120° F	42	44	43	4671	0° F	44	46	45	Normal
	6		A1598	2B	108.0	118.0	24%		6670	−120° F	98	97	101	6671	0° F	100	105	103	Normal
	7		A1598	1A	104.0	116.0	22%		4836	−120° F	48	46	48	4835	0° F	46	49	49	Normal
	8		A1598	1B	105.0	118.0	23%		4670	−120° F	42	41	42	4669	0° F	46	44	44	Normal
	9		A1598	11B	109.0	119.0	21%		4852	−120° F	42	43	46	4851	0° F	42	43	43	Normal
	10		A1598	12A	108.0	117.0	23%		4678	−120° F	46	45	46	4677	0° F	48	47	49	Normal
	11		A1598	14B	107.0	118.0	23%		4674	−120° F	45	47	44	4673	0° F	48	46	46	Normal
	12		A1598	2A	108.0	119.0	22%		4858	−120° F	100	100	98	4857	0° F	105	103	106	Normal
	13		A1598	3A	107.0	119.0	22%		4774	−120° F	43	43	44	4773	0° F	44	42	45	Normal
	14		A1598	4A	105.0	117.0	25%		4834	−120° F	43	42	43	4833	0° F	43	42	43	Normal
	15		A1598	4B	107.0	118.0	21%		4854	−120° F	98	96	96	4853	0° F	99	63	99	Normal
17	1	0.382' x 38" x 288'	B6077	4B	110.0	120.0	23%	NA	4561	−120° F	46	46	44	4560	0° F	48	49	49	Normal
18	1	1 x 121 x 253	B6766	2A	103.0	115.0	25%	71%	9023	−120° F	125	126	128	9022	0° F	134	131	132	Normal
	2		A2014	4	118.0	125.0	21%	66%	5309	−120° F	109	104	107	5308	0° F	114	108	110	Normal
	3		A1607	11	104.0	116.0	22%	66%	3434	−120° F	130	121	122	3435	0° F	135	133	133	Normal
	4		A2014	4	118.1	125.0	21%	66%	8830	−120° F	109	104	107	8829	0° F	114	108	110	Normal
19	1	1 x 87 x 253	B6766	5	113.8	120.4	20%	63.2%	361	−120° F	126	126	126	360	0° F	133	131	136	Normal
	2		B6766	5	113.8	120.4	20%	63.2%	361	−120° F	126	126	126	360	0° F	133	131	136	Normal

TABLE 2 - CHEMICAL PROPERTIES OF PLATES USED IN THE TANK

Heat No. (Melt No.)	Element and Specified Ladle Analysis Requirements											Remarks
	C	M_n	P	S	S_i	N_i	C_r	M_o	T_i	V	C_u	
	0.20 max	0.10–0.40	0.015 max	0.015 max	0.15–0.35	2.25–3.50	1.00–1.80	0.20–0.60	0.02 max	0.02 max	0.25 max	
A1607	0.15	0.32	0.007	0.015	0.24	2.42	1.29	0.30	0.004	0.003	0.20	Ladle
A1607	0.17	0.34	0.012	0.013	0.21	2.57	1.36	0.30	0.002	0.003	0.19	Check
B6766	0.17	0.30	0.014	0.014	0.24	2.42	1.29	0.29	0.003	0.003	0.19	Ladle
B6766	0.15	0.31	0.008	0.012	0.21	2.52	1.31	0.29	0.005	0.003	0.18	Check
B6755	0.15	0.30	0.008	0.014	0.22	2.45	1.33	0.30	0.002	0.003	0.18	Ladle
B6755	0.14	0.32	0.009	0.013	0.21	2.36	1.30	0.29	0.004	0.003	0.17	Check
B6940	0.16	0.33	0.005	0.015	0.23	2.45	1.33	0.30	0.003	0.003	0.12	Ladle
B6940	0.18	0.33	0.008	0.012	0.22	2.38	1.31	0.29	0.002	0.003	0.12	Check
A1598	0.15	0.33	0.006	0.017*	0.20	2.70	1.34	0.29	0.003	0.003	0.14	Ladle
A1598	0.15	0.32	0.007	0.019*	0.19	2.72	1.30	0.28	0.003	0.002	0.13	Check
B5977	0.16	0.29	0.001	0.019*	0.18	2.58	1.42	0.38	0.002	0.003	0.14	Ladle
B5977	0.16	0.29	0.001	0.020*	0.17	2.57	1.41	0.39	0.002	0.003	0.13	Check
A2014	0.16	0.31	0.007	0.014	0.20	2.48	1.39	0.29	0.002	0.003	0.15	Ladle
A2014	0.17	0.33	0.007	0.015	0.21	2.46	1.40	0.29	0.002	0.003	0.15	Check
B7319	0.17	0.30	0.008	0.015	0.23	2.63	1.39	0.30	0.003	0.003	0.14	Ladle
B7319	0.17	0.32	0.007	0.014	0.21	2.69	1.39	0.30	0.003	0.003	0.13	Check
A2076	0.15	0.29	0.010	0.015	0.23	2.43	1.35	0.29	0.003	0.003	0.16	Ladle
A2076	0.14	0.29	0.007	0.014	0.22	2.49	1.34	0.29	0.003	0.003	0.15	Check

*Waver granted, see Message PR251419, August 1973.

TABLE 3 - CHEMICAL PROPERTIES OF FORGINGS USED IN THE TANK

Heat No. (Melt No.)	Element and Specified Ladle Analysis Requirements												Remarks
	C	M_n	P	S	S_i	N_i	C_r	M_o	T_i	V	C_u	A	
	0.20 max	0.10–0.40	0.015 max	0.015 max	0.15–0.35	2.25–3.50	1.00–1.80	0.20–0.60	0.02 max	0.02 max	0.25 max	0	
Ring Forging 1 Item 1	0.17	0.27	0.007	0.008	0.04	3.35	1.58	0.53	Tr.	0.01	0.07	Tr.	Ladle
I.D. 48D1011-1-3	0.16	0.27	0.008	0.007	0.03	3.42	1.60	0.55	Tr.	0.01	0.07	Tr.	Check
Ring Forging 2 Item 2	0.17	0.27	0.007	0.008	0.04	3.35	1.58	0.53	Tr.	0.01	0.07	Tr.	Ladle
I.D. 48D1011-1-1													Check
Ring Forging 3 Item 3	0.17	0.27	0.007	0.008	0.04	3.35	1.58	0.53	Tr.	0.01	0.07	Tr.	Ladle
I.D. 48D1011-1-2													Check
5" OD Nozzles Item 6	0.19	0.37	0.007	0.012	0.19	3.46	1.61	0.49	Tr.	Tr.	0.02	0.026	Ladle
I.D. 48537-1-1 to 6	0.18	0.37	0.007	0.012	0.20	3.39	1.58	0.49	Tr.	Tr.	0.02	0.046	Check
5" OD Nozzles Item 6	0.19	0.40	0.015	0.014	0.10	3.47	1.67	0.50	Tr.	Tr.	0.12	0.025	Ladle
I.D. 48540-1-1 to 5	0.16	0.37	0.014	0.014	0.04	3.47	1.57	0.53	Tr.	Tr.	0.07	0.007	Check
5" OD Nozzles Item 6	0.18	0.36	0.013	0.010	0.10	3.35	1.59	0.52	Tr.	Tr.	0.11	0.021	Ladle
I.D. 48541-1-1 to 2	0.18	0.37	0.013	0.011	0.11	3.32	1.60	0.50	Tr.	Tr.	0.10	0.021	Check
9" OD Nozzles Item 5	0.19	0.29	0.013	0.010	0.06	3.30	1.59	0.49	Tr.	Tr.	0.11	0.01	Ladle
I.D. 48539-1-1 & 2	0.18	0.33	0.014	0.009	0.05	3.37	1.59	0.49	Tr.	Tr.	0.11	0.01	Check

TABLE 4 - MECHANICAL AND IMPACT PROPERTIES OF FORGINGS USED IN THE TANK

Item	Material Description	I.D. No.	Mechanical Properties: Yield Strength	Tensile Strength	% Elong.		% Reduction in Area		Impact Properties: Test Temp. °F	Avg. Charpy Value	Test Temp. °F	Avg. Charpy Value	Test Temp. °F	Avg. Charpy Value	Charpy Spec. Fracture Appearance
			100,000 Psi Min	115,000 Psi Min	Long 18	Trans 16	Long 50	Trans 45		30 ft-lb at −120° F				50 ft-lb at 32° F	
1	Ring Forging 1	48D1011-1-3	107,600 psi	121,410 psi	20.7	21.9	68.4	71.4	−120° F	Avg. 50.5 ft-lb	−90° F	Avg. 55.7 lb-ft	32° F	Avg. 131.4 ft-lb	Normal
2	Ring Forging 2	48D1011-1-1	108,325 psi	122,175 psi	20.4	20.4	67.9	69.6	−120° F	Avg. 50.9 ft-lb	−90° F	Avg. 42.8 lb-ft	32° F	Avg. 100.6 ft-lb	Failed*
3	Ring Forging 3	48D1011-1-2	105,150 psi	119,240 psi	19.9	21.5	67.6	70.6	−120° F	Avg. 59.0 ft-lb	−90° F	Avg. 53.8 lb-ft	32° F	Avg. 117.0 ft-lb	Failed*
6	5" OD Nozzle	48537-1-1 to 6	120,550 psi	136,700 psi	21.6		67.1		−120° F	Avg. 75.1 ft-lb			32° F	Avg. 64.1 ft-lb	Normal
6	5" OD Nozzle	48540-1-1 to 5	116,850 psi	134,750 psi	21.0		69.4		−120° F	Avg. 49.1 ft-lb			32° F	Avg. 56.0 ft-lb	Normal
6	5" OD Nozzle	48541-1-1 to 2	110,380 psi	127,700 psi	21.7		72.1		−120° F	Avg. 78.4 ft-lb			32° F	Avg. 57.4 ft-lb	Normal
5	9" OD Nozzle	48539-1-1 & 2	108,000 psi	126,900 psi	21.5		70.4		−120° F	Avg. 96.7 ft-lb			32° F	Avg. 94.6 ft-lb	Normal

*Failed to meet 100% fibrous fracture appearance, therefore N.1 ductile curve was developed from more charpy specimens. Also, two specimens were made for dynamic tear test. These results showed a NIL ductility temperature below −120° F and good tear properties at 32° F (see NSRDC ltr 73-178-107 of 21 December 1973). Forging accepted on this basis.

TABLE 5 - PROPERTIES OF THE NUMBER 11018 WELD ROD USED ON THE TANK

E2128 7/32 Jetweld LH-110 7000 lbs.

DATE **22 March 1974**

CERTIFICATION OF QUALITY CONFORMANCE TESTS

CUSTOMER'S NAME **Big Three Industries, Inc.** CUSTOMER'S ORDER NO. **H-35551**

SPECIFICATION MIL-E-0022200/1D TYPE MIL- **11018M** SIZE **7/32" x 18"** LOT NO. **13B**

INSPECTION LEVEL **B** LOT IDENTIFICATION MIL-E-0022200E PARA. 4.2.1.2

CORE WIRE HEAT NO. Controlled Core Wire Per MIL-E-0022200E Para. 4.2.1.2 WET BATCH NO. **D1**
Separate periods 2 hrs. or less.

MECHANICAL & X-RAY TEST

	AS-WELDED	STRESS RELIEVED
YIELD STRENGTH 0.2% OFFSET METHOD	100,400	**Not Applicable**
TENSILE STRENGTH	115,700	
% ELONGATION	22.5%	
% REDUCTION IN AREA	65 %	
CHARPY IMPACTS 1.	59	1. **Not Applicable**
2.	38	2.
3.	48	3.
4.	42	4.
5.	39	5.

X-RAY RESULTS Meet Specification Requirements AMPERAGE **270 DC+**

GRINDING DURING 6a TEST PLATE PREPARATION **Limited to grinding weld starts**
OPERATOR ERROR (LAYER NO.S) **None**

WELD PAD CHEMICAL ANALYSIS

CARBON	.068
SULFUR	.019
PHOSPHORUS	.010
SILICON	.39
MANGANESE	1.51
CHROMIUM	.29
NICKEL	1.67
MOLYBDENUM	.31
VANADIUM	≤ .05

AMPERAGE **270 DC+**

CONCENTRICITY 3.5 %

COVERING MOISTURE .11 %

We hereby certify that the above material has been tested in accordance with the listed specification and is in conformance with all requirements, and is free from mercury contamination. All material in one container is from one lot.

J. Warren Smith
Manager, Special Products Department
The Lincoln Electric Company
Cleveland, Ohio 44117

TABLE 5 (Continued)

E2128 7/32 Jetweld LH-110 7000 lbs. .

Date 22 March 1974

CERTIFICATION OF WET MIX EQUIVALENCY TESTS

CUSTOMER'S NAME Big Three Industries, Inc. CUSTOMER'S ORDER NO. H-35551

DIAMETER 7/32" x 18' LOT NO. 13B

SPECIFICATION MIL-E-0022200/ID TYPE MIL 11018M

CORE WIRE HEAT NO. Controlled Core Wire Per MIL-E-0022200E Para. 4.2.1.2 WET BATCH NO. T6, T7 Separate periods 2 hrs. or less.

WELD PAD CHEMICAL ANALYSIS: NOT REQUIRED

SEE 3/ TABLE VIIa OF MIL-E-0022200/ID

WELD TEST 8a

X-RAY RESULTS Meet Specification Requirements AMPERAGE 270 DC+

We hereby certify that the above material has been tested in accordance with the listed specification and is in conformance with all requirements, and is free from mercury contamination. All material in one container is from one lot. We have on file satisfactory radiographs representing each of the wet batches listed above.

J. Warren Smith
Manager, Special Products Department
The Lincoln Electric Company
Cleveland, Ohio 44117

TABLE 6 - PROPERTIES OF THE $NiCu_2$ WELD ROD USED ON THE TANK

CHEMETRON CORPORATION
WELDING PRODUCTS DIVISION

Certificate of Analysis

Hahn & Clay
5100 Clinton Dr.
Houston, Texas 77020

Customer Order No. ____________

____________ Order No. ____________

Shipped ____________

This material conforms to Specification AWS A5.11

X-Ray Satisfactory Type E NiCu- 2

Trade Name: Arcaloy 9N10

Diameter Size: 5/32

Lot Number: 1E508C35DE
Heat Number: M44447H

Element	Typical Analysis	(Specification) (Requirements)
Carbon	.05	(0.40 Max.)
Manganese	3.25	(4.0 Max.)
Chromium		
Nickel	66.0	(62.0/70.0)
Silicon	80	(1.0 Max.)
Columbium		
Tantalum		
Molybdenum		
Tungsten		
Copper	28.5	(Remainder)
Titanium	.75	(1.0 Max.)
Phosphorus	.005	
Sulphur	.010	(0.025 Max.)
Vanadium		
Iron	.50	(2.5 Max.)
Ferrite		
Aluminum	.20	(1.5 Max.)

Typical Mechanical Properties

	As Welded	Stress Relieved
Yield Point (Psi)	50,000	
Tensile Str. (Psi)	75,500	
Elongation, %(2"Ga.)	40%	
Red. of Area %		
Charpy V-Notch Impacts @ (Ft. -lb.)		

(Specification Requirements)

Min. Unless otherwise stated.	As Welded	Stress Relieved
Yield Point (Psi)	-----	
Tensile Str. (Psi)	70,000	
Elongation, %	30	
Red. of Area, %		
Charpy V-Notch Impacts @ (Ft. - lb.)		

Transverse Guided Side Bends-Satisfactory
Surfacing Weld Bends - Satisfactory

State of Texas)
County of Dallas) SS

Subscribed and sworn to before me this 14 day of May 19 75

The undersigned certifies that this report is correct and that no significant change has been made in any of the elements described in the qualification approval.

CHEMETRON CORPORATION
WELDING PRODUCTS DIVISION

EAL ____________
Notary Public
Ron Kramer
My commission expires:
June 1, 1975

BY ____________
Jere L. Crim

TABLE 7 - PROPERTIES OF THE PIN MATERIAL USED ON THE TANK

Chemical Composition

Element	C	M_o	P	S	S_i	N_i	C_r	M_o
Specified	0.37–0.44	0.60–0.95	0.025 max	0.025 max	0.20–0.35	1.55–2.00	0.65–0.95	0.20 0.30
Actual	0.41	0.73	0.008	0.011	0.27	1.71	0.78	0.23

Mechanical Properties

	Yield Strength psi	Tensile Strength psi	% Elongation	% Reduction in Area
Specified	140,000 min	155,000 min	11 min	40 min
Actual	156,000	169,500	15.5	56

Impact Properties

Test Temp. °F	Charpy Value 35 ft-lb Min at −30° F	Lateral Expansion
−30	44.5	0.022
−30	45.0	0.024
−30	44.5	0.021

APPENDIX A

INSPECTION AND WELDING REPORTS FOR LONG SEAM 2

HAHN & CLAY INSPECTION RECORD – A

B NO. 99400 CUSTOMER U.S. NAVY DATE 5-1-74

PART SHELL DWG. NO. 538-A-42 ITEM NO.

WELD NO(S) LS-2 ASSEMBLY 538-C-16

TYPE OF INSPECTION: MTR ☐ MT ☐ UT ☐ VISUAL ☒ DIM ☒ PT ☐ SF ☐

EQPT. USED: TAPE- SCALE

INSPECTED BY. PEREZ OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☒ OK FOR WELDING

☐ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY DATE 5-1-74

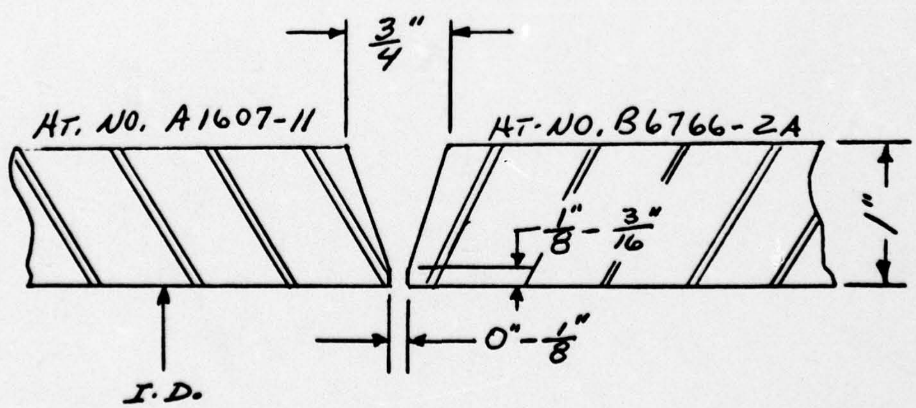
DETAILS: DIMENSIONAL INSPECTION OF THE WELD SEAM FIT-UP FOUND ALL DIMENSIONS TO BE WITHIN PRINT TOLERANCE.

~~ACTION TAKEN~~: (FIT-UP 4-30-74)

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:



HANN & CLAY INSPECTION RECORD - A

JOB NO. 99400 CUSTOMER U.S. NAVY DATE 5-1-74

PART SHELL DWG. NO. 538-A-42 ITEM NO.

WELD NO(S) LS-2 ASSEMBLY 538-C-16

TYPE OF INSPECTION: MTR ☐ MT ☒ UT ☐ VISUAL ☐ DIM ☐ PT ☐ SF ☐

EQPT. USED: KH-09 UNIT

INSPECTED BY. PEREZ OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☒ OK FOR WELDING

☐ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY DATE 5-1-74

DETAILS: MAGNETIC PARTICLE EXAMINATION OF THE ROOT PASS REVEALED NO INDICATIONS OF UNACCEPTABLE DEFECTS.

ACTION TAKEN:

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

HSC STD 6 A 20 - 1 1 70

HAHN & CLAY INSPECTION RECORD - A

B NO. 99400 CUSTOMER U.S. NAVY DATE 5-9-74

PART SHELLS DWG. NO. 538-A-42 ITEM NO.

WELD NO(S) LS-1 & 2; LS-5 & 6 ASSEMBLY

TYPE OF INSPECTION: MTR ☐ MT ☐ UT ☐ VISUAL ☒ DIM ☒ PT ☐ SF ☐

EQPT. USED: TAPE

INSPECTED BY. PEREZ OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☒ OK FOR FURTHER PROCESSING

☐ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY - STRAKA DATE 5-9-74

DETAILS: VISUAL & DIMENSIONAL INSPECTION AFTER RE-ROLLING.

ACTION TAKEN:

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

HAHN & CLAY INSPECTION RECORD - A

JOB NO. 99400 CUSTOMER U.S. NAVY DATE 5-9-74

PART SHELLS DWG. NO. 538-A-42 ITEM NO.

WELD NO(S) LS-1, 2, 5, & 6 ASSEMBLY

TYPE OF INSPECTION: MTR ☐ MT ☒ UT ☐ VISUAL ☐ DIM ☐ PT ☐ SF ☐

EQPT. USED: KH-09 Unit

INSPECTED BY. PEREZ OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☒ OK FOR RADIOGRAPHY

☐ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY DATE 5-9-74

DETAILS: MAGNETIC PARTICLE EXAMINATION OF THE WELD SEAMS - AFTER RE-ROLLING - REVEALED NO INDICATIONS OF UNACCEPTABLE DEFECTS.

ACTION TAKEN:

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

HCC STD QA 20 - 1 1 '70

HANN & CLAY INSPECTION RECORD - A

B NO. 99400 CUSTOMER U.S. NAVY DATE 5-10-74

PART SHELL DWG. NO. 538-A-42 ITEM NO.

WELD NO(S)- LS-1 & 2 ASSEMBLY

TYPE OF INSPECTION: MTR ☐ MT ☐ UT ☐ VISUAL ☐ DIM ☐ PT ☐ SF ☐

EQPT. USED: RADIOGRAPHY

INSPECTED BY. PEREZ- RICHARDSON OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☐ OK FOR

☒ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY- MEGOW DATE 5-10-74

DETAILS: RADIOGRAPHY EXAMINATION OF THE WELD SEAMS REVEALED NO INDICATIONS OF UNACCEPTABLE DEFECTS IN LS-1. WELD SEAM LS-2 WAS REJECTED DUE TO A CRACK IN

~~ACTION TAKEN~~: EXPOSURE NO. 9.

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

RT PERFORMED BY PRECISION INSP.-
H & C P.O. 24565-10.

H&C STD 8 A 20 - 1 1/76

Radiographic Inspection Certification

PRECISION INSPECTION LIMITED
5826 NORTHDALE - HOUSTON, TEXAS 77017

DATE - 5-20-74

CUSTOMER Hahn & Clay
JOB NUMBER 99400
PURCHASE ORDER 24565-10
INSPECTION SPECIFICATIONS Navships 0900-006-9010
INSPECTION STANDARDS Navships 0900-006-9010
INSPECTION PROCEDURE NO. 5-A-3B-1
DRAWING NUMBER

WELDMENTS X
CASTINGS
FORGINGS
OTHER
BASE METAL HY 100
FILLER METAL E11018M
SOURCE: Ir-192 95 curies
FILM: Dupont D-55

PART NUMBER LS-1, LS-2, LS-5, LS-6
VESSEL NO. 99400
HEAT NO.

Serial No.	Seam No.	Exposure No.	Radiographically Acceptable	Borderline	Reject	Slag Inclusion	Lack of Penetration	Gas Porosity	Lack of Weld Fusion	Crack	Undercut	Internal Shrinkage	Lap, Seam or Cold-Shut	Hot Tears	Sand Inclusion	Surface Defect	Film Defect	Section Thickness	Penetrameter	Size	Focal Distance	Exposure Time
	LS-1	1	X															1"	1.0		20"	3¼ min.
		2	X																			
		3	X					X														
		4	X					X														
		5	X					X														
		6	X																			
		7	X					X														
		8	X					X														
		9	X																			
	LS-2	1	X					X														
		2	X																			
		3	X																			
		4	X					X														
		5	X					X														
		6	X					X														
		7	X					X														
		8	X					X														
Retake 2 on Repair		9	X			X				(original film revealed crack												
	LS-5	1	X																			
		2	X																			
		3	X																			
		4	X			X																
		5	X			X																
		6	X					X														
		7	X					X														
	LS-6	1	X					X														
		2	X					X														
		3	X					X														
		4	X																			
		5	X																			
		6	X					X														
		7	X																			

REMARKS: .005" Lead Screens Front & Rear

Inspector J. M Richardson

TEST REPORT NO.

Signed JMRichardson

HANN & CLAY INSPECTION RECORD - A

JOB NO. 99400 CUSTOMER U.S. NAVY DATE 5-10-74

PART SHELL DWG. NO. 538-A-42 ITEM NO.

WELD NO(S) LS-2 ASSEMBLY

TYPE OF INSPECTION: MTR ☐ MT ☐ UT ☐ VISUAL ☐ DIM ☐ PT. ☐ SF ☐

EQPT. USED: RADIOGRAPHY - RETAKE 1

INSPECTED BY. PEREZ - RICHARDSON OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☐ OK FOR

☒ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY DATE 5-10-74

DETAILS: RESHOT RADIOGRAPHY TO VERIFY THE CRACK IN THE WELD SEAM. THE RADIOGRAPHY CONFIRMED A CRACK IN EXPOSURE 9-10.

ACTION TAKEN:

WORK OK BY DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

RT BY PRECISION INSP. - H&C PO-24565-10.

H&C STD 6 A 20 - 1-1-70

PAGE 1 OF 1 PAGE(S)

Radiographic Inspection Certification

PRECISION INSPECTION LIMITED

5826 NORTHDALE - HOUSTON, TEXAS 77017

DATE - 5-20-74

CUSTOMER: Hahn & Clay
JOB NUMBER 99400
PURCHASE ORDER 24565-10
INSPECTION SPECIFICATIONS Navships 0900-006-9010
INSPECTION STANDARDS Navships 0900-006-9010
INSPECTION PROCEDURE NO. 5-A-3B-1
DRAWING NUMBER

WELDMENTS X
CASTINGS
FORGINGS
OTHER
BASE METAL HY 100
FILLER METAL E11018M
SOURCE: Ir-192 95 curies
FILM: Dupont D-55

ART UMBER LS-1, LS-2, LS-5, LS-6
ESSEL NO. 99400
EAT NO.

Serial No.	Seam No.	Exposure No.	Radiographically Acceptable	Borderline	Reject	Slag Inclusion	Lack of Penetration	Gas Porosity	Lack of Weld Fusion	Crack	Undercut	Internal Shrinkage	Lap, Seam or Cold-Shut	Hot Tears	Sand Inclusion	Surface Defect	Film Defect	Section Thickness	Penetrameter	Size	Focal Distance	Exposure Time
	LS-1	1	X															1"	1.0		20"	3¼ min.
		2	X																			
		3	X					X														
		4	X					X														
		5	X					X														
		6	X																			
		7	X					X														
		8	X					X														
		9	X																			
	LS-2	1	X					X														
		2	X																			
		3	X																			
		4	X					X														
		5	X					X														
		6	X					X														
		7	X					X														
		8	X					X														
Retake 2 on Repair		9	X			X				(original film revealed crack												
	LS-5	1	X																			
		2	X																			
		3	X																			
		4	X			X																
		5	X			X																
		6	X					X														
		7	X					X														
	LS-6	1	X					X														
		2	X					X														
		3	X					X														
		4	X																			
		5	X																			
		6	X					X														
		7	X																			

MARKS: .005" Lead Screens Front & Rear

Inspector J. M Richardson

EST REPORT NO.

Signed J.M. Richardson

HANN & CLAY INSPECTION RECORD - A

B NO. 99400 CUSTOMER U.S. NAVY DATE 5-18-74

PART SHELL DWG. NO. 538-A-42 ITEM NO.

WELD NO(S)- LS-2 ASSEMBLY 538-C-16

TYPE OF INSPECTION: MTR ☐ MT ☒ UT ☐ VISUAL ☐ DIM ☐ PT ☐ SF ☐

EQPT. USED: KH-09 UNIT

INSPECTED BY. PEREZ OK BY JEFFRIES DEPT. 10

RESULTS OF INSPECTION

☐ FINISHED ☒ OK FOR RADIOGRAPHY

☐ REJECT ☐ MORE WORK REQ'D. ☐ ENGINEERING ACTION REQ'D.

PERSON NOTIFIED BRANTLEY DATE 5-18-74

DETAILS: MAGNETIC PARTICLE EXAMINATION OF THE REPAIRED WELD SEAM REVEALED NO INDICATIONS OF UNACCEPTABLE DEFECTS. NOTE: THE WELD SEAM WAS REPAIRED IN

~~ACTION TAKEN~~: THE AREA OF EXPOSURES 9-10, THE REPAIR

~~WORK OK~~ BY AREA WAS 9" LONG. DATE QA. OK BY

RECORD OF DIMENSIONS

SKETCH: MATERIAL SPECIFICATION & HEAT NUMBER:

H&C STD 6 A 20 ...

PAGE 1 OF 1 PAGE(S)

Radiographic Inspection Certification

PRECISION INSPECTION LIMITED

5826 NORTHDALE – HOUSTON, TEXAS 77017

DATE – 5-20-74

CUSTOMER: Hahn & Clay	WELDMENTS X
JOB NUMBER 99400	CASTINGS
PURCHASE ORDER 24565-10	FORGINGS
INSPECTION SPECIFICATIONS Navships 0900-006-9010	OTHER
INSPECTION STANDARDS Navships 0900-006-9010	BASE METAL HY 100
INSPECTION PROCEDURE NO. 5-A-3B-1	FILLER METAL E11018M
DRAWING NUMBER	SOURCE: Ir-192 95 curies
	FILM: Dupont D-55

PART NUMBER LS-1, LS-2, LS-5, LS-6

VESSEL NO. 99400

HEAT NO.

Serial No.	Seam No.	Exposure No.	Radiographically Acceptable	Borderline	Reject	Slag Inclusion	Lack of Penetration	Gas Porosity	Lack of Weld Fusion	Crack	Undercut	Internal Shrinkage	Lap, Seam or Cold-Shut	Hot Tears	Sand Inclusion	Surface Defect	Film Defect	Section Thickness	Penetrameter Size	Focal Distance	Exposure Time
	LS-1	1	X															1"	1.0	20"	3¼ min.
		2	X																		
		3	X					X													
		4	X					X													
		5	X					X													
		6	X																		
		7	X					X													
		8	X					X													
		9	X																		
	LS-2	1	X					X													
		2	X																		
		3	X																		
		4	X					X													
		5	X					X													
		6	X					X													
		7	X					X													
		8	X					X													
Retake 2 on Repair		9	X			X			(original film revealed crack												
	LS-5	1	X																		
		2	X																		
		3	X																		
		4	X			X															
		5	X			X															
		6	X					X													
		7	X					X													
	LS-6	1	X					X													
		2	X					X													
		3	X					X													
		4	X																		
		5	X																		
		6	X					X													
		7	X																		

KS: .005" Lead Screens Front & Rear

Inspector J. M. Richardson

TEST REPORT NO.

Signed J M Richardson

RECORD OF WEL ING DATA

WELD NO. LS-2	DWG. REF.	CUST. US NAVY
DATE 4-30-74	LENGTH OF WELD 122"	JOB NO. 99400
POLARITY Rev	AMPS	VOLTS

TIME	AM PM	TEMPERATURES PREHEAT	TEMPERATURES INTERPASS	INSPECTOR	PASS NO.	WELDED BY	NO. RODS	SIZE RODS	ELECTRODE LOT NO.	HEAT INPUT JOULES/INCH
4:00	PM	200	300		1	149	1	1/8	12-C	Heat-35551
500	PM	11	11		2	149	18	5/32	12 V	Heat 2N13
615	PM	11	11		3	149	17	3/16	13 A	
800	PM	11	11		4	149	13	3/16	13 A	
930	PM	11	11		5	149	18	3/16	13 A	
				Root	Cavity	MT	INSP		OK	5-1-74
		5-1-74								
1045	PM	200	250		6	149	12	5/32	12 V	
1130	PM	"	"		7	149	12	"	"	
12:00	PM	200	250		8	149	11	"	"	
		5-2-74								
6:20	PM	150	200	START		128		5/32	12 V	
6:45	PM	"	200		9	"	17	"	"	
			"INSIDE"	FINISHED						

K. [illegible] RECORD OF WEL_ING DATA

WELD NO. LS-2	DWG. REF.	CUST. USN
DATE 5-1-74	LENGTH OF WELD 122"	JOB NO. 99400
POLARITY REV	AMPS	VOLTS

TIME	AM PM	TEMPERATURES PREHEAT	INTERPASS	INSPECTOR	PASS NO.	WELDED BY	NO. RODS	SIZE RODS	ELECTRODE LOT NO.	HEAT INPUT JOULES/INCH
12:15	PM	150°	200	START		128		1/2	13C	
1:20	"	"	"		1	"	20	"	"	
2:30	"	"	"		2	"	17	5/32	12V	
3:30	"	"	"		3	"	16	3/16	13A	
430	"	"	"		4	149	18	3/16	13A	
515		"	"		5	149	16	3/16	13A	
600		"	"		6	149	16	3/16	13A	
645		"	"		7	149	13	3/16	13A	
730		"	"		8	149	15	3/16	13A	
			5-2-74							
8:00	AM	150°	200			128				
830	"	"	"		9	"	13	5/32	12V	
900	"	"	"		10	"	14	5/32	"	
940	"	"	"		11	"	16	1/8	13C	
1020	"	"	"		12	"	15	5/32	12V	
			OUTSIDE	FINISHED						

RECORD OF WELDING DATA

WELD NO. WELD REPAIR	DWG. REF. L.S. 2 FILM" 9-10	CUST. U.S. NAVY
DATE 5-15-74	LENGTH OF WELD 9"	JOB NO. 99400
POLARITY REV.	AMPS 115-150	VOLTS

TIME	AM PM	TEMPERATURES PREHEAT	TEMPERATURES INTERPASS	INSPECTOR	PASS NO.	WELDED BY	NO RODS	SIZE RODS	ELECTRODE LOT NO.	HEAT INPUT JOULES/INCH
10:00	AM	200°	250	START		128		1/8	13C	
10:05	AM	200°	250°		1	"	1	1/8	13C	
10:10	AM	200°	250°		2	"	1	1/8	13C	
10:15	AM	200°	250		3	"	1	1/8	13C	
10:20	AM	200°	250		4	"	1	5/32	12V	
10:25	AM	200°	250°		5	"	1	5/32	12V	
10:30	AM	200	250°		6	"	1	5/32	12V	
10:35	AM	200	250		7	"	1	5/32	12V	
10:40	AM	200°	250°		8	"	1	5/32	12V	
10:45	AM	200	250		9	"	1	5/32	12V	
10:50	AM	200	250		10	"	1	1/8	13C	
10:55	AM	200	250		11	"	1	1/8	13C	
11:00	AM	200	250		12	"	1	1/8	13C	
11:05	AM	200	250		13	"	1	1/8	13C	
11:15	AM	FINISHED								

APPENDIX B

NONDESTRUCTIVE EVALUATION CERTIFICATION PROGRAM

Precision Inspection Limited
5826 Northdale
Houston, Texas 77017

August 29, 1973

TO: Whom It May Concern

SUBJECT: Certification of Nondestructive Testing Personnel
Radiographic Testing Method Levels I, II, and III

This is to certify that the following named personnel, employed at Precision Inspection Ltd, have been certified as Radiographic Method Inspectors at the levels indicated below. This certification is in accordance with SNT-TC-1A Supplement A.

The certification of any of the following personnel may be revoked at anytime at the discretion of this company.

Name	Level	Experience	Percentile Test Grade
Charles Wilson	I	1½ Years	81
Foster Ellison, Jr.	I	6 months	80
Ross Andrews	II	1½ Years	82
Lindley Matthews	II	7 Years	89
Norman Scardino	II	6 Years	90
Leslie Ward	II	5 Years	84
James Roberts	II	2½ Years	82
Richard Hassell	II	4½ Years	85
Everett Hargrove	II	4½ Years	93
Gilbert H. Webb	III	10 Years	
Dallas R. Shroyer, Jr.	III	27 Years	
Joe E. Sink, Jr.	III	27 Years	
J. M. Richardson	III	24 Years	

Certification papers of the above personnel are on file at our office in Houston, Texas, and may be inspected upon request.

PRECISION INSPECTION LTD.

J. M. Richardson, Sr.

J. M. Richardson
Partner

PRECISION INSPECTION LTD.

October 31, 1973

SUBJECT:	Personnel Requirements for Certification in accordance with SNT-TC-1A Supplement A
NDT LEVEL I:	High School graduation plus six months experience and training as described in the Precision Inspection Training Program for radiographic personnel. In addition, the applicant for certification must receive a percentile composite grade of 80% or more on the following examinations: General (40 question Level I exam) Specific (20 question exam) Practical (demonstration of proficiency in radiography)
NDT LEVEL II:	Level I requirements plus one and one half years experience in radiographic testing. Applicants for Level II Certification must receive a percentile composite grade of 80% or more on the following examinations: General (40 question Level II exam) Specific (20 question exam) Practical (demonstration of proficiency in radiography)
NDT LEVEL III:	Our Level III personnel will be certified as such without examination. This certification will be based on a minimum of five years experience in radiographic testing. In our organization Level III Certification is reserved for administrative personnel.
RECERTIFICATION:	Required each 36 months except for eye tests which are required annually.

J. M. Richardson

PRECISION INSPECTION LTD.

TRAINING PROGRAM FOR RADIOGRAPHIC PERSONNEL

1. Upon employment, a radiographic technician trainee will be assigned either to a SNT-TC-1A Level II Radiographic Operator or a SNT-TC-1A Level III Inspector for a period of three (3) days for the purpose of orientation, familiarization and introduction to the industrial radiographic field. The following subject matter will be covered in order that the trainee will have some feeling as to what industrial radiography encompasses; the trainee will be issued a copy of "Radiography in Modern Industry" for home reading.

A. Isotopes and X-ray equipment.

A1. Explanations of their physical properties and how they are used in performing inspections.

A2. Radiation effects on the human body and the importance of the safe handling of equipment.

B. Personnel monitoring.

B1. Trainee will be issued a dosimeter and a film badge and given instruction for the use of them.

C. Darkroom procedures.

C1. Introduction to darkroom and equipment.

C2. Demonstration of film handling and loading.

D. Radiographic theories.

D1. Purposes and need for industrial radiography.

E. Practical demonstration of radiography.

E1. Loading films in darkroom.

E2. Introduction to exposure calculators and charts for the purposes of calculating exposure times.

E3. Placement of high radiation area signs around exposure area.

E4. Demonstration of an actual exposure using proper penetrameters on a given specimen.

E5. Demonstration of proper development, rinsing, and drying of films.

E6. Introduction to film interpretation and explanations of how and why defects appear on radiographs.

Training Program - cont'd

While the above subject matter is to be covered thoroughly, it is understood that an inexperienced trainee can only comprehend and absorb a general understanding of industrial radiography in this short period. The trainee will now be assigned as the third member of a field crew where he will work mainly with the darkroom man in preparation for his becoming a useful Assistant Radiographer.

Dependent upon the individual trainee's capabilities, the time he spends on this assignment will vary. Radiographers are required to make oral reports to the management concerning the progress of the trainee. When the Radiographer feels that the trainee can develop films properly, and understands enough radiographic theory and safety precautions to become a helpful crew member, the trainee will be used as an Assistant Radiographer. Generally speaking, the time to accomplish the above will be five to six weeks.

2. The trainee will now attend a four (4) hour course, administered by Level III personnel, on the Texas Regulations for Control of Radiation, Part 21, entitled "Standards for Protection Against Radiation". The following subject matter will be covered:

   A. Permissible radiation doses allowed to individuals in restricted areas.

   B. Determination of accumulated dose.

   C. The exposure of minors.

   D. Radiation limits in unrestricted areas.

   E. Radiation surverys.

   F. Personnel monitoring.

   G. Caution signs and labels.

   H. Radiation areas.

   I. High radiation areas.

3. If the trainee has demonstrated his understanding of Item 2, he will attend a four (4) hour course on the Texas Regulations for Control of Radiation, Part 31, entitled "Radiation Safety Requirements for Industrial Radiographic Operations". The following subject matter will be covered:

   A. Exposure device and storage containers limits of radiation.

   B. Locking of sources of radiation.

   C. Storage precautions.

   D. Radiation survey instruments.

Training program - cont'd

E. Leak testing.

F. Quarterly inventory of sources.

G. Utilization logs.

H. Inspection of exposure devices.

I. Emergency procedures.

J. Personnel monitoring control.

K. Precautionary procedures in radiographic operations.

4. The trainee will continue his on the job training, directly under the supervision of our Radiographers, until he has been employed for a period of six months. During this period, one hour per week will be devoted to direct counseling on the following subjects:

   A. Revue of safety requirements.

   B. Radiation physics.

      B1. Effects of time, distance, and shielding.

      B2. Inverse square.

      B3. Different types of penetrating radiation.

      B4. Radiation detection devices.

      B5. Allowable radiation emitted from different type exposure devices.

      B6. Emergency procedures.

5. Upon completion of six (6) months employment the trainee will be given the following examination:

   A. General - Precision Inspection examination for Level I personnel.

   B. Specific - Precision Inspection twenty question examination on equipment.

   C. Practical - Demonstrated proficiency in performing actual-in-the-field radiography.

Training Program - cont'd

Examination will be graded on a percentile weight factor as follows:

General - .3
Specific - .2
Practical - .5

A composit grade of 80% or better will be required for the trainee to be certified as a Level I SNT-TC-1A Radiographic Operator. In addition, individual grades for the General, Specific, and Practical examination shall be 70% or greater.

PRECISION INSPECTION LTD.

SNT-TC-1A PERSONNEL CERTIFICATION

NAME CHARLES WILSON

EXPERIENCE 11/2/1971 — 8/23/1973

Examinations

Radiographic testing method - SNT-TC-1A Supplement A NDT Level I

Magnetic particle method - SNT-TC-1A, Supplement B NDT Level ______

Ultrasonic testing method - SNT-TC-1A Supplement C NDT Level ______

Liquid penetrant testing method-SNT-TC-1A Supplement D NDT Level ______

Grade Requirements for Certification

Individual examination grades of at least 70% and a percentile composite grade of at least 80%

Percentile Weights Assigned for each Examination

General (40 question exam)	.3
Specific (20 question exam)	.2
Practical (demonstration of ability in radiography)	.5

Examination Results for Level I Certification

General 87.5 %	Date 8/27/73
Specific 75 %	Date 8/27/73
Practical 80 %	Date 8/27/73

Percentile composite grade 81 %

Examiner

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