GAS HELIUM STORAGE TANK
PRESSURE VESSEL ENGINEERING NOTE

D-ZERO ENGINEERING NOTE # 3823.115 EN-461

November 11, 1996

Approved: [Signature]
RD/D-Zero Mechanical Group leader
1. Description and Identification

Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title: GASEOUS HELIUM TANK

Vessel Number: RD# 10037

Division/Section

Vessel Drawing Number: BEARD INC. MAD-283001

Maximum Allowable Working Pressure (MAP): 275 PSI

Working Temperature Range: -4 °F to 170 °F

Contents: HELIUM

Designer/Manufacturer: BEARD INDUSTRIES INC.

Test Pressure (if tested at Fermi): Acceptance Date: NA

Acceptance as conforming to standard by:

of Division/Section: Date: 11/11/96

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: HARRY F. CARTER Date: 11-6-96

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

Date:

Amendment No.: Reviewed by: Date:

Actual signature required

Fermilab ES&H Manual 5031TA-5 Rev. 3/92
Lab Property Number(s): NONE

Lab Location Code: RP15 - 325 (DAB) (obtain from safety officer)

Purpose of Vessel(s): HELIUM STORAGE

Vessel Capacity/Size: 44,000 GAL. Diameter: 129.5 in. Length: 66.79 ft.

Normal Operating Pressure (OP) 200 PSI

MAXP-OP = 75 PSI
List the numbers of all pertinent drawings and the location of the originals.

<table>
<thead>
<tr>
<th>Drawing #</th>
<th>Location of Original</th>
</tr>
</thead>
<tbody>
<tr>
<td>3823.115-ND-317757</td>
<td>D-ZERO ASSY BUILDING PAPER DRG. FILES</td>
</tr>
<tr>
<td>3823.115-MC-317758 thru 68</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
</tbody>
</table>

Note: Manufacturer's drawings were assigned D-ZERO drawing numbers and filed in our system.

2. Design Verification

Does the vessel(s) have a U stamp? Yes X No. If "Yes", fill out data below and skip page 3; if "No", fill out page 3 and skip this page.

Staple photo of U stamp plate below.

Copy "U" label details to the side

Copy data here:

- **National Board No. 56865**
- **Beaird Industries Inc.**
- MAWP 275 psi at 170°F
- Min. -40°F at 275 psi
- 14.7 psi at 140°F ext. press.
- MAU. No. 158585-01-1
- Year Built, 1993
- Lotepro Corp. Valhalla, N.Y. (Sub-Contractor)
3. System Venting Verification  Provide the system schematic in the Appendix.

Is it possible to isolate the relief valves by a valve from the vessel?
Yes  No  X
If "Yes", the system must conform to code rules. Provide an explanation on the appended schematic. (An isolatable vessel, not conforming to code rule is non-compliant under this chapter.)

Is the relief cracking pressure set at or below the M.A.W.P.?
Yes  X  No____ Actual setting below PSI
(A "No" response violates this chapter.)

Is the pressure drop of the relief system at maximum anticipated flow such that vessel pressure never rises above the following? (UG 125)
Yes  X  No____
110% of MANP (one relief)
116% of MANP (multiple reliefs)
121% of MANP (unexpected heat source)

Provide test or calculational proof in the Appendix.
(Non-conforming pressure rises is non-compliant under this Chapter.)

List of reliefs and settings:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model #</th>
<th>Set Pressure</th>
<th>Flow Rate</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANDERSON GREENWOOD</td>
<td>83E1216-G</td>
<td>250 PSIG</td>
<td>2600 SCFM AIR</td>
<td>1 1/2 x 2&quot;</td>
</tr>
<tr>
<td>FIKE</td>
<td>Relv SP</td>
<td>275 PSIG</td>
<td>11,360 SCFM AIR</td>
<td>2&quot;</td>
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</table>

Does the primary relief device follow UG-129? Yes  X  No____
(A "No" response is non-compliant under this chapter)

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?
Yes  No  X (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes  No  X
If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

⚠️ RELIEF VALVE MODEL CHGD FROM "F" TO "G" TO UTILIZE AN EXISTING VALVE.
6. **Exceptional, Existing, Used and Unmanned Area Vessels**

Is this vessel or any part thereof in the above categories?

Yes [ ] No [X]

If "Yes", follow the Engineering Note requirements for documentation and append to Note.
**GHE Storage tank Relief Summary**

<table>
<thead>
<tr>
<th>Cases (See Appendix A)</th>
<th>Capacity Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Max. Fill rate from tube trailer.</td>
<td>1400 scfm Air</td>
</tr>
<tr>
<td>2.) Compressor discharge.</td>
<td>285 scfm Air</td>
</tr>
<tr>
<td>3.) CGA S1.3-1995 Minimum capacity.</td>
<td>77 scfm Air</td>
</tr>
<tr>
<td>4.) CGA S1.3-1995 Fire condition.</td>
<td>11,203 scfm Air</td>
</tr>
<tr>
<td>5.) Max. Fill rate, Sonic flow</td>
<td>8518 scfm Air</td>
</tr>
</tbody>
</table>

**Relief Capacities** (See Appendix B)

- 2" Fike Rupture disc, Burst Press. = 275 psig
  - 11,360 scfm Air @ 110% MAWP
  - 12,445 scfm Air @ 121% MAWP

- AGCO relief valve, Set Press. = 250 psig
  - 2383 scfm Air @ 275 psig
  - 2609 scfm Air @ 110% MAWP

**Inlet Pressure Drop Cals.** (See Appendix C)

- At maximum flow (Fire case), the pressure drop of inlet piping = 23.9 psig
- The Maximum Vessel Pressure for Fire case = RD Burst press. = 275 psig

Also see Pressure Profile versus Time graph pg. C5

For Reference; MAWP of GHe tank = 275 psig

- 110% MAWP = 1.10(275) = 302.5 psig
- 121% MAWP = 1.21(275) = 333 psig
CASES
1) MAX. FILL RATE FROM TUBE TRAILERS THRU REGULATOR
2) COMPRESSOR DISCHARGE
3) CGA MINIMUM RELIEF CAPACITY
4) CGA FIRE
5) MAX. FILL RATE FROM TUBE TRAILERS, SONIC FLOW

CASE 1)
Tube trailer filling will have to go thru a regulator. The regulator is a Grov. Power Reactor Dome Regulator, Model 302G, Figure 11494P084K.

Find the maximum flow rate possible.

Use Bulletin 123E. Let $P_1 = 2500$ psig & $P_2 = 250$ psig

From nomograph, $Q_1 = 1400$ scfm air

CASE 2)
\[
\dot{m} = 60 \text{ g/s He}
\]

\[
Q_{He} = 60 \text{ g/s He} \times \frac{1 \text{ scf gas}}{0.04690 \text{ kg}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 768 \text{ scfm He}
\]

\[
Q_{Air} = Q_{He} \sqrt{SG} = 768 \text{ scfm} \sqrt{1.38}
\]

"$Q_2 = 285$ scfm Air"
CASE 3) CGA S1.3-1995 PAR. 5.2.1 MINIMUM RELIEF SIZE

\[ Q_a = \frac{0.085 \times P \sqrt{V}}{C} - \frac{0.0085 \times (290 \text{ psia}) \times (5882 \text{ ft}^3)}{377} \]

\[ Q_a = 76.9 = 77 \text{ scfm air} \]

CASE 4) CGA S1.3-1995 PAR. 5.3 FLOW CAPACITY UNDER FIRE COND.

5.3.1 \[ Q_a = 0.0035 \times P \times W_e \]

\[ = 0.0035 \times (289.7 \text{ psia}) \times (44,000 \text{ gal} \times \frac{0.37 \text{ lb}}{\text{gal}}) \]

\[ = 37,342 \text{ scfm air} \]

**PER 5.3 b)** THE TANK IS USED FOR NON-FLAMMABLE GAS AND IS SUITABLY ISOLATED FROM POSSIBLE ENGULFMENT IN A FIRE, THEREFORE THE REQUIREMENT 5.3.1 CAN BE REDUCED TO 30%.

\[ Q_{a} = 0.30 \times (37,342) = 11,203 \text{ scfm air} \]

CASE 5) MAX. FLOW THRU TUBE TRAILER FILL LINE @ SONIC FLOW. THE FILL STATION THAT B-ZERO IS USING COMES FROM AN EXISTING SYSTEM. A REGULATOR BYPASS VALVE EXISTS. MAXIMUM POSSIBLE FLOW IS BOUNDED BY SONIC FLOW THRU THE PIPES.

\[ \dot{m}_{\text{max}} = \dot{S}_{\text{max}} \times V_{\text{sonic}} A_{\text{pipe}} \]

\[ \dot{S}_{\text{max}} = \rho \times (P=2500 \text{ psia}, T=280\text{K}) = 27.42 \frac{\text{kg}}{\text{m}^2} \]

\[ \dot{m}_{\text{max}} = 27.42 \frac{\text{kg}}{\text{m}^2} \times (1062.3^\frac{3}{2}) \times (\frac{.025 \text{ in}^4}{\text{in}^2}) \times \left( \frac{.825 \text{ in}^2}{\text{in}^2} \right) \times \left( \frac{1062 \text{ m/s}}{1000 \text{ m/s}} \right) \times \left( \frac{1 \text{ in}}{2.54 \text{ cm}} \right) \times \left( \frac{1 \text{ in}}{2.54 \text{ cm}} \right) \]

\[ A_{\text{pipe}} = \pi \times \left( \frac{.54 \text{ in}}{4} \right)^2 = .234 \text{ in}^2 \times \left( \frac{1}{2} \text{ in} \times \frac{1}{2} \text{ in} \right) \]

\[ = 4.40 \text{ kg/s He} \]

THRU 1/2" SCH. 80 PIPES @ FILL PANEL
I will calculate the max. flow thru the pipe at the storage tank. Pressure @ exit of pipe is 250 psig.

\[ \rho \left( P = 1.8 \text{MPa}, T = 300 \text{K} \right) = 2.865 \frac{\text{kg}}{\text{m}^3} \]

\[ A = \frac{1.047 \text{m}^2}{4} \left( 0.254 \text{m} \right)^2 = 0.10 \times 10^{-4} \text{ m}^2 \]

\[ V_{\text{sound}} = 1027 \text{ m/s} \]

\[ \dot{m}_{\text{max}} = \rho VA = (2.865 \frac{\text{kg}}{\text{m}^3}) (1027 \frac{\text{m}}{s}) (0.10 \times 10^{-4} \text{ m}^2) \]

\[ \dot{m}_{\text{max}} = 1.794 \frac{\text{kg}}{s} \]

\[ Q = 1.794 \frac{\text{kg}}{s} \times 213 \text{ scf} \times \frac{60}{1 \text{ kg}} = 22,930 \text{ scfm He} \]

\[ Q_{\text{air}} = 22930 \times 0.138 = 8518 \text{ scfm air} \]
### ORDERING INFORMATION
Order Regulator by Figure Number

<table>
<thead>
<tr>
<th>Valve Seat Seal</th>
<th>Seat Gasket</th>
<th>Rubber Parts</th>
<th>Temp Range</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kel-F</td>
<td>Kel-F</td>
<td>Nitrile</td>
<td>-65° F. to +165° F.</td>
<td>A</td>
</tr>
<tr>
<td>Kel-F</td>
<td>Kel-F</td>
<td>High Nitrile</td>
<td>0° F. to +165° F.</td>
<td>K</td>
</tr>
</tbody>
</table>

### DESIGN VARIATIONS

#### ORIFICE SIZE

<table>
<thead>
<tr>
<th>Code</th>
<th>ORIFICE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>⅛&quot;</td>
</tr>
<tr>
<td>5</td>
<td>⅛&quot;</td>
</tr>
<tr>
<td>6</td>
<td>⅛&quot;</td>
</tr>
<tr>
<td>7</td>
<td>⅛&quot;</td>
</tr>
</tbody>
</table>

#### STANDARD INLET AND OUTLET CONNECTIONS

<table>
<thead>
<tr>
<th>CODE</th>
<th>INLET SIZE</th>
<th>OUTLET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO6</td>
<td>⅛&quot; FNPT</td>
<td>⅛&quot; FNPT</td>
</tr>
<tr>
<td>PO7</td>
<td>¼&quot; FNPT</td>
<td>¼&quot; FNPT</td>
</tr>
<tr>
<td>PO8</td>
<td>⅜&quot; FNPT</td>
<td>⅜&quot; FNPT</td>
</tr>
<tr>
<td>AO6</td>
<td>⅛&quot; AND-10050</td>
<td>⅛&quot; AND-10050</td>
</tr>
<tr>
<td>AO7</td>
<td>¼&quot; AND-10050</td>
<td>¼&quot; AND-10050</td>
</tr>
<tr>
<td>AO8</td>
<td>⅜&quot; AND-10050</td>
<td>⅜&quot; AND-10050</td>
</tr>
</tbody>
</table>

### GENERAL SPECIFICATIONS

- **Inlet Pressure:** 3500 psi Maximum
- **Outlet Pressure:** 2000 psi Maximum
- **Operating Temperature Range:** SEE CHART
- **End Connections:** AND-10050, FNPT
- **Sizes:** ⅛" , ¼" , ⅜"
- **OTHER SIZES & TYPES AVAILABLE ON SPECIAL ORDER**
- Internally Dome Loaded: ⅛" FNPT Alternate External Dome Loading Conn.
- **Internal Sensing**
- **Weight:** 40 lbs. (Approx.)

### MATERIAL SPECIFICATIONS

- **Body:** Cast Aluminum Bronze to ASTM B-148
- **Dome:** Carbon Steel
- **Trim:** T-416 CRes (Port Adapters 18/8 CRes)
- **Plastic Parts:** See Ordering Information

### EXAMPLE

Figure Number 11146A087A is the complete description of a Model 302G, ⅛" standard unbalanced valve, 3500 psi inlet and 2000 psi outlet with ⅛" AND-10050 tubing inlet and outlet connections, Kel-F seat seal and gasket, nitrile diaphragm.

**NOTE:** This series is not recommended if the service calls for cleaning in an environmentally controlled room. Use the equivalent 200H and 300H series, or the 200B and 300B series for highly supercleaned systems.
DOME LOADERS

When the ultimate in accuracy is required or in services where remote control of dome pressures is desired, a Grove Small Volume High Pressure Regulator is recommended for use with external dome loaded Powreactor Regulators. (See Bulletin 125-D). This dome loading regulator automatically maintains the desired dome pressure; compensating for ambient temperature changes and variations in flow rate, through the Powreactor, which otherwise would produce changes in the dome pressure, thus affecting the outlet pressure.

CAPACITY INFORMATION

how to use capacity chart (air-gas)

1. Determine the following quantities:
   (A) Minimum expected inlet pressure at the regulator in pounds per square inch gauge, taking into account pipe line drop if appreciable.
   (B) Minimum expected differential pressure. (Inlet pressure minus outlet pressure)
   (C) Desired flow rate "Q" in cubic ft. per minute of free gas at standard conditions of 60°F and 14.7 psia.

2. If the fluid is other than air, the flow must be corrected for specific gravity. To accomplish this, draw a line from the desired flow rate (1-C above) on scale "Q" to a point on the Specific Gravity correction scale corresponding with the specific gravity of the gas being considered. Using the intersection with line Z as a turning point, draw a line through 1.0 on the specific gravity scale. The intersection of this line with scale "Q" will give the equivalent flow rate of air at standard conditions.

3. On the chart locate the curve corresponding to the minimum inlet pressure and the point on the differential pressure scale, corresponding to the minimum differential pressure. From the point on the differential pressure scale, follow a vertical line to the point of intersection with the inlet pressure curve, then follow a horizontal line to the intersection with line Z.

4. From this intersection with line Z, draw a straight line through the desired flow rate on scale Q (1-C above if flow medium is air, or, if not, the equivalent air flow rate as determined in paragraph 2). The intersection of this line with scale C gives the required capacity factor "C".

5. By referring to the appropriate regulator specification sheet, an orifice (inner valve) size having an equal or greater capacity factor can be selected.
**how to use capacity charts for liquids**

1. Determine the following quantities:
   A. Minimum expected pressure drop across the regulator in lbs. per square inch (inlet pressure minus outlet pressure measured at the regulator, taking into account pipe line drop if appreciable).
   B. Desired flow rate in gallons per minute.
   C. Specific gravity of liquid if other than water.

2. If the liquid is other than water, the flow rate must be corrected for specific gravity. To accomplish this, draw a line from the desired flow rate (1-B above) on scale Q to point on the specific gravity correction scale corresponding with the specific gravity of the liquid being considered. Using the intersection with line P as a turning point, draw a second line thru 1.0 on the specific gravity scale. The intersection of this line with scale Q will give the equivalent flow rate of water.

3. From a point on scale P indicating the pressure drop (1-A above) draw a line thru the desired flow rate on scale Q (1-B above), if the liquid is water — otherwise the equivalent water flow rate as determined in paragraph 2). The intersection of this line with scale C gives the required capacity factor "C".

4. By referring to the appropriate regulator specification sheet, an orifice (inner valve) size having an equal or greater capacity factor can be selected.

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**Note:** Refer to regulator specification sheets for relationship between regulator orifice size and capacity factor.
CAPACITY OF GROVE REGULATORS FOR USE ON AIR AND GAS

Note: Refer to regulator specification sheets for relationship between regulator orifice size and capacity factor.
A) Fire Rupture Disc. 2" Size, Burst Press = 275 psi

The flow is sonic since the upstream pressure is much greater than twice the downstream absolute pressure.

Fire Catalog, "Rupture Disc Sizing" given the flow of air & standard conditions - scfm air.

\[ \alpha = \frac{Q_{sa}}{11.4P_0} \sqrt{\frac{t + 460}{520}} \sqrt{M} \text{ sq. in.} \]  

[Eqn]

Re-arranging for \( Q_{sa} \) and recognizing

\[ t + 460 = 520^2 \quad \text{and} \quad M = 29 \text{ for air} \]

\[ Q_{sa} = \alpha (11.4) P_0 \]

\[ \alpha = \frac{\pi d^2}{4} = \frac{\pi (2 \text{ in.})^2}{4} = \pi \text{ in.}^2 \]

\[ P_0 = (275) 1.10 + 14.7 = 317.2 \text{ psig for 110\% MAWP} \]

\[ (275) 1.21 + 14.7 = 347.5 \text{ psig for 121\% MAWP} \]

\[ Q_{sa} = \pi (11.4)(317.2) = 11,360 \text{ scfm air at 110\% MAWP} \]

\[ Q_{sa} = \pi (11.4)(347.5) = 12,445 \text{ scfm air at 121\% MAWP} \]

B) Relief Device

The purchased relief device is an AGCO model 83C1216-G with a set pressure = 250 psig. It has a 0.503 in\(^2\) orifice.

Per the catalog for a "G" orifice relief valve with a set pressure = 250 psig, the relief capacity is 2,383 scfm air at 110\% over pressure.

\[ P_{110\%} = 1.1 (250 \text{ psig}) = 275 \text{ psig} \]

At 110\% of the vessel MAWP = 275(1.1) = 302.5 psig. The cap is:

\[ V_{110\%} = 2383 \text{ scfm air} \times \frac{302.5 + 14.7}{275 + 14.7} = 2609 \text{ scfm air} \]
Adequate flow through a rupture disc can be assured if the disc is sized properly. Improper sizing can result in serious safety hazards to personnel and costly plant equipment.

To aid you in the sizing of Fike rupture discs, Fike offers disCalc, an IBM compatible software program. The program sizes rupture discs for gas, liquid and steam applications. These calculations follow the guidelines of ASME Sect VIII, Div 1, ISO 6718, and the procedures published in this catalog. disCalc is available free from your local representative or by contacting Fike directly.

The following equations and procedures meet the requirements of Section VIII, Div 1, of the ASME Code.

**Assumptions and General Considerations**

- Gases and vapors expand isentropically through the burst rupture disc. Thus the fluid is assumed to be a perfect or ideal gas and friction losses are small enough to be neglected.
- Incompressible fluids are low-viscosity fluids, i.e. the viscosity is less than 0.1.
- The sizing equations include a discharge coefficient, K, to compensate for turbulence and other losses. In normal practice K=0.62 unless determined by laboratory testing.
- The rupture disc device is assumed to be installed on a large vessel where the upstream flow velocity is negligible and the flow area through the device is small compared to the size of the vessel. This assumption results in the maximum disc size required regardless of whether the disc is installed on a vessel or in a pipe run.
- The rupture disc device is assumed to vent directly to the atmosphere with no downstream piping. If downstream piping is present, it may be necessary to consider the device as a fitting and size the piping system accordingly.
- The rupture disc device is NOT installed in combination with any other relief device. For information on rupture discs in combination with safety relief valves, see Sect. 4 of this catalog.
- The pressure in the protected equipment increases slowly. This type of problem may result from an attempt to overfill a closed vessel, from thermal expansion of a contained fluid, or faulty valving in pressure control equipment.

For information on sizing for runaway reactions, explosion venting, and protection against other hazards, consult Fike.

**Overpressure Allowance**

The ASME Code permits the relieving pressure to exceed the MAWP during venting based upon one of several conditions. The following sizing equations assume that the user has chosen the appropriate overpressure allowance. See Section 4 of this catalog for a discussion of overpressure allowance and the ASME Code.

**Recommended Rupture Disc Device Diameter**

The nominal size of the rupture disc device should be greater than or equal to the minimum calculated diameter. In cases where the inlet or outlet diameter of the device is significantly smaller than the nominal disc size, the smaller diameter should be used to determine the minimum flow area.

Example: The minimum flow area of a 1/8"-30SM Screw Type assembly with 1/4" NPT inlet and 1/2" disc should be based on the nominal inside diameter of the 1/4" NPT inlet and NOT the 1/2" disc diameter.

**Sizing for Liquids**

The sizing equation for the flow of incompressible fluids (liquids) through a rupture disc device is derived from Bernoulli's general energy equation and the conservation of momentum. Assuming the fluid enters the device with negligible velocity and with no change in elevation, the velocity at the disc is

\[ V = \sqrt{2gh} \text{ ft/sec, where } h = \frac{P_1 - P_2}{\gamma} \]

From the conservation of momentum equation, the flow rate becomes

\[ Q = AV \text{ cu. ft/sec.} \]

\[ = KA \sqrt{2gP_1} \]

Simplifying and rearranging the equation, the required relief area for any free-flowing liquid through a rupture disc device is given by

\[ a = \frac{L \sqrt{SG}}{37.98K \sqrt{P}} \text{ sq. inches} \quad (1) \]

The pipe "bore" area at the inlet to the rupture disc device is usually taken as the maximum available relief area.

**Sizing for Gases and Vapors**

For compressible fluids (gases and vapors), Bernoulli's equation still holds but the conservation of momentum equation must make use of the changes in the properties of the fluid as it passes through the orifice. These changes are found from the relationships of a gas experiencing an isentropic (frictionless, reversible) expansion. The relationships are well known and can be found in most thermodynamics textbooks.

For isentropic flow, we must consider the differential pressure ratio across the disc. Designating \( P_0 \) as the upstream pressure and \( P_2 \) as the pressure at the exit plane (usually atmospheric pressure) consider first that when the upstream equals the exit pressure, \( P_0/P_2 = 1 \), there is no flow. Increasing the upstream pressure increases the flow and decreases the pressure ratio \( P_0/P_2 \) until a value of \( P_0 \) is reached beyond which there is no further increase in the mass rate of flow through the disc. This value of \( P_0 \) is known as the critical pressure and \( P_0/P_2 \) is known as the critical pressure ratio. At this point the flow velocity is sonic, or equal to the speed of sound. Sonic flow exists through the orifice at all pressure ratios less than the critical pressure ratio. Subsonic flow exists through the orifice at all pressure ratios greater than the critical pressure ratio.
The General Sizing Equation

The general sizing equations for all compressible fluid rupture disc applications are given by

\[ W = K P_o a \sqrt{\frac{2g}{R T_o}} \left( \frac{P_e}{P_o} \right)^{\frac{k-1}{k}} \left( \frac{P_e}{P_o} \right)^{\frac{1}{k}} \text{ lb/sec} \]  
(2)

\[ Q_{act} = \frac{K P_o a R T_o}{2.4 P_o} \sqrt{\frac{2g}{R T_o}} \left( \frac{P_e}{P_o} \right)^{\frac{k-1}{k}} \left( \frac{P_e}{P_o} \right)^{\frac{1}{k}} \text{ ACMF} \]  
(3)

\[ Q_s = \frac{K P_o a R 520}{2.41147 T} \sqrt{\frac{2g}{R T_o}} \left( \frac{P_e}{P_o} \right)^{\frac{k-1}{k}} \left( \frac{P_e}{P_o} \right)^{\frac{1}{k}} \text{ SCFM} \]  
(4)

where

\[ P_o \] is greater than \[ \left( \frac{2}{k+1} \right)^{\frac{k}{k+1}} \] for subsonic flow

\[ P_o \] is equal to or less than \[ \left( \frac{2}{k+1} \right)^{\frac{k}{k+1}} \] for sonic flow

Sizing for Subsonic Flow

When the pressure ratio \( P_e/P_o \) is greater than the Critical Pressure Ratio, the flow is subsonic and equations (2) through (4) can be simplified for ease of application.

The required area of a rupture disc device for any gas or vapor is:

Given the Mass Flow Rate—lb/sec

\[ a = \frac{W}{K C P_o} \sqrt{\frac{t+460}{M}} \text{ Sq. In.} \]  
(5)

Given the Actual Flow Rate—ACFM

\[ a = \frac{Q_{act}}{643.8 K C} \sqrt{\frac{M}{t+460}} \text{ Sq. In.} \]  
(6)

Given the flow at Standard Conditions—SCFM

\[ a = \frac{Q_s}{22772 K C P_o} \sqrt{\frac{t+460}{M}} \text{ Sq. In.} \]  
(7)

Sizing for Sonic Flow

When the pressure ratio \( P_e/P_o \) is less than the Critical Pressure ratio, the flow is sonic and equations (2) through (4) are simplified. For the required area of any gas or vapor where the burst pressure is greater than about two times the exit pressure.

Given the Mass Flow Rate—lb/sec

\[ a = \frac{W}{K C P_o} \sqrt{\frac{t+460}{M}} \]  
(9)

Given the Actual Flow Rate—ACFM

\[ a = \frac{Q_{act}}{643.8 K C} \sqrt{\frac{M}{t+460}} \]  
(10)

Given the flow at Standard Conditions—SCFM

\[ a = \frac{Q_s}{22772 K C P_o} \sqrt{\frac{t+460}{M}} \]  
(11)

Given the flow of Air at Standard Conditions—SCFM

\[ a = \frac{Q_o}{115 C P_o} \sqrt{\frac{t+460}{M}} \]  
(8)

where

\[ C_I = \sqrt{\frac{2g}{1545}} \left( \frac{P_e}{P_o} \right)^{\frac{k-1}{k}} \left( \frac{P_e}{P_o} \right)^{\frac{1}{k}} \]

TABLE 1

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**GLOSSARY**

A = required flow area, in square feet
ACFM = actual cubic feet per minute
a = required flow area, in square inches.
D = number of degrees of superheat. (flowing temp-saturation temp) °F
γ = fluid density, in pounds per cubic foot.
g = 32.2 ft. per sec per sec.
h = pressure head, in feet.
K = coefficient. (ASME requires a coefficient of .62 for rupture discs as sole relieving devices)
k = ratio of specific heats (1.4 approximate for air and most gases.)
L = liquid flow, in gallons per minute.
M = molecular weight.
MAWP = maximum allowable working pressure.
Po = relieving pressure, in pounds per square inch absolute (p+14.7).
Pv = exit pressure, in pounds per square inch absolute.
Pf = pressure, pounds per square foot.
p = relieving pressure, in pounds per square inch gauge.
Q = flow, in cubic feet per second.
Qact = actual flow rate—ACFM.
Qs = standard flow rate—SCFM.
Qsa = flow, in standard cubic feet of air per minute (at 13.7 psi and 60°F).
R = gas constant = 1545/M.
SCFM = standard cubic feet per minute.
SG = specific gravity (water = 1.0) (air = 1.0).
To = upstream temperature °R (t+460).
TR = temperature. °R.
t = temperature of flowing media at disc relieving pressure, in °F.
V = velocity, in feet per second.
W = discharge, in pounds per second.
X = 100%-steam quality.
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<th>H .785</th>
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**NITROGEN #/HR = 4.43 x SCFM**

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**GAS CONSUMPTION**

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RELIEF PIPING PRESSURE DROP

CALCULATE THE INLET PRESSURE DROP

SUDDEN CONTRACTION

\[ K_1 = 0.5 \left( 1 - \frac{d_1}{d_2} \right) \]

Equation 2-10 from Crane Technical Paper 410.

- \( d_1 \): Small Pipe
- \( d_2 \): Large Pipe

\[ K_1 = 0.5 \]

TEE THRU BRANCH: \( K = 60 \) ft

Page A-24 of Crane Technical Paper 410

LET FLOW RATE = MAXIMUM WHICH IS FOR THE FIRE CASE

\[ Q_{FIRE} = 11,203 \text{ scfm} \quad \text{Air} = 22,930 \text{ scfm} \quad \text{He} \]

\[ m_{He} = 22,930 \text{ scfm} \times \frac{5.28^{3} \text{ kg}}{1 \text{ scfm} \cdot \text{hr}} \times \frac{1 \text{ kg}}{213 \text{ scfm} \cdot \text{He}} \times \frac{1 \text{ hr}}{1 \text{ hr}} = 14,210 \text{ lbm/hr He} \]

\[ \text{Re} = 6.31 \frac{\text{W}}{\text{d} \cdot \mu} \]  

Equation 3-3 from Crane; where:

\[ W = 14,210 \text{ lbm/hr} \]

\[ \text{Re} = 2.08 \times 10^6 \]

\[ d = 2.157 \text{ in.} \quad \text{I.D. of 2" scfm} \]

\[ \mu = 19.97 \text{ Pa-s} \times 10^{-3} \text{ cp} \]

\[ \mu = 0.01997 \text{ cp} \]

\[ \frac{E}{D} = 0.0009 \text{ from page A-23} \]

\[ F_t = 0.019 \]

\[ \Sigma K \text{ Resistance Coefficients} = 0.5 + 60(0.019) = 1.64 \]

\[ K = \frac{F}{D} \text{ by definition} \quad \text{Equivalent Length,} \quad L = \frac{KD}{F} \]

\[ L_{eq} = 1.64 \left( \frac{2.157 \text{ in.}}{12 \text{ in/ft}} \right) = 15.515 \text{ ft} \]

Page A-24 of Crane Technical Paper 410
$$\Delta P = 3.36 \times 10^{-6} \frac{FLw^2}{\rho d^8} \quad \text{Eq'n 3-5 CRANE TECH PAPERS 410}$$

$$S(P=1.8\text{MPa}, T=300\text{K}) = 2.865 \frac{\text{kg}}{\text{m}^3} \times 0.0248 \frac{\text{m}^3}{\text{hr}} = 0.179 \frac{\text{lbm}}{\text{hr}}$$

$$\Delta P = 3.36 \times 10^{-6} \left( \frac{0.019 \times 15.5 \text{lbm}}{14.210 \text{lbm}} \right)^2 \left( \frac{2.157 \text{in}}{2.19 \text{in}} \right)^3 = 23.9 \text{ psi}$$

This means that immediately after blowing, the static pressure at the inlet to the rupture disc is 275 psig - 23.9 psig = 251.1 psig.

The relief valve may close at that time due to the frictional losses.

The rupture disc capacity at that point is:

$$Q_{34} = \pi (11.4) (251.1 + 14.7 \text{ psig}) = 9519.4 \text{ scfm AIR}$$

Assuming the relief valve stays closed, the pressure at the rupture disc & steady state will be:

$$Q_{520} = Q_{\text{FIRE}}$$

$$(\pi \text{ in}^2) (11.4) (P_{\text{INLET \ RED}}) = 11,203 \text{ scfm AIR}$$

$$P_{\text{INLET \ RED}} = 312.8 \text{ psia} - 29.8 \text{ psig}$$

$$P_{\text{VESSEL \ MAX}} = P_{\text{INLET \ RED}} + \Delta P = 312.8 \text{ psia} + 23.9 = 336.7 \text{ psia}$$

$$P_{\text{VESSEL \ MAX}} = 322 \text{ psig} < 333 \text{ psig} - 121\% \text{ UAMP ORM}$$

Note: Since $P_{\text{INLET \ RED}} = 298 \text{ psig} > 250 \text{ psig}$ RELIEF VALVE WOULD BE OPEN ALSO.

Assume $P_{\text{INLET \ RELIEF}} = 275 \text{ psig}$ THE RELIEF CAPACITY = 2383 scfm AIR.
Taking into account the relieving of the relief valve, the inlet pressure at the rupture disc at steady state would be:

\[(11 \text{ in}^3/\text{s}) \times 1.4 \times (P_{\text{inlet}} - P_{\text{atm}}) = 11,203 - 2,383 \text{ psi} \times 1 \text{ in}^3/\text{s} \]

\[P_{\text{inlet}} - P_{\text{RD}} = 246.3 \text{ psi} \]

\[P_{\text{vessel}} = P_{\text{inlet}} + \Delta P_{\text{frac}} = 246.3 + 23.9 \text{ psi} = 270.2 \text{ psi} \]

\[\therefore \text{ Calculated pressure @ max anticipated flow} = \frac{270.2}{275} (100) = 98\% \text{ MAMW }\]

During fire.
AN INTERESTING GRAPH TO UNDERSTAND THE PRESSURES DURING A FIRE RELIEF CASE CAN BE MADE.

CONSIDER:

\[ V = \frac{Q_{\text{Fire}}}{11,203 \, \text{scfm}} = \frac{5882 \, \text{ft}^3}{11,203 \, \text{scfm}} = 0.52 \, \text{ft}^3/\text{min} \]

FOR Pressures LESS THAN 250 psig THE PRESSURE BUILDS AT A RATE:

\[ \frac{dp}{dt} = 11,203 \frac{\text{scf}}{\text{min}} \times \frac{14.7 \, \text{psi}}{5882 \, \text{scf}} = 28 \, \text{psi/min} \]

\[ \Delta P = 3.36 \times 10^{-6} \left( \frac{0.019 \times (3.33 \, \text{ft})(3823 \, \text{lbm}/\text{hr})}{1.79 \times (2.157 \, \text{in})^5} \right) = 0.6 \, \text{psi} \text{ NEGIGIBLE} \]

RELIEF WILL STAY OPEN AS PRESSURE RISES.

AT 250 psig IN TANK

\[ \frac{dp}{dt} = (11,203 \, \text{scf/m} - 2383 \, \text{scf/m}) \times \frac{14.7 \, \text{psi}}{5882 \, \text{scf}} = 22.0 \, \text{psi/min} \]

AT 275 psig JUST BEFORE THE RUPTURE DISC OPENS, THE RELIEF CAPACITY IS 2609 scfm Air

\[ \frac{dp}{dt} = (11,203 - 2609) \times \frac{14.7 \, \text{psi}}{5882} = 21.5 \, \text{psi/min} \]

THEN THE RUPTURE DISC BLOWS, DUE TO THE FRICTIONAL LOSSES THE PRESSURE AT THE INLET TO THE RD DROPS TO 251.1 psig AS CALCULATED ON PAGE 2.

THEN PRESSURE IN THE TANK = 275 psig AT THAT INSTANT.

IT THEN WOULD SLOWLY DECREASE until at STEADY STATE, THE PRESSURE IN THE TANK = 270.2 psig and THE PRESSURE AT THE INLET TO THE RUPTURE DISC = 246.3 psig AS CALCULATED ON PAGE 3. THE PRESSURE AT THE INLET TO THE RELIEF VALVE WOULD BE 270.2 - 0.6 = 269.6 psig.
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QUALITY CONTROL DATA BOOK

VESSEL SERIAL NUMBER 158585-01-1
CUSTOMER ORDER NUMBER 50156-5-1
CUSTOMER ITEM NUMBER T-10301

GASEOUS HELIUM TANK
LOTPEPRO CORPORATION
VALHALLA, NEW YORK
FOR
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA
ATTN : BOB SIMS

REFERENCE : CUSTOMER P/O 2032634
TRINITY S/O 2-20196

GENTLEMEN :

ATTACHED ARE COPIES OF MILL TEST REPORTS FOR THE FOLLOWING MATERIAL PROVIDED ON YOUR REFERENCED PURCHASE ORDER.

LABOR & MATERIAL
4-SA516-70 ELLIP-2:1 HEAD 129.5000 ID 1.0937 MIN
WITH 2.0000 SF.

HEAT NUMBER

R8270-14B
R8270-14A
R9424-3
R9424-2

ALL HEADS WERE COLD FORMED AND ARE IN COMPLIANCE WITH REGULATION UG-81 AND UCS-79 (d) AS STATED IN SECTION VIII DIVISION I OF THE ASME BOILER AND PRESSURE VESSEL CODE. HEADS WERE FORMED WITHOUT COMING IN CONTACT WITH MERCURY OR ANY OF IT'S COMPOUNDS.

ALL PLATES WERE NORMALIZED AT 1650 F FOR A HALF HOUR PER INCH AND AIR COOLED.

IF YOU HAVE ANY FURTHER QUESTIONS CONCERNING MILL TEST REPORTS ONLY, PLEASE CONTACT ME IN CINCINNATI, OHIO AT 1-800-543-1644.

VERY TRULY YOURS,

TRINITY INDUSTRIES, INC
HEAD DIVISION

6/1/95

5/21/95
# Test Certificate

**Customer P.O.:** E2234

**Date:** 3/22/92

**File No.:** 978-11-15

**Order No.:** 58403-006

---

**Sold To:**
TRINITY INDUSTRIES
HEAD DIVISION
11861 MOSTELLER ROAD

**Send To:**
TRINITY INDUSTRIES
BUILDING #2 - HEAD DIV.
11861 MOSTELLER ROAD

**Ship To:**
TRINITY INDUSTRIES
BUILDING #2 - HEAD DIV.
11861 MOSTELLER ROAD

**Cincinnati, OH 45241**

---

**Material Grade:** SA516 GR 70 YR 90A

**Spec. Mod. For Carbon**

---

### Melt/Slab

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### Chemical Analysis

---

### Tensiles

---

### Charpy V. Impacts

---

### Other Tests Performed

**Approved**
Q. A. Dept.

**OCT 26 1992**

**Initials:** CB

---

### Information

**Weight Per Piece:** 9429 LBS. 4236 KG.

**Part No.:** 120-058

**Drawing No.:** BC-82388-5

**B/L 399397 CR 576452**

---

**Heat Treat Cycles - Matl. or Tests - Deg**

---

**Heat Treat Cycles - Tests Only - Deg**

---

---

---
**TEST CERTIFICATE**

**CUSTOMER P.O.**: E2234

**DESCRIPTION**: 2 - RECTANGLE 1.375" X 155.5" X 155.5"

**MILL ORDER NO.**: 58403-006

**DATE**: 02/22/92

**FILE NO.**: 978-11-15

**SEND TO**: TRINITY INDUSTRIES

BUILDING #2 - HEAD DIV.

11861 MOSTELLER ROAD

CINCINNATI, OH 45241

**SHIP TO**: TRINITY INDUSTRIES

BUILDING #2 - HEAD DIV.

11861 MOSTELLER ROAD

CINCINNATI, OH 45241

**SPEC MOD FOR CARBON**

---

**MELT/SLAB**

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**CHEMICAL ANALYSIS**

**PRACTICES**

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**TENSILE**

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**INFORMATION**

**HEAT TREAT CYCLES - MATL. OR TESTS - DEG**

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<th>HOLD MINS.</th>
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**HEAT TREAT CYCLES - TESTS ONLY - DEG**

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<th>HOLD MINS.</th>
<th>HEAT RATE MAX</th>
<th>COOL RATE MAX</th>
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**THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATION.**

**ASME SA516 GR 70 YR 90A**

---

**WE HEREBY CERTIFY THE ABOVE INFORMATION**

---

**TRINITY INDUSTRIES**

BUILDING #2 - HEAD DIV.

11861 MOSTELLER ROAD

CINCINNATI, OH 45241
TEST CERTIFICATE

CUSTOMER P.O.: E2234
DESCRIPTION: 2 - RECTANGLE 1.375 -X- 155.5 -X- 155.5

SOLD TO:
TRINITY INDUSTRIES
HEAD DIVISION
11861 MOSTELLER ROAD

SEND TO:
TRINITY INDUSTRIES
BUILDING #2 - HEAD DIV.
11861 MOSTELLER ROAD

CINCINNATI, OH 45241
CINCINNATI, OH 45241
CINCINNATI, OH 45241

THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATIONS.

ASME SA516 GR 70 YR 90A
SPEC NO MOD FOR CARBON

MELT/SLAB
R6270 /149

CHEMICAL ANALYSIS

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PRACTICES

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CHARPY V. IMPACTS

OTHER TESTS PERFORMED

INFORMATION

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HEAT TREAT CYCLES - TESTS ONLY - DEG
**TEST CERTIFICATE**

CUSTOMER P.O.: E-23

DESCRIPTION: 2 - RECTANGLE 1-3/8 -X- 155-1/2 -X- 155-1/2

SOLD TO: TRINITY INDUSTRIES
HEAD DIVISION
11861 MOSTELLER ROAD

SEND TO: TRINITY INDUSTRIES
BUILDING #2 - HEAD DIV.
11861 MOSTELLER ROAD

CINCINNATI, OH 45241

THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATIONS.

ASME SA516 GR 70 YR 5CA SPEC MOD FOR CARBON

---

**CHEMICAL ANALYSIS**

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**PRACTICES**

GS 7-8

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**OTHER TESTS PERFORMED**

APPROVED
Q. A. DEPT.
MAY 21 1993
INITIALS C B

---

**INFORMATION**

| WEIGHT PER PIECE | 9429 LBS. | 4286 KG. |
| PART NO. | 120-053 |
| DRAWING NO. | BC-82385 |
| B/L #08632 | 537020 |

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**HEAT TREAT CYCLES - MATT OR TESTS - DEG**

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**HEAT TREAT CYCLES - TESTS ONLY - DEG**

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<th>HEAT RATE MAX</th>
<th>COOL RATE MAX</th>
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WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT.

Quality Assurance Laboratory
## TEST CERTIFICATE

**CUSTOMER P.O.:** E22344  
**DESCRIPTION:**  
**DATE:** 3/22/92  
**MILL ORDER NO.:** 58403-006

### SOLD TO:
- TRINITY INDUSTRIES  
  - HEAD DIVISION  
  - 11661 MOSTELLER ROAD  
  - CINCINNATI, OH 45241

### SEND TO:
- TRINITY INDUSTRIES  
  - BUILDING 22 - HEAD DIV.  
  - 11661 MOSTELLER ROAD  
  - CINCINNATI, OH 45241

### DESCRIPTION:
- 2 - RECTANGLE 1.375" X 155.5" X 155.5"

### ASME SA516 GR 70 YR 90A  
SPEC MOD FOR CARBON

### MELT/SLAB

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### CHEMICAL ANALYSIS

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<thead>
<tr>
<th>R8270 /14A</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cu</th>
<th>Si</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Ti</th>
<th>B</th>
<th>C3</th>
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<td>0.14</td>
<td>0.17</td>
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### TENSILES

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<tr>
<th>TYPE</th>
<th>YLD</th>
<th>TENS</th>
<th>% ELONG</th>
<th>% R.A.</th>
<th>TYPE</th>
<th>TEMP</th>
<th>MILS LATERAL EXPANSION</th>
<th>% SHEAR</th>
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### CHARPY V. IMPACTS

<p>| | | |</p>
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### OTHER TESTS PERFORMED

- APPROVED  
  - Q. A. DEPT.  
  - OCT 26 1992  
  - INITIALS CB

### INFORMATION

- WEIGHT PER PIECE = 9429 LBS. = 4286 KG.  
- PART NO. = 120-058  
- DRAWING NO. = 3C-82384-S  
- B/L #25397 CR = 576452

### HEAT TREAT CYCLES - MATL. OR TESTS - DEG

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<th>MATL. TEST</th>
<th>NOM TEMP</th>
<th>MIN TEMP</th>
<th>MAX TEMP</th>
<th>HOLD MINS.</th>
<th>COOL METHOD</th>
<th>END TEMP</th>
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### HEAT TREAT CYCLES - TESTS ONLY - DEG

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<th>START END TEMP</th>
<th>NOM TEMP</th>
<th>MIN TEMP</th>
<th>MAX TEMP</th>
<th>HOLD MINS.</th>
<th>HEAT RATE MAX</th>
<th>COOL RATE MAX</th>
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![Image of the test certificate with the specified details.](image-url)
## Test Certificate

**Customer P.O.:** E22344

**Description:** 2 -- Rectangle 1.375" x 155.5" -x- 155.5"

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<tr>
<th>Melt/Slab</th>
<th>Chemical Analysis</th>
<th>Practices</th>
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### Tensiles

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<th>Type</th>
<th>Yld. Tens (PSI x 100)</th>
<th>% Elong</th>
<th>% R.A.</th>
<th>Type</th>
<th>Temp</th>
<th>Mills Lateral Expansion</th>
<th>% Shear</th>
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<td>03-C</td>
<td>718 747 23.9</td>
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### Charpy V Impacts

### Other Tests Performed

### Information

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<td>X 1650</td>
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<table>
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<tr>
<th>Heat Treat Cycles: Tests Only: Deg FAHR</th>
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<tbody>
<tr>
<td>Start End Temp</td>
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**Metallurgical Test Report**

**Vendor**
- GARY WORKS
- GARY, INDIANA 46402
- BEAIRD INDUSTRIES INC
- DIV OF TRINITY INDUSTRIES INC
- P O BOX 31115
- SHREVEPORT LA 71130-1115

**Sold To**
- BEAIRD INDUSTRIES INC
- DIV OF TRINITY INDUSTRIES INC
- 601 BENTON KELLY DR
- SHREVEPORT LA 71106

**THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MFGD., SAMPLED, TESTED AND/INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS REQUIREMENTS IN SUCH RESPECT.**

**Prepared by the Office of:**
- G. D. LUKES
- GEN. MGR. G. A.

**SPEC. & INSPECTION**
- PLATE CARBON ASTM A516-GR70 GRADE 70 ASME SA516-GR1992
- EDITION-1992 ADDENDA DECEMBER 31, 1992 GRADE 70 PRESSURE VESSEL QUALITY NORMALIZE

**INSPECTION: MILL RA/SN CERTIFIED T/R WITH LOAD ANALYSIS**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>MATERIAL DESCRIPTION</th>
<th>QUANTITY</th>
<th>WEIGHT</th>
<th>HEAT NO.</th>
<th>TEST OR PIECE IDENTITY</th>
<th>YIELD PT.</th>
<th>TENSILE STR.</th>
<th>ELONGATION</th>
<th>% RED. OF AREA</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>1.1100 121.0000</td>
<td>01</td>
<td>15669</td>
<td>M6569B</td>
<td>51W 2</td>
<td>51W 2</td>
<td>50.0</td>
<td>75.5</td>
<td>27.0</td>
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<td></td>
<td>STEEL-TYPE = CAST</td>
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<td>REDUCTION RATIO = 8:2 TO 1</td>
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<tr>
<td></td>
<td>PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
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<td>1.1100 121.0000</td>
<td>01</td>
<td>15669</td>
<td>M6569B</td>
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<td>REDUCTION RATIO = 8:2 TO 1</td>
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<td>PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
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**Yield Strength @ 0.5% E.U.L.**

<table>
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<th>HEAT NO.</th>
<th>TYPE</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cu</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>Mn</th>
<th>Sn</th>
<th>Al</th>
<th>N</th>
<th>V</th>
<th>B</th>
<th>Ti</th>
<th>CB</th>
<th>CO</th>
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<tbody>
<tr>
<td>M6569B</td>
<td>HEAT</td>
<td>24</td>
<td>098</td>
<td>018</td>
<td>008</td>
<td>24</td>
<td>02</td>
<td>01</td>
<td>03</td>
<td>00</td>
<td>037</td>
<td>001</td>
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<td></td>
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</tbody>
</table>

**Matrix**
- DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE USE OF 0.
**U.S. STEEL GROUP**

**CERTIFICATION**

**U.S. X.**

**I.V.**

**E.**

**Test Report**

**U.S.C.TE FL GROUP**

**I. R.**

**Dem.**

**M.**

**Corp.**

**U.S.,**

**| VENDOR | SHIPPERS NO. | MILL ORDER NO. | INVOICE NO. | ORDER NO. | PRODUCT DESCRIBED HEREIN WAS MFGD., SAMPLED, TESTED AND INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS REQUIREMENTS IN SUCH RESPECT.**
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>GARY WORKS GARY, INDIANA 46402</strong></td>
<td><strong>H03203 06 15 93</strong></td>
<td><strong>CF32740</strong></td>
<td><strong>154-190665</strong></td>
<td></td>
<td><strong>Prepared by the Office of: G. D. Lukes, Gen. Mgr., Q. C.</strong></td>
</tr>
<tr>
<td><strong>BEAIRD INDUSTRIES INC DIV OF TRINITY INDUSTRIES INC</strong></td>
<td><strong>SHIP TO TO</strong></td>
<td><strong>601 BENTON KELLY DR</strong></td>
<td><strong>SHREVEPORT LA 71130-1113</strong></td>
<td></td>
<td><strong>D1V OF TRI INDIATRIESHIC DIV OF TRINITY INDUSTRIES</strong></td>
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</tbody>
</table>

**PLATE CARBON ASTM A516-90 GRADE 70 ASME SA516-992 EDITION-1992 ADDENDA DECEMBER 31, 1992 GRADE 70 PRESSURE VESSEL QUALITY NORMALIZE**

**INSPECTION CERTIFICATION**

**01 MILL RA/SN CERTIFIED T/R WITH LOAD ANALYSIS**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>MATERIAL DESCRIPTION</th>
<th>QUANTITY</th>
<th>WEIGHT</th>
<th>HEAT NO.</th>
<th>TEST OR PIECE</th>
<th>YIELD PT.</th>
<th>TENSILE STR.</th>
<th>ELONGATION %</th>
<th>% RED.</th>
<th>BENEFITS</th>
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<tr>
<td>01</td>
<td>1.1100 121.0000 411-3/8&quot; PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
<td>01</td>
<td>15669</td>
<td>D61513</td>
<td>56W 3</td>
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<td></td>
<td></td>
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<tr>
<td>01</td>
<td>1.1100 121.0000 411-3/8&quot; STEEL-TYPE = CAST REDUCTION RATIO = 8.2 TO 1 PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
<td>01</td>
<td>15669</td>
<td>D61513</td>
<td>57W 1</td>
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<tr>
<td>01</td>
<td>1.1100 121.0000 411-3/8&quot; STEEL-TYPE = CAST REDUCTION RATIO = 8.2 TO 1 PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
<td>01</td>
<td>15669</td>
<td>D61513</td>
<td>57W 3</td>
<td></td>
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</tbody>
</table>

**HEAT NO. TYPE C Mn P S Si Cu Ni Cr Mo Sn Al V B Ti CB Co**

**D61513 23 098 012 007 02 01 04 01 D18 001 001**

**DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE USE OF PERIODS.**

**END OF DATA"**
# Metallurgical Test Report

**THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MFGD., SAMPLED, TESTED AND/O INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FUL-FILLS REQUIREMENTS IN SUCH RESPECT.**

**PREPARED BY THE OFFICE OF:**  
G. D. LUKES GEN. MGR. QA  
6-11-93

---

## SPEC. & NSP.
- **PLATE CARBON ASTM A516-#90 GRADE 70 ASME SA516-#1992**  
- **EDITION-1992 ADDENDA DECEMBER 31, 1992 GRADE 70 PRESSURE VESSEL QUALITY NORMALIZE**

## INSPECTION
- **01 MILL RA/SN CERTIFIED T/R WITH LOAD ANALYSIS**

## Table: Test Report Details

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Material Description</th>
<th>Thickness or Section</th>
<th>Width in. or Ft., Lb.</th>
<th>Length</th>
<th>Quantity</th>
<th>Weight</th>
<th>Heat No.</th>
<th>Test or Piece Identity</th>
<th>Yield Pt.</th>
<th>Tensile Str.</th>
<th>Elongation %</th>
<th>% Red. of Area</th>
<th>Bend</th>
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<tr>
<td>01</td>
<td>1.1100</td>
<td>121.0000</td>
<td>411-3/8&quot;</td>
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<td>D61513</td>
<td>57W 3</td>
<td>55.0</td>
<td>75.0</td>
<td>29.0</td>
<td>50.0</td>
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<tr>
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<td><strong>PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F.</strong> FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
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<td>121.0000</td>
<td>411-3/8&quot;</td>
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<td>M65698</td>
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<td>75.5</td>
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<td>49.0</td>
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|          | **STEEL-TYPE = CAST**  
|          | **REDUCTION RATIO = 8.2 TO 1**  
|          | **PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F.** FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.** |
|          | **END OF DATA** |

## Yield Strength @ 0.5% E.U.L.

<table>
<thead>
<tr>
<th>Heat No.</th>
<th>Type</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cu</th>
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<th>V</th>
<th>B</th>
<th>Ti</th>
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<th>Co</th>
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<tbody>
<tr>
<td>D61513</td>
<td>HEAT 23</td>
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<td>0.012</td>
<td>0.07</td>
<td>0.24</td>
<td>0.02</td>
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**END OF DATA**

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**NOTE:** DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGINAL VERtical SPACE.
Plate Carbon ASTM A516-870 Grade 70 ASME SA516-81992 Quality Normalize

INSP: 01 Mill RA/SN Certified T/R with Load Analysis

<table>
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<th>ITEM NO.</th>
<th>THICKNESS OR SECTION</th>
<th>MATERIAL DESCRIPTION</th>
<th>QUANTITY</th>
<th>WEIGHT</th>
<th>HEAT NO.</th>
<th>TEST OR PIECE IDENTITY</th>
<th>YIELD PT.</th>
<th>TENSILE STR.</th>
<th>ELONGATION %</th>
<th>% RED. OF AREA</th>
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<td>01</td>
<td>1.100</td>
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<td>411- 3/8&quot;</td>
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<td>75W 1</td>
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<td>50.0</td>
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<tr>
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<td></td>
<td>PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG.F. FOR 0036 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
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</tbody>
</table>

| 01       | 1.100                | 121.0000             | 411- 3/8" | 01     | 15669    | D61513                  | 56W 3     | 56W 3        | 49.1          | 75.5           |
|          |                      | STEEL-TYPE = CAST    |          |        |          |                         |           |              | 29.0          | 50.0           |
|          |                      | REDUCTION RATIO = 8.2 TO 1 |        |        |          |                         |           |              |               |                |

YIELD STRENGTH @ 0.5% E.U.L.

| HEAT NO. | TYPE | C | Mn | P  | S  | Si | Cu | Ni | Cr | Mo | Sn | Al | N  | V  | B  | Ti | Nb | V | Ca | Ni | Fe |
|----------|------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|-----|
| Y66766   | HEAT | 25| 0.014 | 0.05 | 23 | 01 | 01 | 03 | 00 | 021 | 001 | 001 | 002 | FINE GRAIN |
| D61513   | HEAT | 23| 0.012 | 0.07 | 24 | 02 | 01 | 04 | 01 | 018 | 001 | 001 | 001 | FINE GRAIN |
**CUSTOMER ORDER #**

17492

**DATE**

07/16/93

**OUR ORDER #**

101878

---

**ITEMS**

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<th>QTY</th>
<th>DESCRIPTION</th>
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<td>6</td>
<td>2 300 LNH X 9 RF SA 105 125-250 AARH</td>
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<tr>
<td>2</td>
<td>6</td>
<td>2 300 RF BLIND SA 105 125-250 AARH</td>
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<tr>
<td>3</td>
<td>2</td>
<td>20 300 WN FF XH SA105 125-250 AARH</td>
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**CHEMICAL PROPERTIES**

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<th>SIL</th>
<th>Mn</th>
<th>PHOS</th>
<th>SUL</th>
<th>Cr</th>
<th>Ni</th>
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<th>N</th>
<th>CO</th>
<th>V</th>
<th>AL</th>
<th>NB/CB</th>
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<td>0.000</td>
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<td>0.000</td>
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<td>0.014</td>
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**PHYSICAL PROPERTIES**

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<thead>
<tr>
<th>YIELD</th>
<th>TENSILE</th>
<th>ELONG.</th>
<th>RED.</th>
<th>BHN</th>
</tr>
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<tr>
<td>50,000</td>
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<td>52,000</td>
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<tr>
<td>50,600</td>
<td>75,300</td>
<td>34.90</td>
<td>72.00</td>
<td>153-153</td>
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</table>

---

**NOTES**

1. NORM. @ 1650 DEG. F. 1 HR. PER IN. OF THICK, AIR COOLED
2. ELONGATION TAKEN FROM A ROUND SPEICMEN,
3. MANUFACTURED IN U.S.A.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

[Signature]

PIPING PRODUCTS, INC.
Certificate of Tests

Bolt and Gasket, Inc.  P. O. Box 292
Houston, Texas  77001

Daniel Order No.  HB37777  Customer Order No.  12-16363

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>Code</th>
<th>Product</th>
<th>Size</th>
<th>Mill Heat Code</th>
<th>Specification</th>
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<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>EMD</td>
<td>B7 ATS</td>
<td>5/8&quot; X 3-1/2&quot;</td>
<td>46184</td>
<td>ASTM A-193</td>
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<tr>
<td>2</td>
<td>96</td>
<td>GCN</td>
<td>2H HH NUTS</td>
<td>5/8&quot;</td>
<td>M43254</td>
<td>ASTM A-194</td>
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<tr>
<td>3</td>
<td>288</td>
<td>FZC</td>
<td>2H NUTS</td>
<td>1-1/4&quot;</td>
<td>M43170</td>
<td>ASTM A-194</td>
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<td>4</td>
<td>8</td>
<td>FMT</td>
<td>B7 ATS</td>
<td>5/8&quot; X 3-1/4&quot;</td>
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<td>5</td>
<td>16</td>
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<td>2H HH NUTS</td>
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<th>C</th>
<th>MN</th>
<th>P</th>
<th>S</th>
<th>SI</th>
<th>CR</th>
<th>NI</th>
<th>MO</th>
<th>CU</th>
<th>TI</th>
<th>V</th>
<th>B</th>
<th>CB</th>
<th>AL</th>
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<tr>
<td>2</td>
<td>.43</td>
<td>.74</td>
<td>.008</td>
<td>.026</td>
<td>.19</td>
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<td>.07</td>
<td>.02</td>
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<table>
<thead>
<tr>
<th>Yield</th>
<th>% Elg</th>
<th>% Charpy Impact Type V-Notch</th>
<th>24 hr. Test Proof</th>
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<tbody>
<tr>
<td>Item</td>
<td>2% Offset Tensile 2&quot; RA</td>
<td>Type Hardness Temp-F</td>
<td>1 2 3 Temp-F Hdns</td>
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<tr>
<td>1</td>
<td>135270</td>
<td>150300</td>
<td>23.3</td>
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<td>2</td>
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<tr>
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<td>HRB 104</td>
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<tr>
<td>5</td>
<td>HRB 104</td>
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</table>

Note: Elongation is reported at 4 times specimen diameter for smaller sizes.

Item  Processing Notes
1    HARDENED AT 1600 F
2    TEMPERED AT 1202 F. FOR 45 MIN.
3    TEMPERED AT 1202 F. FOR 45 MIN.
4    HARDENED AT 1600 F.
5    TEMPERED AT 1202 F. FOR 45 MIN.

BEAIRD INDUSTRIES, INC.
P.O. BOX 31115
601 BENTON KELLY
SHREVEPORT, LA 71130

I certify that the results reported above are a correct and accurate reflection of the original manufacturers test report as filed in the division records. In addition, the results reported above have been reviewed and found in compliance with the applicable Daniel and/or ASTM, ASME material specification(s).

Quality Assurance Representative: 

BEAIRD INDUSTRIES, INC.
P.O. BOX 31115
601 BENTON KELLY
SHREVEPORT, LA 71130
MTR # A018219
Forged Vessel Connections, Inc.

MATERIAL TEST REPORT

S.O. No.: 2446-3  
Date: July 12, 1993

Purchaser: R & M FORGE & FITTING
Distributor: SHARON STEEL
P.O. No.: 17439
Distributor’s Order No.: 2133975

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>QTY.</th>
<th>DESCRIPTION</th>
<th>SPEC.</th>
<th>HEAT #</th>
<th>HEAT TREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2&quot; X 300# X 14&quot; LWN, RF&amp;D</td>
<td>SA105</td>
<td>C112AN</td>
<td>NORMALIZED</td>
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CHEMICAL ANALYSIS AND MECHANICAL PROPERTIES

Heat #: C112AN
SHARON STEEL #: 330222

<table>
<thead>
<tr>
<th>Element</th>
<th>Mang</th>
<th>Phos.</th>
<th>Sul</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>Cu</th>
<th>Al</th>
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<table>
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<tr>
<th>Element</th>
<th>As</th>
<th>Sb</th>
<th>Sn</th>
<th>Co.</th>
<th>N</th>
<th>Ti</th>
<th>Ta</th>
<th>Nb</th>
<th>Cb</th>
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<tbody>
<tr>
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<td>.004</td>
<td>&lt;.002</td>
<td>.009</td>
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<td></td>
<td>.001</td>
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<table>
<thead>
<tr>
<th>TENSILE</th>
<th>YIELD</th>
<th>ELONG</th>
<th>R.A.</th>
<th>CHARPY</th>
<th>FT LBS</th>
<th>TEMP</th>
<th>COMMENTS</th>
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<tr>
<td>P.S.I.</td>
<td>P.S.I.</td>
<td>IN 2&quot;</td>
<td>%</td>
<td>FT LBS</td>
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<tr>
<td></td>
<td>80,000</td>
<td>56,000</td>
<td>27.00</td>
<td>52.00</td>
<td>/</td>
<td>/</td>
<td>/</td>
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<tr>
<td>SHEAR %</td>
<td>LAT. EXPANSION MLS</td>
<td>BHN</td>
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<td></td>
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<td></td>
<td>Less than 187</td>
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</table>

FVC STANDARD MANUFACTURING PRACTICES:
1. FLANGE DIMENSIONS & BOLTING COMPLY -B16.5.
2. SELF-REINFORCING NOZZLES COMPLY WITH SPECIFICATION OF SECT. B DIV. I OR DIV. II PER CUSTOMER DESIGN/FVC DESIGN.
3. MATERIAL SPECIFICATION COMPLIES WITH ASME SECT. 2, PART A.
4. ALL FVC MATERIAL MANUFACTURED PER FINE GRAIN PRACTICE.
5. PRODUCT LIABILITY INSURANCE NUMBER: 46-CEN-SS2728-HARTFORD.

Rigoberto Mendejas
MTR Operator

Madhu Sarangam
Quality Assurance

18-129
TEST CERTIFICATE
CUSTOMER P.O.: 20-31
DESCRIPTION: 2 - RECTANGLE 1 - X - 96 - X - 240

SOLD TO:
BEAIRD IND.
P.O. BOX 31115

SEND TO:
BEAIRD IND.
P.O. BOX 31115

SHIP TO:
BEAIRD IND.
601 BENTON KELLY ST.

DESCRIPTION: EDD ORDER
NO: 94965-004

SOLD TO:
DEAIRD IND.
P.O. BOX 31115

SEND TO:
BEAIRD IND.
P.O. BOX 31115

SHREVEPORT LA 71130-1115 SHREVEPORT LA 71130-1115 SHREVEPORT LA 71130-1115

MELT/SLAB
C1123 /3
C1128 /5

CHEMICAL ANALYSIS
C
0.23
0.23
MN
0.95
0.017
0.09
PS
27
21
SI
14
16
NI
CR
MO
V
TI
B
0.05
0.002
CR
0.003

PRACTICES
GS 7-8

DESCRIPTION:

TENSILE
TYPE
YLD
503
TENS
761
% ELONG
85
% R.A.

CHARPY V IMPACTS
TYPE
TEMP
BL
-50F
FT L35
42
52
55

INFORMATION
WEIGHT PER PIECE: 6534 LBS.
2970 KG.
ALL STEEL HAS BEEN MELTED AND MANUFACTURED IN U.S.A.
V/L #22295 CR 715496

WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT:

Quality Assurance Laboratory
Cantonville, PA 18220

Donald G. Weaver
**Metallurgical Test Report**

**Vendor Sold To:**
- GARY WORKS
  - GARY, INDIANA 46402
- BEAIRD INDUSTRIES INC
  - DIV OF TRINITY INDUSTRIES INC
    - P.O. BOX 31115
    - SHREVEPORT, LA 71130-1115

**Vendor]**
- BEAIRD INDUSTRIES INC
  - DIV OF TRINITY INDUSTRIES INC
    - 601 BENTON KELLY DR
    - SHREVEPORT, LA 71106

**SHIPPERS NO.**
- H03030
**MILL ORDER NO.**
- GF31101
**INVOICE NO.**
- 154-188468

**THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS:**
- MFG'D., SAMPLED, TESTED AND/INSPECTED IN ACCORDANCE WITH
- THE SPECIFICATION AND FUL-FILLS REQUIREMENTS IN SUCH RESPECT.

**PREPARED BY THE OFFICE OF:**
- G.D. LUKES GEN. MGR, G.A.

**SPEC.

- PLATE CARBON ASTM A516-90 GRADE 70 ASME SA516-9192**
- EDITION-1992 ADDENDA DECEMBER 31, 1992 GRADE 70 PRESSURE VESSEL QUALITY NORMALIZE CHARPY V-NOTCH LONGITUDINAL IMPACT TESTS EACH PLATE AS HEAT TREATED 15/12 FT/LBS AT MINUS 50 DEG F
- INSPE: 01 MILL RA/SN CERTIFIED T/R WITH LOAD ANALYSIS

---

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>MATERIAL DESCRIPTION</th>
<th>QUANTITY</th>
<th>WEIGHT</th>
<th>HEAT NO.</th>
<th>TEST OR PIECE IDENTIFIER</th>
<th>YIELD PT. KSI</th>
<th>TENSILE STR. KSI</th>
<th>ELONGATION %</th>
<th>% RED. OF AREA</th>
<th>BEND</th>
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<tbody>
<tr>
<td>02</td>
<td>1/2&quot; 96.0000 240&quot;</td>
<td>02</td>
<td>6534</td>
<td>E63764</td>
<td>55X 4</td>
<td>55X 4</td>
<td>54.0</td>
<td>75.5</td>
<td>25.0</td>
<td>37.0</td>
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<tr>
<td></td>
<td>STEEL-TYPE = CAST REDUCTION RATIO = 18 2 TO 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>LONG. FL SZ CHARPY IMP V-NOTCH -050 DEG F FT LBS/ 087-069-068 AVERAGE IMPACT STRENGTH +75 FT LBS IMPACT PCE ID = 55X 4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>PRODUCT &amp; TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0016 MINUTES. COOLING COMPLETED IN STILL AIR.</td>
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<tr>
<td>02</td>
<td>1/2&quot; 96.0000 240&quot;</td>
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<td>6534</td>
<td>E63764</td>
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</tbody>
</table>

---

**YIELD STRENGTH @ 0.5% E.U.L.**

- E63764: HEAT 21 101 012 007 25 01 01 02 00 022 001 001 FINE GRAIN

---

**ATRIX**

- DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE HEAT NUMBER.

---

**P.O. DATE:**
- 05 29 93
**PURCHASE ORDER NO.:**
- 20-32138
**INVOICE NO.:**
- 154-188468

---

- THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS:
- MFG'D., SAMPLED, TESTED AND/INSPECTED IN ACCORDANCE WITH
- THE SPECIFICATION AND FUL-FILLS REQUIREMENTS IN SUCH RESPECT.

**PREPARED BY THE OFFICE OF:**
- G.D. LUKES GEN. MGR, G.A.
**Plate Carbon ASTM A516-70 Grade 70 ASME SA516-701992**  
**Edition-1992 Addenda December 31, 1992 Grade 70 Pressure Vessel Quality Normalize Charpy V-Notch Longitudinal Impact Tests Each Plate As Heat Treated 15/12 FT/LBS At Minus 50 Deg F**

**INSP: 01 Mill RA/SN Certified T/R With Load Analysis**

### Material Description

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Material Description</th>
<th>Weight</th>
<th>Heat No.</th>
<th>Test or Piece Identity</th>
<th>Yield Pt.</th>
<th>Tensile Str.</th>
<th>Elongation %</th>
<th>% Red. of Area</th>
<th>Bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Long. Fl Sz Charpy Impet V-Notch -050 Deg F</td>
<td>E63764 55Y 4</td>
<td>IMPACT PCE ID = 55Y 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Product & Test Specimens Were Normalized At 1660 Deg. F. For 0016 Minutes. Cooling Completed In Still Air.**

---

**Heat No.**  
**Type**  
**C**  
**Mn**  
**P**  
**S**  
**Si**  
**Cu**  
**Ni**  
**Cr**  
**Mo**  
**Sn**  
**Al**  
**N**  
**V**  
**B**  
**Ti**  
**Cb**  

E63764  
HEAT 21 101 012 007 25 01 01 02 00 022 001 001 001 001 001 001 001 001 001 001 001 001

---

**DECLARATIONS FOR ELEMENTS ARE INDICATED IN THE HEAT.**
Report of CHEMICAL and PHYSICAL TESTS of STEEL PLATE

Shipped To: HIGH STRENGTH STEEL, INC.

Customer's Order No.: 1894

<table>
<thead>
<tr>
<th>Melt No.</th>
<th>Slab No.</th>
<th>Spec.</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>Cr</th>
<th>Yield Point</th>
<th>Tensile Strength</th>
<th>Charpy</th>
<th>Elongation</th>
<th>Bend Test</th>
<th>SIZE OF PLATE</th>
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<tbody>
<tr>
<td>D22944</td>
<td>D8453A516-70</td>
<td>22</td>
<td>1.05</td>
<td>0.23</td>
<td>0.24</td>
<td>27</td>
<td>B</td>
<td>54,000</td>
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<tr>
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<td>D8453A516-70</td>
<td>20</td>
<td>1.07</td>
<td>0.04</td>
<td>0.30</td>
<td>30</td>
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<td>52,000</td>
<td>80,000</td>
<td>27.0</td>
<td>OK</td>
<td>24X120X380</td>
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</tr>
</tbody>
</table>

All material was Norm @ 1700°F for 1 hour per inch of thickness @ temp. Still air cooled.

I hereby certify that the above tests are correct to the best of my knowledge and belief.

Q.C. APPROVED

Bobby D. McMillan
Engr. of Tests
March 22, 1989

High Strength Steel, Inc.
P.O. Box 40606
Houston, TX 77240
ATTN: Mr. Warren Frahlman

P.O. No. HS 2569
Report No. 89-0679-6

IDENTIFICATION: 3" Plate #H670T00030-1, HT #D22946, Slab #D040
MATERIAL: ASME SA516-70 Norm.
REFERENCE: SH 2299

IMPACT TEST
(Longitudinal)

10mm x 10mm CVN 0°F+10°F

<table>
<thead>
<tr>
<th>Foot/Pounds</th>
<th>Lateral Expansion (mils)</th>
<th>%Shear</th>
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</thead>
<tbody>
<tr>
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<td>30</td>
</tr>
<tr>
<td>49.0</td>
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<tr>
<td>44.0</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

Donald Barrick
Mechanical Testing Supervisor

DD/sg/377

Our letters and reports are for the exclusive use of the client to whom they are addressed. Our reports apply only to the actual samples tested and are not necessarily indicative of the properties of other identical or similar materials.
TEXAS BOLT COMPANY
Manufacturers of Industrial Fasteners
3223 WEST 11TH ST. • P.O. BOX 1211
HOUSTON, TEXAS 77201-1211

August 13, 1973

BEAIRD INDUSTRIES
P.O. BOX 31115
SHREVEPORT, LA 71130

YOUR ORDER NO: 12-34181
OUR ORDER NO: 015645

Gentlemen:

We hereby certify that the stud on your above order were produced, inspected, and/or tested in accordance with specifications:

ASTM A193-92 GRADE B7

These products meet all applicable requirements.

"ALL MATERIAL IS OF U.S. ORIGIN AND MANUFACTURE, FREE OF WELD REPAIR AND NO MERCURY CONTAMINATION."

Very truly yours,

GINA M. LAWRENCE
LAB SUPERVISOR

GL/KF
State of Texas
County of Harris
Subscribed and sworn to before me this __________ day of ____________.

Notary public in and for Harris County, Texas
My commission expires ____________.
# REPORT OF MECHANICAL AND CHEMICAL TESTS

**HEAVY HEX NUTS**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM DESCRIPTION</th>
<th>REPORT</th>
<th>MATERIAL</th>
<th>QUANTITY</th>
<th>NO. PCS. TESTED</th>
<th>Spec 120 Deg. Cone Proof Load lbs</th>
<th>T/M</th>
<th>Minimum Tempering</th>
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<td>Elevated Temperature Test 24 hrs at 1000°F</td>
<td>1045</td>
<td>288</td>
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<td>29 RC</td>
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<td>59,100</td>
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"ALL MATERIAL IS OF U.S. ORIGIN AND MANUFACTURE. FREE OF WELD REPAIR AND NO MERCURY CONTAMINATION.

**ASME SECTION VIII DIV 1 NON NUCLEAR**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>HEAT NUMBER</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>S</th>
<th>P</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>V</th>
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<td>.044</td>
<td>.01</td>
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<td>.69</td>
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<td>.018</td>
<td>.007</td>
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</tbody>
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---

**NOTICE!**

This report must not be altered in any manner. This report is to be presented only for the exact product and quantity of product described above. Bolts described in this report must be marked on the head with either "TB"® or "Texas Bolt"®. Nuts and Studs described in this report must be marked with a "T"®. These marks are registered trademarks of Texas Bolt Company, Inc., and no other markings are certified by this report. If you suspect any alteration has been made to this report, or if you would like verification of its authenticity, please contact Quality Assurance Manager, Texas Bolt Company, 1-800-237-1517.

Inspector Evaluation Approved by: J. P. ROBINSON NDE LEVEL III INSPECTOR

[Signature]

Authorized Signature
FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop-Fabricated Vessels Only)
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by: Beaird Industries, Inc., 601 Benton Kelly Road, Shreveport, LA 71106
   (Name and address of manufacturer)

2. Manufactured for: Lotepro Corporation, 115 Stevens Avenue, Valhalla, NY 10595
   (Name and address of purchaser)

3. Location of Installation: Babcock and Wilcox, Lynchburg, VA
   (Name and address)

4. Type: Horiz. Tank 158585-01-1
   (Drawing No.)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Boiler and Pressure Vessel Code. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1.

6. Shell:

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>SA-516-70</td>
<td>1.093&quot;</td>
<td>1/32&quot;</td>
<td>2:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Concave</td>
</tr>
</tbody>
</table>

7. Seams:

   | Type | UN-12 Full | 100 | None | Type | UN-12 Full | 6 |

8. Heads:

<table>
<thead>
<tr>
<th>Material</th>
<th>SA-516-70</th>
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<tbody>
<tr>
<td>Type</td>
<td>(Spec. No., Grade)</td>
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<table>
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<tr>
<th>Ends</th>
<th>1.0937&quot;</th>
<th>1/32&quot;</th>
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<tr>
<td>(b)</td>
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<table>
<thead>
<tr>
<th>Seams</th>
<th>Side</th>
<th>Material</th>
<th>Diameter</th>
<th>Reinforcement</th>
<th>Head</th>
<th>Location</th>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Nozzles, inspection and safety valve openings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose (Inlet, Outlet, Drain)</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Manway</td>
</tr>
<tr>
<td>Inlet</td>
</tr>
<tr>
<td>Outlet</td>
</tr>
<tr>
<td>Drain</td>
</tr>
</tbody>
</table>

   | Supports: Skirt | Legs | Legs | Other | (2) Saddles | Attached | Shell Welded | |
   |-----------------|------|------|-------|-----------|----------|--------------|
   | (Yrs.) | (No.) | (No.) | (Yrs.) | | | |

9. M.A.W.P.:

<table>
<thead>
<tr>
<th>Min. design metal temp.</th>
<th>275</th>
<th>psi at max. temp.</th>
<th>140</th>
<th>°F</th>
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</thead>
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<tr>
<td>Ext. 14.7 @ 140°F</td>
<td>275</td>
<td>psi, Hydro.</td>
<td>439</td>
<td>psi.</td>
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10. CERTIFICATE OF SHOP COMPLIANCE

   We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. "U" Certificate of Authorization No. 11840, expires March 12, 1994.

   Date: 8/17/93
   Co. name: Beaird Industries, Inc.
   Signed: Beaird Industries, Inc.
   (Manufacturer)

   Date: 8/17/93
   Co. name: Beaird Industries, Inc.
   Signed: Beaird Industries, Inc.
   (Manufacturer)

   Date: 8/17/93
   Co. name: Commercial Union Insurance Company
   Signed: Commercial Union Insurance Company
   (Insurance)

11. Nozzles, inspection and safety valve openings:

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<tr>
<th>Purpose (Inlet, Outlet, Drain)</th>
<th>No.</th>
<th>Diam or Size</th>
<th>Type</th>
<th>Mat.</th>
<th>Reinforcement</th>
<th>Mat.</th>
<th>Mat.</th>
<th>Mat.</th>
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<th>Location</th>
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<td>300# WN</td>
<td>SA-516-70</td>
<td>SA-105</td>
<td>1/2&quot;</td>
<td>SA-516-70</td>
<td>UW-16.1(e)</td>
<td>Head</td>
<td></td>
<td></td>
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<tr>
<td>Inlet</td>
<td>1</td>
<td>2&quot;</td>
<td>300# LWN</td>
<td>SA-105</td>
<td>5/8&quot;</td>
<td>--</td>
<td>SA-516-70</td>
<td>UW-16.1(e)</td>
<td>Shell</td>
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<td>5/8&quot;</td>
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</table>

   | Supports: Skirt | Legs | Legs | Other | (2) Saddles | Attached | Shell Welded | |
   |-----------------|------|------|-------|-----------|----------|--------------|
   | (Yrs.) | (No.) | (No.) | (Yrs.) | | | |

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:

   None

   (Name of part, item number, Mfg.'s name and identifying stamp)

   129-1/2" I.D. x 66' -9/7/16" O.A. Length 43,725 W.G. Gaseous Helium Tank

   Impact testing - No Exempt per UCS-66(a) & (e)

   Vent | (1) | 2" | 300# LWN | SA-105 | 5/8" | -- | UW-16.1(e) | Shell |

   CERTIFICATE OF SHOP INSPECTION

   We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. "U" Certificate of Authorization No. 11840, expires March 12, 1994.

   Date: 8/17/93
   Co. name: Beaird Industries, Inc.
   Signed: Beaird Industries, Inc.
   (Manufacturer)

   Date: 8/17/93
   Co. name: Commercial Union Insurance Company
   Signed: Commercial Union Insurance Company
   (Insurance)
CERTIFICATE OF COMPLIANCE
BY
BEAIRD INDUSTRIES, INC.
SHREVEPORT, LOUISIANA

Dear Sirs:

This is to certify that Beaird Industries, Inc. has done a white metal blast per SSPC-SP5 as required per specifications on the vessel internal. Following the blast, a black light inspection was performed by Beaird Quality Control personnel to assure that all debris, grease, etc. was removed and interior was clean prior to closing vessel for helium test.

RE: BEAIRD INDUSTRIES, INC. SALES ORDER 158585-01-1

SIGNED B. Allen

TITLE Q. C. Supervisor

DATE 8/31/93

PRESSURE VESSELS, TOWERS, AND STORAGE TANKS • FABRICATED AND MACHINED WELDMENTS • MAXIM® EVAPORATORS AND HEAT EXCHANGERS • MAXIM® SILENCERS AND HEAT RECOVERY EQUIPMENT
**CUSTOMER:** Lotepro Corp.

**Work Order or Sales Order:** 15885-01-1

**Date:** 8-16-93

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- **K:** Good Weld
- **P:** Pinhole or Excessive Porosity
- **C:** Crack
- **L:** Lack of Penetration
- **S:** Slag
- **D:** Surface Defect

**Note:** Date is handwritten as 8-16-93.
## N.D.F. Radiography

**X-Ray Report**

**Unit Serial Number:** 158585-D11  
**Customer:** Lot 200  
**Specifications:** ASME Code Sec VIII Div 2 & B1 OC-6007  
**Weld Procedure No.:** 01-01-02-62  
**Material Type:** SA-S76-70N  
**Thickness:** 7.1/8  
**X-Ray / Gamma Ray:**  
**Retorter:** 30  
**Film:** Single / Double  
**Film Type:** Kodak  
**Kv:** 250  
**Exposure Time:** 6:45  
**Source to Film Distance:** 30"  
**Focal Spot:** 4mm  
**Processor:** Kodak  
**Quality Level Test:**  
**No. of Film Viewing:** Single / Double  
**Test Results:** Acceptable to ASME Code Sec VIII  
**Drawing No.:** 158585-01

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- Crack  
- Porosity  
- Ph-Pinhole  
- S-Slag  
- T-Tungsten  
- BT-Burn Through  
- LP-Lack of Penetration  
- D-Surface Defect  

- Shooting Sketch Attached When Applicable  
- OK

**Radiographer:** Bobi Montford  
**SNT-TC-1A Level:** 2
<table>
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<th>UNIT SERIAL NUMBER</th>
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<th>MATERIAL TYPE</th>
<th>PENETRATION</th>
<th>FILM TYPE</th>
<th>SOURCE TO FILM DISTANCE</th>
<th>FOCAL SPOT</th>
<th>PROCESSOR</th>
<th>QUALITY LEVEL</th>
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**C-CRACK P-POROSITY PH-PINHOLE S-SLAG T-TUNGSTEN LP-LACK OF PENETRATION SD-SURFACE DEFECT BT-BURN THROUGH**

**OK**

**Radiographer:**

**SNT-TC-1A Level 1**

**Date:** 7-27-92
**X-RAY REPORT**

**RADIOPHONY**

**NO. Q.C. FORM N.D.E.-1**

**UNIT SERIAL NUMBER** 155585-01-1  
**CUSTOMER** Lotepeco Corp.  
**SPECIFICATIONS** ASME Code, Section III, PC-6021 BE  
**WELD PROCEDURE NO.** OA-93-63-5  
**RADIOGRAPHY** BT, Burn Through  
**PENETRATON** 25  
**FILM:** SINGLE  
**FILM TYPE** Kodak PA  
**KV** 100  
**MA** 117  
**EXPOSURE TIME** 2:00  
**FOCAL SPOT** 1/2  
**FOCUS** 0.5  
**PROCESSOR** Kodak X-omat  
**QUALITY LEVEL** 2-2+  
**NO. OF FILM** 6  
**VIEWING** SINGLE  
**TEST RESULTS:** Acceptable to ASME Code  
**DRAWING NO.** 155585-01-1

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C-ck F-Porosity PH-Pinhole S-Slag T-Tungsten BT-Burn Through LP-Lack of Penetration SD-Surface Defect.  
SHOOTING SKETCH ATTACHED WHEN APPLICABLE.

**RADIOPHYSICAL** A. P. Feulner  
**SNT-TC-1A LEVEL II**  
**DATE 7-21-93**
Q.C. FORM N.D.E.-1
REV. B - 2/78

NONDESTRUCTIVE EXAMINATION
RADIOPHraphy

UNIT SERIAL NUMBER 158385-01
CUSTOMER LOTEPRO CORP.

SPECIFICATIONS ASME, CODE SECTION IX - Q.C. 6007 BT
WELD PROCEDURE NO. 0201-02-62

+---+---+---+---+---+
| E | E | E | E | E |
+---+---+---+---+---+
| K | K | K | K | K |
+---+---+---+---+---+
| P | P | P | P | P |
+---+---+---+---+---+

Penetrator 3.0
Film: SINGLE

PENETRAMETER 5A-5/18-10
THICKNESS 1.0737
X-RAY X RAY
SCREENS 0.0548

KODAK AA

NO. FOCAL SPOT 5
MANUFACT. NO. 05-250
PROCESSOR KODAK KOMAT

QUALITY LEVEL 2RT
NO. OF FILM 1
VIEWING SINGLE

TEST RESULTS: ACCEPTABLE
ASME, CODE DRAWING NO. 158385-01

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Cack P-Porosity PH-Pinhole S-Slag T-Tungsten BT-Burn Through LP-Lack of Penetration
SD-Surface Defect.

SHOOTING SKETCH ATTACHED WHEN APPLICABLE.

RADIOGRAPHER G. R. 7/3/93

SNT-TC-1A LEVEL 7-13-93
NOT DESTRUCTIVE EXAMINATION
MAGNETIC PARTICLE

S. O. NUMBER: 158585-01-2  
CUSTOMER: LTE PRO  
REPORT NO.:

SPECIFICATION: ASME SECT.  Fort.  
TEST JOINT: NOZZLE BACK GAUGE  
SURFACE PREP.: CLEAN  
MANUFACTURER: MAGNAFLUX  
MANUFACTURER: MAGNAFLUX  

CURRENT: 200 AMPERAGE: 600 V LIFT 
PROD. SPACING: 6"  
OTHER: N/A  

TYPE PARTICLES: DRY IRON  
COLOR: RED  
MFG.: MAGNAFLUX  

ADDITIONAL PROCEDURE REQUIREMENTS: REAIRD 5/1 3/81.04

ACCEPTANCE STANDARDS: ASME S ECT VIII DIV 1 APX. 6

APPROVED BY: Bob Ball  
DATE: 7/22/93

NOZZLE TO HD + SHELL BACK GAUGE

ITEM  
DESCRIPTION:

<table>
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<tr>
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<th>INS. /DATE</th>
<th>RESULTS-LIST DEFECTS TO BE REPAIRED</th>
<th>RETEST RESULTS INS. /DATE</th>
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<tr>
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<td>8/4/93</td>
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DE MAGNETIZATION: N/A  

ATTACH SUPPLEMENTS WHEN USED

EXAMINER: Lloyd Sallee  
SNT-TC-1A LEVEL  
DATE: 8-12-93
NONDESTRUCTIVE EXAMINATION
MAGNETIC PARTICLE

S. O. NUMBER 15858-01-2  CUSTOMER LOF-P E P  REPORT NO.
SPECIFICATION ASME SEC VIII ART 7 TEST JOINT B/G & F.
TEST METHOD CONTINUOUS SURFACE PREP. CLEAN
EQUIPMENT: TYPE YAKKYE AC MANUFACTURER MAGNAFLUX
CURRENT 1/20 AMPERAGE 10816 FT PROD. SPACING 6" OTHER N/A
TYPE PARTICLES: TYPE DRYican COLOR L/E/D MFG. MAGNAFLUX
ADDITIONAL PROCEDURE REQUIREMENTS: BEACRD 59 388104

ACCEPTANCE STANDARDS: ASME Sec VIII DIV 1 APPX. 6

APPROVED BY  CuibBalceu DATE 3-1-93

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>NO. TO HD</th>
<th>B/G &amp; F/O</th>
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<tr>
<td></td>
<td>MH#1-1</td>
<td>28/4/92</td>
<td>F/W</td>
<td></td>
<td>N/A ED</td>
</tr>
<tr>
<td></td>
<td>H#1-2</td>
<td>ED 8/1/93</td>
<td>B/G</td>
<td></td>
<td>N/A ED</td>
</tr>
<tr>
<td></td>
<td>MH#1-2</td>
<td>8/1/93</td>
<td>FW</td>
<td></td>
<td>N/A ED</td>
</tr>
</tbody>
</table>

DEPERSONIZATION

ATTACH SUPPLEMENTS WHEN USED

EXAMINER  ED  SNT-TC-1A LEVEL II  DATE 8/1/93
### Nondestructive Examination

**Magnetic Particle**

**S. O. Number:** 158585-01-2  
**Customer Lot:** 01-2  
**Report No.:** 

**Specification:** ASME Sec. VIII  
**Test Joint:** Final Welds  
**Test Method:** Continuous Current  
**Surface Prep.:** Clean  
**Equipment:** Type Yoke  
**Manufacturer:** Magnaflux  
**Current:** 110V  
**Amperage/Dwell:** 
**Prod. Spacing:** 6"  
**Other MVA:** 

**Type Particles:** Type Dry Iron  
**Color:** Red  
**Mfg.:** Magnaflux  
**Additional Procedure Requirements:**

**Acceptance Standards:** ASME Sec. VIII Div. 1 Appendix G

**After Hydro: Approved by:**  
**Curt Balles**  
**Date:** 7/22/93

**Nozzle to Shell x Shell Welds**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Mark</th>
<th>Inspect. / Date</th>
<th>Results - List Defects to Be Repaired</th>
<th>Retest Results Inspect. / Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>MH1</td>
<td></td>
<td></td>
<td>7/14/93</td>
<td>Final No Defect</td>
<td></td>
</tr>
<tr>
<td>N1</td>
<td></td>
<td></td>
<td>8/14/93</td>
<td>Final No Defect</td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td></td>
<td></td>
<td>8/14/93</td>
<td>Final No Defect</td>
<td></td>
</tr>
<tr>
<td>N3</td>
<td></td>
<td></td>
<td>7/14/93</td>
<td>Final No Defect</td>
<td></td>
</tr>
<tr>
<td>N4</td>
<td></td>
<td></td>
<td>8/14/93</td>
<td>Final No Defect</td>
<td></td>
</tr>
</tbody>
</table>

**Demagnetization:**

**Examiner:**

**SNT-TC-1A Level:**

**Date:** 8/14/93
# Nondestructive Examination

## Magnetic Particle

**S.O. Number**: 158585-012

**Customer/Lot Number**:

**Specification**: ASME Sec XA-7

**Test Method**: Continuous Current

**Equipment**: Type 40K

**Current/Area**: 1000 A/M

**Surface Prep**: Clean

**Manufacturer**: MAGNAFLUX

**Product Spacing**: 0 in

**Type Particles**: Type 7, Color Red

**Mfg.**: MAGNAFLUX

**Additional Procedure Requirements**: Reaip Sp1 3881.04

**Acceptance Standards**: ASME Sec VIII Div 1 Ann. G

**Approved By**: Curtis Ballow

**Date**: 7/22/93

## Nozzle To HA + Shell Finished Weld and Lugs

### Item Description

- Lugs

### Mark Number

<table>
<thead>
<tr>
<th>Mark Number</th>
<th>Insp./Date</th>
<th>Results - List Defects to Be Repaired</th>
<th>Retest Results Insp./Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>8/8-11/93</td>
<td>No Ind.</td>
<td>NA 8/8-11/93</td>
</tr>
<tr>
<td>N2</td>
<td>8/8-11/93</td>
<td>No Ind.</td>
<td>NA 8/8-11/93</td>
</tr>
<tr>
<td>N3</td>
<td>8/8-11/93</td>
<td>No Ind.</td>
<td>NA 8/8-11/93</td>
</tr>
<tr>
<td>N4</td>
<td>8/8-11/93</td>
<td>No Ind.</td>
<td>NA 8/8-11/93</td>
</tr>
</tbody>
</table>

**Lift Lugs**

- Temporary Attach: DT 8/12/93

### No Ind.

**Demagnetization**: NA

**Examiner**: EJ

**SNT-TC-1A Level**: 4

**Date**: 8-11-93

**Attach Supplements When Used**
**Welding Procedure Specification No.** 01-01-01-56

**Date** 8-14-92

**Revision No.** - **Date** - **Supporting POR No.(s)** 1

**Welding Process(es)** SMAW

**Type(s)** Manual

(Auto, Manual, Machine, or Semi-Auto)

### JOINTS (OW-402)

<table>
<thead>
<tr>
<th>Joint Design</th>
<th>Groove and Fillet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backing (Yes)</td>
<td>X (No)</td>
</tr>
<tr>
<td>Backing Material (Type)</td>
<td>Base and Weld</td>
</tr>
</tbody>
</table>

- Metal
- Nonfusing Metal
- Nonmetallic
- Other

### BASE METALS (OW-403)

<table>
<thead>
<tr>
<th>P-No. 1</th>
<th>Group No. 1-2 to P-No. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>Specification type and grade N/A</td>
</tr>
<tr>
<td>to Specification type and grade N/A</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>Chemical Analysis and Mech. Prop. N/A</td>
</tr>
<tr>
<td>to Chemical Analysis and Mech. Prop. N/A</td>
<td></td>
</tr>
<tr>
<td>Base Metal Thickness Range: Groove 3/16&quot; - 8&quot;</td>
<td>Fillet Unlimited</td>
</tr>
<tr>
<td>Pipe Dia. Range: Groove ≥ 1/2&quot;</td>
<td>Fillet ≥ 1&quot;</td>
</tr>
<tr>
<td>Other No Weld pass shall exceed 3/8&quot; in thickness.</td>
<td></td>
</tr>
</tbody>
</table>

### FILLER METALS (OW-404)

<table>
<thead>
<tr>
<th>Spec. No. (SFA)</th>
<th>5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS No. (Class)</td>
<td>E-7018-1</td>
</tr>
<tr>
<td>F-No.</td>
<td>4</td>
</tr>
<tr>
<td>A-No.</td>
<td>1</td>
</tr>
<tr>
<td>Deposited Weld Metal Thickness Range: Groove 3/16&quot; - 8&quot;</td>
<td>Fillet Unlimited</td>
</tr>
<tr>
<td>Electrode-Flux (Class)</td>
<td>N/A</td>
</tr>
<tr>
<td>Flux Trade Name</td>
<td>N/A</td>
</tr>
<tr>
<td>Consumable Insert</td>
<td>N/A</td>
</tr>
<tr>
<td>Other Alloy Rods E7018-1 electrode shall be used.</td>
<td></td>
</tr>
</tbody>
</table>
POSSESSIONS (OW-405)

Position(s) of Groove: 1G-6G
Welding Progression: Up X Down
Position(s) of Fillet: 1F-5F

POSTWELD HEAT TREATMENT (OW-407)

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Range</td>
<td>N/A</td>
</tr>
</tbody>
</table>

GAS (OW-408)

<table>
<thead>
<tr>
<th>Composition</th>
<th>Percent</th>
<th>Gas(es)</th>
<th>Mixture</th>
<th>Flow Rate</th>
</tr>
</thead>
</table>

PREHEAT (OW-406)

<table>
<thead>
<tr>
<th>Preheat Temp. Min.</th>
<th>3&quot; from the weld joint.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpass Temp. Max.</td>
<td>450°F</td>
</tr>
<tr>
<td>Preheat Maintenance</td>
<td>None</td>
</tr>
<tr>
<td>T ≤ 3/4&quot;</td>
<td>50°F</td>
</tr>
<tr>
<td>T &gt; 21/2&quot;</td>
<td>300°F</td>
</tr>
<tr>
<td>3/4&quot; &lt; T ≤ 1 1/4&quot;</td>
<td>150°F</td>
</tr>
<tr>
<td>1 1/4&quot; &lt; T ≤ 2 1/2&quot;</td>
<td>225°F</td>
</tr>
</tbody>
</table>

ELECTRICAL CHARACTERISTICS (OW-409)

<table>
<thead>
<tr>
<th>Current AC or DC</th>
<th>DC</th>
<th>Polarity</th>
<th>Reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps(Range)</td>
<td>70-350</td>
<td>Volts(Range)</td>
<td>21-26</td>
</tr>
<tr>
<td>Tungsten Electrode Size and Type</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMAW Transfer Mode</td>
<td>N/A</td>
<td>Electrode Wire Feed Range</td>
<td>N/A</td>
</tr>
</tbody>
</table>

TECHNIQUE (OW-410)

<table>
<thead>
<tr>
<th>String or Weave Bead</th>
<th>Both -3/32&quot;- 5/32&quot; φ</th>
<th>Orifice or Gas Cup Size</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial and Interpass Cleaning (Brushing, Grinding, etc.)</td>
<td>Initial - Grind area up to 1&quot; from the weld joint to bright metal. Interpass - Chip slag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of Back Gouging</td>
<td>Air-Carbon Arc Oscillation</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Electrical Stick-out</td>
<td>N/A</td>
<td>Multiple or Single Pass(Per side)</td>
<td>Both</td>
</tr>
<tr>
<td>Multiple or Single Electrodes</td>
<td>Single</td>
<td>Travel Speed(Range)</td>
<td>Varies</td>
</tr>
<tr>
<td>Peening</td>
<td>None permitted</td>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weld Layer(s)</th>
<th>Filler Metal</th>
<th>Current</th>
<th>Travel Speed Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>Dia.</td>
<td>Type</td>
<td>Polar.</td>
</tr>
<tr>
<td>1G-6G, 1F-5F</td>
<td>SWW</td>
<td>E7018-1</td>
<td>3/32&quot;</td>
</tr>
<tr>
<td>1G-6G, 1F-5F</td>
<td>SAW</td>
<td>E7018-1</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>1G-3G, 1F-4F</td>
<td>SAW</td>
<td>E7018-1</td>
<td>5/32&quot;</td>
</tr>
<tr>
<td>1G</td>
<td>1F-2F</td>
<td>SAW</td>
<td>E7018-1</td>
</tr>
<tr>
<td>1G-1F-2F</td>
<td>SAW</td>
<td>E7018-1</td>
<td>7/32&quot;</td>
</tr>
</tbody>
</table>

Optimum Amperage: 90

Welding Engineer: Shannon Hunt
Date: 12-19-92
**Procedure Qualification Record No.** 1

**Date** 8-17-92

**WPS No.** 01-01-01-56

**Welding Process(es)** SMAW

**Type(s)** Manual

**JOINTS (GW-402)**

![Groove Design of Test Coupon](image)

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

### BASE METALS (GW-403)

<table>
<thead>
<tr>
<th>Material Spec.</th>
<th>SA-516</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type or grade</td>
<td>Grade 70</td>
</tr>
<tr>
<td>P-No. Group2 to P-No.</td>
<td>1Group2</td>
</tr>
<tr>
<td>Thickness of Test Coupon</td>
<td>11/2&quot;</td>
</tr>
<tr>
<td>Diameter of Test Coupon</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### FILLER METALS (GW-404)

<table>
<thead>
<tr>
<th>SFA Specification</th>
<th>E7018-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Classification</td>
<td>E7018-1</td>
</tr>
<tr>
<td>Filler Metal F-No.</td>
<td>4</td>
</tr>
<tr>
<td>Weld Metal Analysis A-No.</td>
<td>1</td>
</tr>
<tr>
<td>Size of Filler Metals</td>
<td>5/32, 3/16, 7/32&quot;</td>
</tr>
<tr>
<td>Deposited Weld Metal</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>Other</td>
<td>Alloy Rods E7018-1 Electrode was used.</td>
</tr>
</tbody>
</table>

### POSITION (GW-405)

<table>
<thead>
<tr>
<th>Position of Groove</th>
<th>1g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld Progression (Uphill, Downhill)</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### PREHEAT (GW-406)

<table>
<thead>
<tr>
<th>Preheat Temp.</th>
<th>50°F Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpass Temp.</td>
<td>450°F Maximum</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### POSTWELD HEAT TREATMENT (GW-407)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### GAS (GW-408)

<table>
<thead>
<tr>
<th>Percent Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas(es) (Mixture) Flow Rate</td>
</tr>
<tr>
<td>Shielding</td>
</tr>
<tr>
<td>Trailing</td>
</tr>
<tr>
<td>Backing</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS (GW-409)

<table>
<thead>
<tr>
<th>Current</th>
<th>DC Polarity Reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
<td>170-300</td>
</tr>
<tr>
<td>Volts</td>
<td>21-24</td>
</tr>
<tr>
<td>Tungsten Electrode Size</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td>Maximum heat input was 47,368 J/in.</td>
</tr>
</tbody>
</table>

### TECHNIQUE (GW-410)

<table>
<thead>
<tr>
<th>Travel Speed</th>
<th>6-9.5 IPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>String or Weave Bead</td>
<td>String</td>
</tr>
<tr>
<td>Oscillation</td>
<td>N/A</td>
</tr>
<tr>
<td>Multipass or Single Pass</td>
<td>Multipass (per side)</td>
</tr>
<tr>
<td>Single or Multiple Electrodes</td>
<td>Single</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Tensile Test (OW-150)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Width</th>
<th>Thickness</th>
<th>Area</th>
<th>Ultimate Total Load (lb)</th>
<th>Ultimate Unit Stress (psi)</th>
<th>Type of Failure &amp; Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.749</td>
<td>1.419</td>
<td>1.0628</td>
<td>85,100</td>
<td>80,071</td>
<td>Ductile-Base Metal</td>
</tr>
<tr>
<td>2</td>
<td>0.750</td>
<td>1.416</td>
<td>1.062</td>
<td>85,200</td>
<td>80,225</td>
<td>Ductile-Base Metal</td>
</tr>
</tbody>
</table>

### Guided-Bend Tests (OW-160)

(OW-462.2(Side) Results (OW-462.3(a) (Trans. R&W) Results (OW-462.3(b) (Long. R&W) Results

4 - Satisfactory

### Toughness Test (OW-170)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Notch Location</th>
<th>Notch Type</th>
<th>Test Temp.</th>
<th>Impact Values</th>
<th>Lateral Exp. Mils</th>
<th>Drop Weight Break No Break</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fillet Weld Test (OW-180)

Result - Satisfactory: Yes N/A No Penetration into Parent Metal: Yes N/A No

Macro Results: N/A

### Hardness Test

<table>
<thead>
<tr>
<th>Location</th>
<th>Type Brinell</th>
<th>Location</th>
<th>Weld Metal Surface</th>
<th>1.179</th>
<th>2.192</th>
<th>3.187</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZ Surface</td>
<td></td>
<td></td>
<td>1.192</td>
<td>2.197</td>
<td>3.192</td>
<td></td>
</tr>
<tr>
<td>Base Metal Surface</td>
<td></td>
<td></td>
<td>1.170</td>
<td>2.179</td>
<td>3.179</td>
<td></td>
</tr>
</tbody>
</table>

### Other Tests

<table>
<thead>
<tr>
<th>Test Conducted by</th>
<th>Beaird Industries, Inc.</th>
</tr>
</thead>
</table>

Beaird Industries certifies that the statements in this record are correct and that test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Date: 12-19-92 By Shannon Hunt
# WELDING PROCEDURE (WPS)

**Welding Procedure Specification No.** 01-01-02-62  
**Date** 2/28/85  
**Revision No.** C  
**Supporting PQR No.(s)** 28526  
**Welding Process(es)** SAW  
**Type** Machine  
*(Automatic, Manual, Machine, or Semi-Auto.)*

## JOINTS (QW-402)

- **Joint Design** Butt  
- **Groove Design** Single & Double V  
- **Backing (Yes) X (No)** Root Spacing 0 to 1/8"  
- **Backing Material (Type)** Base Metal for fillets & Weld Metal for double Welded Joints

## BASE METALS (QW-403)

- **P. No.** 1  
- **Group No.** 1 & 2 to P. No. 1  
- **Group No.** 1 & 2  
- **Specification Type and Grade** N/A  
- **Chem. Analysis and Mech. Prop.** N/A  
- **Thickness Range:**  
  - Base Metal: Groove 3/16" - 1-1/2" Filllet All Size  
  - Deposited Weld Metal 1-1/2" Max. (3/8" Max. Weld Metal Deposited Per Pass)  
  - Pipe Dia. Range: Groove 6" & Up Filllet All Size  
  - Other 5/8" Minimum Thickness Notch Toughness

## FILLER METALS (QW-404)

- **F No.** 6  
- **A No.** 1  
- **Spec. No. (SFA)** 5.17  
- **AWS No. (Class)** EM13K  
- **Size of Filler Metals** 5/64" or 5/32"  
- **Electrode-Flux (Class)** F7A2-EM13K  
- **Flux Trade Name** Lincoln 860  
- **Consumable Insert** N/A  
- **Supplement Filler Metal**  
- **Supplement Powdered Filler Metal**
POSITIONS (QW-405)

Position(s) of Groove: 1G
Welding Progression: Up N/A Down N/A
Position(s) of Fillet: 1F - 2F

POSTWELD HEAT TREATMENT (QW-407)

Temperature Range: N/A - As Welded
Up 400°F/t Hold N/A Down 500°F/t = Thickness

GAS (QW-408)

Shielding Gas(es): N/A
% Composition: N/A
Flow Rate: N/A
Gas Backing: N/A
Trailing Shield Gas Comp.: N/A

PREHEAT (QW-406)

Preheat Temp. Min.: See Note I
Interpass Temp. Max.: 450°F Max.
Preheat Maintenance: N/A

ELECTRICAL CHARACTERISTICS (QW-409)

Current AC or DC: 300-650 AC & DC Polarity: 28-36 Volts (Range)
Amps (Range): N/A Tungsten Size and Type: Pure Tungsten, 2% Thoriated, or Other
Spray Arc, Short Circuiting Arc, or Other
Electrode Wire Feed Range: N/A

TECHNIQUE (QW-410)

Stringer or Weave Bead: Stringer
Orifice or Gas Cup Size: N/A
Initial and Interpass Cleaning (Brushing, Grinding, etc.): Air Powered Chipping, Grinding and Brushing
Method of Back Gouging: Arc Air, Spacing 3/4" - 1-1/4"
Method of Inspection: Visual Peening: 3/4" Max. Tandem Arc
Multiple or Single Pass (Per Side): Multiple, Tandem Arc
Multiple or Single Electrodes: Both
Layer(s) Process Filler Metal Current

<table>
<thead>
<tr>
<th>Layer(s)</th>
<th>Process</th>
<th>Class</th>
<th>Dia.</th>
<th>Type Polar.</th>
<th>Amp Range</th>
<th>Volt Range</th>
<th>Travel Range</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>SAW</td>
<td>EM13K</td>
<td>5/64&quot;</td>
<td>DC-Rev.</td>
<td>300-400</td>
<td>28-30</td>
<td>16-20IPM</td>
<td>Single Arc</td>
</tr>
<tr>
<td>All</td>
<td>SAW</td>
<td>EM13K</td>
<td>5/32&quot;</td>
<td>DC-Rev.</td>
<td>500-600</td>
<td>28-32</td>
<td>16-20IPM</td>
<td>Single Arc</td>
</tr>
<tr>
<td>All</td>
<td>SAW</td>
<td>EM13K</td>
<td>5/32&quot;</td>
<td>DC-Rev.</td>
<td>550-600</td>
<td>30-32</td>
<td>30-36IPM</td>
<td>Tandem Arc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead</td>
<td>5/32&quot;</td>
<td>AC</td>
<td>550-600</td>
<td>32-36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trail</td>
<td>5/32&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE I: Preheat
a) Up to 1-1/4" - Ambient temp. with no welding below 50°F.
b) 1-1/4" - 1-1/2" - 200°F min.

Piley-Beaird Welding Engineer
Piley-Beaird Quality Control
**PROCEDURE QUALIFICATION RECORD (PQR)**

**Procedure Qualification Record No.** 28526-1  
**Revision - Date** 2/28/85

**Welding Process(es)** SAN

**Type(s) (Manual, Automatic, Machine, or Semi-Automatic)** Machine

<table>
<thead>
<tr>
<th>Joint (QW-102)</th>
<th>PASS</th>
<th>ELECT.</th>
<th>AMPS</th>
<th>VOLTS</th>
<th>SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-SA</td>
<td>5/32&quot;</td>
<td>DC-500</td>
<td>28</td>
<td>16</td>
<td>IPM</td>
</tr>
<tr>
<td>2-TA</td>
<td>L-5/32&quot;</td>
<td>DC-550</td>
<td>32</td>
<td>34</td>
<td>IPM</td>
</tr>
<tr>
<td>3-TA</td>
<td>T-5/32&quot;</td>
<td>AC-600</td>
<td>34</td>
<td>30</td>
<td>IPM</td>
</tr>
<tr>
<td>4-TA</td>
<td>L-5/32&quot;</td>
<td>DC-600</td>
<td>32</td>
<td>34</td>
<td>IPM</td>
</tr>
</tbody>
</table>

**BASE METALS (QW-403)**

- **Material Spec.** SA-516  
- **Type or Grade** 70  
- **P No.** 1  
- **To P No.** 1  
- **Thickness** 3/16"  
- **Diameter** N/A  
- **Other** N/A

**FILLER METALS (QW-404)**

- **Weld Analysis A No.** 1  
- **Size of Electrode** 5/32"  
- **Filler Metal F No.** 6  
- **STA Specification** 5.17  
- **AWS Classification** EM13K  
- **Other** Lincoln 860 Flux

**POSITION (QW-405)**

- **Position of Groove** Flat  
- **Fill Progression (Uphill, Downhill)** N/A  
- **Other** N/A

**PREHEAT (QW-405)**

- **Preheat Temp.** None  
- **Terpass Temp.** 450°F  
- **Other** N/A

**POSTWELD HEAT TREATMENT (QW-407)**

- **Temperature** N/A  
- **Time** N/A  
- **Other Tested in as-welded condition**

**GAS (QW-409)**

- **Type** N/A  
- **Composition** N/A  
- **Other** N/A

**ELECTRICAL CHARACTERISTICS (QW-409)**

- **Current** AC-DC  
- **Polarity** Reverse  
- **Amps** 550-600  
- **Volts** 30-36  
- **Other** N/A

**TECHNIQUE (QW-410)**

- **Travel Speed** 18-36 IPM  
- **Arc Stringer** Stringer  
- **Oscillation** None  
- **Multipass or Single Pass (Per Side)** Multipass  
- **Single or Multiple Electrodes** Both  
- **Other** N/A  
- **1st Side**
  1. Single Arc Pass  
  2. Tandem Arc Passes  
  3. Back Gouge - 2nd Side  
  4. Tandem Arc Pass
**PROCEDURE QUALIFICATION RECORD (PQR)**

### TENSILE TEST QW-150)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Width</th>
<th>Thick</th>
<th>Area</th>
<th>Ultimate Load Lb.</th>
<th>Ultimate Unit Stress PSI</th>
<th>Character of Failure &amp; Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.502</td>
<td>.712</td>
<td>1.069</td>
<td>80,200</td>
<td>75,023</td>
<td>Plate</td>
</tr>
<tr>
<td>2.</td>
<td>1.498</td>
<td>.717</td>
<td>1.079</td>
<td>80,400</td>
<td>74,860</td>
<td>Plate</td>
</tr>
</tbody>
</table>

### GUIDED BEND TESTS (QW-160)

<table>
<thead>
<tr>
<th>Type and Figure No.</th>
<th>Results</th>
<th>Type and Figure No.</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side QW-462.2</td>
<td>4 - OK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Welder's Name**  
J. C. Shelton  
**Clock No.**  
8497  
**Stamp No.**  
Tech.  
**Test Conducted By**  
Riley-Beaird  
**Lab Test No.**  
28526

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.

Riley-Beaird Welding Engineer  
Riley-Beaird Quality Control

**Notes:**
1. See page 3 for Toughness Test (QW-170) when applicable.
2. " " 4 " Hardness Test when applicable.
3. " " 5 " Chemical Analysis when applicable.
4. " " 5 " Other (NDT, etc) when applicable.
**PROCEDURE QUALIFICATION RECORD (PQR)**

<table>
<thead>
<tr>
<th>PQR No.</th>
<th>28526-2</th>
<th>DATE 2/28/85</th>
<th>WPS No.</th>
<th>01-01-02-62</th>
<th>DATE 2/28/85</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVISION</td>
<td></td>
<td>DATE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HARDNESS TEST**

**BASE METALS (QW-403)**

Material Spec.  
SA-516-70  To  SA-516-70  Thickness 3/4"  
P No. 1  Group No. 2  To  P No. 1  Group No. 2  
Diameter  N/A  Other  Tested in as-welded condition

**Type**  
BRINELL

<table>
<thead>
<tr>
<th>Location</th>
<th>WELD</th>
<th>Location</th>
<th>HAZ</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>170</td>
<td>1.</td>
<td>174</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>170</td>
<td>2.</td>
<td>179</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>167</td>
<td>3.</td>
<td>183</td>
<td>3.</td>
</tr>
</tbody>
</table>

Welder  
J. C. Shelton  
Emp #  8497  
Symbol  Tech.

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. Test Conducted By  
Riley-Beaird Laboratory Test No. 28526

Riley-Beaird Welding Engineer  
Riley-Beaird Quality Control

Form QW-483 Rev 3/23/81 Page 4
## Welding Procedure Specification No. 01-01-03-63

**Date**: 5/28/92

**Revision No.**

**Supporting POR No.**(s): 1

**Welding Process(es):** FCAW

**Type(s):** Semi-Automatic

### JOINTS (QW-402)

- **Joint Design:** Groove and fillet
- **Backing (Yes):** X
- **Material (Type):** Base and weld
  - Metal
  - Nonfusing Metal
  - Nonmetallic
  - Other

### BASE METALS (QW-403)

- **P-No.:** 1
- **Group No.:** 1 & 2 
- **to P-No.:** 1
- **Group No.:** 1 & 2

- **Specification type and grade:** N/A
  - **to Specification type and grade:** N/A

- **Chemical Analysis and Mech. Prop.:** N/A
  - **to Chemical Analysis and Mech. Prop.:** N/A

- **Base Metal Thickness Range:** Groove 3/16" - 8" Fillet Unlimited
- **Pipe Dia. Range:** Groove ≥ 2" Fillet ≥ 1"

**Other:** After the root pass, no weld layer shall exceed 1/8" in thickness in the flat, horizontal, and overhead positions and 3/16" in the vertical position.

### FILLER METALS (QW-404)

- **Spec. No. (SFA):** 5.20
- **AWS No. (Class):** E71T-1
- **F-No.:** 6
- **A-No.:** 1
- **Size of Filler Metals:** 0.045"

- **Deposited Weld Metal Thickness Range:** Groove 3/16" - 8" Fillet Unlimited

- **Electrode-Flux (Class):** N/A
- **Flux Trade Name:** N/A
- **Consumable Insert:** N/A

**Other:** KOBE FRONTIARC-711 WIRE SHALL BE USED.
## POSITIONS (OW-405)

<table>
<thead>
<tr>
<th>Position(s) of Groove</th>
<th>1G - 6G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Progression</td>
<td>Up X Down</td>
</tr>
<tr>
<td>Position(s) of Fillet</td>
<td>1F - 5F</td>
</tr>
</tbody>
</table>

## POSTWELD HEAT TREATMENT (OW-407)

| Temperature Range     | N/A |
| Time Range            | N/A |

## PREHEAT (OW-406)

| Preheat Temp. Min. See Note (1) | 450°F |
| Interpass Temp. Max. | 150°F |
| Preheat Maintenance  | None |

### Note (1)
- Verify preheat: 3/16" ≤ T ≤ 3/4" 50°F
- Verify preheat: 3/4" ≤ T ≤ 1-1/4" 100°F
- Verify preheat: 1-1/4" ≤ T ≤ 2-1/2" 225°F
- Verify preheat: T ≥ 2-1/2" 300°F

## GAS (OW-408)

<table>
<thead>
<tr>
<th>Gas(es) (Mixture)</th>
<th>CO₂ 100%</th>
<th>Flow Rate</th>
<th>40-50 CFH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielding</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trailing</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backing</td>
<td>None</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## ELECTRICAL CHARACTERISTICS (OW-409)

<table>
<thead>
<tr>
<th>Current AC or DC</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps (Range)</td>
<td>120-300</td>
</tr>
<tr>
<td>Volts (Range)</td>
<td>20-33</td>
</tr>
</tbody>
</table>

## TECHNIQUE (OW-410)

### String or Weave Bead
- Both

### Initial and Interpass Cleaning (Brushing, Grinding, etc.)
- INITIAL: Grind area up to 1" away from weld joint to bright metal.
- INTERPASS: Chip slag

### Weld Layer(s)
- FCAW

### Filler Metal
- E71T-1

### Current
- Dia.: 0.045" DCRP
- Amp Range: 120-300
- Volts Range: 20-33
- Travel Speed Range: 4-28 IPM

### Other
- Torch angle shall be 0°-20° lagging or leading in the travel direction.

## Welding Engineer

Shannon D. Hunt Date 8-31-92
**Beaird INDUSTRIES, INC.**

**Welding Procedure Qualification Record No.** 1  
**Date** 5/29/92  
**WPS No.** 01-01-03-63

**Welding Process(es):** FCAW  
**Type(s):** Semi-Automatic

### JOINTS (OW-402)

![Diagram of Joint Design]

**WIRE FEED**

<table>
<thead>
<tr>
<th>PASS</th>
<th>AMPS</th>
<th>SPEED (IPM)</th>
<th>VOLTS</th>
<th>SPEED (IPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>200</td>
<td>303</td>
<td>25</td>
<td>9.5 - 11.6</td>
</tr>
<tr>
<td>10-21</td>
<td>200</td>
<td>303</td>
<td>25</td>
<td>8.75 - 12.0</td>
</tr>
</tbody>
</table>

**BACKGOUGED SECOND SIDE TO SOUND METAL**

**PASS AMPS SPEED (IPM) VOLTS**

- 1-9 200 303 25 9.5 - 11.6
- 10-21 200 303 25 8.75 - 12.0

**Groove Design of Test Coupon**

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

**BASE METALS (OW-403)**

<table>
<thead>
<tr>
<th>Material Spec.</th>
<th>Type or grade</th>
<th>P-No. 1 Group 2 to P-No. 2 Group 2</th>
<th>Thickness of Test Coupon</th>
<th>Diameter of Test Coupon</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-516</td>
<td>Grade 70</td>
<td></td>
<td>1-3/4&quot;</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**FILLER METALS (OW-404)**

<table>
<thead>
<tr>
<th>SFA Specification</th>
<th>AWS Classification</th>
<th>Filler Metal F-No.</th>
<th>Weld Metal Analysis A-No.</th>
<th>Size of Filler Metals</th>
<th>Deposited Weld Metal</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.20</td>
<td>E71T-1</td>
<td>6</td>
<td>1</td>
<td>0.045&quot;</td>
<td>1-3/4&quot;</td>
<td>KOBE FRONTIARC-711 WIRE WAS USED.</td>
</tr>
</tbody>
</table>

**POSITION (OW-405)**

<table>
<thead>
<tr>
<th>Position of Groove</th>
<th>Weld Progression</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>Uphill</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**PREHEAT (OW-406)**

<table>
<thead>
<tr>
<th>Preheat Temp.</th>
<th>Interpass Temp.</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>50°F Minimum</td>
<td>450°F Maximum</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**POSTWELD HEAT TREATMENT (OW-407)**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Time</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**GAS (OW-408)**

<table>
<thead>
<tr>
<th>Percent</th>
<th>Composition</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shielding</td>
<td>CO2</td>
</tr>
<tr>
<td></td>
<td>Trailing</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Backing</td>
<td>None</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS (OW-409)**

<table>
<thead>
<tr>
<th>Current</th>
<th>DC Polarity</th>
<th>Amps</th>
<th>Volts</th>
<th>Tungsten Electrode Size</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reverse</td>
<td>200</td>
<td>25</td>
<td>N/A</td>
<td>Maximum heat input was 34,286 J/in.</td>
</tr>
</tbody>
</table>

**TECHNIQUE (OW-410)**

<table>
<thead>
<tr>
<th>Travel Speed</th>
<th>String or Weave Bead</th>
<th>Oscillation</th>
<th>Multipass or Single Pass</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.75 - 12.0 IPM</td>
<td>String</td>
<td>N/A</td>
<td>Multipass (per side)</td>
<td>Single</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maximum bead width was 1/2&quot;</td>
</tr>
</tbody>
</table>

**REV 3/12/90 PAGE 1**
## TENSILE TEST (OW-150)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Width (in)</th>
<th>Thickness (in)</th>
<th>Area (in²)</th>
<th>Ultimate Total Load (lb)</th>
<th>Ultimate Unit Stress (psi)</th>
<th>Type of Failure &amp; Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>0.749</td>
<td>0.555</td>
<td>0.4157</td>
<td>31,000</td>
<td>79,384</td>
<td>Ductile - Plate</td>
</tr>
<tr>
<td>1-2</td>
<td>0.748</td>
<td>0.630</td>
<td>0.4712</td>
<td>37,100</td>
<td>78,735</td>
<td>Ductile - Plate</td>
</tr>
<tr>
<td>2-1</td>
<td>0.745</td>
<td>0.740</td>
<td>0.5513</td>
<td>43,500</td>
<td>78,904</td>
<td>Ductile - Plate</td>
</tr>
<tr>
<td>2-2</td>
<td>0.748</td>
<td>0.690</td>
<td>0.516</td>
<td>40,800</td>
<td>79,069</td>
<td>Ductile - Plate</td>
</tr>
</tbody>
</table>

## GUIDED-BEND TESTS (OW-160)

4 Satisfactory

## TOUGHNESS TEST (OW-170)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Notch Location</th>
<th>Notch Type</th>
<th>Test Temp</th>
<th>Impact Values</th>
<th>Lateral Exp.</th>
<th>Drop Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weld</td>
<td>V</td>
<td>-20°F</td>
<td>64 Ft. Lbs.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>V</td>
<td></td>
<td>67</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>V</td>
<td></td>
<td>70</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>HAZ</td>
<td>V</td>
<td></td>
<td>84</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>V</td>
<td></td>
<td>84</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>V</td>
<td></td>
<td>85</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>1/4&quot;t</td>
<td>V</td>
<td></td>
<td>68</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>V</td>
<td></td>
<td>62</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>V</td>
<td></td>
<td>66</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

## FILLET WELD TEST (OW-180)

Result - Satisfactory: Yes No

Macro Results N/A

Penetration into Parent Metal: Yes No

## HARDNESS TEST

<table>
<thead>
<tr>
<th>Location</th>
<th>Brinell</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld</td>
<td>1. 187</td>
<td>2. 187</td>
</tr>
<tr>
<td>HAZ</td>
<td>1. 192</td>
<td>2. 187</td>
</tr>
<tr>
<td>Plate</td>
<td>1. 174</td>
<td>2. 170</td>
</tr>
</tbody>
</table>

## OTHER TESTS

Type of Test N/A

Deposit Analysis All Weld Metal Analysis: C- .045, Mn- 1.33, Si-.51

Welder's Name Shannon Hunt

Test Conducted by: Beaird Industries, Inc.

Beaird Industries certifies that the statements in this record are correct and that test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Date 8/31/92 By Dean K. McKee

FORM OW-4B3 REV. 3/12/90 PAGE 2
HYDROSTATIC TEST CERTIFICATION

DATE 8/11/93

ORDER NUMBER 158585-01 ITEM NUMBER Gaseous Helium Tank

SERIAL NUMBER 1 DRAWING NUMBER Sheet-1

TEST PRESSURES:

INITIAL 439 PSI

FINAL 275

BEAIRD INDUSTRIES INSPECTOR

AUTHORIZED INSPECTOR
RILEY-BEAIRD
LEAK TESTING REPORT

S. O. No. 153585-01-1  CUSTOMER KOTE PRO CORP

(1) ITEM IDENTIFICATION GASEOUS HELIUM TANK

(2) SHELL TESTING V  WELD TESTING V  TUBE TESTING

(3) TEST METHOD ASTM E-498 METHOD A

(4) TEST INSTRUMENT VARIAN 933-41

(5) LEAK CALIB. STD. 4.9 x 10^-8 std cc sec helium

(6) TEST PRESSURE VACUUM less 50 % GAS CONCENTRATION 100% Microns

(7) GAGE(S) MANUFACTURER HASTINGS MODEL TV-4-7

RANGE ATM TO LESS THAN 10 Micron I.D. NO. 543

(8) TEMPERATURE MEASURING DEVICE

(9) SKETCH SHOWING METHOD OR TECHNIQUE ASTM E-498

(10) TEST PROCEDURE (NUMBER) & REV. NO. ASTM E-498 METHOD A

DATE OF TEST 9-30-93  OPERATOR DM Walz
