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UNITED STATES GOVERNMENT

Memorandum

TO : R. S. Boyd, Assistant Director
for Reactor Projects
Division of Reactor Licensing

DATE: May 4, 1967

FROM : B. H. Grier, Senior Reactor Inspector
Division of Compliance
B H Grier

SUBJECT: NORTHERN STATES POWER COMPANY (MONTICELLO)
DOCKET NO. 50-263

The attached report by our inspector of a visit to the Chicago Bridge and Iron Company plant in Birmingham, Alabama, on March 8-9, 1967, is forwarded for information. Based on the results of this visit, we are of the opinion that CB&I's effort on the Monticello vessel, both with respect to work being performed and the management of the job, is entirely satisfactory and the quality being achieved is equal to that of the other two pressure vessel fabricators.

You will note that Addendums I, II and III of the report contain proprietary information.

Attachment:
CO Rpt No. 263/67-1
by G. W. Reinmuth
dtd 4/27/67

Distribution:
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U. S. ATOMIC ENERGY COMMISSION
HEADQUARTERS
DIVISION OF COMPLIANCE

April 27, 1967

CO Report No. 263/67-1

TITLE: NORTHERN STATES POWER CO. (MONTICELLO)
LICENSE NO. Pending
Date of Visit: March 8-9, 1967

By: G. W. Reinmuth, Reactor Inspector (Prog. Stnds.)

SUMMARY

The Chicago Bridge and Iron Company (CB&I) plant in Birmingham, Alabama, was visited to review fabrication progress of the reactor vessel for the Northern States Power Company Monticello reactor.

Results of the visit disclosed that fabrication of the bottom head and lower shell section is in progress. Fabrication and testing procedures in use were observed to be those described in Amendment No. 2 to the application. Based on observations of the work and review of the records, work quality and management of the program were found to be satisfactory and comparable with other pressure vessel vendors.

Test data demonstrating the effects of cold forming upon the properties of A302-B and A533 material was provided and is included in this report as Addendums I and II. Results of these tests indicate there are no adverse effects upon the material due to cold forming.

DETAILS

I. Scope of Visit

A visit was made to the Chicago Bridge and Iron Company fabrication plant in Birmingham, Alabama, for the purpose of reviewing the progress of the pressure vessel for the Northern States Power Company Monticello reactor project.

The principal persons contacted during the visit were the following:

A. G. Smith, Vice President, Southeast Operations
A. J. Larson, Birmingham Plant Manager
E. E. Varnum, Manager, Quality Control (Monticello job)
Q. W. Kneen, Quality Control Coordinator (Monticello job)
R. E. Clotfelter, Regional Welding Engineer
E. Ripley, Production Control Engineer (Monticello job)
H. Stiles, Test Engineer
C. D. Pugh, Test Engineer
A. Parker, Nondestructive Testing Supervisor

(continued)

II. Results of Visit

A. Status of Vessel

Nine plates for the Monticello reactor vessel were on site at the Birmingham plant. Physical and chemical test data from this material were provided as shown by Addendum IV.

Welding of the three formed segments for the bottom dollar plate was in progress and was approximately 70% complete. Fit-up of the eight formed pieces which make up the knuckle section between the bottom dollar plate and the first ring section was also in progress. All of the above pieces had been cold formed according to procedures described in the application (Amendment No. 2). Cold ultrasonic tests (UT) by the plate supplier in the flat condition and by CB&I after forming disclosed no imperfection in the material used. Two doubtful areas were found, however, in locations which could be discarded as scrap. No repairs, except for minor surface indentations, were needed on any of the material received to date.

Two of the larger plates to be used for the ring shell sections had been cold formed. Magnetic particle (MP) and UT tests of these two pieces were pending at the time of the visit.

B. Schedule

Completion of work on the bottom dollar plate at the Birmingham plant is scheduled in June at which time the piece will be shipped to the CB&I Greenville, Pennsylvania, plant for rough machining of the rod drive holes. Initial work at the Monticello site is not expected before November 1967 and is more dependent upon other facility work than shop progress of the pressure vessel components.

C. Observations of Work in Progress

1. Welding

Observation of the welding process employed on the two main welds of the bottom dollar plate indicated the procedure in use followed that described in the application. Three welders were working on the piece applying weld metal by the manual electrode process. They were under the direct supervision of a supervisor who remained with the welders and had no other assigned duties. CB&I personnel stated all welding on the Monticello vessel both in the shop and field would be performed by the manual method.

(continued)

Results of Visit (continued)

Preheat to the work was being applied by gas jets to maintain temperatures within the 3-400°F range.

While the quality of the welds must ultimately be determined by radiographic testing, visual observations appeared to indicate the high quality claimed by CB&I.

2. Fit-up

Fit-up of the bottom knuckle section was being performed through use of a circular forming and supporting jig. At the top and bottom of the jig were circular rings fabricated to the final outside dimensions against which the work was fitted. Gaps between the work and the jig at these two circumferential reference surfaces were no greater than ¼" at any point.

The knuckle section of eight individual pieces was to be welded together in halves of four pieces each. Preparation and sizing of the two final weld joints between the halves were left until last to compensate for any expansion or distortion resulting from the welds in the half sections.

Out of roundness is checked by use of templates. Allowable variation between the template and the work are greater than ½" on a six-foot chord; however, CB&I personnel state they are able to achieve variations in the neighborhood of 1/8" by use of the cold forming process.

3. Ultrasonic Testing

A demonstration of the normal UT techniques used by CB&I was performed on one of the bottom knuckle sections. The procedure employs manual manipulation of the detector transducer over the surface in both the longitudinal and transverse directions giving 100% volumetric coverage. Longitudinal wave inspection only on the formed plates is required. A hydroxy ethyl cellulose couplant is used.

(continued)

Results of Visit (continued)

Adjustment of the scope readout against a drilled flat bottom hole in a test block is used as the calibration and acceptance standard. See Appendix F, Amendment No. 2 to the Application for the detailed UT procedure. Compliance with the approved procedure was demonstrated in all respects. To aid in initial detection of potential flaw areas, the scope gain was routinely set up by a factor of ten by the operator. Upon detection of a suspect area, the gain is reset to the normal range, the instrument recalibrated, and the area scrutinized in detail to determine size and acceptability.

D. Cold Forming Considerations

Since cold forming of the plate after quench and temper is one of the principal differences in method used by CB&I as compared to other fabricators, CB&I conducted a series of tests to demonstrate the effects upon the physical and impact properties of the material.

Addendum I is a detailed report of the tests conducted on A302-B steel prior to receipt of the production material. Similar tests were also conducted on a portion of the A533 Gr. B. production material, during the welding procedure qualification tests as required by code and G-E. All information provided in Addendums I, II and III should be treated as proprietary.

The principal results demonstrated by these tests are:

1. Significant variation in both tensile and impact properties occurs across the thickness of a plate. Plate surfaces show better properties than the center.

2. Cold forming does not significantly affect properties at the surface of a plate but does result in some improvement internally with the maximum improvement at the mid-plane.

3. Longitudinal test specimens (parallel to direction of plate rolling) show significantly better impact properties than transverse test specimens (90° orientation to direction of plate rolling) taken at comparable locations.

4. Test results between A302-B and A533 Gr. B. material were consistent as to the effects of cold forming.

(continued)

Results of Visit (continued)

5. All data indicate the production material exceeds the minimum requirements for use in a nuclear pressure vessel.

Impact tests were conducted on a new, charpy test apparatus installed and calibrated within the past six months. Calibration of the machine was checked by standard samples supplied by the U. S. Army Materials Research Agency (Watertown Arsenal). A new automated drop weight test apparatus had also been installed. Impact, drop weight and tensile tests on material from plates 1-16 and 1-17 (see Addendum IV) were observed. Standard procedures were employed.

Test samples of all types for the material received to date had been taken from the top end of the billet which presumably represents the worst part of a plate. CB&I indicated, however, they would not necessarily follow this procedure on subsequent tests.

One advantage noted in using cold forming techniques was the improved surface conditions of the plates. With hot forming, followed by quench and temper operations, a heavy scale is left on the plate which has to be removed by sand blasting prior to cladding. Only minor touch up work is required on the cold formed plates.

A precaution practiced by CB&I was the preliminary machining or rounding-off of the edges of a plate on the tension side prior to cold forming. This procedure is intended to eliminate possible "crack starter" imperfections. Preheat to 100°F is also employed. No difficulty has been experienced to date in cold forming the thicknesses used in the Monticello vessel (6¼" on bottom dollar plate and 5¼" on shell plates).

E. Welder Qualifications

CB&I classify their permanent employee welders at Montgomery into Class I, II or III categories. Pay scales are based upon these classifications. The conditions of qualification tests for Class II and III welders are arranged and agreed to by both CB&I and the union local. For Class I welders, the company has sole authority for establishing and controlling qualifications. CB&I personnel stated that the work of Class I welders is matched against radiographic results and that 70% of the Class I welders consistently demonstrate 100% acceptability. The remaining 30% score above 90%. For the Monticello work only Class I welders will be used and those only on a selected basis.

(continued)

Results of Visit (continued)

In reviewing records of welder qualification tests, it was noted that no recent qualification records existed. Those that were examined indicated that the welders were qualified primarily on A387-D material. CB&I stated that the welding of A387-D was considerably more difficult than the A533 material used in the Monticello vessel. Their position was that if a welder were qualified to weld A387-D material, he was automatically qualified on A533. CB&I further pointed out that their shop employees are permanent employees who are welding day after day, under supervision and are continuously demonstrating their competency. To require periodic welding of test plates only for the purpose of updating a record is in their opinion meaningless. CB&I emphasizes, however, that this applies only to permanent shop employees and not to temporary field employees.

CB&I recognized that the lack of up to date records was a technical violation of code and indicated that steps would be taken to comply with the requirements. The G-E quality control representative also indicated he would insist that formal qualification of welders be conducted and that the records be updated. Follow-up on this particular item will be accomplished during the next visit. No further effort is considered necessary at this time.

F. Record System

G-E has required CB&I to establish a record system similar to that in use by other fabricators. While this type of comprehensive system is new to CB&I and minor difficulties are being experienced in orienting personnel in its use, CB&I management is making a diligent effort to make the system work. From observation of the work to date, the system is proving to be effective in providing a record of and controlling the work in progress. Some future difficulty is anticipated when simultaneous work is in progress on several pieces of the vessel at three different locations.

G. Exit Interview

Discussions were held periodically during the visit with Mr. Varnum and a short final one at the conclusion of the visit. Updating of welder qualification records was agreed upon. Since in the inspector's judgment, progress of the work was satisfactory, no further items of significance were discussed.

Attachments:
Addendums I-IV

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CHICAGO BRIDGE & IRON COMPANY
BIRMINGHAM WELDING

Experiment No. L 125
Reported Sept. 20, 1966

Title:

Effects of Forming A302-B - 4% Deformation

Introduction:

The plate material for Contract 9-5624 is 5½" thick A533 Grade B. This material has been ordered Q & T at the mill and will be cold formed at the Birmingham plant. The shell material will be deformed approximately 2½%.

Since impact properties are critical with Nuclear Power Plant work, this investigation was made to determine the effects of cold deformation on this type of material. The shell material on 9-5624 will be deformed approximately 2½%, but it was decided to use 4% deformation in this test.

Since A533 Grade B was not available, A302-B was substituted in this experiment. The alloys are the same except for .5% Ni which is added to improve impacts in A533-B. This evaluation was made to determine the relative effects of cold deformation, therefore this substitution of similar materials should have no bearing on the results.

Material:

A plate 16" x 5½" x 45" of A302-B was used in this investigation. This plate had been quenched from 1625-1675°F and tempered at 1200-1250°F for 5½ hours by the mill. Mill test report showed the following:

Heat #	C	Mn	P	S	Si	Mo
A8049	.19	1.25	.011	.017	.22	.46

Heat #	Yield	Tensile	Elong .2"	"V" notch +10°F
A8049	64.0	81.7 88.2	29	86-68-78
	64.3	86.7 86.7	34	96-66-84

Equipment:

The test plate was formed on the 3,000 ton press. Heat treating was done in the Lindberg electric furnace. Machining and testing was done with equipment in the Birmingham laboratory.

Procedure:

After removing one test sample 7" x 5½" x 16", (125A) the remainder of the 5½" thick test plate (125B) was cold formed in one direction to a 66" radius which is equivalent to 4% stretch. Forming was done perpendicular to the mill rolling direction. After cold forming on the 3,000 ton press both samples, 125A & 125B, were stress relieved at 1150°F ± 25°F for 20 hours.

Tensile and impact specimens from these samples were taken at the top, 1/4T, 1/2T, 3/4T and bottom as shown in Fig. 1.

Results:

All results are given in Tables I and II.

Discussion:

A. Tensile Strength - From the data given in Table I it may be noted that tensile properties are not detrimentally affected by cold forming to 4% stretch. The only real change was an increase in strength in the center of the plate which was beneficial. This is shown in Figures 2 and 3. This change may be due to some cold work the center of the plate received during the cold pressing operation.

B. Impact Properties - Impact properties are not adversely affected by cold deformation as shown by the data of Table II and Figures 4 & 5. These properties appear to have been enhanced as may be noted in Figures 4 & 5.

Thickness does have a major effect on impact properties as may be noted in Figures 6, 7, 8 and 9. This is probably the reason for the nickel addition in A533 Gr. B.

Conclusions:

1) Cold deformation of 4% stretch in 5½" thick A302-B does not adversely affect tensile properties.

2) Cold deformation of 4% stretch in 5½" thick A302-B does not adversely affect impact properties.

3) Impact properties of Q & T A302-B are adversely affected by plate thickness.

C. D. Pugh

C. D. Pugh
Birmingham Welding

mj

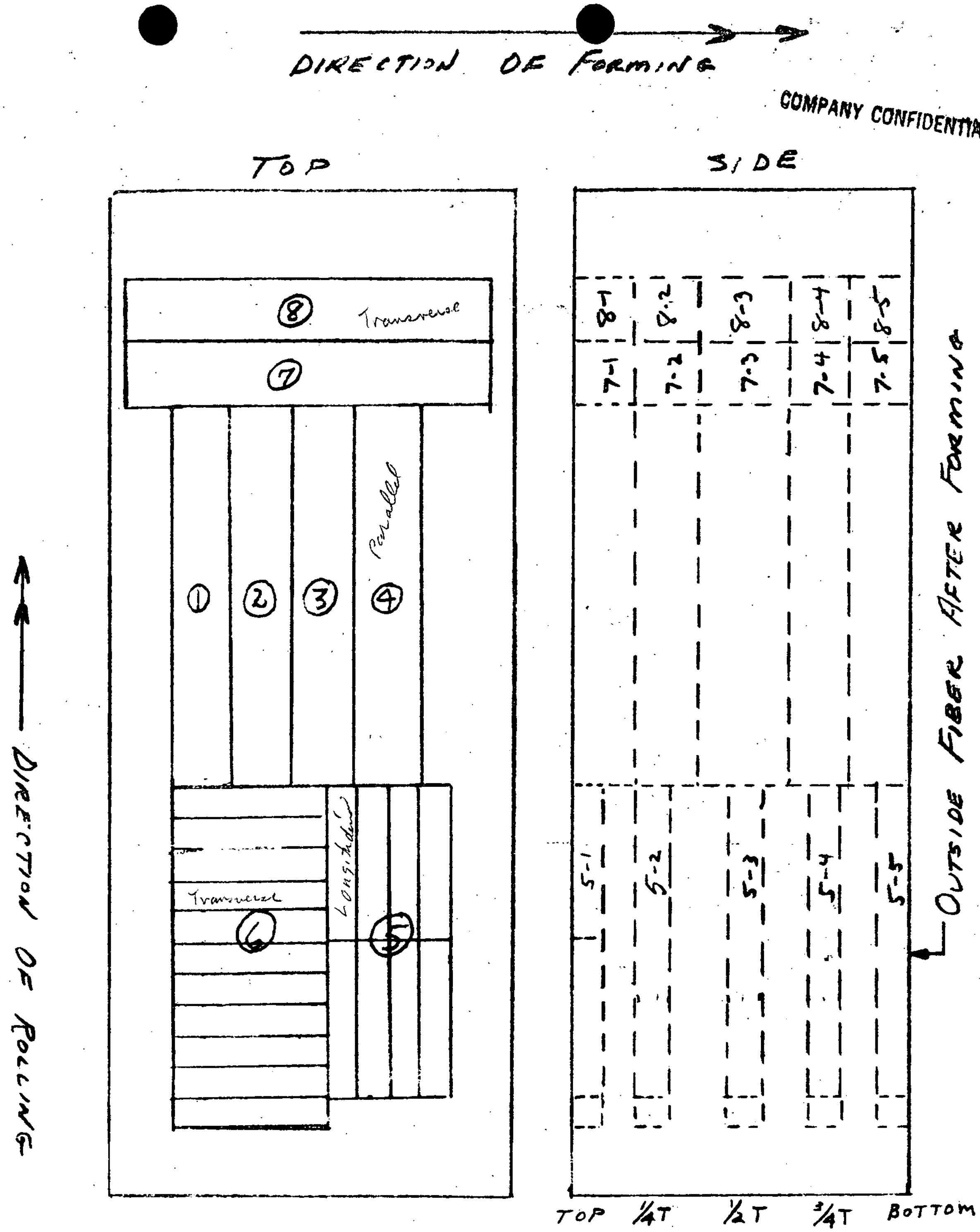

FIGURE 1. LOCATION OF SAMPLES FOR 125A & 125B

① - TENSILES AT 575°F
② - TENSILES AT 575°F
③ - TENSILES AT R.T.
④ - TENSILES AT R.T.
⑤ - IMPACTS
⑥ - IMPACTS
⑦ - TENSILES AT 575°F
⑧ - TENSILES AT RT

Table I - Tensile Data of Samples 125A & 125B

Sample	Temp.	Tensile X1000 psi	Yield X1000 psi	R/A %	E (2")
125A - Q & T & S.R.- Flat Plate					
A-3 - Top	R.T.	86.8	65.5	73.3	27.0
A-3 - ¼T	"	84.1	62.2	69.8	28.0
A-3 - ½T	"	80.5	58.6	67.8	27.5
A-3 - 3/4T	"	84.0	62.2	69.8	27.5
A-3 - Bottom	"	84.5	63.2	71.1	27.5
A-4 - Top	R.T.	86.0	65.0	72.4	26.5
A-4 - ¼T	"	84.1	62.2	69	27.0
A-4 - ½T	"	80.7	59.4	65.6	26.5
A-4 - 3/4T	"	83.7	62.2	70.4	28.0
A-4 - Bottom	"	84.8	63.2	72	28.0
A-8 - Top	R.T.	87.5	65.8	62.4	25.0
A-8 - ¼T	"	84.4	62.4	59	25.0
A-8 - ½T	"	81.1	59.3	61.1	24.5
A-8 - 3/4T	"	83.5	61.6	59	25.5
A-8 - Bottom	"	83.4	62.6	61.6	25.0
A-1 - Top	575°F	82.1	57.2	67.9	25.0
A-1 - ¼T	"	78.7	57.9	44.4	-
A-1 - ½T	"	77.5	57.4	57.1	20.5
A-1 - 3/4T	"	78.6	56.0	64.9	23.5
A-1 - Bottom	"	79.0	56.3	68	23.5
A-2 - Top	575°F	82.4	56.8	69.5	24.0
A-2 - ¼T	"	79.0	57.6	64.8	24.0
A-2 - ½T	"	78.4	58.5	56.5	20.0
A-2 - 3/4T	"	78.2	53.8	64.1	22.5
A-2 - Bottom	"	79.1	55.5	68.0	24.5
A-7 - Top	575°F	80.5	55.5	58.5	21.0
A-7 - ¼T	"	78.7	54.9	49.7	20.5
A-7 - ½T	"	77.5	56.8	45.5	18.5
A-7 - 3/4T	"	78.7	55.6	51.2	20.0
A-7 - Bottom	"	78.6	53.7	36.5	-
125B- Q & T - Cold Formed & S.R.					
B-3 - Top	R.T.	88.2	67.5	73.8	27.0
B-3 - ¼T	"	84.0	61.5	69.8	27.5
B-3 - ½T	"	85.8	61.9	67	26.5
B-3 - 3/4T	"	84.0	62.9	69.5	26.5
B-3 - Bottom	"	84.1	63.7	71.6	28.0
B-4 - Top	R.T.	87.5	66.5	74.4	27.0
B-4 - ¼T	"	84.0	62.7	71	28.0
B-4 - ½T	"	85.8	63.0	68.2	27.0
B-4 - 3/4T	"	84.2	63.2	70.3	27.0
B-4 - Bottom	"	84.6	64.0	71.9	27.0

Table I (Cont'd.)

Sample	Temp.	Tensile X1000 psi	Yield X1000 psi	R/A %	E(2")
125B - Q & T - Cold Formed & S.R.					
B-8 - Top	R.T.	85.5	64.5	64	26.5
B-8 - ¼T	"	83.2	61.1	58.7	25.5
B-8 - ½T	"	85.5	61.6	57.1	26.0
B-8 - 3/4T	"	84.1	62.4	54.8	24.5
B-8 - Bottom	"	84.4	62.7	62.4	26.5
B-1 - Top	575°F	81.8	57.8	69.5	23.0
B-1 - ¼T	"	78.3	54.2	65.1	23.0
B-1 - ½T	"	79.7	58.4	59.9	21.0
B-1 - 3/4T	"	78.2	58.0	65.6	22.5
B-1 - Bottom	"	78.9	59.4	67.4	23.0
B-2 - Top	575°F	78.1	58.5	68	25.0
B-2 - ¼T	"	82.1	-	65.8	23.0
B-2 - ½T	"	78.6	54.5	60.5	21.5
B-2 - 3/4T	"	80.4	56.5	61	22.0
B-2 - Bottom	"	78.8	59.4	68.3	23.0
B-7 - Top	575°F	82.0	60.6	58.8	24.0
B-7 - ¼T	"	78.4	57.0	39.3	-
B-7 - ½T	"	80.5	59.6	50.7	21.0
B-7 - 3/4T	"	78.6	54.5	51.7	20.0
B-7 - Bottom	"	78.4	54.5	58.4	20.5

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Table II - Impact Data of Samples 125A & 125B

Sample	Temp.	Ft.Lbs.	L.E. mils	%Shear
125A - Flat Plate				
5-1 - Top	+50	158	97	100
"	+50	138	90	100
"	+10	122	79	80
"	+10	118	82	75
"	-50	114	79	65
"	-50	92	65	50
"	-100	60	45	20
"	-100	15	14	2
5-2 - ¼T	+50	94	70	50
"	+50	130	85	75
"	+10	78	62	40
"	+10	64	52	40
"	-50	20	18	0
"	-50	47	37	10
"	-100	8	5	0
"	-100	6	5	0
5-3 - ½T	+50	48	44	30
"	+50	39	37	30
"	+10	19	20	5
"	+10	20	23	5
"	-50	7	9	2
"	-50	6	5	2
"	-100	3	1	0
"	-100	3	3	0
5-4 - 3/4T	+50	106	77	70
"	+50	112	83	75
"	+10	120	84	90
"	+10	88	70	40
"	-50	40	44	5
"	-50	52	33	8
"	-100	10	12	0
"	-100	11	8	0
5-5 - Bottom	+50	128	88	80
"	+50	142	91	100
"	+10	106	76	70
"	+10	104	76	70
"	-50	72	52	20
"	-50	60	47	10
"	-100	24	20	0
"	-100	16	8	0
125A - 6-1 Top	+50	64	58	80
"	+50	68	62	75
"	+10	60	49	55
"	+10	46	43	50
"	+10	57	50	60
"	0	48	46	50
"	0	54	47	60
"	-50	34	30	15
"	-50	38	34	20
"	-100	28	22	5
"	-100	28	23	5

Table II (Cont'd.)

Sample	Temp.	Ft.Lbs.	L.E. mils	% Shear
125A - 6-2 - 1/4T	+50	52	48	50
	+50	48	48	50
"	+10	37	37	30
"	+10	33	34	30
"	+10	38	40	35
"	0	32	32	30
"	0	33	32	30
"	-50	18	26	2
"	-50	24	20	2
"	-100	8	5	0
"	-100	6	3	0
6-3 - 1/4T	+50	33	33	30
	+50	28	30	30
"	+10	20	30	20
"	+10	8	9	10
"	+10	22	14	25
"	0	10	12	10
"	0	17	18	15
"	-50	6	7	2
"	-50	4	3	0
"	-100	2	2	0
"	-100	3	2	0
6-4 - 3/4T	+50	56	53	50
	+50	54	51	50
"	+10	39	39	40
"	+10	36	36	35
"	+10	38	39	40
"	0	33	34	35
"	0	33	36	35
"	-50	28	24	5
"	-50	22	18	5
"	-100	12	21	10
"	-100	8	5	0
6-5 - Bottom	+50	70	59	75
"	+50	70	58	75
"	+10	54	46	45
"	+10	52	47	45
"	+10	56	49	50
"	0	50	44	50
"	0	53	46	50
"	-50	37	33	30
"	-50	38	34	30
"	-100	26	23	5
"	-100	28	15	5
125B (Cold Formed) 5-1 - Top	+50	157	93	100
"	+50	150	94	100
"	+10	147	92	100
"	+10	158	95	100

Table II (Cont'

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Sample	Temp.	Ft.Lbs.	L.E. mils	% Shear
125B (Cold Formed)				
5-1 - Top	-50	116	79	75
"	-50	129	86	80
"	-100	120	22	35
"				
125B				
5-2 - ¼T	+50	106	80	75
"	+50	80	66	70
"	+10	87	70	50
"	+10	94	67	55
"	-50	84	57	20
"	-50	76	62	20
"	-100	8	5	0
"	-100	10	6	2
5-3 - ½T	+50	60	53	50
"	+50	68	57	50
"	+10	50	42	15
"	+10	64	54	20
"	-50	44	36	10
"	-50	46	38	10
"	-100	13	8	0
"	-100	8	7	0
5-4 - 3/4T	+50	82	68	55
"	+50	116	84	75
"	+10	96	70	55
"	+10	85	79	55
"	-50	60	48	20
"	-50	50	40	10
"	-100	14	11	0
"	-100	9	6	0
5-5 - Bottom	+50	120	84	85
"	+50	130	89	100
"	+10	118	84	80
"	+10	98	73	70
"	-50	62	48	20
"	-50	90	69	40
"	-100	52	39	10
"	-100	33	24	5
125B (Cold Formed)				
6-1 - Top	+50	78	64	100
"	+50	82	67	100
"	+10	65	58	79
"	+10	66	56	70
"	+10	56	51	50
"	+10	62	57	65
"	0	59	54	55
"	0	56	47	55
"	-50	31	41	30
"	-50	41	38	30
"	-100	28	22	2
"	-100	33	26	5

Table II (Cont'd.)

Sample	Temp.	Ft.Lbs.	L.E. mils	% Shear
125B (Cold Formed)				
6-2 - 1/4T	+50	49	48	55
"	+50	52	51	60
"	+10	32	39	35
"	+10	34	36	35
"	+10	32	33	35
"	+10	31	34	30
"	0	34	32	35
"	0	32	35	35
"	-50	24	27	5
"	-50	29	30	5
"	-100	10	8	0
"	-100	14	12	0
6-3 - 1/2T	+50	36	37	50
"	+50	48	48	45
"	+10	32	30	35
"	+10	26	26	30
"	+10	36	38	30
"	+10	30	32	30
"	0	32	20	25
"	0	32	30	20
"	-50	29	23	2
"	-50	20	17	0
"	-100	7	9	0
"	-100	7	4	0
6-4 - 3/4T	+50	50	51	50
"	+50	43	45	50
"	+10	43	39	45
"	+10	46	42	45
"	+10	43	41	35
"	+10	36	39	35
"	0	41	40	35
"	0	30	31	30
"	-50	26	24	2
"	-50	27	22	2
"	-100	8	9	0
"	-100	8	8	0
6-5 - Bottom	+50	73	69	98
"	+50	72	67	95
"	+10	55	50	60
"	+10	62	53	60
"	+10	57	50	60
"	+10	64	56	55
"	0	49	44	50
"	0	50	48	50
"	-50	44	38	35
"	-50	38	35	15
"	-100	30	26	10
"	-100	22	8	8

FIGURE 2 - TENSILE STᵢ AT ROOM TEMP.

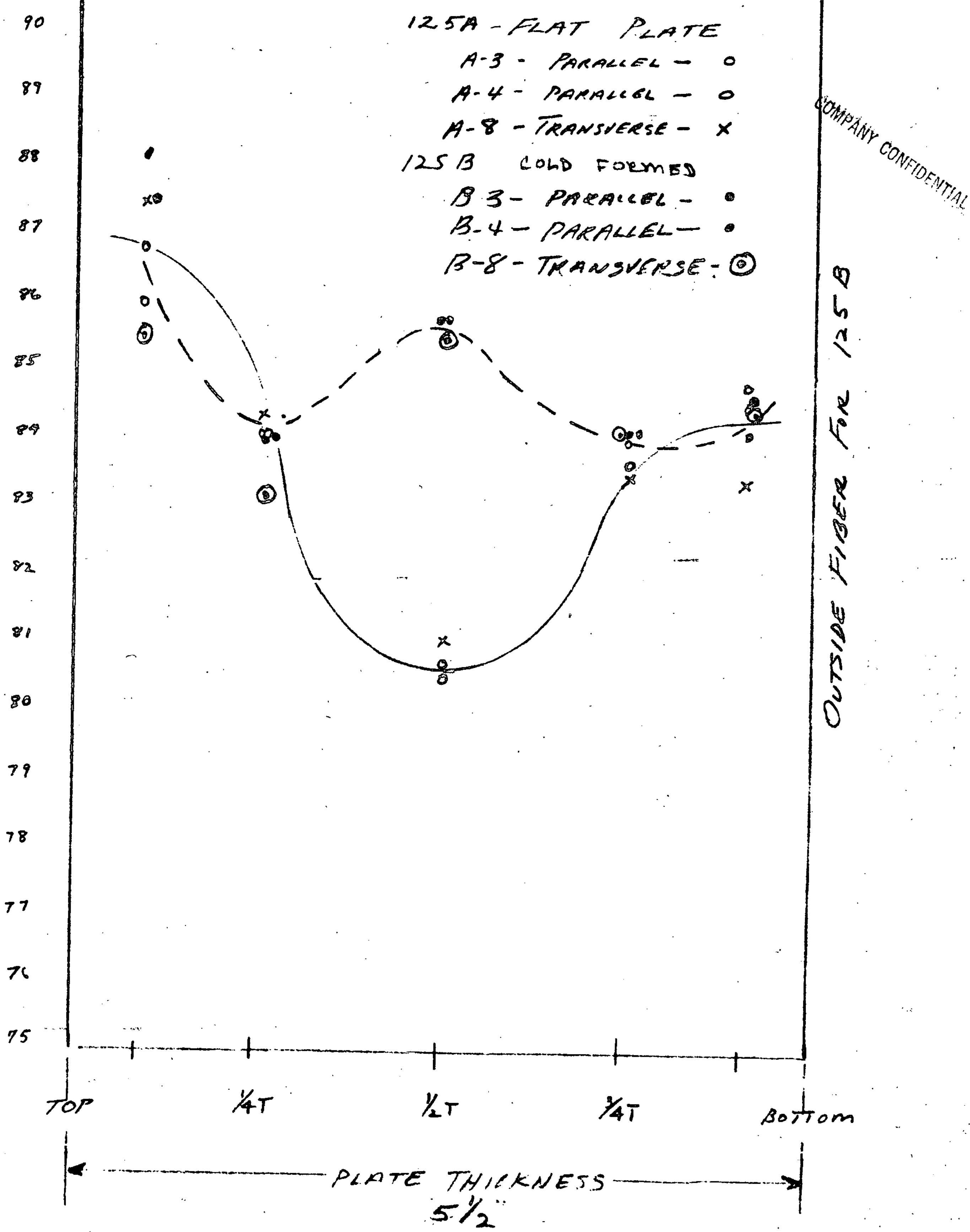


FIGURE 3 - TENSILE ST. AT. 575°F

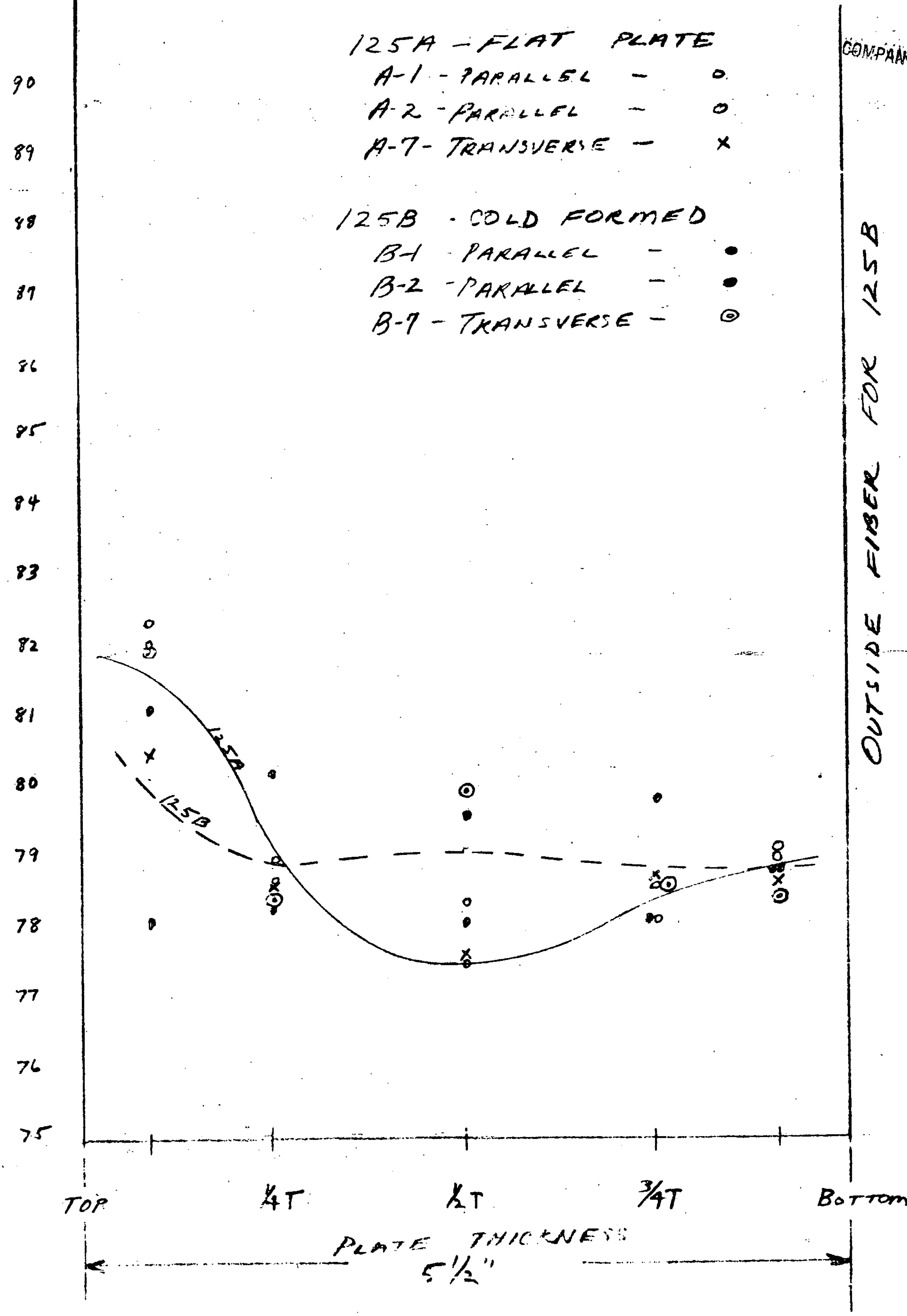
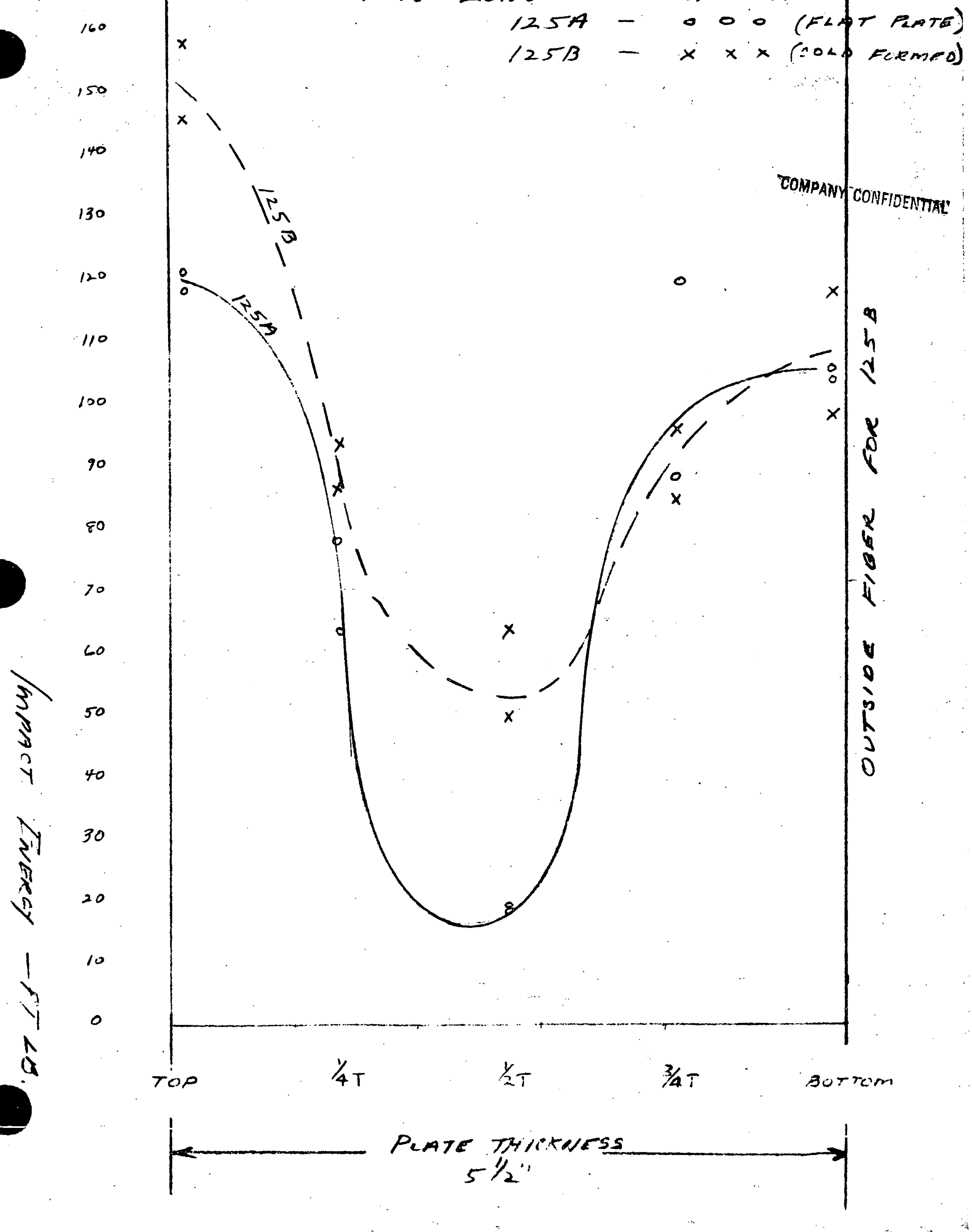


FIG 4 IMPACT ENERGY AT +10°F
FOR LONGITUDINAL SPECIMENS



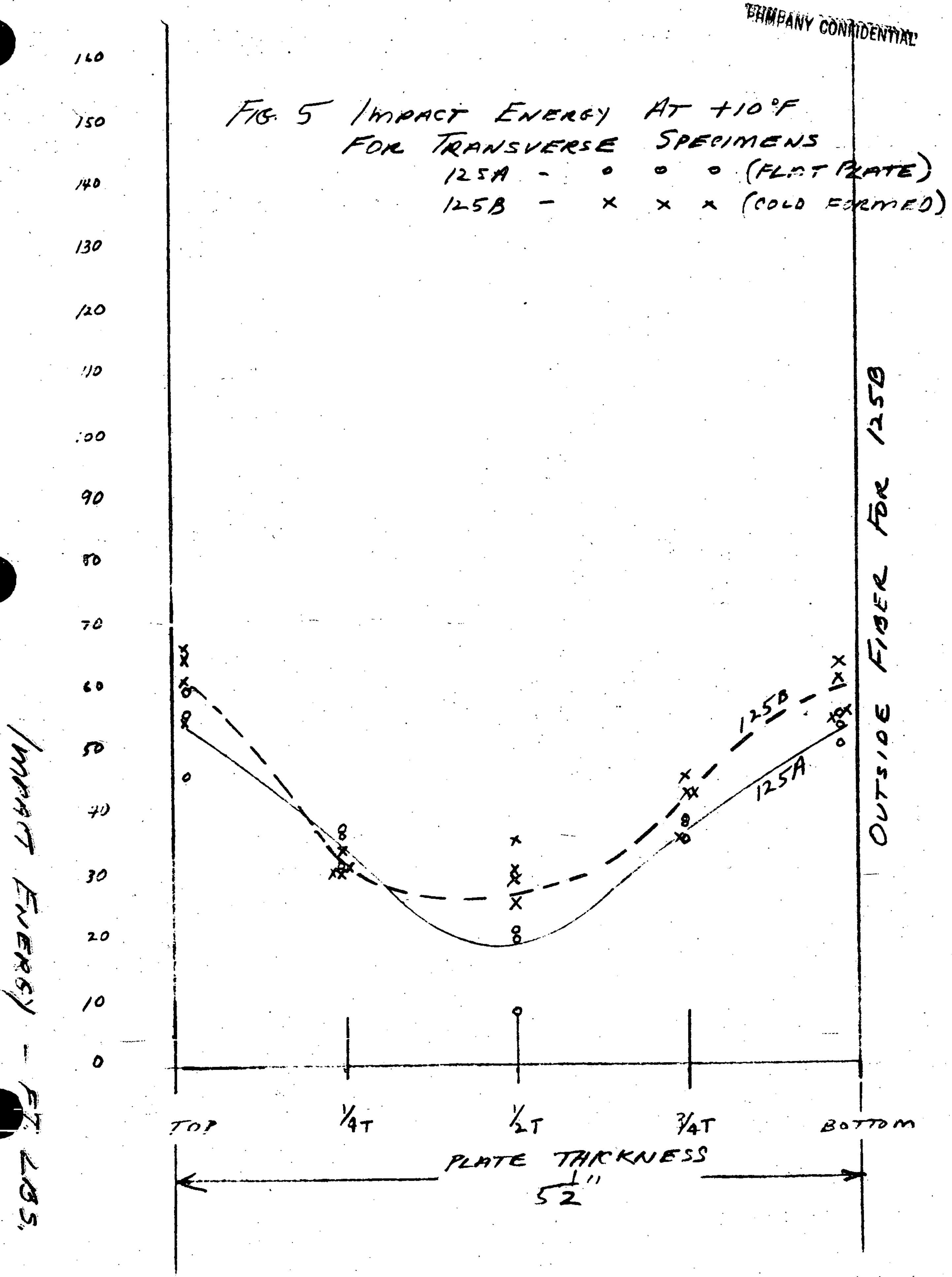


FIG. 5 IMPACT ENERGY AT +10°F
FOR TRANSVERSE SPECIMENS
125A - o o o (FLAT PLATE)
125B - x x x (COLD FORMED)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
IMPACT ENERGY - FT. LBS.
125B
125A
OUTSIDE FIBER FOR 125B
TOP
1/4T
1/2T
3/4T
BOTTOM
PLATE THICKNESS
5 1/2"

FIG. 6 IZ[illegible]A - CHARPY V-NOTCH TRANSITION CURVES FOR LONGITUDINAL SPECIMENS (FLAT PLATE)

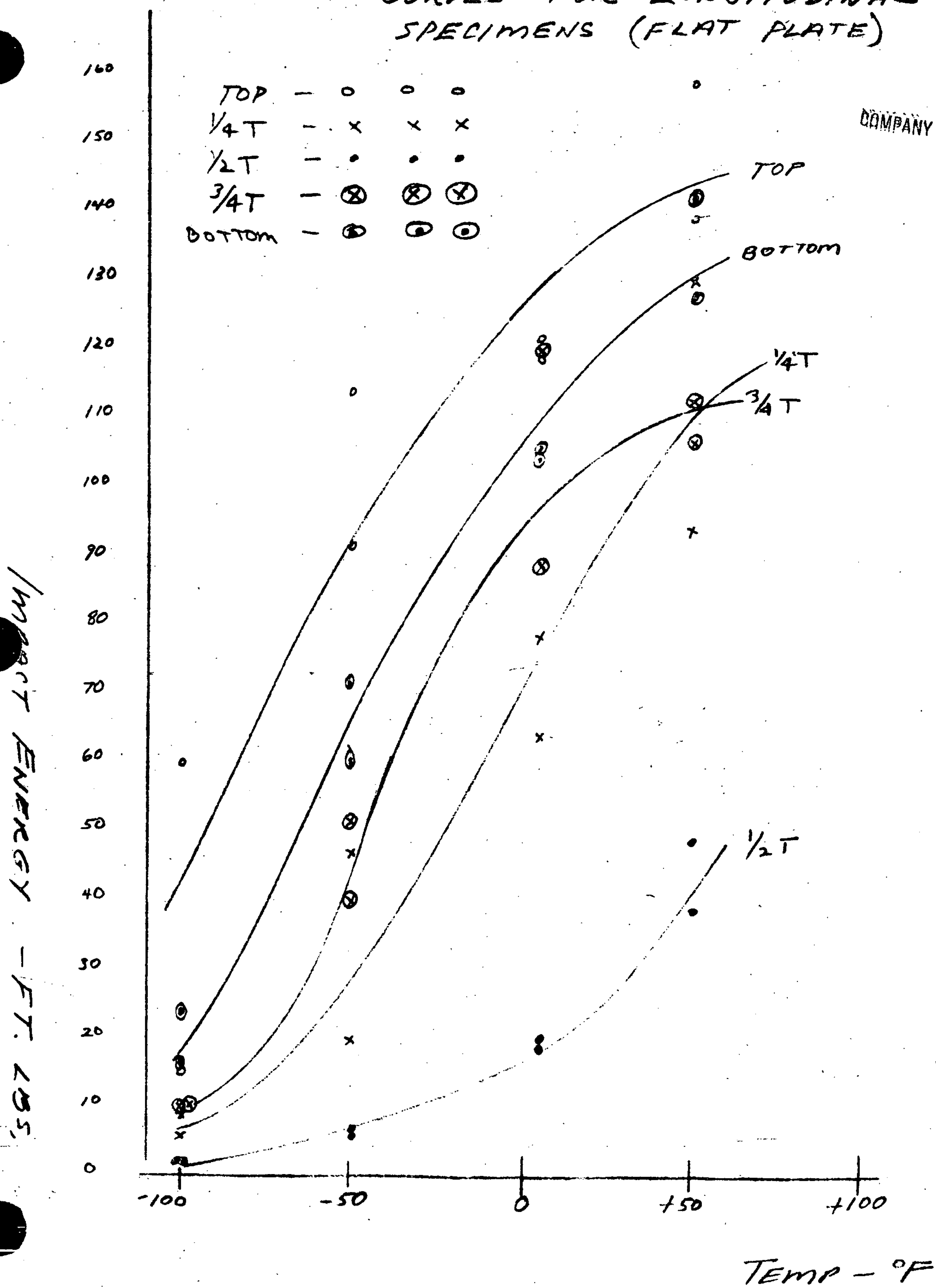
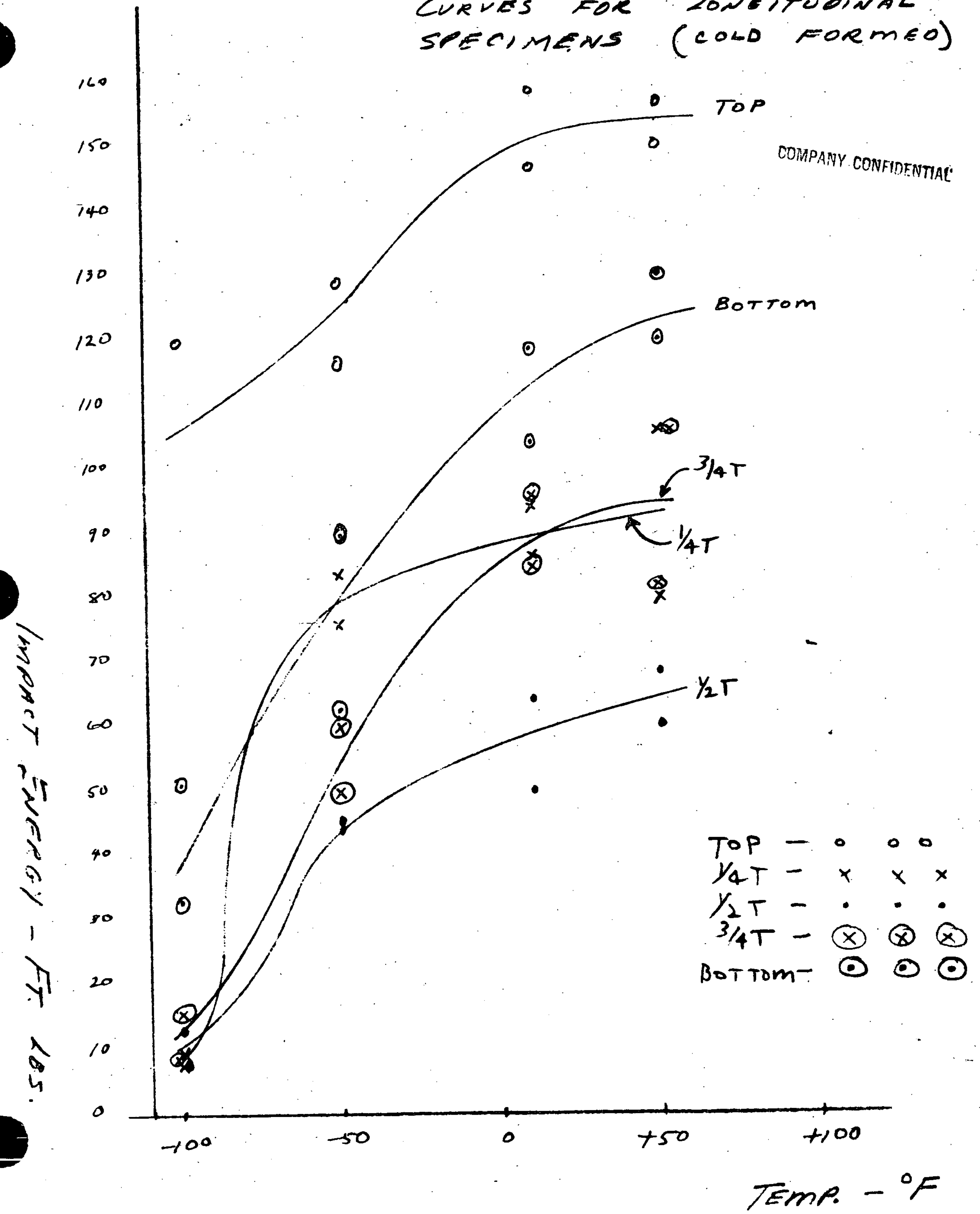


FIG 7 125B - CHARPY V-NOTCH TRANSITION CURVES FOR LONGITUDINAL SPECIMENS (COLD FORMED)



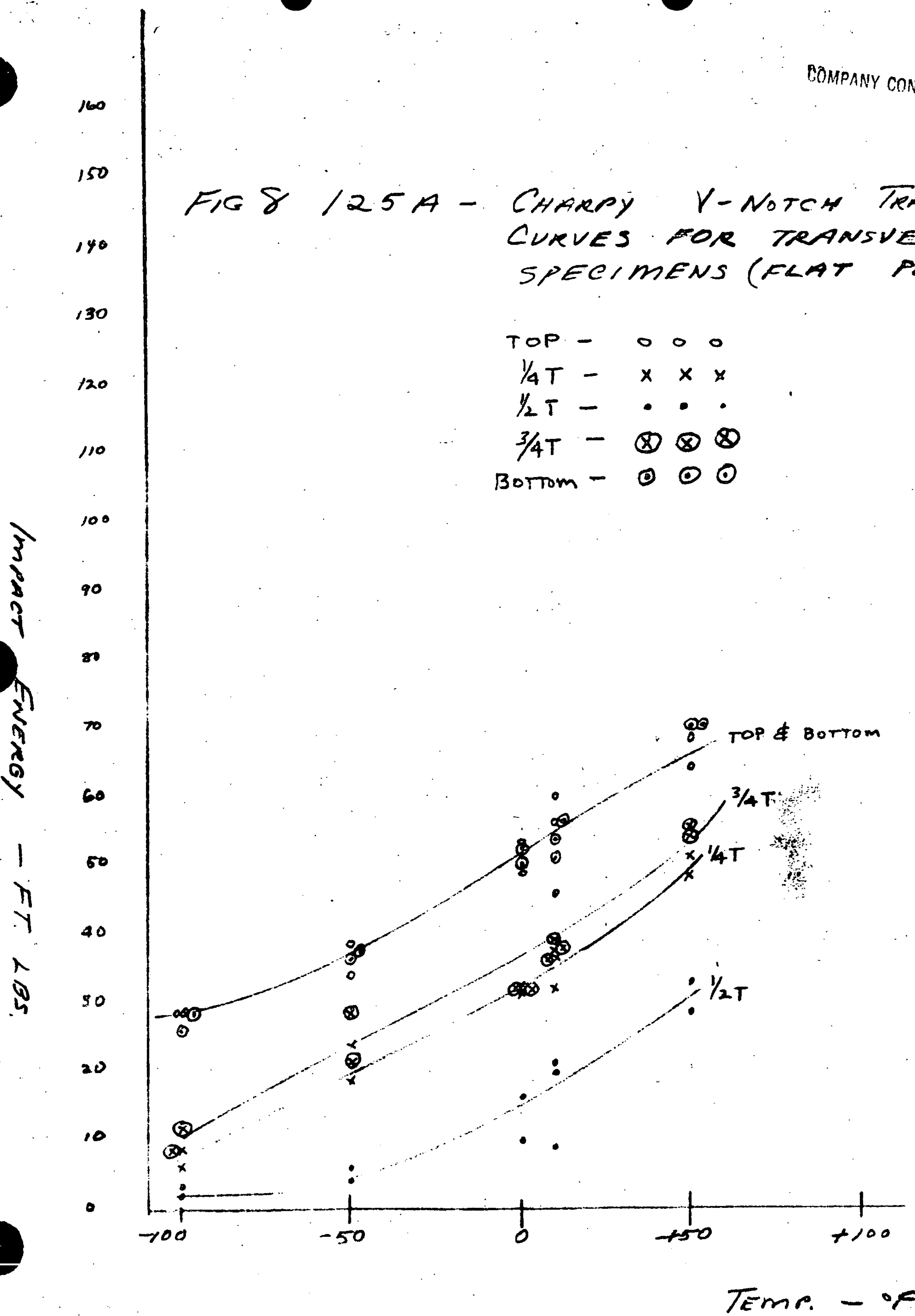


FIG 8 125A - CHARPY V-NOTCH TRANSITION CURVES FOR TRANSVERSE SPECIMENS (FLAT PLATE)

FIG 9 125B - CHARPY V-NOTCH TRANSITION CURVES FOR TRANSVERSE SPECIMENS (COLD FORMED)

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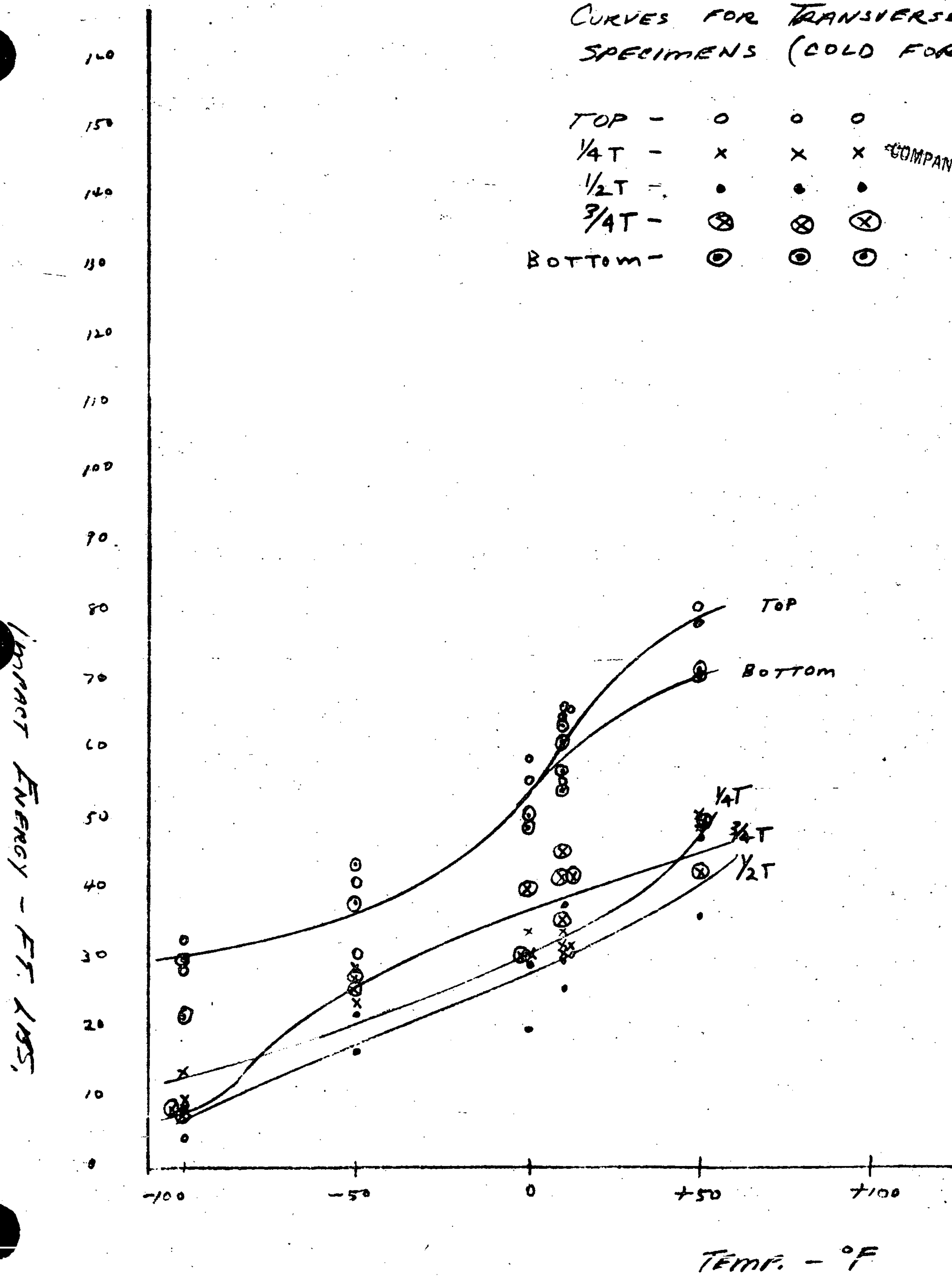


CHICAGO BRIDGE & IRON COMPANY

1500 N. 50TH ST. P.O. BOX 277, BIRMINGHAM, ALABAMA 35202

Experiment PT 64
Reported Feb. 6, 1967

COMPANY CONFIDENTIAL

Title:

Cold Forming Effect on A533 Material
(Contract 9-5624, Procedure No. CFE-1)

Introduction:

The A533 Gr. B material for Contract 9-5624 has been ordered Q & T at the mill and will be cold formed at the Birmingham plant. To insure that tensile and impact properties are not adversely affected by cold forming this investigation (Procedure #CFE-1) was made.

Material:

Heat #A0998, Slab #2 was used in this investigation. A copy of the CTR is encluded in this report as Figure 1. Test coupons were taken from the top of the plate. Location of Sample D is shown in C.B.& I. Drawing T3, Rev. 7 of this contract.

Equipment & Procedure:

A copy of CFE-1, which covers Equipment & Procedures, is included in this report as Enclosure #1. After the samples had been heat treated it was decided to include drop weight tests for comparison. Since there was not enough material for ¼T samples they were taken adjacent to the center line as shown in Figure 2. Later new samples were taken so that ¼T drop weight specimens could be used to actually qualify the plate.

Results:

Copies of all test results are included as Enclosure II. Test Data for Samples D, A and B and Enclosure III - Test Data for Samples D1, A1 and B1.

Discussion:

A. Tensile Strength - Normally tensile and yield strength levels of heavy plate could be expected to decrease slightly at the surface, increase markedly at the center and remain approximately the same at the ¼T location after cold forming and stress relieving. Results given in Enclosure to show that strength levels decreased approximately

2000 psi at the surface and approximately 1000 psi at the $\frac{1}{4}$T level after cold forming and stress relieving. Final values are well above ASTM minimum requirements.

B. Impact Properties - Data shown in Enclosures II and III show that impact properties are not adversely affected by cold work of this degree and stress relief. In fact, it may be noted in Figures 3 through 8 that the impact properties, which are so important in a nuclear reactor, are actually improved.

C. Drop Weight Tests - There were not enough samples to actually determine the NDT for each condition, therefore a good comparison could not be made. Results do indicate that effects may be beneficial, and the plate was qualified for use in this vessel after forming.

Conclusions:

1. Cold deformation of 4% stretch and stress relief of $6\frac{1}{4}$" thick A533 Gr. B does not adversely affect the tensile and yield strengths at the surface and $\frac{1}{4}$T levels. These results show a minor decrease in strength levels, but final values are well above ASTM requirements.

2. Cold deformation of 4% stretch and stress relief in $6\frac{1}{4}$% thick A533 Gr. B improves the impact properties at the surface and $\frac{1}{4}$T levels.

C. D. Pugh

C. D. Pugh
Birmingham Welding

mj

Figure 1 - CTR of Heat A0998.

NOTE: Corrected mill CTR will show second temper @ 1000°F ± 20°F for 4 hours and air cool. Performed after burning plate to size.

Enclosure #1 - Procedure CFE-1

CBI

CONTRACT 9-5624 MONTICELLO, MINN.
17'-1" DIA. X 63'-1½" INS. OA REACTOR VESSEL
NORTHERN STATES POWER COMPANY
GE/APED P. O. 205-55582-1 - REACTOR

COMPANY CONFIDENTIAL

Cold Forming Effect on A533 Material

CUSTOMER	General Electric Company
PRODUCT	Boiling Water Nuclear Reactor
ASSEMBLY	Test Plate
DESCRIPTION	

PROCEDURE NUMBER	CFE-1
PAGE NO.	1 OF 4
DATE	9-19-66
REVISION NO.	1 (10-18-66)

GENERAL ELECTRIC
ATOMIC POWER EQUIPMENT DEPT.
SAN JOSE, CALIFORNIA
APPROVED
AS CHECKED BELOW

- [ ] Not Approved. Revise and re-submit for approval
- [x] No further action required. Proceed with fabrication.
- [ ] As noted. Revise, proceed with fabrication and submit final certified transparency and prints.
- [ ] Return to APED for comments
- [ ] Without comments. Proceed with fabrication and submit final certified transparency and prints.

Approved by: [signature] Date: 11/14/66

Approval is in regard to general design and controlling dimensions. This does not constitute acceptance of any designs, materials or equipment which will not fulfill the functional or performance requirements established by the purchase contract.

0.1 Scope:

To determine the effect of the cold forming operation upon ASTM A533 Grade B, Class I material with respect to the tensile and impact properties. This procedure may be conducted using either a separate plate or the first bottom head plate received for the contract. (1)

0.2 Specification and Code Reference:

ASTM E23 (Type A longitudinal), ASTM A370 and Paragraph N515, Section III, ASME Code, Nuclear Vessels, Class A Vessels. Cold Forming Procedure CFP-1, Ultrasonic Examination Procedure UTP-1, Magnetic Particle Examination Procedure MTP-1, Liquid Penetrant Procedure PTP-1. (1)

1.0 Apparatus:

1.1 3000 Ton Press
1.2 Various Machining Equipment
1.3 Calibrated Testing Machines
 1.3.1 Tensile Testing Machine
 1.3.2 Charpy Impact Testing Machine

2.0 Procedure:

(1) 2.1 Inspect the plate prior to forming in order to determine (and accurately record) all defects present in the plate as received from the mill. Perform 100% volumetric UT examination (Procedure UTP-1), 100% Magnetic particle examination of all surfaces (Procedure MTP-1), and 100% liquid penetrant examination on all surfaces (Procedure PTP-1). Designate plate surface to be brought into tension.

(1) 2.2 Pieces D, E, & F shall be removed prior to the forming operation using burning methods for rough cutting.

(1) 2.3 Piece D shall be post heat treated for 50 hours at 1150°F (-50°F/+25°F).

(1) 2.3.1 Remove 32 full size longitudinal Charpy Vee notch impact specimens from Piece D after post heat treating. Sixteen specimens shall be removed from the 1/4T location and sixteen from 1/8 inch below the surface.

MONTICELLO-NSP
GENERAL ELECTRIC CO.
APED – SAN JOSE
VPF # 1811-7-2
EP # 2-1-1

CUSTOMER APPROVAL

REVIEWALS
FEM LPZ AJL
WAD AGS CSS
PCA WHS

PREPARED	OGS	10-18-66
CHECKED	EEV/DLM	10-19-66
APPROVED	EEV	

2.3.2 Remove four (4) .505"Ø Tensile specimens. Two (2) are to be removed from the 1/4T location and two (2) from 1/8 inch below the surface.

2.4 Pieces E & F shall be set aside for "back-up" purposes if required.

2.5 The remaining test plate is to be cold formed * with the aid of a 3000 ton press to cause a permanent strain = 3.9%

$$\% = \frac{65t}{R}$$

t = Plate thickness (6¼ inches)
R = Final Spherical radius (103 inches)

The cold forming shall be performed in two steps. The initial forming operation shall be to a radius approximately two times the final radius, (206 inches). Post heat treat the test plate at 1150°F (-50°F; +25°F), for 1½ hours. Final form the test plate to a 103 inch radius before again post heat treating at 1150°F (-50°F; +25°F) for 1½ hours. (The amount of strain on the test plate will be approximately the same amount of strain as the dollar portion of the bottom head in the Reactor at the Monticello location).
*If bottom head plate is used, forming radii are to be as shown on the contract drawings.

2.6 Inspect the plate after final forming and second post heat treatment to determine (and accurately record) all defects present in the plate after forming. Duplicate the UT, MT, and PT requirements of Paragraph 2.1.

2.7 Remove Pieces A and B. Piece C is to remain attached for back-up purposes in case heat treatment for development of properties is required. Final heat treat Piece B only for 47 hours at 1150°F (-50°F/+25°F). Piece A does not receive heat treatment specified for Piece B.

2.8 Remove 24 full size longitudinal Charpy Vee notch impact specimens from Piece A (cold formed material before final post heat treatment). Twelve specimens shall be removed from the 1/4T location and twelve from 1/8 inch below the surface.

2.9 Remove 32 full suze longitudinal Charpy Vee notch impact specimens from Piece B (cold formed material after final post heat treating). Sixteen specimens shall be removed from the 1/4T location and sixteen from 1/8 inch below the surface.

2.9.1 Remove four (4) .505"Ø tensile specimens from Piece B. Two specimens to be removed from the 1/4T location and two from 1/8 inch below the surface.

2.10 All specimen cutting shall be done by machining methods. Removal shall be made by the same methods, except burning methods may be used for rough cutting. ⟨1⟩

2.11 All depth locations are to be measured from the tensile surface.

3.0 Testing:

3.1 Six impact-transition curves, 2 each from Pieces A,B and D ⟨1⟩ representing breaking energy (energy absorbed) in ft. lbs. vs. temperature shall be made. The temperature range of testing shall establish an upper plateau. Each plateau shall be determined by at least one but not more than two points. ⟨1⟩ The values at 10°F and 40°F for Pieces B and D shall be developed using six specimens. The remaining specimens in ⟨1⟩ each group of sixteen or twelve shall be used to develop the transition region. The lower plateau need not be developed if it occurs below -80°F. (The two curves developed from Piece A are for information only).

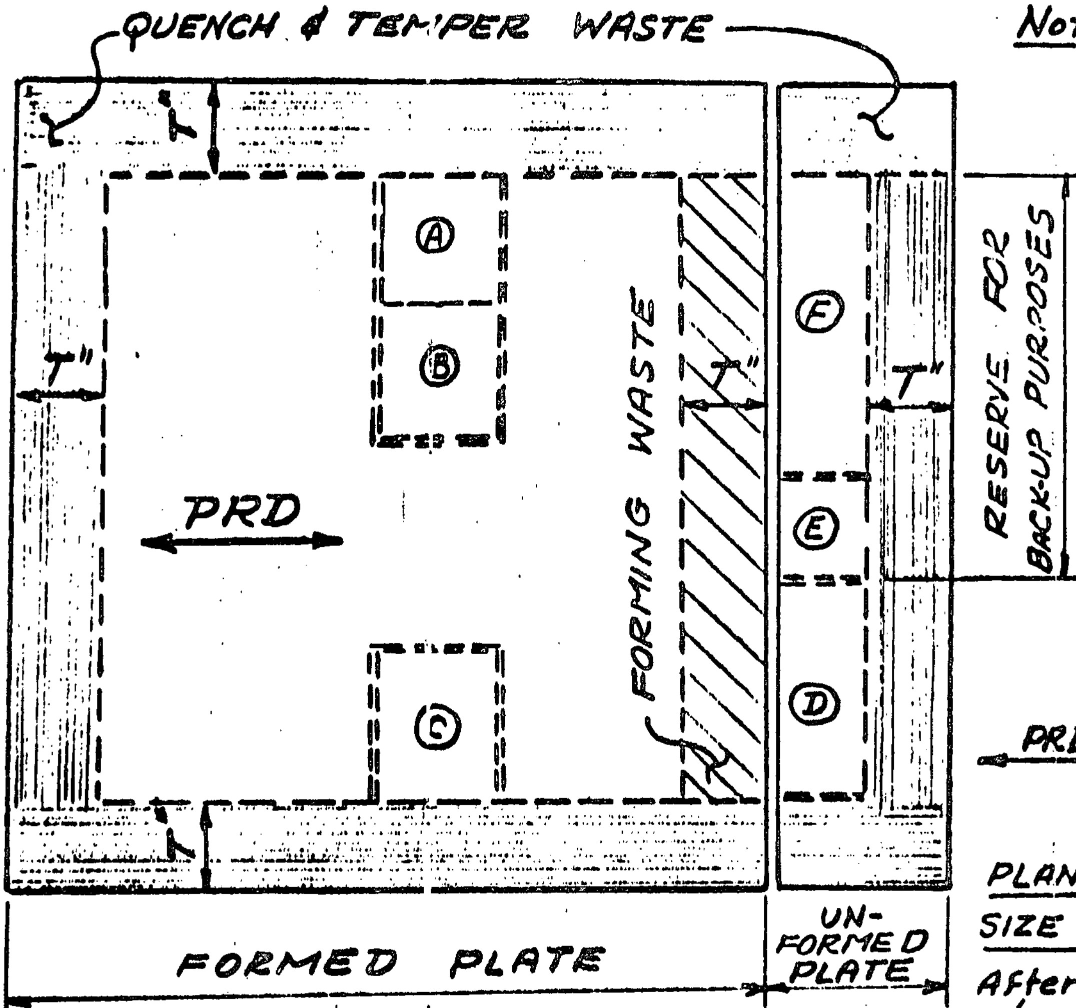
3.2 Tensile strength of the unformed post heat treated material shall be determined from Piece D by tests at the 1/4T location and the 1/8 inch below the surface location. The effects of cold forming upon the tensile strength shall be determined by comparing the sets of test results from Pieces B and D. (ASTM A533 Grade B, Class I tensile requirements shall be met).

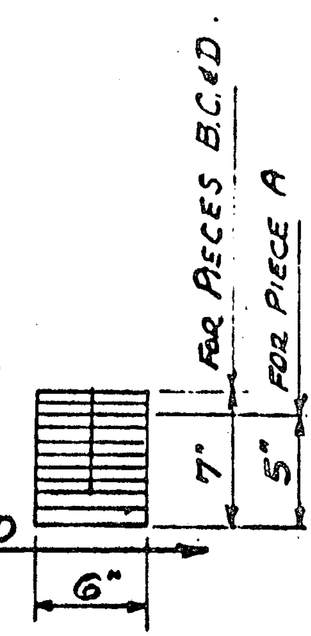
3.3 The results for Piece D and Piece B shall be compared to determine if they meet the requirements of Section III of ASME Code.

CONTRACT 9-5624 MONTICELLO, MINN.
17'-1" DIA. X 63'-1½" INS. OA REACTOR VESSEL
NORTHERN STATES POWER COMPANY
GE/APED P. O. 205-55582-1 - REACTOR

Cold Forming Effect on A533 Material

CUSTOMER	General Electric Company	PROCEDURE NUMBER	CFE-1
PRODUCT	Boiling Water Nuclear Reactor	PAGE NO.	4 OF 4
ASSEMBLY	Test Plate	DATE	9-19-66
DESCRIPTION		REVISION NO.	1 (10-18-66)





PLAN VIEW OF MIN. SIZE FOR TEST BLOCK
After removing Q.&T. &/or forming waste.

TYPICAL PLATE for TESTING

1) Layout shown is for 48"x60" test plate. Other plate sizes may be used to fit available material.
2) Size and locate test blocks to provide sufficient material so that required tensile and impact specimens can be cut.
3) No test specimen shall be taken from material closer than T" to either a formed edge or a quenched & tempered edge.
4) Orient test blocks & specimens with respect to PRD.
5) Maintain identity of tensile surface, both on formed & on un-formed test blocks.

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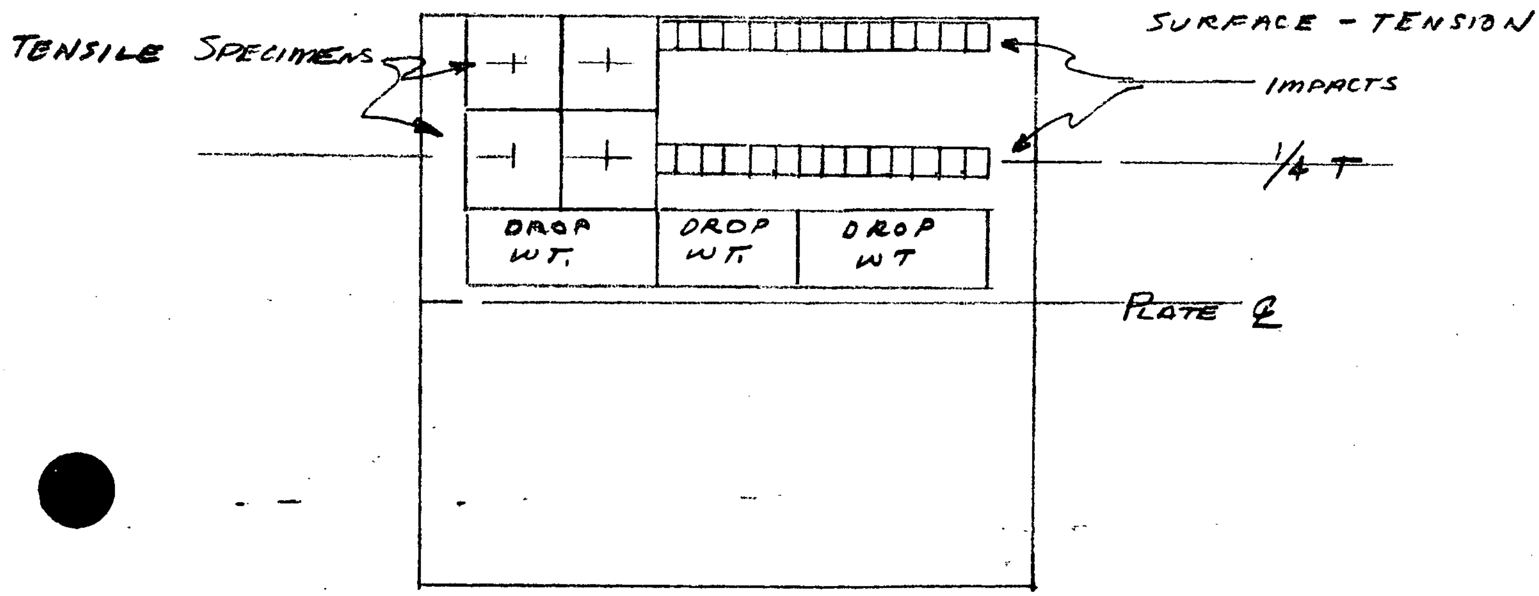

FIGURE 2. SKETCH SHOWING LOCATIONS OF SPECIMENS TAKEN FROM SAMPLES D, A AND B.

Revised Copy 12/20/66 Revised Copy 1/9/67 Revised Copy 2-1-67

LUKENS STEEL COMPANY

COATESVILLE, PA.

TEST CERTIFICATE

PURCHASER:

10· Chicago Bridge & Iron Co.
Mr.G.H.Putman, P.A.
P.O. Box 277
Birmingham, Ala. 35202

MILL ORDER NO.	CUSTOMER P.O.	
43211-1	5624	MB 112166 EM

Affi.

DATE: 11/26/66 FILE NO. 1543

CONSIGNEE:

Same
Boyles, Ala.

SPECIFICATIONS:

A-533-65 Gr.B Class 1 Mod. by C.B.&.I. Spec. MS-1 DTD ~~XXXX~~ 8/26/66 Fbx. 80000 Cont.# 9-5624

BEND TEST O.K. HOMOGENITY TEST O.K.

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	XX	X		Grain Size
C1946	22	1.35	010	015		23	50		47			V.I.P.Steel			T#7 B#8
A0998	20	1.27	008	017		18	48		49			" " " "			T#7 B#8

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN 2 "	% R.A.	BHN	IMPACTS V-Notch +10°F.				DESCRIPTION
C1946	3		914								1-190 x 86 x 6-1/4"
		614	848	26			56	55	52		
A0998	2		873								1-300 x 120 x 6-1/4"
		626	864	27			51	37	45		

Two Surface D.W.T. Tests @+10°F. Satisfactory.

Plates & tests heated 1650-1700°F., held 1 hr. per inch min. & W.S.Q. to 500°F., then tempered 1200-1250°F., held 1 hr. per inch min., & air cooled.

Tests stress relieved by heating within a rate of 64°F. per hr. to 1113-1187°F., held 50 hrs. and furnace cooled within a rate of 80°F. per hr. to 600°F. & air cooled.

Mill inspection by Chicago Bridge & Iron Co.

COMPANY CONFIDENTIAL

Affirmed and subscribed before me this ___ day of FEB 1 1967 19___

Phillip A. Romandino Jr.

Notary Public

My Commission Expires Apr. 1, 1968

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

SUPERVISOR-TESTING H. W. Kline

COMPANY CONFIDENTIAL

DATA SHEET NO. 1

Cold Forming Effect on A533 Material

All data from tension side surface specimens

Impact Test Data

Spec. No.	Test Temp.	Piece A Cold Formed No stress relief Longitudinal Specimen Energy (Ft-lbs)	Piece B Cold Formed Stress Relieved Longitudinal Specimen Energy (Ft-lbs)	Piece D Before Forming Stress Relieved Longitudinal Specimen Energy (Ft-lbs)
1	+70	105	105	117
2	+40	98	104	117
3	+40	100	104	83
4	+40	93	68	88
5	+10	70	75	81
6	+10	68	47	70
7	+10	82	82	117
8	-20	44	19	21
9	-50	35	14	16
10	-80	7	10	11
11	+100	140	122	129
12	+130	146	138	130
13	+160	---	140	131
14	+190	---	149	126

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DATA SHEET NO.1 (continued)

Tensile Test Results

	Piece A		Piece B		Piece D	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Yield (psi)	62180	65050	63640	63570	66080	66920
Ultimate (psi)	85280	85200	85860	85930	87940	87970

Drop Weight Test Results

(Test data incomplete on surface samples)

Piece D

Test Temp.	Result
+10	Break
+20	Break
+30	No break
+30	No break

RPY V-NOTCH TRANSITION CURVES

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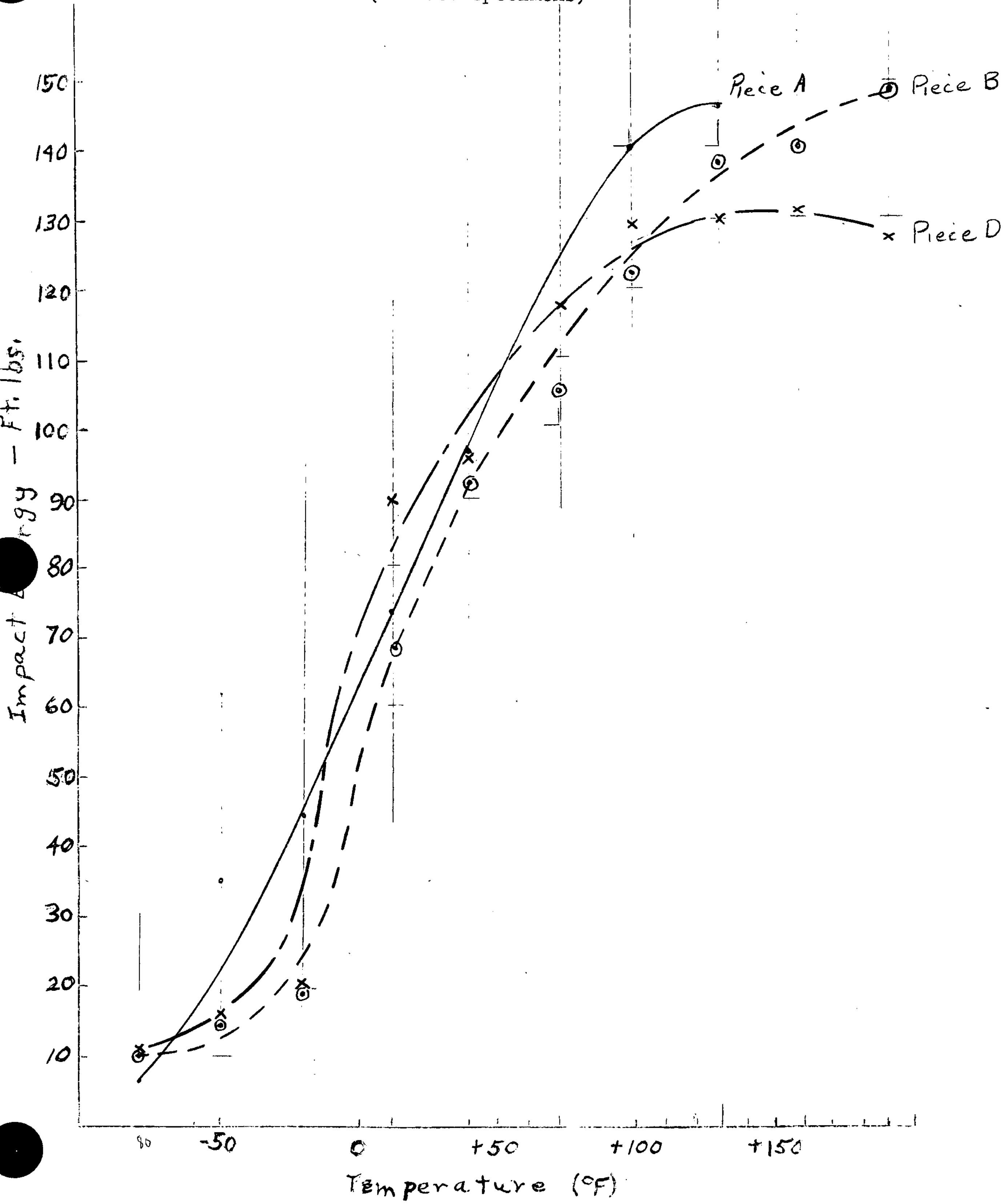
Effects of Cold Forming
(Surface Specimens)



Surface.

DATA SHEET NO. 2

COMPANY CONFIDENTIAL

Cold Forming Effect on A533 Material

Data from specimens at ¼T location (See Figure 2)

Impact Test Data

Spec. No.	Test Temp.	Piece A Cold Formed No stress relief Longitudinal Specimen Energy (Ft-lbs)	Piece B Cold Formed Stress relieved Longitudinal Specimen Energy (Ft-lbs)	Piece D Before Forming Stress Relieved Longitudinal Specimen Energy (Ft-lbs)
1	+70	104	92	91
2	+40	88	77	47
3	+40	81	94	49
4	+40	102	61	56
5	+10	73	50	26
6	+10	57	30	25
7	+10	63	55	28
8	-20	69	18	14
9	-50	26	6	5
10	-80	10	2	6
11	+100	126	100	98
12	+130	144	134	115
13	+160	---	132	134
14	+190	---	144	137

A SHEET NO. 2 (continued) COMPANY CONFIDENTIAL

Tensile Test Results

	Piece A		Piece B		Piece D	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Yield (psi)	56390	57110	62810	62400	65160	65250
Ultimate (psi)	81700	81980	86180	86190	87220	87000

Drop Weight Test Results

Piece A				Piece B				Piece D	
Temp.	Test 1	Temp.	Test 2	Temp.	Test 1	Temp.	Test 2	Temp.	Test 1
+10	No break	+10	Break	+10	Break	+10	Break	+10	Break
+10	Break	+20	No break	+10	No break	+20	No break	+10	Break
[illegible]	Break	+20	Break	+10	Break	+50	No break	+10	No break
		+30	No break			+50	No break	+20	Break

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ADDENDUM III

CHICAGO BRIDGE & IRON COMPANY

WELDING PROCEDURE QUALIFICATION TESTS

Specification No. 533-P3-6-M Date 12/5/66

Welding Process MANUAL Manual ☒ Machine ☐

Material Specification for A533 - Gr B in Group P No. 3

Thickness 6" Flux Trade Name or Composition —

Thickness Range Qualified 3/16" - 12" Inert Gas Composition —

Filler Metal E-8018 NM Trade Name — Flow Rate —

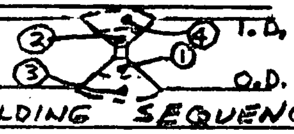
Weld Metal Analysis See Pg. 2 Backing Strip YES

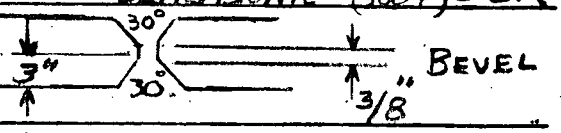
Type of Groove See Below

Single ☐ Multiple ☒ Pass Preheat 300°F

Single ☐ Multiple ☐ Head Postheat 1150°F °F for 50 hr/[redacted]

Position VERTICAL X-ray - OK ULTRASONIC - (300°F) - OK





.505" Ø [redacted] Tensile Test TRANSVERSE

Specimen No	Dimensions Width	Dimensions Thickness	Original Area Sq. in.	Total Load, Lbs. Yield Point	Total Load, Lbs. Ultimate	Unit Stress, Lbs. sq. in. Yield Point	Unit Stress, Lbs. sq. in. Ultimate	Elongation In 2 in.	Elongation Per Cent	Reduction of Area Per Cent	Fracture
1-Room Temp	3/4T —	.502	.1979	13200	16,100	66,700	81,400	.46	23	71.8	
2-Room Temp	—	.502	.1979	12200	16,750	61,700	84,700	.52	26	70.1	
3-575°F	3/4T —	.499	.1955	11250	15000	57,600	76,700	.43	21.5	67.1	
4-575°F	—	.500	.1963	11450	15,350	58,400	78,200	.38	19	51.8	

.505 [redacted] Tensile Test PLATE

Specimen No	Diameter	Original Area Sq. in.	Total Load, Lbs. Yield Point	Total Load, Lbs. Ultimate	Unit Stress, Lbs. sq. in. Yield Point	Unit Stress, Lbs. sq. in. Ultimate	Elongation In 2 in.	Elongation Per Cent	Reduction of Area Per Cent	Fracture
1-Room Temp	3/4T .501	.1971	13,650	17,850	69,300	90,500	.45	22.5	63.1	
2-Room Temp	.499	.1955	12,300	17,000	62,900	87,000	.47	23.5	60.1	
1-575°F	.503	.1987	11,350	15,650	57,200	78,800	.41	20.5	58.8	
2-575°F	3/4T .502	.1979	10,550	15,700	53,400	79,400	.41	20.5	60.5	

Guided Bend Test

Specimen No	Type of Bend	Results	Specimen No	Type of Bend	Results

Impact Test - V NOTCH

% SHEAR	Specimen No	Dimensions Width	Dimensions Thickness	L.E. [redacted]	Temp °F	Ft. Lbs.	Specimen No	Dimensions Width	Dimensions Thickness	L.E. [redacted]	Temp °F	Ft. Lbs.	% SHEAR
60	WELD	.393	.315	74	+10	93	HAZ	.392	.315	62	+10	76	75
65	WELD	.394	.316	79	+10	102	HAZ	.392	.315	51	+10	50	15
75	WELD	.393	.316	78	+10	98	HAZ	.393	.317	86	+10	108	80

Operator's Name ______________ No. ________

Tested By: ______________

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

In Charge Of Testing: C. D. Pugh

Birmingham Welding

7

CHICAGO BRIDGE & IRON COMPANY

WELDING PROCEDURE QUALIFICATION TESTS

Specification No. 533-P3-6-M Date 12/5/66
Welding Process Manual Manual ☒ Machine ☐
Material Specification for A-533 Gr B in Group P No. ______
Thickness 6"
Thickness Range Qualified 3/16 - 12"
Filler Metal E-8018 NM
Weld Metal Analysis ______
Flux Trade Name or Composition ______
Inert Gas Composition ______
Trade Name ______ Flow Rate ______
Backing Strip Yes
Type of Groove ______

Single ☐ Multiple ☒ Pass
Single ☐ Multiple ☐ Head
Position Vertical

Preheat ______
Postheat ______ °F for ____ hr/inch
X-ray ______

ALLOY RODS HT. # 85B326
LOT NO. 1627A27A
WELD METAL ANALYSIS - 1/4T - { C - .075, MN - 1.04, Ni - .89, MO - .54, Si - .45 }

WELDING CONDITIONS

SIZE	1/8"Φ	5/32"Φ	3/16"Φ
AMPS	90-135	110-160	150-220
POLARITY	DC REVERSE	–	–

Reduced Section Tensile Test

Specimen No	Dimensions Width	Dimensions Thickness	Original Area Sq. in.	Total Load, Lbs. Yield Point	Total Load, Lbs. Ultimate	Unit Stress, Lbs. sq. in. Yield Point	Unit Stress, Lbs. sq. in. Ultimate	Elongation In 2 in	Elongation Per Cent	Reduction of Area Per Cent	Fracture
1	.530	2.853	1.511	103,200	127,700	68,300	84,400	.66	33	–	WELD
2	.534	2.845	1.520	103,500	130,000	68,100	85,500	.60	30	–	WELD
3	.580	2.829	1.656	109,200	139,700	66,000	84,400	.75	37.5	–	WELD
4	.576	2.848	1.641	111,000	138,200	67,600	84,200	.64	32	–	WELD

.505 All Weld Tensile Test

Specimen No	Diameter	Original Area Sq. in.	Total Load, Lbs. Yield Point	Total Load, Lbs. Ultimate	Unit Stress, Lbs. sq. in. Yield Point	Unit Stress, Lbs. sq. in. Ultimate	Elongation In 2 in.	Elongation Per Cent	Reduction of Area Per Cent	Fracture
1-RoomTemp	.501	.1971	14,800	16,800	75,000	85,100	.45	22.5	73.7	–
2-RoomTemp	.496	.1932	12,850	15,650	66,500	81,000	.45	22.5	73.6	–
1- 575°F	.499	.1955	9,550	14,950	48,700	76,500	.45	22.5	61.2	–
2- 575°F	.500	.1963	12,450	15,650	63,500	79,800	.41	20.5	63.5	–

Guided Bend Test

Specimen No	Type of Bend	Results	Specimen No	Type of Bend	Results
1, 2, 3	SIDE	OK	7, 8, 9	SIDE	OK
4, 5, 6	SIDE	OK	10, 11, 12	SIDE	OK

Impact Test - V NOTCH

% SHEAR	Specimen No	Dimensions Width	Dimensions Thickness	L.E. (~~Notch~~)	Temp °F	Ft. Lbs.	Specimen No	Dimensions Width	Dimensions Thickness	Notch	Temp °F	Ft. Lbs.
15	PLATE	.392	.316	37	+10	41						
18	PLATE	.393	.316	56	+10	40						
25	PLATE	.393	.318	40	+10	47						

Operator's Name K. L. JOHNSON No. 658
Tested By: C.B. & I

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

In Charge Of Testing: C. A. Pugh

Bham Welding

B

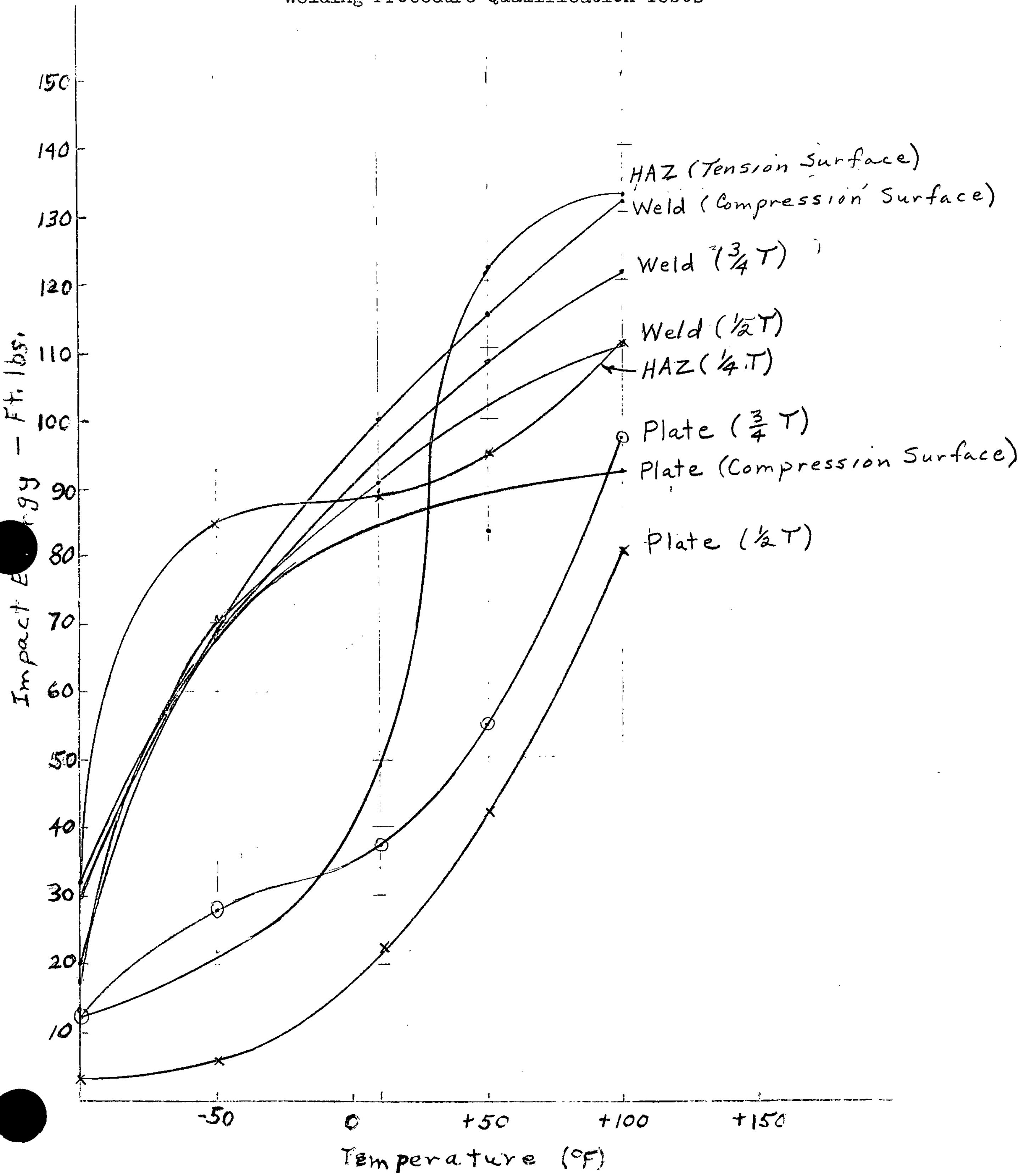
CHARPY IMPACT TEST RESULTS

Welding Procedure Qualification

	Temp (°F)	Plate Ft-lbs	Weld Ft-lbs	Heat Affected Zone Ft-lbs
	-100			13
Surface	- 50	66	53	22
Specimens	+ 10	85	98	49
(Tension Side)	+ 50			123
	+100			132
	-100			30
¼ T	- 50			85
Specimens	+ 10	43	100	89
	+ 50			95
	+100			108
	-100	3	17	
	- 50	6	71	
½ T	+ 10	22	90	25
Specimens	+ 50	42	95	
	+100	79	109	
	-100	12	20	
	- 50	18	68	
3/4 T	+ 10	37	89	62
Specimens	+ 50	54	108	
	+100	97	121	
	-100	32	29	
Surface	- 50	68	69	
Specimens	+ 10	91	100	35
(Compression side)	+ 50	86	114	
	+100	93	131	

IMPACT TEST DATA

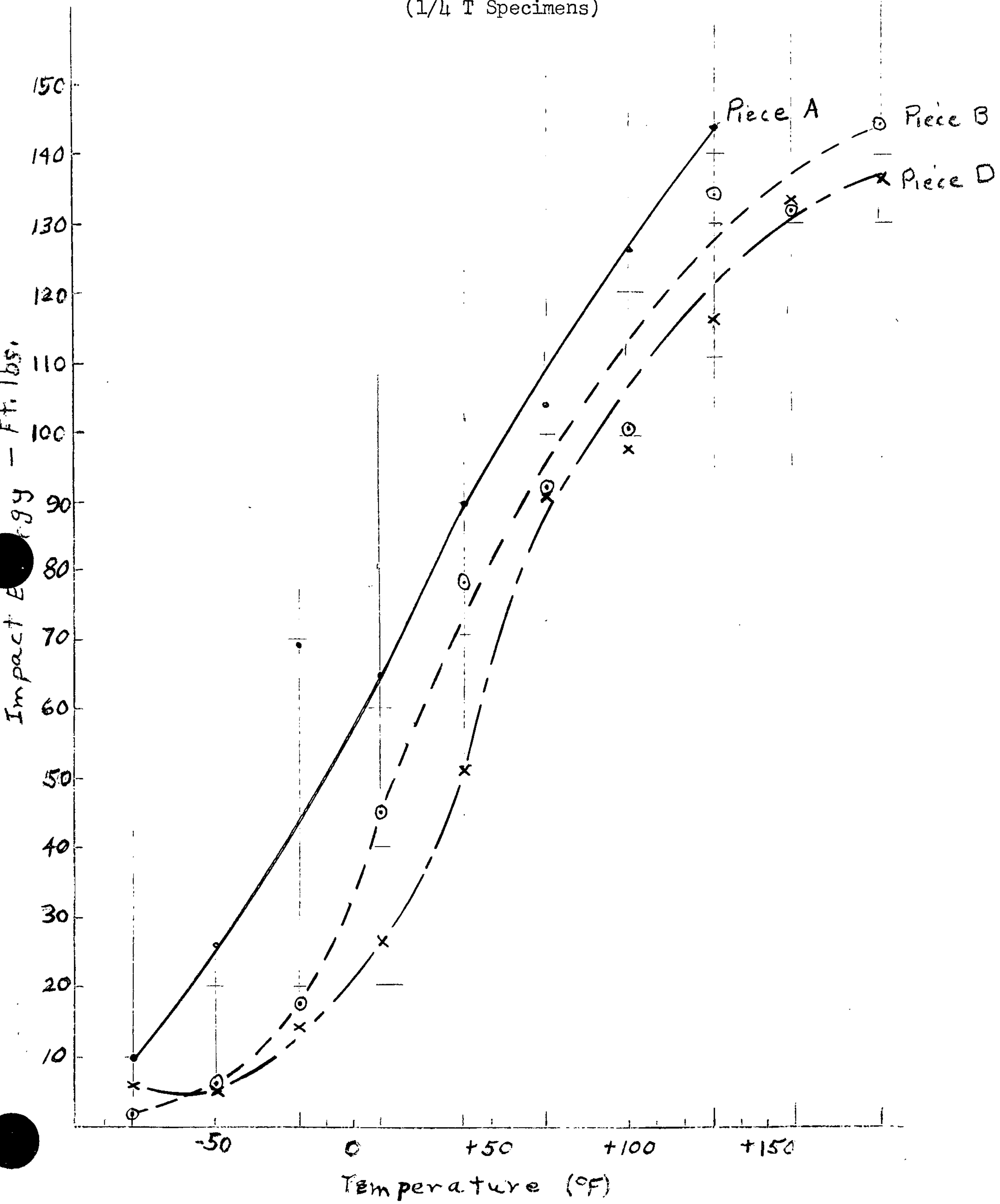
Welding Procedure Qualification Tests



CHARPY V-NOTCH TRANSITION CURVES
(A533 Material)

COMPANY CONFIDENTIAL

Effects of Cold Forming
(1/4 T Specimens)



T/4

PHYSICAL TEST RESULTS

Monticello Pressure Vessel Plates

Pc. Mark	Heat No.	Slab No.	Yield Psi x 10^3 CTR/As Fab.	Tensile Psi x 10^3 CTR/As Fab.	V-Notch Results °F CTR/As Fab.	V-Notch Results Ft.-Lbs. CTR/As Fab.		
1-28	A0998	2	62.6/62.4	87.3/86.4	+ 10°	51	37	55
				86.2/86.2	+ 40°	77	94	61
1-27	C2193	3	67.8/62.7	90.8/89.9	10°	50	26	35
				85.2/85.1	40°	86	124	113
1-26	C1946	3	61.4/67.0	91.4/84.8	10°	56	55	52
				90.6/90.6	40°	42	70	44
1-18/21	C1485	3	72.6/67.5	94.9/95.5	10°	65	32	47
				92.5/92.5	40°	77	94	68
1-22/25	A1000	2	65.2/62.0	87.4/86.9	10°	67	71	38
				85.8/85.5	40°	123	105	118
1-17	C2193	1	66.0/63.5	89.5/87.5	10°	37	53	37
				87.1/87.3	40°	81	88	87
1-16	A0946	1	73.4/66.2	91.5/91.5	10°	53	42	47
				90.5/90.5	40°	67	64	63
1-15	C2220	1	64.8/	90.0/88.4	10°	60	93	81
1-14	C2220	2	65.2/	91.4/90.4	10°	81	33	61

Drop weight test results - no breaks in any sample from above plates at + 10°F or 40°F.

CTR - Certified Test Report (From Lukens Steel Co.)

CHEMICAL TEST RESULTS

Monticello Pressure Vessel Plates

Pc. Mark	Heat No.	Slab No.	C	Mn	P	S	Si	Ni	Mo
1-28	A0998	2	.20	1.27	.008	.017	.18	.48	.49
1-27	C2193	3	.21	1.15	.010	.010	.24	.50	.48
1-26	C1946	3	.22	1.35	.010	.015	.23	.50	.47
1-18/21	C1485	3	.22	1.37	.010	.022	.22	.50	.48
1-22/25	A1000	2	.21	1.36	.013	.017	.18	.54	.45
1-17	C2193	1	.21	1.15	.010	.010	.24	.50	.48
1-16	A0946	1	.21	1.41	.010	.016	.15	.56	.47
1-15	C2220	1	.20	1.31	.010	.014	.22	.58	.45
1-14	C2220	2	.20	1.31	.010	.014	.22	.58	.45