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MASTER

FRACTURE MECHANICS EVALUATION
OF REACTOR VESSEL STEELS
QUARTERLY PROGRESS REPORT
FOR THE PERIOD ENDING
JUNE 30, 1968

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TABLE OF CONTENTS

	<u>Page No.</u>
LIST OF FIGURES	iv
LIST OF TABLES	vi
PROGRAM DESCRIPTION	1
EUFM-100 Program Management (Summary of Progress)	2
EUFM-200 Irradiation and Analysis	4
EUFM-300 Pre-Irradiation Testing	7

LIST OF FIGURES

<u>Figure No.</u>	<u>Title</u>	<u>Page No.</u>
300.1	Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Top Surface	8
300.2	Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Quarter Thickness	9
300.3	Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel Half Thickness	10
300.4	Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Three Quarter Thickness	11
300.5	Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Bottom Surface	12
300.6	Pre-Irradiation Charpy V-notch Energy as a Function of Temperature - Top Surface	15
300.7	Pre-Irradiation Charpy V-notch Energy as a Function of Temperature - Quarter Thickness	16
300.8	Pre-Irradiation Charpy V-notch Energy as a Function of Temperature - Half Thickness	17
300.9	Pre-Irradiation Charpy V-notch Energy as a Function of Temperature - Three Quarter Thickness	18
300.10	Pre-Irradiation Charpy V-notch Energy as a Function of Temperature - Bottom Surface	19
300.11	Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Top Surface	20
300.12	Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Quarter Thickness	21
300.13	Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Half Thickness	22

LIST OF FIGURES (Continued)

<u>Figure No.</u>	<u>Title</u>	<u>Page No.</u>
300.14	Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Three Quarter Thickness	23
300.15	Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Bottom Surface	24

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page No.</u>
200.1	Post-Irradiation Charpy V-notch Impact Data	5
300.1	Pre-Irradiation Tensile Properties of 12" A533 Grade B Class I Steel Heat No. 1195-1, Plate 2	13
300.2	Pre-Irradiation Charpy V-notch Impact Data for 12" A533 Grade B Class I Steel Heat No. 1195-1, Plate 2 Top Surface	25
300.3	Pre-Irradiation Charpy V-notch Impact Data for 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Top Quarter Thickness	27
300.4	Pre-Irradiation Charpy V-notch Impact Data for 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Center Thickness	28
300.5	Pre-Irradiation Charpy V-notch Impact Data for 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Three Quarter Thickness	29
300.6	Pre-Irradiation Charpy V-notch Impact Data for 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Bottom Surface	30
300.7	Drop Weight Test Data for 12" Thick Plate A533 Grade B Class I Steel Heat No. 1195-1 Plate 2	32
300.8	Results of Fracture Toughness Tests 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Top Surface	35
300.9	Results of Fracture Toughness Tests 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Top Quarter Thickness	36
300.10	Results of Fracture Toughness Tests 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Center Thickness	37
300.11	Results of Fracture Toughness Tests 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Bottom Quarter Thickness	38
300.12	Results of Fracture Toughness Tests 12" A533 Grade B Class I Steel Heat No. 1195-1 Plate 2 Bottom	39

PROGRAM DESCRIPTION

An experimental program is being performed directed towards further development and evaluation of a fracture mechanics approach to the problem of brittle fracture of reactor vessel materials, based upon the use of modified Wedge Opening Loading (WOL) specimens. Experimental testing of a group of reactor vessel steels is being performed to investigate the application of the fracture mechanics technique to these materials in both the unirradiated and irradiated conditions. Because of test reactor dimensional constraints, scaled-up specimens can only be used to obtain pre-irradiation data; therefore, irradiation effects will be determined only on small specimens.

Testing in the unirradiated and irradiated conditions will be conducted to determine the variability in fracture toughness of various materials. Materials being investigated include base metal samples from two different heats of nickel modified, manganese-molybdenum steel and European forging grade material; and weld and heat affected zone samples from one heat of a nickel modified, manganese-molybdenum steel. Tensile, Charpy V-notch and drop weight specimens from those materials are included in the program in order to provide correlation data.

EUFM-100 - Program Management (Summary of Progress)

L. F. Cochrun - Project Engineer

This is the eighth technical progress report on a USAEC-Euratom joint program on fracture mechanics. The previous technical progress reports were:

EURAEC-2007 WCAP-3677-7	"Fracture Mechanics Evaluation of Reactor Vessel Steels Quarterly Progress Report for the Period Ending March 31, 1968"
EURAEC-1953 WCAP-3677-6	"Fracture Mechanics Evaluation of Reactor Vessel Steels Quarterly Progress Report for the Period Ending December 31, 1967"
EURAEC-1924 WCAP-3677-5	"Fracture Mechanics Evaluation of Reactor Vessel Steels Quarterly Progress Report for the Period Ending September 30, 1967"
EURAEC-1879 WCAP-3677-4	"Fracture Mechanics Evaluation of Reactor Vessel Steels Quarterly Progress Report for the Period Ending June 30, 1967"
EURAEC-1829 WCAP-3677-3	"Fracture Mechanics Evaluation of Reactor Vessel Steels Technical Progress Report for the Period Ending March 31, 1967"
EURAEC-1780 WCAP-3677-2	"Fracture Mechanics Evaluation of Reactor Vessel Steels Technical Progress Report for the Period Ending December 31, 1966"
EURAEC-1720 WCAP-3677-1	"Fracture Mechanics Evaluation of Reactor Vessel Steels Technical Progress Report for the Period Ending September 30, 1966"

Progress during the period April 1, 1968 through June 30, 1968 is summarized as follows:

1. The irradiation of the second set of three (3) capsules in the Babcock and Wilcox Test Reactor (BAWTR) is continuing. Approximately 82 EFPD or 60% of the target exposure has been accumulated.

2. Testing of the irradiated Charpy "V" notch specimens from the first set of capsules was initiated.
3. The pre-irradiation testing of the tensile, Charpy "V" notch and drop weight specimens from the 12-inch thick plate of A533 Grade B Class I steel was completed this quarter.

EUFM-200 - Irradiation and Analysis

T. R. Mager, W. S. Hazelton, F. O. Thomas

This task provided for the planning of the irradiation experiment, including the design, manufacture and assembly of the irradiation capsules. Technical direction shall be provided during the capsule irradiation, capsule disassembly and post-irradiation examination of specimens. Analysis and evaluation of the experimental results will be performed under this task.

The irradiation of the second set of three (3) capsules in the Babcock and Wilcox Test Reactor (BAWTR) is continuing. The total exposure accumulated by the capsules was 82 EFPD or about 60% of the target exposure. During BAWTR outting in July, the capsules will be rotated 180 degrees to homogenize the fast neutron exposure through the specimen thickness.

The testing of the irradiated Charpy "V" notch specimens from the European forging grade steel, the 8-inch thick plate of A533 Grade B Class I steel, and the weldment (both weld and HAZ) was initiated at Westinghouse's Post-Irradiation Laboratory at Waltz Mill during this report period. Since the test data are incomplete, the results will not be presented graphically. The incomplete set of data are summarized in Table 200.1. The material had a total exposure of 132 EFPD or an estimated fluence of 1.3×10^{19} . The dosimeters used for monitoring the exposure of the first three (3) capsules are presently undergoing analytical evaluation at the Post-Irradiation Laboratory.

TABLE 200.1

POST-IRRADIATION CHARPY V-NOTCH IMPACT DATA

<u>Specimen Number</u>	<u>Test Temp (°F)</u>	<u>Impact Strength (Ft-Lbs)</u>	<u>Capsule Number</u>
A533 Grade B Class I - 8 Inch Thick Plate			
L16	80	9.0	2
L23	150	14.0	3
L14	150	16.0	2
L10	200	20.5	2
L26	200	25.9	3
L15	225	25.0	2
L19	250	28.0	3
L28	250	31.0	3
L12	250	39.0	2
L18	350	40.0	3
L5	350	48.0	2
European Forging Grade Steel			
N5	80	12.5	2
N9	80	17.9	2
N14	80	38.0	2
N25	125	41.0	3
N8	150	17.0	2
N31	150	59.0	3
N10	175	37.0	2
N12	200	59.0	2
N24	350	67.8	3
N7	350	88.0	2
Weld, (A533 Grade B Class I)			
PW4	150	23.0	1
PW5	200	30.0	1
PW6	200	36.0	1
PW2	275	40.0	1
HAZ, (A533 Grade B Class I)			
PH6	- 40	18.0	1
PH7	- 25	23.0	1
PH2	0	50.0	1
PH4	32	44.0	1
PH3	80	56.0	1
PH5	150	110.0	1

TABLE 200.1 (continued)

POST-IRRADIATION CHARPY V-NOTCH IMPACT DATA

A302 B Reference Steel

R2	150	8	1
R5	150	8	3
R3	150	25	2
R6	275	26	3
R4	275	37	2
R1	275	61	1

EUFM-300 - Pre-Irradiation Testing

T. R. Mager, W. S. Hazelton, F. O. Thomas

Under this task, the material required for the test specimens was procured and the pre- and post-irradiation specimens were manufactured. The testing of the pre-irradiation specimens will be carried out and the results developed for analysis and evaluation under Task EUFM-200.

Specimen Fabrication

The specimens required for the pre-irradiation portion of the program were fabricated from the 12-inch thick plate of A533 Grade B Class I (Mn Mo with Ni) steel. Specimens were machined from the top surface, 1/4 thickness, 1/2 thickness, 3/4 thickness and bottom surface of the 12-inch plate. Tensiles, Charpy V-notch, drop weight, 1X WOL, 1/2T, 1T and 2T Compact K_{IC} specimens were machined from each of the five locations through the thickness of the plate. The required 1X WOL's, 1T and 2T Compact K_{IC} specimens were fatigue cracked prior to the initiation of the test program.

Mechanical Testing

The pre-irradiation testing of the tensile, Charpy V-notch and drop weight specimens fabricated from the 12-inch thick plate of A533 Grade B Class I steel was completed this quarter. The tensile properties were evaluated from -250°F to $+600^{\circ}\text{F}$. The results are summarized in Figures 300.1 through 300.5 and Table 300.1.

Charpy V-notch and drop weight test specimens from the 12-inch thick plate were tested at various temperatures. Test data are shown in Figures 300.6 through 300.10 (energy versus temperature), Figures 300.11 through 300.15 (per cent brittle fracture and lateral expansion versus temperature) and Tables 300.2 through 300.6. The drop weight data are summarized in Table 300.7.

Figure 300.1. Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A-533 Grade B Class I Steel-Top Surface

Figure 300.2. Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A-533 Grade B Class I Steel - Quarter Thickness

Figure 300.3. Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A-533 Grade B Class I Steel Half Thickness

Figure 300 4 Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Three Quarter Thickness

Figure 300.5. Pre-Irradiation Tensile Properties of 12-Inch Thick Plate of A533 Grade B Class I Steel - Bottom Surface

TABLE 300.1

PRE-IRRADIATION TENSILE PROPERTIES OF 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1, PLATE 2

Specimen Number	Test Temp (°F)	Yield Point (Psi)	Tensile Strength (Psi)	Elongation (%)	Reduction of Area (%)
Top Surface					
T1	-250	132,050	134,900	23.1	58.7
T2	-250	127,700	137,700	20.0	58.0
T3	-150	103,250	119,150	21.1	61.7
T4	-150	105,950	118,300	22.1	64.3
T5	75	80,900	97,550	20.7	66.5
T6	75	82,450	97,450	20.5	71.9
T7	300	74,750	88,050	16.7	71.8
T8	300	75,350	87,150	17.6	70.5
T9	600	68,050	91,600	16.1	66.5
T10	600	67,850	92,800	17.3	69.1
Top Quarter Thickness					
1Q1	-250	114,300	119,650	5.9	7.6
1Q2	-250	111,400	124,850	19.7	50.9
1Q3	-150	91,250	112,000	21.8	62.1
1Q4	-150	91,400	112,450	21.1	60.3
1Q5	75	71,850	91,250	18.4	66.1
1Q6	75	69,100	91,150	16.6	62.8
1Q7	300	63,350	83,150	15.6	66.9
1Q8	300	63,550	83,350	17.0	69.2
1Q9	600	59,100*	85,900	16.4	66.3
1Q10	600	58,500*	86,350	16.6	61.9
Center Thickness					
C1	-250	116,900	128,300	6.5	7.9
C2	-250	113,750	128,550	18.9	53.4
C3	-150	90,500	110,750	18.9	56.3
C4	-150	95,150	110,150	18.9	52.0
C5	75	67,650	92,050	19.1	63.4
C6	75	68,400	91,600	17.4	61.8
C7	300	64,150	83,150	15.2	65.7
C8	300	62,950	83,350	16.0	64.3
C9	600	59,950*	86,150*	16.1	59.4
C10	600	59,750*	86,050*	14.1	49.5

TABLE 300.1 (continued)

PRE-IRRADIATION TENSILE PROPERTIES OF 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1, PLATE 2

Bottom Quarter Thickness

3Q1	-250	113,600	125,550	21.9	59.0
3Q2	-250	116,100	128,100	21.4	60.5
3Q3	-150	88,100	110,000	18.6	60.8
3Q4	-150	93,850	111,300	19.6	59.8
3Q5	75	72,600	91,150	17.9	65.1
3Q6	75	72,150	91,950	19.1	68.2
3Q7	300	63,550	82,950	15.7	70.2
3Q8	300	63,850	81,300	16.4	70.2
3Q9	600	59,550*	86,250	16.5	64.7
3Q10	600	59,450*	84,200	16.1	66.1

Bottom Surface

B1	-250	127,200	137,550	19.6	57.9
B2	-250	128,250	134,000	21.2	59.0
B3	-150	104,100	118,750	21.3	63.1
B4	-150	99,800	118,900	21.8	64.7
B5	75	88,000	97,550	20.0	71.5
B6	75	85,300	97,950	18.3	71.0
B7	300	74,650	88,700	17.3	71.0
B8	300	75,050	88,300	17.1	71.0
B9	600	68,250*	87,150	17.5	67.2
B10	600	69,050	92,350	17.5	60.6

* Indicates 0.2% Offset Yield Strength

Figure 300.6. Pre-Irradiation Charpy V-notch Energy
as a Function of Temperature - Top Surface

Figure 300.7. Pre-Irradiation Charpy V-notch Energy as a Function of Temperature-Quarter Thickness

Figure 300.8. Pre-Irradiation Charpy V-notch Energy as a Function of Temperature-Half Thickness

Figure 300.9. Pre-Irradiation Charpy V-notch Energy as a Function of Temperature-Three Quarter Thickness

Figure 300.10. Pre-Irradiation Charpy V-notch Energy
as a Function of Temperature - Bottom Surface

Figure 300.11. Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Top Surface

Figure 300.12. Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Quarter Thickness

Figure 300.13. Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Half Thickness

Figure 300.14. Pre-Irradiation Charpy V-notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Three Quarter Thickness

Figure 300.15. Pre-Irradiation Charpy V-Notch Lateral Expansion and Brittle Fracture as a Function of Temperature - Bottom Surface

TABLE 300.2

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

TOP SURFACE

<u>Specimen Number</u>	<u>Test Temp (°F)</u>	<u>Impact Strength (Ft-Lbs)</u>	<u>Fracture Appearance (% Brittle Fracture)</u>	<u>Lateral Expansion (Mils)</u>
T43	-140	14	95	1
T44		10	95	2
T45		10	95	4
T46	-120	34	85	22
T47		27	80	20
T48		37	80	27
T40	-100	35	80	25
T41		40	80	30
T42		43	80	31
T37	- 60	82	40	56
T38		88	30	60
T39		55	60	42
T5	- 10	75	50	50
T7		101	15	67
T9		117	0	76
T10	+ 10	115	0	74
T12		111	0	71
T15		108	0	70
T17	+ 30	111	0	74
T18		114	0	74
T19		113	0	72
T20	+ 60	116	0	72
T21		112	0	73
T22		112	0	74
T23	+110	114	0	74
T25		116	0	80
T27		117	0	75

TABLE 300.2 (continued)

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

TOP SURFACE

T31	+160	126	0	80
T33		125	0	79
T35		120	0	77

TABLE 300.3

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO 1195-1 PLATE 2

Specimen Number	Test Temp (°F)	TOP QUARTER THICKNESS		
		Impact Strength (Ft-Lbs)	Fracture Appearance (% Brittle Fracture)	Lateral Expansion (Mils)
1Q1	- 35	9	95	6
1Q2		11	95	8
1Q6		11	95	8
1Q8	- 10	33	95	25
1Q9		20	95	15
1Q10		15	95	11
1Q34		45	85	32
1Q36		39	85	28
1Q11	+ 10	35	90	25
1Q12		35	85	25
1Q14		27	85	21
1Q16	+ 30	36	80	26
1Q19		46	75	34
1Q20		46	80	33
1Q21	+ 60	58	65	42
1Q22		58	70	41
1Q24		53	70	39
1Q25	+110	90	30	64
1Q27		95	30	69
1Q28		110	25	78
1Q35		108	25	75
1Q30	+160	124	0	80
1Q31		118	10	84
1Q32		127	0	84

TABLE 300.4

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

CENTER THICKNESS

<u>Specimen Number</u>	<u>Test Temp (°F)</u>	<u>Impact Strength (Ft-Lbs)</u>	<u>Fracture Appearance (% Brittle Fracture)</u>	<u>Lateral Expansion (Mils)</u>
C1	- 35	50	65	35
C2		41	75	29
C4		19	85	15
C36		15	90	9
C6	- 10	30	80	23
C9		35	80	25
C12		20	85	16
C37		22	85	17
C13	+ 10	38	70	38
C14		37	80	27
C15		36	80	27
C16	+ 30	40	80	30
C18		35	80	26
C20		45	80	33
C21	+ 60	61	55	44
C24		51	70	38
C25		54	65	41
C26	+110	83	30	62
C27		100	25	71
C28		83	35	61
C38		90	30	65
C32	+160	126	2	82
C34		120	1	84
C35		119	10	80

TABLE 300.5

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

THREE QUARTER THICKNESS				
Specimen Number	Test Temp (°F)	Impact Strength (Ft-Lbs)	Fracture Appearance (% Brittle Fracture)	Lateral Expansion (Mils)
3Q1	- 35	9	95	6
3Q2		10	95	6
3Q3		14	95	9
3Q4	- 10	14	90	10
3Q5		17	95	13
3Q6		18	95	14
3Q7	+ 10	30	85	23
3Q8		30	85	23
3Q9		33	90	24
3Q10	+ 30	46	75	34
3Q11		46	80	33
3Q12		37	80	29
3Q13	+ 60	55	70	38
3Q14		38	70	28
3Q15		43	75	33
3Q22		50	70	34
3Q16	+110	88	40	62
3Q17		85	40	60
3Q18		77	35	56
3Q19	+160	119	0	76
3Q20		119	0	79
3Q21		127	0	75

TABLE 300.6

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

BOTTOM SURFACE

<u>Specimen Number</u>	<u>Test Temp (°F)</u>	<u>Impact Strength (Ft-Lbs)</u>	<u>Fracture Appearance (% Brittle Fracture)</u>	<u>Lateral Expansion (Mils)</u>
B28	-140	23	90	14
B29		23	90	11
B30		22	90	14
B31	-120	38	85	25
B32		31	85	23
B33		24	85	17
B25	-100	51	65	33
B26		40	75	25
B27		34	70	23
B22	- 60	89	20	58
B23		76	30	52
B24		87	15	59
B1	- 35	101	0	66
B2		107	0	71
B3		107	0	74
B4	- 10	104	0	67
B5		112	0	69
B6		109	0	70
B7	+ 10	99	0	63
B8		111	0	72
B9		108	0	80
B10	+ 30	110	0	71
B11		112	0	73
B12		110	0	70
B13	+ 60	112	0	74
B14		105	0	71
B15		113	0	68

TABLE 300.6 (continued)

PRE-IRRADIATION CHARPY V-NOTCH IMPACT DATA FOR 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

<u>BOTTOM SURFACE</u>				
B16	+110	111	0	73
B17		119	0	81
B18		115	0	77
B19	+160	117	0	75
B20		125	0	77
B21		121	0	76

TABLE 300.7

DROP WEIGHT TEST DATA FOR 12" THICK PLATE
A533 GRADE B CLASS I STEEL - HEAT NO. 1195-1 PLATE 2

Specimen Length	5 in.
Specimen Width	2 in.
Specimen Thickness	5/8 in.
Support Span	4 in.
Stop Height	.075 in.
Weight of Head	60 lb
Drop Weight	5 ft

TOP SURFACE

<u>No.</u>	<u>Temp</u>	<u>Result</u>	<u>N.D.T.</u>
D2-T-1	0°F	Not Broken	
D2-T-2	- 40°F	Not Broken	
D2-T-3	- 80°F	Not Broken	
D2-T-4	-120°F	Broken	
D2-T-5	-100°F	Not Broken	
D2-T-6	-110°F	Broken	
D2-T-7	-100°F	Broken	
D2-T-8	- 90°F	Broken	-90°F*

TOP QUARTER THICKNESS

D1-1Q-1	0°F	Not Broken	
D1-1Q-2	- 20°F	Broken	
D1-1Q-3	- 10°F	Broken	
D1-1Q-4	0°F	Not Broken	-10°F

CENTER THICKNESS

D2-C-1	0°F	Not Broken	
D2-C-2	- 40°F	Broken	
D2-C-3	- 20°F	Broken	
D2-C-4	- 10°F	Broken	
D2-C-5	0°F	Broken	
D2-C-6	+ 10°F	Not Broken	
D2-C-7	+ 10°F	Not Broken	0°F

TABLE 300.7 (continued)

THREE QUARTER THICKNESS

D1-3Q-1	0°F	Broken	
D1-3Q-2	+ 20°F	Not Broken	
D1-3Q-3	+ 10°F	Not Broken	
D1-3Q-4	+ 10°F	Not Broken	0°F

BOTTOM SURFACE

D2-B-1	0°F	Not Broken	
D2-B-2	- 40°F	Not Broken	
D2-B-3	- 80°F	Not Broken	
D2-B-4	-120°F	Broken	
D2-B-5	-100°F	Broken	
D2-B-6	- 90°F	Broken	
D2-B-7	- 80°F	Broken	
D2-B-8	- 70°F	Broken	-60°F*

* Tentative N.D.T. - Additional tests in progress

Fracture toughness testing was initiated utilizing 1X WOL, 1T and 2T Compact K_{IC} specimens fabricated from the 12-inch thick plate. Since only limited data were obtained during this report period the fracture toughness K_{IC} is not plotted graphically as a function of temperature. Instead, the stress intensity factors (fracture toughness) for the 12-inch thick plate are summarized in Tables 300.8 through 300.12. As discussed in previous quarterly reports pertaining to fracture mechanics, the requirements of the type of fracture toughness testing employed are unusual in that it is necessary to compare post-test data to specimen pre-test dimensions to determine if the fracture toughness measured (K_Q) is the critical value (K_{IC}) for the material. In other words, validity of the test can be determined only after testing. Two criteria for validity have been proposed:

1. Reference 1 proposes use of the secant offset method to determine that the majority of strain is due to slow crack growth.
2. Reference 2 proposes that both the crack length and specimen thickness exceeds $2.5 \times (\text{Fracture Toughness}/\text{Strength})^2$. Fracture toughness measured for specimens meeting these criteria is considered to be the critical value (K_{IC}) for the material. If the criteria are not met, the measured fracture toughness (K_Q) is considered to have been biased by specimen size.

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- (1) J. E. Srawley, Notes Pertaining to Sect. 7.3.2 of Draft Recommended Practice, "Interpretation of Test Record and Calculation of K_{IC} ," January 2, 1967.
 - (2) ASTM, E24 Sub I Task Group, "Recommended Practice for Plane-Strain Fracture Toughness Testing of High Strength Metallic Materials Using a Fatigue-Cracked Bend Specimen," draft of proposal practice, December 14, 1966.

TABLE 300.8

RESULTS OF FRACTURE TOUGHNESS TESTS 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

TOP SURFACE

Specimen Number	Size	Temp (°F)	Y.S. (Ksi)	a (in.)	a/W	Plastic Zone Size r(in.)	Stress Intensity Factor K_{IC}, K_Q (Ksi $\sqrt{\text{in.}}$)	Validity
W-1T11	1X	-200	115.0	0.548	0.487	0.009	48.3	1
K3-1T5	1T	-200	115.0	1.022	0.511	0.010	50.1	1
K2-2T5	2T	-150	114.0	2.041	0.510	0.011	51.0	1
K1-2T3	2T	-100	97.0	2.029	0.507	0.028	70.0	1
K1-2T1	2T	-100	97.0	2.050	0.513	0.036	79.4	1
K2-2T8	2T	-100	97.0	2.200	0.550	0.078	117.3	4
K2-2T6	2T	- 50	90.0	2.031	0.508	0.065	99.5	2

- Note: 1. Meets both criteria: a and B greater than $2.5(K_{IC}/Y.S.)^2$ and secant offset
 2. Fails a and B greater than $2.5(K_{IC}/Y.S.)^2$, meets secant offset
 3. Meets a and B greater than $2.5(K_{IC}/Y.S.)^2$, fails secant offset
 4. Fails both criteria

TABLE 300.9

RESULTS OF FRACTURE TOUGHNESS TESTS 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

TOP QUARTER THICKNESS

Specimen Number	Size	Temp (°F)	Y.S. (Ksi)	a (in.)	a/W	Plastic Zone Size r(in.)	Stress Intensity Factor K_{IC}, K_Q (Ksi $\sqrt{\text{in.}}$)	Validity
W-1Q12	1X	-200	99.0	0.523	0.465	0.008	37.5	1
K6-1Q38	1T	-200	99.0	1.011	0.506	0.005	31.2	1
K5-1Q17	2T	-100	86.0	2.029	0.507	0.023	56.2	1
K5-1Q16	2T	-100	86.0	2.034	0.509	0.025	59.0	1
K6-1Q20	2T	- 50	81.0	2.010	0.503	0.034	65.0	1

- Note: 1. Meets both criteria: a and B greater than $2.5 (K_{IC}/Y.S.)^2$ and secant offset
 2. Fails a and B greater than $2.5 (K_{IC}/Y.S.)^2$, meets secant offset
 3. Meets a and B greater than $2.5 (K_{IC}/Y.S.)^2$, fails secant offset
 4. Fails both criteria

TABLE 300.10

RESULTS OF FRACTURE TOUGHNESS TESTS 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

CENTER THICKNESS

Specimen Number	Size	Temp (°F)	Y.S. (Ksi)	a (in.)	a/W	Plastic Zone Size r(in.)	Stress Intensity Factor		Validity
							K_{IC}	K_Q (Ksi $\sqrt{\text{in.}}$)	
W-1C10	1X	-200	93.0	0.555	0.493	0.012		44.0	1
K3-1C16	1T	-200	93.0	1.030	0.515	0.008		35.1	1
K1-2C4	2T	-100	79.0	2.091	0.523	0.021		50.2	1
K2-2C6	2T	- 50	74.0	2.036	0.509	0.041		65.0	1
K1-2C2	2T	- 50	74.0	2.023	0.506	0.041		65.1	1
K1-2C1	2T	- 50	74.0	2.041	0.510	0.061		79.2	2
K2-2C5	2T	0	73.0	2.024	0.506	0.065		81.0	2

- Notes:
1. Meets both criteria: a and B greater than $2.5 (K_{IC}/Y.S.)^2$ and secant offset
 2. Fails a and B greater than $2.5 (K_{IC}/Y.S.)^2$, meets secant offset
 3. Meets a and B greater than $2.5 (K_{IC}/Y.S.)^2$, fails secant offset
 4. Fails both criteria

TABLE 300.11

RESULTS OF FRACTURE TOUGHNESS TESTS 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

BOTTOM QUARTER THICKNESS

<u>Specimen Number</u>	<u>Size</u>	<u>Temp (°F)</u>	<u>Y.S. (Ksi)</u>	<u>a (in.)</u>	<u>a/W</u>	<u>Plastic Zone Size r(in.)</u>	<u>Stress Intensity Factor K_{IC}, K_Q (Ksi $\sqrt{\text{in.}}$)</u>	<u>Validity</u>
W-3Q4	1X	-200	98.0	0.626	0.556	0.009	41.0	1
K6-3Q51	1T	-200	98.0	1.016	0.508	0.005	30.8	1
K4-3Q12	2T	-100	87.0	2.031	0.508	0.018	51.3	1
K5-3Q19	2T	-100	87.0	2.065	0.516	0.018	51.4	1
K4-3Q13	2T	- 50	82.0	2.074	0.519	0.025	56.7	1
K4-3Q14	2T	0	79.0	2.026	0.507	0.037	66.4	1

- Notes: 1. Meets both criteria: a and B greater than $2.5 (K_{IC}/Y.S.)^2$ and secant offset
 2. Fails a and B greater than $2.5 (K_{IC}/Y.S.)^2$, meets secant offset
 3. Meets a and B greater than $2.5 (K_{IC}/Y.S.)^2$, fails secant offset
 4. Fails both criteria

TABLE 300.12

RESULTS OF FRACTURE TOUGHNESS TESTS 12" A533 GRADE B CLASS I STEEL
HEAT NO. 1195-1 PLATE 2

BOTTOM

Specimen Number	Size	Temp (°F)	Y.S. (Ksi)	a (in.)	a/W	Plastic Zone Size r(in.)	Stress Intensity Factor K_{IC}, K_Q (Ksi $\sqrt{\text{in.}}$)	Validity
W-1B9	1X	-200	109.0	0.534	0.475	0.012	51.0	1
K3-1B28	1T	-200	109.0	1.023	0.512	0.016	59.5	1
K3-2E11	2T	-150	102.0	2.031	0.508	0.018	60.2	1
K2-2E7	2T	-100	98.0	2.023	0.506	0.017	55.2	1
K1-2E2	2T	-100	98.0	2.005	0.501	0.021	61.5	1
K1-2E3	2T	-100	98.0	2.028	0.507	0.024	66.3	1
K1-2E4	2T	-100	98.0	2.024	0.506	0.036	80.5	1
K2-2E5	2T	- 50	94.0	2.045	0.511	0.058	98.1	4

- Notes:
1. Meets both criteria: a and B greater than $2.5 (K_{IC}/Y.S.)^2$ and secant offset
 2. Fails a and B greater than $2.5 (K_{IC}/Y.S.)^2$, meets secant offset
 3. Meets a and B greater than $2.5 (K_{IC}/Y.S.)^2$, fails secant offset
 4. Fails both criteria