Table 3.37: Statistical Analysis of absorbed Energy for the 4-Mill Group.

Group	No. of Test Locations	Absorbed Energy (ft-lbs) 0 F				MSA	MSW	F-Ratio	p-value
		Min	Max	Mean	COV, %	(ft^2-lbs^2)	(ft^2-lbs^2)		
A572-T1	91	4.7	175.0	70.0	71.4	16776.6	302.8	55.4	0.000
A572-T2	70	5.7	148.0	62.9	55.7	8299.8	166.6	49.8	0.000
A572-T3	49	3.0	167.3	59.3	86.4	18285.4	394.6	46.3	0.000
A572-T4	14	8.3	29.7	13.7	44.6	268.7	18.2	14.8	0.002
A588-T1	105	10.7	254.3	106.4	54.9	18148.2	1123.0	16.2	0.000
A588-T2	91	10.3	303.3	148.3	52.8	38849.0	1108.0	35.1	0.000
A588-T3	49	7.0	142.7	58.1	73.3	11464.3	434.5	26.4	0.000
A588-T4	14	19.3	98.3	42.8	58.6	4754.6	284.5	16.7	0.002
A572 All Groups	224	3.0	175.0	61.9	74.6	13704.0	262.5	52.2	0.000
A588 All Groups	259	7.0	303.3	108.6	66.2	31210.3	942.1	33.1	0.000
Group	No. of Test Locations	40 F				MSA	MSW	F-Ratio	p-value
		Min	Max	Mean	COV, %	(ft^2-lbs^2)	(ft^2-lbs^2)		
A572-T1	91	10.0	183.7	88.3	52.4	14344.6	257.3	55.8	0.000
A572-T2	70	33.0	160.0	94.1	35.9	7449.8	191.0	39.0	0.000
A572-T3	49	5.7	194.7	74.1	82.3	24976.2	685.4	36.4	0.000
A572-T4	14	10.7	42.7	23.5	46.1	1201.0	27.8	43.2	0.000
A588-T1	105	23.0	267.0	142.8	42.6	18883.6	1346.5	14.0	0.000
A588-T2	91	64.7	299.0	192.3	35.1	27697.1	996.6	27.8	0.000
A588-T3	49	12.0	155.3	76.5	63.7	16257.9	387.0	42.0	0.000
A588-T4	14	35.0	130.7	70.2	43.1	5734.1	515.5	11.1	0.005
A572 All Groups	224	5.7	194.7	82.9	58.0	14667.5	315.9	46.4	0.000
A588 All Groups	259	12.0	299.0	143.7	51.9	33660.0	997.1	33.8	0.000
Group	No. of Test Locations	70 F				MSA	MSW	F-Ratio	p-value
		Min	Max	Mean	COV, %	(ft^2-lbs^2)	(ft^2-lbs^2)		
A572-T1	91	20.7	210.0	106.1	39.4	11281.5	281.4	40.1	0.000
A572-T2	70	43.3	210.0	114.9	30.1	7942.6	181.8	43.7	0.000
A572-T3	49	7.7	189.3	89.6	69.7	27123.0	574.3	47.2	0.000
A572-T4	14	14.3	75.7	33.4	57.9	3669.8	99.7	36.8	0.000
A588-T1	98	50.0	269.7	162.5	35.4	18168.3	815.3	22.3	0.000
A588-T2	91	91.0	318.7	204.4	26.7	19765.2	402.4	49.1	0.000
A588-T3	49	17.7	166.0	95.8	52.1	16974.8	419.8	40.4	0.000
A588-T4	14	75.0	166.0	111.3	23.8	6586.7	213.0	30.9	0.000
A572 All Groups	224	7.7	210.0	100.7	47.8	14823.3	303.0	48.9	0.000
A588 All Groups	259	17.7	318.7	162.4	40.9	28198.0	562.8	50.1	0.000

It can also be observed from Table 3.37 that most plates had relatively high absorbed energy values with average values (considering all thickness groups) of 61.9, 82.9, and 100.7 ft-lbs, respectively at 0, 40 and 70°F for the A572 steel; and 108.6, 143.7 and 162.4 ft-lbs, respectively, at 0, 40 and 70°F for the A588 steel. Clearly, the A588 steel plates showed higher absorbed energy values than the A572 steel plates did. The trend of a decrease in absorbed energy being accompanied by a decrease in test temperature is what one might expect because the material has lower resistance to brittle fracture at lower temperatures. Another observation from the test results is that, in most of the cases studied, the absorbed energy tends to decrease with an increase in plate thickness. In other words, the thicker the steel plate, the lower the fracture toughness measured (through the absorbed energy value).

Frequency distributions of the absorbed energy for each steel grade and thickness group are presented in Figures 3.8 to 3.15. Both histograms and cumulative distributions are shown for the three test temperatures. Finally, frequency distributions of the absorbed energy for the A572 and A588 steel grades are presented in Figures 3.16 and 3.17, respectively, where plates of all thickness groups are included.

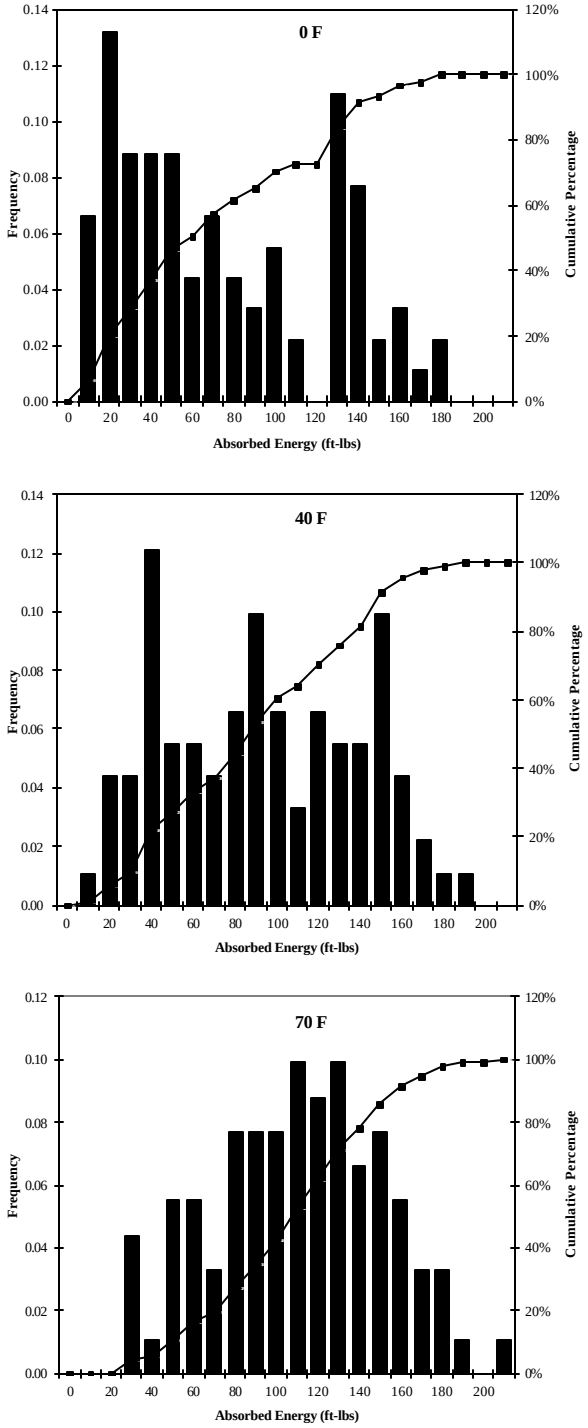

Figure 3.8: Absorbed Energy Frequency Distribution for the A572-T1 Group.

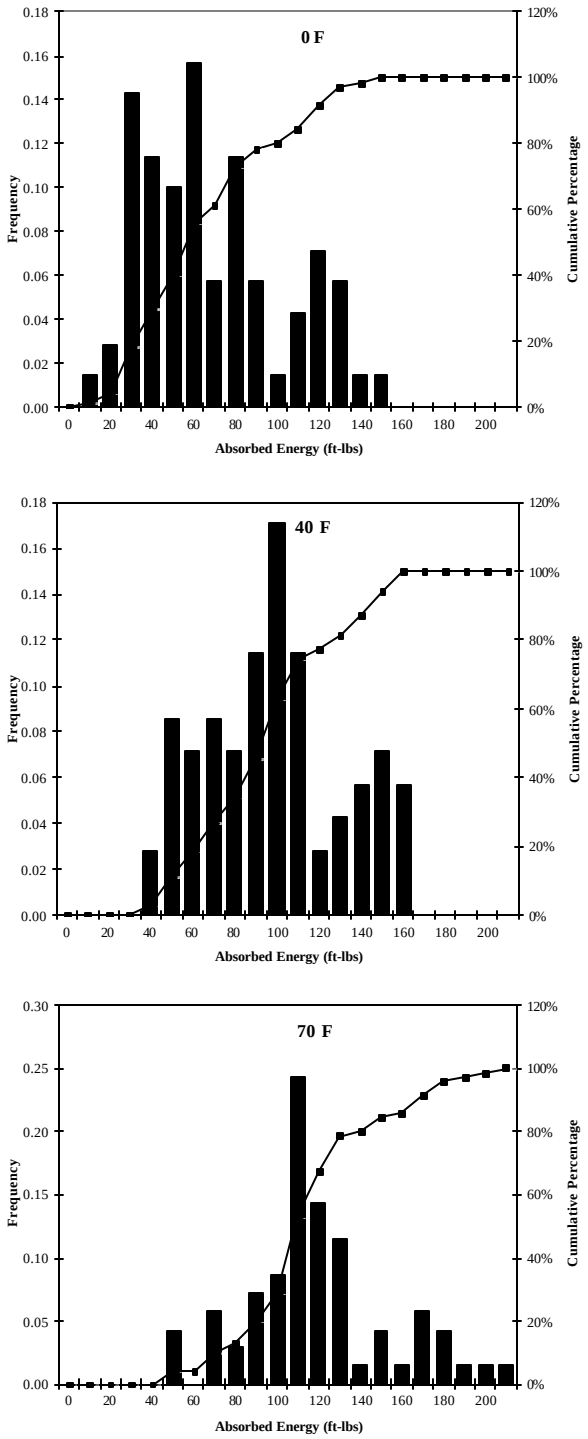

Figure 3.9: Absorbed Energy Frequency Distribution for the A572-T2 Group.

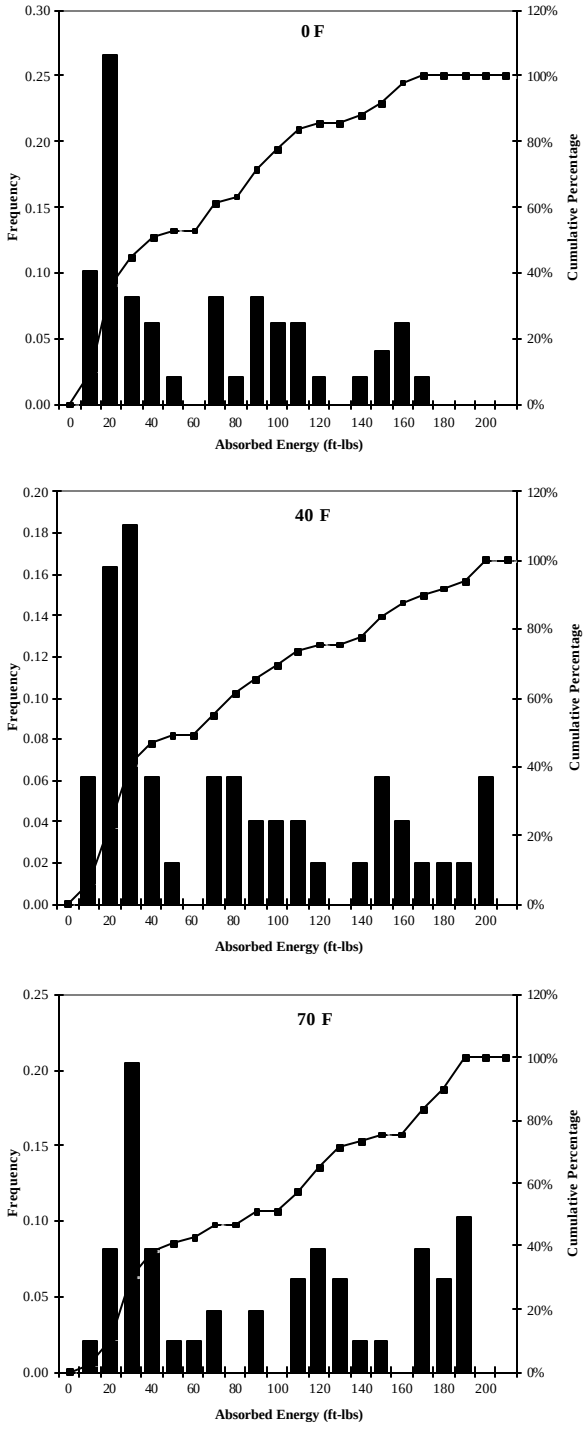

Figure 3.10: Absorbed Energy Frequency Distribution for the A572-T3 Group.

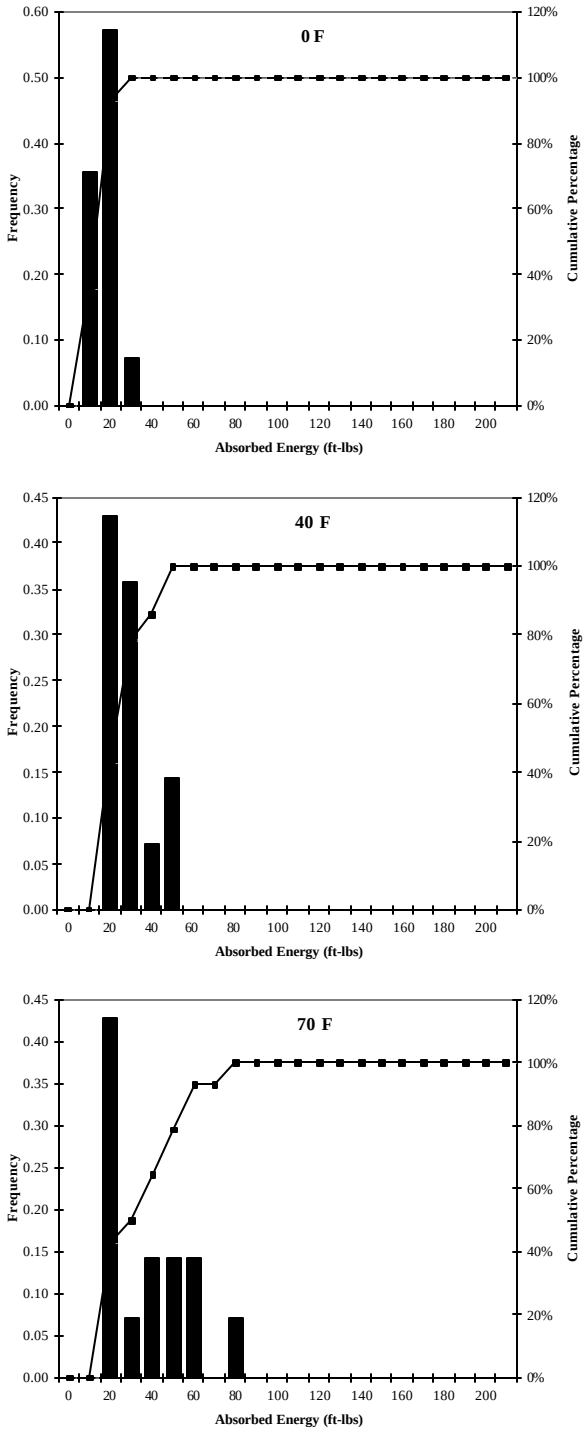

Figure 3.11: Absorbed Energy Frequency Distribution for the A572-T4 Group.

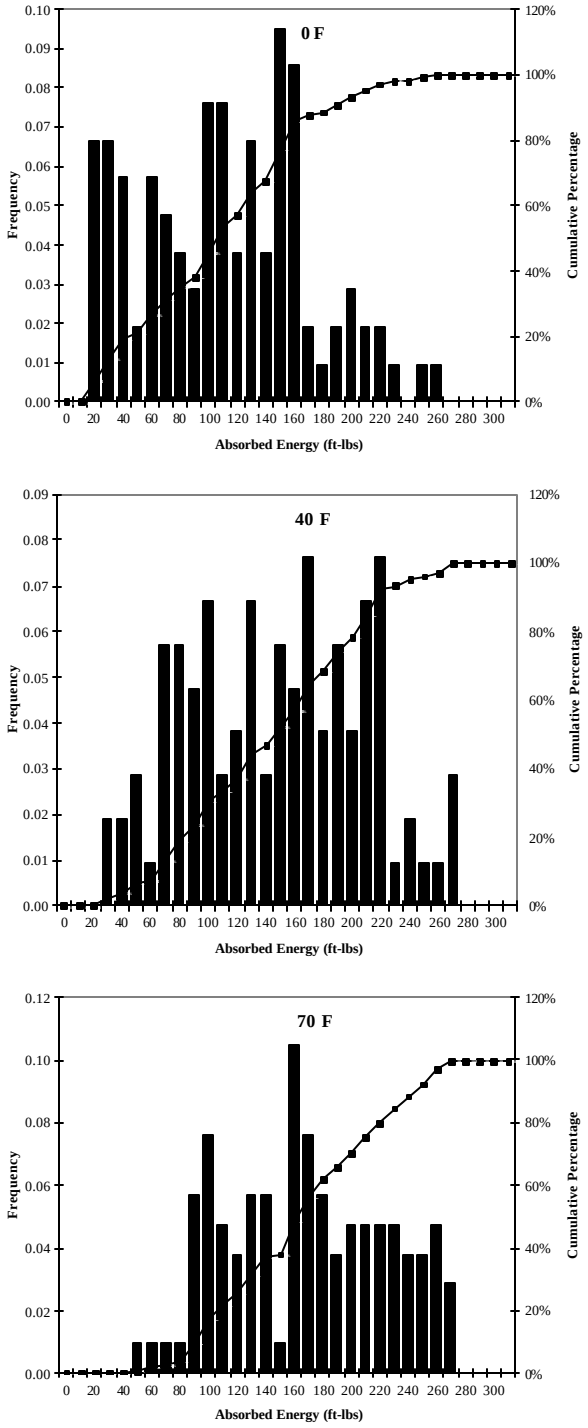

Figure 3.12: Absorbed Energy Frequency Distribution for the A588-T1 Group.

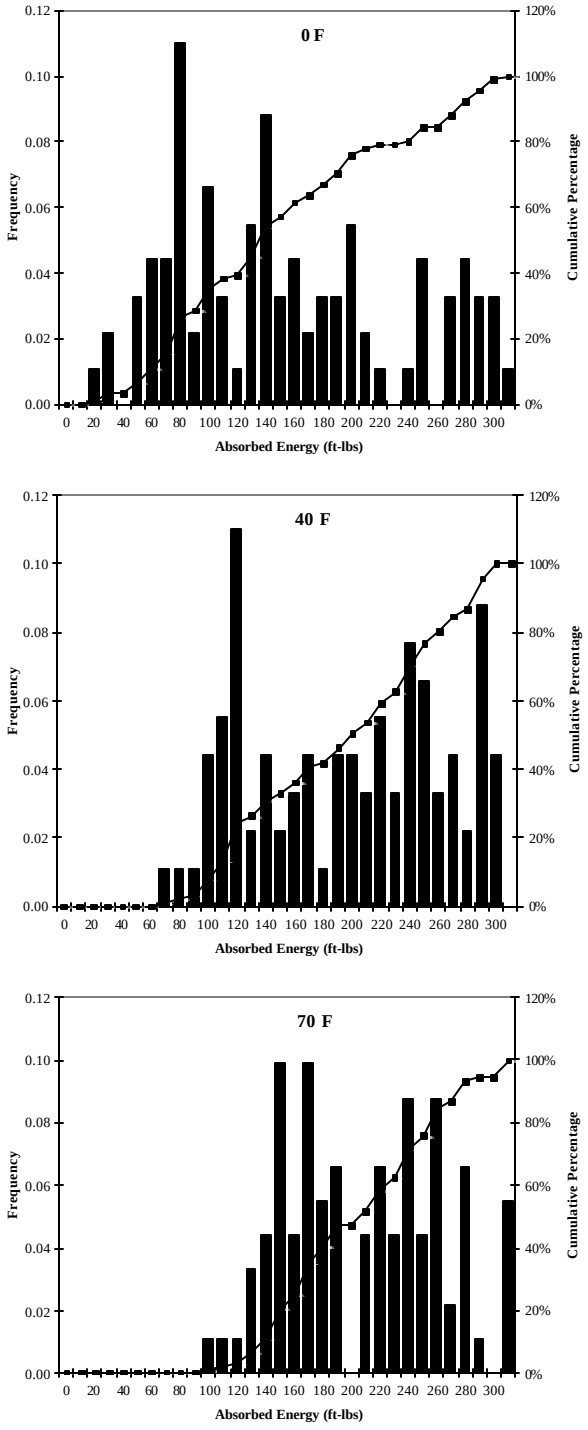

Figure 3.13: Absorbed Energy Frequency Distribution for the A588-T2 Group.

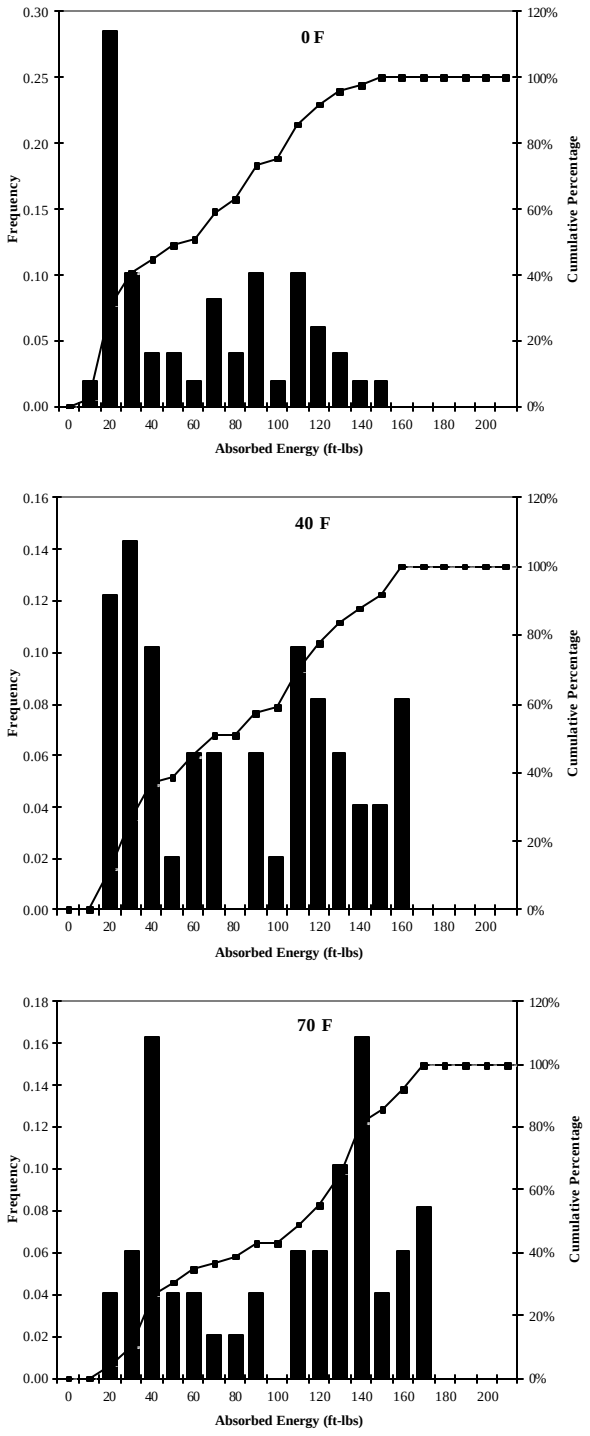

Figure 3.14: Absorbed Energy Frequency Distribution for the A588-T3 Group.

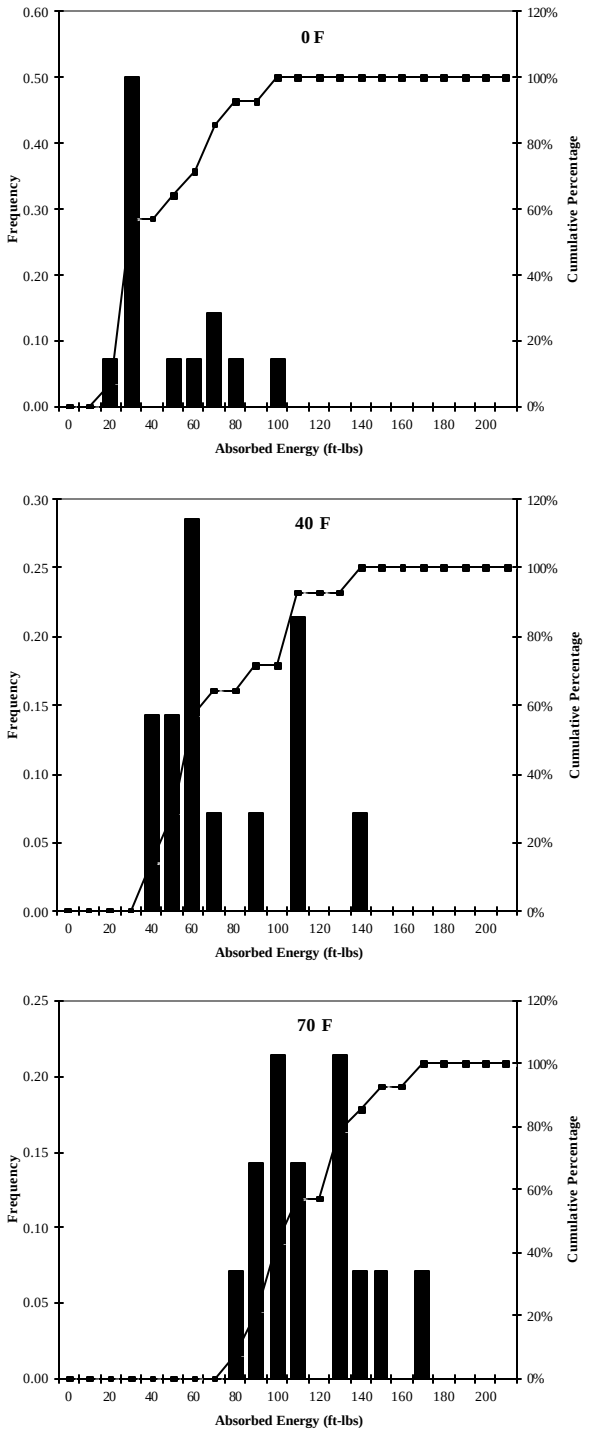

Figure 3.15: Absorbed Energy Frequency Distribution for the A588-T4 Group.

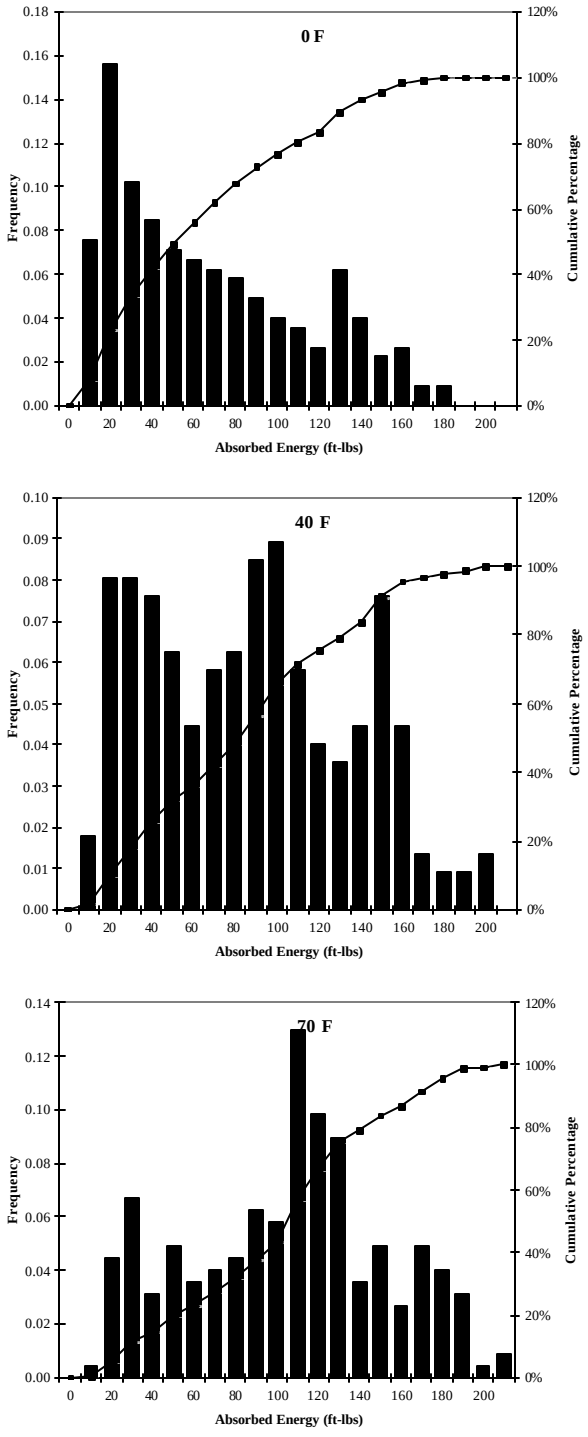

Figure 3.16: Absorbed Energy Frequency Distribution for all A572 Steel Plates.

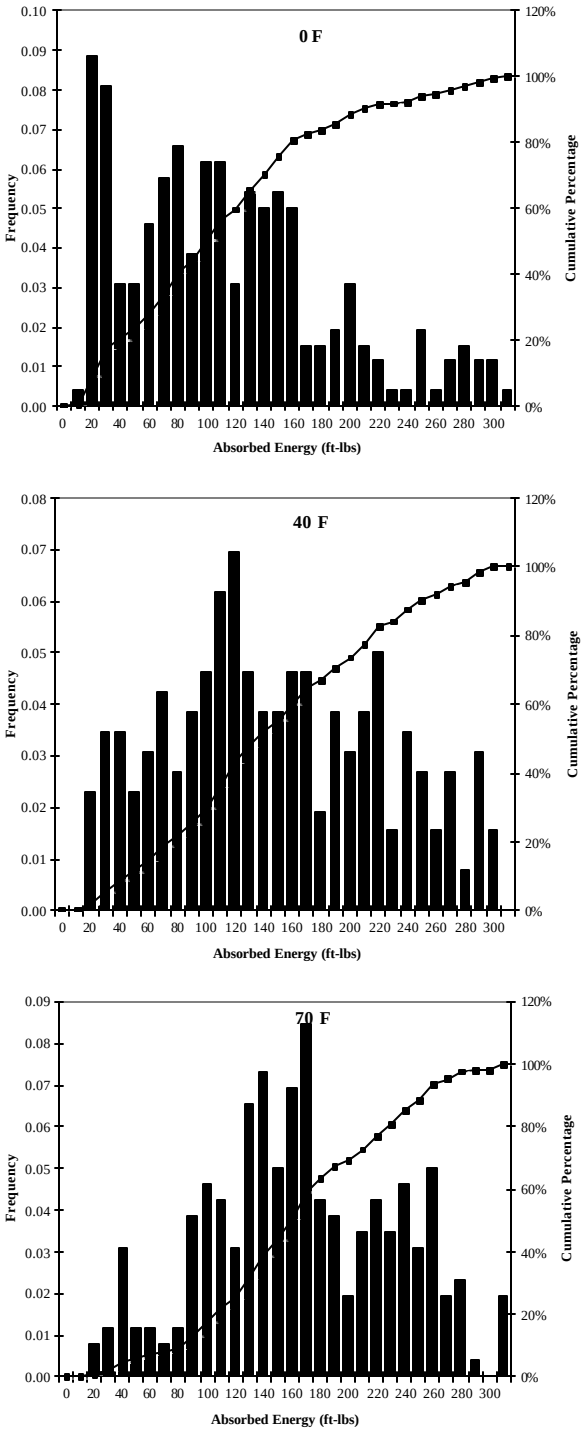

Figure 3.17: Absorbed Energy Frequency Distribution for all A588 Steel Plates.

3.6.3 REFERENCE LOCATION EFFECT IN CHARPY V-NOTCH TESTS

With Charpy V-notch test results, it is customary to calculate the probability that a three-test average absorbed energy value for any location tested will exceed the absorbed energy associated with a reference location less some specified value, α (AISI, 1979). In this study, the seven locations in a plate are each considered as the reference location and for different values of α equal to 5, 10, and 15 ft-lbs, results are presented for the percentage of samples that had absorbed energy greater than that the absorbed energy at the reference location, E_{ref}, reduced by α.

Results of the analyses are summarized in Tables 3.38 to 3.49. Tables 3.38 to 3.40 are for Mill 1 with α = 5, 10, and 15 ft-lbs, respectively. Tables 3.41 to 3.43 are for Mill 3 with α = 5, 10, and 15 ft-lbs, respectively. Tables 3.44 to 3.46 are for Mill 4 with α = 5, 10, and 15 ft-lbs, respectively. Tables 3.47 to 3.49 are for Mill 5 with α = 5, 10, and 15 ft-lbs, respectively.

In each table, for a given plate, the percent of locations with three-test average absorbed energy greater than $E_{ref}-\alpha$ is presented for each of seven possible choices of reference location. For each mill in the 4-mill group, results are presented for each grade of steel, for each thickness group, and for each test temperature. Average percentages for each plate are also presented, as are the minimum mean and maximum mean values for each thickness group and test temperature.

By way of illustration, the first six rows of Table 3.38 present Mill 1 results for group A572-T1 at a test temperature of 0°F. On average, the percentage of plates in this group that had absorbed energy greater than $E_{ref}-5$ ranged from 61.2 % to 73.5%. This means that if an A572-T1 steel plate were to be ordered from Mill 1 and a location, x, was selected at random to conduct CVN impact tests at 0°F and yielded an absorbed energy average value, $E_{ref,x}$, from three tests, the probability that any other location on the plate might have yield an averaged absorbed energy (from three tests) greater than $E_{ref,x}-5$ (ft-lbs) would vary between 61.2% and 73.5%. For higher values of α, these probabilities would increase.

Table 3.38: Effect of Reference Location for Mill 1, a = 5.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 5 For Mill 1									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	42.9	28.6	100.0	100.0	100.0	57.1	14.3	63.3	61.2	73.5
			42.9	14.3	71.4	100.0	100.0	71.4	42.9	63.3		
			85.7	42.9	100.0	71.4	71.4	28.6	42.9	63.3		
			14.3	57.1	28.6	100.0	57.1	71.4	100.0	61.2		
			14.3	100.0	28.6	100.0	85.7	100.0	85.7	73.5		
			28.6	100.0	14.3	100.0	85.7	71.4	71.4	67.3		
		40 F	42.9	28.6	85.7	100.0	100.0	28.6	57.1	63.3	59.2	65.3
			42.9	14.3	71.4	100.0	100.0	57.1	42.9	61.2		
			28.6	57.1	100.0	100.0	71.4	28.6	57.1	63.3		
			14.3	100.0	28.6	100.0	42.9	71.4	57.1	59.2		
			28.6	100.0	28.6	85.7	57.1	100.0	57.1	65.3		
			71.4	100.0	42.9	85.7	28.6	71.4	28.6	61.2		
		70 F	42.9	14.3	71.4	100.0	100.0	42.9	71.4	63.3	59.2	67.3
			57.1	57.1	85.7	100.0	85.7	28.6	14.3	61.2		
			28.6	100.0	85.7	42.9	100.0	14.3	100.0	67.3		
			14.3	85.7	57.1	100.0	42.9	71.4	57.1	61.2		
			57.1	100.0	57.1	85.7	28.6	100.0	28.6	65.3		
			57.1	100.0	57.1	71.4	14.3	85.7	28.6	59.2		
	T2	0 F	14.3	100.0	28.6	71.4	100.0	71.4	71.4	65.3	63.3	65.3
			100.0	85.7	14.3	71.4	28.6	71.4	71.4	63.3		
		40 F	71.4	71.4	100.0	71.4	28.6	85.7	14.3	63.3	59.2	63.3
			100.0	85.7	57.1	28.6	28.6	71.4	42.9	59.2		
		70 F	57.1	57.1	100.0	57.1	57.1	85.7	100.0	73.5	59.2	73.5
			100.0	85.7	28.6	14.3	57.1	57.1	71.4	59.2		
	T3	0 F	100.0	100.0	100.0	57.1	57.1	57.1	14.3	69.4	69.4	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		40 F	100.0	100.0	100.0	57.1	57.1	57.1	28.6	71.4	71.4	79.6
			14.3	71.4	71.4	100.0	100.0	100.0	100.0	79.6		
		70 F	100.0	85.7	85.7	57.1	42.9	42.9	14.3	61.2	61.2	75.5
			71.4	85.7	85.7	71.4	100.0	14.3	100.0	75.5		
A 588	T1	0 F	57.1	100.0	42.9	85.7	42.9	71.4	14.3	59.2	57.1	65.3
			42.9	85.7	14.3	100.0	57.1	71.4	28.6	57.1		
			14.3	100.0	42.9	71.4	28.6	100.0	71.4	61.2		
			28.6	100.0	14.3	100.0	57.1	100.0	57.1	65.3		
			71.4	85.7	42.9	71.4	42.9	100.0	42.9	65.3		
			71.4	100.0	100.0	57.1	42.9	57.1	28.6	65.3		
		40 F	57.1	100.0	14.3	71.4	42.9	85.7	42.9	59.2	59.2	63.3
			42.9	100.0	28.6	85.7	71.4	57.1	42.9	61.2		
			28.6	100.0	71.4	85.7	71.4	71.4	14.3	63.3		
			28.6	100.0	42.9	71.4	57.1	100.0	28.6	61.2		
			14.3	100.0	71.4	100.0	42.9	71.4	28.6	61.2		
			14.3	100.0	57.1	100.0	28.6	71.4	42.9	59.2		
		70 F	14.3	85.7	28.6	71.4	71.4	100.0	42.9	59.2	57.1	63.3
			57.1	100.0	42.9	85.7	14.3	71.4	28.6	57.1		
			85.7	100.0	28.6	28.6	42.9	71.4	71.4	61.2		
			57.1	85.7	42.9	85.7	57.1	100.0	14.3	63.3		
			57.1	71.4	57.1	85.7	42.9	100.0	14.3	61.2		
			42.9	57.1	85.7	71.4	28.6	100.0	14.3	57.1		
	T2	0 F	85.7	42.9	57.1	42.9	100.0	42.9	71.4	63.3	57.1	63.3
			57.1	14.3	71.4	100.0	85.7	28.6	42.9	57.1		
		40 F	57.1	42.9	85.7	28.6	71.4	100.0	14.3	57.1	57.1	61.2
			42.9	14.3	42.9	100.0	85.7	71.4	71.4	61.2		
		70 F	28.6	14.3	57.1	85.7	85.7	57.1	100.0	61.2	61.2	63.3
			57.1	100.0	14.3	85.7	71.4	57.1	57.1	63.3		
	T3	0 F	100.0	100.0	100.0	100.0	100.0	100.0	71.4	95.9	75.5	95.9
			100.0	14.3	100.0	100.0	42.9	85.7	85.7	75.5		
		40 F	71.4	100.0	100.0	100.0	14.3	85.7	100.0	81.6	75.5	81.6
			42.9	42.9	85.7	100.0	100.0	100.0	57.1	75.5		
		70 F	85.7	14.3	71.4	42.9	42.9	100.0	85.7	63.3	63.3	67.3
			100.0	100.0	42.9	14.3	57.1	100.0	57.1	67.3		

Table 3.39: Effect of Reference Location for Mill 1, a = 10.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 10 For Mill 1									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	57.1	28.6	100.0	100.0	100.0	57.1	28.6	67.3	65.3	83.7
			71.4	28.6	71.4	100.0	100.0	71.4	71.4	73.5		
			85.7	42.9	100.0	71.4	71.4	42.9	42.9	65.3		
			14.3	57.1	28.6	100.0	57.1	100.0	100.0	65.3		
			14.3	100.0	28.6	100.0	100.0	100.0	100.0	77.6		
			71.4	100.0	14.3	100.0	100.0	100.0	100.0	83.7		
		40 F	42.9	42.9	100.0	100.0	100.0	28.6	57.1	67.3	67.3	75.5
			57.1	14.3	85.7	100.0	100.0	57.1	57.1	67.3		
			57.1	71.4	100.0	100.0	71.4	57.1	71.4	75.5		
			14.3	100.0	28.6	100.0	57.1	100.0	71.4	67.3		
			28.6	100.0	28.6	100.0	57.1	100.0	57.1	67.3		
			85.7	100.0	71.4	100.0	42.9	71.4	42.9	73.5		
		70 F	57.1	14.3	71.4	100.0	100.0	57.1	71.4	67.3	65.3	75.5
			57.1	57.1	100.0	100.0	100.0	28.6	14.3	65.3		
			28.6	100.0	100.0	85.7	100.0	14.3	100.0	75.5		
			28.6	85.7	57.1	100.0	57.1	85.7	57.1	67.3		
			57.1	100.0	57.1	100.0	57.1	100.0	42.9	73.5		
			71.4	100.0	71.4	85.7	28.6	85.7	28.6	67.3		
	T2	0 F	14.3	100.0	71.4	71.4	100.0	71.4	71.4	71.4	69.4	71.4
			100.0	100.0	14.3	85.7	28.6	71.4	85.7	69.4		
		40 F	85.7	85.7	100.0	85.7	71.4	100.0	28.6	79.6	63.3	79.6
			100.0	100.0	71.4	28.6	28.6	71.4	42.9	63.3		
		70 F	57.1	57.1	100.0	57.1	57.1	100.0	100.0	75.5	67.3	75.5
			100.0	85.7	57.1	28.6	57.1	57.1	85.7	67.3		
	T3	0 F	100.0	100.0	100.0	100.0	100.0	100.0	28.6	89.8	89.8	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		40 F	100.0	100.0	100.0	57.1	57.1	57.1	57.1	75.5	75.5	91.8
			42.9	100.0	100.0	100.0	100.0	100.0	100.0	91.8		
		70 F	100.0	100.0	100.0	71.4	57.1	57.1	14.3	71.4	71.4	95.9
			100.0	100.0	100.0	100.0	100.0	71.4	100.0	95.9		
A 588	T1	0 F	57.1	100.0	42.9	100.0	42.9	71.4	14.3	61.2	61.2	71.4
			42.9	85.7	28.6	100.0	57.1	71.4	42.9	61.2		
			14.3	100.0	57.1	71.4	28.6	100.0	85.7	65.3		
			28.6	100.0	14.3	100.0	71.4	100.0	57.1	67.3		
			71.4	85.7	57.1	71.4	57.1	100.0	57.1	71.4		
			71.4	100.0	100.0	57.1	57.1	57.1	42.9	69.4		
		40 F	57.1	100.0	42.9	71.4	57.1	85.7	42.9	65.3	59.2	73.5
			42.9	100.0	42.9	85.7	71.4	71.4	42.9	65.3		
			57.1	100.0	85.7	85.7	85.7	85.7	14.3	73.5		
			28.6	100.0	42.9	100.0	57.1	100.0	28.6	65.3		
			14.3	100.0	71.4	100.0	42.9	71.4	28.6	61.2		
			14.3	100.0	57.1	100.0	28.6	71.4	42.9	59.2		
		70 F	28.6	100.0	28.6	71.4	71.4	100.0	42.9	63.3	57.1	77.6
			71.4	100.0	42.9	85.7	28.6	71.4	28.6	61.2		
			85.7	100.0	28.6	28.6	71.4	71.4	71.4	65.3		
			85.7	100.0	57.1	100.0	85.7	100.0	14.3	77.6		
			57.1	71.4	57.1	85.7	57.1	100.0	28.6	65.3		
			42.9	57.1	85.7	71.4	28.6	100.0	14.3	57.1		
	T2	0 F	85.7	42.9	71.4	42.9	100.0	42.9	85.7	67.3	61.2	67.3
			57.1	14.3	71.4	100.0	85.7	42.9	57.1	61.2		
		40 F	57.1	42.9	85.7	42.9	71.4	100.0	14.3	59.2	59.2	69.4
			71.4	14.3	42.9	100.0	85.7	85.7	85.7	69.4		
		70 F	42.9	14.3	85.7	85.7	85.7	71.4	100.0	69.4	69.4	69.4
			57.1	100.0	42.9	85.7	85.7	57.1	57.1	69.4		
	T3	0 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	89.8	100.0
			100.0	42.9	100.0	100.0	85.7	100.0	100.0	89.8		
		40 F	100.0	100.0	100.0	100.0	28.6	100.0	100.0	89.8	85.7	89.8
			57.1	57.1	100.0	100.0	100.0	100.0	85.7	85.7		
		70 F	100.0	42.9	85.7	42.9	42.9	100.0	100.0	73.5	69.4	73.5
			100.0	100.0	57.1	14.3	57.1	100.0	57.1	69.4		

Table 3.40: Effect of Reference Location for Mill 1, a = 15.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 15 For Mill 1									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	57.1	42.9	100.0	100.0	100.0	57.1	28.6	69.4	67.3	87.8
			71.4	42.9	85.7	100.0	100.0	85.7	71.4	79.6		
			100.0	42.9	100.0	71.4	71.4	42.9	42.9	67.3		
			28.6	71.4	28.6	100.0	71.4	100.0	100.0	71.4		
			28.6	100.0	28.6	100.0	100.0	100.0	100.0	79.6		
			100.0	100.0	14.3	100.0	100.0	100.0	100.0	87.8		
		40 F	42.9	42.9	100.0	100.0	100.0	42.9	57.1	69.4	69.4	81.6
			57.1	14.3	100.0	100.0	100.0	71.4	57.1	71.4		
			57.1	71.4	100.0	100.0	100.0	57.1	71.4	79.6		
			14.3	100.0	28.6	100.0	71.4	100.0	71.4	69.4		
			28.6	100.0	42.9	100.0	57.1	100.0	57.1	69.4		
			85.7	100.0	71.4	100.0	71.4	85.7	57.1	81.6		
		70 F	71.4	14.3	71.4	100.0	100.0	71.4	71.4	71.4	69.4	79.6
			57.1	57.1	100.0	100.0	100.0	57.1	14.3	69.4		
			42.9	100.0	100.0	100.0	100.0	14.3	100.0	79.6		
			57.1	85.7	57.1	100.0	57.1	85.7	57.1	71.4		
			57.1	100.0	57.1	100.0	57.1	100.0	57.1	75.5		
			85.7	100.0	85.7	85.7	28.6	85.7	57.1	75.5		
	T2	0 F	28.6	100.0	71.4	85.7	100.0	85.7	85.7	79.6	71.4	79.6
			100.0	100.0	14.3	85.7	28.6	85.7	85.7	71.4		
		40 F	100.0	100.0	100.0	85.7	71.4	100.0	71.4	89.8	65.3	89.8
			100.0	100.0	71.4	28.6	28.6	85.7	42.9	65.3		
		70 F	57.1	57.1	100.0	57.1	57.1	100.0	100.0	75.5	71.4	75.5
			100.0	85.7	57.1	57.1	57.1	57.1	85.7	71.4		
	T3	0 F	100.0	100.0	100.0	100.0	100.0	100.0	57.1	93.9	93.9	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		40 F	100.0	100.0	100.0	100.0	100.0	57.1	57.1	87.8	87.8	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		70 F	100.0	100.0	100.0	85.7	71.4	57.1	14.3	75.5	75.5	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
A 588	T1	0 F	71.4	100.0	42.9	100.0	42.9	71.4	14.3	63.3	63.3	79.6
			57.1	100.0	42.9	100.0	57.1	71.4	42.9	67.3		
			28.6	100.0	71.4	100.0	28.6	100.0	100.0	75.5		
			28.6	100.0	14.3	100.0	100.0	100.0	100.0	77.6		
			71.4	100.0	71.4	71.4	71.4	100.0	71.4	79.6		
			71.4	100.0	100.0	57.1	57.1	71.4	57.1	73.5		
		40 F	57.1	100.0	42.9	85.7	57.1	85.7	57.1	69.4	59.2	75.5
			57.1	100.0	42.9	85.7	71.4	71.4	57.1	69.4		
			71.4	100.0	85.7	85.7	85.7	85.7	14.3	75.5		
			42.9	100.0	42.9	100.0	71.4	100.0	42.9	71.4		
			14.3	100.0	71.4	100.0	42.9	71.4	28.6	61.2		
			14.3	100.0	57.1	100.0	28.6	71.4	42.9	59.2		
		70 F	28.6	100.0	42.9	71.4	71.4	100.0	42.9	65.3	59.2	87.8
			71.4	100.0	42.9	100.0	28.6	71.4	28.6	63.3		
			85.7	100.0	42.9	42.9	71.4	71.4	71.4	69.4		
			100.0	100.0	85.7	100.0	100.0	100.0	28.6	87.8		
			57.1	71.4	57.1	100.0	57.1	100.0	57.1	71.4		
			57.1	57.1	85.7	71.4	28.6	100.0	14.3	59.2		
	T2	0 F	85.7	42.9	85.7	42.9	100.0	42.9	85.7	69.4	65.3	69.4
			71.4	14.3	71.4	100.0	85.7	57.1	57.1	65.3		
		40 F	57.1	42.9	85.7	42.9	71.4	100.0	14.3	59.2	59.2	73.5
			71.4	14.3	71.4	100.0	85.7	85.7	85.7	73.5		
		70 F	57.1	14.3	85.7	85.7	85.7	85.7	100.0	73.5	71.4	73.5
			57.1	100.0	57.1	85.7	85.7	57.1	57.1	71.4		
	T3	0 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.0	100.0
			100.0	85.7	100.0	100.0	100.0	100.0	100.0	98.0		
		40 F	100.0	100.0	100.0	100.0	85.7	100.0	100.0	98.0	98.0	98.0
			100.0	85.7	100.0	100.0	100.0	100.0	100.0	98.0		
		70 F	100.0	42.9	100.0	71.4	71.4	100.0	100.0	83.7	73.5	83.7
			100.0	100.0	57.1	14.3	71.4	100.0	71.4	73.5		

Table 3.41: Effect of Reference Location for Mill 3, a = 5.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 5 For Mill 3									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	85.7	14.3	28.6	57.1	85.7	85.7	65.3	65.3	65.3
		40 F	71.4	42.9	71.4	28.6	85.7	100.0	42.9	63.3	63.3	63.3
		70 F	100.0	100.0	100.0	85.7	28.6	100.0	100.0	87.8	87.8	87.8
	T2	0 F	57.1	71.4	71.4	100.0	100.0	28.6	28.6	65.3	65.3	65.3
			100.0	85.7	14.3	28.6	57.1	85.7	85.7	65.3		
		40 F	71.4	100.0	85.7	57.1	100.0	14.3	28.6	65.3	63.3	65.3
			71.4	42.9	71.4	28.6	85.7	100.0	42.9	63.3		
		70 F	57.1	85.7	85.7	85.7	100.0	14.3	71.4	71.4	71.4	87.8
			100.0	100.0	100.0	85.7	28.6	100.0	100.0	87.8		
	T3	0 F	14.3	85.7	42.9	71.4	42.9	100.0	57.1	59.2	59.2	63.3
			100.0	100.0	28.6	71.4	14.3	57.1	42.9	59.2		
			85.7	100.0	42.9	71.4	14.3	71.4	57.1	63.3		
		40 F	57.1	100.0	14.3	71.4	42.9	85.7	28.6	57.1	57.1	65.3
			85.7	100.0	42.9	71.4	42.9	57.1	14.3	59.2		
			100.0	85.7	42.9	42.9	57.1	57.1	71.4	65.3		
		70 F	14.3	85.7	85.7	100.0	28.6	85.7	42.9	63.3	59.2	77.6
			85.7	100.0	42.9	71.4	14.3	57.1	42.9	59.2		
			71.4	100.0	100.0	57.1	28.6	100.0	85.7	77.6		
A 588	T1	0 F	14.3	28.6	71.4	100.0	85.7	42.9	57.1	57.1	57.1	65.3
			14.3	57.1	71.4	100.0	100.0	42.9	71.4	65.3		
		40 F	28.6	42.9	100.0	85.7	57.1	14.3	85.7	59.2	57.1	59.2
			14.3	28.6	57.1	71.4	42.9	100.0	85.7	57.1		
		70 F	42.9	14.3	71.4	42.9	57.1	100.0	100.0	61.2	61.2	61.2
			14.3	28.6	100.0	100.0	57.1	71.4	57.1	61.2		
	T2	0 F	57.1	14.3	100.0	42.9	28.6	100.0	85.7	61.2	61.2	71.4
			85.7	85.7	28.6	14.3	100.0	85.7	100.0	71.4		
			85.7	100.0	57.1	71.4	57.1	42.9	57.1	67.3		
			85.7	100.0	42.9	71.4	14.3	71.4	57.1	63.3		
		40 F	85.7	57.1	14.3	42.9	85.7	42.9	100.0	61.2	59.2	77.6
			100.0	100.0	14.3	57.1	28.6	42.9	71.4	59.2		
			100.0	100.0	57.1	57.1	57.1	71.4	100.0	77.6		
			100.0	85.7	42.9	42.9	57.1	57.1	71.4	65.3		
		70 F	100.0	42.9	57.1	100.0	100.0	28.6	14.3	63.3	61.2	85.7
			85.7	100.0	42.9	57.1	71.4	14.3	57.1	61.2		
			14.3	100.0	85.7	100.0	100.0	100.0	100.0	85.7		
			71.4	100.0	100.0	57.1	28.6	100.0	85.7	77.6		
	T3	0 F	57.1	42.9	14.3	85.7	28.6	100.0	71.4	57.1	57.1	61.2
			57.1	85.7	28.6	100.0	28.6	71.4	57.1	61.2		
		40 F	71.4	85.7	14.3	100.0	42.9	42.9	71.4	61.2	57.1	61.2
			42.9	100.0	28.6	85.7	14.3	71.4	57.1	57.1		
		70 F	28.6	71.4	71.4	14.3	71.4	100.0	85.7	63.3	63.3	65.3
			14.3	85.7	71.4	85.7	71.4	100.0	28.6	65.3		
	T4	0 F	57.1	42.9	14.3	85.7	57.1	100.0	71.4	61.2	61.2	61.2
		40 F	14.3	85.7	28.6	100.0	57.1	57.1	71.4	59.2	59.2	59.2
		70 F	28.6	71.4	71.4	14.3	71.4	100.0	85.7	63.3	63.3	63.3

Table 3.42: Effect of Reference Location for Mill 3, a = 10.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 10 For Mill 3									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	14.3	42.9	85.7	100.0	100.0	77.6	77.6	77.6
		40 F	71.4	71.4	85.7	42.9	100.0	100.0	57.1	75.5	75.5	75.5
		70 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	T2	0 F	71.4	71.4	71.4	100.0	100.0	42.9	28.6	69.4	69.4	77.6
			100.0	100.0	14.3	42.9	85.7	100.0	100.0	77.6		
		40 F	100.0	100.0	100.0	71.4	100.0	28.6	28.6	75.5	75.5	75.5
			71.4	71.4	85.7	42.9	100.0	100.0	57.1	75.5		
		70 F	85.7	100.0	85.7	85.7	100.0	14.3	85.7	79.6	79.6	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
	T3	0 F	14.3	85.7	42.9	85.7	57.1	100.0	71.4	65.3	65.3	73.5
			100.0	100.0	42.9	71.4	28.6	57.1	57.1	65.3		
			100.0	100.0	57.1	85.7	28.6	71.4	71.4	73.5		
		40 F	57.1	100.0	14.3	71.4	42.9	85.7	28.6	57.1	57.1	73.5
			100.0	100.0	42.9	71.4	42.9	57.1	14.3	61.2		
			100.0	100.0	57.1	57.1	57.1	71.4	71.4	73.5		
		70 F	28.6	85.7	85.7	100.0	28.6	85.7	71.4	69.4	63.3	95.9
			85.7	100.0	42.9	71.4	42.9	57.1	42.9	63.3		
			100.0	100.0	100.0	100.0	71.4	100.0	100.0	95.9		
A 588	T1	0 F	14.3	28.6	71.4	100.0	85.7	42.9	57.1	57.1	57.1	71.4
			14.3	71.4	71.4	100.0	100.0	71.4	71.4	71.4		
		40 F	28.6	42.9	100.0	85.7	57.1	28.6	85.7	61.2	59.2	61.2
			14.3	28.6	57.1	71.4	57.1	100.0	85.7	59.2		
		70 F	42.9	14.3	100.0	42.9	71.4	100.0	100.0	67.3	67.3	67.3
			28.6	28.6	100.0	100.0	71.4	71.4	71.4	67.3		
	T2	0 F	57.1	28.6	100.0	42.9	28.6	100.0	100.0	65.3	65.3	77.6
			100.0	100.0	28.6	14.3	100.0	100.0	100.0	77.6		
			100.0	100.0	71.4	71.4	71.4	57.1	71.4	77.6		
			100.0	100.0	57.1	85.7	28.6	71.4	71.4	73.5		
		40 F	85.7	57.1	28.6	42.9	85.7	42.9	100.0	63.3	63.3	91.8
			100.0	100.0	14.3	71.4	28.6	57.1	71.4	63.3		
			100.0	100.0	71.4	85.7	85.7	100.0	100.0	91.8		
			100.0	100.0	57.1	57.1	57.1	71.4	71.4	73.5		
		70 F	100.0	42.9	85.7	100.0	100.0	42.9	14.3	69.4	69.4	98.0
			85.7	100.0	57.1	57.1	71.4	42.9	71.4	69.4		
			85.7	100.0	100.0	100.0	100.0	100.0	100.0	98.0		
			100.0	100.0	100.0	100.0	71.4	100.0	100.0	95.9		
	T3	0 F	57.1	57.1	14.3	85.7	42.9	100.0	71.4	61.2	61.2	61.2
			57.1	85.7	28.6	100.0	28.6	71.4	57.1	61.2		
		40 F	71.4	85.7	42.9	100.0	42.9	42.9	71.4	65.3	63.3	65.3
			57.1	100.0	42.9	85.7	14.3	71.4	71.4	63.3		
		70 F	28.6	85.7	85.7	14.3	71.4	100.0	85.7	67.3	67.3	71.4
			28.6	85.7	85.7	85.7	85.7	100.0	28.6	71.4		
	T4	0 F	71.4	57.1	14.3	85.7	71.4	100.0	71.4	67.3	67.3	67.3
		40 F	14.3	85.7	57.1	100.0	57.1	57.1	71.4	63.3	63.3	63.3
		70 F	28.6	85.7	85.7	14.3	71.4	100.0	85.7	67.3	67.3	67.3

Table 3.43: Effect of Reference Location for Mill 3, a = 15.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 15 For Mill 3									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	28.6	57.1	100.0	100.0	100.0	83.7	83.7	83.7
		40 F	85.7	71.4	85.7	71.4	100.0	100.0	71.4	83.7	83.7	83.7
		70 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	T2	0 F	71.4	71.4	71.4	100.0	100.0	57.1	57.1	75.5	75.5	83.7
			100.0	100.0	28.6	57.1	100.0	100.0	100.0	83.7		
		40 F	100.0	100.0	100.0	100.0	100.0	28.6	28.6	79.6	79.6	83.7
			85.7	71.4	85.7	71.4	100.0	100.0	71.4	83.7		
		70 F	85.7	100.0	100.0	100.0	100.0	42.9	85.7	87.8	87.8	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
	T3	0 F	42.9	85.7	57.1	85.7	57.1	100.0	71.4	71.4	67.3	83.7
			100.0	100.0	57.1	71.4	28.6	57.1	57.1	67.3		
			100.0	100.0	71.4	100.0	57.1	85.7	71.4	83.7		
		40 F	57.1	100.0	28.6	71.4	57.1	85.7	42.9	63.3	61.2	77.6
			100.0	100.0	42.9	71.4	42.9	57.1	14.3	61.2		
			100.0	100.0	71.4	57.1	71.4	71.4	71.4	77.6		
		70 F	28.6	85.7	85.7	100.0	28.6	85.7	85.7	71.4	65.3	100.0
			100.0	100.0	42.9	71.4	42.9	57.1	42.9	65.3		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
A 588	T1	0 F	28.6	28.6	85.7	100.0	100.0	42.9	57.1	63.3	63.3	71.4
			14.3	71.4	71.4	100.0	100.0	71.4	71.4	71.4		
		40 F	42.9	42.9	100.0	85.7	57.1	28.6	85.7	63.3	59.2	63.3
			14.3	28.6	57.1	71.4	57.1	100.0	85.7	59.2		
		70 F	57.1	42.9	100.0	57.1	100.0	100.0	100.0	79.6	67.3	79.6
			28.6	28.6	100.0	100.0	71.4	71.4	71.4	67.3		
	T2	0 F	57.1	28.6	100.0	57.1	28.6	100.0	100.0	67.3	67.3	83.7
			100.0	100.0	28.6	14.3	100.0	100.0	100.0	77.6		
			100.0	100.0	71.4	71.4	71.4	71.4	71.4	79.6		
			100.0	100.0	71.4	100.0	57.1	85.7	71.4	83.7		
		40 F	100.0	57.1	42.9	42.9	100.0	57.1	100.0	71.4	65.3	100.0
			100.0	100.0	28.6	71.4	28.6	57.1	71.4	65.3		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			100.0	100.0	71.4	57.1	71.4	71.4	71.4	77.6		
		70 F	100.0	57.1	100.0	100.0	100.0	42.9	28.6	75.5	75.5	100.0
			85.7	100.0	71.4	71.4	71.4	57.1	71.4	75.5		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
	T3	0 F	71.4	57.1	14.3	85.7	57.1	100.0	71.4	65.3	61.2	65.3
			57.1	85.7	28.6	100.0	28.6	71.4	57.1	61.2		
		40 F	71.4	85.7	42.9	100.0	42.9	42.9	71.4	65.3	65.3	67.3
			57.1	100.0	42.9	100.0	28.6	71.4	71.4	67.3		
		70 F	42.9	85.7	85.7	14.3	85.7	100.0	100.0	73.5	71.4	73.5
			28.6	85.7	85.7	85.7	85.7	100.0	28.6	71.4		
	T4	0 F	71.4	71.4	14.3	85.7	71.4	100.0	71.4	69.4	69.4	69.4
		40 F	14.3	85.7	57.1	100.0	57.1	57.1	71.4	63.3	63.3	63.3
		70 F	42.9	85.7	85.7	14.3	85.7	100.0	100.0	73.5	73.5	73.5

Table 3.44: Effect of Reference Location for Mill 4, a = 5.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 5 For Mill 4									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	28.6	71.4	14.3	71.4	71.4	65.3	61.2	79.6
			71.4	14.3	85.7	57.1	100.0	57.1	42.9	61.2		
			100.0	100.0	100.0	42.9	100.0	85.7	28.6	79.6		
			57.1	71.4	85.7	100.0	14.3	71.4	28.6	61.2		
		40 F	100.0	100.0	28.6	100.0	14.3	100.0	71.4	73.5	63.3	73.5
			71.4	71.4	71.4	100.0	14.3	71.4	100.0	71.4		
			100.0	85.7	14.3	42.9	42.9	85.7	85.7	65.3		
			42.9	100.0	71.4	100.0	14.3	71.4	42.9	63.3		
		70 F	100.0	85.7	28.6	57.1	14.3	71.4	57.1	59.2	59.2	69.4
			71.4	100.0	28.6	28.6	85.7	85.7	85.7	69.4		
			100.0	85.7	14.3	42.9	42.9	71.4	71.4	61.2		
			57.1	100.0	42.9	57.1	14.3	100.0	71.4	63.3		
	T2	0 F	14.3	42.9	100.0	100.0	71.4	71.4	57.1	65.3	63.3	73.5
			28.6	85.7	57.1	100.0	100.0	57.1	28.6	65.3		
			71.4	100.0	71.4	42.9	100.0	14.3	42.9	63.3		
			71.4	71.4	100.0	71.4	71.4	28.6	100.0	73.5		
		40 F	28.6	85.7	85.7	85.7	100.0	85.7	28.6	71.4	65.3	71.4
			42.9	71.4	85.7	100.0	85.7	14.3	57.1	65.3		
			71.4	100.0	85.7	71.4	100.0	28.6	42.9	71.4		
			57.1	85.7	85.7	100.0	57.1	57.1	57.1	71.4		
		70 F	42.9	42.9	100.0	85.7	85.7	71.4	42.9	67.3	65.3	73.5
			42.9	85.7	71.4	100.0	100.0	42.9	42.9	69.4		
			100.0	85.7	100.0	85.7	100.0	14.3	28.6	73.5		
			42.9	42.9	85.7	28.6	71.4	85.7	100.0	65.3		
A 588	T1	0 F	100.0	100.0	71.4	71.4	71.4	28.6	28.6	67.3	63.3	75.5
			100.0	85.7	28.6	57.1	85.7	57.1	28.6	63.3		
			42.9	100.0	42.9	85.7	57.1	57.1	71.4	65.3		
			85.7	100.0	14.3	28.6	100.0	100.0	100.0	75.5		
		40 F	100.0	71.4	42.9	42.9	71.4	85.7	42.9	65.3	59.2	65.3
			100.0	85.7	14.3	42.9	71.4	57.1	42.9	59.2		
			42.9	100.0	71.4	85.7	71.4	14.3	42.9	61.2		
			57.1	85.7	42.9	14.3	28.6	100.0	100.0	61.2		
		70 F	100.0	71.4	42.9	57.1	28.6	28.6	85.7	59.2	59.2	67.3
			100.0	71.4	28.6	28.6	85.7	42.9	71.4	61.2		
			100.0	100.0	14.3	57.1	100.0	42.9	57.1	67.3		
			85.7	85.7	42.9	28.6	28.6	100.0	85.7	65.3		
	T2	0 F	85.7	71.4	71.4	14.3	100.0	28.6	71.4	63.3	59.2	63.3
			71.4	100.0	14.3	28.6	71.4	85.7	42.9	59.2		
			42.9	100.0	100.0	28.6	71.4	14.3	71.4	61.2		
			28.6	42.9	100.0	85.7	71.4	28.6	57.1	59.2		
		40 F	100.0	28.6	42.9	71.4	85.7	71.4	71.4	67.3	65.3	81.6
			42.9	100.0	100.0	14.3	100.0	42.9	85.7	69.4		
			100.0	100.0	100.0	100.0	42.9	28.6	100.0	81.6		
			42.9	85.7	85.7	100.0	85.7	42.9	14.3	65.3		
		70 F	85.7	57.1	28.6	57.1	100.0	57.1	71.4	65.3	65.3	93.9
			100.0	57.1	100.0	14.3	57.1	57.1	100.0	69.4		
			100.0	85.7	100.0	100.0	100.0	71.4	100.0	93.9		
			85.7	71.4	28.6	71.4	100.0	14.3	100.0	67.3		

Table 3.45: Effect of Reference Location for Mill 4, a = 10.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 10 For Mill 4									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	28.6	71.4	14.3	71.4	71.4	65.3	65.3	95.9
			85.7	14.3	85.7	71.4	100.0	57.1	57.1	67.3		
			100.0	100.0	100.0	100.0	100.0	100.0	71.4	95.9		
			71.4	71.4	85.7	100.0	28.6	71.4	42.9	67.3		
		40 F	100.0	100.0	28.6	100.0	28.6	100.0	100.0	79.6	65.3	81.6
			71.4	71.4	85.7	100.0	71.4	71.4	100.0	81.6		
			100.0	85.7	14.3	42.9	42.9	85.7	85.7	65.3		
			42.9	100.0	100.0	100.0	14.3	100.0	42.9	71.4		
		70 F	100.0	85.7	28.6	57.1	28.6	71.4	57.1	61.2	61.2	75.5
			85.7	100.0	57.1	28.6	85.7	85.7	85.7	75.5		
			100.0	100.0	28.6	42.9	42.9	85.7	85.7	69.4		
			71.4	100.0	57.1	57.1	14.3	100.0	71.4	67.3		
	T2	0 F	14.3	71.4	100.0	100.0	85.7	85.7	71.4	75.5	73.5	85.7
			57.1	100.0	57.1	100.0	100.0	57.1	42.9	73.5		
			71.4	100.0	85.7	71.4	100.0	14.3	71.4	73.5		
			71.4	85.7	100.0	85.7	85.7	71.4	100.0	85.7		
		40 F	28.6	100.0	100.0	85.7	100.0	100.0	28.6	77.6	75.5	89.8
			71.4	85.7	85.7	100.0	85.7	42.9	85.7	79.6		
			85.7	100.0	100.0	100.0	100.0	71.4	71.4	89.8		
			57.1	100.0	100.0	100.0	57.1	57.1	57.1	75.5		
		70 F	57.1	42.9	100.0	100.0	100.0	85.7	57.1	77.6	73.5	81.6
			57.1	100.0	100.0	100.0	100.0	71.4	42.9	81.6		
			100.0	100.0	100.0	100.0	100.0	14.3	28.6	77.6		
			57.1	57.1	85.7	42.9	85.7	85.7	100.0	73.5		
A 588	T1	0 F	100.0	100.0	71.4	71.4	71.4	28.6	28.6	67.3	65.3	79.6
			100.0	100.0	28.6	57.1	85.7	57.1	28.6	65.3		
			57.1	100.0	57.1	85.7	57.1	57.1	71.4	69.4		
			100.0	100.0	14.3	42.9	100.0	100.0	100.0	79.6		
		40 F	100.0	71.4	42.9	42.9	71.4	85.7	42.9	65.3	63.3	73.5
			100.0	85.7	28.6	42.9	85.7	57.1	42.9	63.3		
			71.4	100.0	71.4	85.7	71.4	42.9	71.4	73.5		
			71.4	100.0	42.9	28.6	42.9	100.0	100.0	69.4		
		70 F	100.0	85.7	42.9	57.1	28.6	28.6	85.7	61.2	61.2	75.5
			100.0	71.4	42.9	42.9	85.7	42.9	71.4	65.3		
			100.0	100.0	14.3	100.0	100.0	57.1	57.1	75.5		
			85.7	85.7	42.9	28.6	42.9	100.0	85.7	67.3		
	T2	0 F	85.7	71.4	71.4	14.3	100.0	28.6	71.4	63.3	61.2	77.6
			71.4	100.0	14.3	42.9	71.4	100.0	42.9	63.3		
			71.4	100.0	100.0	42.9	100.0	28.6	100.0	77.6		
			28.6	42.9	100.0	100.0	71.4	28.6	57.1	61.2		
		40 F	100.0	42.9	71.4	71.4	85.7	71.4	71.4	73.5	69.4	95.9
			42.9	100.0	100.0	42.9	100.0	42.9	100.0	75.5		
			100.0	100.0	100.0	100.0	100.0	71.4	100.0	95.9		
			71.4	85.7	85.7	100.0	85.7	42.9	14.3	69.4		
		70 F	85.7	57.1	57.1	71.4	100.0	71.4	71.4	73.5	73.5	100.0
			100.0	100.0	100.0	14.3	100.0	100.0	100.0	87.8		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			100.0	100.0	71.4	100.0	100.0	14.3	100.0	83.7		

Table 3.46: Effect of Reference Location for Mill 4, a = 15.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 15 For Mill 4									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	28.6	71.4	14.3	71.4	71.4	65.3	65.3	100.0
			85.7	28.6	85.7	85.7	100.0	71.4	71.4	75.5		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			71.4	71.4	100.0	100.0	28.6	71.4	57.1	71.4		
		40 F	100.0	100.0	28.6	100.0	28.6	100.0	100.0	79.6	77.6	91.8
			100.0	85.7	100.0	100.0	71.4	85.7	100.0	91.8		
			100.0	100.0	42.9	85.7	85.7	100.0	85.7	85.7		
			42.9	100.0	100.0	100.0	42.9	100.0	57.1	77.6		
		70 F	100.0	85.7	28.6	71.4	28.6	85.7	71.4	67.3	67.3	85.7
			85.7	100.0	85.7	71.4	85.7	85.7	85.7	85.7		
			100.0	100.0	42.9	42.9	42.9	100.0	100.0	75.5		
			71.4	100.0	57.1	71.4	14.3	100.0	85.7	71.4		
	T2	0 F	42.9	71.4	100.0	100.0	100.0	100.0	85.7	85.7	77.6	93.9
			57.1	100.0	71.4	100.0	100.0	57.1	57.1	77.6		
			85.7	100.0	100.0	71.4	100.0	14.3	71.4	77.6		
			85.7	100.0	100.0	100.0	100.0	71.4	100.0	93.9		
		40 F	28.6	100.0	100.0	100.0	100.0	100.0	28.6	79.6	79.6	95.9
			85.7	85.7	100.0	100.0	85.7	71.4	85.7	87.8		
			100.0	100.0	100.0	100.0	100.0	85.7	85.7	95.9		
			85.7	100.0	100.0	100.0	85.7	85.7	85.7	91.8		
		70 F	85.7	57.1	100.0	100.0	100.0	100.0	71.4	87.8	79.6	91.8
			85.7	100.0	100.0	100.0	100.0	85.7	71.4	91.8		
			100.0	100.0	100.0	100.0	100.0	28.6	28.6	79.6		
			71.4	85.7	100.0	57.1	85.7	100.0	100.0	85.7		
A 588	T1	0 F	100.0	100.0	71.4	71.4	71.4	28.6	28.6	67.3	67.3	87.8
			100.0	100.0	28.6	57.1	100.0	57.1	28.6	67.3		
			57.1	100.0	57.1	100.0	71.4	57.1	71.4	73.5		
			100.0	100.0	14.3	100.0	100.0	100.0	100.0	87.8		
		40 F	100.0	71.4	42.9	42.9	71.4	85.7	42.9	65.3	65.3	75.5
			100.0	100.0	42.9	42.9	85.7	57.1	42.9	67.3		
			71.4	100.0	71.4	85.7	71.4	57.1	71.4	75.5		
			100.0	100.0	42.9	42.9	42.9	100.0	100.0	75.5		
		70 F	100.0	85.7	57.1	71.4	28.6	42.9	85.7	67.3	67.3	87.8
			100.0	85.7	42.9	42.9	85.7	42.9	85.7	69.4		
			100.0	100.0	14.3	100.0	100.0	100.0	100.0	87.8		
			85.7	100.0	42.9	42.9	42.9	100.0	100.0	73.5		
	T2	0 F	85.7	71.4	71.4	28.6	100.0	28.6	71.4	65.3	63.3	87.8
			71.4	100.0	28.6	42.9	71.4	100.0	71.4	69.4		
			100.0	100.0	100.0	71.4	100.0	42.9	100.0	87.8		
			28.6	42.9	100.0	100.0	71.4	42.9	57.1	63.3		
		40 F	100.0	71.4	71.4	71.4	85.7	71.4	71.4	77.6	77.6	100.0
			57.1	100.0	100.0	42.9	100.0	57.1	100.0	79.6		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			85.7	85.7	85.7	100.0	85.7	85.7	42.9	81.6		
		70 F	85.7	71.4	71.4	71.4	100.0	71.4	71.4	77.6	77.6	100.0
			100.0	100.0	100.0	14.3	100.0	100.0	100.0	87.8		
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
			100.0	100.0	100.0	100.0	100.0	14.3	100.0	87.8		

Table 3.47: Effect of Reference Location for Mill 5, a = 5.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 5 For Mill 5									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	71.4	100.0	28.6	71.4	14.3	42.9	61.2	61.2	69.4
			42.9	14.3	71.4	85.7	71.4	100.0	100.0	69.4		
		40 F	85.7	100.0	85.7	28.6	71.4	14.3	71.4	65.3	65.3	69.4
			85.7	85.7	100.0	85.7	71.4	28.6	28.6	69.4		
		70 F	71.4	85.7	85.7	42.9	57.1	14.3	100.0	65.3	65.3	73.5
			71.4	14.3	71.4	100.0	100.0	57.1	100.0	73.5		
	T2	0 F	85.7	100.0	100.0	57.1	85.7	14.3	28.6	67.3	67.3	77.6
			71.4	42.9	100.0	100.0	28.6	100.0	100.0	77.6		
		40 F	71.4	71.4	85.7	14.3	71.4	71.4	100.0	69.4	63.3	69.4
			85.7	14.3	71.4	100.0	42.9	42.9	85.7	63.3		
		70 F	100.0	71.4	71.4	100.0	42.9	14.3	28.6	61.2	61.2	61.2
			57.1	28.6	100.0	71.4	28.6	57.1	85.7	61.2		
	T3	0 F	71.4	42.9	28.6	71.4	100.0	85.7	42.9	63.3	63.3	73.5
			100.0	100.0	85.7	57.1	57.1	71.4	42.9	73.5		
		40 F	100.0	28.6	57.1	57.1	14.3	85.7	100.0	63.3	63.3	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		70 F	100.0	100.0	71.4	57.1	14.3	71.4	71.4	69.4	67.3	69.4
			85.7	71.4	71.4	14.3	57.1	100.0	71.4	67.3		
	T4	0 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	77.6	100.0
			85.7	100.0	57.1	100.0	85.7	100.0	14.3	77.6		
		40 F	100.0	100.0	100.0	100.0	100.0	14.3	100.0	87.8	75.5	87.8
			100.0	100.0	28.6	100.0	100.0	28.6	71.4	75.5		
		70 F	100.0	100.0	100.0	100.0	100.0	57.1	100.0	93.9	71.4	93.9
			42.9	100.0	100.0	100.0	14.3	100.0	42.9	71.4		
A 588	T1	0 F	28.6	71.4	85.7	100.0	42.9	57.1	14.3	57.1	57.1	71.4
			28.6	100.0	57.1	71.4	85.7	71.4	85.7	71.4		
			28.6	57.1	28.6	57.1	71.4	85.7	100.0	61.2		
		40 F	71.4	28.6	85.7	100.0	71.4	71.4	14.3	63.3	59.2	63.3
			42.9	100.0	14.3	42.9	57.1	71.4	85.7	59.2		
			14.3	42.9	100.0	85.7	71.4	57.1	42.9	59.2		
		70 F	28.6	57.1	85.7	100.0	57.1	85.7	14.3	61.2	59.2	61.2
			14.3	71.4	42.9	28.6	71.4	100.0	85.7	59.2		
			14.3	57.1	100.0	71.4	100.0	42.9	42.9	61.2		
	T2	0 F	14.3	100.0	57.1	85.7	42.9	57.1	85.7	63.3	63.3	63.3
			28.6	100.0	85.7	57.1	28.6	85.7	57.1	63.3		
			71.4	57.1	57.1	14.3	42.9	100.0	100.0	63.3		
		40 F	28.6	14.3	100.0	85.7	71.4	71.4	85.7	65.3	61.2	65.3
			100.0	85.7	71.4	71.4	14.3	42.9	42.9	61.2		
			85.7	100.0	85.7	71.4	14.3	28.6	71.4	65.3		
		70 F	28.6	28.6	100.0	71.4	42.9	57.1	100.0	61.2	61.2	69.4
			85.7	100.0	42.9	42.9	14.3	57.1	100.0	63.3		
			100.0	100.0	71.4	42.9	71.4	42.9	57.1	69.4		
	T3	0 F	14.3	42.9	85.7	71.4	100.0	85.7	42.9	63.3	61.2	63.3
			85.7	100.0	28.6	42.9	14.3	100.0	57.1	61.2		
			42.9	57.1	85.7	14.3	85.7	100.0	42.9	61.2		
		40 F	71.4	28.6	71.4	57.1	100.0	85.7	42.9	65.3	63.3	75.5
			57.1	100.0	57.1	57.1	71.4	14.3	85.7	63.3		
			85.7	85.7	100.0	71.4	57.1	57.1	71.4	75.5		
		70 F	14.3	28.6	85.7	100.0	100.0	42.9	57.1	61.2	61.2	69.4
			100.0	100.0	42.9	42.9	14.3	85.7	100.0	69.4		
			42.9	57.1	100.0	100.0	71.4	42.9	28.6	63.3		
	T4	0 F	57.1	85.7	85.7	85.7	57.1	57.1	85.7	73.5	73.5	73.5
		40 F	71.4	85.7	71.4	71.4	71.4	71.4	71.4	73.5	73.5	73.5
		70 F	42.9	28.6	28.6	14.3	42.9	14.3	57.1	32.7	32.7	32.7

Table 3.48: Effect of Reference Location for Mill 5, a = 10.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 10 For Mill 5									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	71.4	100.0	28.6	71.4	14.3	71.4	65.3	65.3	85.7
			71.4	42.9	100.0	100.0	85.7	100.0	100.0	85.7		
		40 F	85.7	100.0	85.7	28.6	85.7	14.3	85.7	69.4	69.4	79.6
			100.0	100.0	100.0	100.0	85.7	42.9	28.6	79.6		
		70 F	85.7	85.7	85.7	71.4	85.7	14.3	100.0	75.5	75.5	93.9
			100.0	57.1	100.0	100.0	100.0	100.0	100.0	93.9		
	T2	0 F	100.0	100.0	100.0	85.7	100.0	14.3	57.1	79.6	79.6	95.9
			100.0	100.0	100.0	100.0	71.4	100.0	100.0	95.9		
		40 F	85.7	85.7	85.7	71.4	85.7	85.7	100.0	85.7	71.4	85.7
			100.0	28.6	85.7	100.0	42.9	42.9	100.0	71.4		
		70 F	100.0	71.4	71.4	100.0	42.9	14.3	42.9	63.3	63.3	71.4
			57.1	57.1	100.0	85.7	57.1	57.1	85.7	71.4		
	T3	0 F	71.4	42.9	42.9	71.4	100.0	100.0	42.9	67.3	67.3	87.8
			100.0	100.0	100.0	71.4	71.4	100.0	71.4	87.8		
		40 F	100.0	28.6	57.1	71.4	14.3	100.0	100.0	67.3	67.3	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		70 F	100.0	100.0	100.0	71.4	14.3	85.7	100.0	81.6	77.6	81.6
			100.0	85.7	85.7	14.3	71.4	100.0	85.7	77.6		
	T4	0 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	89.8	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	28.6	89.8		
		40 F	100.0	100.0	100.0	100.0	100.0	85.7	100.0	98.0	83.7	98.0
			100.0	100.0	42.9	100.0	100.0	42.9	100.0	83.7		
		70 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	71.4	100.0
			42.9	100.0	100.0	100.0	14.3	100.0	42.9	71.4		
A 588	T1	0 F	28.6	85.7	100.0	100.0	57.1	57.1	14.3	63.3	63.3	87.8
			71.4	100.0	85.7	85.7	100.0	85.7	85.7	87.8		
			28.6	57.1	28.6	57.1	85.7	85.7	100.0	63.3		
		40 F	71.4	28.6	85.7	100.0	85.7	85.7	14.3	67.3	61.2	67.3
			57.1	100.0	14.3	57.1	57.1	85.7	100.0	67.3		
			14.3	42.9	100.0	100.0	71.4	57.1	42.9	61.2		
		70 F	28.6	57.1	85.7	100.0	57.1	85.7	14.3	61.2	61.2	69.4
			28.6	85.7	71.4	28.6	85.7	100.0	85.7	69.4		
			14.3	57.1	100.0	100.0	100.0	57.1	42.9	67.3		
	T2	0 F	28.6	100.0	57.1	85.7	57.1	57.1	85.7	67.3	67.3	71.4
			28.6	100.0	85.7	85.7	28.6	85.7	85.7	71.4		
			85.7	57.1	57.1	14.3	57.1	100.0	100.0	67.3		
		40 F	28.6	28.6	100.0	85.7	85.7	85.7	85.7	71.4	65.3	71.4
			100.0	85.7	71.4	71.4	14.3	57.1	57.1	65.3		
			85.7	100.0	85.7	85.7	28.6	28.6	85.7	71.4		
		70 F	28.6	28.6	100.0	85.7	57.1	71.4	100.0	67.3	67.3	77.6
			100.0	100.0	57.1	57.1	14.3	57.1	100.0	69.4		
			100.0	100.0	71.4	57.1	71.4	71.4	71.4	77.6		
	T3	0 F	14.3	57.1	100.0	85.7	100.0	100.0	57.1	73.5	67.3	73.5
			100.0	100.0	28.6	57.1	28.6	100.0	57.1	67.3		
			57.1	85.7	85.7	14.3	85.7	100.0	57.1	69.4		
		40 F	71.4	42.9	71.4	71.4	100.0	100.0	71.4	75.5	75.5	89.8
			71.4	100.0	71.4	71.4	71.4	57.1	85.7	75.5		
			100.0	100.0	100.0	85.7	71.4	85.7	85.7	89.8		
		70 F	14.3	42.9	100.0	100.0	100.0	57.1	57.1	67.3	67.3	73.5
			100.0	100.0	42.9	57.1	14.3	100.0	100.0	73.5		
			57.1	57.1	100.0	100.0	100.0	57.1	42.9	73.5		
	T4	0 F	85.7	100.0	100.0	100.0	85.7	85.7	100.0	93.9	93.9	93.9
		40 F	71.4	100.0	85.7	85.7	71.4	71.4	71.4	79.6	79.6	79.6
		70 F	42.9	42.9	28.6	14.3	57.1	28.6	57.1	38.8	38.8	38.8

Table 3.49: Effect of Reference Location for Mill 5, a = 15.

Grade	Thickness Group	Test Temperature	Percent Greater Than Eref - 15 For Mill 5									
			LOCATION							Mean	Min Mean	Max Mean
			1	2	3	4	5	6	7			
A 572	T1	0 F	100.0	100.0	100.0	42.9	100.0	28.6	71.4	77.6	77.6	95.9
			100.0	71.4	100.0	100.0	100.0	100.0	100.0	95.9		
		40 F	85.7	100.0	85.7	57.1	85.7	14.3	85.7	73.5	73.5	93.9
			100.0	100.0	100.0	100.0	100.0	85.7	71.4	93.9		
		70 F	85.7	85.7	85.7	85.7	85.7	14.3	100.0	77.6	77.6	98.0
			100.0	85.7	100.0	100.0	100.0	100.0	100.0	98.0		
	T2	0 F	100.0	100.0	100.0	100.0	100.0	14.3	85.7	85.7	85.7	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		40 F	85.7	85.7	100.0	71.4	85.7	85.7	100.0	87.8	75.5	87.8
			100.0	42.9	100.0	100.0	42.9	42.9	100.0	75.5		
		70 F	100.0	71.4	71.4	100.0	42.9	14.3	42.9	63.3	63.3	77.6
			71.4	57.1	100.0	85.7	57.1	71.4	100.0	77.6		
	T3	0 F	71.4	42.9	42.9	71.4	100.0	100.0	42.9	67.3	67.3	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		40 F	100.0	28.6	85.7	100.0	28.6	100.0	100.0	77.6	77.6	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
		70 F	100.0	100.0	100.0	100.0	14.3	100.0	100.0	87.8	87.8	87.8
			100.0	85.7	100.0	57.1	85.7	100.0	85.7	87.8		
	T4	0 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	93.9	100.0
			100.0	100.0	100.0	100.0	100.0	100.0	57.1	93.9		
		40 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.9	100.0
			100.0	100.0	100.0	100.0	100.0	71.4	100.0	95.9		
		70 F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	77.6	100.0
			71.4	100.0	100.0	100.0	14.3	100.0	57.1	77.6		
A 588	T1	0 F	28.6	100.0	100.0	100.0	57.1	71.4	28.6	69.4	63.3	93.9
			85.7	100.0	85.7	85.7	100.0	100.0	100.0	93.9		
			28.6	57.1	28.6	57.1	85.7	85.7	100.0	63.3		
		40 F	85.7	28.6	85.7	100.0	85.7	85.7	14.3	69.4	65.3	69.4
			57.1	100.0	14.3	57.1	57.1	100.0	100.0	69.4		
			14.3	42.9	100.0	100.0	85.7	57.1	57.1	65.3		
		70 F	57.1	57.1	85.7	100.0	57.1	85.7	14.3	65.3	65.3	71.4
			28.6	85.7	85.7	28.6	85.7	100.0	85.7	71.4		
			14.3	57.1	100.0	100.0	100.0	57.1	57.1	69.4		
	T2	0 F	57.1	100.0	57.1	100.0	57.1	57.1	85.7	73.5	71.4	73.5
			28.6	100.0	85.7	85.7	28.6	85.7	85.7	71.4		
			100.0	71.4	71.4	14.3	57.1	100.0	100.0	73.5		
		40 F	28.6	28.6	100.0	85.7	85.7	85.7	85.7	71.4	71.4	77.6
			100.0	100.0	71.4	85.7	14.3	71.4	71.4	73.5		
			100.0	100.0	85.7	85.7	28.6	57.1	85.7	77.6		
		70 F	42.9	28.6	100.0	100.0	71.4	71.4	100.0	73.5	73.5	79.6
			100.0	100.0	57.1	57.1	14.3	85.7	100.0	73.5		
			100.0	100.0	71.4	71.4	71.4	71.4	71.4	79.6		
	T3	0 F	14.3	85.7	100.0	100.0	100.0	100.0	85.7	83.7	69.4	85.7
			100.0	100.0	42.9	57.1	28.6	100.0	57.1	69.4		
			85.7	85.7	100.0	42.9	100.0	100.0	85.7	85.7		
		40 F	71.4	71.4	71.4	71.4	100.0	100.0	71.4	79.6	79.6	98.0
			71.4	100.0	71.4	71.4	85.7	71.4	85.7	79.6		
			100.0	100.0	100.0	100.0	85.7	100.0	100.0	98.0		
		70 F	14.3	57.1	100.0	100.0	100.0	57.1	57.1	69.4	69.4	89.8
			100.0	100.0	85.7	100.0	42.9	100.0	100.0	89.8		
			57.1	71.4	100.0	100.0	100.0	57.1	57.1	77.6		
	T4	0 F	85.7	100.0	100.0	100.0	100.0	85.7	100.0	95.9	95.9	95.9
		40 F	85.7	100.0	100.0	85.7	71.4	71.4	71.4	83.7	83.7	83.7
		70 F	57.1	42.9	42.9	14.3	57.1	42.9	57.1	44.9	44.9	44.9

3.6.3.1 REFERENCE LOCATION EFFECT AS A FUNCTION OF TOUGHNESS

Results from the study of the effect of selecting a reference location in the use of Charpy V-notch test results for individual mills in the 4-mill group were presented in Tables 3.38 to 3.49.

The results from the four mills were combined and then grouped by (i) steel grade; (ii) thickness range; and (iii) toughness in order to determine overall statistical summaries based on the CVN test data and to examine the role of reference location selection. For each steel grade and thickness group, plates were divided into "Lower Toughness" and "Higher Toughness" groups depending on whether or not the absorbed energy value was below 50 ft-lbs. The lower toughness plates, thus, had absorbed energy below 50 ft-lbs in at least one location while the higher toughness plates had absorbed energy equal to or greater than 50 ft-lbs in all seven locations. The purpose of this separate analysis was to concentrate on the results from the group of plates that might be critical in actual use, namely, the lower toughness plates. The higher toughness plates were considered to be non-critical since their very high toughness (or absorbed energy) values greatly exceeded any requirements that might be made of them. It was thought to be interesting to see if similar conclusions related to reference location may be made for lower toughness plates as for the higher toughness plates.

Figure 3.18 presents the distribution of plates by toughness. It should be noted that the number of plates shown corresponds to plates at three test temperatures; hence, the number of plates is three times the actual number of plates presented in Figure 3.7. It may be observed from Figure 3.18 that a larger fraction of the plates were in the higher toughness category, especially for the A588 steel where, for example, the group A588-T2 had only two plates of "lower toughness." Our study, again, is focused on the determining if different conclusions about the CVN test results are reached for the lower toughness plates than for the higher toughness plates.

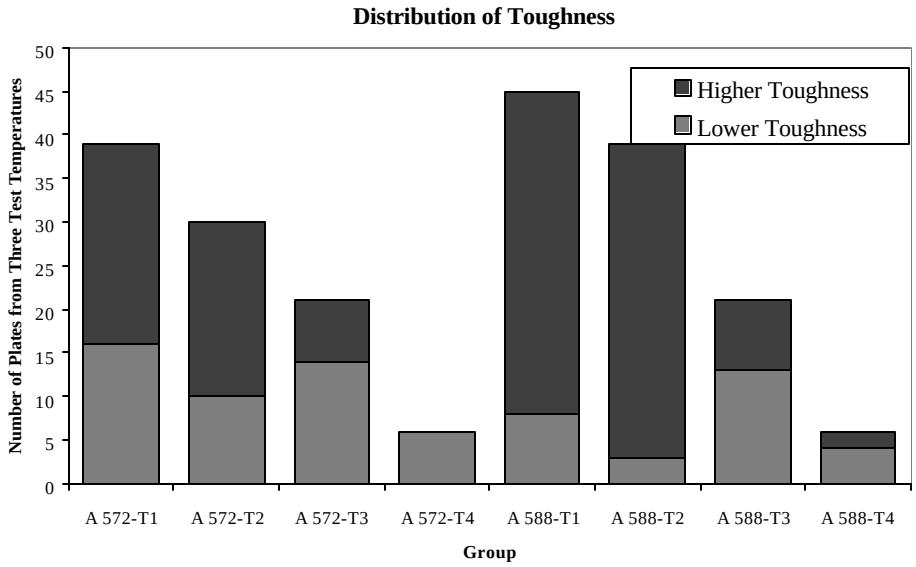

Figure 3.18: Distribution of Plates by Toughness.

The range of mean values for the percentage of plates that had absorbed energy greater than E_{ref}–a is presented in Figures 3.19 and 3.20 for A572 and A588 steels, respectively. The figures show the range of mean values for two cases: lower toughness plates and higher toughness plates, for three values of α (5, 10, and 15 ft-lbs), and for three test temperatures: 0°F, 40°F and 70°F. Also, indicated on the figures is the number of mean values in the two toughness groups.

By way of illustration, Figure 3.19 for the 0°F test temperature suggests that from the 22 lower toughness plates gathered from all four mills, it was found that the probability that the three-test-averaged absorbed energy might exceed E_{ref}–5 (ft-lbs) varies from 59.2% to 100%. For E_{ref}–10 (ft-lbs), this probability range varies from 65.3% to 100%, and for E_{ref}–15 (ft-lbs), this probability range varies from 67.3% to 100%. In contrast, for the higher toughness plates, the probability range for E_{ref}–5 (ft-lbs) varies from 61.2% to 79.6%; for E_{ref}–10 (ft-lbs), it varies from 65.3% to 95.9%; and for E_{ref}–15 (ft-lbs), it varies from 65.3% to 100%.

Studying all the results, it is seen that the range of probabilities that a three-test-averaged absorbed energy might exceed E_{ref}–a (for a equal to 5, 10, or 15 ft-lbs) seems

to vary from 55% to 100% for higher toughness plates and 57% to 100% for lower toughness plates. Hence, in general, no significant difference was noted in the results from lower toughness plates and higher toughness plates.

With reference to Figures 3.19 and 3.20, in the vertical lines displaying the data, only when the bottom (or top) circles for the lower toughness plates are significantly lower than the corresponding bottom (or top) horizontal dashes for the higher toughness plates, might there be any concern related to the lower toughness plates. Studying Figures 3.19 and 3.20, again, it might be concluded that, for the cases studied, there are no major differences between the lower and higher toughness plates based on the CVN test data, except perhaps for A588 steel at 70°F but this might be due to insufficient data for the lower toughness plates (only four mean values were available there).

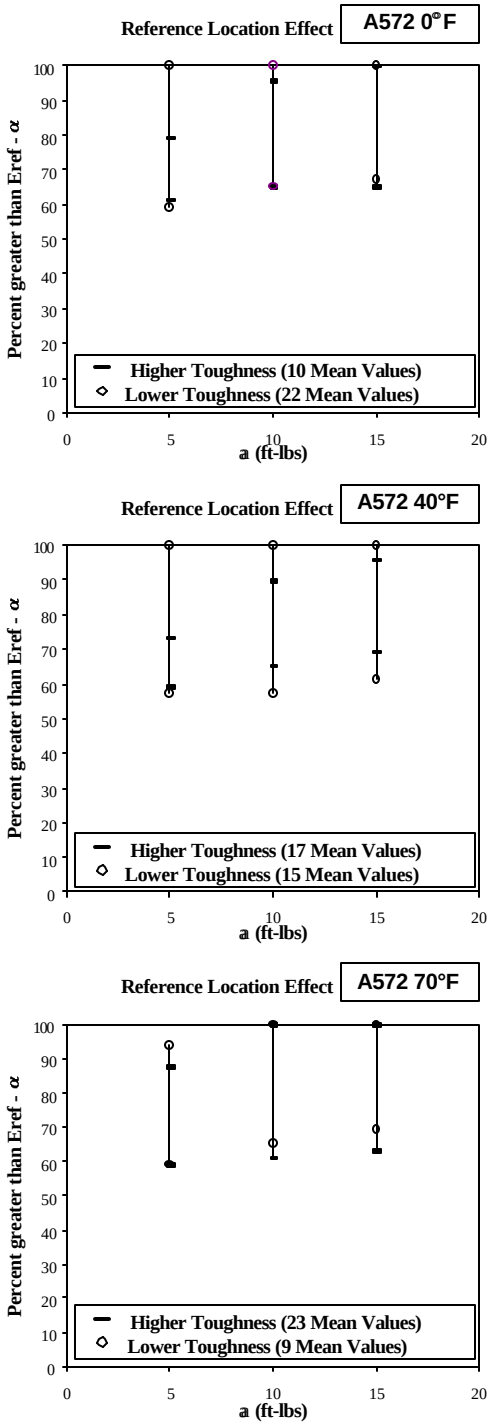

Figure 3.19: Reference Location Effect for A572 Steel as a Function of Toughness (Data from the 4-Mill Group).

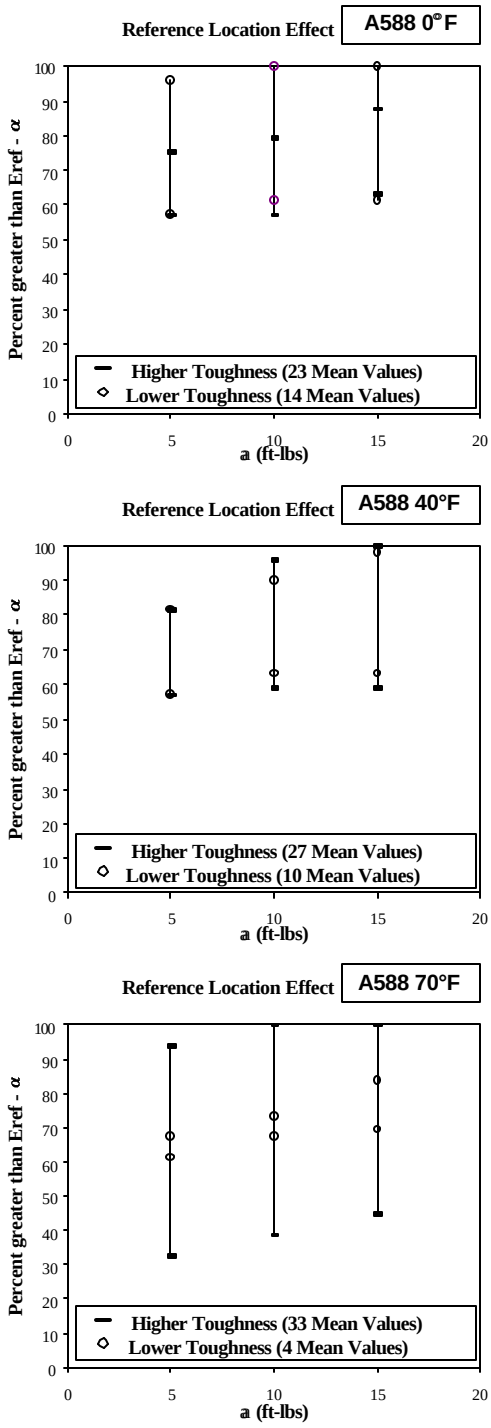

Figure 3.20: Reference Location Effect for A588 Steel as a Function of Toughness (Data from the 4-Mill Group).

3.6.4 CORRELATION BETWEEN ABSORBED ENERGY AND LATERAL EXPANSION

Statistical correlation between absorbed energy and lateral expansion obtained from CVN tests was studied and is described graphically in Figures 3.21, 3.22, and 3.23 for the test temperatures of 0°F, 40°F, and 70°F, respectively. In each figure, the data from all mills in the 4-mill group are shown along with two least-squares regression lines, one using the data where absorbed energy was below 100 ft-lbs, and the other where the absorbed energy was above 150 ft-lbs. The correlation coefficient between absorbed energy and lateral expansion is also indicated for the two portions separately. It should be noted that the number of data in each plot is not the same due to the missing lateral expansion data from some tests.

From Figures 3.21 to 3.23, it may be observed that absorbed energy shows strong positive correlation with lateral expansion for absorbed energy levels below 100 ft-lbs, with correlation coefficients varying from 0.935 at 70°F to 0.959 at 0°F. The regression lines are, expectedly, good fits to the data in this range.

In contrast, no significant correlation was found between absorbed energy and lateral expansion for absorbed energy levels greater than 150 ft-lbs at all test temperatures. The lateral expansion appears to stop increasing when it reaches approximately 100 mils in the CVN tests even as absorbed energy levels increase.

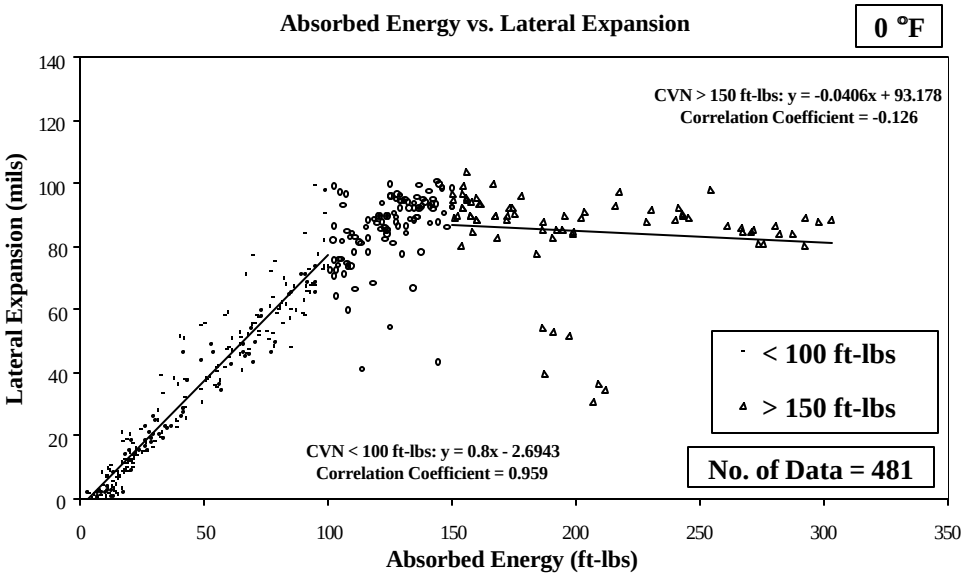

Figure 3.21: Absorbed Energy versus Lateral Expansion Plot at 0° F based on Test Data from the 4-Mill Group.

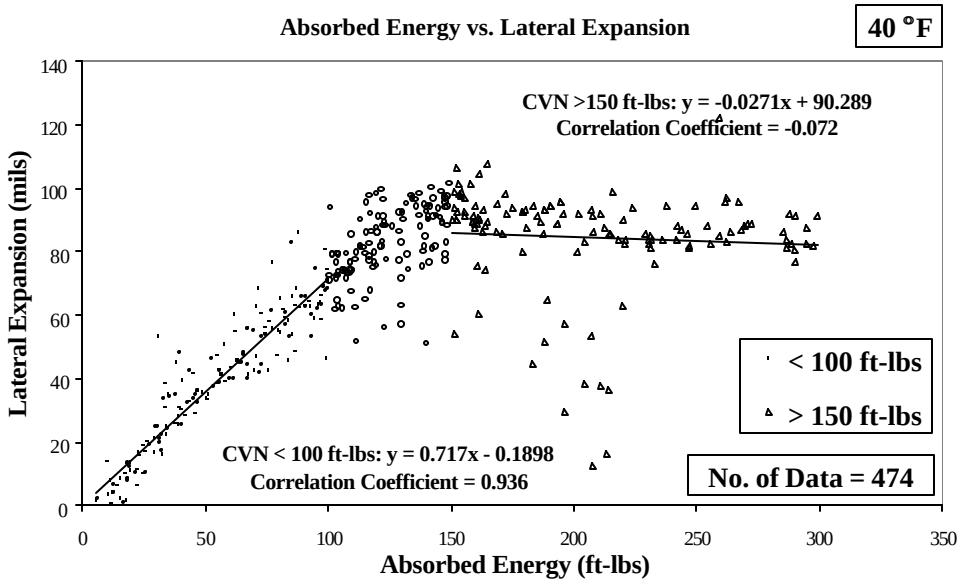

Figure 3.22: Absorbed Energy versus Lateral Expansion Plot at 40° F based on Test Data from the 4-Mill Group.

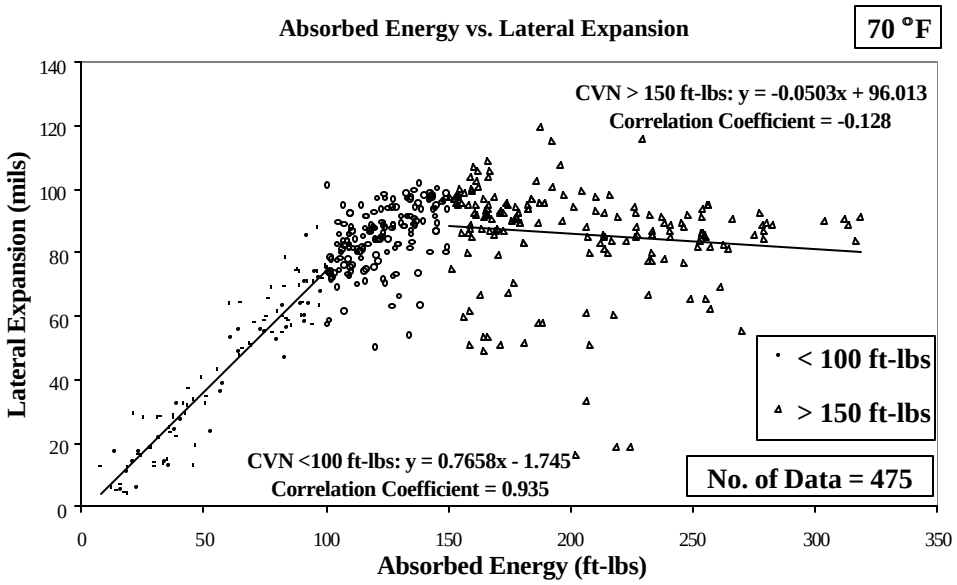

Figure 3.23: Absorbed Energy versus Lateral Expansion Plot at 70° F based on Test Data from the 4-Mill Group.