PHILADELPHIA ELECTRIC COMPANY

2301 MARKET STREET

P.O. BOX 8699

PHILADELPHIA, PA. 19101

(215) 841-4502

JOHN S. KEMPER
VICE-PRESIDENT
ENGINEERING AND RESEARCH

SEP 06 1984

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Docket Nos.: 50-352
50-353

Subject: Limerick Generating Station, Units 1 and 2
Information for Materials Engineering Branch (MTEB) Regarding SER Confirmatory Issue No. 22 (Fracture Toughness of Containment Pressure Boundary).

Reference: (1) Letter, J. S. Kemper (PECO) to A. Schwencer (NRC), dated May 25, 1984.

Attachments: (1) Compliance with General Design Criterion (GDC) 51.
(2) Certified Material Test Reports (CMTR).
(3) Stress Intensity Factor KI Calculation for Assumed Flaws in 24-inch Feedwater Check Valve Body Castings.

File: GOVT 1-1 (NRC)

Dear Mr. Schwencer:

Attachment (1) is submitted to confirm compliance of Limerick Generating Station Units 1 and 2 with the requirements of GDC 51, "Fracture Prevention of Containment Pressure Boundary". Attachment (2) provides the CMTRs for the containment pressure boundary components evaluated in Attachment (1). Attachment (3) is a fracture mechanics calculation summary which provides, in part, the results of the fracture mechanics evaluations performed at the 1180 psi maximum pressure during the 40°F lowest temperature operation experienced by the feedwater check valves when acting as a containment pressure boundary. This summary also includes information on the size and location of the assumed flaw, the stress direction, and a description of how the fracture mechanics analysis was performed. Reference (1) previously documented the fracture toughness capability of the Limerick Class 1 feedwater isolation check valves.

Sincerely,

J W Gallagher
for
J S Kemper

JHA/gra/08318401

cc: See Attached Service List

A001
1/1

cc: Judge Lawrence Brenner (w/o enclosure)
Judge Peter A. Morris (w/o enclosure)
Judge Richard F. Cole (w/o enclosure)
Judge Christine N. Kohl (w/o enclosure)
Judge Gary J. Edles (w/o enclosure)
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Atomic Safety & Licensing Appeal Board (w/o enclosure)
Atomic Safety & Licensing Board Panel (w/o enclosure)
Docket & Service Section (w/o enclosure)
Mr. James Wiggins (w/o enclosure)
Mr. Timothy R. S. Campbell (w/o enclosure)

Attachment (1)
Limerick Generating Station, Units 1 and 2
Compliance with General Design Criterion (GDC) 51

From June 21 to June 24, 1983, a compliance review was held at the offices of Bechtel and General Electric by Mr. J. Halapatz (NRC/MTEB) to assess compliance with GDC-51. The reviewer examined drawings, certified material test reports (Attachment 2), and heat treatment records of the reactor containment pressure boundary ferritic materials for compliance with GDC-51. The limiting components were identified. The metallurgical characterization of these materials, when correlated with the data presented in NUREG-0577 and the Summer 1977 Addenda of the ASME Code Section III, provides the technical basis for the staff's evaluation of the compliance with Code Class 2 requirements of these materials.

The following are the conclusions of the MTEB reviewer concerning permissible lowest service metal temperature (PLSMT).

1. Main Steam Isolation Valve (F028A typ., S/N 1-683 typ.)

Body: SA 216 WCB by Quaker Alloy
Normalized: 4-$\frac{1}{4}$" min design thk: NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ + 1.3σ) TNDT of +57°F. NUREG-0577 Fig. B2 would infer (because material is normalized) a TNDT in the population at or below the $\overline{NDT}$ of +35°F (Table 4.4). S'77 Addenda CL-2 rules, assuming a TNDT of +35°F, would assign a PLSMT of +85°F to the material.

Cover: SA 105 Gr II: Heat treated by Cann & Saul:
Normalized: 4-$\frac{1}{4}$" min design thk: NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ + 1.3σ) TNDT of -5°F. S'77 Addenda CL-2 rules assign a PLSMT of +45°F.

Poppet: SA 105 Gr II: Heat Treated by Cann & Saul:
Normalized: 5-7/8" min design thk: As with the cover, a ($\overline{NDT}$ +1.3σ) TNDT is assumed to be -5°F: S'77 Addenda CL-2 rules assign a PLSMT of +55°F.

Bolting: 2"SA 193 Gr-B7 and SA 194 Gr-2H:
NUREG-0577 Table 4.6 categorizes these materials as having the least susceptibility to brittle fracture.

2. Main Steam Flued Head (Process pipe is integral within flued head)

SA 105 Gr II and SA 350 Gr. LF2: Quenched and tempered: 5 in. axial thickness: NUREG-0577 Table 4.4 assigns a TNDT of -28°F to normalized material. The materials are both categorized as C-MN, quenched and tempered, and, therefore, could be assumed to have a TNDT below -28°F. Assuming a TNDT of -28°F, S'77 Addenda CL-2 rules assign a PLSMT of +27°F.

3. Feedwater Flued Head (Process pipe is integral within flued head)

SA 350 Gr. LF2: 8" Axial Thk: Normalized: NUREG-0577 Table 3.2 categorize material as C-MN comparable to SA-105. NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ +1.3σ) TNDT of -5° to normalized SA 350 LF2: S'77 Addenda CL-2 rules assign a PLSMT of +67°F.

4. Feedwater Isolation Valve (F074A typ.)

Body: SA 352 Gr LCB: Quaker Alloy: Normalized (interrupted quench): 6 hrs @1630/1650°F; Furnace Cool 1440/1460°F, for 2 hrs; 1420-1430°F, for 40 min; SA 352 Gr. LCB is categorized as similar to SA 216.

NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ +1.3σ) TNDT of +57°F. NUREG-0577 Fig. B-2, however, would assign a TNDT in the population below $\overline{NDT}$ of +35°F (Table 4.4). Based on assuming TNDT of +35°F, S'77 Addenda CL-2 rules would assign a PLSMT of +80°F.

Cover: SA 350 Gr LF2 (by Cann & Saul): Normalized and tempered: 5" min design thk: SA 350 Gr LF2 is categorized as C-MN (per NUREG-0577 Table 3.2) comparable to SA 105: NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ +1.3σ) TNDT of -5°F: S'77 Addenda CL-2 rules assign a PLSMT of +50°F.

Disc: SA 352 Gr LCB: Quaker Alloy: 3.75" min Thk. Normalized: NUREG-0577 Table 4.4 assigns a ($\overline{NDT}$ +1.3σ) TNDT of +57°F. However, S'77 Addenda CL-2 rules based on Fig. B2 data for normalized material assign a PLSMT of +85°F, assuming a TNDT +35°F (Table 4.4).

Bolting: SA 193 B7: SA 194 2H: NUREG-0577 Table 4.6 categorizes these materials as having the least susceptability to brittle fracture.

5. Flued Heads - General

Flued heads identified are limiting materials, SA 105 (X-8 penetration) was specified but SA 350 Gr LF-2 was applied. Normalized, quenched and tempered: 3" max Thk: NUREG-0577 Table 4.4 would assume a TNDT of -28°F: S'77 Addenda CL-2 rules assign a PLSMT of +2°F.

6. Penetrations

All penetration sleeves apply per Bechtel Spec. 8031-C-2 Rev. 10: SA 516 Gr 60 or Gr 70, Normalized; or SA 333 Gr 1: SA 537 Gr B is identified, but not applied.

PEN X. 9A/B: (Limiting)	SA 516 Gr 60: 1-½" Thk: S'77 Addenda CL-2 rules assign a TNDT of 0°F and a PLSMT of +30°F.
X-11: (Limiting)	SA 333 Gr 6: 0.812" Thk: NUREG-0577 Table 4.4 assigns a (NDT +1.3σ) TNDT of 67°F: S'77 Addenda CL-2 rules assign a PLSMT of 97°F. However, the material was Cv tested at -50°F to criteria consistent with S'77 Addenda CL-2 rules given the design LMST of 65°F.
X-15 Typ: Pipe Caps	SA 420 WPL 1: Applying SA 516 Gr 70 and A350 LF1: Limiting Thk is 1.156" WL x 18": Cv tested at -50°F to Cv criteria consistent with S'77 Addenda CL-2 rules given the design LMST of 65°F.

7. Equipment Hatch/Personnel Airlocks

69-3 (Typ. Limiting)	SA 516 Gr 60: 3" Thk: quenched and tempered. Door and barrel reinforcement is identified as limiting. S'77 Addenda CL-2 rules assign a TNDT -10°F and a PLSMT of +30°F.
MK-70-7: (Limiting)	SA 516 Gr 60: 1" thk door assembly. Normalized: S'77 Addenda CL-2 rules assign a TNDT of 0°F and a PLSMT of +30°F.
162-1	SA 516 Gr 70: 3" thk. Quenched and tempered.

The above data was compared by the applicant with system design data to determine if the lowest service metal temperature (LMST) for any system was below the PLSMT for the equipment in that system. The LMSTs are identified in Table 1.

The ambient air temperature was assumed to equal the LSMT for those identified components that are part of the primary containment. The ambient air temperature was conservatively calculated by postulating failure of the Reactor Enclosure Air Supply System and all heating under those conditions cited in GDC-51. The reactor enclosure was calculated to maintain ambient temperature above 65°F.

Fluid temperatures were assumed to equal the LMST for those identified components in intimate contact with the fluid. One mode of the feedwater system results in a LMST of 42°F due to HPCI injection from the condensate storage tank. For this mode, four items associated with the feedwater system appeared as potential problems because this LMST was below the NRC-calculated PLSMT provided earlier. These four items are the feedwater flued head and the cover, disk, and body of the outboard feedwater isolation check valve.

Subsequent to the June 1983 review, the applicant reviewed these components with the following dispositions:

- Feedwater Flued Head - the actual thickness of the flued head is 8". This is considerably larger than the minimum design thickness of less than 2.5" and yields a PLMST of 25°F.

- Feedwater Valve Cover - the actual thickness of the valve cover is 5". This is considerably larger than the minimum design thickness of 2.75" and yields a PLMST of 30°F.

- Feedwater Valve Disk - Under the limiting condition, HPCI is injecting into the vessel and, therefore, the disc does not have a pressure retaining function in this case.

- Feedwater Valve Body - The evaluation of PLMST and a fracture mechanics analysis has been provided in a report transmitted by letter, J. S. Kemper to A. Schwencer, dated May 25, 1984. The report calculates a PLMST of 30°F.

The results of these evaluations are summarized in Table 1.

Conclusion

The materials of the reactor containment pressure boundary under the conditions of operation, maintenance testing, and a postulated accident will not fail in brittle fracture and the probability of a rapidly propagating fracture is minimized.

DEFINITIONS

General Design Criteria 51

The reactor containment pressure boundary shall be designed with sufficient margin to assure that under operating, maintenance, testing and postulated accident conditions (1), its ferritic materials behave in a non-brittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the containment boundary material during operation, maintenance, testing and postulated accident conditions, and the uncertainties in determining (1) material properties, (2) residual, steady state and transient stresses, and (3) size of flaws.

Reactor Containment Pressure Boundary

The reactor containment pressure boundary as addressed in the NRC licensing review process, consists of those ferritic steel parts of the reactor containment system which sustain loading and provide a pressure boundary in the performance of the containment function under the operating, maintenance, testing and postulated accident conditions. These include equipment hatches, personnel airlocks, drywell head, containment penetration sleeves, process pipes, end closure caps, flued heads and penetrating-piping systems connecting penetration process pipes extending to and including the system outboard isolation valves.

Lowest Service Metal Temperature (LSMT)

The lowest service metal temperature (LSMT) is defined as the minimum temperature of the fluid or metal whenever the component must perform its pressure retaining function under operating, maintenance, testing, and postulated accident conditions.

Permissible Lowest Service Metal Temperature (PLSMT)

The permissible lowest service metal temperature (PLSMT) as defined by the ASME Code Section III NC-2311, is the sum of the temperature (T_{NDT}) and the value of A which is equal to or less than (LSMT - T_{NDT}) as shown in Figure NC-2311(A)-1 corresponding to the thickness of the material. To insure fracture toughness, the PLSMT of the limiting ferritic steel components of the reactor containment pressure boundary must be less than or equal to the LSMT under operating, maintenance, testing and postulated accident conditions.

SUMMARY
TABLE 1

Limiting Item*	Part	MTL	Thickness (in) Min. Req. Thk	Thickness (in) Actual Thk	PLSMT* (°F) (Using Min. Req.Thk)	Limiting Condition	LMST (°F)	Remarks
Main Steam								
Flued Hd.	X-7A(Typ)	SA350 Gr. LF2		5.0 (Axial)	27°F	Maint. & Test	120°F	The reactor, MSIV's, flued head, and piping water hydrotested at 120°F.
MSIV	F028(Typ)							
Body		SA216WCB		4.25	85°F	"	"	
Cover		SA105 Gr II		4.25	45°F	"	"	
Poppet		SA105 Gr II		5.88	55°F	"	"	
Feedwater								PLSMT based upon material thickness required to perform its pressure retaining function.
Flued Hd.	X-9A/B(Typ)	SA350 Gr LF2	<2.5	8.00 (Axial)	25°F	Postulated Accident	42°F	
Isolation Valve	F074A(Typ)							
Body#		SA352 Gr LCB	1.18	2.31	30°F	"	"	
Cover		SA350 Gr LF2	2.75	5.00	30°F	"	"	
Disc****		SA352 Gr LCB	2.78	3.75	NA	NA	NA	
Flued Heads (Gen)	X-8(Typ)	SA350 Gr LF2 SA105 Gr II		3.00	2°F	Postulated Accident	65°F	
Sleeves								
Feedwater***	X-9A/B(Typ)	SA516 Gr. 60		1.50 (wall)	30°F	"	"	
Steam to HPCI	Pen X-11	SA333 Gr. 6		0.81	**65°F	"	"	
Spare Pen & Pipe Caps	X-15(Typ)	SA420 WPL1		1.16	**65°F	"	"	
Equip. Hatch	69-3 Door/barrel Assy.	SA516 Gr 60		3.00	30°F	Maint. & Testing	65°F	Postulated loss of reactor enclosure air supply and heating system
	70-7 (Door Assy)	SA516 Gr 60		1.00	30°F	"	"	
Personnel Air Locks	162-1	SA516 Gr 70		3.00	30°F	"	"	

NOTES: * Defined by the NRC.
** Use Lowest Metal Service Temp. (LMST)
*** Categorized by the NRC as a Sleeve.
**** Disc does not have a pressure retaining function under limiting condition.
# For evaluation of PLSMT see report submitted by letter, J. S. Kemper (PECo) to A. Schwencer (NRC), dated 5/25/84.

T-55/6(8/84)

ATTACHMENT #2: Index for Attached CMTRs (Sh 1/2)

Limiting Item - Part		Mtl Heat No	
Main Steam Penetrations	X-7A	44736 - 8	{Flued Head (Typ.) Heat No: 2L257-1}
	7B	- 6	
	7C	- 6	
	7D	- 8	
Feedwater Penetration	X-9A	B3596	(flued heads: Heat No: K-5073)
	X-9B		
Penetration (Gen)	X-8	68328	(flued head heat No. is 326N077)
	X-11	N31420	
	X-15	X5996	
Equip Hatch	69-3	66B094	
	70-7	67A756	
Airlock	162-1	C8676	
Feedwater Isolation Valve	1F074A/B		
Body		F6137/F6152	
Cover		213643/213643	
Disc		F6589/F6589	

INDEX FOR ATTACHED CMTRs (Sh 2/2)

LIMITING ITEM — PART	MATERIAL HEAT NO.
MAIN STEAM ISOLATION VALVE — 1F028A (TYP.)	
BODY	8816
COVER	219222
POPPET	219727

Penetration X-7A
7B
7C
7D

Heat No: U4736-8
-6
-6
-8

GO 837

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT # 60 UNIT # 1 Q-G-F 1141-1

Piece-Mark	Serial No.	CTR REF. NO.	Material Heat No.	Matl. Type
(1)			312-A ~ INSERT ASS'Y	
(4) [illegible]	-1-	211	B3666	1 1
(1) 313-2	—	131	[illegible]2431	A36 3
(2) [illegible]	-2-	80	U4736	8 1
(3) 313-4	—	131	[illegible]2431	A36 3
(2) 313-5	—	131	516C2431	A36 3
(1) 313-6	—	131	[illegible]2431	A36 3
(1) 313-7	—	374	9059	A36 3
(15) 313-8	—	114	[illegible]2545	A36 3
(5) 313-9	—	114	[illegible]	A36 3
(2) 314-2	-2-	80	U4736	8 1
(2) 315-1	-1-	96	U4736	6 1
(16) 314-12	—	53	748232	A36 3
(8) 314-3	—	53	748232	A36 3
(16) 314-4	—	53	748232	A36 3
(4) [illegible]	—	53	748232	A36 3
(2) [illegible]	—	53	748232	A36 3
(2) [illegible]	—	53	748232	A36 3
(2) [illegible]	—	53	748232	A36 3
(3) [illegible]	—	53	748232	A36 3
(2) 314-10	—	53	748232	A36 3
(4) 314-11	—	—	[illegible]	A36 3
(2) 315-2	—	53	748232	A36 3
(2) 315-3	—	53	748232	A36 3
(2) 315-4	—	53	748232	A36 3
(2) 315-5	—	53	748232	A36 3
(2) 315-6	—	53	748232	A36 3
(2) 315-7	—	53	748232	A36 3
(2) 316-1	-1-	128	479C2711	A36 3
(2) 316-2	-1-	128	479C2711	A36 3
(4) 316-7	-1-	85	723419	A36 3
(4) 76-7	-1-	128	479C2711	A36 3
(12) 76-7	—	85	723419	A36 3

Piece-Mark	Serial No.	CTR REF. NO.	Material Heat No.	Matl. Type
			4 ~ COMPLETE ANCHORAGE ASS'Y 76-AB	
(4) 76-7	—	90	68B423	A36 3
(16) 76-10	—	85	723419	A36 3
(4) 76-12	—	85	723182	A36 3
(2) 316-3	-1-	116	6616579	A36 3
(2) 316-4	-1-	116	6616579	A36 3
(2) 316-5	-1-	116	6616579	A36 3
(2) 316-6	-1-	116	6616579	A36 3
(2) 315-2	-1-	96	U4736	6 1
(1) [illegible]				

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
~~SPEC. 8091-C-2~~
CBI 70-7198

Data taken from applicable CBI records.
CBI Shop QA [illegible] Date 3-1-75

Revisions: By / Chkd / Date 10005

Reviewed (for material covered by code):
Authorized Inspector [illegible] Date 4-7-75

Contract No. 70-7198 J

No. 60 Sh 1 of 1

PURCHASER: 08
Chicago Bridge & Iron Co.
6 Pur. Dept.

LUKENS STEEL COMPANY
COATESVILLE, PA. 19320
TEST CERTIFICATE

DATE: 6-3-71
CONSIGNEE:
FILE NO 1540-03-06

MILL ORDER NO.	CUSTOMER P.O.	
50018-3	70-7198U-23	RG 6171 LK

SPECIFICATIONS:
SA-516 Gr. 60 CB & I MS-603B Rev. 0 DTD 3/9/70 Sect. 111 Winter 68 Addenda CB & I GP3 516 Rev. 4 DTD 2/25/70

BEND TEST O.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B		Grain Size
U4736	14	1.02	012	028		29									7 - 8

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

Affirmed and subscribed before me
this ____ day of JUN 3 1971
Phillip A. Romandini Jr.
Notary Public
My Commission Expires April 1, 1972

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN 8"	% R.A.	BHN	IMPACTS Long. V-Notch -30°F.			Fracture Appearance % Shear	DESCRIPTION
U4736	8	505	709	29			63 -	56 -	63 -	50-50-50	1-280 x 129-3/4 x 1"
							Lateral Expansion in Inches				
							.054	.058	.056		
40030 "	7	477	713	28			66 -	58 -	55 -	50-50-50	1-322 x 129-3/4 x 1"
							Lateral Expansion in Inches				
							.047	.050	.059		

RAM 6-10-71

Plates and tests heated to 1625°F. ±25°F., held 1/2 hr. per inch min. and air cooled.

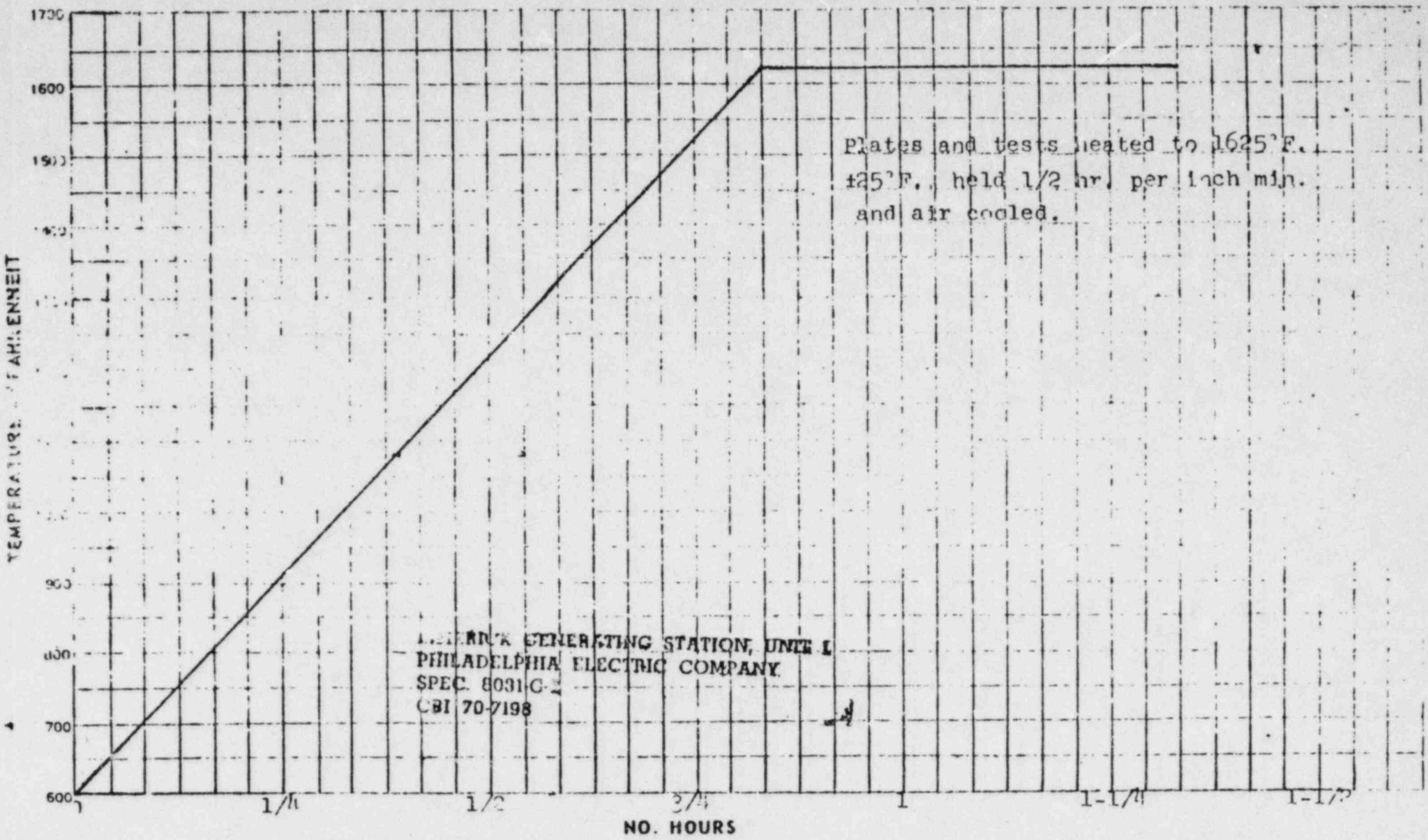
We hereby certify that the above material has been manufactured according to SA-516 Gr. 60 CB & I MS-603B Rev. 0 DTD 3/9/70 Sect. 111 Winter 68 Addenda CB & I GP3 516 Rev. 4 DTD 2/25/70 and that we have complied with all the requirements of these specifications.

We hereby certify the above figures are correct as contained in the records of the Lukens Steel Company. 6-7-71 SUPERVISOR TESTING

08

LUKENS STEEL COMPANY

COATESVILLE PA.



Order # 50018-3 Contract _____ Furnace 200' Date 5-9-71

Heat No. U4736-7
" -8

Original Charts are available for customer verification

H. Jr. Klin 80

8030

MAIN STEAM PENETRATION X-7A

FLUED HEAD (TYP.)

HEAT NO. 2L2574

NATIONAL FORGE COMPANY

TEST CERTIFICATION Limerick Flued Head

CUSTOMER: The M. W. Kellogg Company

NATIONAL FORGE CO. ORDER: 60-4875

CUSTOMER ORDER NO.: N-8774-11

SPECIFICATION: ASME-SA 350-LF2, ES-11 and ES-151, Addendum "A" G.E. Spec. 21-A-1556 & 21-A-9416 and ASME Code, Section III, NE2310 and NE2321

ITEM-SERIAL NO.	DESCRIPTION:
02-001	42" OD Flued Head Fittings
N42	Drawing 131-C-7525-2, Rev. 2, Part No. 2-EE
MARK: Item 15	

ITEM-SERIAL	HEAT NO.	C.	Mn.	P.	S.	Si.	Ni.	Cr.	Mo.	V.
02-001	2L2574	.23	1.03	.014	.014	.23				.04

TEST	ULTIMATE TENSILE STRENGTH (P.S.I.)	YIELD PT (P.S.I.)	% ELONGATION	% REDUCTION OF AREA	% Shear	Charpy IMPACT (FT. LBS.) @ 0°F	Lat. Exp.
02-001	84,250	72,000	32.0	72.3	59%	109.0	.078
					57%	95.0	.070
					63%	113.0	.081

QUENCHED @ 1580°F for 6 hrs. in water
TEMPERED @ 1220°F for 6 hrs.
GRAIN SIZE 8-9
FREE OF MERCURY CONTAMINATION
ROUND FLUTED INGOT MOLD
TENSILE SPEC. 505
TESTED LONGITUDINAL
GAGE LENGTH 2"

M. W. KELLOGG CO.
M.T.R. APP'D
DATE 4/9/73

HEAT TREAT PROCEDURE HT-60-A-4875-0A 10/27/72
IMPACT PROCEDURE LT-60-A-4875-0A, Rev. A 1/22/

State of Pennsylvania
Warren County } ss:

Before me, a Notary Public in and for above County, personally appeared N. C. Baxter, Jr.

of the National Forge Company, who being duly Sworn according to Law, deposes and says that the above Report is a true and correct copy of tests as contained in the records of the Company.

N. C. Baxter Jr.

Subscribed and Sworn to this 14th day of March 19 73

Kathleen J. Hawley

My Commission expires

Embossed Hereon Is My
Irvine, Warren County, Pennsylvania, Notary P...
My Comm...

APED QC
JFK
4/12/73

FW Flued Head
Penetration X-9A/B

Heat No. B3596

S.I. #21

See Standard 607-3-7 for instructions for using this form.

CBI

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT # 81 UNIT #1 C 2 F. 10-1

Piece-Mark	Serial No.	CTR Ref. No.	Material Heat No.	Matl. Type
(1)			335-A ~ INSERT ASS'Y	
(1) [redacted]	-1-	[redacted]	B3611	1
(9) 245-4	—	114	518C2540 A36	3
(2) 336-1	-1-	163	B3594	1
	-2-	163	B3594	
(2) [redacted]	-1-	[redacted]	B3594	1
	-2-	[redacted]	B3594	
(4) 336-3	—	49	74B232 A36	3
(6) 336-4	—	49	74B232 A36	3
(8) 336-5	—	49	74B232 A36	3
(2) [redacted]	—	[redacted]	74B232 A36	3
(2) [redacted]	—	[redacted]	74B232 A36	3
(2) [redacted]	—	[redacted]	74B232 A36	3
(2) [redacted]	—	[redacted]	74B232 A36	3
(2) [redacted]	—	[redacted]	74B232 A36	3
(2) 336-11	—	49	74B232 A36	3
(2) 336-12	—	—	L2x2x3/16 A36	3
(1) 245-2A	—	131	516C2431 A36	3
(1) 245-3A	—	131	516C2431 A36	3
(4) 307-2	-1-	85	72B418 A36	3
(16) 307-3	-1-	85	72B418 A36	3
(16) 307-4	-1-	85	72B418 A36	3
(4) 307-5	-1-	85	72B418 A36	3
(4) 307-6	-1-	122	658C819 A36	3
(4) 307-7	-1-	122	658C819 A36	3
(4) 307-8 RL	-1-	119	661C579 A36	3
(4) 307-9 RL	-1-	119	661C579 A36	3
(4) 307-10	-1-	85	72B418 A36	3

Piece-Mark	Serial No.		Material Heat No.	Matl. Type

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

[redacted] Buchtel
7-9-75

Revisions: By / Chkd / Date

Data taken from applicable CBI records.
CBI Shop QA [redacted] Date 7-10-75

Reviewed (for material covered by code):
Authorized Inspector [redacted] Date 7/11/75

Contract No. 70-7198 J

No. 81
Sh 1 of 1

GO 830 REV DEC

E71

PURCHASER: Chicago Bridge & Iron Co.
Pur. Dept.

LUKENS STEEL COMPANY

COATESVILLE, PA. 19320

TEST CERTIFICATE

C 2-F-1-1

DATE: 9-23-71

CONSIGNEE:

FILE NO 1540-03-06

MILL ORDER NO.	CUSTOMER P.O.	
52474-2	71-7198U-40	RG 91571 DR

SPECIFICATIONS: MS-603-B Rev. 0 DTD 3/9/70 & SA-516-69 Gr. 60 Sect. III thru Winter 1968 Addenda

BEND TEST O.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B		Grain Size
3596	12	95	006	020		22									7-8

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN 8"	% R.A.	BHN	Long. IMPACTS V-Notch -30°F.			Fracture Appearance % Shear	DESCRIPTION
3596	9	436	668	33			58	87	49	60-60-60	1-256 x 128 x 1-1/2"
					Lateral Expansion in inches		.074	.053	.056		
"	8	441	643	34			97	98	67	70-70-70	1- "
					Lateral Expansion in inches		.073	.075	.059		

Plates and tests heated 1550-1650°F., held 1/2 hr. per inch min. and air cooled.

Sworn and subscribed before me this ____ day of SEP 23 1971

Phillip A. Romandini Jr.

Notary Public

My Commission Expires April 1, 1972

10-5-71

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

SUPERVISOR TESTING

Feedwater
Penetration X-9A

Inner head

heat No. K-5073

Cameron

IRON WORKS, INC.

P. O. BOX 1212 HOUSTON, TEXAS 77001

CERTIFICATE OF TESTS

Date 10 September 1975

SOLD TO
SARGENT INDUSTRIES
AIRITE DIVISION
1700 East Grand Avenue
El Segundo, Ca 90245

SHIP TO

Customer Order No.	C.I.W. Sales Order No.	Specification
N5035	F-12979	Carbon Steel In accordance with ASME Sec. II SA-350 LF2 ASME Sec. III Class 1 Component, except as modified by P.O.

Description of Material: Fluid Head Dwg.# 9256-13 N/C

C.I.W. Part Number	Heat No.	CHEMICAL ANALYSIS C	MN	P	S	SI	CR	NI	MO	W	V	CU
60607-1	[redacted]	.20	1.23	.015	.012	.23						

C.I.W. Part No. or Size	Quantity	Heat No.	MECHANICAL PROPERTIES Yield PSI	Tensile PSI	% Elong. In.	% Red. Area	Charpy Impact	Hardness
60607-1	4	K 5073	See attachment for mechanical properties.					

Code requirements for U.T. and P.T. not performed.

Bechtel Corp.
M. Schlipp
9-22-75

C.I.W. Heat No. | Jominy Hardenability | Grain Size

Heat treat performed in accordance with approved CIW procedure FH-414 Rev. B.
1550°F., held 6 hrs. at temp. Air cooled.

VENDOR DOC. REVIEW GRP.

P 126A E 188 1

REVIEW
QUALITY CONTROL
APP 28 DEC
STAMP 9/15/75

Subscribed and Sworn to before me this 10th Day of September 1975

MATERIAL CODE No. 418

We certify that the contents of this report are correct as contained in the records of this company.

H. O. WRIGHT, Metallurgist

Notary Public
G. A. TOUCHTON
Notary Public In And For Harris County, Texas
My Commission Expires June 1, 1977

CAMERON 488-1 P.O. 3773

33

P.O.# N5035 CIW F-12979 10 Sept. 1975

MECHANICAL PROPERTIES:

Impact test performed in accordance with approved CIW Inspection procedure FI-77 N/C

Forging Ser.#	Heat#	.2% Offset Y.S. psi	Ult. T.S. psi	Elong. %	R.A. %	Test Temp.	Absorbed Energy Lat. Expansion Fracture	Tensile Test Lot#
0001	K 5073					+32°F.	138.0 Ft.Lbs. .084 100%	4
						32	92.0 .072 60	
						32	104.0 .072 80	
						32	140.0 .090 99	
						32	140.0 .084 100	
						32	136.0 .086 100	
0002	K 5073					+32°F.	147.0 .089 100%	4
						32	134.0 .085 100	
						32	101.0 .071 80	
						32	100.0 .071 80	
						32	114.0 .075 80	
						32	121.5 .079 80	
0003	K 5073					+32°F.	144.0 .090 100%	4
						32	143.0 .094 100	
						32	114.0 .081 70	
						32	97.0 .082 70	
						32	102.0 .083 80	
						32	126.0 .093 99	
0004	K 5073	52,400	76,100	30.8	70.4	+32°F.	102.0 .075 80	4
						32	154.0 .085 100	
						32	108.0 .076 80	
						32	146.0 .088 100	
						82	109.0 .080 80	
						32	138.0 .079 99	

MRR-8031-SF-1325

VENDOR DOC. REVIEW GRP

126A F 188.1

MATERIAL CODE No. 418

REVIEW QUALITY CONTROL AP 26 QC STAMP 9/15/75

Bechtel Corp.
M L Rhlyppe
9-22-75

FW penetration X-9B

fixed head

Heat No. K-5073

Correct

CONSOLIDATED IRON WORKS, INC.

P. O. BOX 1212 HOUSTON, TEXAS 77001

CERTIFICATE OF TESTS

Date 10 September 1975

SOLD TO
SARGENT INDUSTRIES
AIRITE DIVISION
1700 East Grand Avenue
El Segundo, Ca 90245

SHIP TO

Customer Order No.	C.I.W. Sales Order No.	Specification
15035	F-12979	Carbon Steel In accordance with ASME Sec. II SA-3[illegible] LF 2, ASME Sec. III 1974 Class 1 Component, except as modified by P.O.

Description of Material: Fluid Head Dwg.# 9256-13 N/C

CHEMICAL ANALYSIS

C.I.W. Part Number	Heat No.	C	MN	P	S	SI	CR	NI	MO	W	V	CU
60607-1	K 5073	.20	1.23	.015	.012	.23						

MECHANICAL PROPERTIES

C.I.W. Part No. or Size	Quantity	Heat No.	Yield PSI	Tensile PSI	% Elong. In.	% Red. Area	Charpy Impact	Hardness
60607-1	4	K 5073	See attachment for mechanical properties.					

Code requirements for U.T. and P.T. not performed.

Bechtel Corp.
M. Schlippe
9-22-75

C.I.W. Heat No. | Jominy Hardenability | Grain Size

Heat treat performed in accordance with approved CIW procedure FH-414 Rev. B.
1550°F., held 6 hrs. at temp. Air cooled.

REVIEW
QUALITY CONTROL
STAMP 9/15/75

Subscribed and Sworn to before me this 11th Day of September 1975

MATERIAL CODE No. 418

H. O. WRIGHT, Metallurgist

G. A. TOUCHTON
Notary Public in and for Harris County, Texas
My Commission Expires June 1, 1977

P.126 A F 175 1 33

P.O.# N5035 CIW F-12979 10 Sept. 1975

MECHANICAL PROPERTIES:

Impact test performed in accordance with approved CIW Inspection procedure FI-77 N/C

Forging Ser.#	Heat#	.2% Offset Y.S. psi	Ult. T.S. psi	Elong. %	R.A. %	Test Temp.	Absorbed Energy	Lat. Expansion	% Shear Fracture	Tensile Test Lot#
0001	K 5073					+32°F.	138.0 Ft.Lbs.	.084	100%	#4
						32	92.0	.072	60	
						32	104.0	.072	80	
						32	140.0	.090	99	
						32	140.0	.084	100	
						32	136.0	.086	100	
0002	K 5073					+32°F.	147.0	.089	100%	4
						32	134.0	.085	100	
						32	101.0	.071	80	
						32	100.0	.071	80	
						32	114.0	.075	80	
						32	121.5	.079	80	
0003	K 5073					+32°F.	144.0	.090	100%	4
						32	143.0	.094	100	
						32	114.0	.081	70	
						32	97.0	.082	70	
						32	102.0	.083	80	
						32	126.0	.093	99	
0004	K 5073	52,400	76,100	30.8	70.4	+32°F.	102.0	.075	80	4
						32	154.0	.085	100	
						32	108.0	.076	80	
						32	146.0	.088	100	
						32	109.0	.080	80	
						32	138.0	.079	99	

MATERIAL CODE No. 418

REVIEW QUALITY CONTROL AP 26 QC STAMP 9/15/75

Bechtel Corp.
M L Rehfuss
9-22-75

Fluid Head (Gen): X-B

heat No 326N077

CARLTON FORGE WORKS

7743 EAST ADAMS STREET
PARAMOUNT, CALIFORNIA

METALLURGICAL ANALYSIS REPORT

DATE 6-6-75

QUANTITY 6 & T.S.

C.F.W. S.O. NO. 34463

CUSTOMER ORDER NO. N5058 Item #1

CUSTOMER Sargent-Airite Div.

PART NAME OR DESCRIPTION

MATERIAL 1029

SPECIFICATIONS ASME-SA-105-73, Sect. II, 1974 *

PART NO. 9256-11 N/C

CONDITION OF FORGINGS Normalize 1650 F., 2hrs., air cool, Quench 1500 F., 2hrs., oil cool, Temper 1200 F., 6hrs., air cool per NP-AS-004 N/C ***

HARDNESS OF FORGINGS BHN 137/156

Forgings fluorescent penetrant inspected per
Forgings magnetic particle inspected per — Not performed, to be performed by SI/AD
Forgings ultrasonic inspected per — Not performed, to be performed by SI/AD
Forgings radiographically inspected per

Mechanical property acceptance of listed forgings are based on results from:
___ Sectioned forgings or rolled ring ___ Separately forged test bar X per lot
X Integral test ring or slug ___ Heat treat response test bar ___ per heat ___ per forging
which conforms to material specifications listed above and are tabulated below:

MILL Bethlehem Steel
HEAT NO. 326N077

CHEMICAL ANALYSIS

	C	Mn	P	S	Si	Cr	Ni	Fe	Al	Ti	Cb & Ta	Cu W	B Sn	Co V	Mg Zr	Zn Mo	N	H	O
MILL DATA	.29	.80	.026	.030	.20			Bal											

TENSILE

SERIAL NO.	CODE	TEST LOCATION & DIRECTION	TEMP.	YIELD .2% OFF. KSI	ULTIMATE KSI	% ELONG. IN 4D	% RED OF AREA
CFW DATA #001 thru #016		Heavy	RT	46.6	75.2	32.0	69.5
		Thin	RT	45.1	76.7	33.0	71.3

STRESS RUPTURE

TYPE BAR	STRESS KSI	TEMP. °F	HRS. TO BREAK	% ELONG. IN 4D	INCREASED STRESS TO

GRAIN SIZE

Bechtel Corp.
M.L. Phillips
7-1-75

CODE	CLEANLINESS AND FREQ.	SEV.

JOM. HARD. IN 1/16 OF AN INCH - R "C" -

1	2	4	6	8	12	16	22	32

MICROSTRUCTURE:

REVIEW
QUALITY CONTROL
AP 29 QC
STAMP 7/1/75

REMARKS: ***@Aerocraft Heat Treat
*ASME-Section III, Class 1, 1974, Edition.
Contract No. 8031-P-310

ASME MATERIAL CODE No. 404

COPIES OF TEST REPORTS SHOWING CONFORMANCE TO APPLICABLE SPECIFICATION ARE ON FILE AND ARE AVAILABLE FOR YOU OR YOUR CUSTOMER. WE HEREBY CERTIFY THAT THESE FORGINGS HAVE BEEN TESTED, INSPECTED AND ACCEPTED IN ACCORDANCE WITH THE APPLICABLE BLUEPRINTS AND SPECIFICATIONS.

I HEREBY CERTIFY THAT TO THE BEST OF MY KNOWLEDGE AND BELIEF THIS MATERIAL ANALYSIS REPORT IS TRUE AND CORRECT.

METALLURGIST

SWORN AND SUBSCRIBED TO BEFORE ME THIS 5 DAY JUNE 75

MY COMMISSION EXPIRES

D-126 AC-F-180-1

Penetration X-8

Heat No. 68328

GO 830   2.7.1

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT # 62 UNIT #1   9-2-F-1153-1

Piece-Mark	Serial No.	CTP REF. No.	Material Heat No.	Matl. Type
(1)		1	82-A ~ DRYWELL	
			INSERT ASS'Y	
(1) 79-24	-1-	220	B3390 9	1
			1 ~ PENETRATION	
			SUB-ASS'Y (X101-A)	
		1	81-E	
(1) 81-1	-1-	320	110563 G-42199	1
(1) 81-2	—	46	663204 A36	3
(2) 25-1	—	—	BAR ~ 2 x 1/4 A36	3
(1) 25-2	—	—	PL ~ 12 5/8 O.D x 1/4 A36	3
			1 ~ PENETRATION	
			SUB-ASS'Y (X101-C)	
		1	81-F	
(1) 81-1	-1-	320	110563 G-42199	1
(1) 81-2	—	46	663204 A36	3
(2) 25-1	—	—	BAR ~ 2 x 1/4 A36	3
(1) 25-2	—	—	PL ~ 12 5/8 O.D x 1/4 A36	3
			302-A ~ INSERT	
			ASSEMBLY ~ 1	
(2) 303-6	1			3
(1) 303-1				3
(2) 303-7	1			3
(2) 303-8	1			3
(2) 303-9				3
(2) 303-10				3
(3) 303-11				3
(5) 303-12				3

Piece-Mark	Serial No.	CTP REF. No.	Material Heat No.	Matl. Type
(2)		1	84-CR$_L$ ~ DRY-	
			WELL INSERT	
			ASS'Y	
(2) 84-1	-1-	320	110563 G-42199	1
(2) 79-27	-1-	220	B3690 9	1
(2) 81-2	—	46	663204 A36	3
(4) 25-1	—	—	BAR ~ 2 x 1/4 A36	3
(4) 25-2	—	—	PL ~ 12 5/8 O.D x 1/4 A36	3
			310-A ~ INSERT	
			ASS'Y ~ 1	
(2) 303-6				3
(1) 310-2				3
(2) 303-7	1			3
(3) 303-8	1			3
(3) 303-9				3
(2) 303-10				3
(2) 303-11	1			3
(5) 303-12				3
(1)		1	90-A ~ DRYWELL	
			INSERT ASS'Y	
			(X-8)	
(1) 90-1	-1-	220	B3690 9	1
(1) 90-2	-1-	274	68323 G-40275-2	1
(1) 43-6	—	52	742232 A36	3
(1) 43-7	—	53	742232 A36	3
(1) 25-1	—	—	BAR ~ 2 x 1/4 A36	3
(1) 25-2	—	—	PL ~ 12 5/8 O.D x 1/4 A36	3

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

[signature] 5-14-75

Data taken from applicable CBI records.

CBI Shop QA [signature] Date 3-14-75

Revisions	
By	
Chkd	
Date	

Reviewed (for material covered by code):
Authorized Inspector [signature] Date 5/14/75

Contract No. 70-7198

No. 62   Sh 1 of 5

FORM NO. 4-60 (6/52)

NUCLEAR

ARMCO STEEL CORPORATION
AMBRIDGE WORKS
Ambridge, Pennsylvania

12" Sch 100 Gr. 1

REPORT OF TESTS

9-2-F-1153-1

CUSTOMER Capital Pipe & Tube Products, Inc.

DATE 10-24-69

SPECIFICATION ASTM A333 Gr. 1 — ASME SA333 Gr. 1

OUR ORDER NO. CC184155-C148

MATERIAL Seamless Gr. 1 Steel Pipe

CUSTOMER'S ORDER NO. 43933

100' cap pipe #43119

IDENTIFICATION TRIP TEST	TENSILE TESTS: YIELD PSI	TENSILE TESTS: ULTIMATE PSI	TENSILE TESTS: % ELONG. IN 2 IN.	HYDRO TEST PSI	HEAT NUMBER	ANALYSIS: C	Mn	P	S	Si	Ni	Cr	Mo
Norm.													
12 3/4 x .844	49500	72100	44.0	2400#	68328	.22	.81	.014	.014				
						.21	.82	.012	.012				
Keyhole Charpy -	-50°F	32 - 34 - 31	= 32 Avg.			10 x 10 mm Size							
Material Normalized				1100°F - 53 min. Soak - Still Air Cooled									
Charpy Impact Results				1100°F - 53 min. Soak - Furnace Cooled									
	Testing Tests OK												

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

Sworn to and subscribed before me this 4th day of November A.D. 1969.

Pauline Dimitrakis

PAULINE DIMITRAKIS, NOTARY PUBLIC
AMBRIDGE BOROUGH, BEAVER COUNTY
MY COMMISSION EXPIRES MARCH 6, 1972

RJM 6-7-71

Chicago Bridge & Iron Co.
P. O. #G-40295-2
Contract #70-7198U
ITEMS 12 & 13

THE CHEMICAL ANALYSES AND PHYSICAL OR MECHANICAL TESTS REPORTED ABOVE ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

ARMCO STEEL CORPORATION

P. M. ... Date 74

12" S/100 Gr-1

W. B. COLEMAN CO.

METALLURGISTS — CHEMISTS — ENGINEERS

9TH AND RISING SUN AVENUE
PHILADELPHIA, PA. 19140

Physical Test of: Seamless Carbon Steel Pipe Date 10/7/69

Received from: Capitol Pipe & Steel Prods., Inc.

P. O. No. W 44047

G-40295-2
70-7192 4
ITEMS 12 & 13

Laboratory Number	906604			
MARKING Ht.#68328-	12"Sch.100 A-333 Gr.1 1	2	3	
Size of Bar 10mm x 10mm Linear Inch 0.394 x 0.394	0.394 x 0.394	0.394 x 0.394	0.394 x 0.394	
Tensile Strength Linear Inch				
Transverse Load Lbs. Corrected (In. Centers)				
Deflection Inches - Corrected				
Impacts Charpy				
Notch V				
Broken at Minus 50 ° F				
Resistance to Impact in Ft. Lbs.				Avg. impact value
Brinell Hardness 500 3000 Kg. Load	36.0	29.0	37.0	34.0
Rockwell Hardness Standard Superficial Scale	Minimum average impact value required of a set of three specimens-15.0ft.lb.			
Equivalent to Brinell Rockwell	Minimum impact value permitted on one specimen only of a set-10.0ft. lb.			
Witnessed by				
% Shear	30.0	30.0	30.0	
Lateral Expansion (in inches)	0.0345	0.026	0.033	

Remarks:

W. B. COLEMAN CO.

BY J. Bamph

FORM ZP REV. 5-67 F.P.

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

RJM 6-7-71

26

Penetration X-11

MHI Heat No. N31420

GO 320 SL-57

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT #56 UNIT #1

Piece-Mark	Serial No.		Material Heat No.	Matl. Type
(1)			DRYWELL INSERT	
			ASSY 44-A	
			(1) PENETRATION SUB	
		/	ASSY 44-B	
(1) 44-1	1	95	✓U4716 7HB	1
(1) 44-2	-	46	✓66B204 A36	3
(4) 43-3	-	311	✓516J0615 A36	3
(4) 2432	-	153	✓526C0060 A36	3
			(2) PENETRATION SUB	
			ASSY 44-C	
(2) 44-5	-	46	✓66B204 A36	3
(2) 24-22	—	—	PIPE CAP (TEMP PLUG)	3
(2) 44-4	-1-	60	✓65358 G40295-1	1
(2) 44-8	-	274	✓ALNR MS-9033 G-70161	1
			(1) PENETRATION SUB	
			ASSY 44-D	
(1) 24-16	-	155	✓55B272 A36	3
(1) 24-17	-	63	✓69B298 A36	3
(4) 43-7	-	53	✓74B232 A36	3
(1) 44-6	1	147	✓N31420 G40295-2	1
(1) 44-7	-	52	✓74B232 A36	3
(1) 40-72	1	179	✓A8640 - 1B	1

Piece-Mark	Serial No.		Material Heat No.	Matl. Type
			(1) PENETRATION SUB	
			ASSY 44-E	
(1) 44-9	1	348	✓29199 G53021	1
(1) 44-10	-	46	✓66B204 A36	3
(4) 43-3	-	311	✓516J0615 A36	3
(1) 24-20	-	-	PIPE TEMP. A36	3
(1) 24-21	-	-	PIPE TEMP. A36	3
			(1) INS. RESTRAINT PR-77	
(2) 94-1	1	87	✓68B414 A441	3
(2) 94-2 R&L	1	84	✓14B405 A441	3
(2) 94-3	1	87	✓68B414 A441	3
(4) 94-4	1	86	✓69B390 A441	3
(4) 94-5	1	89	✓67B431 A36	3
(8) 94-6	1	89	↓ ↓	3
(2) 94-7	1	86	✓69B390 A441	3
(1)			49-A ~ DRYWELL	
			INSERT ASS'Y	
(1) 49-1	-1-	160	✓B3596 2	1
			(1) ~ PENETRATION	
			SUB-ASS'Y ~ 47-R	
(1) 47-10	-1-	321	✓N31420 G-42199	1
(4) 43-7	—	53	✓74B232 A36	3
(1) 44-7	—	52	✓74B232 A36	3
(1) 24-16	—	155	✓55B272 A36	3
(1) 24-17	—	63	✓69B298 A36	3

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

Data taken from applicable CBI records.
CBI Shop QA Steven V. Bonge Date 2-18-75

Revisions: By / Chkd / Date

QC005

Reviewed (for material covered by code):
Authorized Inspector [illegible] Date 2/19/75

Contract No. 70-7198U

No. 56 Sh 1 of 1

United S..tes Steel Corporation

20 [illegible]

National WORKS

C-2-F-[illegible]

STANDARD SWORN TEST REPORT
TUBULAR PRODUCTS

Seamless pressure pipe

8-16-71 DATE

GRADE 1&6 ASTM A-333 ASME SA-333

Normalized at 1600°F for 105 min. & air cooled

CUSTOMER NAME Capitols Pipe & Steel Products Inc.

CUSTOMER'S ORDER NO. 57256

U.S. STEEL ORDER NO. KC 34675

INVOICE NO. 356-03600

COM. OR LOT NO.	SIZE O.D.	WALL THICKNESS		HEAT NUMBER	HYDRO. TEST PRESSURE MIN. P.S.I.	YIELD STRENGTH P.S.I.	TENSILE STRENGTH P.S.I.	ELONG. % IN 2"	C	Mn	P	S	Si	Mo	
7455	20"	812		N31420	1800	46270	68670	51.0	20	82	016	021	18		CHECK
				N31420	1800	45730	68640	49.0	20	82	016	021	18		CHECK
									21	85	012	024	17		LADLE

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

Flattening test: Satisfactory

FULL SIZE LONGITUDINAL KEYHOLE CHARPY SPECIMEN @ MINUS -50°F

FT LBS	27	28	26
% SHEAR	67	67	65
LAT. EXP.	030	.031	029

FULL SIZE LONGITUDINAL CHARPY V NOTCH IMPACTS @ MINUS -50°F

FT LBS	26	28	24
% SHEAR	36	38	30
LAT. EXP.	022	027	020

[illegible] 12-10-[illegible]

Chicago Bridge & Iron Company
PO# G-40293
Contract#70-7198U

STATE OF PENNSYLVANIA
COUNTY OF ALLEGHENY } SS

C. F. Lofstrom BEING DULY SWORN ACCORDING TO LAW, DEPOSES AND SAYS THAT THE FIGURES SET FORTH ABOVE ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY

SUBSCRIBED AND SWORN TO BEFORE ME THIS 16th DAY OF Aug 1971

[illegible] R. Torley NOTARY PUBLIC

COMMISSION EXPIRES

Monongahela, Allegheny County
My Commission Expires March [illegible] 1973

C. F. Lofstrom
(SIGNATURE OF AFFIANT)

C. [illegible]
Chief Metallurgist

00018

United States Steel Corporation National - Duquesne [illegible]

Penetration X-15

Heat No. X5996

GO 830 SL-35

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT #37 UNIT #1 C.2.F 6.4.1

Piece-Mark	Serial No.	CTR REF	Material Heat No.	Matl. Type
			DRYWELL INSERT	
			ASSY 43-A	
			(1) SUB ASSY SHELL	
			PL W/STIFFENERS 56-MM	
(1) 40-67	-1-	221	B3680 1B	1
(1) 56-M-1	—	322	N90857 A36	3
(1) 56-M-2	—	322	↓ ↓	3
(2) 56-M-2A	—	322	N90857 A36	3
(1) 56-2M-1	—	301	B7500Z A36	3
(1) 56-2M-2	—	301	↓ ↓	3
(7) 56-2M-3	—	114	516C 2545 A36	3
(7) 56-2M-4	—	114	↓ ↓	3
			(1) PENETRATION SUB	
			ASSY 43-D	
(1) 43-9	1	103	102997 G42877	1
(1) 43-10	—	46	66B204 A36	3
(4) 43-3	—	311	516-060-E A36	3
(1) 24-26	—	—	(1) PIPE CAP MATL	3
			(1) PENETRATION SUB	
			ASSY 43-B	
(1) [redacted]	1	[redacted]	X5996 10	1
(1) 43-2	—	46	66B204 A36	3
(4) 43-3	—	311	516-060-E A36	3
(1) 43-4	—	259	TNEL PLATE G10161	1
(1) 24-13	—	—	PIPE A36	3
(1) 24-19	—	—	PL A36	3

Piece-Mark	Serial No.	CTR REF	Material Heat No.	Matl. Type
			(1) PENETRATION ASSY	
			43-C	
(1) 43-6	—	52	74B 232 A36	3
(4) 43-7	—	53	748232 A36	3
(1) 25-1	—	—	BAR A36	3
(1) 25-2	—	—	PL A36	3
(1) [redacted]	1	[redacted]	68328 G40295-2	1
			(8) INS. RESTRAINT	
			ATT. SUB-ASSY	
			41-A	
(8) 41-1	—	79	68B414 A441	3
(16) 41-2	—	79	68B414 A441	3
(8) 41-3	—	79	68B414 A441	3
(16) 41-5	—	69 312 79	6913298 A21397 A36	3
(24) 15-15	—	362	1174508 G11051	2
(2) 93-1	1	79	68B414 A441	3
(1) 93-2	1	79	↓ ↓	3
(1) 93-3	1	46	66B204 A36	3
(1) 93-4	1	46	66B204 A36	3
(1) 93-5	1	46	66B204 A36	3
(2) 92-1	1	79	68B414 A441	3
(2) 92-2½	1	79	↓ ↓	3
(2) 92-3	1	79	↓ ↓	3
(4) 92-4	1	46	66B204 A36	3
(4) 92-5	1	46	66B204 A36	3

LIMERICK GENERATING STATION UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 2031-C-2
CBI 70-7198

Data taken from applicable CBI records.
CBI Shop QA Robert L. Dill Date 11/23/74

Revisions: By / Chkd / Date

(820) #3

Reviewed (for material coverage by cutting)
Authorized Inspector [signature] Date 11/25/74

Contract No. 70-7199 U

No. 37 Sh 1 of 1

PURCHASER: 66
Chicago Bridge & Iron Co.
Pur. Dept.
Greenville, Pa. 16125

LUKENS STEEL COMPANY
COATESVILLE, PA. 19320
TEST CERTIFICATE

DATE: 6-7-71
CONSIGNEE:
FILE NO 1540-03-06 C 1

MILL ORDER NO.	CUSTOMER P.O.	
50018-2	70-7198U-23	DP 6271 LX

C-2-F-609-1

SPECIFICATIONS: SA-516 Gr. 60 CB & I MS-603B Rev. 0 DTD 3/9/60 Sect. 111 Winter 68 Addenda CB & I GPS 516 Rev. 4 DTD 2/25/70

BEND TEST C.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	Grain Size
U4736	14	1.02	012	028		29								7 - 8
X5996	12	1.11	010	028		23								6 - 7

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

Affirmed and subscribed before me
this ____ day of JUN 7 1971
Phillip A. Romanelli Jr.
Notary Public
My Commission Expires April 1, 1972

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG IN 8"	% R.A.	BHN	Long. IMPACTS V-Notch -30°F.	Fracture Appearance % Shear	DESCRIPTION
U4736	1	482	714	27			42 | 39 | 44	40-40-40	1-256 x 115 x 1-1/2" - ITEM 60
							Lateral Expansion in Inches .042 | .041 | .044		ITEM 60
U4736	10	487	718	25			57 | 69 | 49	50-50-50	2-224 x 109-1/4 x 1-1/2"
							Lateral Expansion in Inches .053 | .062 | .047		ITEM 61
X5996	10	442	653	32			111 | 119 | 139	80-80-80	2-240 x 54 x 1-1/4"
							Lateral Expansion in Inches .094 | .097 | .091		ITEM 61A

RAM 6-10-71

Plates and tests heated 1625°F. ±25°F., held 1/2 hr. per inch min. and air cooled.

We hereby certify that the above material has been manufactured according to SA-516 Gr. 60 CB & I MS-603B Rev. 0 DTD 3/9/70 Sect. 111 Winter 68 Addenda XX CB & I GPS 516 Rev. 4 DTD 2/25/70 and that we have complied with all the requirements of these specifications.

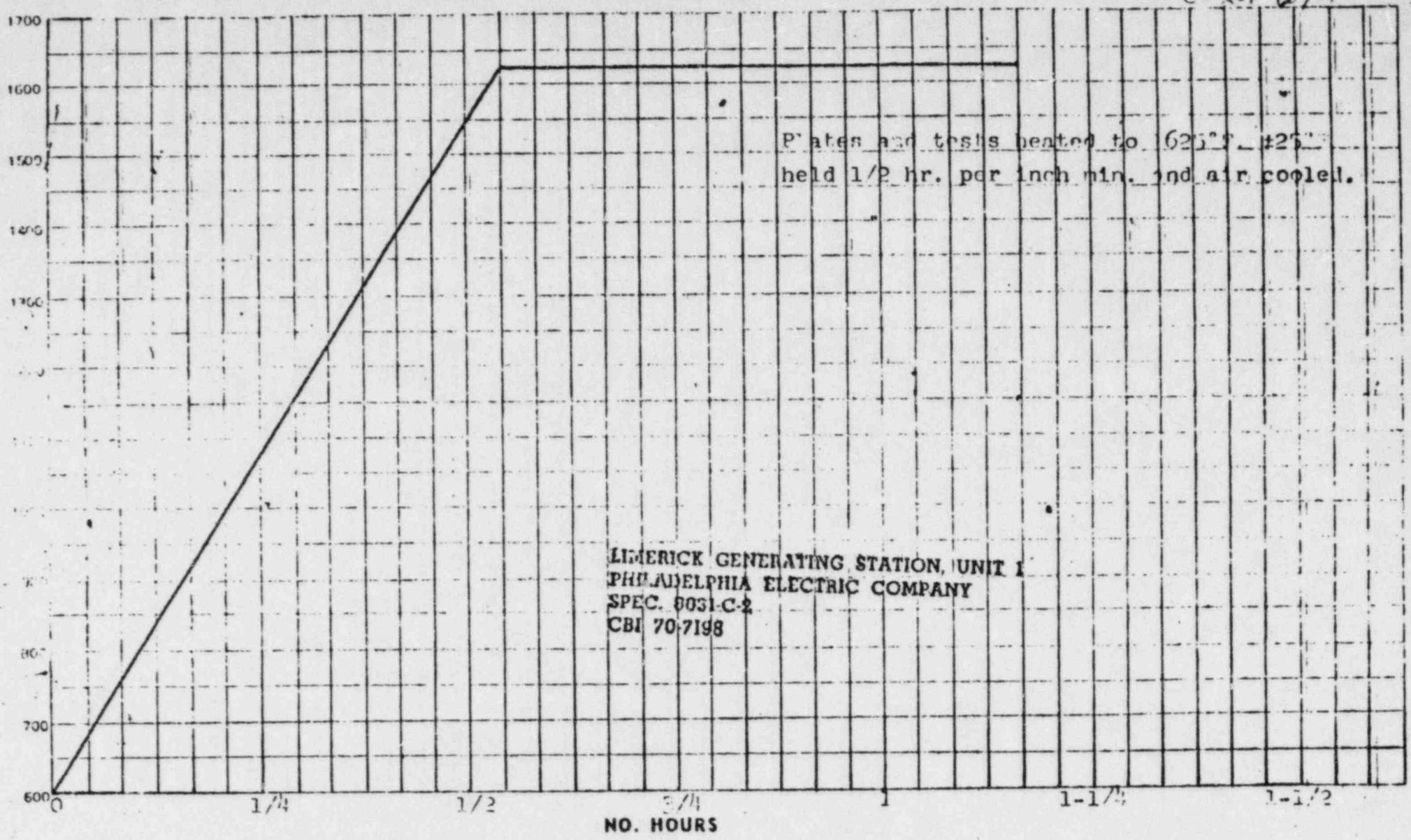
L. H. Kline

... contained in the records of the company

66

LUKENS STEEL COMPANY
COATESVILLE, PA.

C-2-F-69-1



Order # 50018·2 Contract _____ Furnace 200' Date 5·16·71

Heat No. X5996·10 Original Charts are available for customer verification

77

Equipment Hatch 69-3

Heat No. 66B094

Equipment Hatch 70-7

Heat No 67A756

See Standard 602 3-7 for instructions for using this form.

MATERIAL HEAT NUMBER SHEET

Material Types:
1. Welded Assemblies
2. Non-Welded Code Matl.
3. Non Code Matl.

SHIPMENT #75 UNIT #1

Piece-Mark	Serial No.	CTR REF No.	Material Heat No.	Matl Type
(1)			69-A~EQUIPMENT DOOR NECK & HEAD ASSEMBLY~1 1~EQUIPMENT DOOR PENETRATION NECK SUB-ASSEMBLY~67-B	
(1) 67-4	—	275	655H111 A36	3
(2) 67-5	—	275	655H111 A36	3
(1) [illegible]	—	[illegible]	P35?6 5	1
(1) [illegible]	—	[illegible]	X6003 17A	1
(1) 67-13	—	275	655H111 A36	3
(1) 69-1	—	278	2Q72 MS-5T2 G-21166	3
(1) 69-2	—	275	2Q72 MS-5T2 G-21166	3
(1) [illegible]	-1-	[illegible]	66B094 46253	1
(1) [illegible]	-2-	[illegible]	66B094 46253	1
(1) [illegible]	—	[illegible]	70A541 210723	1
(1) [illegible]	—	[illegible]	70A541 210723	1
(2) [illegible]	—	[illegible]	67A756 224703	1
(3) [illegible]	—	[illegible]	72B392 139036	1
(48) [illegible]	—	[illegible]	70A541 210723	1
(2) [illegible]	—	[illegible]	70A541 210723	1
(2) [illegible]	—	[illegible]	70A541 210723	1
(24) [illegible]	—	[illegible]	70A541 210723	1
(24) [illegible]	—	[illegible]	G23 06A4523 MS-800-E G-112262	1
(24) 70-10	—	266	G-51 73M351 MS-600-2 G-112262	1
(50) 70-15	—	263	1/8 COTTER STEEL PINS G-2164	3
(24) [illegible]	—	[illegible]	G91 78A691 MS-801B G-112262	1
(24) 70-13	—	267	G55 320165 AISI 4140 G-112262	3

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

J. Lynn Bacitti 4-25-75

a taken from applicable CBI records.

CBI Shop QA [illegible] Date 4-25-75

Revisions: By / Chkd / Date

Reviewed (for material covered by code):

Authorized Inspector [illegible] Date 4/25/75

Contract No. 70-7198U

No. 75 Sh 1 of 1

GO 830 REV DEC

PRODUCTION DEPARTMENT — METALLURGICAL

United States Steel Corporation

CORRECTED TEST REPORT

C-2-F 1187-1

HOMESTEAD BORO. ALLEGHENY COUNTY
MY COMMISSION EXPIRES APRIL 30 1973
Member, Pennsylvania Association

TEST REPORT OF PLATES

WORKS HOMESTEAD DISTRICT -46 U.S.S. ORDER NO. LA34248 LOAD TALLY OR INVOICE NO. 163-17251

CUSTOMER ORDER NO 70-71960 6/30/71

CAR OR TRUCK NO BLF 012206 SHIPPER NO. & DATE 51769 10/28/71 160

STATE OF PENNSYLVANIA
COUNTY OF ALLEGHENY

SUBSCRIBED AND SWORN TO BEFORE ME THIS 31st DAY OF Oct., 1971

E. Diamond

BEING DULY SWORN ACCORDING TO LAW, DEPOSES AND SAYS THAT THE CHEMICAL ANALYSIS AND/OR TESTS SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

SIGNATURE M. N. JAYSON, CH. LET.

DATE 10/29/71

CHICAGO BRIDGE & IRON CO
P. O. BOX 610
GREENVILLE PA 16125

SHIP TO

CHICAGO BRIDGE & IRON CO
GREENVILLE PA

AS-ER-SA-D1.6-D2-GRADE-70-PRESSURE-VESSEL-QUAL-WELDERS-&-TEAPER-LOMO-CHARPY-V-NOTCH-IMPACT-PR-TEST-E-MILUS-30-DEG-F-STRESS-RELIEVE-TEST-HRS-15-HRS-MOD-PER-CB&I-SPEC-MS601B-DTD-2/25/70-&-GPS-516-REV4

008975

ADDITIONAL NOTES & FOR INSPECTION FOR HEAT TREATMENT ONLY BUT SUB-SEQUENT TESTING NOTIFY MR SMITH 412-588-5500 PRIOR TO HEAT TREAT ASSESSMENT SLOPE T/R LADLE FULL ANAL ALSO CUST SPEC GPS516 REV

0703

ITEM NO.	HEAT NO.	TEST OR PIECE IDENTITY NO.		MATERIAL DESCRIPTION: NO. PCS.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	WEIGHT	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION IN 8"	ELONGATION IN 2"	% RED OF AREA
105	668094	46253	BC TC	1	3.0000	57	233	11288	*49500 *52600	75800 77600		30.0 32.0	
	FULL SIZE LONG. V NOTCH CHARPY IMPACT TEST 10-10MM MADE AT - 30 DEG. F. 094.0-070.0-067.0 FT. LBS. % SHEAR RATE 055.0-064.0-043.0-000.0 AND LATERAL EXPANSION .074-.060-.058 MILS. AVERAGE IMPACT STRENGTH - 77												
105	668094	46254	BC TC	1	3.0000	57	233	11288	*50400 *51800	78800 80200		29.0 32.0	
	FULL SIZE LONG. V NOTCH CHARPY IMPACT TEST 10-10MM MADE AT - 30 DEG. F. 065.0-095.0-063.0 FT. LBS. % SHEAR RATE 044.0-052.0-032.0-000.0 AND LATERAL EXPANSION .055-.076-.056 MILS. AVERAGE IMPACT STRENGTH - 74												

Above Test Specimens Stress Relieved at 1150 Deg. F., Maintained 15 hrs. Furnace cooled to below 600 Deg. F.
Test Specimens Charged Cold. Heating Rate 110 Deg. F. Per Hour. Cooling Rate 140 Deg. F. Per Hour.
Heat treated in accordance with heat treat reference Number C2.2
Above Plates Quenched at 1697 Deg. F., Tempered at 1185 Deg. F.

YIELD POINT 0.2% OFFSET.

TESTED ACCORDING TO COMPANY RECORDS CONFORMS TO THE REQUIREMENTS OF THE SPECIFICATION LISTED ABOVE

* B OR H INDICATE COMPLIANCE OF BEND OR HOMO TESTS, RESPECTIVELY

HEAT NO.	TYPE	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Cb	Co
668094	LADL	.22	.82	.015	.015	.20												

LIMERICK GENERATING STATION, UNIT 1
PHILADELPHIA ELECTRIC COMPANY
SPEC. 8031-C-2
CBI 70-7198

GRAIN SIZE # 8 AVG GR SIZ

11-15-71

235

PRODUCTION DEPARTMENT — METALLURGICAL

U. ed States Steel Corporation

Sheet No. 1

J. JAMES HEPPY, NOTARY PUBLIC
HOMESTEAD BORO., ALLEGHENY COUNTY
MY COMMISSION EXPIRES JULY 30, 1973
Member, Pennsylvania Association of Notaries

TEST REPORT OF PLATES C2.F.1171

WORKS HOMESTEAD DISTRICT U.S.S. ORDER NO. LA34246 LOAD TALLY OR INVOICE NO. 163-17249

CUSTOMER ORDER NO 70-719BU-46 8/30/71

CAR OR TRUCK NO BLE 019288 SHIPPER NO. & DATE 51789 10/28/71 160

STATE OF PENNSYLVANIA
COUNTY OF ALLEGHENY

SUBSCRIBED AND SWORN TO BEFORE ME
THIS 31st DAY OF Oct., 1971

J. James Heppy

J. Heppy

BEING DULY SWORN ACCORDING TO LAW, DEPOSES AND SAYS THAT THE CHEMICAL ANALYSIS AND/OR TESTS SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

SIGNATURE M.W. MAYSON, CH. MET.

DATE 10/29/71

CHICAGO BRIDGE & IRON CO
PO BOX 610
GREENVILLE PA 16125

SHIP TO

CHICAGO BRIDGE & IRON CO
GREENVILLE PA

AS E-54-516-69-GRADE-70-PRESSURE-VESSEL-QUAL-NORMALIZED-LONG-CHARP
Y-V-NOTCH-IMPACT-TESTS-R-MINUS-30-DEG-F-MOD-PER-CBRI-SPEC-MS601B-R
C-1-DTD-2/25/70-&-GPS-516-REV-4-DTD-2/25/70-&-GPS-516-REV-4-

008974

CHICAGO BRIDGE & IRON INSPECTION FOR HEAT TREATMENT ONLY NOT SUB
FACE OR TESTING NOTIFY NK SMITH 412-588-5500 PRIOR TO HEAT TREAT
QUIPMENT SWORN T/R LADLE FULL ANAL ALSO CUST SPEC GPS 516 RE

0703

ITEM NO	HEAT NO	TEST OR PIECE IDENTITY NO	MATERIAL DESCRIPTION: NO. PCS.	THICKNESS OR SECTION	WIDTH, DIA OR FT. WT	LENGTH	WEIGHT	YIELD PT PSI	TENSILE STR PSI	ELONGATION % IN 8	ELONGATION % IN 2	% RED OF AREA
04	67A756	224763 BC	1	1.0000	79	300	6714	* 47100	75800		35.0	
	FULL SIZE LONG. V NOTCH CHARPY IMPACT TEST 10X10MM MADE AT - 30 DEG.F. 023.0-025.0-024.0 Ft. Lbs. & SHEAR RATE 029.0-027.0-027.0-000.0 AND LATERAL EXPANSION .027-.020-.024 MILS.											
	Avg. Impact Str.- 24											
04	75A924	272637 HC	1	1.0000	79	300	6714	* 45200	76100	25.0		
	FULL SIZE LONG. V NOTCH CHARPY IMPACT TEST 10X10MM MADE AT - 30 DEG. F. 034.0-025.0-025.0 FT. LBS. & SHEAR RATE 066.0-038.0-038.0-000.0 AND LATERAL EXPANSION .020-.021-.027 MILS.											
	AVERAGE IMPACT STRENGTH - 28											
	Above Plates Normalized at 1660 Deg. F. for 40.0 Minutes											
	Heat treated in accordance with heat treat reference Number: C2.1											
	LIMERICK GENERATING STATION, UNIT 1 PHILADELPHIA ELECTRIC COMPANY SPEC. 8031-C-2 CBI 70-7198											
	11-3-71											
	*YIELD POINT @ .0050 EXT.											

THESE SIZE TESTED ACCORDING TO COMPANY RECORDS CONFORMS TO THE REQUIREMENTS OF THE SPECIFICATION LISTED ABOVE

* B OR H INDICATE COMPLIANCE OF BEND OR HOMO TESTS RESPECTIVELY

HEAT NO	TYPE	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Cb	Co
67A756	LADL	.24	1.06	.011	.027	.19												
75A924	LADL	.25	1.00	.010	.022	.21												

Grain Size #7
Grain Size #8

227

Airlock 162-1

Heat No. C8076

C-2-F-98-1

CZ-F-1184

CBI 880 Rev 6-69

METAL MATERIAL VERIFICATION SUMMARY SHEET

CHICAGO BRIDGE & IRON COMPANY

Contract No. 70-7198

Sheet 1 of 4

Conv to Engineering – By ____________ Date ____________

No. of Ctrs For Customer ____________

NO. OF PCS.	ORDERED ITEM NO.	SUPPLIER'S HEAT, LOT OR OTHER IDENTIFICATION NUMBER	SUPPLIER'S SLAB NUMBER	MATERIAL SPEC. AND THICKNESS FOR PLATES	CAR OR TRUCK NUMBER AND SUPPLIER	CTR CHECKED DATE AND INITIAL	METAL REC'G INSPECTION REPORT CHECKED DATE AND INITIAL	DAILY FAB'R OR STORES RELEASE REPORT CHECKED DATE AND INITIAL	ENGR. PIECE MARK	SERIAL NUMBER	NO. OF PIECES FABRICATED	CHECKED COMPLETE INITIAL	REMARKS
1	MI-5	801C01200	C31547	SA516-70 M5601B T=3/4	M7198-3 Beth.	RCC 5-13-71	RCC 6-1-71	RCC 10-11-71	See Attached	1		RCC	
1	MI-7(A)	819C02046	C31571	T=1		RCC 5-13-71	RCC 5-71	RCC 9-14-71	See ATTACHED	9	See attached	RCC	
1	MI-22	[illegible]	P41319	T=3 1/4	M7198-5 ARMCO	RCC 6-7-71	RCC 6-7-71	RCC 9-30-71	[redacted]	8	4	RCC	
1	MI-9	X5998	5A	T=2	M7198-6 LUKENS	RCC 6-3-71	RCC 6-11-71	RCC 1-13-72	[redacted]	1	1	RCC	Shpd to Granite
1	MI-11	CB676	1B	T=3		RCC 7-15-71	RCC 7/9/71 RCC 7/23/71	RCC 9-23-71	See Attached	11/1-2	See attached	RCC	Part Return
1	MI-13	X30C403	2C	SA240-304 T=3/16	M7198-2 G.O. CARLSON	RCC 7-15-71	RCC 3-17-71	RCC 10-12-71	166-2	1	1	RCC	
2	MI-15	X30C403	2C				RCC 3-17-71	RCC 4-28-72	156-14°	1	1	RCC	
1	MI-6	801B09500	B32510	SA516-70 M5601B T=3/8	(M1449-2) Beth.	RCC 3-4-71	RCC 3-4-71	RCC 9-21-71	See Attached			RCC	
1	MI-7B	802C04120	C31587	SA516-70 M5601B T=1 5/8	M7199-2 Beth	RCC 5-13-71	RCC 6-1-71	RCC 10-23-71	See Attached			RCC	4+2 9A Spls not shipped
1	Spec Stock	801B09500	B10553	SA516-70 T=1/2	M5T-222 Beth	RCC 2-24-71	UNASSIGNED MAT'L RCC 6-4-71	9-22-71	See Attached	6	See attached		4 Vouhs used
1	Spec Stock	50181153C	B32526	SA516-70 T=2"			Good St mat'l 9-3-71	9-2-71	See Attached	12	See attached		4 Vouhs used
1	LO 7199	501B09500	C31586-1	SA516 G70 T=1" M5601B	M7198-3 Beth	RCC 5-13-71	7-23-71	4-18-72	158-8	5	1	RCC	Pc 158-8 Sent to Grove Ctr 7199
1	157-2	71A527	170008	SA516-70 T=1 3/4	M0-7198-12 Granite	RCC 11-4-71	RCC 11-4-71	RCC 12-2-71	[redacted]	39	1	RCC	
	MI-2	801C03400	10265-1	SA516-70 M5601B T=3/8	M7197-2 Beth.			7-20-73	141-4	7	4		
	Stock	23D169	T3763	A516-70 T=1/2	UCS	1/15	1/15	1-15-74	162-2°	1-5	5		UM

Contract No. 70-7198

?NTIFICA... PART NO.-SYSTEM ITEM	QUAL. NO.	ENG. PC. NO.	SERIAL NO.	NO. POS.
ML-5?	2	[redacted]	11	2
[illegible]376-18 ✓	1	[redacted]	11	1
[illegible]S L3	1	[redacted]	11	1
G'ville	2	[redacted]	1-2	2
11-7	2	[redacted]	4	2
1 5/3"	4	[redacted]	4	4
M104 L8	1	[redacted]	4 This Pc. Rejected	
302C 04120	1	[redacted]	4	1
C31587	2	141-6	4	1
	1	150-12	4	1
				C-2-F-1188-1
01B11530-B32526	1	[redacted]	12	1
2"	1	[redacted]	12	1
	2	[redacted]	12	2
	2	[redacted]	12	2
	1	[redacted]	12	1
M101 L17	1	[redacted]	12	1
	1	? [redacted]	12	1
	2	[redacted]	12	2
	2	[redacted]	12	2
	2	[redacted]	12	2
	2	[redacted]	12	2
	4	144-4	12	4
	1	? [redacted]	12	1
	1	[redacted]	12	1
	2	[redacted]	12	2
	1	[redacted]	12	1
	1	[redacted]	12	1
	2	[redacted]	12	2

C-2-F-1188-1

(1) 2/15

PURCHASER:
Chicago Bridge & Iron Co.
Mr. Grant Wagner
P.O. Box 13308
Presidents Island
Memphis, Tenn. 38101

LUKENS STEEL COMPANY
COATESVILLE, PA. 19320
TEST CERTIFICATE

DATE: 7-9-71 FILE NO. 1540-06499

CONSIGNEE:
Chicago Bridge & Iron Co.
Greenville, Pa.

MILL ORDER NO.	CUSTOMER P.O.	
48174-2	M7198-6	RQ 7771 DD

SPECIFICATIONS:
A-516-69 Gr. 70, A-300-68 Class 1 Mod. CB&I MS-601B Rev. 1 Sup. 5,16 & GPS 516 Rev. 4 Sup. 18 (ASME Sect. 11 & 111 Winter 1969 Addenda)

Sheet 1 of 2

BEND TEST O.K. HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	drain size
C8676	.27	1.01	.010	.019	.22									6-7

CBI 70-7198
BECHTEL 8031-C-2
LGS I

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN 2"	% R.A.	BHN	Long. IMPACTS V-Notch -30°F.			Fracture Appearance % Shear	DESCRIPTION
C8676	1B	552	773	29			57	64	69	30-30-30	2-232 x 83-3/8 x 3"
					Lateral Expansion in inches		.060	.050	.049		

Plates and tests heated 1650°F ±25°F., held 1/2 hr. per inch min. and water quenched to below 400°F. then tempered 1180°F., held 1/2 hr. per inch min. and air cooled.

Tests stress relieved by heating to 1150°F., held 15 hrs. and furnace cooled to 600°F.

We hereby certify that the above material has been manufactured and tested according to A-516-69 Gr. 70 A-300-68 Class 1 Mod. CB&I MS-601B Rev. 1 Sup. 5,16 & GPS 516 Rev. 4 Sup. 18 (ASME Sect. 11 & 111 Winter 1969 Addenda), and that we have complied with all the requirements of these specifications.

RC 7-15-71

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

SUPERVISOR-TESTING H. H. Rogers

PURCHASER:

Chicago Bridge & Iron Co.
Mr. Grant Wagner
P.O. Box 13308
Presidents Island
Memphis, Tenn. 38101

LUKENS STEEL COMPANY

COATESVILLE, PA. 19320

TEST CERTIFICATE

DATE: 7-9-71 FILE NO. 1540-06-99

CONSIGNEE:
Chicago Bridge & Iron Co.
Greenville, Pa.

MILL ORDER NO.	CUSTOMER P.O.	
48174-2	M7198-6	RG 7771 DD

SPECIFICATIONS:
SA-516-69 Gr. 70, A-300-68 Class 1 Mod. CB&I MS-601B Rev. 1 Sup. 5,16 & GPS 516 Rev. 4 Sup. 18 (ASME Sect. 11 & 111 Winter 1969 Addenda)

Sheet 1 of 2

BEND TEST O.K. HOMOGENEITY TEST

RECEIVED JUL 14 1971 MEMPHIS, TENN.

CBI 70-7198
BECHTEL 8031-C-2
LGS I

M Hutchins Bechtel 4-16-75

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	Grain Size
C8676	27	1.01	010	019		22								6-7

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN 2"	% R.A.	BHN	Long. IMPACTS V-Notch -30°F.			Fracture Appearance % Shear	DESCRIPTION
C8676	1B	552	773	29			57	64	69	30-30-30	2-232 x 83-3/8 x 3"
							Lateral Expansion in inches				
							.060	.050	.049		

Plates and tests heated 1650°F ±25°F., held 1/2 hr. per inch min. and water quenched to below 400°F., then tempered 1180°F., held 1/2 hr. per inch min. and air cooled.

Tests stress relieved by heating to 1150°F., held 15 hrs. and furnace cooled to 600°F.

We hereby certify that the above material has been manufactured ~~xxxxxx~~ according to A-516-69 Gr. 70 A-300-68 Class 1 Mod. CB&I MS-601B Rev. 1 Sup. 5,16 & GPS 516 Rev. 4 Sup. 18 (ASME Sect. 11 & 111 Winter 1969 Addenda), and that we have complied with all the requirements of these specifications.

RCC 7-15-71

P.O. # 156-23 156-24 156-25 162-1

C.O. 1-8811-1-2

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

SUPERVISOR TESTING F. H. Kline

Feedwater Valve
Body 1F074A

Heat No. F6137

Body: [illegible] S/N 2-521

QUAKER ALLOY CASTING CO.

A DIVISION OF HARSCO CORP.
MYERSTOWN, PENNA. 17067

MATERIAL TEST REPORT

CUSTOMER ORDER NO	PATTERN NO	QUAKER ALLOY DESIGNATION	SPECIFICATION	SHOP ORDER NUMBER	DATE SHIPPED
N124171	16435-30223-305	C50-LCB	ASME SA352 GR.LCB		7-29-75

CUSTOMER: Atwood and Morrill

HEAT NO	C	Mn	Si	P	S	Cr	Ni	Mo			YIELD P.S.I.	TENSILE P.S.I.	ELONG. %	RED of AREA %	CSG. SER.#	B.T. SER.#	PCS SHIPPED
F6137	.20	.75	.46	.017	.013						42,500	71,500	30.0	53.3	F6137-1	N1127	[illegible]

Charpy Impact V Notch Plus 30°F 43-45-42 foot pounds

41-44-43 Lateral expansion

40-40-40 % Ductile Fracture

REMARKS: Castings produced in accordance with ASME Boiler and Pressure Vessel Code Sect.III 1971 and 1972 Winter addenda, and with SA352. All special requirements of Art. NB2000 Sect. III 1971 and 1972 Winter Addenda have been met.

Castings produced in accordance with Bechtel spec 3031-P-350 and CC100-RAd, CC102-Welding, [illegible] Magnetic Particle Inspection, and 9-71-101-Markings.

V. [illegible] Atwood + Morrill Co. 9/11/75

"I CERTIFY THE ABOVE INFORMATION IS CORRECT."
QUAKER ALLOY CASTING CO.

BY [signature]

John Paul Jones - Authorized Inspector

(P) TI 9-23-75 verified [illegible]

Followed by 8A

Feedwater Valve
Body 1F074 B

Heat No. F6152

Kit: 12681-01-
BSD4 for 14"-90#

QUAKER ALLOY CASTING CO.

A DIVISION OF HARSCO CORP.
MYERSTOWN, PENNA. 17067

MATERIAL TEST REPORT

CUSTOMER ORDER NO	PATTERN NO	QUAKER ALLOY DESIGNATION	SPECIFICATION	SHOP ORDER NUMBER	DATE SHIPPED
AM24171	16435-30228-606	Q60-LCB	ASME SA352 GR.LCB		

CHEMICAL & PHYSICAL
REPORT CHECKED
BY L J Shaw
DATE 5/5/75
ATWOOD & MORRILL CO. INC.

CUSTOMER: Atwood and Morrill

HEAT NO	C	Mn	Si	P	S	Cr	Ni	Mo			YIELD PSI	TENSILE PSI	ELONG %	RED OF AREA %	CSTG. SER.#	F.T. SER.#	PCS SHIPPED
F6152	.19	.32	.50	.021	.015						61,000	93,000	28.0	63.3	F6152-1	M1134	
		Charpy Impact V Notch Plus 30°F							47-53-57		foot pounds						
									41-47-45		lateral expansion						
									40-40-40		% Ductile Fracture						

REMARKS

Approved N. Stillman Atwood + Morrill Co. 9/2/75

Castings produced in accordance with ASME Boiler and Pressure Vessel Code Sect.III 1971 and 1972 Winter addenda and with Bechtel spec 8031-P-350 and QC100-Rad., QC102-Welding, QC103 Mag, and 90-71-101-Markings.

Castings produced in accordance with ASME SA352. All requirements of Art. NB2000 Sect.III 1971 & 1972 Winter add. have been met.

S C Cuic
Bechtel Corp
7/31/75

Followed by BB

7-31-75

"I CERTIFY THE ABOVE INFORMATION IS CORRECT"
QUAKER ALLOY CASTING CO.

STATE OF PENNSYLVANIA COUNTY OF LEBANON SS
SWORN TO AND SUBSCRIBED BEFORE ME

THIS DAY OF 19

John Paul Jones-Authorized Inspector

BY
METALLURGIST

(L) A.T. 9-23-75 Verified & in agreement

FW Valve 1F074A

Cover

Heat No. 213643

Form 7-14

CANN & SAUL STEEL CO.

ROYERSFORD, PA. 19468

Report of Physical Tests and/or Chemical Compositions

7/25/75

Customer's Order No. AM-24522 Ref. 12521-01-014(4) #12681-01-009(4)

Cann & Saul Order No. 32759

Customer: Atwood & Morrill Co., Inc.

Address: 285 Canal St. Salem, Mass. 01970

Attention: Purchasing Dept.

CHEMICAL COMPOSITIONS

HEAT NO.	C	MN	P	S	SI	CR	NI	MO	CB
213643	.23	1.10	.011	.018	.21				

Lab. No.

PHYSICAL TESTS

CUT FROM	TEST NUMBER		GAUGE	YIELD PT. LBS.	YIELD PER Square In Lbs.	BROKE AT LBS.	ULTIMATE TENSILE LBS.	ELONG %	REDUCED AREA	Reduction %	B.H.N.
Forging	32759	1	.505	8,500	42,500	14,000	70,000	35.0	.070	65.0	
Charpy Impacts			20.0	20.0	22.0 Ft. Lbs. @ plus 30°F						
V Notch			52	49	50 mils Lat. Exp.						
			15	15	15 percent shear						

APPROVED BY N. Sullivan DATE 9/23/75 ATWOOD & MORRILL CO. INC.

OTHER TESTS

Per C&S Proc. A388, Rev. 16 Mod. 2(4/25/75) Attach. #1(4/25/75) O.K.

We certify the material meets the requirements of the specification and/or P.O.

Customer's Specifications: ASME SA-350, Gr. LF-2 Charpy "V" impacts 40 Mils Lat. Exp. @ plus 30°F Ft. Lbs. and percent shear for Info. .30 Carbon

Y. P. 36,000
T. 70,000
E. 22.0
R. 30.0

B.H.N.

CHEMICAL & PHYSICAL REPORT CHECKED BY W. Francis DATE 7-30-75 ATWOOD & MORRILL CO. INC.

THE ABOVE TESTS COVER THE FOLLOWING MATERIAL:

Cover Forgings 23-1/4" dia. x 5-1/4" thick
Forgings serialized #1 thru 8

A&M Q.C.S A

VENDOR DOC. REVIEW ACP. 1

P 116AC E 2

[signature] Level II 7-25-75

Inspection

[signature] 7/25/75

Inspector

Resonant Ley

CANN & SAUL STEEL CO.

M E Baltrusaitis

Mgr. of Tests

John Paul Jones
Authorized Inspector

(P) A.I. 9-23-75 - Ori/... [illegible]

127

FW Valve 1F074B

Cover

Heat No. 213643

Form T-14

CANN & SAUL STEEL CO.

S/N 3-52X2

ROYERSFORD, PA. 19468

Report of Physical Tests and/or Chemical Compositions

7/25/75

	Customer's Order No.	Cann & Saul Order No.
Customer	Atwood & Morrill Co., Inc. AM-24502	32759
Address	285 Canal St. Salem, Mass. 01970	Ref. #12521-01-014(4) #12081-01-009(4)

Attention Purchasing Dept.

CHEMICAL COMPOSITIONS

HEAT NO.	C	MN	P	S	SI	CR	NI	MO	CB
213643	.23	1.10	.011	.018	.21				

Lab. No.

PHYSICAL TESTS

CUT FROM	TEST NUMBER	GAUGE	YIELD PT. LBS.	YIELD PER Square In Lbs.	BROKE AT LBS.	ULTIMATE TENSILE LBS.	ELONG %	REDUCED AREA	Reduction %	B.H.N.
Forging	32759 1	.505	8,500	42,500	14,000	70,000	35.0	.070	65.0	
Charpy Impacts V Notch		20.0	20.0	22.0 Ft. Lbs. @ plus 30°F						
		52	49	50 Mils Lat. Exp.						
		15	15	15 percent shear						

APPROVED
BY N. Sullivan
DATE 9/23/75
ATWOOD & MORRILL CO. INC.

OTHER TESTS

Sonic C&S Proc. A388, Rev. 16 Mod. 2(4/25/75)
Attach. #1(4/25/75) O.K.

We certify the material meets the requirements of the specification and/or P.O.

Customer's Specifications: ASME SA-350, Gr. LF-2
Cvpy "V" Impacts 40 Mils Lat. Exp. @ plus 30°F
Lbs. and percent shear for Info.
.30 Carbon BHN.

Y. P. 36,000
T. 70,000
E. 22% CHEMICAL & PHYSICAL
R. 30% REPORT CHECKED

THE ABOVE TESTS COVER THE FOLLOWING MATERIAL:

- Cover Forgings 23-1/4" dia. x 5-1/4" thick
Forgings serialized #1 thru 8

By W. Franzini
DATE 7-30-75
ATWOOD & MORRILL CO. INC

ASME QC S A

Inspection

7-25-75

Inspector

Receiving Insp.

CANN & SAUL STEEL CO.

Dept. of Tests

John Paul Jones
Authorized Inspector

123

FW Valve 1F074A

Disc

Heat No. F6589

Disc. A.E. 12521-01

13/14 - 521

QUAKER ALLOY CASTING CO.

A DIVISION OF HARSCO CORP.
MYERSTOWN, PENNA. 17067

MATERIAL TEST REPORT

CUSTOMER ORDER NO	PATTERN NO	QUAKER ALLOY DESIGNATION	SPECIFICATION	SHOP ORDER NUMBER	DATE SHIPPED
[illegible]	16612-20545-501	CSG-LCB	ASME SA352 GR.LCB		8-14-75

CUSTOMER: Atwood and Morrill

CSTG. R.T.

HEAT NO.	C	Mn	Si	P	S	Cr	Ni	Mo			YIELD P.S.I.	TENSILE P.S.I.	ELONG %	RED of AREA %	SER.#	S ER.#	PCS SHIPPED
6589	.22	.95	.49	.020	.011						40,000	78,000	31.0	65.7	F6589-5	H1476	1
		~~Charpy~~ Impact V Notch Plus 30°								69-65-69		foot pounds					
										65-54-53		lateral expansion					
										99-80-90		% Ductile Fracture					

REMARKS: J. Sullivan 9/11/75 v Atwood + Morrill Co.

Castings produced in accordance with ASME Boiler and Pressure Vessel Code SEct.III 1971 and Winter addenda 72 and with Bechtel spec 8031-P-350 and QC100 - Rad, QC102 - Welding, QC103 - Mag, and 90-71-101 - Markings; and with SA352. All special requirements of Art. NB2000 Sect. III 1971 and 1972 Winter Addenda have been met.

9/5/75 fm

A.R.M. Q.C.S. A 9-13-75

PAGE 2

STATE OF PENNSYLVANIA, COUNTY OF LEBANON, SS
SWORN TO AND SUBSCRIBED BEFORE ME

DAY OF 19 9-22-75

"I CERTIFY THE ABOVE INFORMATION IS CORRECT"
QUAKER ALLOY CASTING CO.

BY _____
METALLURGIST

Atwood & Morrill Co. 730

FW Valve 1F074B

Disc

Heat No F6589

Y/C 13521-C1 2

1 Disc

QUAKER ALLOY CASTING CO.

A DIVISION OF HARSCO CORP.
MYERSTOWN, PENNA. 17067

MATERIAL TEST REPORT

CUSTOMER ORDER NO.	PATTERN NO.	QUAKER ALLOY DESIGNATION	SPECIFICATION	SHOP ORDER NUMBER	DATE SHIPPED
X124171	16550-30545-601	Q50-LCB	ASME SA352 GR.LCB		8.14.75

RECEIVED

CUSTOMER: Atwood and Morrill

HEAT NO.	C	Mn	Si	P	S	Cr	Ni	Mo			YIELD P.S.I.	TENSILE P.S.I.	ELONG. %	RED. of AREA %	CSTG. SER.#	R.T. SER.#	PCS SHIPPED
F6589	.22	.93	.49	.020	.011						43,000	73,000	31.0	66.7	F6589-8	M1477	1
		Charpy Impact V Notch Plus 30°F							39-65-69			foot pounds					
									65-54-58			Lateral expansion					
									99-00-00			% Ductile Fracture					

REMARKS:

Castings produced in accordance with ASME Boiler and Pressure Vessel Code Sect.III 1971 and Winter addenda 72 and with Bechtel spec 8031-P-350 and QC100-Rad, QC102-Welding, QC103-Mag, QC 90-71-101-Marking; and with SA352.... All special requirements of Art. NB2000 Sect. III 1971 and 1972 Winter Addenda have been met.

CHEMICAL & PHYSICAL REPORT CHECKED

BY

8/3/75 fm I

QC 8 8-13-75

STATE OF PENNSYLVANIA COUNTY OF LEBANON SS
SWORN TO AND SUBSCRIBED BEFORE ME

DAY OF 19

John Paul Jones
Authorized Inspector

"I CERTIFY THE ABOVE INFORMATION IS CORRECT"
QUAKER ALLOY CASTING CO.

BY Ralph E Redinger

MSIV (1F028 A, TYP.)

- BODY

HEAT NO: 8816

Limerick MSIV

#1

S.O.# 11683
Body 26"-655#
AE M11603-11
GE 2:5 AB319

Form 126 5-M 9-71

QUAKER ALLOY CASTING CO., MYERSTOWN, PA.

Report of Chemical Analysis and Physical Properties

CUSTOMER Atwood + Morrill Co. ORDER No. AM-3750 FILE No.

ADDRESS PATTERN No. 16614-30147-001 DESIGNATION 070

ATTENTION OF SPECIFICATION ASTM A216 WCB DATE 2-16-72

HEAT No.	C	Mn	Si	P	S	Cr.	Ni	Mo			Yield P. S. I.	Tensile P. S. I.	Elong. Per Cent.	Red. of Area Per Cent.	Categ Level	Grade Level #	Sh
F816	.25	.81	.47	.020	.013						43,500	75,000	27.5	53.8	F8816-1	K24 K295	
	"	"	"	"	"						"	"	"	"			
													S/N 1-683				

ADED QC ALP 2-18-1972 ASTM A216-68

AM - OK @ 2-17-72

100% Radiography Satisfactory in Accordance with ASTM E94 & E142 and Requirements of Quality Level 2 of ASTM E71 E446 & E280

100% Magnaflux Inspection Satisfactory per App. B-3 of Pump + Valve Code

Visual Inspection Satisfactory per MSS-SP-55

REMARKS: 2-16-72 TD

CHEMICAL & PHYSICAL REPORT CHECKED BY [signature]

"I Certify the above information is correct." DATE 3-29-72

QUAKER ALLOY CASTING CO.

BY Mark M. Lindi

2-1-72 Authorized Inspector

MSIV (1F028A, TYP.)

- COVER

HEAT NO: 219222

Form T-1c

C. NN & SAUL STEEL CO.

All Pcs. 11683

ROYERSFORD, PA.

Report of Physical Tests and/or Chemical Compositions

Date 9-21-71

Customer Atwood & Morrill Co.,Inc. Customer's Order No. AM-4075 Cann & Saul Order No. 7375

Address 285 Canal St. Salem, Mass. 01970

Attention Purch. Dept.

CHEMICAL COMPOSITIONS

HEAT NO.	C	MN	P	S	SI	CR	NI	MO	CB		
219222	.30	.68	.009	.014	.19						

Lab. No.

PHYSICAL TESTS

CUT FROM	TEST NUMBER	GAUGE	YIELD PT. LBS.	YIELD PER Square In Lbs.	BROKE AT LBS.	ULTIMATE TENSILE LBS.	ELONG %	REDUCED AREA	Reduction %	B.H.N.
Forging	7375 2	.505	9,400	47,000	15,100	75,500	30.0	.098	51.0	

OTHER TESTS

Ultrasonic to C&S Proc. A388, Rev. 4: O.K. 9-22-71

Mag. Part. C&S P&V #1.

Heat Treat Procedure C&S #1.

Customer's Specifications: ASTM A-105, Gr. 2

B.H.N.

Y. P. 36,000
T. 70,000
E. 22%
R. 30%

THE ABOVE TESTS COVER THE FOLLOWING MATERIAL:

7 - Machined Cover Forgings, Dwg. 20884-D, Code 32113-012-2972.
Forgings serial numbered #9,10,11,12,(13),14 & 15

A&M & G.E. Inspection

9/22/71 Vit. only

CANN & SAUL STEEL CO.

Inspector

C Bauer
Eng. of Tests

MSIV (1F028 A, TYP.)

- POPPET

HEAT NO: 21972

Form T-14

C[illegible]N & SAUL STEEL CO.

C+S # 15

POYERSFORD, PA.

11683-01-002 POPPET

Report of Physical Tests and/or Chemical Compositions

Date 1-12-72
6-27-72

S/N 5 THRU 8-683

Customer	Atwood & Morrill Co., Inc. 285 Canal St.	Customer's Order No. AM-4075 Add'l.	Cann & Saul Order No. 8018
Address	Salem, Mass. 01970	AM S.O. 11683-01 GE 205-AB319	

Attention Purch. Dept.

CHEMICAL COMPOSITIONS

HEAT NO.	C	MN	P	S	SI	CR	NI	MO	CB		
219727	.33	.72	.009	.016	.24						

Lab. No.

PHYSICAL TESTS

CUT FROM	TEST NUMBER		GAUGE	YIELD FT. LBS.	YIELD PER Square In Lbs.	BROKE AT LBS.	ULTIMATE TENSILE LBS.	ELONG %	REDUCED AREA	Reduction %	B.H.N.
Forging	8018	3	.505	9,500	47,500	15,000	75,000	30.0	.089	55.5	

OTHER TESTS

Ultrasonic to C&S Proc. A388, Rev. 4 dated 5-10-71 & Mod. 8-11-71:- O.K. Ref. D.D.R. #4377
Mag. Part to C&S Proc. P & V #1, Rev. 1 (7-14-71): O.K.
Heat Treat Procedure C&S #1.

QA TM # 7-683
C+S # 15

Customer's Specification: ASTM A-105, Gr. 2

B.H.N.

Y. P. 36,000
T. 70,000
E. 22%
R. 30%

THE ABOVE TESTS COVER THE FOLLOWING MATERIAL:

4 - Machined Poppet Forgings, Dwg. 30521-801D, Alt. 5, dated 1-17-72.

Forgings serial numbered #13 thru 16 inclusive.

AM S/N. 5 THRU 8-683

APED QC EHB

AM & GE
Inspection

CHEMICAL & PHYSICAL REPORT CHECKED

CANN & SAUL STEEL CO.

Inspector

BY [signature]
Eng. of Tests

DATE 7-31-72

Cert - Authorized Inspector

ATTACHMENT (3)

Stress Intensity Factor K_I Calculations for Assumed Flaws in 24-inch Feedwater Check Valve Body Castings

1. Bechtel prepared a report, Acceptability of 24-inch Feedwater Check Valves, Technical Report No. 1183-05EV, Revision 2, May 1984. It provided several justifications including a fracture mechanics evaluation to support the acceptability of the feedwater check valves. The fracture mechanics methodology used and actual step-by-step calculations are presented below in support of the use-as-is recommendation.

2. The Class II shrinkage criteria for X-ray examination of valve body castings were conservatively equated to a 3.50-inch long crack for the purpose of calculating K_I. This flaw was assumed to lie normal to the principal stress (membrane and bending stresses). For a mid-thickness flaw, the width (2a) was assumed to be 1.00-inch. For a surface flaw, the depth (a) was assumed to be 1.00-inch.

   (a) The methodology of ASME Section XI, Appendix A, Analysis of Flaw Indications, was used to calculate K_I.

$$K_I = \sigma_m M_m \sqrt{\pi} \sqrt{a/Q} + \sigma_b M_b \sqrt{\pi} \sqrt{a/Q} \qquad (1)$$

where

σ_m, σ_b = membrane and bending stresses, psi, in accordance with A-3200

a = minor half-diameter, in., of embedded flaw; flaw depth for surface flaw

Q = flaw shape parameter as determined from Fig. A-3300-1 using $(\sigma_m + \sigma_b)/\sigma_{ys}$ and the flaw geometry

M_m = correction factor for membrane stress (see Fig. A-3300-2 for subsurface flaws; Fig. A-3300-3 for surface flaws)

M_b = correction factor for bending stress (see Fig. A-3300-4 for subsurface flaws; Fig. A-3300-5 for surface flaws)

   (b) The results of calculations in the attached sheets are summarized as follows.

	Stress Intensity Factor K_I ksi$\sqrt{in}$ (For flaws in flat plate)	
	Midthickness	Surface
For design stresses Membrane stress = 18.5 ksi Bending stress = 10.2 ksi	26	32
For conservatively assumed stresses Membrane stress = 20 ksi Bending stress = 20 ksi	30	36

(c) The membrane stress correction factor M_m was compared with a correction factor F for surface flaws in an internally pressurized cylindrical body. See Sheet No. 6. Using an adjustment factor ($F/M_m = 1.27$), the following values were obtained to represent K_I for the assumed flaws in the valve body castings.

	Stress Intensity Factor K_I ksi$\sqrt{in}$ (For flaws in cylindrical bodies)	
	Midthickness	Surface
For design stresses Membrane stress = 18.5 ksi Bending stress = 10.2 ksi	26	40
For conservatively assumed stresses Membrane stress = 20 ksi Bending stress = 20 ksi	30	46

3. The maximum internal pressure during the 40°F lowest temperature operation is 1180 psi as compared to the 2100 psi standard calculation pressure for the above design stresses. The membrane stress corresponding to the 1180 psi internal pressure is 10.4 ksi. Using this value and the conservatively estimated 20 ksi bending stress, K_I calculations resulted in the following values.

	Stress Intensity Factor K_I ksi$\sqrt{in}$ (For flaws in cylindrical bodies)	
	Midthickness	Surface
Membrane stress = 10.4 ksi (corresponding to 40°F initial temperature) Bending stress = 20 ksi assumed	17	25

4. Estimated values for K_{Ic} from CVN energy absorption in certified material test reports are 110 to 190 ksi$\sqrt{in}$ (corresponding to 34 to 74 ft-lbs). These values give an ample margin against the above K_I values.

5. A surface flaw, 3.50-inch long x 1.00-inch deep, is a grossly exaggerated assumption for a valve body casting which was RT and MTed. This was done only to demonstrate the unlikelihood of brittle fracture.

6. Because of the solidification pattern of a casting, shrinkage will occur around the midthickness. Equating that to a flat crack-like flaw is still another conservative assumption.

7. The number of thermal transients and loading conditions are such that fatigue cracking will not develop from the above flaws. This is due to the low number of thermal cycles and low stress intensity factor ranges (ΔK).

8. A K_I value of 90 ksi$\sqrt{in}$ on page 9 of the Bechtel report (No. 1183-05EV) is a typographical error of 50 ksi$\sqrt{in}$, which was a value by rounding off 46 ksi$\sqrt{in}$ for the worst case.

BECHTEL

CALCULATION SHEET

DATE 8/22/84

DESIGN BY YUN CHUNG DATE _____ CHECKED BY RAW 8/30/84 SHEET NO 1

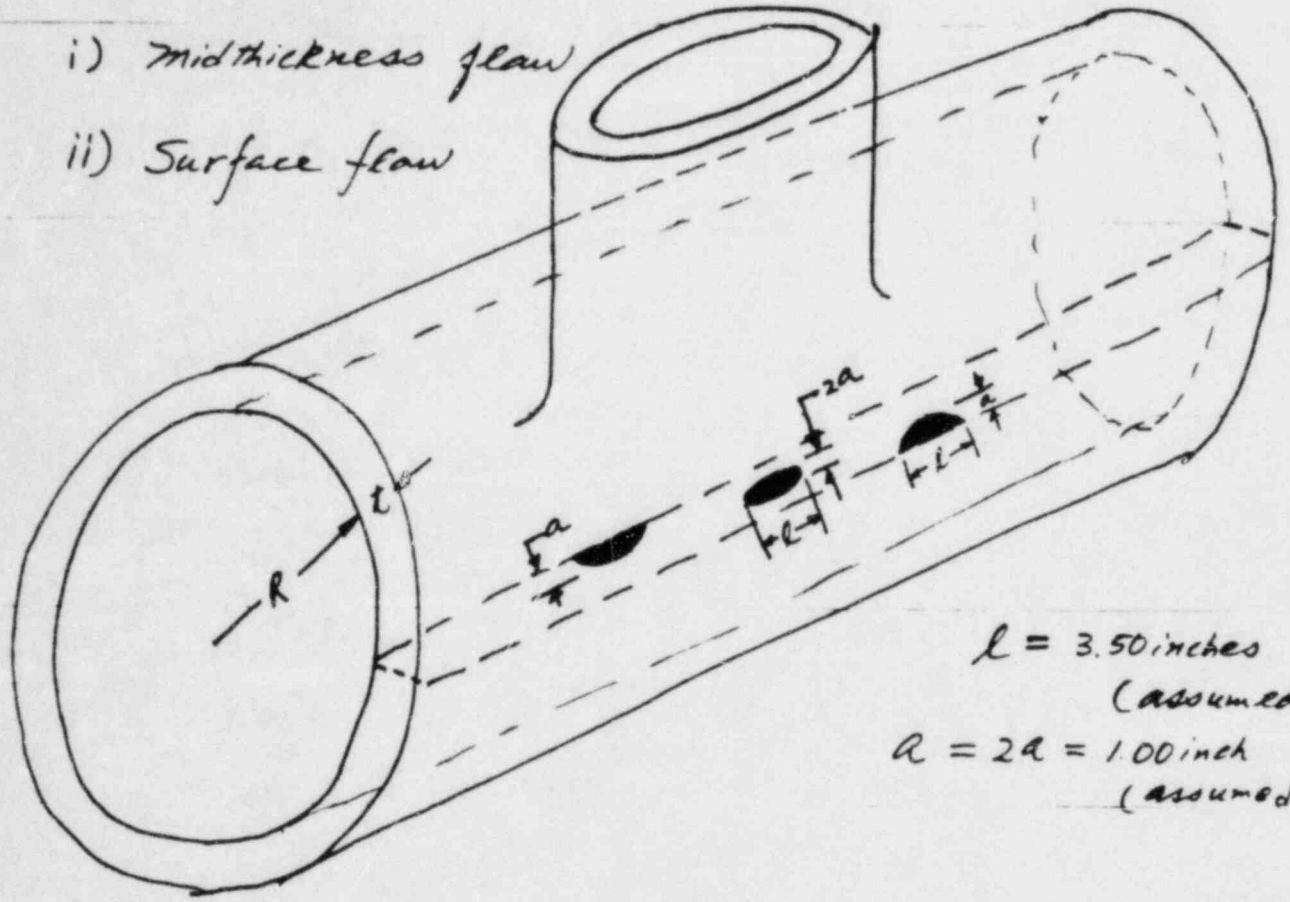
PROJECT Limerick JOB NO 8031-000

SUBJECT Fracture Mechanics Evaluation of 24-inch Feedwater Check Valves CALCULATION NO _____ FILE NO _____

1. Flaw assumptions

i) Midthickness flaw

ii) Surface flaw



ℓ = 3.50 inches (assumed)

$a = 2a$ = 1.00 inch (assumed)

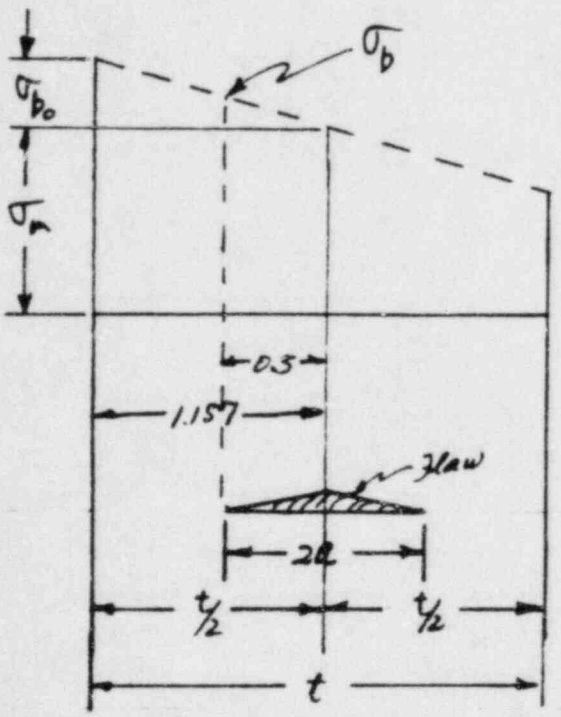
2. Data from Design Report for 24" Feedwater Check Valve (Atwood & Morrill order No. 12521, Sept 28, 1972)

R = 11.50 inches t = 2.313 inches

P_m = 18.5 ksi membrane stress

P_{eb} = 10.2 ksi Bending Stress

3. K_I Calculation for a Midthickness Flaw



(Fig. A-3200-1 (b))

$t = 2.313$ inches

$2a = 1.00$ (assumed)

$\sigma_m = P_m = 18.5$ ksi

$\sigma_{bo} = P_{eb} = 10.2$ ksi

$\sigma_b = \sigma_{bo} \cdot \frac{0.5}{1.157}$

$= (10.2)\left(\frac{0.5}{1.157}\right) = 4.41$ ksi

$\sigma_{ys} = 40$ ksi

$\frac{\sigma_m + \sigma_b}{\sigma_{ys}} = \frac{18.5 + 4.4}{40} = 0.57$

$\frac{a}{l} = \frac{0.5}{3.5} = 0.143$

$Q = 1.13$ (From Fig. A-3300-1)

$\frac{2e}{t} = 0$ $\frac{2a}{t} = \frac{1}{2.313} = 0.43$

$M_m = 1.14$ (Fig. A-3300-2)

$M_b = 0.24$ (Fig. A-3300-4)

$K_I = \sigma_m M_m \sqrt{\pi} \sqrt{a/Q} + \sigma_b M_b \sqrt{\pi} \sqrt{\frac{a}{Q}}$

$= \sqrt{3.14} \cdot \sqrt{\frac{0.5}{1.13}} \{(18.5)(1.14) + (4.4)(0.24)\}$

$= (1.77)(0.67)(21.1 + 1.1)$

$K_I = 26$ ksi $\sqrt{\text{in}}$

If $\sigma_m = P_m = 20$ ksi

$\sigma_{bo} = 20$ ksi

Then, $\sigma_b = \sigma_{bo} \cdot \frac{0.5}{1.157} = 8.64$

$\frac{\sigma_m + \sigma_b}{\sigma_{ys}} = \frac{20 + 8.64}{40} = 0.72$

$Q = 1.08$

$M_m = 1.14$

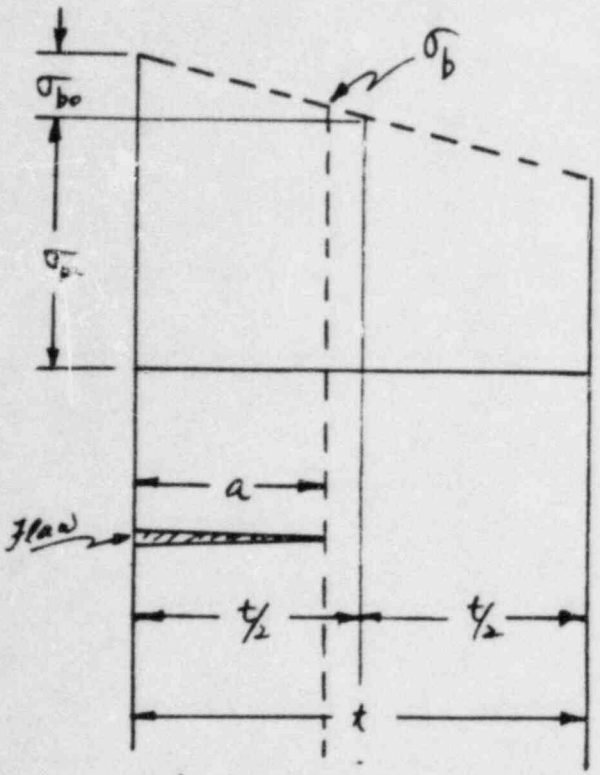
$M_b = 0.24$

$K_I = \sqrt{3.14}\sqrt{\frac{0.5}{1.08}}\{(20)(1.14) + (8.64)(0.24)\}$

$= (1.77)(0.68)(22.8 + 2.1)$

$= 30$ ksi $\sqrt{in}$

4. K_I Calculation for a Surface Flaw



$t = 2.313$ inches

$a = 1.00$ inch (assumed)

$\sigma_m = P_m = 18.5$ ksi

$\sigma_{bo} = P_{eb} = 10.2$ ksi

$$\sigma_b = (10.2)\left(\frac{t/2 - a}{t/2}\right) = (10.2)\left(\frac{1.157 - 1.00}{1.157}\right)$$

$$= 1.4 \text{ ksi}$$

$$\frac{\sigma_m + \sigma_b}{\sigma_{ys}} = \frac{18.5 + 1.4}{40} = 0.5$$

$$\frac{a}{\ell} = \frac{1.00}{3.50} = 0.286$$

$Q = 1.56$ (from Fig. A-3300-1)

$a/t = 1/2.313 = 0.43$

$a/\ell = 1/3.50 = 0.29$

$M_m = 1.18$ (from Fig. A-3300-3)

$M_b = 0.50$ (from Fig. A-3300-5)

$$K_I = \sigma_m M_m \sqrt{\pi} \sqrt{a/Q} + \sigma_b M_b \sqrt{\pi} \sqrt{a/Q}$$

$$= \sqrt{3.14}\sqrt{\frac{1}{1.56}}\{(18.5)(1.18) + (1.4)(0.5)\}$$

$$= (1.77)(0.801)(21.8 + 0.7)$$

$K_I = 32$ ksi $\sqrt{\text{in}}$

If $\sigma_m = 20$ ksi, $\sigma_{bo} = 20$ ksi

Then, $\sigma_b = (20)\left(\frac{1.157 - 1.00}{1.157}\right) = 2.7$ ksi

$$\frac{\sigma_m + \sigma_b}{\sigma_{ys}} = \frac{20 + 2.7}{40} = 0.57$$

$Q = 1.54$

$M_m = 1.18$

$M_b = 0.50$

$$K_I = \sigma_m M_m \sqrt{\pi}\sqrt{\frac{a}{Q}} + \sigma_b M_b \sqrt{\pi}\sqrt{\frac{a}{Q}}$$

$$= \sqrt{3.14}\sqrt{\frac{1.00}{1.54}}\left\{(20)(1.18) + (2.7)(0.5)\right\}$$

$$= (1.77)(0.81)(23.6 + 1.4)$$

$$= 36 \text{ ksi}\sqrt{\text{in}}$$

5. Boundary-Correction Factor F for surface flaws

Raju and Newman, Jr* gave the following equations for F for surface cracks in an internally pressurized cylinder.

*J. of Pressure Vessel Technology, V.104 (Nov. 1982) PP 293-298

For internal surface cracks

$$F_i = \frac{t}{R}\left(\frac{R_o^2}{R_o^2 - R^2}\right)\left[2G_0 - 2\left(\frac{a}{R}\right)G_1 + 3\left(\frac{a}{R}\right)^2 G_2 - 4\left(\frac{a}{R}\right)^3 G_3\right]$$

$R_o = R + t = 11.50 + 2.313 = 13.8$ $\quad a/t = 1/11.5 = 0.087$

$G_0, \cdots, G_3$ are given in Table 2* ($t/R = 0.25$, $a/t = 0.4, 0.5$, $\frac{2\phi}{\pi} = 1.0$)

$$= \frac{2.313}{11.5}\left(\frac{13.8^2}{13.8^2 - 11.5^2}\right)\left[(2)(1.193) - 2(0.087)(0.715) + 3(0.087)^2(0.545) - 4(0.087)^3(0.454)\right]$$

$$= (0.201)(3.27)\{2.386 - 0.124 + 0.012 - 0.001\}$$

$$= 1.5$$

For external surface cracks

$$F_e = \frac{t}{R}\left(\frac{R^2}{R_o^2 - R^2}\right)\left[2G_0 + 2\left(\frac{a}{R_o}\right)G_1 + 3\left(\frac{a}{R_o}\right)^2 G_2 + 4\left(\frac{a}{R_o}\right)^3 G_3\right]$$

$a/R_o = 1/138 = 0.072$

For $G_0, \cdots, G_3$, see Table 4 of the reference (see the next page)

$$= \frac{2.313}{11.5}\left(\frac{11.5^2}{13.8^2 - 11.5^2}\right)\left[(2)(1.360) + 2(0.072)(0.773) + 3(0.072)^2(0.575) + 4(0.072)^3(0.472)\right]$$

$$= (0.201)(2.27)(2.72 + 0.111 + 0.009 + 0.001)$$

$$= 1.3$$

6. Ratio of F_i vs M_m $\quad F_i/M_m = 1.5/1.18 = 1.27$

7. Correction for K_I surface flaw $= 32 \text{ ksi}\sqrt{\text{in}} \times 1.27 = 40 \text{ ksi}\sqrt{\text{in}}$, of $P_m = 18.5$ ksi, $P_{eb} = 10.2$ ksi.

$\text{or} = 36 \times 1.27 = 46 \text{ ksi}\sqrt{\text{in}}$, of $P_m = 20$ ksi, $P_{eb} = 20$ ksi.

Table 4 Influence coefficients, G_j, for semi-elliptical surface crack on outside of a cylinder ($t/R = 0.25$)

Type of loading	a/c	$\frac{2\phi}{\pi}$ \ $\frac{a}{t}$	0.2	0.5	0.8	0.2	0.5	0.8	0.2	0.5	0.8
			0.2			0.4			1.0		
Uniform (G_0)		0	0.612	0.786	1.160	0.793	0.994	1.400	1.163	1.286	1.498
		0.25	0.752	0.952	1.346	0.828	1.016	1.365	1.088	1.184	1.320
		0.5	0.972	1.278	1.860	0.967	1.175	1.513	1.049	1.123	1.183
		0.75	1.114	1.541	2.364	1.072	1.311	1.682	1.034	1.100	1.163
		1.0	1.162	1.640	2.510	1.109	1.360	1.727	1.030	1.094	1.156
Linear (G_1)		0	0.080	0.134	0.242	0.130	0.195	0.318	0.204	0.243	0.302
		0.25	0.209	0.272	0.389	0.252	0.315	0.421	0.365	0.396	0.435
		0.5	0.430	0.532	0.713	0.451	0.521	0.626	0.546	0.570	0.583
		0.75	0.618	0.767	1.044	0.620	0.702	0.833	0.674	0.698	0.724
		1.0	0.691	0.861	1.178	0.685	0.773	0.914	0.720	0.743	0.777
Quadratic (G_2)		0	0.023	0.049	0.097	0.045	0.078	0.134	0.077	0.096	0.122
		0.25	0.076	0.106	0.159	0.100	0.130	0.180	0.156	0.171	0.188
		0.5	0.241	0.291	0.376	0.261	0.295	0.345	0.336	0.347	0.350
		0.75	0.437	0.513	0.654	0.447	0.489	0.556	0.516	0.527	0.542
		1.0	0.524	0.613	0.782	0.530	0.575	0.653	0.591	0.603	0.625
Cubic (G_3)		0	0.010	0.025	0.051	0.022	0.041	0.073	0.040	0.051	0.064
		0.25	0.032	0.050	0.079	0.046	0.064	0.093	0.077	0.086	0.095
		0.5	0.148	0.177	0.225	0.164	0.184	0.212	0.220	0.226	0.226
		0.75	0.337	0.383	0.468	0.350	0.375	0.416	0.418	0.424	0.433
		1.0	0.434	0.488	0.596	0.445	0.472	0.523	0.513	0.520	0.536

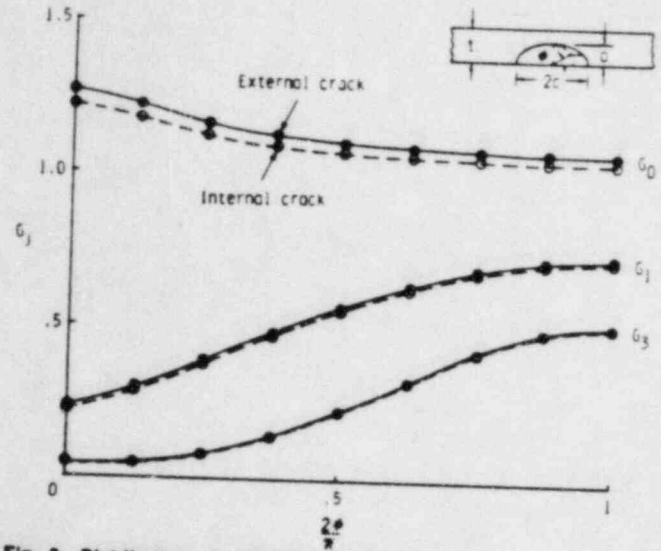


Fig. 3 Distribution of influence coefficients along crack front for semi-circular internal or external surface crack in cylindrical vessel ($t/R = 0.1$; $a/c = 1.0$; $a/t = 0.5$)

cylinder under the desired loading. The hoop stress distribution is then expanded or fitted into the form

$$\sigma_{\theta\theta} = \sum_{j=0}^{3} A_j z^j \tag{3}$$

where z is measured from the proposed crack mouth toward the crack front (see Fig. 2(c)). Rewriting equation (3) to agree with the form of equation (1) gives

$$\sigma_{\theta\theta} = \sum_{j=0}^{3} A_j a^j \left(\frac{z}{a}\right)^j \tag{4}$$

where the term $A_j a^j$ is the scale factor to be applied to equation (2) to obtain the corresponding stress-intensity factor. The stress-intensity factor for the $\sigma_{\theta\theta}$ distribution is then given by

$$K_I = \sqrt{\pi \frac{a}{Q}} \sum_{j=0}^{3} G_j A_j a^j \tag{5}$$

The G_j values for all crack configurations analyzed in this study are tabulated in Tables 1 through 4.

Application to Internal Pressure

The influence-coefficient procedure was applied to obtain the stress-intensity factors for internally pressurized cylinders with internal and external surface cracks.

Internal Surface Cracks. The stress-intensity factors for an internal surface crack in an internally pressurized cylinder were obtained from equations (3) through (5) using Lamé's solution [11] for the hoop stress ($\sigma_{\theta\theta}$) in an uncracked internally pressurized cylinder. For convenience, the stress-intensity factor was written as

$$K_I = \frac{pR}{t} \sqrt{\pi \frac{a}{Q}} F_i \left(\frac{a}{c}, \frac{a}{t}, \frac{t}{R}, \phi\right) \tag{6}$$

where pR/t is the "average" hoop stress and F_i is the boundary-correction factor for a surface crack on the inside of an internally pressurized cylinder. The expression for F_i, in terms of G_j, was obtained from the first four terms of a power-series expansion of Lamé's solution with the coordinate origin at the inside of the cylinder, plus the internal pressure applied to the crack surfaces. The result is

$$F_i = \frac{t}{R} \left(\frac{R_0^2}{R_0^2 - R^2}\right) \left[2G_0 - 2\left(\frac{a}{R}\right) G_1 + 3\left(\frac{a}{R}\right)^2 G_2 - 4\left(\frac{a}{R}\right)^3 G_3\right] \tag{7}$$

where each G_j was obtained from the appropriate finite-element solution (Tables 1 and 2) for the particular values of t/R, a/c, a/t, and ϕ.

External Surface Crack. The stress-intensity factors for an external surface crack in an internally pressurized cylinder were also obtained from equations (3) through (5), again using Lamé's solution. The stress-intensity factor was written as

$$K_I = \frac{pR}{t} \sqrt{\pi \frac{a}{Q}} F_e \left(\frac{a}{c}, \frac{a}{t}, \frac{t}{R}, \phi\right) \tag{8}$$

where F_e is the boundary-correction factor for a surface crack located on the outside of an internally pressurized cylinder. The expression for F_e, in terms of G_j, was obtained from the first four terms of a power-series expansion of Lamé's solution with the coordinate origin at the outside of the cylinder. The result is