Muon Design Note #26

SUBSYSTEM: CCM CVM X Cryoplant

TITLE: Heat Exchanger #5 (EX-5)

AUTHOR: R. Sanders RA
M. Stone MES

DATE: May 20, 1986

Objective

The purpose of this design note is to present pressure vessel calculations done by the manufacturer (CDM) and pressure ratings of the adjoining piping components, and to demonstrate the adequacy of the vessel relief valves.

Description

Heat exchanger #5 is a counterflow heat exchanger employing internal lateral finned tubing. The tubing is totally contained within a 304 stainless steel pressure vessel composed of 6" Sch 10 pipe and pipe caps. The pressure vessel has two identical 22 foot sections which are shown in drawing 2753.700-ME-193163. The piping connecting these sections is not considered part of the pressure vessel. According to the ASME Boiler and Pressure Vessel Code, Division I, Section VIII, Paragraph U-1(c)(5), piping components used for distributing flow are not pressure vessels.

The heat exchanger will be used in cooling CVM from 300 to 80 K. It will be operated 1 or 2 weeks once or twice a year. Helium gas is employed in both sides of the heat exchanger. The heat exchanger will use the return flow from CVM to precool high pressure warm helium from the compressor.

Analysis

The pressure vessel is considered to be the outer 6" Sch 10 stainless steel pipe and pipe caps. The pressure vessel code calculations done by CDM (the manufacturer) for a MWAP of 350 psig are presented in Appendix A. Calculations for the end flanges, although not necessary for code calculations, are in Appendix B and the calculation showing the adequacy of the pressure vessel relief is in Appendix C. The pressure vessel was pressure tested by CDM to 441 psig.

Using procedures in ANSI B31.3, the allowable internal pressure for the pipe adjoining the heat exchanger is 1468 psig for the 2" 304 SS Sch 10S pipe and 2652 psig for the 1" 304 SS Sch 10S pipe. The tube manufacturer, Noranda, gives for the double fin tubing a pressure rating for the internal tube of 300 psig and a pressure rating for the external tube of 400 psig.

The external low pressure piping between MV-511-H and MV-526-H and all high pressure piping will be pressure tested to 385 psig and have an MWAP of 350 psig. The tubes on the low pressure side of the heat exchanger will be pressurized both internally and externally at the same time thus permitting a high pressure test of the piping between MV-511-H and MV-526-H. The high pressure piping is protected by the same relief valves as described in Appendix C.During operations the low pressure piping is protected by SV-204-H (see D/N 10) having a capacity of 110 g/sec 60°F helium at its set pressure of 50 psig. When MV-511-H is closed the low pressure piping is protected by trapped volume relief SV-510-H with a capacity of 107 SCFM (305 SCFM of He) air at its set pressure of 65 psig.

In order to allow the heat exchanger to be vacuum jacketed, if this need were to ever arise, the heat exchanger was leak checked with a helium mass spectrometer by the manufacturer. However the piping connections between the two sections of the heat exchanger were only bubble tested.

Conclusion

The pressure vessel, EX-5, conforms to the standards of the Boiler Pressure Vessel Code, Division I, Section VIII. The piping associated with EX-5 conforms to ANSI B31.3 piping code.

Reviewed By

R L Schmitt 6-11-86

Appendix A

These are calculations as supplied by
CDM for heat exchanger EX-5

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

RECEIVED
FERMILAB
CONTRACTS
86 25 AM 10:35

February 20, 1986

Fermi National Accelerator Lab.
P.O. Box 500
Batavia, Ill. 60510

Dick Mau,
Enclosed is one copy of the Code Calculations for the Heat Exchangers, on your P.O. 909740. If there are any questions please call.

Thankyou
Richard Jaeger
Richard Jaeger

DESIGN ANALYSIS

Client: Fermi Lab — Job No. A840
Subject: He-He Heat Exchanger — Date: 2-19-86 — By: RN
Per ASME SECT VIII, DIV 1, 1983 Ed. — Checked — By
Location: Summer Addendum — Revised — By

Fermi DWG No. 2753.700-ME-193163
Design Press = 350 PSID internal
= 15 PSID external

Design Temp = 100°F

I) Shell: 6 Sch 10 Pipe, A312 304 S.S.
W.T. = .134 in.

A) Internal Press: UG-27(c)(1)(i)
$P = SEt / R + 0.6t$
$= (16000)(1)(.134) / 3.139 + 0.6(.134)$
$= 657.79$ PSI — Acceptable

B) External Press: UG-28(c)
$L = 235.625$ $L/D_o = 35.57$ $D_o/t = 49.44$
$A = .00047$ $B = 6550$

$P_a = 4B / 3(D_o/t)$
$= 4(6550) / 3(49.44)$
$= 176.65$ PSI — Acceptable

II) Heads: 6 Sch 10 B.W. Pipe Cap
A403, WP304 S.S., WP-S .134 THK.

A) Internal Press: UG-32(d)
$P = 2SEt / D + 0.2t$
$= 2(18800)(1)(.134) / 5.750 + 0.2(.134)$
$= 872.18$ PSI — Acceptable

DESIGN ANALYSIS

Client	Fermi Lab	Job No.	A762
Subject	He-He Heat Exchanger	Date 2-19-86	By RJ
		Checked	By
Location		Revised	By

B) External Press: UG-33 (d)

$A = 0.125/(R_o/t)$
$= 0.125/(5.963/.134)$
$= .0028$

$R_o = K_o D_o$
$= (.9)(6.625)$
$= 5.963$

$D_o/2h_o$
$6.625/2(1.656)$
$2.00 \rightarrow K_o = 0.90$

$B = 12300$

$P_a = B/(R_o/t)$
$= 12300/(5.963/.134)$
$= 276.40$ PSI Acceptable

III) Penetrations
2 ea, 1 SCH 10 Pipe } Per UG-36(c)(3)(a) no
2 ea, 2 SCH 10 Pipe } additional Reinforcement Req'd.

DESIGN ANALYSIS

Client: Fermi Lab
Job No. A840
Subject: He-He Heat Exchanger
Date: 2-19-86 By: R.K.
Checked By
Revised By
Location

IV) Nozzles

A) 1 SCH 10 Pipe, A312 304 S.S.,
W.T. = .109"

internal P = SEt / R + 0.6t
= 16000(1)(.109) / .549 + 0.6(.109)
= 2838.54 PSI Acceptable

B) 2 SCH 10 Pipe, A312 304 S.S.
W.T. = .109"

internal P = SEt / R + 0.6t
= 16000(1)(.109) / 1.079 + 0.6(.109)
= 1523.94 PSI Acceptable

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

March 3, 1986

Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, Ill. 60510

Dick Mau,

Enclosed find one copy of the flange stress calculations requested by Peggy.

Also this letter is to confirm in writing our telephone conversation on 2-27-86. I am planning to use Fermi Lab's drawings to fabricate the Muon Heat Exchanger #5. If there are any changes during fabrication, I will redline one set of drawings and send them to Fermi Lab.

If you have any questions don"t hesitate to call.

Thankyou

Richard Jaeger

Richard Jaeger

'86 MAR 5 P4:34
RECEIVED
FERMILAB
CONTRACTS

DESIGN ANALYSIS

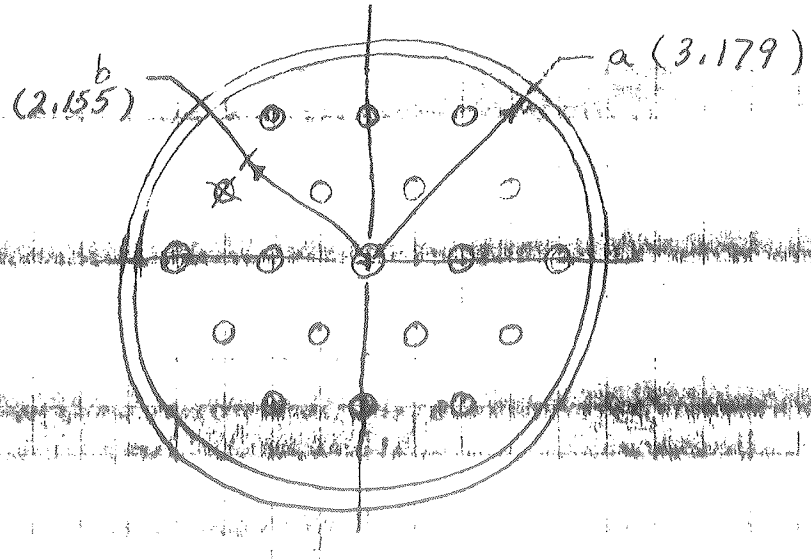
Client: Fermi lab — Job No. A840

Subject: He - He Heat Exchanger — Date: 2-27-86 — By: RJ

Checked — By

Location — Revised — By

Stress in outer shell (6 sch 10 pipe) & DF Tubing brought about by pressure on end flanges. (Roark 5th Ed., Table 24, Case 2h, inner and outer edge fixed, uniform load over entire plate)



$r_o = b$

$b/a = 2.155 / 3.179 = .678$

$W = 350 [(3.179 \times 2)^2 (.785 4) - (2.155 \times 2^2)(.785 4)]$
$= 6005.81$ lb.

$K_{mra} = -.0120$

$w = 6005.81 / 2(3.179)\pi$
$= 300.68$ lb./in

$M_{ra} = K_{mra}\, w a$
$= -.0120 (300.68)(3.179)$
$= -11.47$

$\sigma_{ra} = 6 M_{ra} / t^2$
$= 6(-11.470)/.625^2$
$= -176.18$ PSI

DESIGN ANALYSIS

Client: Fermi Lab
Job No. A840
Subject: He - He Heat Exchanger
Date: 2-27-86 By: RN
Checked By
Location
Revised By

A) Stress in Shell from Sect VIII, UG-27(c)(1)(1)

$P = SEt / R + 0.6t$

$SEt = P(R + 0.6t)$

$S = P(R + 0.6t) / Et$

$= (350)[3.179 + 0.6(.134)] / 1(.134)$

$= 8513.36$ PSI

B) Total Stress in shell $= S + \sigma$

$= 8513.36 + 176.18$

$= 8689.54$ PSI

16000 PSI allowable ⇒ Acceptable

Appendix B

Purpose:

To calculate the required thickness of end flanges.

Assumptions:

Use rules of paragraph UG-34 (p. 101) of Section VIII, Division I.

Calculations:

$t = d \quad (CP/SE)^{1/2}$

t = minimum required thickness (in)
d = diameter of head (in)
P = design pressure
S = maximum allowable stress (18800 plate)
E = joint efficiency (= 1 since solid plate)
C = attachment factor = 0.33

d = inside diameter of shell
= 6.357 in (6" Sch 10)

$$t = 6.357 \sqrt{\frac{(0.33)(350)}{(18800)}}$$

= 0.498 in.

The holes are far enough apart so that no reinforcement is required, i.e. centers > 2 x average diameter. Also all holes are only 1/2" in diameter.

Conclusion

The 0.625" thickness of the tube sheet inside heat exchanger #5 is sufficiently thick to prevent rupture. This tube sheet is not considered part of the pressure vessel.

Appendix C

Sizing of Relief Valve for Heat Exchanger 5

Heat exchanger #5 can be pressurized only by the compressors in Lab A, a trapped volume warming up or a fire. As for the compressors, their capacity is relieved at Lab A and the relief setting is 50 psig lower than the MWAP of the heat exchanger and therefore overpressure by the compressor is not a concern. Each compressor has a kickback valve capable of bypassing the full compressor flow back to suction. This valve should keep compressor discharge at or below 300 psia for the Mycom and 250 psia for the Norwalk. In addition each compressor has a relief valve back to suction which for the Mycom is set for 300 psig and for the Norwalk is set for 275 psig. Suction has three relief valves each sized to handle the flow of at least two compressors.

A fire condition is by far more severe than the simple case of a trapped gas volume warming up. The heat exchanger is surrounded by foam insulation with a minimum thickness of three inches. In the case of fire the aluminum skin encasing the insulation would remain intact but the insulation would eventually decompose.

The CGA Code S-1.3 section 5.3.2 states "For uninsulated containers for non-liquefied gases the minimum required flow capacity of the pressure relief device shall be calculated by using the formula:

$$Q_a = 0.029\ W_c$$

where

Q_a = flow capacity in CFM of free air
W_c = water capacity of container in pounds

Ignore the internal parts of the heat exchanger. The volume of the 44 feet of 6" schedule 10S pipe that comprises its shell is 9.7 ft^3. As a result

$$W_c = 62.4\ lb/ft^3 \times 9.7\ ft^3 = 605.2\ lb$$

and

$$Q_a = (0.029)(605.2) = 17\ SCFM\ of\ air$$

which is the required capacity of the relief valve. The relief valve is a code stamped Anderson and Greenwood model 89-S44-2 with a 0.014 in^2 orifice and the valve coefficient of discharge K = 0.9.

The capacity of the relief valve is given by

$$V = \frac{(6.32)\ A\ C\ K\ P_1}{\sqrt{(MTZ)}}$$

From Anderson and Greenwood catalog 1800, page 6, a copy of which is attached. Using the substitutions

$A = 0.014\ in^2$
$K = 0.9$
$C = 356$ (air)
$P_1 = 320 + 15 = 335$ psia
$M = 29$
$T = 520$ R
$Z = 1$

The capacity is then

$V = 77.3$ SCFM air

which exceeds the required capacity.

The relief for the low pressure piping is the aforementioned trapped volume relief SV-510-H. This is a Circle Seal with a set pressure of 65 psig and a capacity of 64.3 SCFM of air at 1660 R.

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 Robinson Mfg. Company 2210 So. Delaware St. Denver, Colorado 80223 (Name and address of manufacturer)

2. Manufactured for C.D.M. Machining & Fab. 8570 Valentia St. Commerce City, Colorado 80022 (Name and address of purchaser)

3. Location of installation Unknown (Name and address)

4. Type Horiz. (Horiz. or vert., tank) | I - 7 (Mfg'r serial No.) | NA (CRN) | 2753-700 ME-193163 (Drawing No.) | NA (Nat'l. Bd. No.) | 1986 (Year built)

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 1983 (Year) to Summer 1985 (Addenda (Date)) NA (Code Case Nos.) Heat Exchanger (Special Service per UG-120(d))

6. Shell: SA 312 304 SS (Mat'l. (Spec. No., Grade)) | .134 (Nom. Thk. (in.)) | NA (Corr. Allow. (in.)) | 6" (Diam. I.D. (ft. & in.)) | 20' 6" (Length (overall) (ft. & in.))

7. Seams: NA (Long. (Welded, Dbl., Sgl., Lap, Butt)) | NA (R.T. (Spot or Full)) | 1 (Eff. (%)) | NA (H.T. Temp. (°F)) | NA (Time (hr.)) | Single Butt (Girth (Welded, Dbl., Sgl., Lap, Butt)) | NA (R.T. (Spot, Partial, or Full)) | 1 (No. of Courses)

8. Heads: (a) Matl. SA 240 304 SS (Spec. No., Grade) (b) Matl. SA 240 304SS (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	End	.134	NA	NA	NA	2:1	NA	NA	NA	Concave
(b)	End	.134	NA	NA	NA	2:1	NA	NA	NA	Concave

If removable, bolts used (describe other fastenings) NA (Mat'l., Spec. No., Gr., Size, No.)

9. MAWP INT 350 EXT 15 psi at max. temp. 100 °F
Min. temp. (when less than -20°F) NA °F. ~~hydro.~~, pneu., ~~combin.~~ test pressure 440 psi.

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam or Size	Type	Matl	Nom. Thk	Reinforcement Matl	How Attached	Location
Outlet	1	2"	Pipe	SA 312	.109	None	Weld	End
Inlet	1	2"	Elbo	SA 312	.109	None	Weld	End
Outlet	1	1"	Pipe	SA 312	.109	None	Weld	End Side
Inlet	1	1"	Pipe	SA 312	.109	None	Weld	End Side

11. Supports: Skirt None (Yes or no) Lugs NA (No.) Legs NA (No.) Other NA (Describe) Attached NA (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: NA (Name of part, item number, Mfg'r. name and identifying stamp)

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. 12110 expires May 6, 19 86

Date JUN 10 1986 Co. name Robinson Mfg. Company (Manufacturer) Signed Jesse M. Robinson (Representative)

CERTIFICATE OF SHOP INSPECTION

Vessel constructed by Robinson Mfg. Company at 2210 So. Delaware St. Denver, Co. 80223

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of Colo. and employed by HSBI & I Co. have inspected the component described in this Manufacturer's Data Report on JUN 10 1986, To _____, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date JUN 10 1986 Signed H. M. Burkhardt (Authorized Inspector) Commissions COLO/354 (Nat'l Board (incl. endorsements), State, Prov. and No.)

(12/82) This form (E00117) may be obtained from the Order Dept., ASME, 345 E. 47th St., New York, N.Y. 10017

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 Robinson Mfg. Company 2210 So. Delaware St. Denver, Colorado 80223 (Name and address of manufacturer)

2. Manufactured for C.D.M. Machining & Fab. 8570 Valentia St. Commerce City, Colorado 80022 (Name and address of purchaser)

3. Location of installation Unknown (Name and address)

4. Type Horiz. (Horiz. or vert., tank) I - 8 (Mfgr's serial No.) NA (CRN) 2753-700 ME-193163 (Drawing No.) NA (Nat'l. Bd. No.) 1986 (Year built)

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 1983 (Year)

to Summer 1985 (Addenda (Date)) NA (Code Case Nos.) Heat Exchanger (Special Service per UG-120(d))

6. Shell: SA 312 304 SS (Matl. (Spec. No., Grade)) .134 (Nom. Thk. (in.)) NA (Corr. Allow. (in.)) 6" (Diam. I.D. (ft. & in.)) 20' 6" (Length (overall) (ft. & in.))

7. Seams: NA (Long. (Welded, Dbl., Engl., Lap, Butt)) NA (R.T. (Spot or Full)) 1 (Eff. (%)) NA (H.T. Temp. (°F)) NA (Time (hr)) Single Butt (Girth (Welded, Dbl., Engl., Lap, Butt)) NA (R.T. (Spot, Partial, or Full)) 1 (No. of Courses)

8. Heads: (a) Matl. SA 240 304 SS (Spec. No., Grade) (b) Matl. SA 240 304SS (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	End	.134	NA	NA	NA	2:1	NA	NA	NA	Concave
(b)	End	.134	NA	NA	NA	2:1	NA	NA	NA	Concave

If removable, bolts used (describe other fastenings) NA (Matl., Spec. No., Gr., Size, No.)

9. MAWP INT 350 EXT 15 psi at max. temp. 100 °F
Min. temp. (when less than -20°F) NA °F. ~~XXXXX~~, pneu., ~~XXXXX~~, test pressure 440 psi.

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam. or Size	Type	Matl.	Nom. Thk.	Reinforcement Matl.	How Attached	Location
Outlet	1	2"	Pipe	SA 312	.109	None	Weld	End
Inlet	1	2"	Elbo	SA 312	.109	None	Weld	End
Outlet	1	1"	Pipe	SA 312	.109	None	Weld	End Side
Inlet	1	1"	Pipe	SA 312	.109	None	Weld	End Side

11. Supports: Skirt None (Yes or no) Lugs NA (No.) Legs NA (No.) Other NA (Describe) Attached NA (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: NA (Name of part, item number, Mfgr's. name and identifying stamp)

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. 12110 expires May 6, 19 86

Date JUN 10 1986 Co. name Robinson Mfg. Company (Manufacturer) Signed Jesse M. Robinson (Representative)

CERTIFICATE OF SHOP INSPECTION

Vessel constructed by Robinson Mfg. Company at 2210 So. Delaware St. Denver, Co. 8022

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of Colo. and employed by HSBI & I Co. have inspected the component described in this Manufacturer's Data Report on JUN 10 1986, 19 ____, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date JUN 10 1986 Signed H. M. Burkhardt (Authorized Inspector) Commissions COLO/354 (Nat'l Board (incl. endorsements), State, Prov. and No.)

(12/82)

This form (E00117) may be obtained from the Order Dept., ASME, 345 E. 47th St., New York, N.Y. 1001

RT. 2. BOX 14, HWY. 301 N.
WILDWOOD, FLORIDA 32785

40-3744-J VS

SOLD TO:

Marmon/Keystone Corp.
10700 Marmon Drive
Lemont, Ill. 60439

BUYER ORDER NO. 60-S-2422

MILL ORDER NO. S4-1542

DATE SHIPPED 6-8-84

ITEM	QUANTITY	DESCRIPTION	SPECIFICATIONS & PROCEDURES
1	2017' 2"	2" Sch 10 NPS x 21' c/l Type 304 FF/A&P (2.375 x .109)	ASTM A312-82, ASME SA312 welded DuPont SW41N, no end caps
~~2~~	~~19' 2"~~	~~16" Sch 40S NPS x 20' r/l~~ ~~Type 304 AW/A&P (16.000 x .375)~~	ASTM A312-82, ASME SA312 welded

CHEMICAL ANALYSIS

ITEM	HEAT NO.	PLATE HEAT ANAL	PLATE PROD. ANAL	WELD ANAL	C	Mn	P	S	Si	Cr	Ni	Mo	N_2	Ti
1	231231				.059	1.42	.022	.017	.50	18.23	8.29			
	~~240067~~				~~.052~~	~~1.38~~	~~.018~~	~~.016~~	~~.60~~	~~18.14~~	~~8.32~~			
2	~~20833~~				~~.040~~	~~1.46~~	~~.030~~	~~.028~~	~~.58~~	~~18.46~~	~~8.25~~			

MECHANICAL TESTS

ITEM	HEAT NO.	PLATE	PIPE	YIELD PSI	TENSILE PSI	EL IN 2"	HARD	HYDRO T.P.	FLARE	FLNG	FLAT	REV FLAT	EDDY TEST	GUIDED BEND FACE / ROOT
1	231231			42,667	94,267	50	RB80	1400	ok	ok	ok	ok	ok	
	~~240067~~			~~40,237~~	~~88,787~~	~~60~~	~~RB78~~	~~1400~~	~~ok~~	~~ok~~	~~ok~~	~~ok~~	~~ok~~	
2	~~20833~~			~~50,627~~	~~91,222~~	~~58~~	~~RB86~~	~~600~~			~~ok~~			

This report, to which this stamp is affixed, is a copy of the original supplier's test report. There is indicated, not only the complete identification of this material but also a record of tests made in accordance with specification requirements. If several items are shown in this report, [illegible] checked (✓) as being pertinent. We certify herewith that the material supplied to you is completely identifiable by this document.

Cust. P.O. 9013
M/KC Order No. 40-04872
Date 3/3/86
MARMON/KEYSTONE CORPORATION
Q.C.
THE QUALITY CONTROL DEPARTMENT

CERTIFICATION/REMARKS

HEAT TREATMENT

PO. 9013
S.O. A840
RW
3-4-86

Q. C. REVIEWED
[illegible] 3/6/86

CERTIFY THAT THE CHEMICAL ANALYSIS AND PHYSICAL TEST RESULTS APPLYING ON THE ABOVE ORDER NUMBER ARE CORRECT AND TRUE TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

V. Forrester
Q. A. Clerk

ARMCO INC.
V. Forrester
QUALITY CONTROL DEPARTMENT

Sworn and subscribed to before me this _____ day of _____, 19 _____

TB1726M 5/83

--- PACKING SLIP ---

ALLOY PIPING PRODUCTS, INC.
8505 NORTH LOOP EAST
HOUSTON, TEXAS 77013
(713) 672-7311

INVOICE DATE	ORDER NUMBER	MEMO	INVOICE NUMBER
2/25/86	4667 H		14532

SOLD TO
STAINLESS TUBULAR PRODUCTS
1825 W. CASPIEU PLACE
WAREHOUSE # 3
ENGLEWOOD, CO 80110

SHIPPED TO
C D M MACHINING
4950 NIAGARA ST
COMMERCE CITY CO 80022

QUANTITY SHIPPED	DESCRIPTION		
	*** MTR W/SHIPMT & INV. ****		
	TAG #: 9014	4	WH
4	6" S/10S A403 WP 304L S CAP HT# 4C1417		
2	2" S/10S A403 WP 304L W LR 90 ELBOW HT# 24CZ084	2	/

SHIP VIA	TYPE FREIGHT CHARGES
UPS	PREPAID-CHARGE

20th
none

P.O. 9014
S.O. A840
RW
3-3-86

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

S.O. A840 (1-8) Specification ASME SECT V, ART 10, APP IV (CND-005)

Part No. 2753700-ME-193163 Test COLD SHOCK & HELIUM LEAK TEST

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak) ÷ (Response-Bckgnd) = MDL								
ELBOW END -1	.02	3.5×10^{-8}	$.98 \times 1$	$.06 \times 1$	7.6×10^{-10}	5-6-86 9:15	.42	.40	DPT
STRAIGHT END -1	.02	3.5×10^{-8}	1.04×1	$.10 \times 1$	7.7×10^{-10}	5-6-86 11:38	.76	.68	DPT
BOTH TESTS INDICATED NO DETECTABLE LEAK									
AFTER COLD SHOCK									
			DPT						
			5-6-86						

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

S.O. A840 (1-8) Specification ASME SECT. IX, ART. 10, APP III (CND-005)

Part No. 2753700-ME-193163 Test COLD SHOCK & HELIUM LEAK TEST.

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak) ÷ (Response-Bckgnd) = MDL								
UNIT 1 TUBE 1	.02	3.5×10^{-8}	.96 x1	.08 x1	7.9×10^{-10}	5-29-86 3:15	.80	.74	[illegible]
UNIT 1 TUBE 2	.02	3.5×10^{-8}	.96 x1	.08 x1	7.9×10^{-10}	5-29-86 3:50	.84	.66	[illegible]

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-8) Specification ASME SECT V, ART. 10 APP. IV (CND005)

Part No. 2753.700-ME-193163 Test Helium Leak Test

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date / Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak	) ÷	(Response-	Bckgnd) =	MDL				
1/2 o.d. Cu. Tubes	.02	3.5×10^{-8}	1.5	.02	4.7×10^{-10}	6-5-86 / 9:45	.04	.02	[illegible]

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-8) Specification ASME SECT V, ART. 10 APP. IV (CND005)

Part No. 2753.700-ME-193163 Test Helium Leak Test

ITEM TESTED	DETERMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak	) ÷	(Response-	Bckgnd) =	MDL				
1/2 O.D. Cu. Tubes	.02	3.5×10^{-8}	1.5	.02	4.7×10^{-10}	6-5-86 9:45	.04	.02	[illegible]

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

S.O. A840 Specification ASME SECT. V, ARTICLE 10 APPENDIX I.

Part No. 2753.700-ME-19363 Test Bubble Test
SN. A840-(1-8)

Press. Reading	Vac. Press. Reading	Date	Time	Perf. By
440 PSIG		6-3-86	7:25	RJJ

Test Results No apparent leaks or deformation.

Signed By [illegible] Date 6-3-86

CDM MACHINING & FABRICATING CORP.
4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

S.O. A840 (1-7) Specification ASME SECT V, ART 10, APP IV (CND-005)

Part No. 2153.700-ME-193163 Test COLD SHOCK & HELIUM LEAK TEST.

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak) ÷ (Response-Bckgnd) = MDL								
ELBOW END -2	.02	3.5×10^{-8}	$.96 \times 1$	$.06 \times 1$	7.8×10^{-10}	5-6-86 1:36	.86	.70	DM
STRAIGHT END -2	.02	3.5×10^{-8}	$.88 \times 1$	$.02 \times 1$	8.1×10^{-10}	5-6-86 3:20	.50	.48	DM
BOTH TESTS INDICATED NO DETECTABLE LEAK AFTER COLD SHOCK.									
			DM 5-6-86						

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-7) Specification ASME SECT V, ART. 10 APP. IV (CND005)

Part No. 2753.700-ME-193163 Test Helium Leak Test

ITEM TESTED	DETERMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak	) ÷	(Response-	Bckgnd) =	MDL				
1/2 O.D. Cu. Tubes	.02	3.5×10^{-8}	1.5	.02	4.7×10^{-10}	6-5-86 13:19	.04	.02	[illegible]

CDM MACHINING & FABRICATING CORP.

4950 Niagara Street • COMMERCE CITY, COLORADO 80022 • Phone: 287-0187

S.O. A840 Specification ASME SECT V, ARTICLE 10 APPENDIX I

Part No. 2753.700-ME-193163 Test BUBBLE TEST

S.N. A840-(1-7)

Press. Reading	Vac. Press. Reading	Date	Time	Perf. By
440 PSIG		6-4-86	3:30	RW

Test Results No apparent leaks or deformation

Signed By Richard Jeyes Date 6-4-86

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (8-7) Specification ASME SECT V, ART. 10, APP. III (CND005)

Part No. 2753.700-ME-193163 Test COLD SHOCK & HELIUM LEAK TEST

ITEM TESTED	DETERMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak	) ÷	(Response-	Bckgnd) =	MDL				
350 PSI SIDE FLANGE	.02	3.5×10^{-8}	2.3	.04	3.10×10^{-10}	11-6-81 12:40	0.2	0.19	[illegible]
10 PSI SIDE FLANGE	.02	3.5×10^{-8}	2.3	.04	3.10×10^{-10}	11-6-81 15:05	0.2	0.19	[illegible]

CDM MACHINING & FABRICATING CORP.

8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 Specification ASME SECT VIII, UG-100

Part No. 2753, 700-ME-193163 SN A840 (1-7) (Repair) Test Pneumatic Test

Press. Reading	Vac. Press. Reading	Date	Time	Perf. By
440 PSIG		7-16-86	1:50	RW
440 PSIG		7-16-86	2:15	RW

Test Results No Apparent Leaks or Deformation

Signed By Richard Wagner Date 7-16-86

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 Specification ASME SECT. VIII, UG-100

Part No. 2753.700-ME-193163 Test Pneumatic Test
S.N A840 (1-8) (Repair)

Press. Reading	Vac. Press. Reading	Date	Time	Perf. By
440 PSIG		7-16-86	2:46	RW
440 PSIG		7-16-86	3:01	RW

Test Results No apparent leaks or Deformation

Signed By [signature] Date 7-16-86

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-8) Repair Specification ASME SECT V, ART. 10, APP IV (CND005)

Part No. 2253.700-ME-193163 Test COLD SHOCK & Helium Leak Check

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak	) ÷	(Response-	Bckgnd)	= MDL				
1/2 O.D. Cu. Tubes	.02	3.5×10^{-8}	1.3	.02	5.5×10^{-10}	7-14-86 2100	.75	.75	[illegible]

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-8) Repair Specification ASME SECT V, ART 10, APP III (CND005)

ITEM TESTED	(.02 X Leak	) ÷ (Response-Background) = MDL				Time	Probe	Probe	Perf. By
350 PSI SIDE FLANGE	.02	3.5×10^{-8}	1.6	.04	4.5×10^{-10}	7-14-86 7:00	.6	.6	
10 PSI SIDE FLANGE	.02	3.5×10^{-8}	1.6	.04	4.5×10^{-10}	7-14-86 11:18	.75	.70	

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-7) Repair Specification ASME SECT V, ART 10, APP III (CND005)

Part No. 2753.700-ME-193163 Test COLD SHOCK & Helium Leak Test

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak)	÷	(Response	-Bckgnd)	= MDL				
350 PSI SIDE FLANGE	.02	3.5×10^{-8}	1.6	.04	4.5×10^{-10}	7-18-85 8:15	.05	.05	[illegible]
10 PSI SIDE FLANGE	.02	3.5×10^{-8}	1.6	.04	4.5×10^{-10}	7-18-85 13:00	.07	.065	[illegible]

CDM MACHINING & FABRICATING CORP.
8570 VALENTIA STREET • COMMERCE CITY, COLORADO 80022 • Phone: 289-5678

S.O. A840 (1-7) Repair Specification ASME SECT V, ART. 10, APP IV (CND005)

Part No. 2253.700-ME-193163 Test COLD SHOCK & Helium Leak Check

ITEM TESTED	DETEPMINATION OF MINIMUM DETECTABLE LEAK					Date Time	Meter Reading Before Helium Probe	Meter Reading With Helium Probe	Perf. By
	Calib. (.02 X Leak)	÷	(Response-	Bckgnd)	= MDL				
1/2 O.D. Cu. Tubes	.02	3.5×10^{-8}	1.3	.02	5.5×10^{-10}	7-17-86 11:10	.65	1000	Flum-

PHYSICAL TEST REPORT

Metals & Services Co.

330 W. NORTH AVENUE ADDISON, IL 60101
(312) 627-2900

CUSTOMER ADDRESS

FERMI NATIONAL ACCELERATOR LAB.
P. O. BOX 500
BATAVIA, IL. 60510

ATTN: MR. ED FAHY

Date	Our Order No.	Customer Order Number
3-7-86		SHOWN BELOW

Number	Quantity	Size and Type
	5 Plts.	5/8" x 48" x 48" T-304 HRAP 2192# (YOUR P.O. #75977 11-30-83)

Heat No.	Mill	C.	MN.	P.	S.	Si.	CU.	Ni.	CHR.	MO.	SE.	Other Elements Sym.	Other Elem Sym.
33285		MILL	REPORT	ATTACHED									

Hardness	Hardenability	Yield Strength	Tensile Strength	Elongation % in 2"	Reduction in Area %	Specification Number

Other

Number	Quantity	Size and Type
	20 Plts.	1/4" x 48" x 48" T-304 HRAP 3572# (YOUR P.O. #19128 9-25-84)

Heat No.	Mill	C.	MN.	P.	S.	Si.	CU.	Ni.	CHR.	MO.	SE.	Other Elements Sym.	Other Elem Sym.
43084		MILL	REPORT	ATTACHED									

Hardness	Hardenability	Yield Strength	Tensile Strength	Elongation % in 2"	Reduction in Area %	Specification Number

Other

Number	Quantity	Size and Type

Heat No.	Mill	C.	MN.	P.	S.	Si.	CU.	Ni.	CHR.	MO.	SE.	Other Elements Sym.	Other Eleme Sym.

Hardness	Hardenability	Yield Strength	Tensile Strength	Elongation % in 2"	Reduction in Area %	Specification Number

Other

Number	Quantity	Size and Type

Heat No.	Mill	C.	MN.	P.	S.	Si.	CU.	Ni.	CHR.	MO.	SE.	Other Elements Sym.	Other Elem Sym.

Hardness	Hardenability	Yield Strength	Tensile Strength	Elongation % in 2"	Reduction in Area %	Specification Number

Other

STATE OF ILLINOIS
COUNTY OF DUPAGE

Sworn to and subscribed before me, A Notary Public in and for DuPage County, this _____ day of _____, 19____

Commission Expires _____

NOTARY PUBLIC

I HEREBY CERTIFY THE ABOVE FIGURES ARE CORRECT AS SHOWN IN THE RECORDS OF THE COMPANY
METALS & SERVICES COMPANY

BY: Paul Gross
METALLURGICAL DEPARTMENT

S.O. A840
Dwg 2753.700-MC-193165
" " " -193166

COMPLETE STEEL SERVICE

STEEL
an LTV company

Jones & Laughlin Steel Corporation
SPECIALTY STEELS DIVISION
BOX 20 LOUISVILLE, OHIO 44641

TEST REPORT

CODE	MILL ORDER NO.	CUSTOMER PART NO.	DESCRIPTION	SHIPPER DATE	SHIPPER NO.
30	60704		304 HR PLATE	09/20/82	B90160 PAGE 1 OF 1

END USE

.2500 NOM IN	48.000 IN	240.000 IN
6.35 MM	1219.20 MM	6096.00 MM

MATERIALS PRODUCED TO AND CONFORM WITH: ASTMA 240

P.O. NO. 3432

SHIP TO:
METALS & SERVICE CO.
FRONT ENTRANCE
2900 S. 25TH AVENUE
BROADVIEW, ILL 60153

SOLD/SEND TO:
METALS & SERVICE CO.
2900 S. 25TH AVENUE
BROADVIEW, ILLINOIS 60153

HEAT NO.	LIFT NO.	COIL NO.	PIECES	NET WEIGHT LBS	NET WEIGHT KG
43084	A00514	236675	5	4465	2025
43084	A00515	236675	5	4465	2025
43084	A00516	236675	4	3572	1620
43084	A00517	236675	4	3572	1620

HEAT NO.	C	MN	P	S	SI	Cr	Ni	Mo	Cu	Co	Cb	N2	Al
L 43084	.050	1.59	.016	.013	0.54	18.45	08.30	0.15	.16	.13		.080	

COIL/LIFT NO.	SIDE	HARDNESS	YIELD PSI	YIELD MPA	TENSILE PSI	TENSILE MPA	ELONG. %	OLSEN	BEND TEST	ANGLE	RA% FACTOR
236675		RB 88	43,300	299	86,200	594	55		1XT	180	

S.O. A840
Dwg 2753.700-MC-193166

COIL/LIFT NO.	GRAIN SIZE	MIN SOL ANN TEMP °F	MIN SOL ANN TEMP °C	CLEANLINESS ASTME-45 PLATE 1	CARBIDE	CORROSION	HUEY TEST IN/MO	HUEY TEST MM/MO
236675		CORR						

I HEREBY CERTIFY THAT ALL ANALYSIS FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

E. A. PARKER CRU

STATE OF COUNTY OF

SUBSCRIBED AND SWORN TO BEFORE ME

DAY OF 19

NOTARY PUBLIC

MY COMM. EXPIRES

B 34343 (4-82)

Division of A. Johnson & Co., Inc.

Certificate of Analysis and Tests

SOLD TO

SHIP TO

METALS & SERVICES
330 WEST NORTH AVENUE
ADDISON, IL 60101

YOUR ORDER NO. 4734

USC ORDER NO: 3218
DATE SHIPPED:

TYPE 304 HRAP 5/8 x 96 x 274 ASTM A-240 & ASME SA-240

PHYSICAL TEST PLATES AND TEST PCS. SOLUTION ANNEALED 1900 DEG. F MIN. THEN WATER QUENCHED OR RAPIDLY COOLED BY AIR

HEAT NUMBER	HARDNESS RB	PIECES	YIELD STRENGTH LBS. PER SQ. IN.	TENSILE STRENGTH LBS. PER SQ. IN.	ELONG % IN 2"	BEND	RED. AREA %	INTERGRANULAR CORROSION	GRAIN SIZE			REMARKS:
33285	83	1	43800	84300	62.5	ok	64.0	ok				

CHEMICAL COMPOSITION (WHEN CALLED FOR BY SPECIFICATIONS)

HEAT NO.	C	Mn	P	S	Si	Cr	Ni	Co	Cu	Mo	N	Cb/Ta	Ti	V	W
33285.	.041	1.92	.028	.012	.51	18.19	8.08	.23	.28	.35	.99				

S.O. 840
Dwg 2753:700-MC-193165

Ingersoll Johnson Steel Co.

Dorothy M. Cazula

7 307L 1.8120 1.0

CRUCIBLE INC-TRENT TUBE DIVISION

EAST TROY, WISCONSIN 53120

Trent Weld Stainless Steel Tubing

12

831-07320 40-04488-T

CUSTOMER ORDER NO.	CPO. DATE	RATING	RC	ENTRY DATE	SHIP	MARKS	MILL ORDER NO.
60-S-7189	12/04	K	8	12/04/4	P	SEE BELOW	W 517-17769-4-

MARLEMA 1 25180 21 MARLEMA 25180 9 4 **

SOLD TO: MARMON/KEYSTONE CORP
10700 MARMON DR.
LEMONT, IL IL 60439

SHIP TO: MARMON/KEYSTONE CORP
10700 MARMON DR.
LEMONT, IL IL 60439

SPECIAL INSTRUCTIONS

F.O.B. S/P I/A
TERMS: 30-1%-10

01315 109 M00200000 02 101 1.417 LB/FT SOURCE STK-
1 10S 20 - FT RML
FULL FINISHED ANNEALED & PICKLED
TRENTWELD STAINLESS PIPE
SW41M ASTM A312 ASME SA312 MILP1144D
304L

600 FT
850 LBS
PCS
QUANTITY ORDERED

~~12/04/84~~ WANTED
12/07/84 PROMISED

**

This report, to which this stamp is affixed, is a copy of the original supplier's test report. There is indicated, not only the complete identification of this material but also a record of tests made in accordance with specification requirements. If several items are shown in this report, those items which are shipped to you are checked (✓) as being pertinent. We certify herewith that the material supplied to you is completely identifiable by this document.

Cust. P.O. 9013

M/KC Order No. 40-04872

Date 3/3/86

MARMON/KEYSTONE CORPORATION

Signed D.W.

FOR THE QUALITY CONTROL DEPARTMENT

MFG. BY: TRENT TUBE DIVISION, East Troy, Wisconsin

517-17769-4

MFG. ON ORDER NO.

MADE FROM HEAT NO. 70786

DESCRIPTION

TEST REPORT

(See Above)
SOURCE=3438

NONDESTRUCTIVE TESTING

- ☐ AIR UNDERWATER TESTED AT ____ PSI—OK
- ☒ HYDROSTATIC TESTED AT 2100 PSI—OK
- ☒ EDDY CURRENT TESTED—OK
- ☐ ULTRASONIC TESTED—OK
- ☐ 100% X-RAY OF WELD—OK

CHEMICAL ANALYSIS

C	MN	P	S	SI	NI	CR	MO	TI	CU	CO	N_2	AL			
.024	1.64	.008	.019	.45	8.93	18.48									

MECHANICAL TESTS / CORROSION TESTS

TENSILE STRENGTH PSI	YIELD STRENGTH PSI	ELONG. 2"	HARDNESS	FLANGE	FLAT	FLARE	REV. FLAT	REV. BEND	GRAIN SIZE	$CuSO_4$	HNO_3-HF	HNO_3
80,861	43,540	60%	RB 81/82	OK	OK	OK	OK			OK		

s this order approved to ship YES

WE HEREBY CERTIFY THIS REPORT TO BE TRUE AND CORRECT ACCORDING TO RECORDS IN POSSESSION OF THIS CORPORATION.

TRENT TUBE DIVISION
COLT INDUSTRIES

REVIEWED 12-11-87

SIGNED: _____

SWORN TO AND SUBSCRIBED BEFORE ME

P.O. 9013
S.O. A840

THIS _____ DAY OF _____ 19 _____

RW 3-4-86

MY COMMISSION EXPIRES _____ NOTARY

ARMCO INC.
STAINLESS PIPE & TUBE
RT 2. BOX 1A. HWY. 301 N
WILDWOOD. FLORIDA 32785

CERTIFIED MATERIAL TEST REPORT

SOLD TO
Marmon Keystone Corporation
10700 Marmon Drive
Lemont, Ill. 60439

BUYER ORDER NO. 60 S 6300

MILL ORDER NO. S52547

DATE SHIPPED 12-9-85

ITEM	QUANTITY	DESCRIPTION	SPECIFICATIONS & PROCEDURES
7	520' 6"	6" Sch 10s NPS x 17/24' r/l Type 304 FF/A&P 6.625X134	ASTM A312-83, ASME SA312, welded duPont SW42M, no end caps

CHEMICAL ANALYSIS

ITEM	HEAT NO.	PLATE HEAT ANAL.	PLATE PROD. ANAL.	WELD ANAL.	C	Mn	P	S	Si	Cr	Ni	Mo	N_2	Ti	Cb/Ta
7	~~350758~~				~~.062~~	~~1.41~~	~~.026~~	~~.016~~	~~.53~~	~~18.15~~	~~8.30~~				
	450659				.061	1.41	.028	.017	.55	18.41	8.31				

MECHANICAL TESTS

ITEM	HEAT NO.	PLATE	PIPE	YIELD PSI	TENSILE PSI	EL IN 2"	HARD	HYDRO T.P.	FLARE	FLNG	FLAT	REV. FLAT	EDDY TEST	GUIDED BENDS FACE / ROOT / SIDE
7	~~350758~~			~~37,799~~	~~86,890~~	~~55~~	~~RB77~~	~~650~~	~~ok~~	~~ok~~	~~ok~~			
	450659			34,802	86,432	60	RB78	650	ok	ok	ok			

CERTIFICATION/REMARKS

P.O. 9013
S.O. A840
RW 3-4-86

12-16-85

HEAT TREATMENT

This report, to which this stamp is affixed, is a copy of the original supplier's test report. There is indicated not only the complete identification of this material but also a record of tests made in accordance with specification requirements. If several items are shown in this report, those items which are shipped to you are checked (✓) as being pertinent. We certify herewith that the material supplied to you is completely identifiable by this document.

Cust. P.O. 9013
M/KC Order No. 40-04721
Date 3/3/86
MARMON/KEYSTONE CORPORATION
Signed R.W.
FOR THE QUALITY CONTROL DEPARTMENT

WE CERTIFY THAT THE CHEMICAL ANALYSIS AND PHYSICAL TEST RESULTS APPLYING ON THE ABOVE ORDER NUMBER ARE CORRECT AND TRUE TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

Y. Forrester
Q. A. Clerk

ARMCO INC.
Y. Forrester
QUALITY CONTROL DEPARTMENT

Sworn and subscribed to before me this _____ day of _____, 19 _____

TR1755M 5/83

— ALLOY PIPING PRODUCTS, INC. —

** MILL TEST REPORT **

TO:
STAINLESS TUBULAR PRODUCTS
1825 W. CASPIEU PLACE
WAREHOUSE # 3
ENGLEWOOD, CO 80110

YOUR ORDER NUMBER
4667 H
OUR INVOICE NUMBER
14532

HEAT NO.	ITEM DESCRIPTION
4C1417	4 - 6" S/10S A403 WP 304L S CAP
24CZ084	2 - 2" S/10S A403 WP 304L W LR 90 ELBOW

HEAT NO.	MATERIAL	SPEC.	C	MN	P	S	SI	CR
4C1417	A240	A403	.023	1.32	.033	.004	.67	18.18
24CZ084	A312	A403	.018	1.14	.033	.002	.44	18.48

HEAT NO.	NI	MO	CU	CO	N	CB/TA	EE	TI	MO
4C1417	10.11				.05				
24CZ084	10.16								

HEAT NO.	YIELD POINT	TENSILE STRENGTH	ELONGATION	REDUCTION	BRINELL/ROCKWELL
4C1417	40,233	80,319	59%		B76
24CZ084	45,500	88,200	57%		

P.O. 9014
S.O. A840
RW
3-3-86

WE HEREBY CERTIFY THAT TO THE BEST OF OUR KNOWLEDGE AND BELIEF, THE MATERIALS LISTED ABOVE HAVE BEEN MANUFACTURED IN ACCORDANCE WITH, AND MEET THE ABOVE APPLICABLE SPECIFICATIONS AND GRADES.

AUTHORIZED SIGNATURE DA