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AISI Technical Committee on Plates and Shapes

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CONTRIBUTIONS TO THE METALLURGY OF STEEL

The Variations of Charpy V-Notch Impact Test Properties In Steel Plates

AMERICAN IRON AND STEEL INSTITUTE
1000 16th STREET, N.W., WASHINGTON, D.C. 20036

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FOREWORD

The processes of melting, solidification, rolling, and thermal treatment inherently lead to non-uniformity of chemical and/or mechanical properties. This survey was conducted to quantify the mechanical non-uniformity of impact properties found at various locations of three common fine grain plate steels in the as-rolled, normalized, and quenched and tempered conditions. It is recommended that users of plates that have impact testing specified familiarize themselves with the range of variability found in this survey and observe the probabilities that impact properties at other locations may differ from those of the test location.

By way of illustration, let us presume that an order calls for A572 grade 50 with longitudinal Charpy V-Notch at +40° F. The test value reported on a specific plate is 28 ft. lbs., and the user wants to know what variation can be expected at other locations in that plate.

The survey shows test results at seven locations on the test plate (re: Figure 1). Referring to Figure 15, we may predict the likelihood of other values within the plate in comparison to the reference test supplied by the manufacturer. With the reference test of 28 ft. lbs., Figure 15 will show the probabilities of other values. Three illustrations are cited below:

1. Plot line B of Figure 15 (range 20-29 ft. lbs.) includes our example of 28 ft. lbs. Line B indicates a 95% probability that other tests from the same plate will be 18 ft. lbs. or greater (line B intercepts 95% at -10, hence 28-10=18).
2. To determine the probability that none of the other tests would be lower than the reference test, follow line B to 0 ft. lbs. or greater (difference from reference test), and there is a 70% probability of this occurrence.
3. Conversely, there is a probability of at least 99.4% that other test locations would show at least 10 ft. lbs. (28 minus 18, the intercept of line B at 99.4% min. confidence.)

Attention should be paid to the effect of test temperature on impact values and the scatter around the average. As the temperature drops, impact values will drop, but variation around the average is different.

It should be noted that this survey shows only the variability within individual plates. The variabilities shown may not be applicable to other plates in a heat or rolling, lighter or heavier thicknesses, or deoxidations other than killed fine grain.

AISI Technical Committee on Plates and Shapes

AMERICAN IRON AND STEEL INSTITUTE
Committee on Product Standards

SU/24 — Survey of Variation of Charpy V-Notch Impact Test Properties — Plates

Summary

A survey of the variation to be expected in Charpy V-Notch tests obtained from plates was conducted by the Committee on Product Standards at the request of the Committee on General Metallurgy. The results of the survey are presented in this report.

The survey data consisted of longitudinal and transverse impact test values obtained from seven specified locations on plates produced to ASTM A-572 as-rolled, A-516 normalized and A-537 quenched and tempered. Three testing temperatures were used for each grade.

The data were collected from industry production during 1973 and 1974. Sufficient data were received to estimate limits of variation for impact tests taken at specified locations in plates.

THE VARIATIONS OF CHARPY V-NOTCH IMPACT PROPERTIES IN PLATES

Introduction

The Committee on General Metallurgy of the American Iron and Steel Institute (AISI) decided that there was a need for information on the extent of the variation within plates to be expected in Charpy V-Notch impact values. They, therefore, directed that an industry-wide survey be conducted and that the results of the survey be published.

AISI has established a standard procedure for conducting such surveys. The Committee on General Metallurgy authorizes the survey; the Product Technical Committee concerned determines the parameters of the product to be surveyed; and the Committee on Product Standards conducts the surveys, analyzes the data and prepares a report for publication.

The Survey

The Technical Committee on Plates and Shapes met with the Committee on Product Standards in order to establish the parameters for the survey, the most important of which were the grades to be surveyed, the number of plates in each grade to be tested and the test locations.

The Technical Committee limited the survey to three grades.

ASTM Standard	Condition	Thickness
A-572 — Grade 50 Killed Fine Grain	As-rolled	Over 3/4" to 1-1/2", Incl.
A-516 — Grade 70	Normalized	7/16" to 2-1/2", Incl.
A-537 — Class 2	Quenched and Tempered	7/16" to 2-1/2", Incl.

The Committee on Product Standards prepared instructions for conducting the surveys so that all information requested would be collected and reported by the participants in a similar manner, and thus, the data would represent industry practice.

Exhibit I contains the official documents for the survey identified as SU/24. Those documents are Procedure, Sample Location Diagram, Recording Instructions and an Official Data Reporting From for each grade.

The procedure prescribed that each participant test the plate product of two slabs from each of five heats for each grade. Preferably the slabs were to be from different ingots in the heat. Each pair of slabs was to be rolled to the same plate thickness and approximately the same width and length, but the slabs were not to be consecutive in the hot rolling sequence.

There were no restrictions on the material to be tested other than that strand cast material and plates from "tail end" ingots, specially treated ingots or ingots otherwise not representative of the heat were to be excluded. Controlled rolled A-572 plates were also excluded.

The locations for the test samples in each plate are shown in Figure 1. It would have been an ideal situation if the sampling could have been random. However, the committees recognized that it would be impractical to test at random locations. Consequently, test locations were chosen which were judged to represent the maximum variation. Samples were to be cut from the thermally treated plates after treatment.

Sufficient full-size specimens were machined from each sample so that three longitudinal and three transverse specimens could be broken at the following temperatures:

Specification	Testing Temperature (° F)
A-572	0, +40, +70
A-516	-50, 0, +32
A-537	-75, -50, 0

It was requested that all machining and testing be in accordance with ASTM Standard A-370 and be performed in production laboratories in the same way as tests for compliance with order requirements are handled.

The Data Reporting Form provided space to record absorbed energy, lateral expansion and percent shear area for all 126 specimens from each plate. Space was also provided to record the producer, plate size, plate identity, ordered impact requirements, ladle analysis and rolling information. Instructions for completing these forms were also prepared.

All producers of plates in the U.S. and Canada were invited by AISI to participate. The survey documents plus an ample supply of Data Reporting Forms were sent to those who accepted the invitation. February 1, 1973 was established as the starting date for data collection. The survey was terminated on February 3, 1975. Completed forms were returned to AISI were they were inspected for conformance to instructions and coded to assure anonymity. Cards were punched and the Committee on Product Standards proceeded with analysis of the data.

Sampling Summary

Table I contains a summary of the sources and amounts of data received. The Committee considered that the quantity of data was sufficient on absorbed energy and lateral expansion to justify accepting the survey as representing industry practice. While shear data were collected, they were subsequently excluded from the scope of this report.

Table II shows the distribution of plate thicknesses for each grade studied by percent frequency. The A-572 data range from 0.750 inches to 1.500 inches while the A-516 data extended from 0.500 inch to 3.000 inches and the A-537 from 0.625 inch to 2.500 inches.

METHOD OF ANALYSIS

The method of analysis used with these impact data was similar to that used previously in the study of mechanical properties of steel plate.[1]

Seven sets of tests were taken from the plate rolled from each slab as shown in Figure 1. Each set of tests consisted of three longitudinal and three transverse tests and each of these triples was tested at three temperatures. The impact strength was measured as foot-pounds of absorbed energy and as lateral expansion in mils (mil = 0.001″). The number two position (top corner) was selected as the reference test for the plate and the difference between the three-test average at each of the other six locations and the average at the number two position was calculated for each plate.

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(1) AISI "Contributions to the Metallurgy of Steel" — *The Variation of Product Analysis and Tensile Properties, Carbon Steel Plates and Wide Flange Shapes*, September, 1974.

The data were separated by test orientation, test temperature and ranges of the reference test average. For each data subset, the differences were split into two groups, those above and those below the overall mean value and separate standard deviations calculated for each of the resulting half-distributions. Only the lower distribution were used to develop the minimum probabilities as depicted in Figure 2. These means and standard deviations were used, along with the formulas given in the Appendix, to calculate the minimum probability that the three-test average would equal or exceed a specified difference from the reference test average. These probabilities are based on the concept of statistical tolerance limits. A separate probability is given for each of the three grades, each testing temperature, each test orientation and each of the two test measures-absorbed energy and lateral expansion.

These probability charts may be better understood by means of Figure 2. This curve represents the idealized distribution of three-test averages for the longitudinal A-516 Grade 70 tests tested at -50° F when the reference test average was 30 Ft.-Lbs.

In Figure 2 one should note the relationship between the actual product test averages and the negative difference between the Product Test and the Reference Test averages. The probability charts which follow use this negative difference.

The shaded area under the curve in Figure 2 is the minimum probability that a three-test average will be at most 12 Ft.-Lbs. below the Reference Test average. This probability is 92.6% which can be read from Line B of Figure 3 for a difference of -12 Ft.-Lbs. from the Reference Test.

Similar probabilities may be read from each of the probability charts.

DATA PRESENTATION

The data will be presented similarly for each of the three (3) grades studied.

ASTM A-572 GR-50

In Figures 4 to 7 the distribution of three (3) test averages are shown for this grade. Each figure shows a particular test direction for that grade and the distribution for each test temperature is ascending order (top to bottom of figure). The percent frequency for each cell is shown above the histogram bar. The sample size, mean, and the standard deviation (sigma) are shown for each group. The cell limits are inclusive.

Figures 8 and 9 show the relationship between test temperature and impact properties. As expected, the mean values and variabilities increase with increasing test temperature.

Figures 10 to 13 show the distribution of the 3 test averages for the Reference Tests (#2 Test). The percent frequency is shown above each bar. The cell limits are inclusive. The sample size, mean, and the standard deviation (sigma) are shown for each group.

The differences from the #2 test position are summarized in Tables III and IV. As mentioned in the Method of Analysis, the distribution of these differences for ranges of the Reference Test were divided into a portion below and a portion above the mean value. The standard deviations were calculated for each portion of the distribution.

From these tables the probability curves were calculated for absorbed energy and lateral expansion for this grade and test temperatures. These are shown in Figures 14 to 25 as the minimum probability that the 3-test average will equal or exceed a given difference from the Reference Test.

ASTM A-516 GR-70 Normalized

Figures 26 through 29 illustrate the distribution of the 3-Test Averages for this grade. Figures 30 and 31 plot the mean values of absorbed energy and lateral expansion versus test temperature. The number 2 test position (Reference Test) distributions are displayed in

Figures 32 through 35. Tables V and VI summarize the differences from the Reference Test as described for A-572.

Most of the distribution of this A-516 exhibited skewness characteristics which were not noted in the A-572 distribution.

The minimum probabilities that the 3-Test Average will equal or exceed the difference from the Reference Test are represented in Figures 36 through 47.

ASTM A-537 GR-B Quenched and Tempered

Figures 48 through 51 represent the 3-Test Average distribution for this grade. Figures 52 and 53 plot the mean values versus test temperature for both absorbed energy and lateral expansion. The number 2 test position (Reference Test) distributions are charted in Figures 54 through 57. Tables VII and VIII summarize the differences from the reference test results. All presentations in the above figures and tables are the same as explained for A-572.

The minimum probability that the 3-Test Average will equal or exceed the difference from the Reference Test are represented in Figures 58 to 69.

RELATIONSHIP BETWEEN ABSORBED ENERGY AND LATERAL EXPANSION

Since lateral expansion could be measured more precisely on impact test specimens, it was desirable to study its relationship to absorbed energy. The latter is the more commonly reported property. This study afforded an unique opportunity of observing these properties for 3 different grades.

Figures 70 through 72 present the regression line with 95 % confidence limits for each grade.

The data indicate a strong statistical relationship between absorbed energy and lateral expansion as measured by computed t value, correlation coefficient and F value which are shown in Table IX. Also, from Table IX it should be noted the slopes of A-572 and A-516 are quite comparable. The A-537 slope is less than that of the other two (2) grades.

TABLE I

SOURCE AND NUMBER OF TESTS

	A-572	A-516	A-537
Source: Producers	5	3	3
Mills	5	5	3
Data: No. of Plates	52	34	25
No. of Tests	6,552	4,284	3,150

TABLE II

PER CENT DISTRIBUTION OF PLATE THICKNESSES

Thickness-inches	A-572	A-516	A-537
.500 - .625 excl.		3	
.625 - .750 excl.			4
.750	4	21	8
.875	16	6	
1.000	39		24
1.125	4		
1.250	19	21	
1.375	12		
1.500	8	18	32
1.625		3	
1.750		3	
1.875			
2.000		3	4
2.125		9	8
2.250			4
2.375			
2.500		9	16
2.625			
2.750			
2.875			
3.000		6	

TABLE III

DIFFERENCE FROM #2 TEST POSITION

ABSORBED ENERGY IN FT. LBS (LONGITUDINAL)

		0°F			+40°F			+70°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A572	0-9	4.87	52	4.18	10.61	8	4.79	8.74	20	8.00
	10-19	2.56	126	5.78	5.59	18	5.49	12.56	50	11.79
	20-29	-1.54	94	6.39	4.93	132	8.15	3.71	100	8.48
	30-39	-4.81	38	7.11	4.68	118	8.97	-0.31	100	12.58
	40-49	-9.43	28	7.31	-1.10	62	8.70	-4.98	28	7.44
	50-59				-13.92	12	6.08	-2.90	38	18.12
	60-69				-5.76	22	9.93	-11.26	18	8.69

LATERAL EXPANSION IN MILS (LONGITUDINAL)

		0°F			+40°F			+70°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A572	0-9	3.19	80	3.62	5.97	58	6.17	7.33	48	8.46
	10-19	3.18	90	5.89	4.60	78	8.32	4.44	72	7.02
	20-29	-1.09	102	7.05	3.15	110	8.61	1.08	108	9.78
	30-39	-4.42	30	4.27	-1.52	72	7.51	-2.81	58	10.73
	40-49	-3.61	30	6.52	-6.50	14	6.58	1.36	34	11.25
	50-59				-7.50	14	10.54	-5.75	20	9.57

TABLE IV

DIFFERENCE FROM #2 TEST POSITION

ABSORBED ENERGY IN FT. LBS (TRANSVERSE)

		0°F			+40°F			+70°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A572	0-9	1.02	110	1.57	2.39	20	1.59			
	10-19	-0.27	224	2.14	1.17	226	2.62	2.99	120	3.12
	20-29	-4.53	10	2.79	0.00	50	4.70	1.47	140	3.04
	30-39				-5.02	16	3.14	-1.31	62	3.78
	40-49							-5.26	26	3.60

LATERAL EXPANSION IN MILS (TRANSVERSE)

		0°F			+40°F			+70°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A572	0-9	1.59	116	2.45	2.31	12	2.28			
	10-19	-0.32	174	3.28	1.21	178	3.58	3.55	94	3.66
	20-29	-4.34	38	4.50	1.92	86	5.52	3.37	130	5.31
	30-39	-7.50	18	5.54	-3.70	40	3.35	-1.07	70	3.87
	40-49				-14.99	6	3.90	-3.48	28	6.88
	50-59							-9.49	24	5.49

Table V

DIFFERENCE FROM #2 TEST POSITION

ABSORBED ENERGY IN FT LBS (LONGITUDINAL)

		0°F			+40°F			+70°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A 516	0-19	-0.17	80	5.80	0.00	0	0.00	0.00	0	0.00
	20-39	-1.18	98	6.56	0.87	70	9.65	1.58	16	1.52
	40-59	9.67	14	16.55	-2.73	74	9.31	-0.63	92	10.83
	60-79				-5.97	28	10.72	-1.87	78	9.10
	80-99				-15.74	24	4.29	-9.19	30	6.91

LATERAL EXPANSION IN MILS (LONGITUDINAL)

		-50°F			0°F			+32°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A516	0-19	0.03	108	5.73	-1.39	6	4.44	0.00	0	0.00
	20-39	-0.46	76	9.53	1.65	112	7.73	1.14	12	2.32
	40-59	-10.92	12	9.57	-3.15	56	9.53	0.10	120	9.07
	60-69				-8.13	28	5.48	-1.03	72	6.78

TABLE VI

DIFFERENCE FROM #2 TEST POSITION

ABSORBED ENERGY IN FT LBS (TRANSVERSE)

		-50°F			0°F			+32°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A516	0-19	0.60	218	3.16	6.90	36	5.89			
	20-39	-5.14	12	3.41	-0.53	198	4.64	-1.55	170	4.97
	40-59							5.06	22	6.26

LATERAL EXPANSION IN MILS

		-50°F			0°F			+32°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A516	0-19	0.92	198	3.84	3.59	42	2.96	8.61	10	6.10
	20-39	-7.54	22	4.21	0.00	200	4.64	-0.16	130	5.80
	40-59							-1.17	46	4.28

TABLE VII

DIFFERENCE FROM #2 TEST POSITION

		ABSORBED ENERGY IN FT LBS (LONGITUDINAL)								
		-75 °F			-50 °F			0 °F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A537	0-19	1.44	6	2.53	-3.00	6	3.17	0.00	0	0.00
	20-39	4.47	42	10.44	2.57	18	6.29	10.44	8	5.84
	40-59	2.65	64	10.24	15.22	22	13.00	11.73	6	4.92
	60-79	-16.75	14	15.55	-2.13	48	13.78	-9.22	22	9.83
	80-99	-10.21	38	17.15	-3.05	60	13.05	5.98	44	14.47
	100-119				-1.61	12	8.23	3.37	54	15.60
	120-139							3.04	28	10.56
	140-159							-8.33	6	4.85

		LATERAL EXPANSION IN MILS								
		-75 °F			-50 °F			0 °F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A537	0-19	1.37	14	7.13	4.53	10	4.34	10.28	6	5.65
	20-39	2.64	50	9.58	7.43	30	7.88	0.00	0	0.00
	40-59	-1.47	70	10.03	-2.13	42	12.28	-2.43	32	6.82
	60-79	-11.26	26	11.43	-2.74	66	9.05	2.04	62	7.75
	80-99				-7.54	10	7.92	-3.59	40	11.95

TABLE VIII

DIFFERENCE FROM #2 TEST POSITION

ABSORBED ENERGY IN FT LBS (TRANSVERSE)

		-75°F			-50°F			0°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A 537	0-19	2.56	60	2.36	-1.47	12	2.25	3.61	6	2.26
	20-39	-0.30	92	3.10	-1.78	124	5.68	1.32	64	3.68
	40-59							-0.69	64	5.96
	60-79							0.61	2	15.01

LATERAL EXPANSION IN MILS

		-75°F			-50°F			0°F		
SPEC	RANGE OF 3 TEST AVERAGE OF #2 TEST	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION	MEAN	LOWER SAMPLE SIZE	LOWER STANDARD DEVIATION
A537	0-19	1.84	70	2.95	0.37	32	3.32	4.06	12	3.28
	20-39	0.04	98	4.02	-1.62	114	5.27	0.68	100	3.80
	40-59				-8.50	6	2.24	-1.23	34	9.17

TABLE IX

SUMMARY OF REGRESSION LINE STATISTICS FOR ABSORBED ENERGY (DEPENDENT VARIABLE) VERSUS LATERAL EXPANSION (INDEPENDENT VARIABLE)

SPEC	A572	A516	A537
Number of Observations	2184	1428	1050
Intercept	-2.08	-1.29	8.58
Regression Coefficient	1.08	1.10	0.63
Standard Error of Regression Coefficient	0.0098	0.0081	0.0058
Computed t Value	111	136	109
Standard Error of Estimate	7.27	5.17	6.25
Correlation Coefficient	0.92	0.96	0.96
F Value	12242	18557	11906

OFFICIAL DATA REPORTING FORM

SU/24 AISI SURVEY OF VARIATION OF CHARPV V-NOTCH IMPACT PROPERTIES – PLATE

DATE 19

CT 1 1	COMPANY	CODE 2 3	PLANT	CODE 4	PLATE SPECIFICATION ASTM A572 – GRADE 50
CODE 2 5	HEAT NUMBER	CODE 6	INGOT NO.	PLATE NUMBER	CODE 7

PLATE DIMENSIONS INCHES

LENGTH	WIDTH	THICKNESS
8 9 10	11 12 13	14 15 16 17

TYPE OF MILL CODE

REVERSING MILL - - - - - - - - - 1

SEMI-CONTINUOUS - - - - - - - - 2

CODE 18

FINAL ROLLING DIRECTION CODE

PARALLEL TO INGOT AXIS - - - - - - - - - 1

PERPINDICULAR TO INGOT AXIS - - - - - - - 2

CODE 19

ORDERED IMPACT TEST REQUIREMENTS

RECORD + OR – TEMPERATURE

MIN ENERGY	TEST TEMP	ORIENTATION CODE
20 21 22	23 24 25	26 LONG - - - 1 TRANS - - 2

INSTRUCTIONS

1 SEE "RECORDING INSTRUCTIONS FOR OFFICIAL DATA REPORTING FORM" FOR DETAILED INFORMATION

2 THE POSITION OF TEST SPECIMENS WITHIN THE SAMPLE LOCATIONS SHALL BE IN ACCORDANCE WITH A593

3 TESTING SHALL BE IN ACCORDANCE WITH ASTM A370 FOR PROPERTIES AT TEMPERATURES SHOWN.

LADLE ANALYSIS

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al (Tot.)	Cb	V	N
		O.	O.					.O	.O			
27 28	29 30 31	32 33	34 35	36 37	38 39	40 41	42 43	44	45 46	47 48 49	50 51	52 53 54

CHARPY V NOTCH IMPACT TEST RESULTS

CARD TYPE	TEST		TESTING TEMPERATURE °F								
			0			+40			+70		
	SAMPLE LOCATION	SPECIMEN DIRECTION	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT
2 1	1 8	LONG 1 9	10 11 12 13 14 15 16 17 18	19 20 21 22 23 24 25 26	27 28 29 30	31 32 33 34 35 36 37 38 39	40 41 42 43 44 45	46 47 48 49 50 51	52 53 54 55 56 57 58 59 60	61 62 63 64 65 66	67 68 69 70 71 72
	1	TRANS 2									
	2	LONG 1									
	2	TRANS 2									
	3	LONG 1									
	3	TRANS 2									
	4	LONG 1									
	4	TRANS 2									
	5	LONG 1									
	5	TRANS 2									
	6	LONG 1									
	6	TRANS 2									
	7	LONG 1									
	7 8	TRANS 2 9	10 11 12 13 14 15 16 17 18	19 20 21 22 23 24 25 26	27 28 29 30	31 32 33 34 35 36 37 38 39	40 41 42 43 44 45	46 47 48 49 50 51	52 53 54 55 56 57 58 59 60	61 62 63 64 65 66	67 68 69 70 71 72

KEY PUNCH INSTRUCTION
PUNCH CC2 TO 7 INCL FROM CT1 IN ALL CT2 CARDS

APPROVED BY ____________________

OFFICIAL DATA REPORTING FORM
SU/24 AISI SURVEY OF VARIATION OF CHARPV V-NOTCH IMPACT PROPERTIES – PLATE

DATE 19

CT	COMPANY	CODE	PLANT	CODE	PLATE SPECIFICATION	CODE	HEAT NUMBER	CODE	INGOT NO.	PLATE NUMBER	CODE
1					ASTM A516 – GRADE 70	6					
1		2 3		4		5		6			7

PLATE DIMENSIONS INCHES	LENGTH	WIDTH	THICKNESS
	8 9 10	11 12 13	14 15 16 17

TYPE OF MILL: CODE
REVERSING MILL - - - - - - - - - 1
SEMI-CONTINUOUS - - - - - - - - 2
CODE 18

FINAL ROLLING DIRECTION CODE
PARALLEL TO INGOT AXIS - - - - - - - - - 1
PERPINDICULAR TO INGOT AXIS - - - - - - - 2
CODE 19

ORDERED IMPACT TEST REQUIREMENTS
RECORD + OR – TEMPERATURE

MIN. ENERGY	TEST TEMP.	ORIENTATION	CODE
20 21 22	23 24 25	26	LONG - - - 1 TRANS. - - 2

INSTRUCTIONS:
1 SEE "RECORDING INSTRUCTIONS FOR OFFICIAL DATA REPORTING FORM" FOR DETAILED INFORMATION.
2 THE POSITION OF TEST SPECIMENS WITHIN THE SAMPLE LOCATIONS SHALL BE IN ACCORDANCE WITH A593.
3 TESTING SHALL BE IN ACCORDANCE WITH ASTM A370 FOR PROPERTIES AT TEMPERATURES SHOWN.

LADLE ANALYSIS

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al (Tot.)
.	.	.0	.0	.	.	.	.	.0	.0
27 28	29 30 31	32 33	34 35	36 37	38 39	40 41	42 43	44	45 46

CHARPY V NOTCH IMPACT TEST RESULTS

CARD TYPE	TEST			TESTING TEMPERATURE °F								
				–50			0			+32		
	SAMPLE LOCATION		SPECIMEN DIRECTION	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT
2	1	LONG	1									
1	8		9	10 11 12 13 14 15 16 17 18	19 20 21 22 23 24 25 26	27 28 29 30	31 32 33 34 35 36 37 38 39	40 41 42 43 44 45	46 47 48 49 50 51	52 53 54 56 56 57 58 59 60	61 62 63 64 65 66	67 68 69 70 71 72
	1	TRANS	2									
	2	LONG	1									
	2	TRANS	2									
	3	LONG	1									
	3	TRANS	2									
	4	LONG	1									
	4	TRANS	2									
	5	LONG	1									
	5	TRANS	2									
	6	LONG	1									
	6	TRANS	2									
	7	LONG	1									
	7	TRANS	2									
	8		9	10 11 12 13 14 15 16 17 18	19 20 21 22 23 24 25 26	27 28 29 30	31 32 33 34 35 36 37 38 39	40 41 42 43 44 45	46 47 48 49 50 51	52 53 54 56 56 57 58 59 60	61 62 63 64 65 66	67 68 69 70 71 72

KEY PUNCH INSTRUCTION
PUNCH CC2 TO 7 INCL FROM CT1 IN ALL CT2 CARDS

APPROVED BY: ______________________

OFFICIAL DATA REPORTING FORM

SU/24 AISI SURVEY OF VARIATION OF CHARPV V–NOTCH IMPACT PROPERTIES – PLATE

DATE 19

CT 1 COMPANY

CODE PLANT

CODE PLATE SPECIFICATION ASTM A537 – GRADE B

CODE 7 HEAT NUMBER

CODE 6 INGOT NO.

PLATE NUMBER

PLATE DIMENSIONS INCHES: LENGTH | WIDTH | THICKNESS

TYPE OF MILL CODE
REVERSING MILL ---------- 1
SEMI-CONTINUOUS -------- 2

FINAL ROLLING DIRECTION CODE
PARALLEL TO INGOT AXIS ---------- 1
PERPENDICULAR TO INGOT AXIS -------- 2

ORDERED IMPACT TEST REQUIREMENTS RECORD + OR – TEMPERATURE: MIN. ENERGY | TEST TEMP | ORIENTATION CODE
LONG --- 1
TRANS --- 2

INSTRUCTIONS:
1 SEE "RECORDING INSTRUCTIONS FOR OFFICIAL DATA REPORTING FORM" FOR DETAILED INFORMATION.
2 THE POSITION OF TEST SPECIMENS WITHIN THE SAMPLE LOCATIONS SHALL BE IN ACCORDANCE WITH A593.
3 TESTING SHALL BE IN ACCORDANCE WITH ASTM A370 FOR PROPERTIES AT TEMPERATURES SHOWN.

LADLE ANALYSIS

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al (Tot.)
		.0	.0					.0	.0

CHARPY V NOTCH IMPACT TEST RESULTS

CARD TYPE	TEST		TESTING TEMPERATURE °F								
			–75			–50			0		
	SAMPLE LOCATION	SPECIMEN DIRECTION	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT	ABSORBED ENERGY FOOT POUNDS	LATERAL EXPANSION IN MILS	SHEAR AREA PER CENT
2	1	LONG 1									
	1	TRANS 2									
	2	LONG 1									
	2	TRANS 2									
	3	LONG 1									
	3	TRANS 2									
	4	LONG 1									
	4	TRANS 2									
	5	LONG 1									
	5	TRANS 2									
	6	LONG 1									
	6	TRANS 2									
	7	LONG 1									
	7	TRANS 2									

KEY PUNCH INSTRUCTION
PUNCH CC2 TO 7 INCL FROM CT1 IN ALL CT2 CARDS

APPROVED BY: ______________________

September 14, 1972

SU/24 - SURVEY OF VARIATION OF CHARPY V-NOTCH IMPACT TEST PROPERTIES-PLATES

Procedure

This survey has been requested by the Committee on General Metallurgy and is to be conducted by the Committee on Product Standards.

The purpose of the survey is to study the variation to be expected in Charpy V-Notch tests which have been obtained from plates of three analyses and three treatment conditions and which have been tested at several temperatures.

The results of the survey will be published for the information of all concerned.

A. OBJECTIVES

1. To conduct an industry-wide survey of variations of Charpy V-notch impact test properties, in accordance with the request of the Committee on General Metallurgy.
2. To analyze the data in accordance with recognized statistical methods.
3. To prepare a report of the survey suitable for publication.

B. PRODUCT TO BE SURVEYED

1. Heats made for and meeting an impact requirement and the specifications, conditions and size ranges shown in Table 1.

Table 1

Specification	Condition	Size Range
ASTM A516 - Grade 70	Normalized	7/16" to 2-1/2" incl.
ASTM A572 - Grade 50 Killed Fine Grain	As Rolled	over 3/4 to 1-1/2" incl.
ASTM A537 - Grade B	Quenched & Tempered	7/16" to 2-1/2" incl.

2. Plates rolled on Sheared Plate Mill or Hot Strip Mill.

C. TEST PROCEDURE

1. Five heats from each grade shall be tested.
2. The plate product of two slabs from each heat shall be tested but the two slabs shall not be consecutive in the hot rolling sequence. It would be preferable for the slabs to be from different ingots.
3. Both slabs shall be rolled to the same plate thickness and approximately the same width and length.
4. Samples shall be taken from the front, middle and back of the as-rolled plate (A572) and from the front, middle and back of the as-heat-treated plate (A516 and A537). Refer to sketch for sample locations.
5. Plates selected for testing should represent the full range of thickness if possible.
6. Plates shall be sampled at the location shown in the attached Figure 1 "Sample Location Diagram".
7. Test coupons for A516 and A537 should not be cut from the plate until after heat treatment.
8. The position of the test specimens within the sampling locations shall be in accordance with ASTM A593.

9. Three specimens taken longitudinally and three specimens taken transversely at each location shall be broken at each of the temperatures shown.

Grade	Specimen Testing Temperature in Degree Fahrenheit		
A 516	-50,	0,	+32
A 572	0.	+40.	+70
A 537	-75,	-50	0

10. Only full size tests shall be used (10 mm x 10 mm).
11. Tests are to be conducted according to ASTM A370.
12. Absorbed energy in foot pounds, lateral expansion in mils and percent shear area are to be reported for each test specimen. Do not report averages.
13. Machining and testing of impact specimens shall follow normal procedures for production tests.

D. PRODUCT TO BE EXCLUDED

1. Do not report on product from "tail end" ingots, specially treated ingots, or ingots otherwise not representative of the heat.
2. Do not report on strand cast material.

E. COMMENCEMENT OF SURVEY

Data collection and reporting will commence upon receipt of Procedure and Data Reporting Form from American Iron and Steel Institute.

F. DURATION OF SURVEY

Collection and reporting of data shall continue for a period of one year or until terminated by notice from American Iron and Steel Institute.

G. REPORTING INSTRUCTIONS

1. Follow instructions issued with AISI Data Reporting Forms.

G. REPORTING INSTRUCTIONS (cont'd)

2. Use the appropriate Official Data Reporting Form for the specification. Use a separate form for each as-rolled or as-heat-treated plate tested. Printed numbers in data boxes are provided for data processing information only.
3. Report all the data requested. Prior to submission of data check for conformance with conditions outlinedin the survey documents. Send one copy of each completed form as soon as possible to:

Mr. H. C. Lacy
Metallurgical Engineer
American Iron and Steel Institute
150 East 42nd Street
New York, New York 10017

Endorsement

SIGNATURES HERETO constitute endorsement of all the foregoing, and of the Data Reporting Form attached.

Jan 22, 1973
Date

H. A. Grubb
Chairman, Technical Committee on Plates and Shapes

Jan 26, 1973
Date

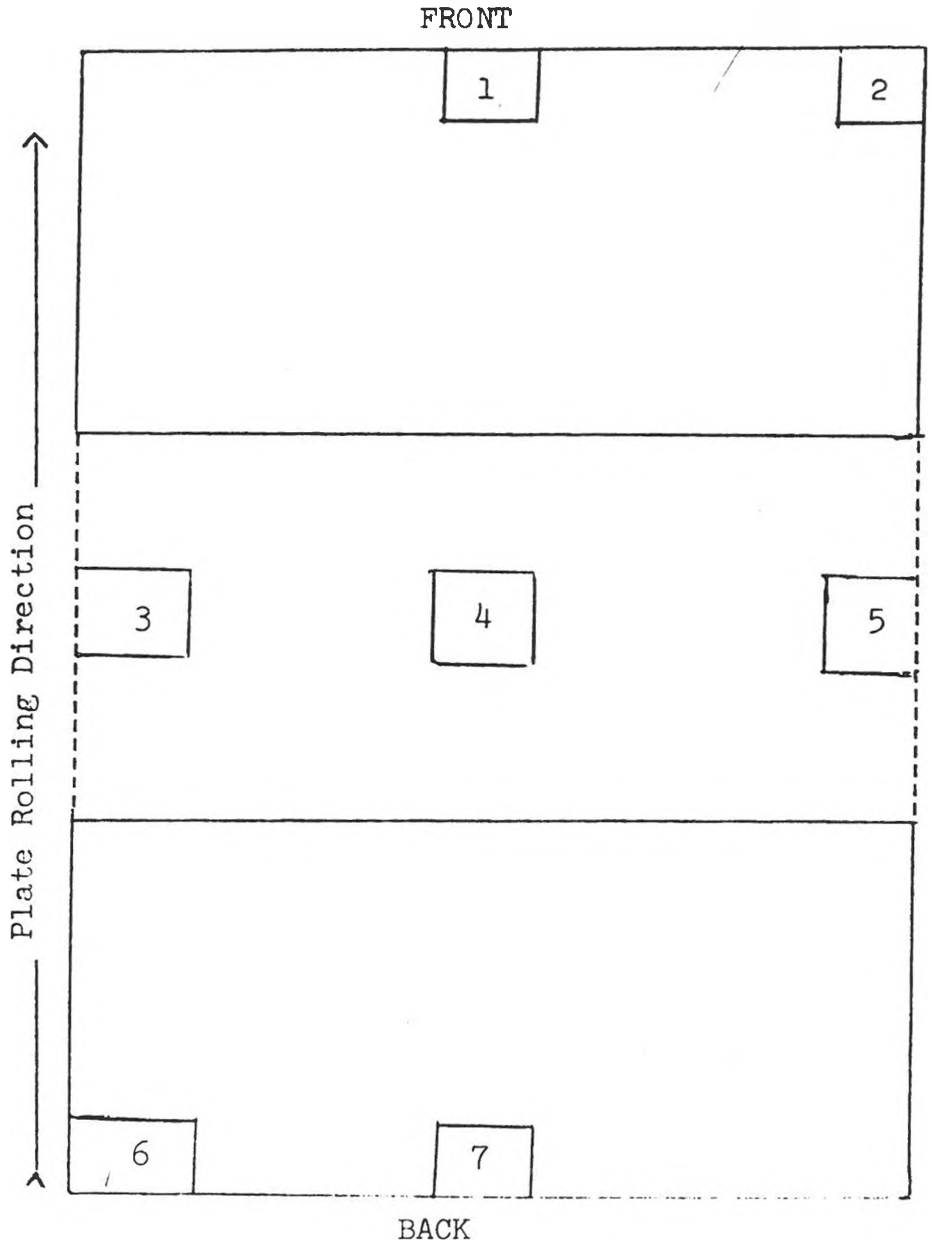
Chairman, Technical Committee on High Strength Steel

Jan 19, 1973
Date

J. R. Behrman
Chairman, Committee on Product Standards

Figure 1. Sample Location Diagram

SU/24 - Survey of Variation of Charpy V-Notch Impact Test Properties-Plates



The above outline represents the original as-rolled or as-heat-treated plate. No restrictions are intended on shearing other than that tests 3,4 and 5 should come as near the middle as possible.

SU/24 - AISI SURVEY OF VARIATION OF CHARPY V-NOTCH IMPACT PROPERTIES - PLATES

RECORDING INSTRUCTIONS FOR "OFFICIAL DATA REPORTING FORM"

General Information

The forms have been designed for hand or type written entries. Boxes have been provided for data entry and numbered for ease of keypunching. Entries are not required in boxes that have been preprinted. The Institute staff shall record the appropriate codes in boxes 2, 3, 4, 6, 7. All other boxes shall be completed by the producing company.

Instructions

Enter the following information in the sections or boxes provided (refer to Official Data Reporting Form).

Section	Card Column	Entry - Comment	
1. Date		Enter date used for identity of test record.	
2. Company	2-3	Company Name	To be coded by Inst. Staff
3. Plant	4	Plant Name	"
4. Heat Number	6	Heat Number	"
5. Ingot No.		Ingot Number	"
6. Plate No.	7	Plate Number	"
7. Plate Dimensions	8-17	Enter length, width and thickness of plate. Note preprinted decimal position provided for thickness.	
8. Type of Mill	18	Enter appropriate code in box provided.	
9. Final Rolling Direction	19	Enter appropriate code in box provided.	

10.	Impact Test Requirements	20-26	Enter the ordered minimum energy, testing temperature and orientation of test specimen (longitudinal or transverse) agreed upon between the customer and producer. The sign of the testing temperature (+ or -) shall be entered in the left hand box. If the customer does not specify impact requirements, show the aim.
11.	Ladle Analysis	27-54	Enter percentages of all elements in boxes provided. Al is to be reported as total aluminum content. Note preprinted decimal positions.
12.	Charpy V-Notch Impact	CT2 10-72	"Absorbed Energy Foot Pounds" and "Shear Area Per Cent" are to be entered with the units digit located in the right hand box.
13.	Approved by		The person's name who is responsible for submission of data to AISI should appear in this section.

FIGURE 1

SAMPLE LOCATIONS
VARIATION IN IMPACT PROPERTIES WITHIN A PLATE

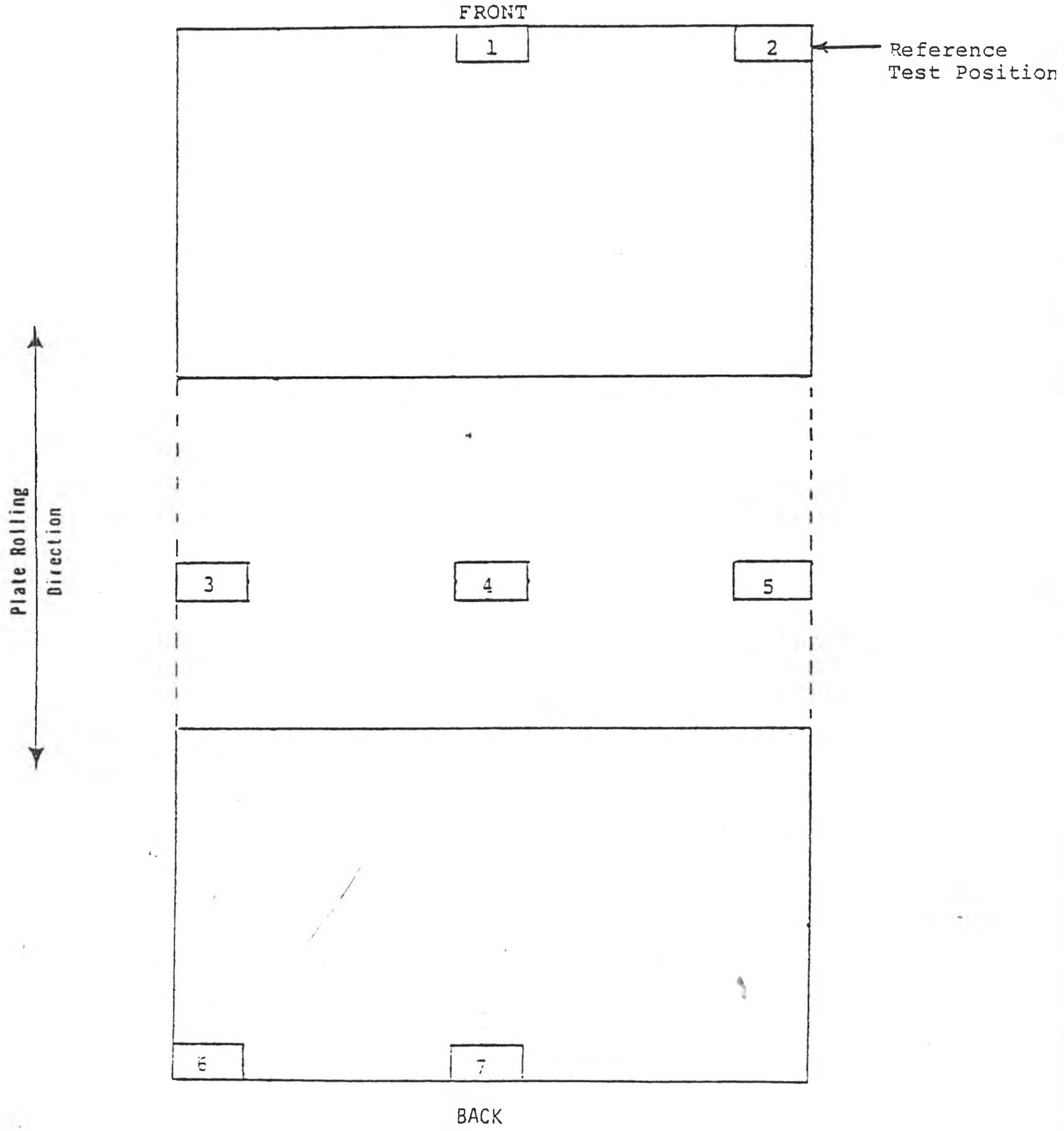


Figure 2. Distribution of Absorbed Energy
3-Test Averages

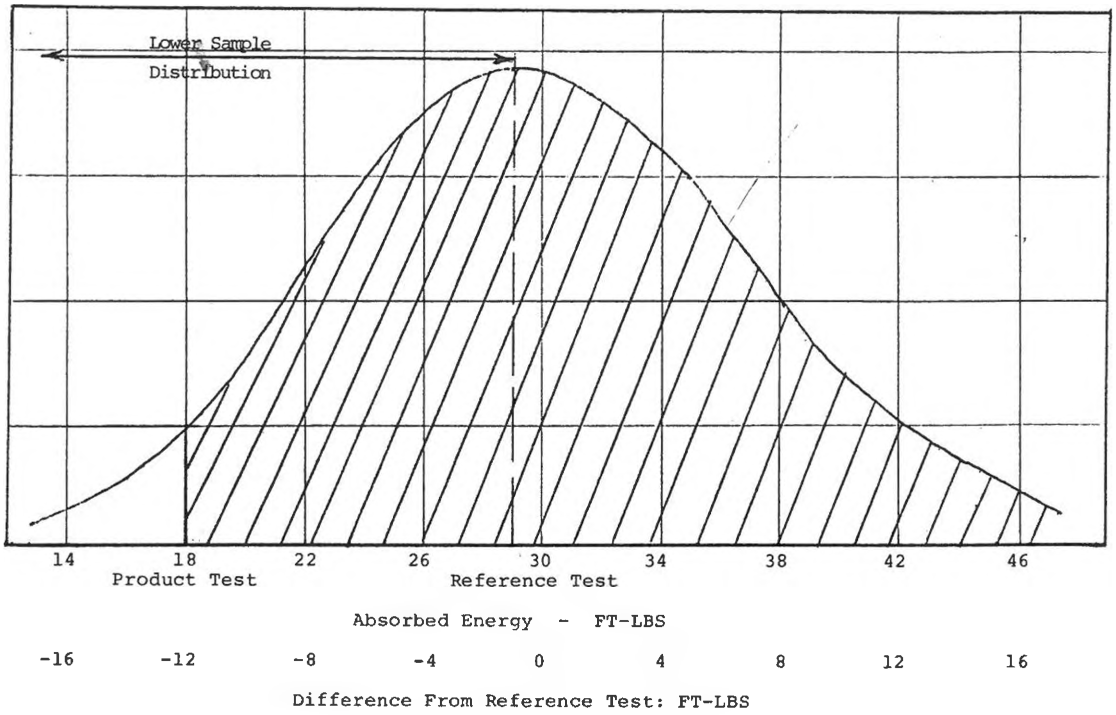
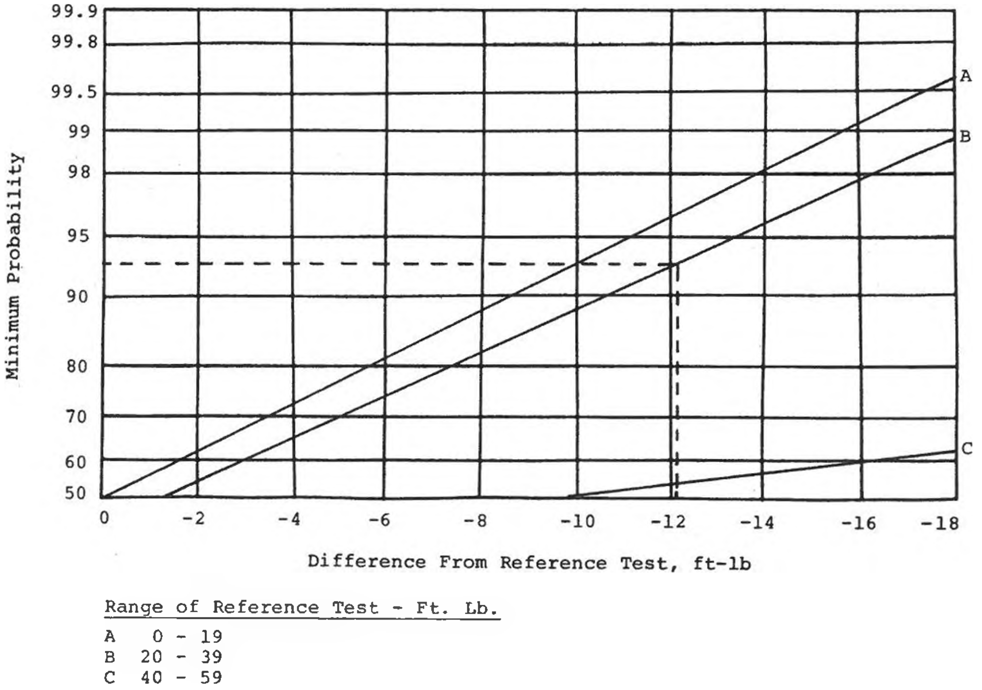


Figure 3. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test Absorbed Energy at -50°F, 3-Test Average



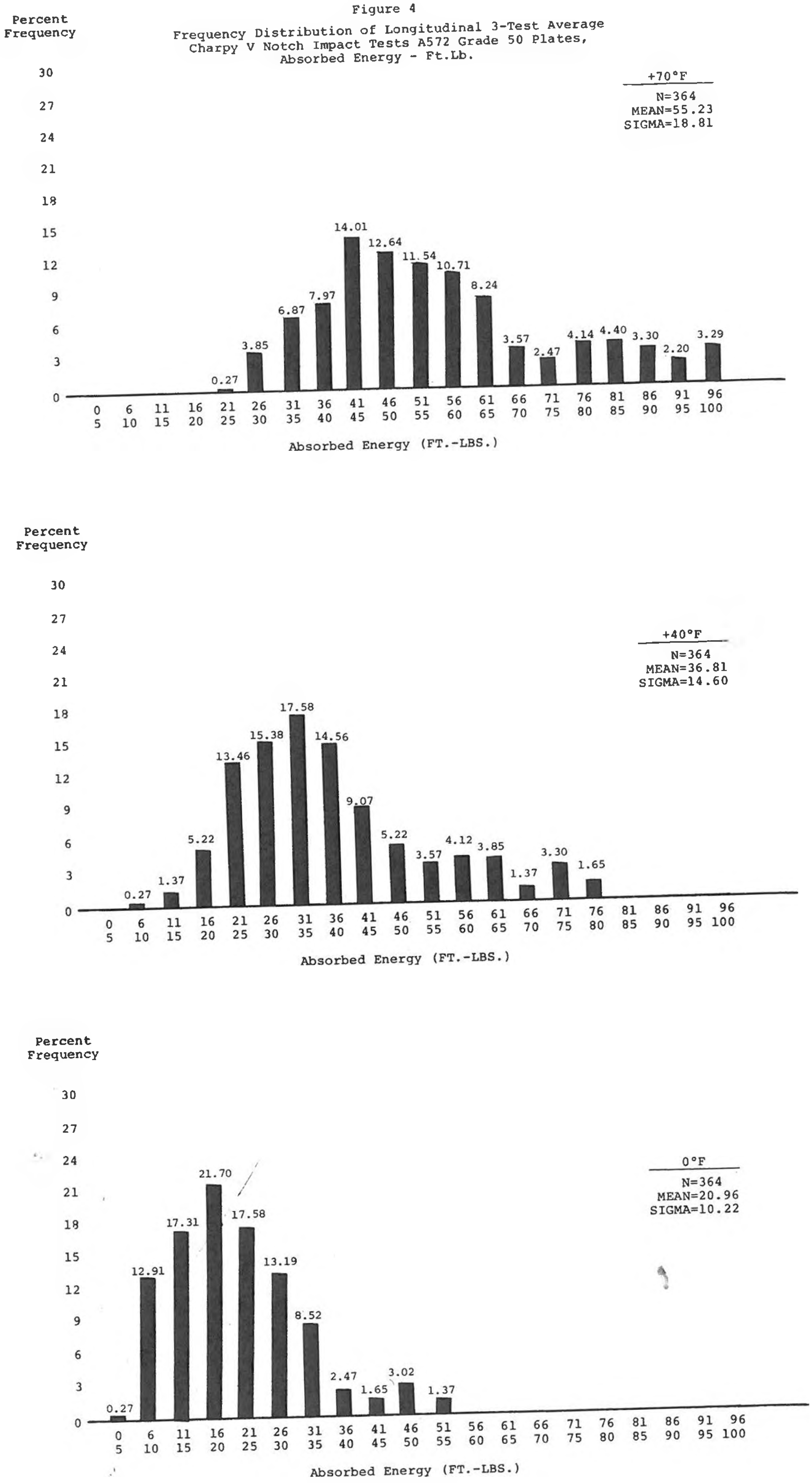


Figure 4

Frequency Distribution of Longitudinal 3-Test Average Charpy V Notch Impact Tests A572 Grade 50 Plates, Absorbed Energy - Ft.Lb.

Figure 5

Frequency Distribution of Longitudinal 3-Test Average Charpy V Notch Impact Tests, A572 Grade 50 Plates, Lateral Expansion - Mils

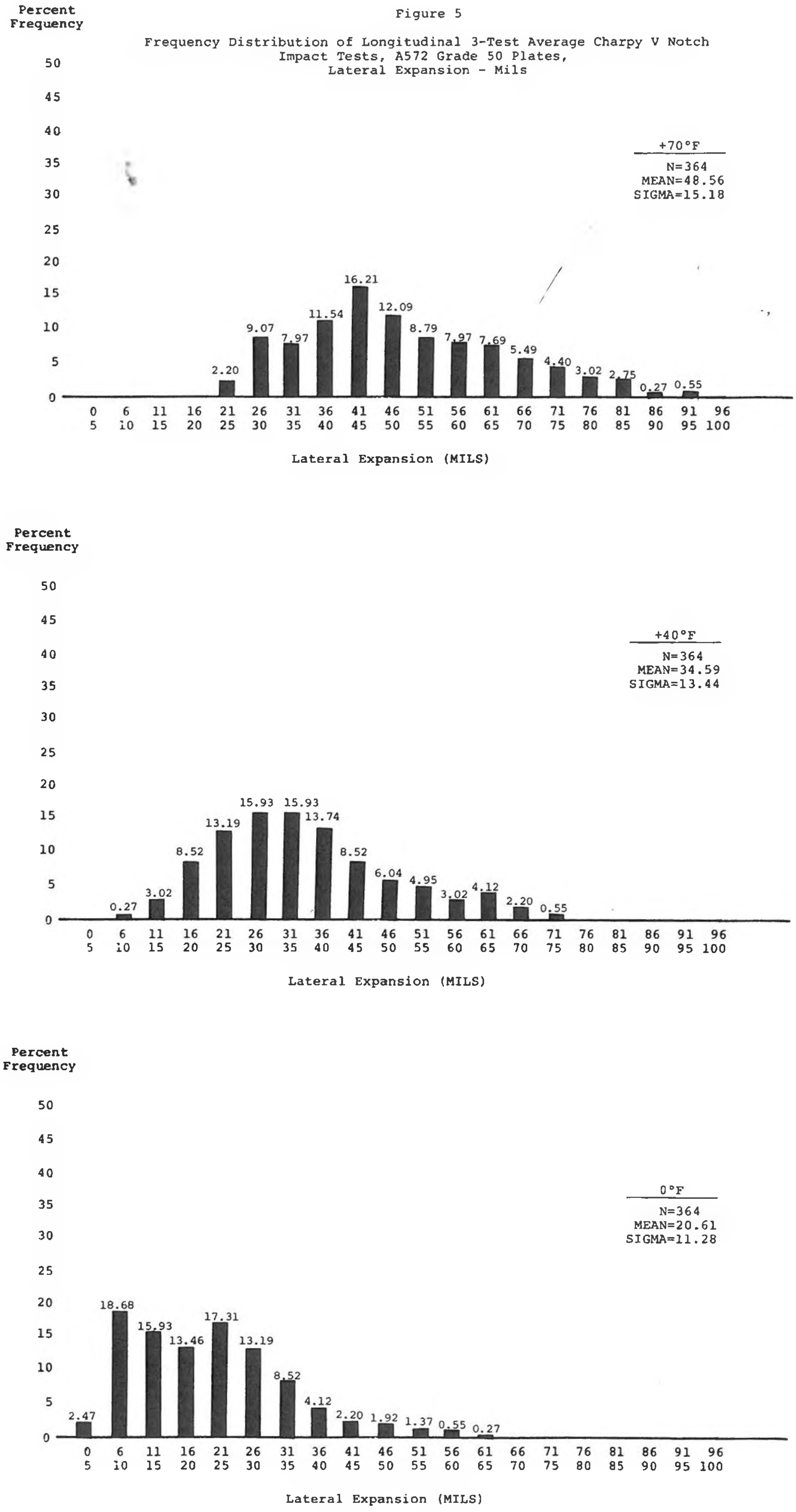


Figure 6

Frequency Distribution of Transverse 3-Test Average Charpy V Notch Impact Tests, A572 Grade 50 Plates, Absorbed Energy - Ft.Lb.

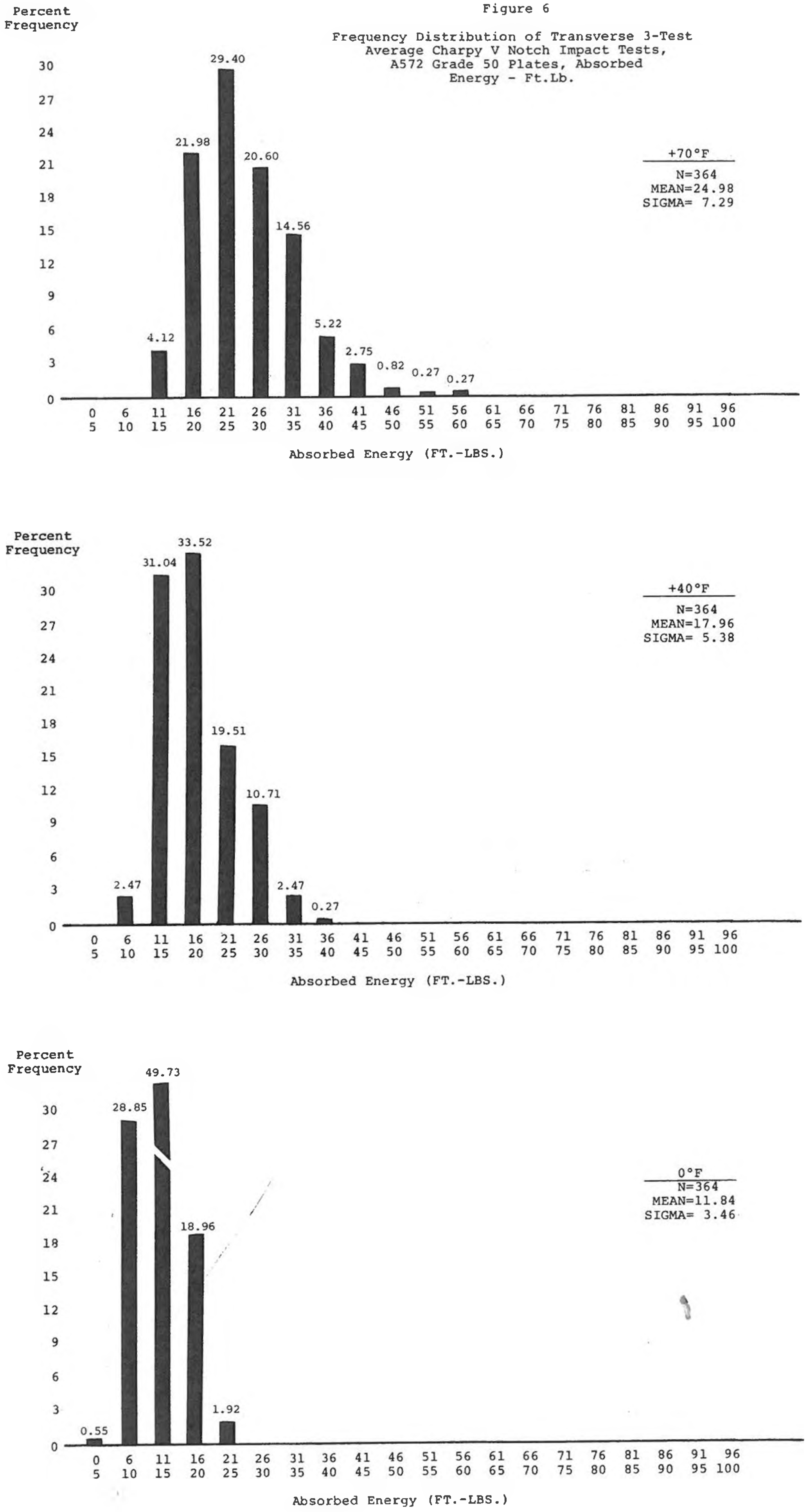


Figure 7

Frequency Distribution of Transverse 3-Test Average Charpy V Notch Impact Tests, A572 Grade 50 Plates, Lateral Expansion - Mils

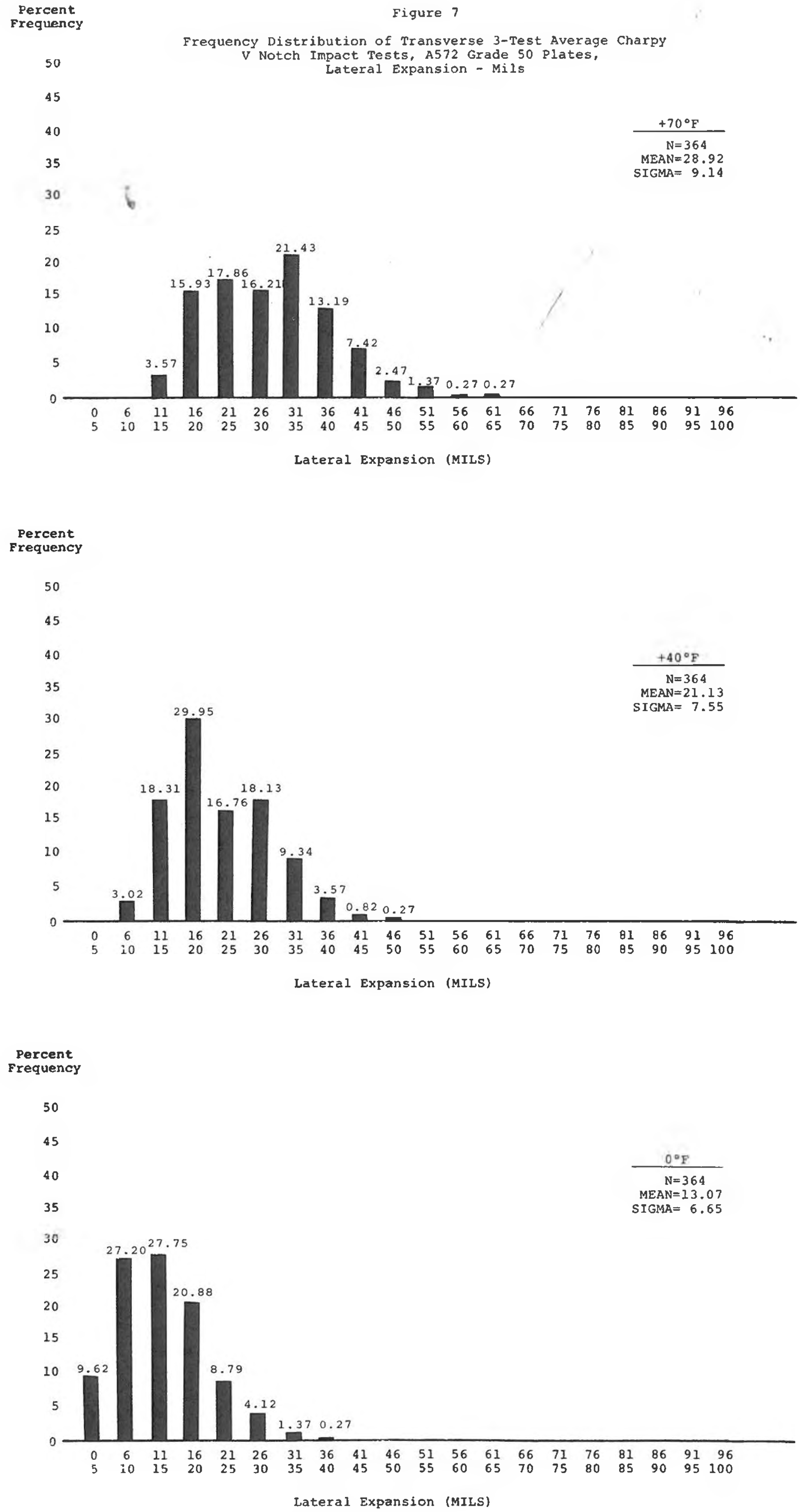
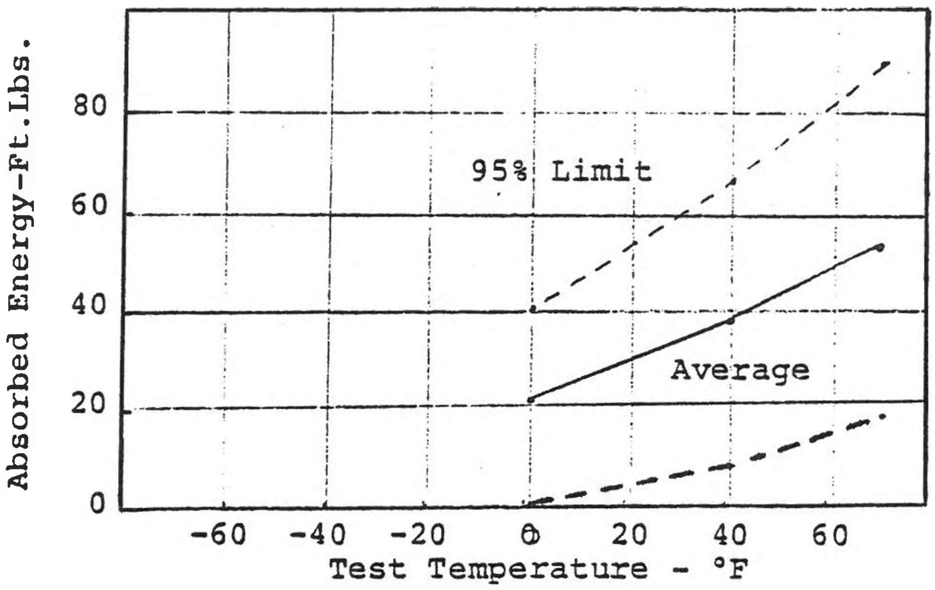


Figure 8. Absorbed Energy vs Test Temperature
A572 Grade 50 Plates

Longitudinal Charpy V Notch Impact Tests
3-Test Average



Transverse Charpy V Notch Impact Tests
3-Test Average

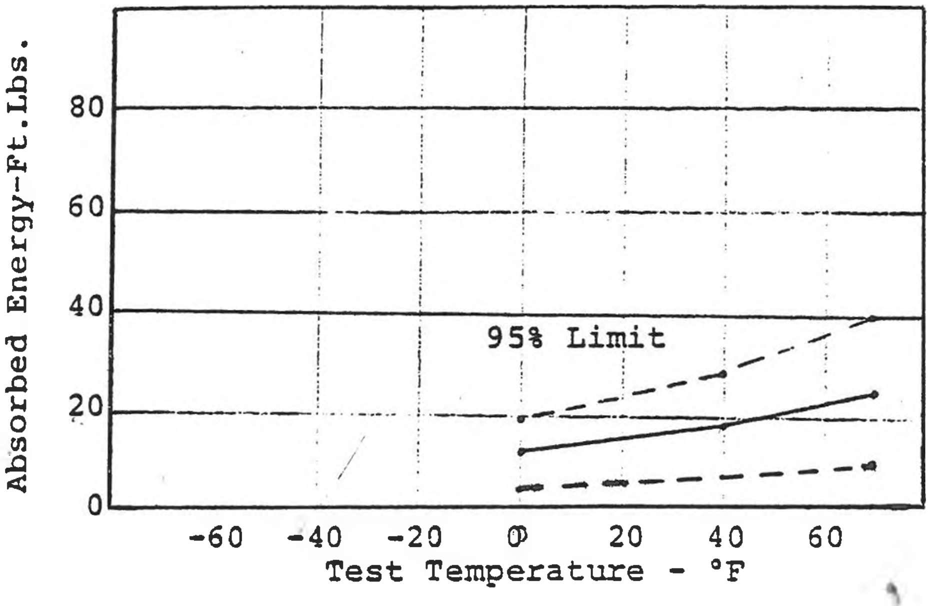
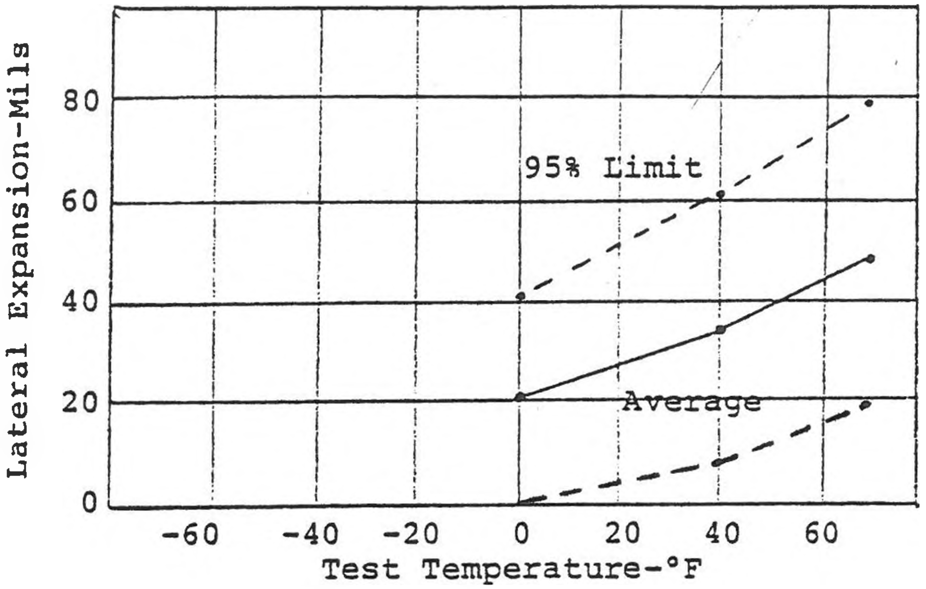


Figure 9. Lateral Expansion vs Test Temperature
A572 Grade 50 Plates


Longitudinal Charpy V Notch Impact Tests
3-Test Average

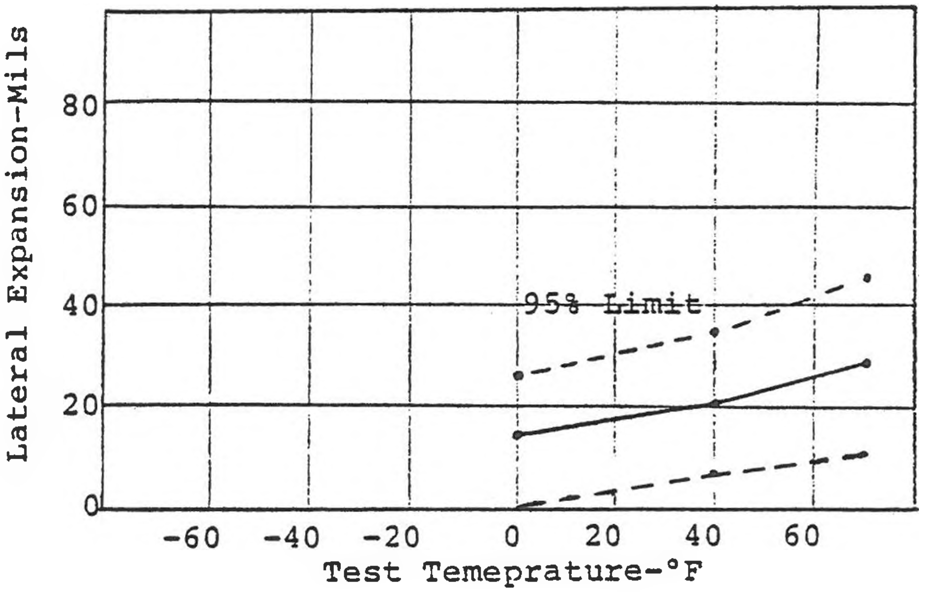

Transverse Charpy V Notch Impact Tests
3-Test Average

Figure 10

Frequency Distribution of the 3-Test Averages of the Reference Test,
Longitudinal Charpy V Notch Impact Test A572 Grade 50 Plates
Absorbed Energy - Ft.Lbs.

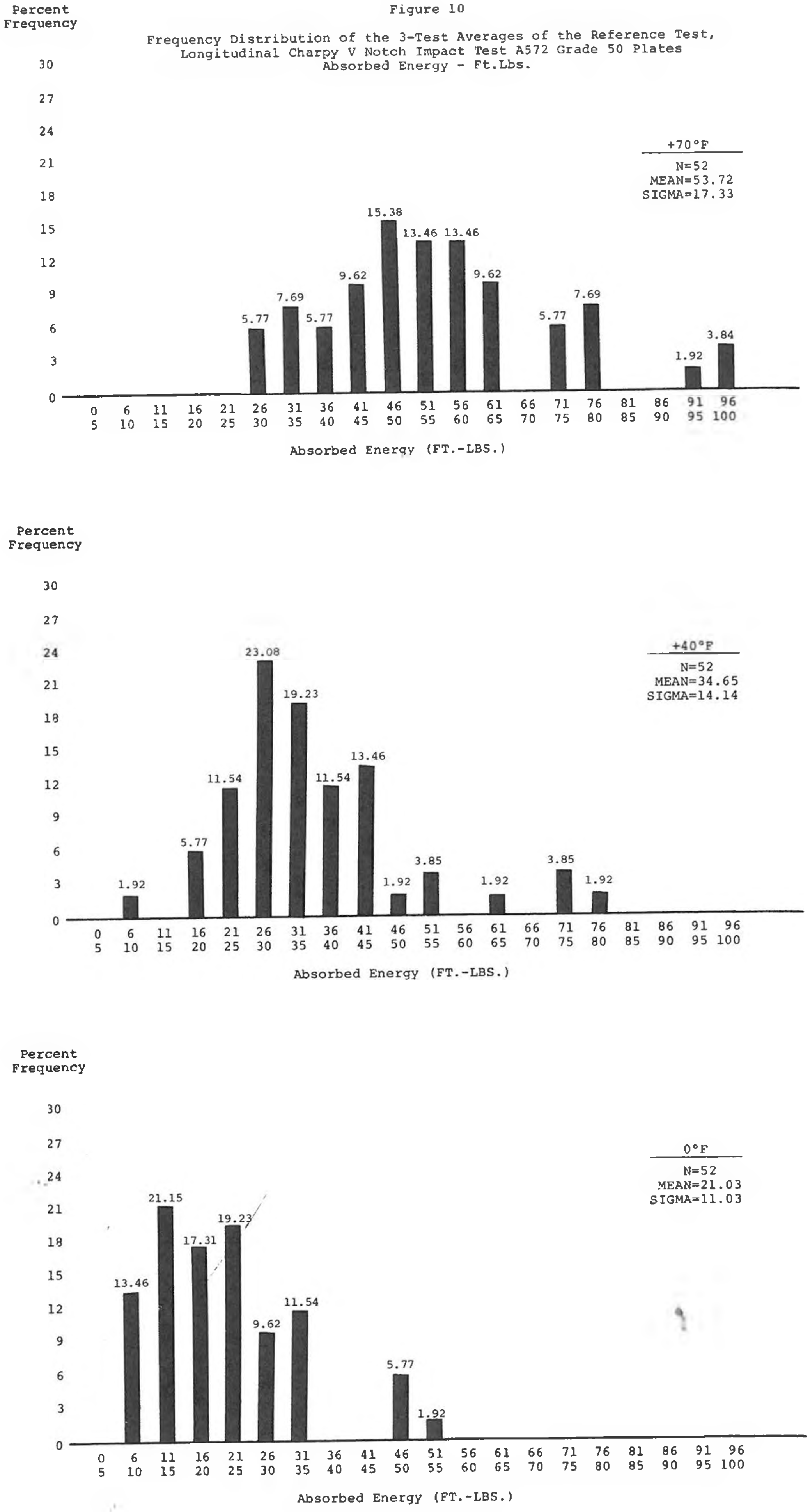


Figure 11

Frequency Distribution of the 3-Test Averages of the Reference Test,
Longitudinal Charpy V Notch Impact Test, A572 Grade 50 Plates
Lateral Expansion - Mils

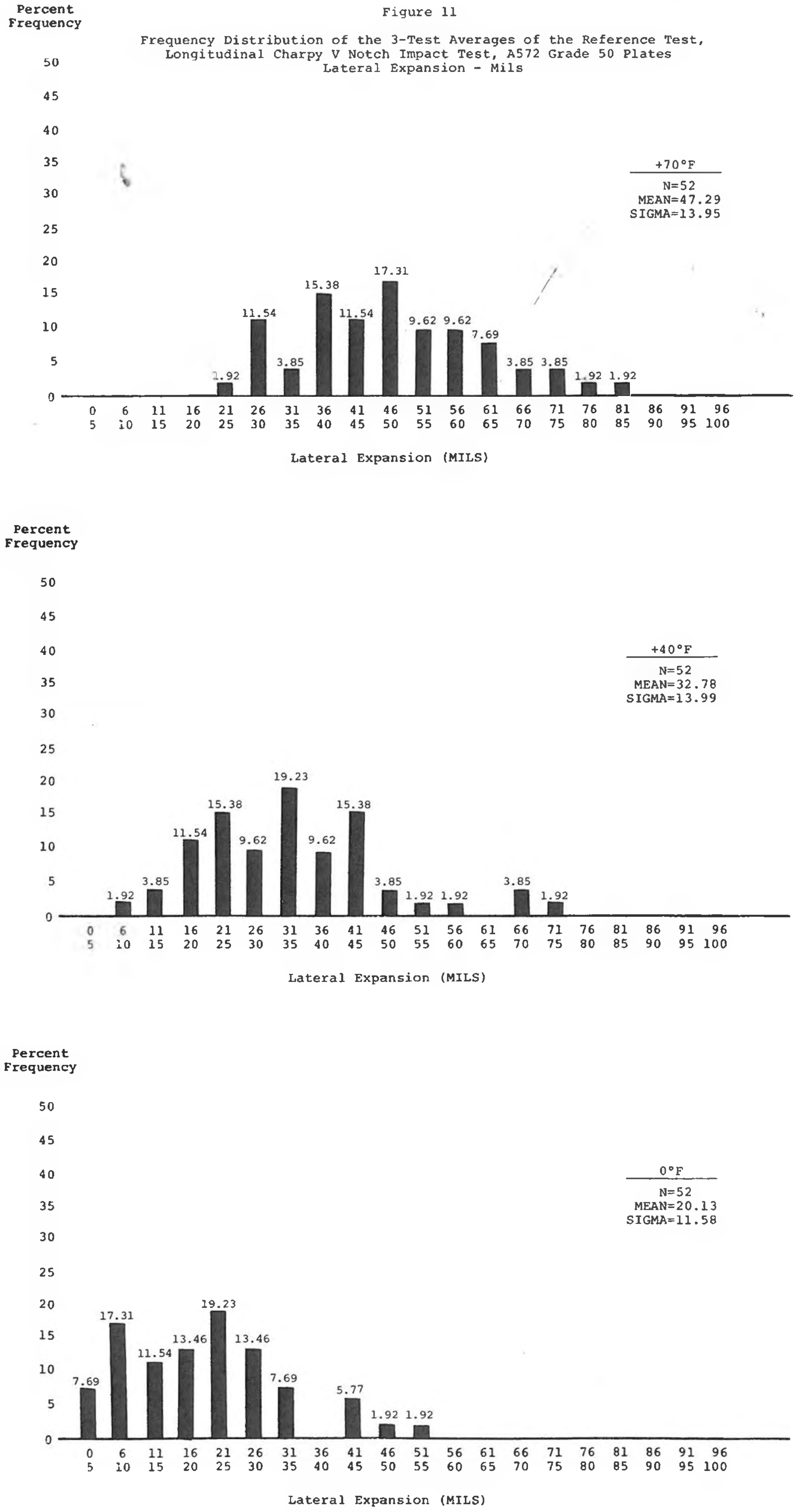


Figure 12

Frequency Distribution of the 3-Test Averages of the Reference Test, Transverse Charpy V Notch Impact Test A572 Grade 50 Plates Absorbed Energy - Ft.Lb.

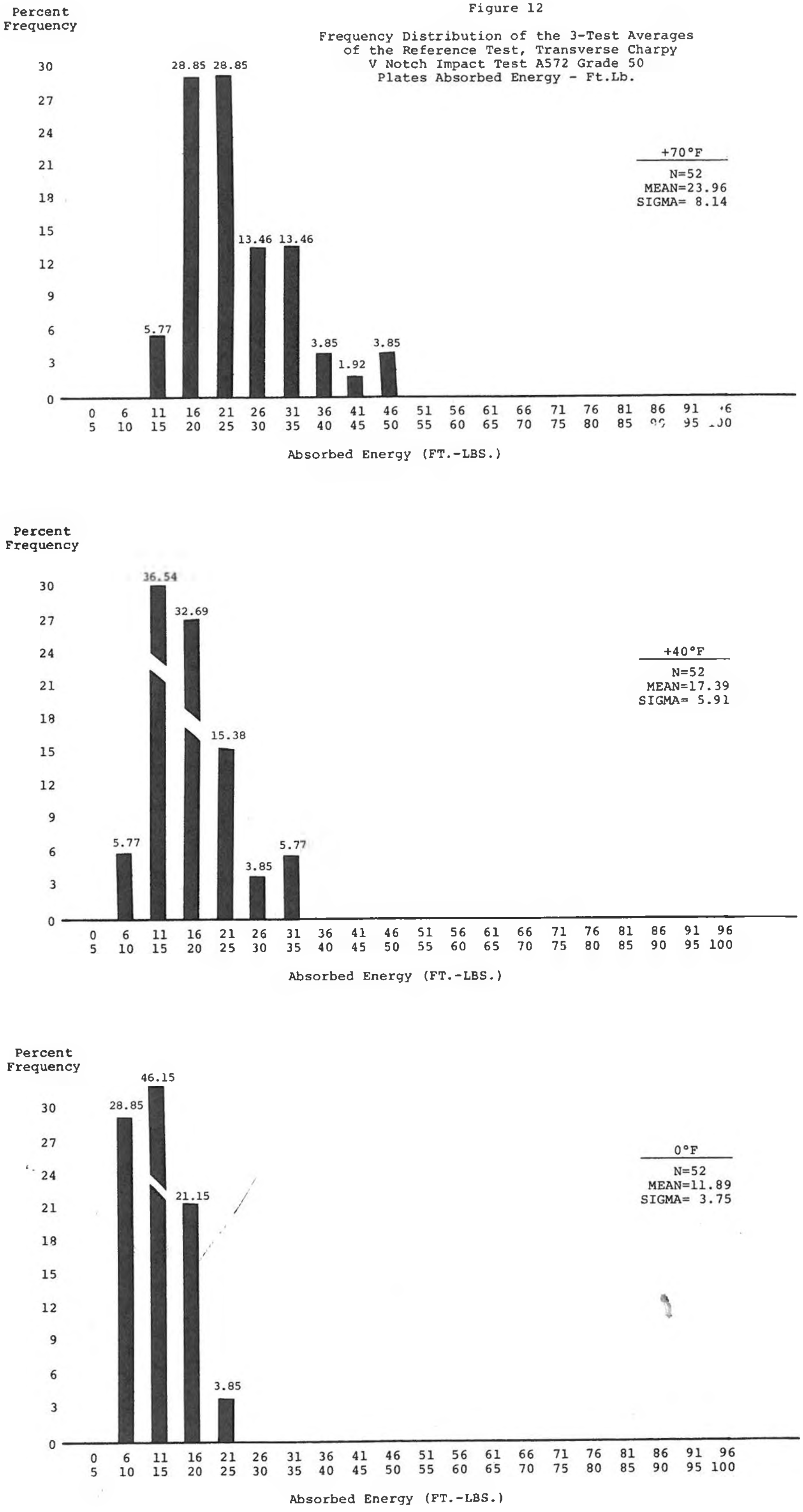


Figure 13

Frequency Distribution of the 3-Test Averages of the Reference Test, Transverse Charpy V Notch Impact Test, A572 Grade 50 Plates
Lateral Expansion - Mils

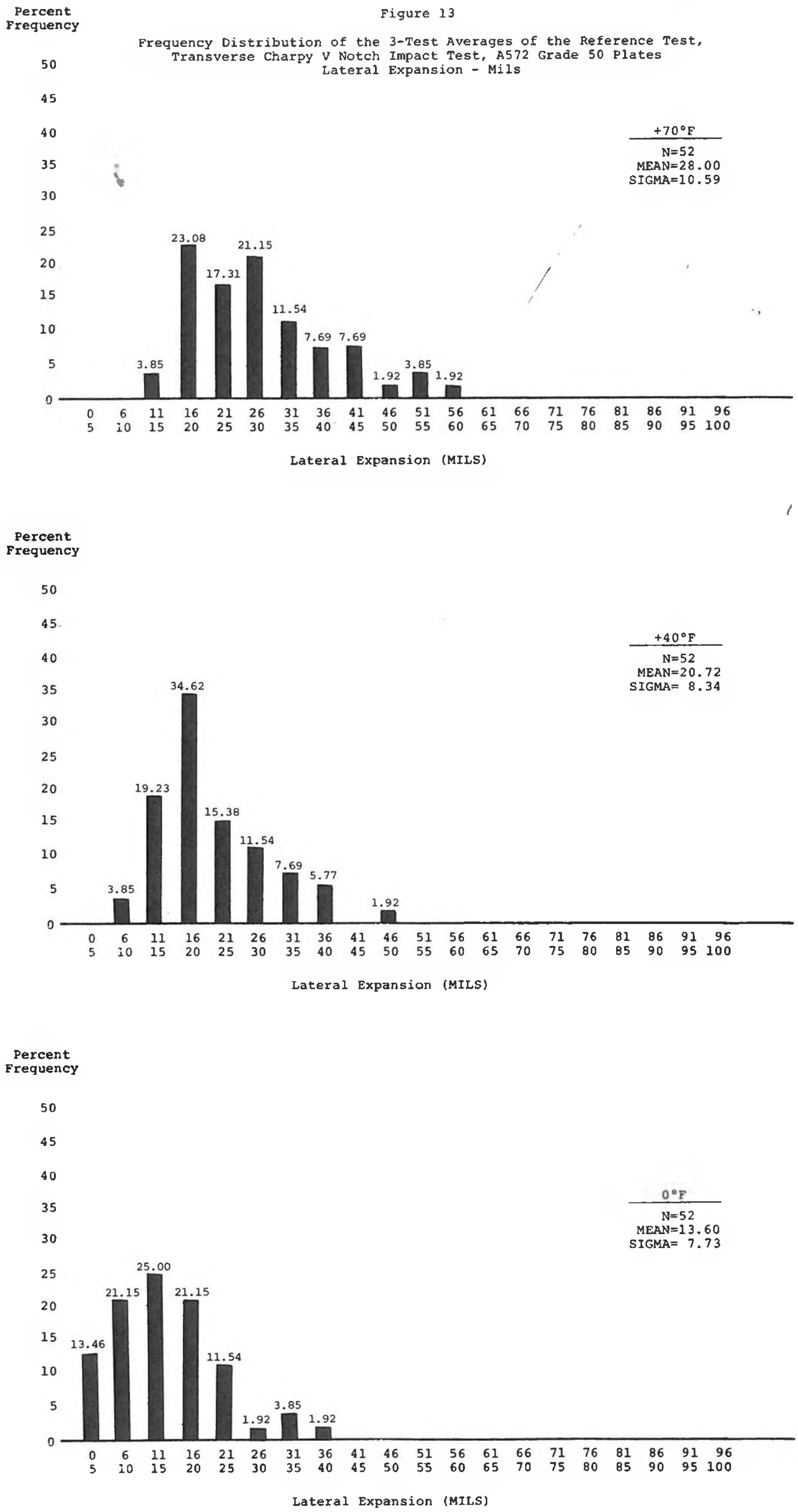
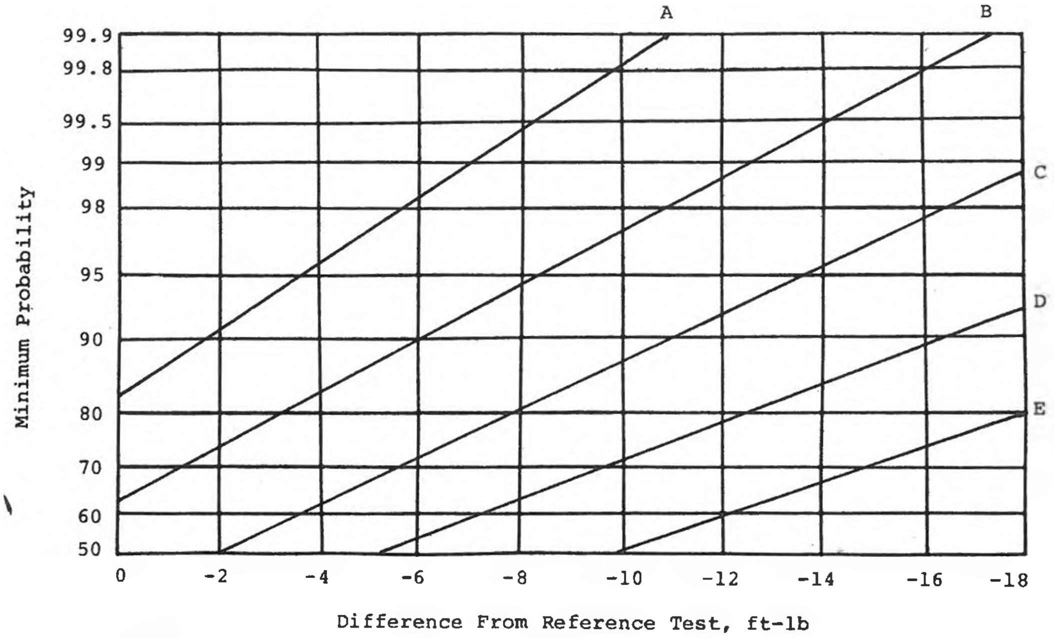


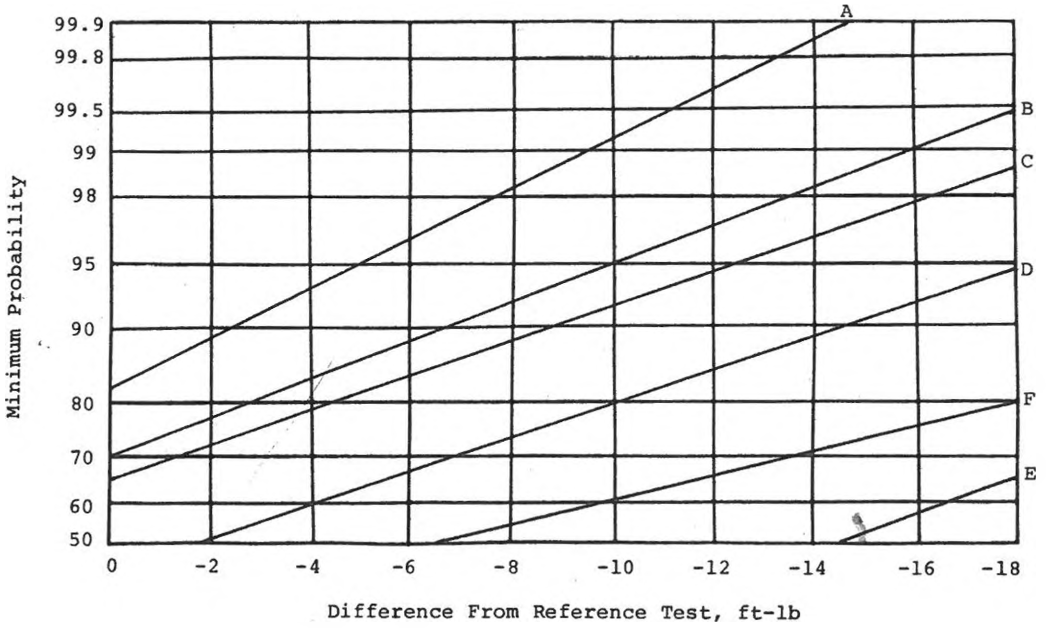
Figure 14, Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test - Ft. Lb.

A	0 - 9
B	10 - 19
C	20 - 29
D	30 - 39
E	40 - 49

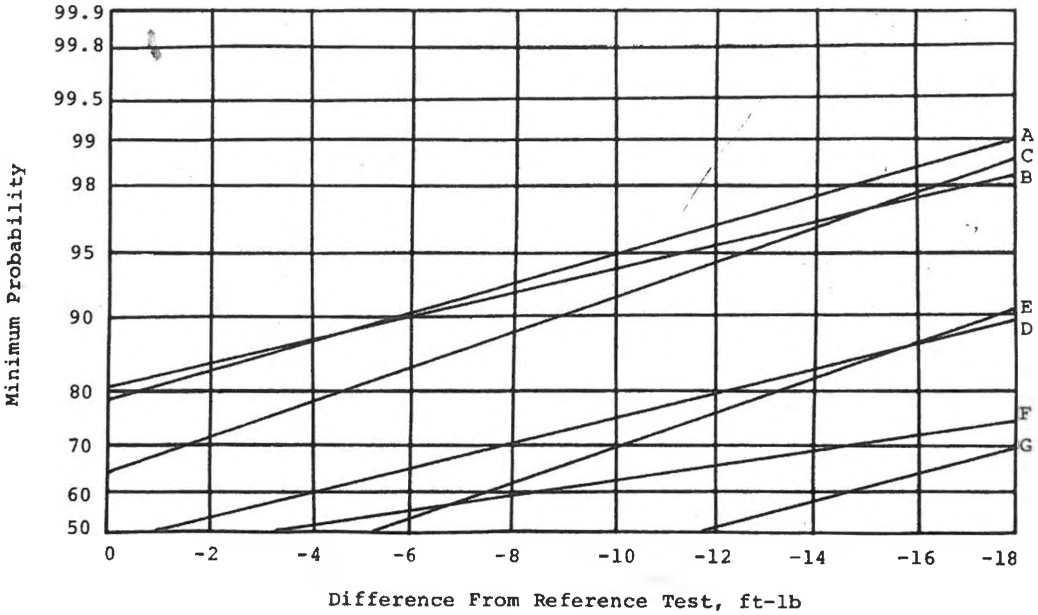
Figure 15. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from the Reference Test, A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at +40°F, 3-Test



Range of Reference Test - Ft. Lb.

A	0 - 19
B	20 - 29
C	30 - 39
D	40 - 49
E	50 - 59
F	60 - 79

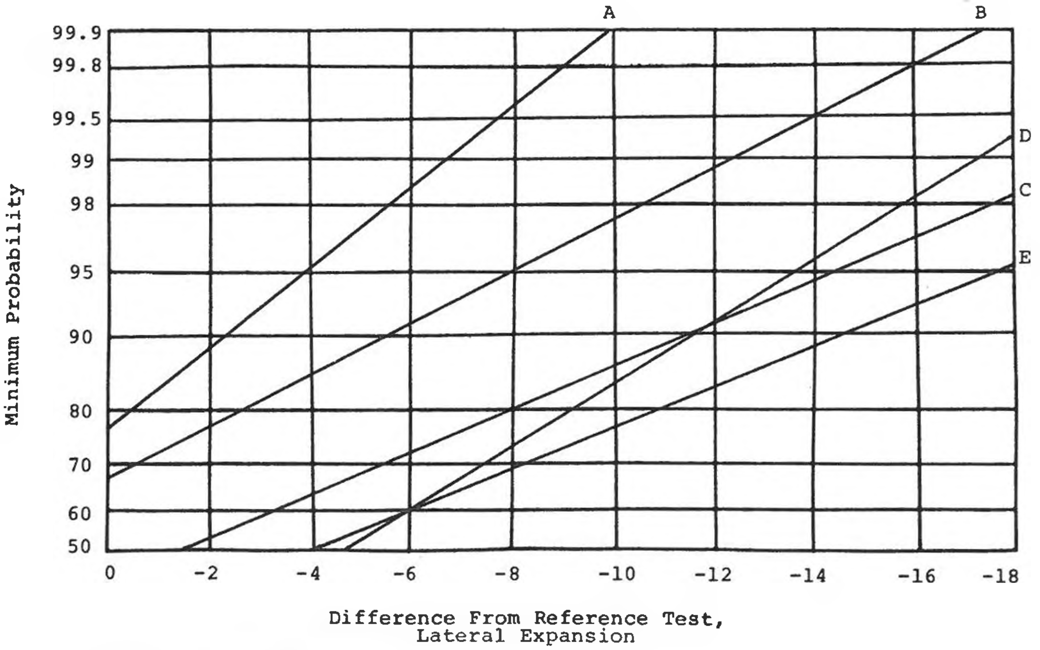
Figure 16. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at +70°F, 3-Test Average



Range of Reference Test - Ft. Lbs.

A 20 - 29
B 30 - 39
C 40 - 49
D 50 - 59
E 60 - 69
F 70 - 79
G 80 - 89

Figure 17. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average



Range of Reference Test

A 0 - 9
B 10 - 19
C 20 - 29
D 30 - 39
E 40 - 59

Figure 18. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at +40°F, 3-Test Average

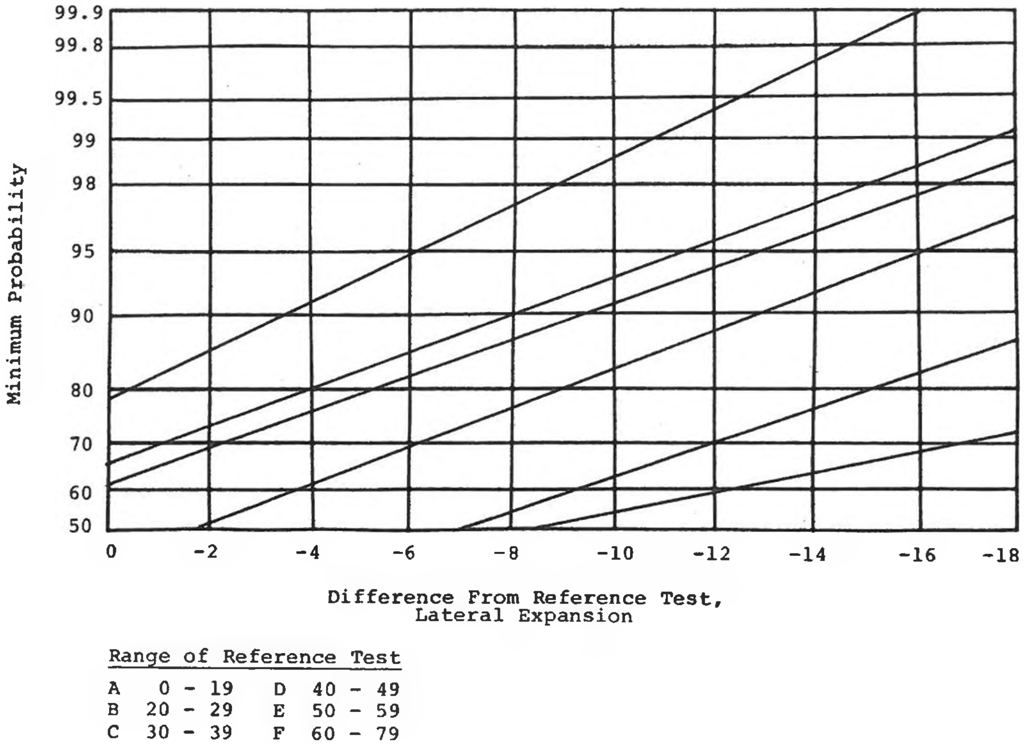


Figure 19. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at 70°F, 3-Test Average

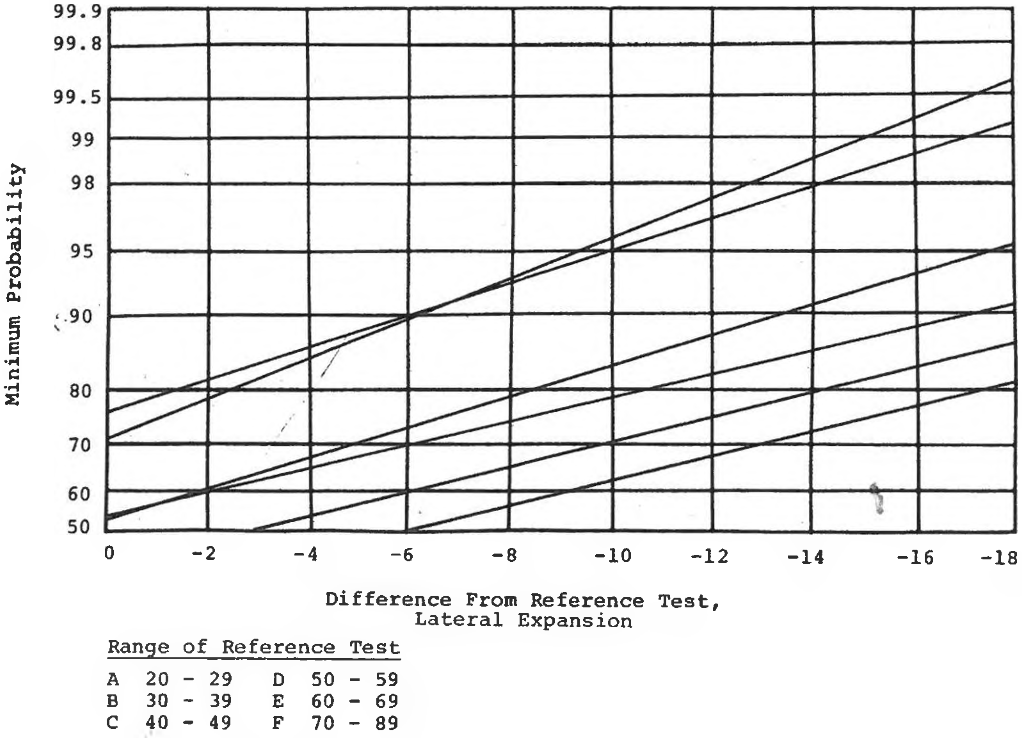
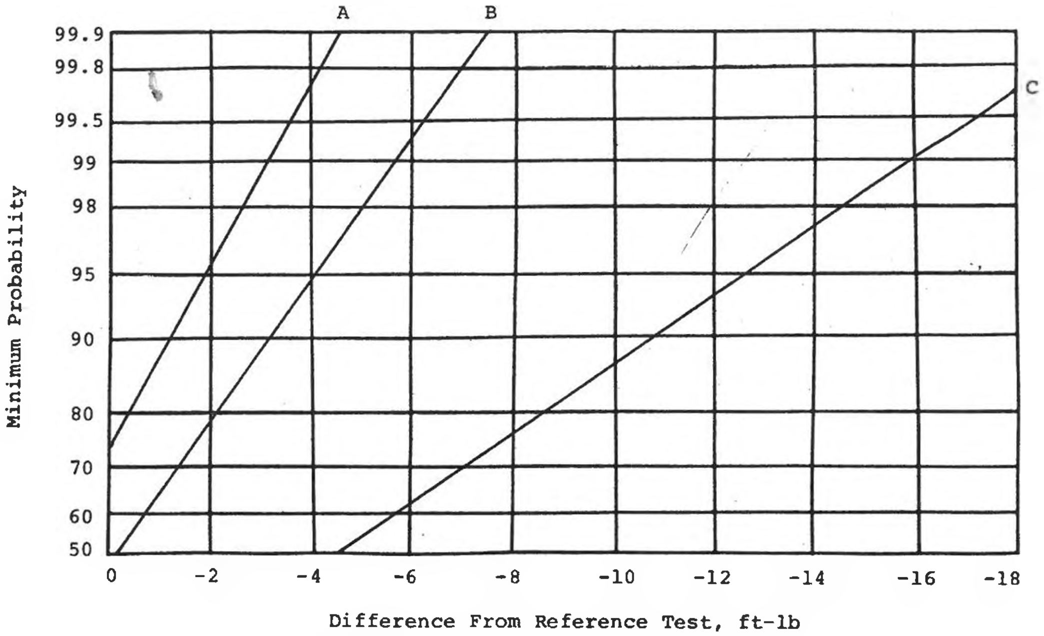


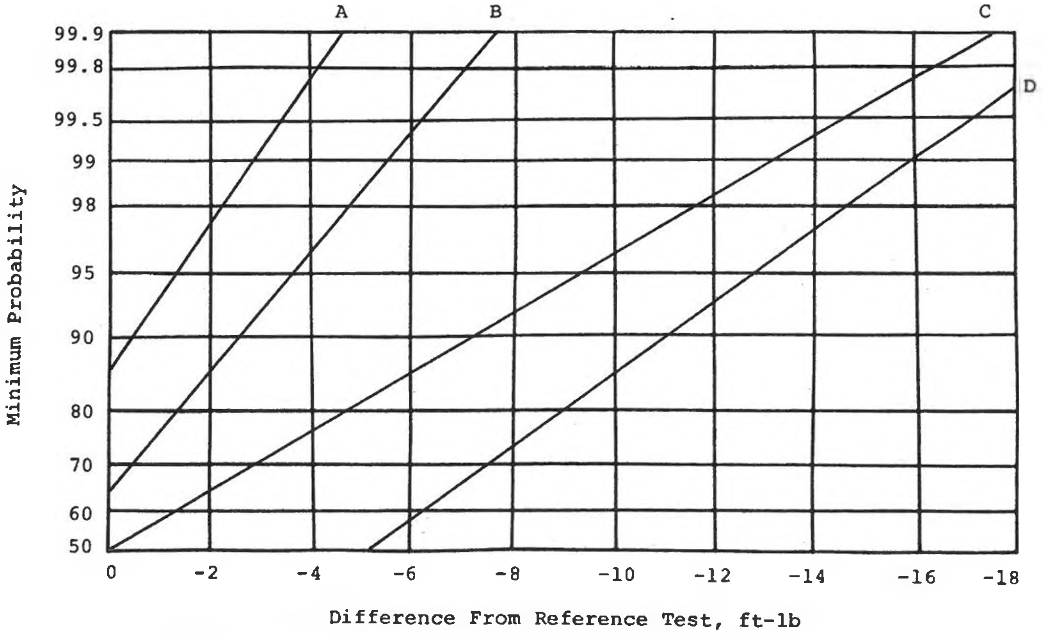
Figure 20. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test

A 0 - 9
B 10 - 19
C 20 - 29

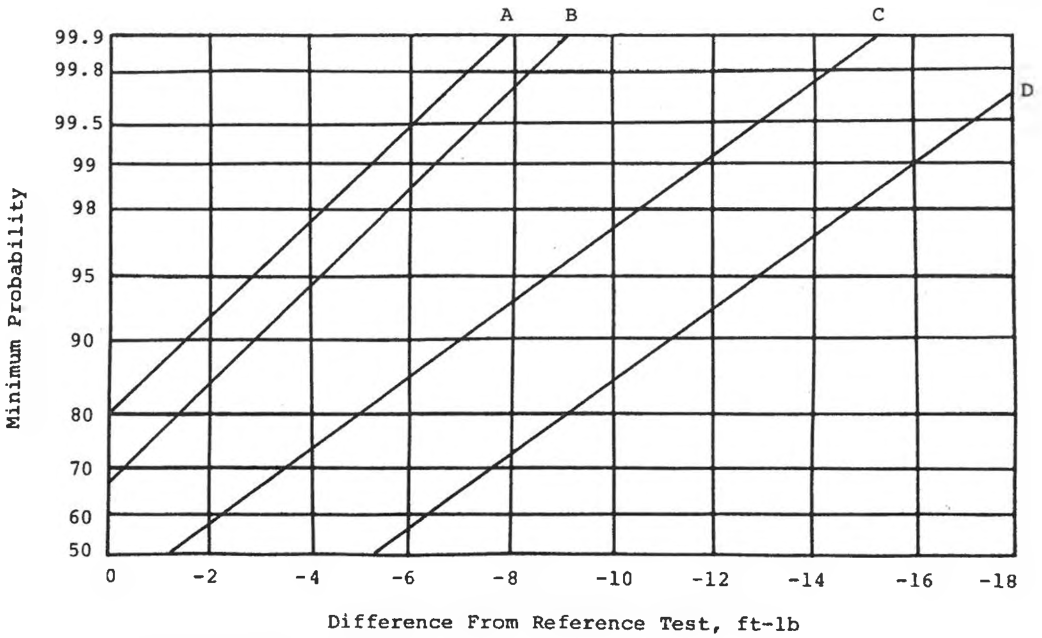
Figure 21. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at +40°F, 3-Test Average



Range of Reference Test

A 0 - 9
B 10 - 19
C 20 - 29
D 30 - 39

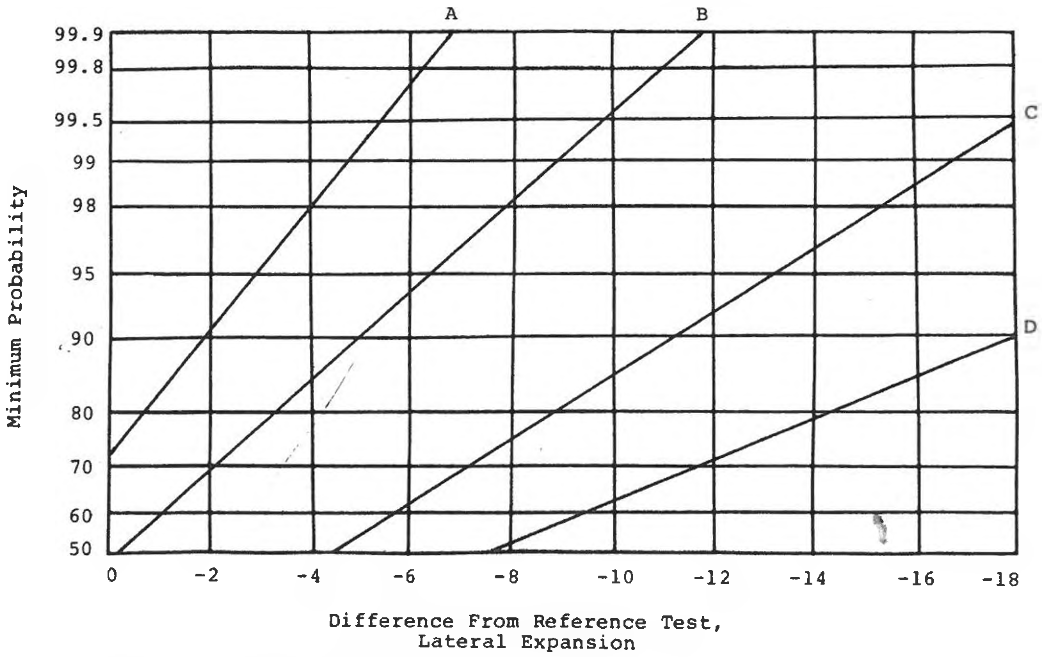
Figure 22. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at +70°F, 3-Test Average



Range of Reference Test

A 10 - 19
B 20 - 29
C 30 - 39
D 40 - 49

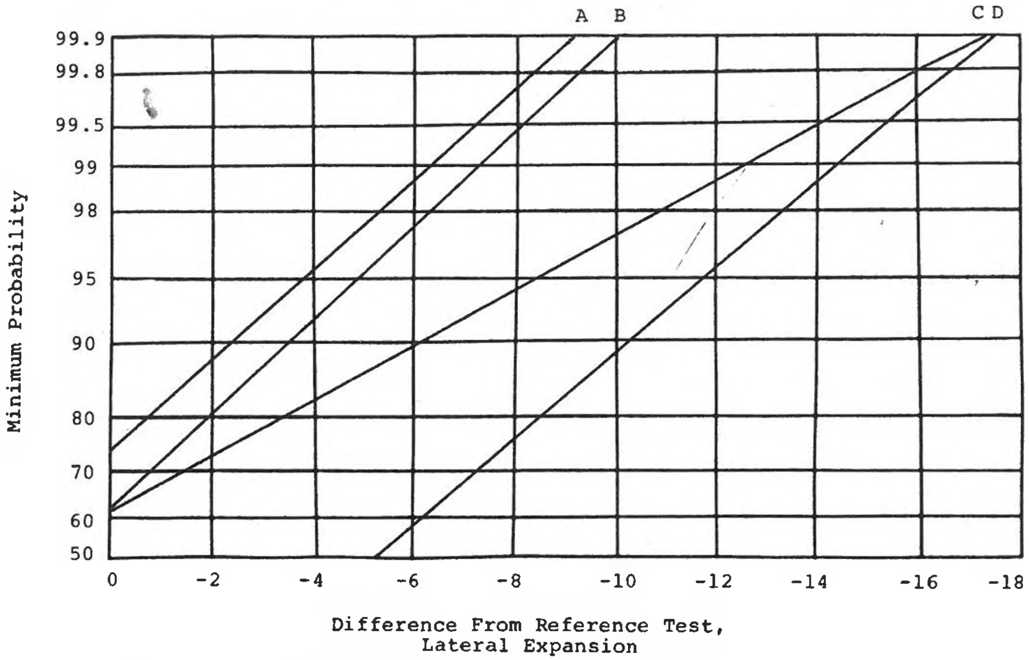
Figure 23. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average



Range of Reference Test

A 0 - 9
B 10 - 19
C 20 - 29
D 30 - 39

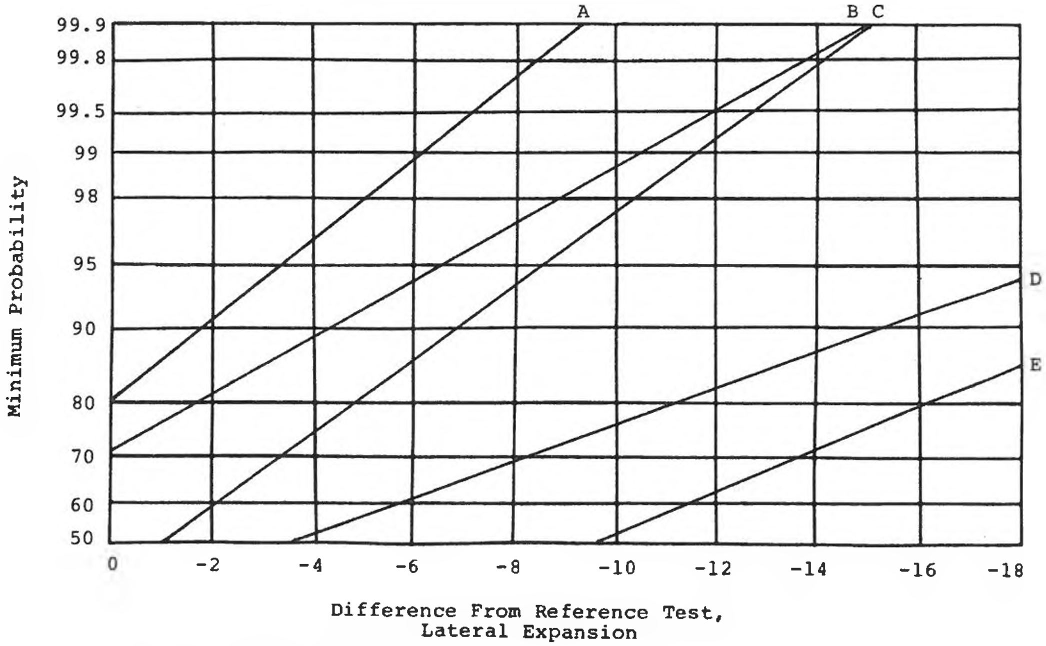
Figure 24. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at 40°F, 3-Test Average



Range of Reference Test

A 0 - 9
B 10 - 19
C 20 - 29
D 30 - 39

Figure 25. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A572 Grade 50 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at 70°F, 3-Test Average



Range of Reference Test

A 10 - 19
B 20 - 29
C 30 - 39
D 40 - 49
E 50 - 59

Figure 26

Frequency Distribution of the 3-Test Averages of the Reference Test, Longitudinal Charpy V Notch Impact Test, A516 Grade 70 Plates, Absorbed Energy - Ft.Lb.

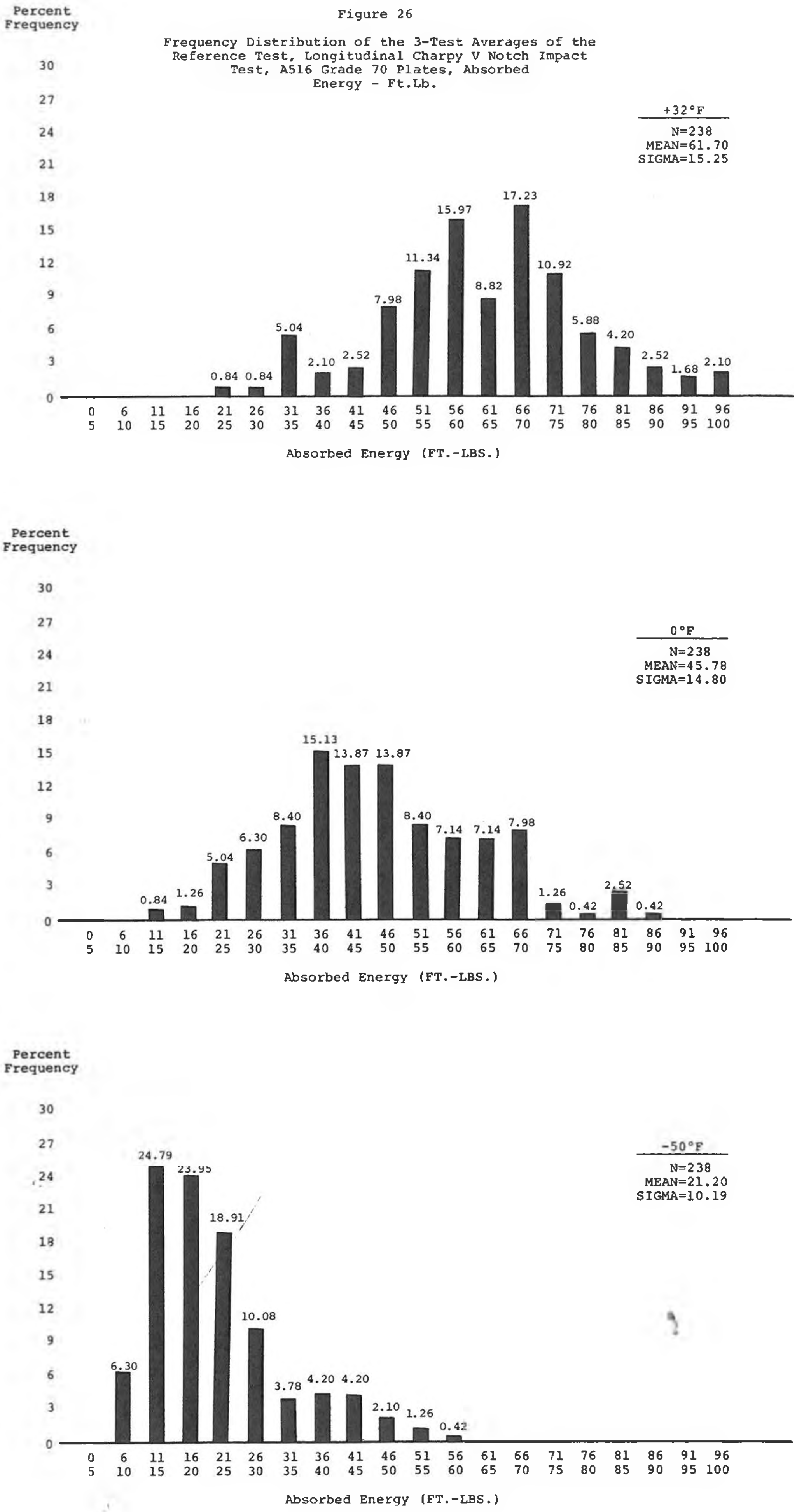


Figure 27

Frequency Distribution of Longitudinal 3-Test Average Charpy
V Notch Impact Tests, A516 Grade 70 Plates,
Lateral Expansion - Mils

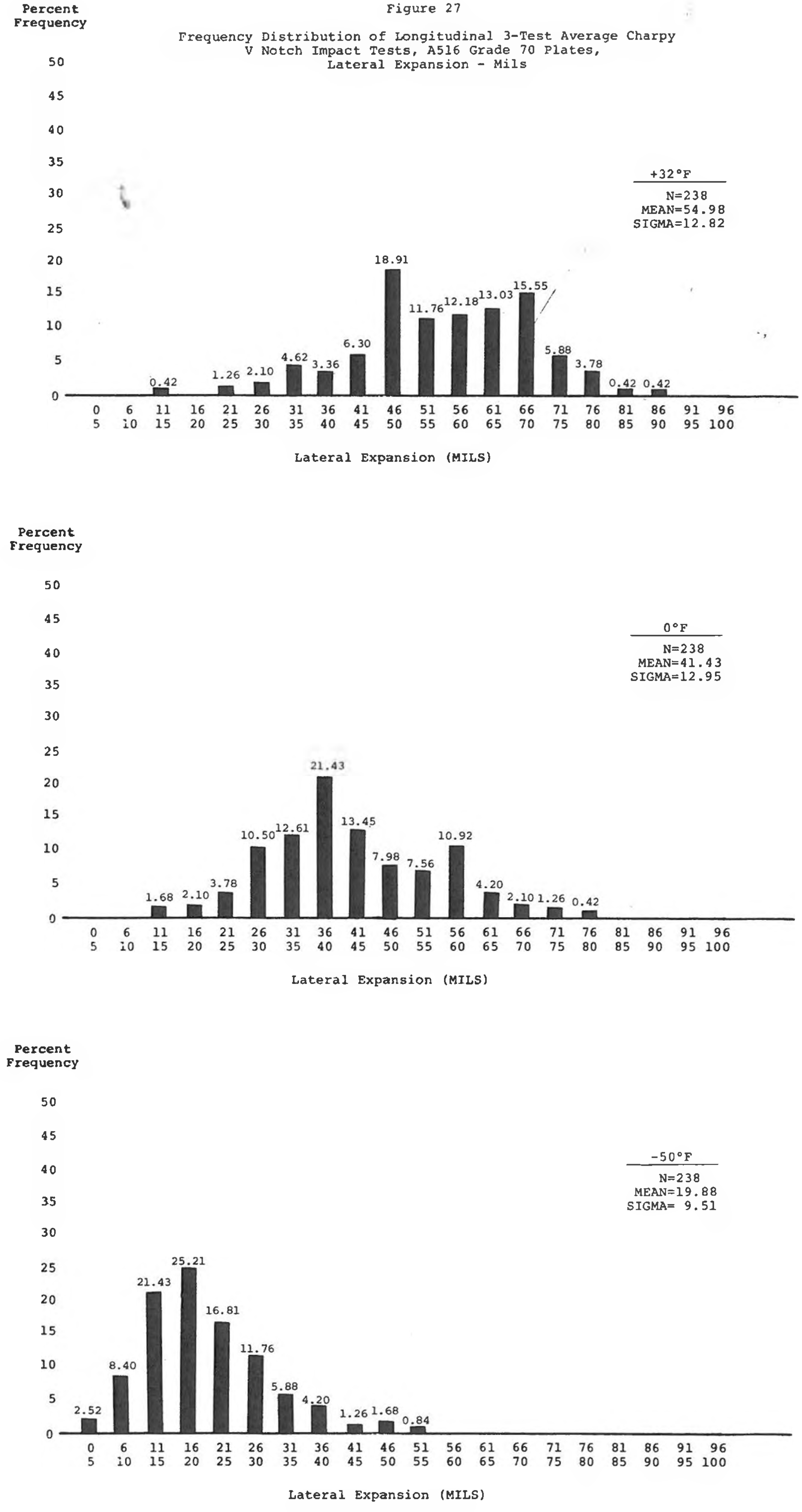


Figure 28

Frequency Distribution of Transverse 3-Test Average Charpy V Notch Impact Tests, A516 Grade 70 Plates, Absorbed Energy - Ft.Lb.

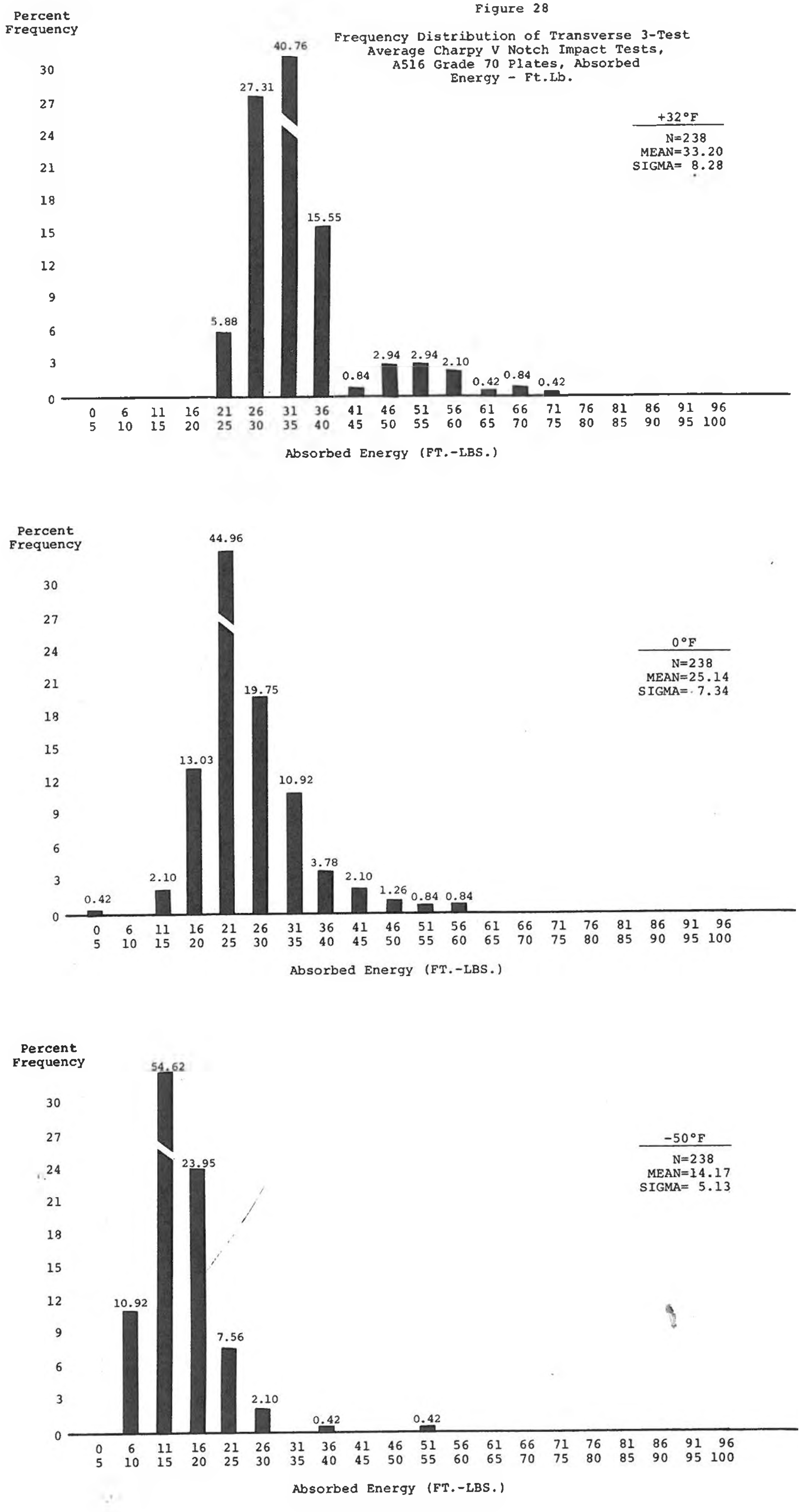


Figure 29

Frequency Distribution of Transverse 3-Test Average Charpy V Notch
Impact Tests, A516 Grade 70 Plates,
Lateral Expansion - Mils

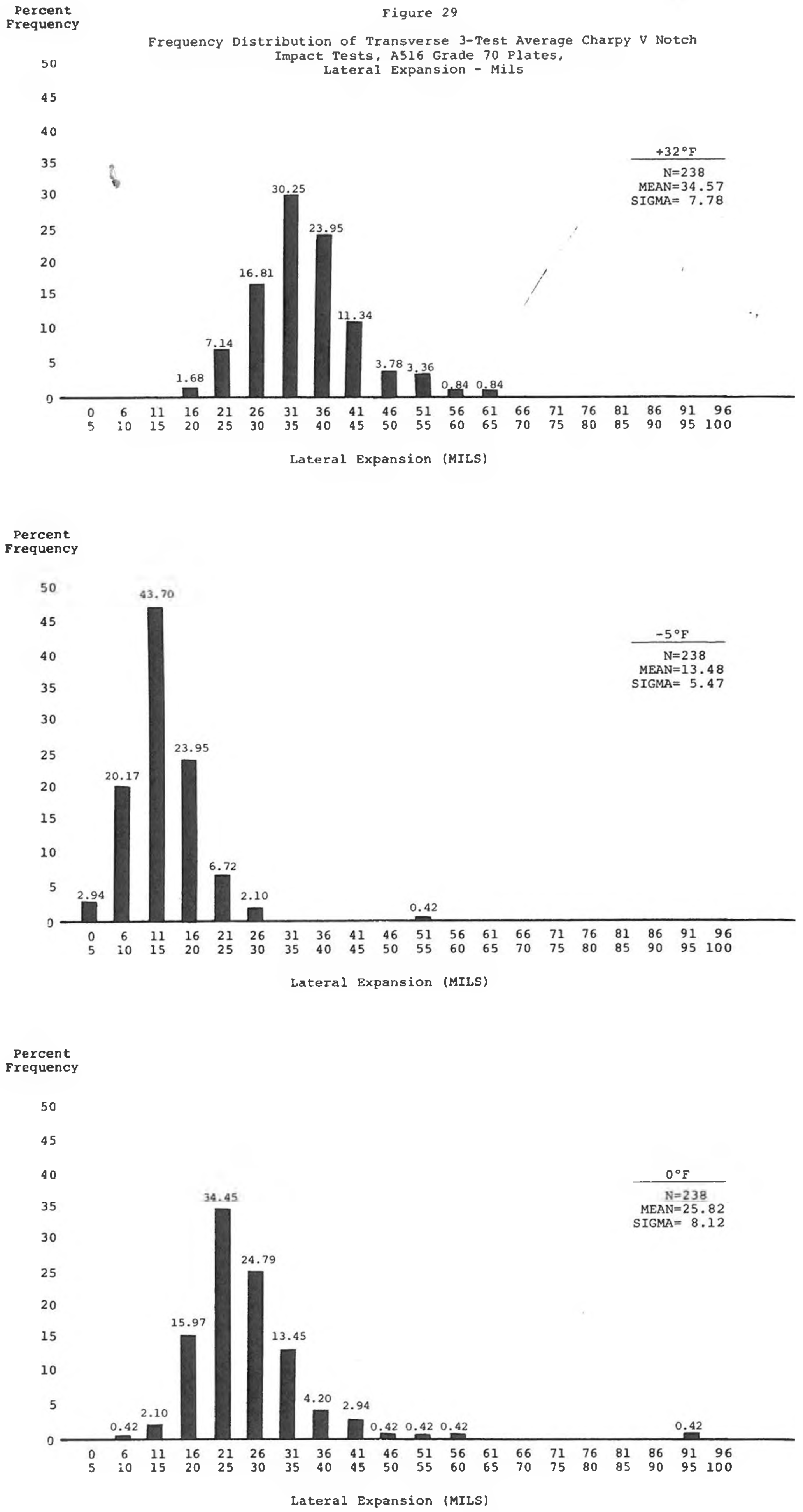
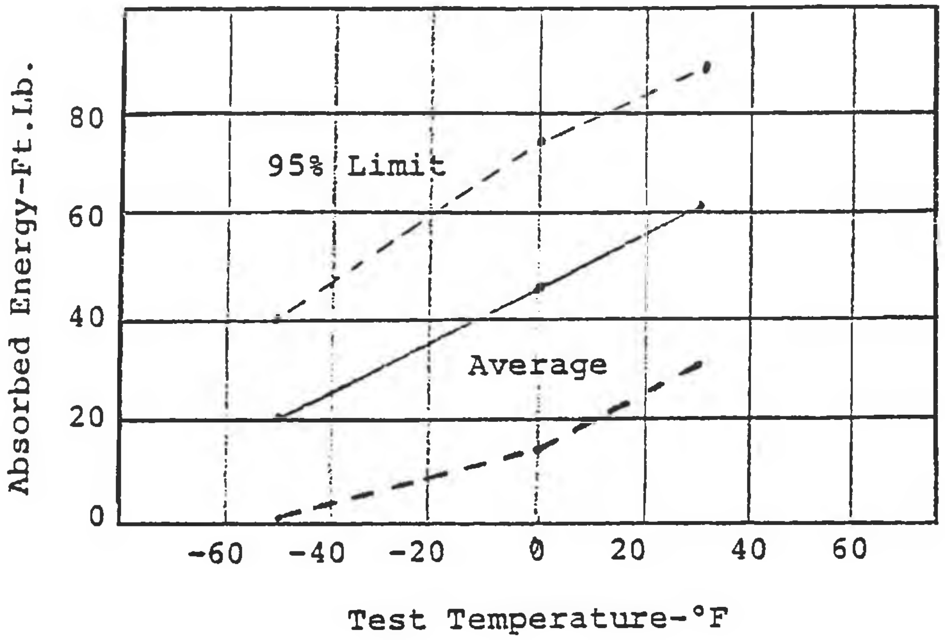


Figure 30. Absorbed Energy vs Test Temperature, A516 Grade 70 Plates

Longitudinal Charpy V Notch Impact Tests
3-Test Average



Transverse Charpy V Notch Impact Tests
3-Test Average

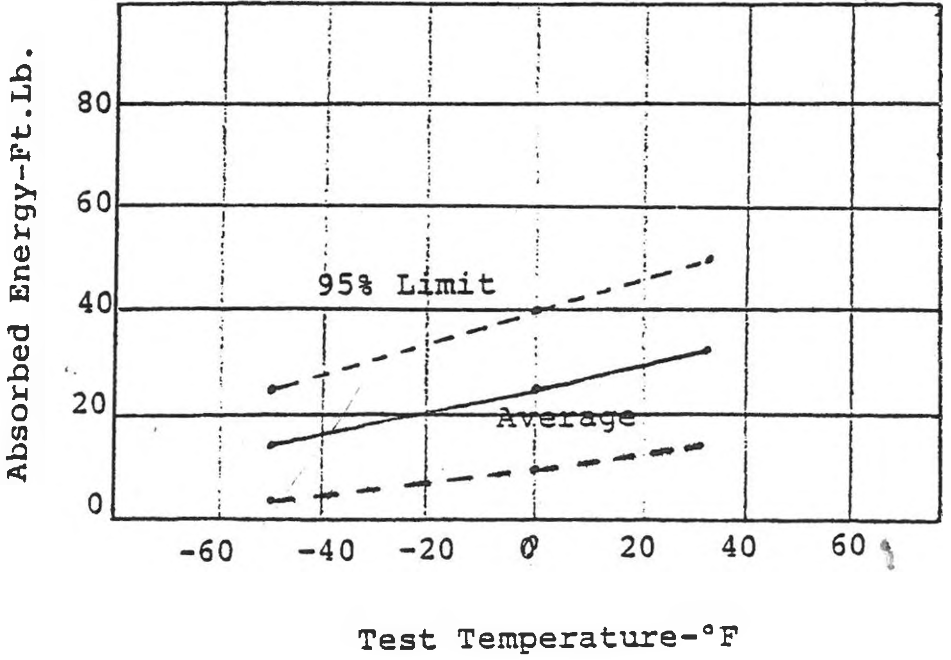
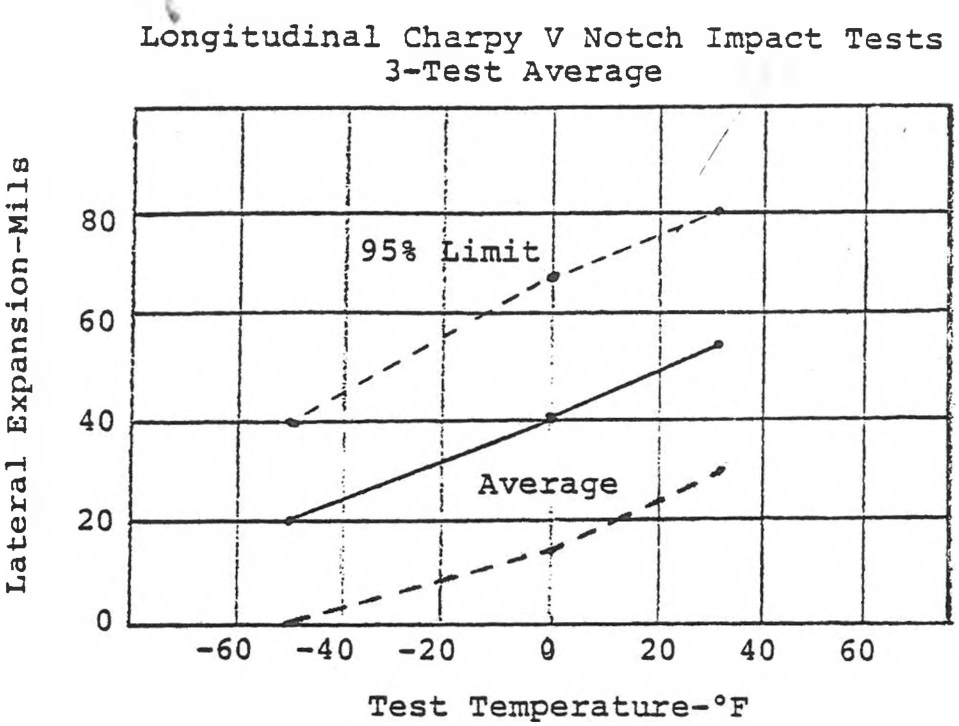


Figure 31. Lateral Expansion vs Test Temperature, A516 Grade 70 Plates



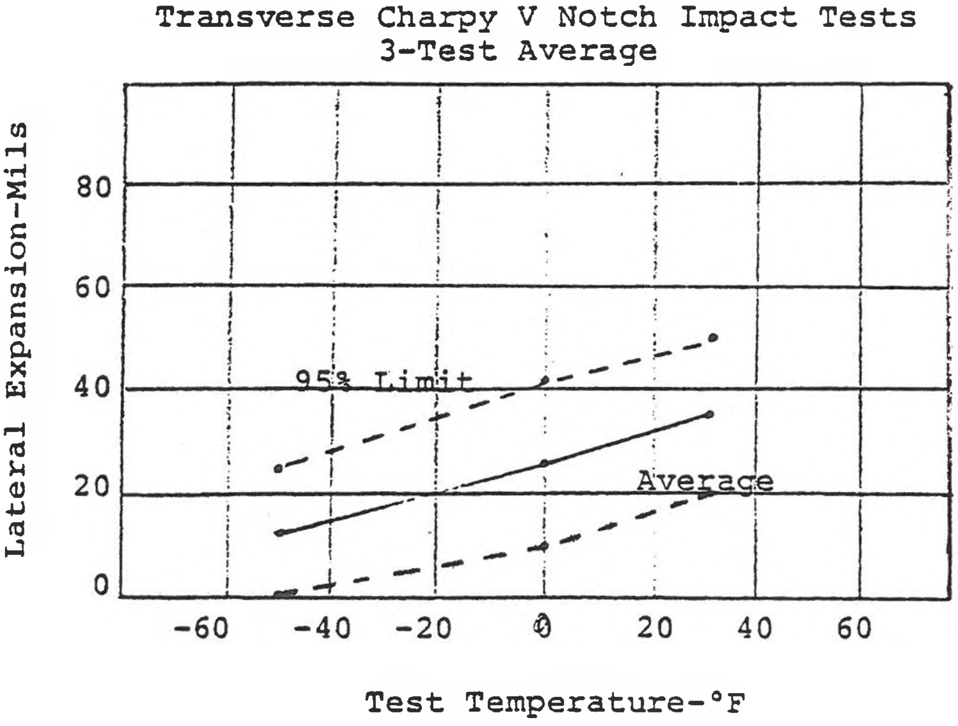


Figure 32

Frequency Distribution of the 3-Test Averages of the Reference Tests, Longitudinal Charpy V Notch Impact Test, A516 Grade 70 Plates Lateral Expansion - Mils

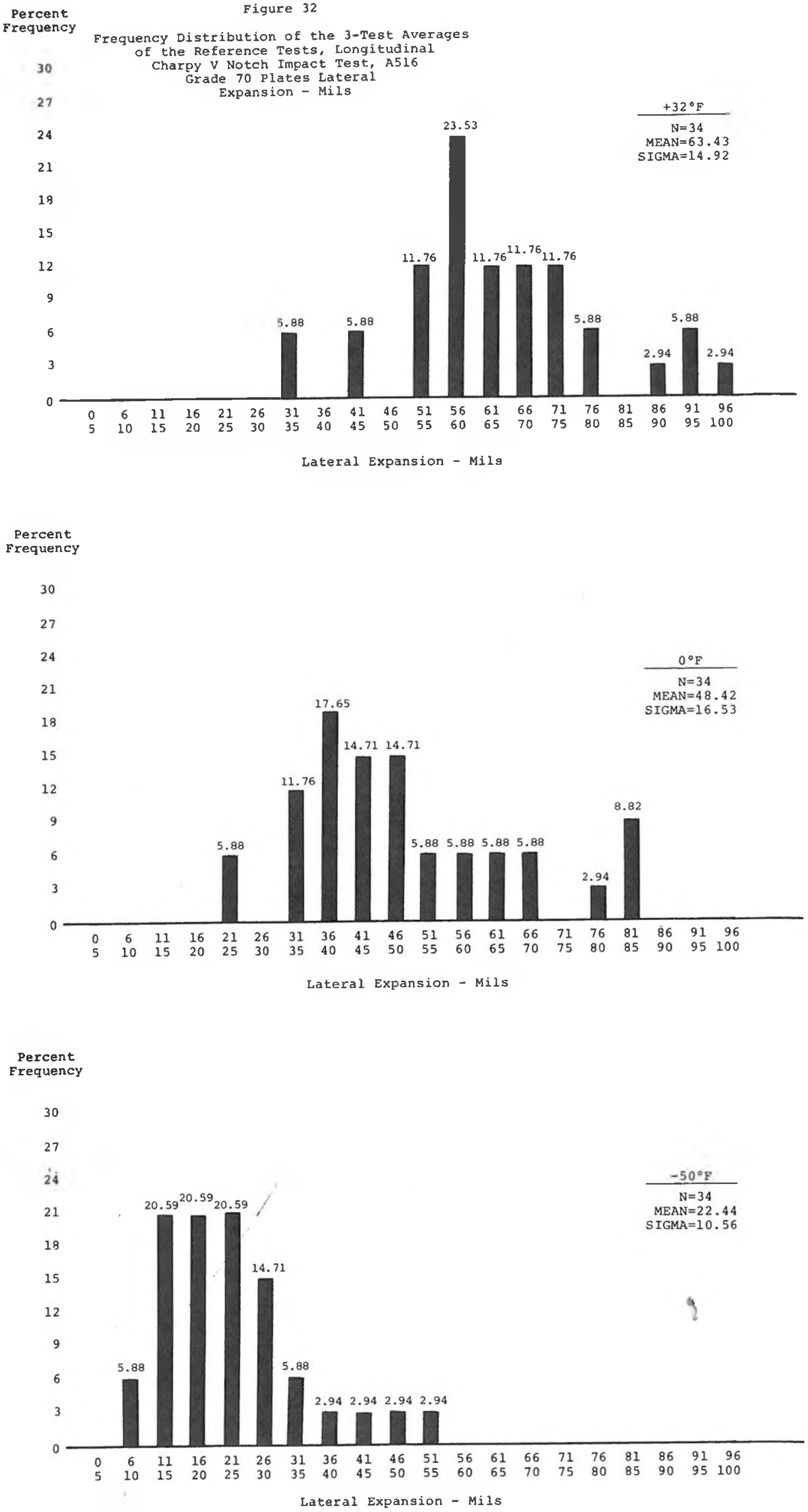
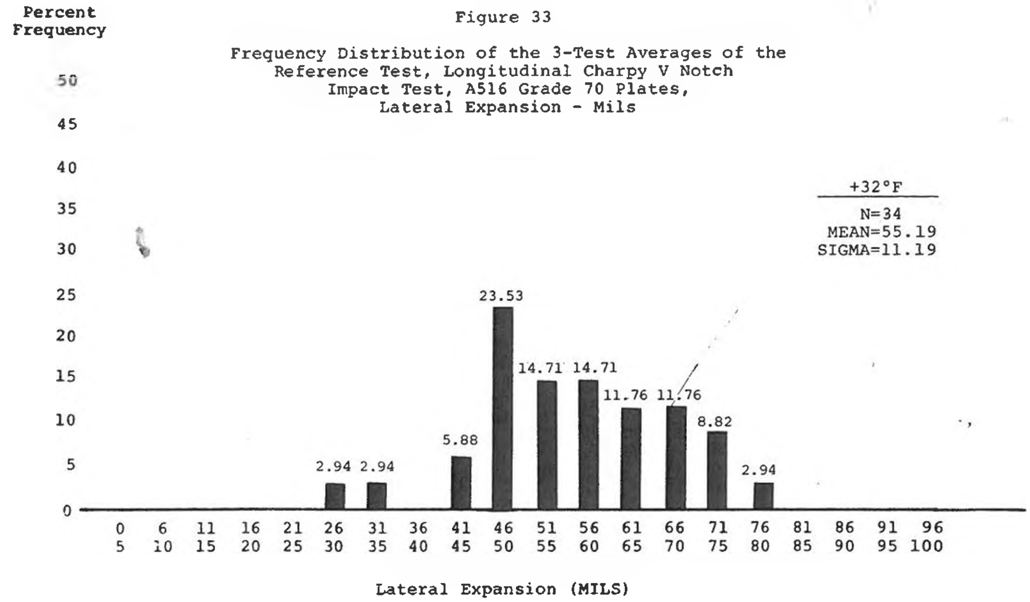
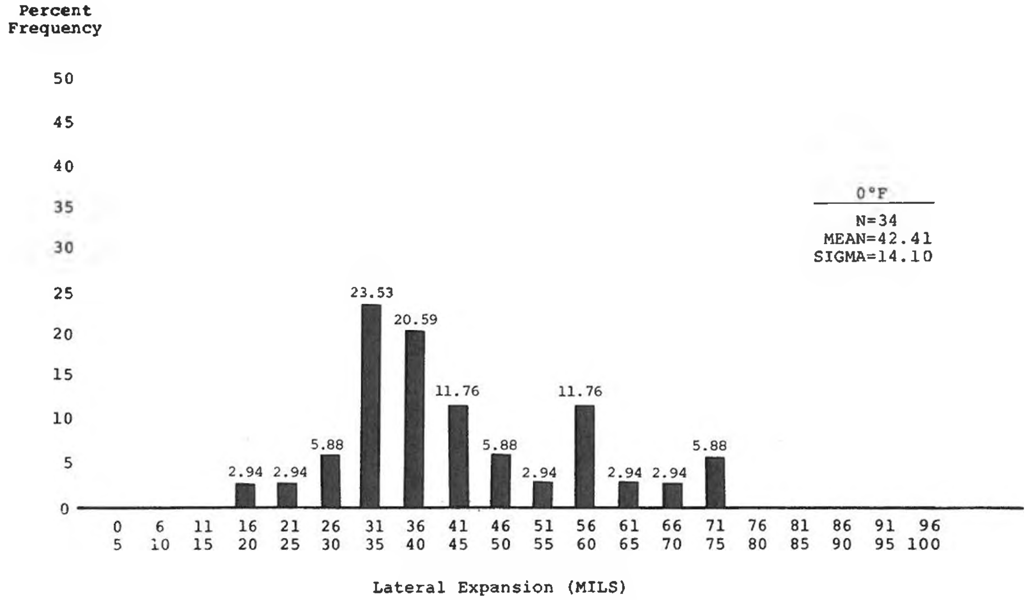


Figure 33

Frequency Distribution of the 3-Test Averages of the Reference Test, Longitudinal Charpy V Notch Impact Test, A516 Grade 70 Plates, Lateral Expansion - Mils





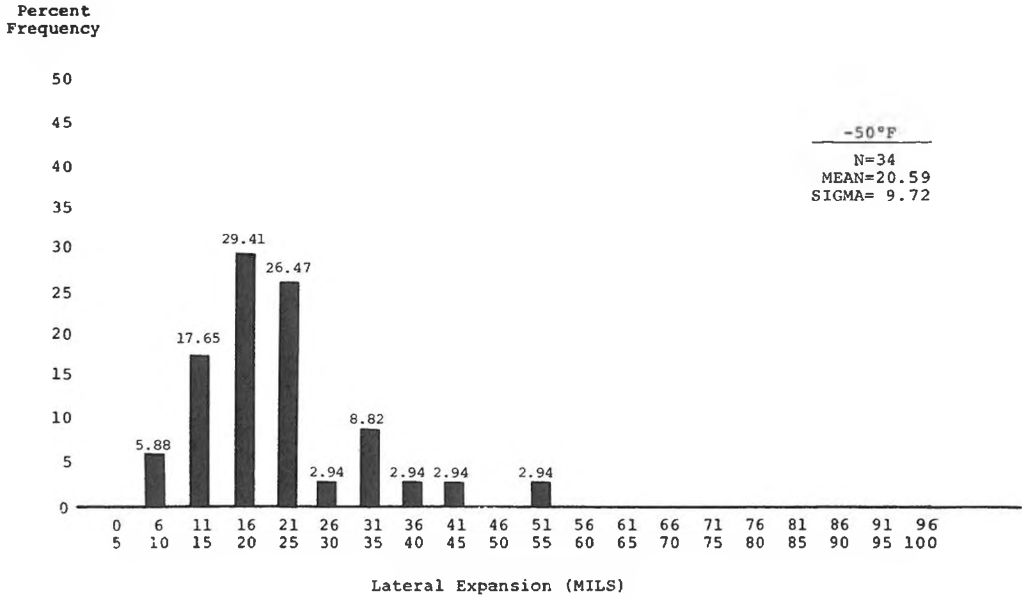


Figure 34

Frequency Distribution of the 3-Test Averages of the Reference Test, Transverse Charpy V Notch Impact Test, A516 Grade 70 Plates, Absorbed Energy - Ft.Lb.

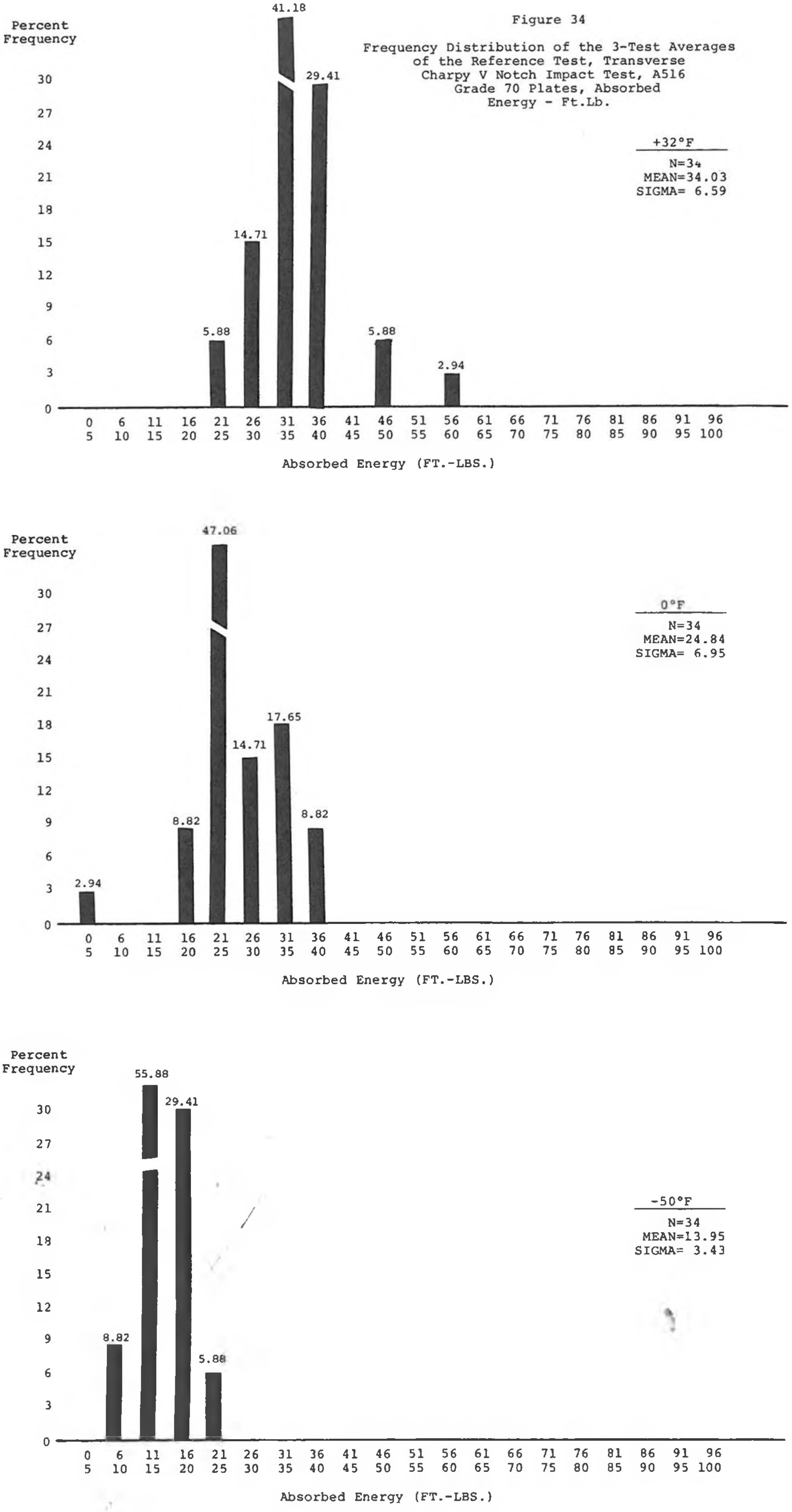


Figure 35

Frequency Distribution of the 3-Test Averages of the Reference Tests, Transverse Charpy V Notch Impact Test, A516 Grade 70 Plates, Lateral Expansion - Mils

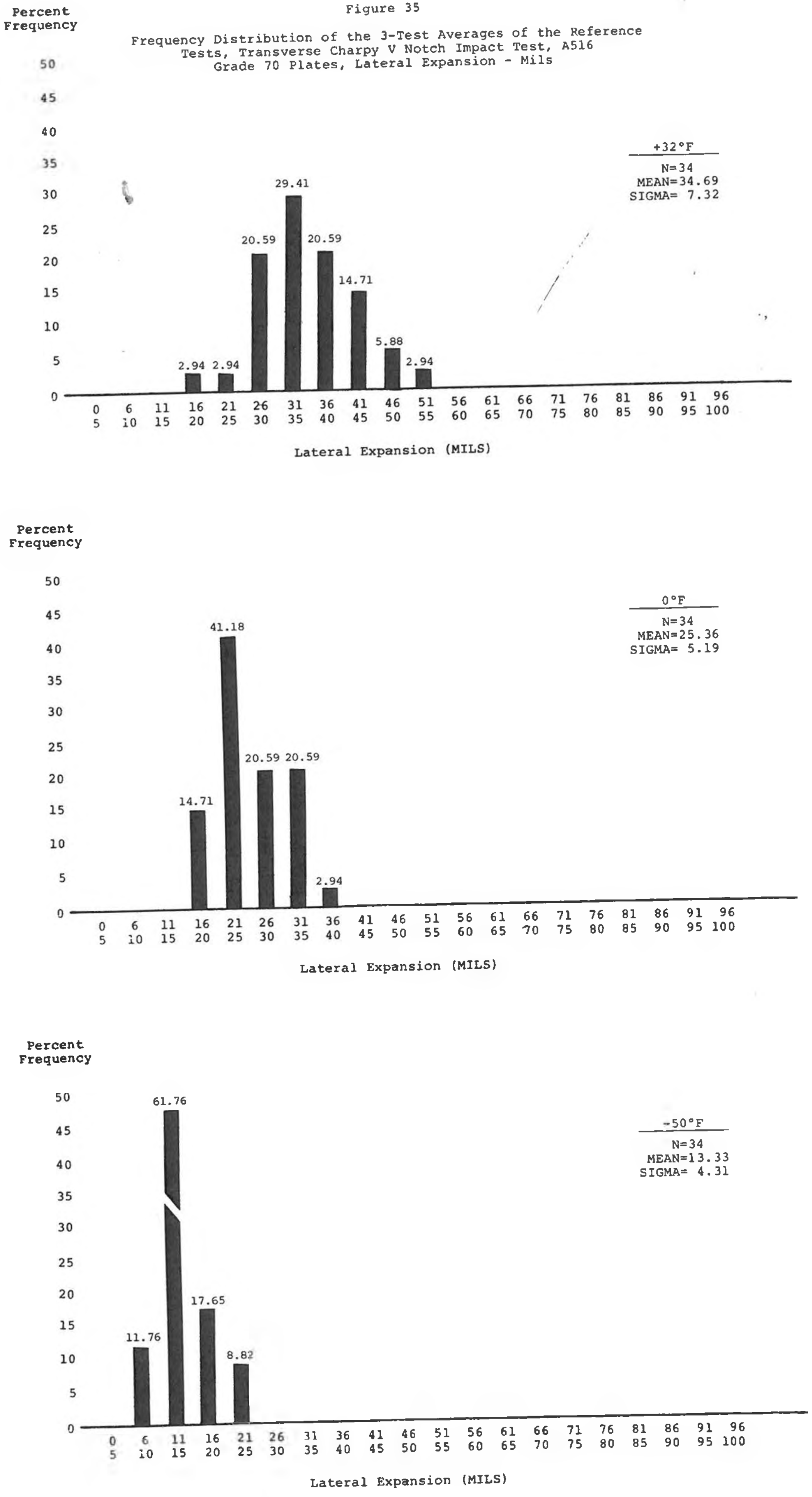
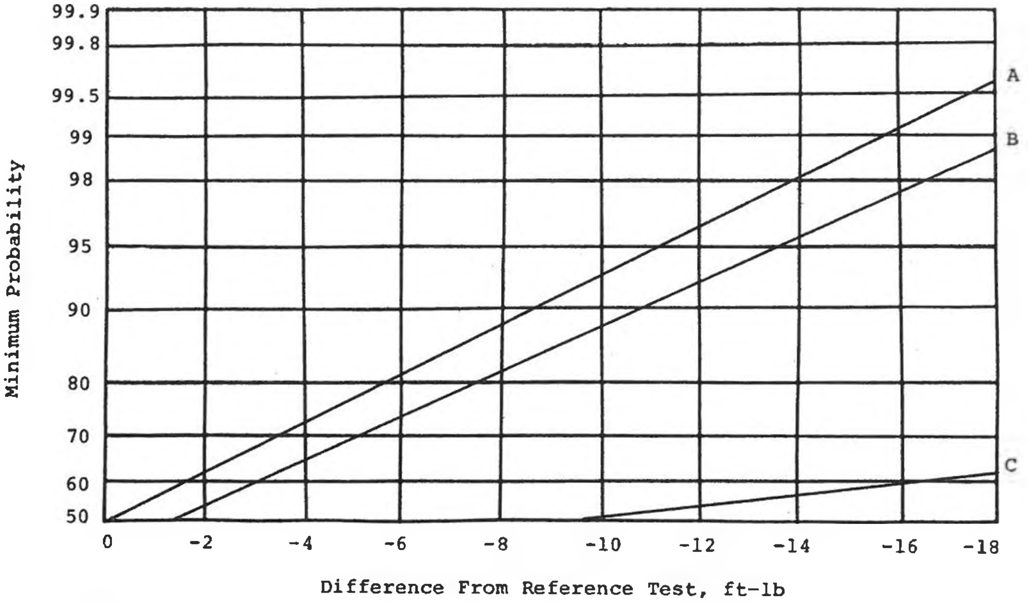


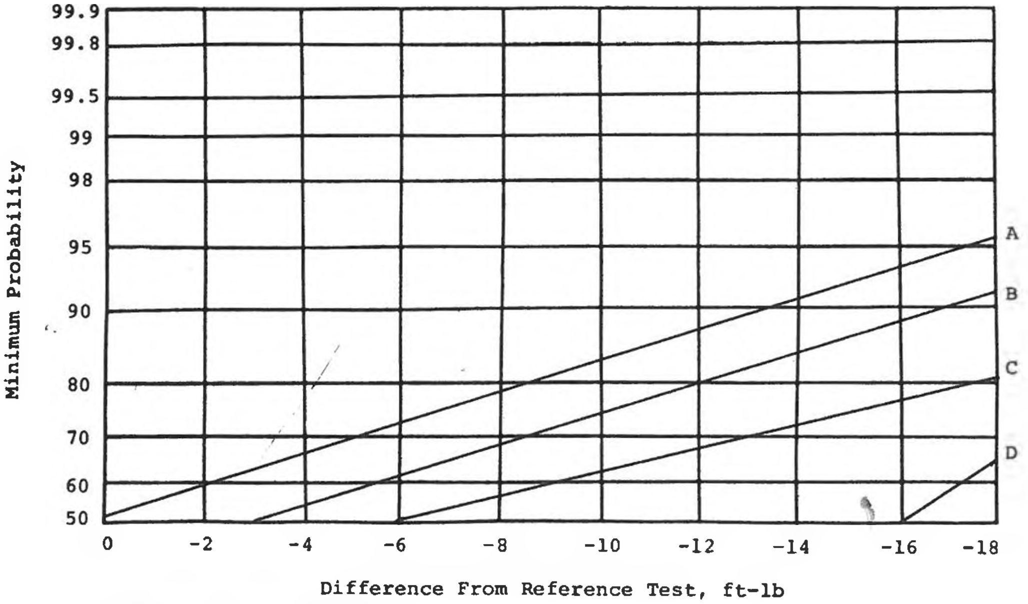
Figure 36. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at -50°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39
C 40 - 59

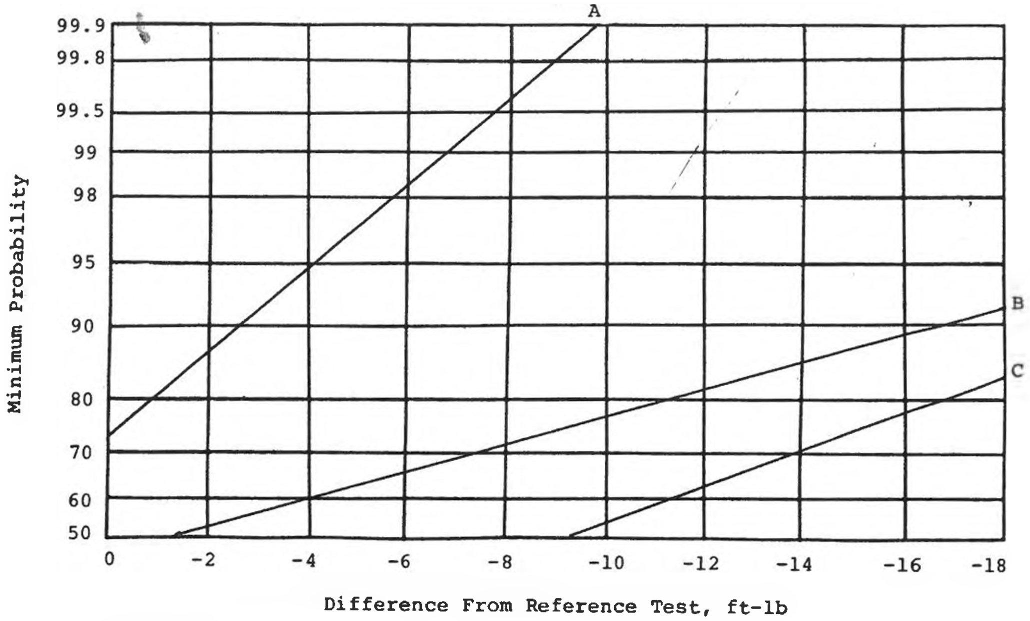
Figure 37. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test

A 20 - 39
B 40 - 59
C 60 - 79
D 80 - 99

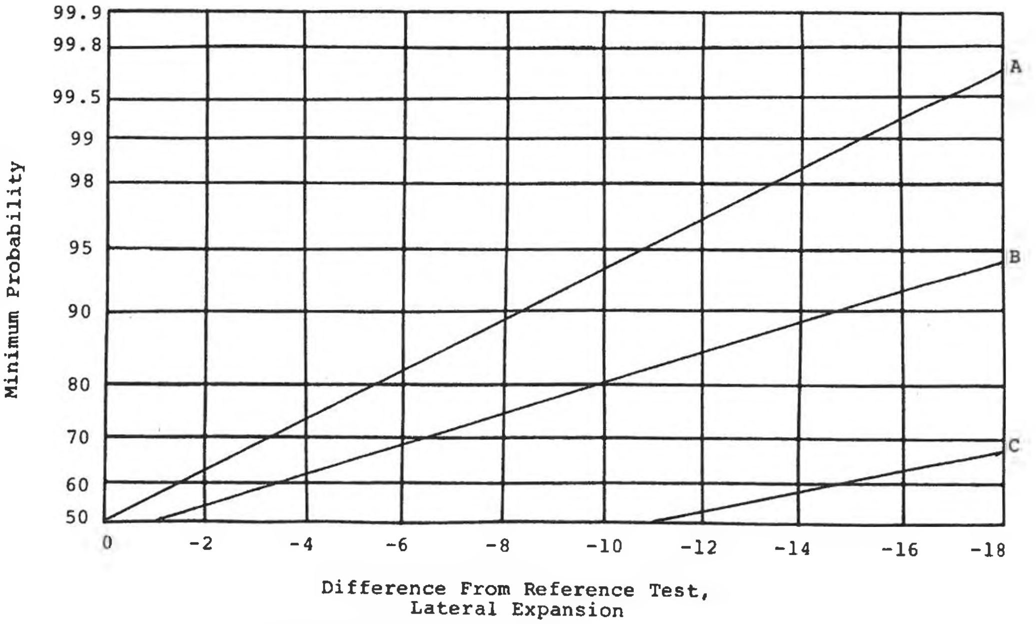
Figure 38. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at +32°F, 3-Test Average



Range of Reference Test

A 20 - 39
B 40 - 79
C 80 - 99

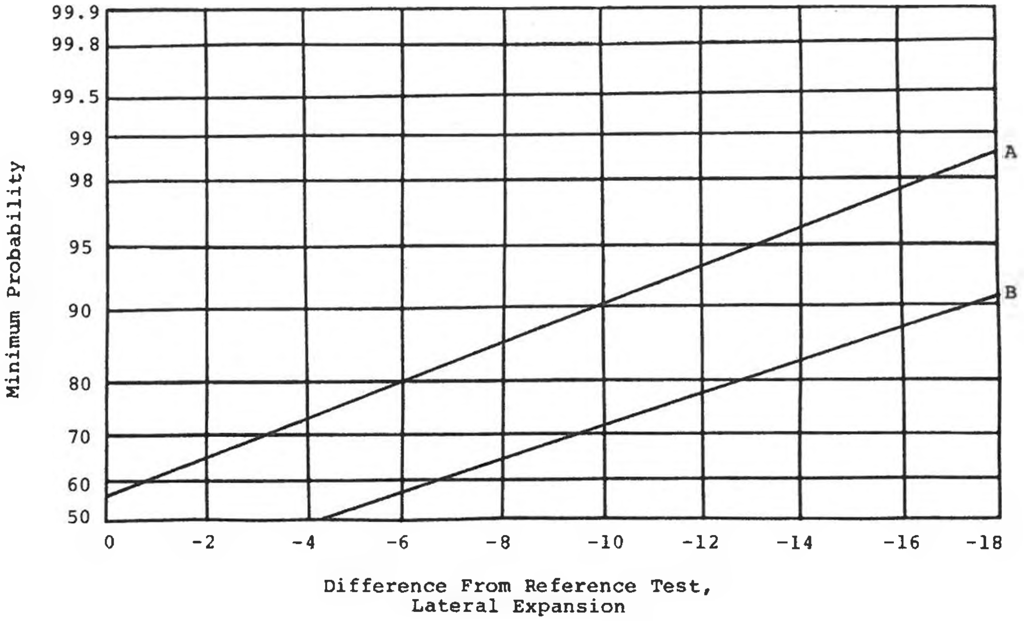
Figure 39. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at -50°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39
C 40 - 59

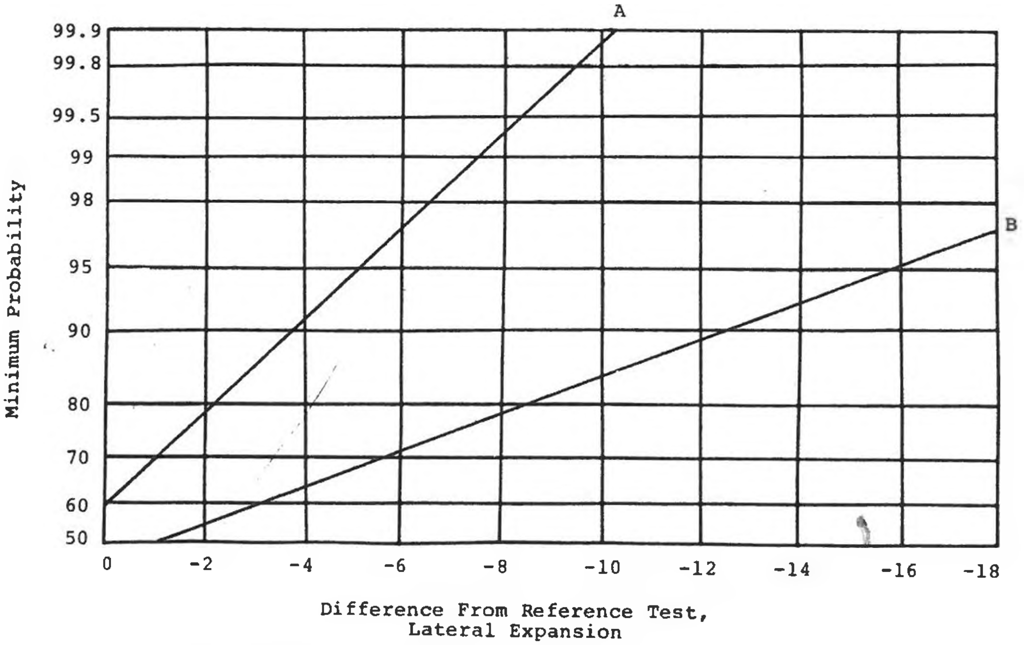
Figure 40. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average



Range of Reference Test

A 20 - 39
B 40 - 79

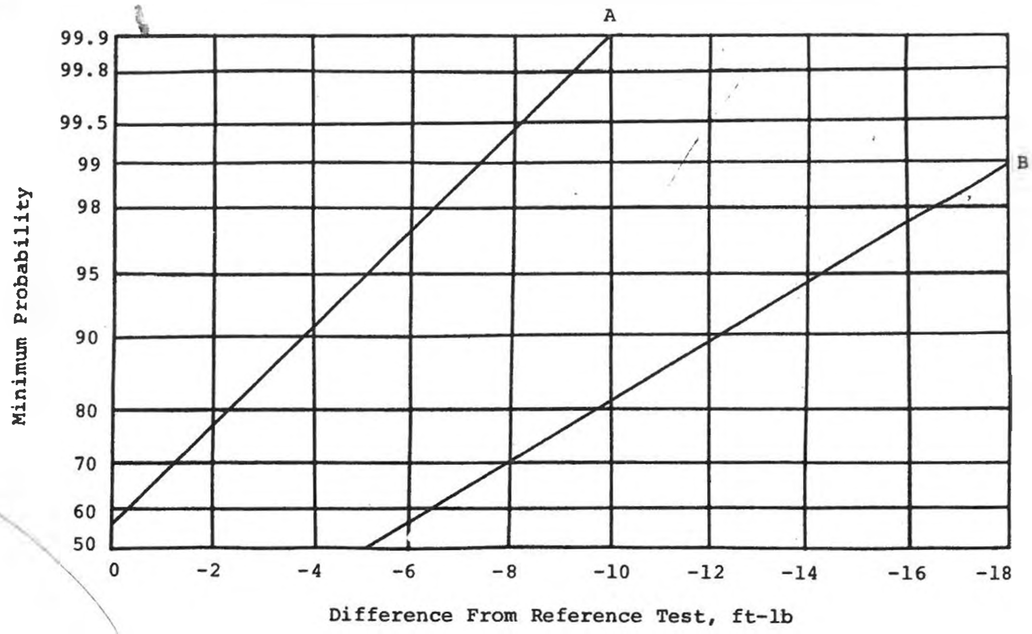
Figure 41. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at +32°F, 3-Test Average



Range of Reference Test

A 20 - 39
B 40 - 79

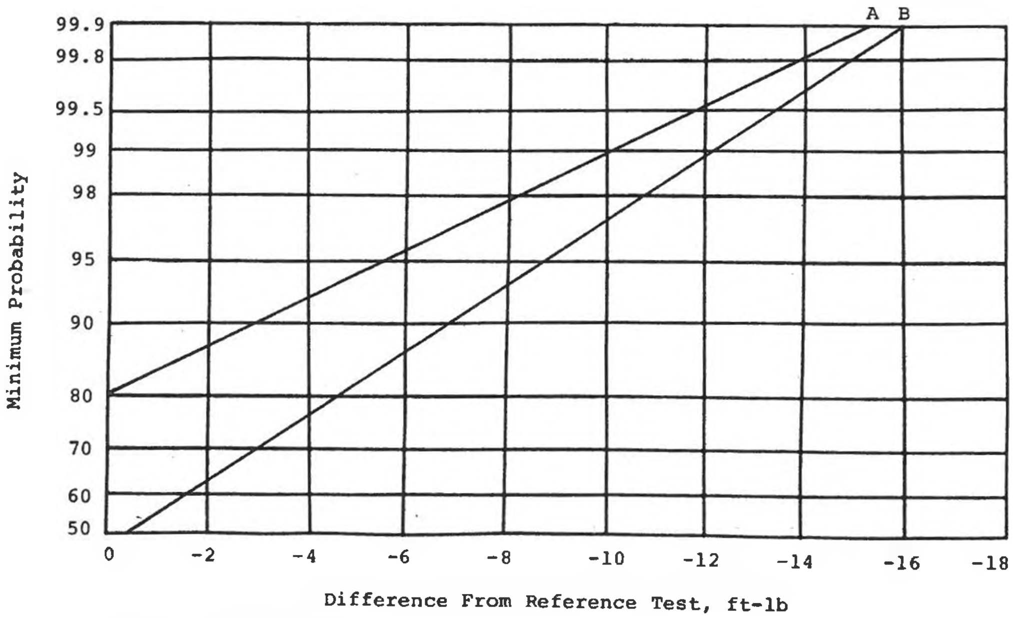
Figure 42. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from the Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at -50°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39

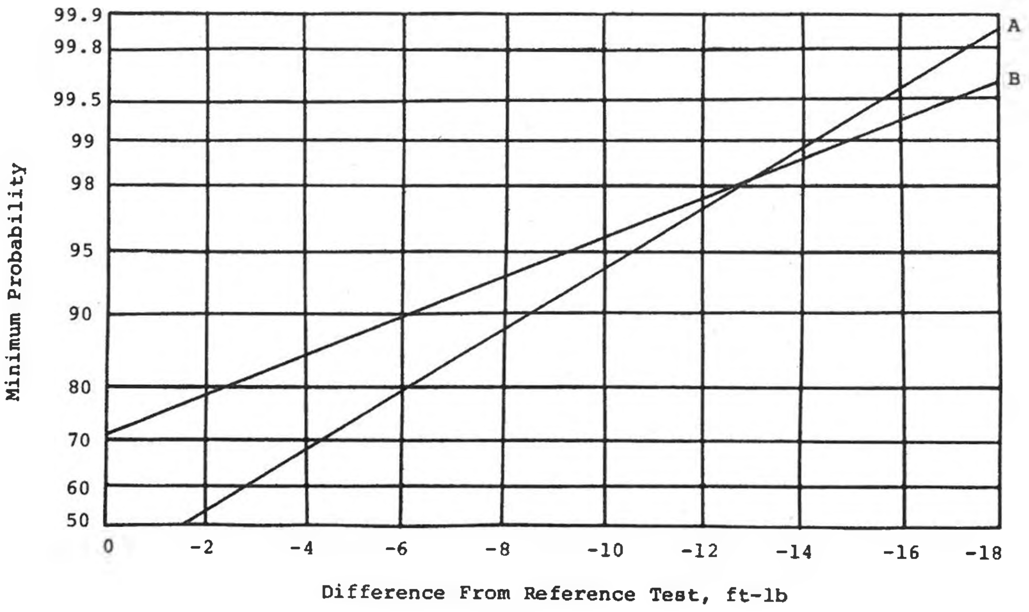
Figure 43. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 29

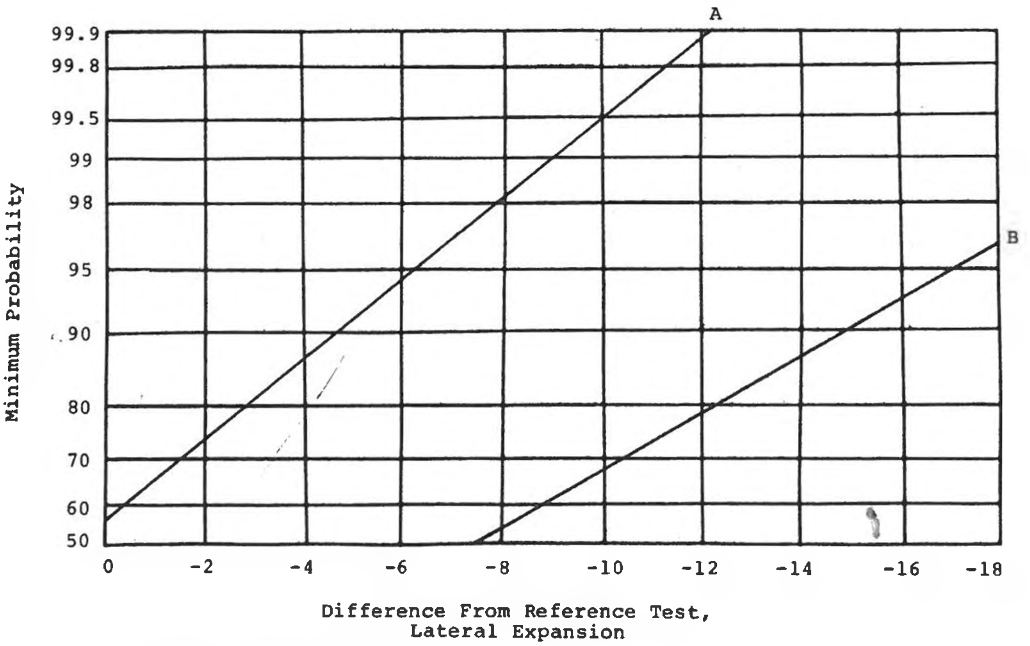
Figure 44. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at +32°F, 3-Test Average



Range of Reference Test

A 20 - 39
B 40 - 59

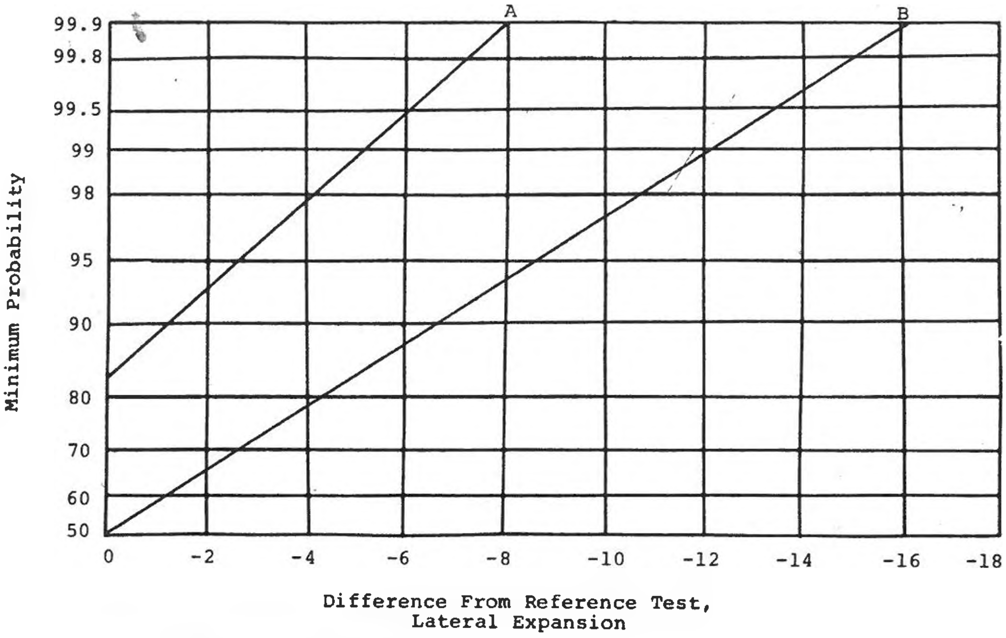
Figure 45. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at -50°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39

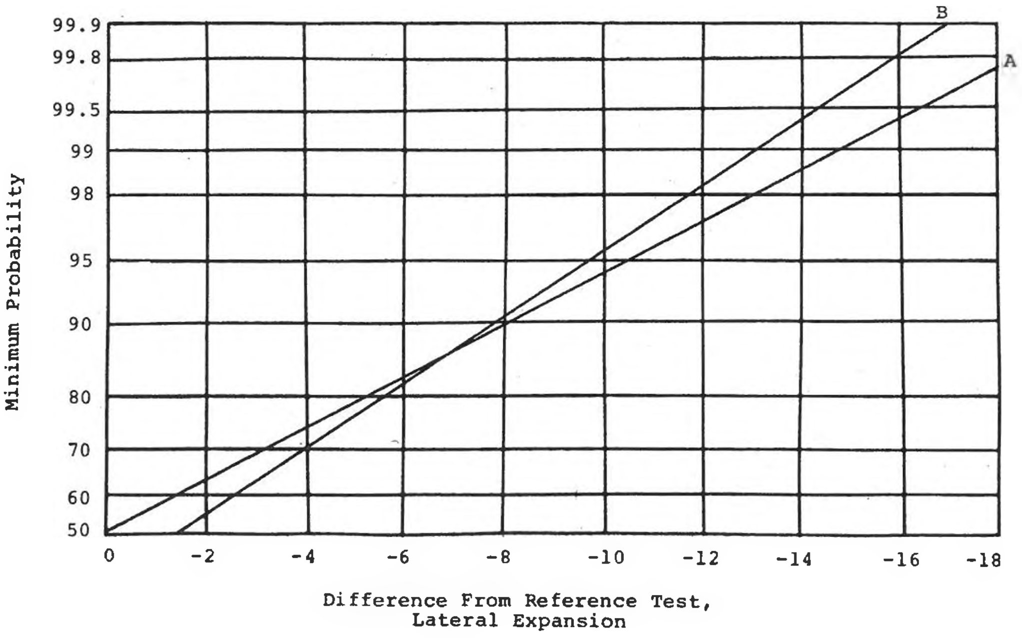
Figure 46. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39

Figure 47. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A516 Grade 70 Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at +32°F, 3-Test Average

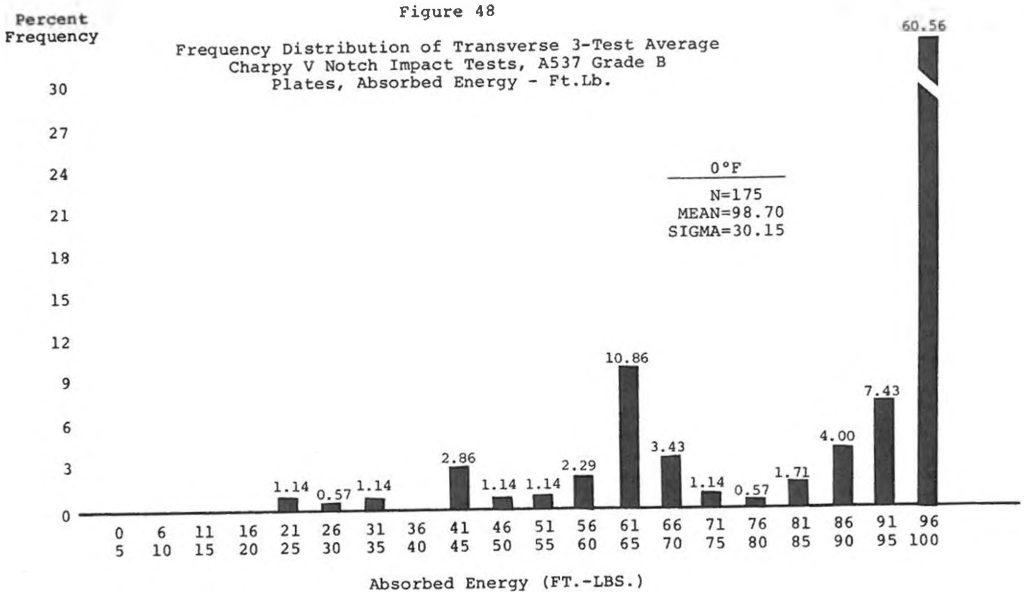


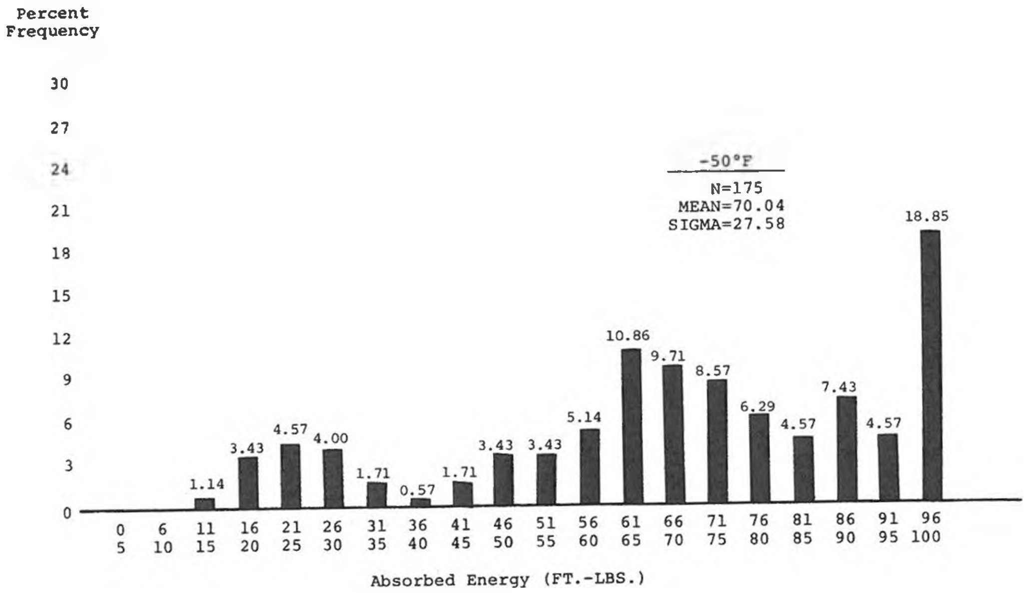
Range of Reference Test

A 0 - 39
B 40 - 59

Figure 48

Frequency Distribution of Transverse 3-Test Average Charpy V Notch Impact Tests, A537 Grade B Plates, Absorbed Energy - Ft.Lb.





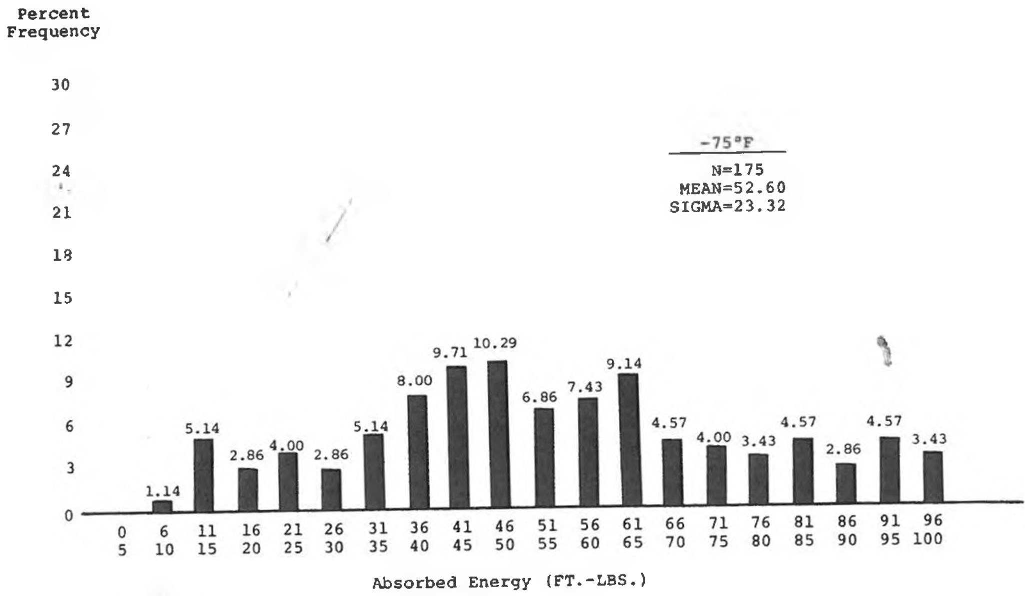


Figure 49

Frequency Distribution of Longitudinal 3-Test Average Charpy
V Notch Impact Tests, A537 Grade B Plates,
Lateral Expansion - Mils

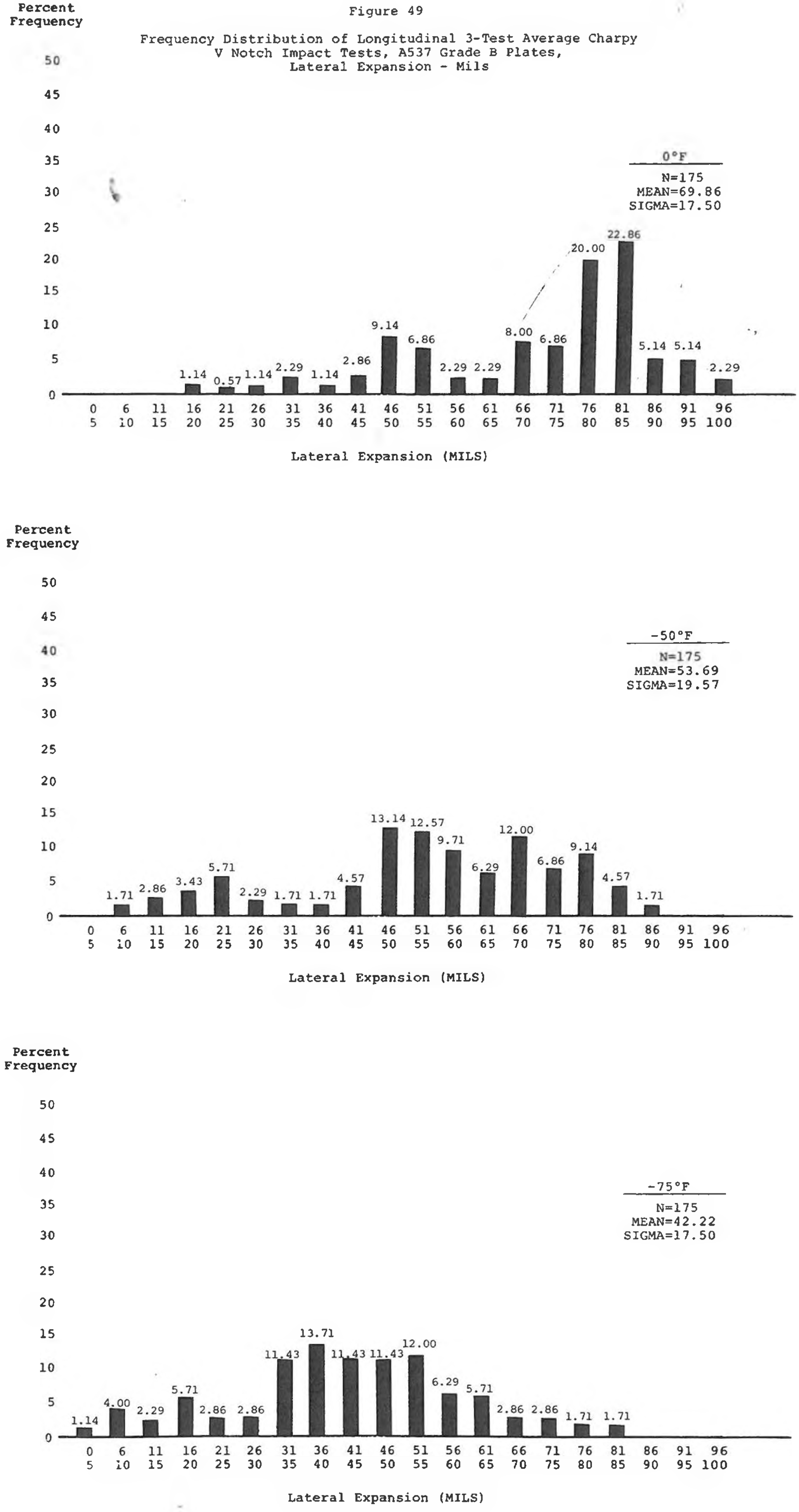


Figure 50

Frequency Distribution of Longitudinal 3-Test Average Charpy V Notch Impact Tests, A537 Grade B Plates, Absorbed Energy - Ft.Lbs.

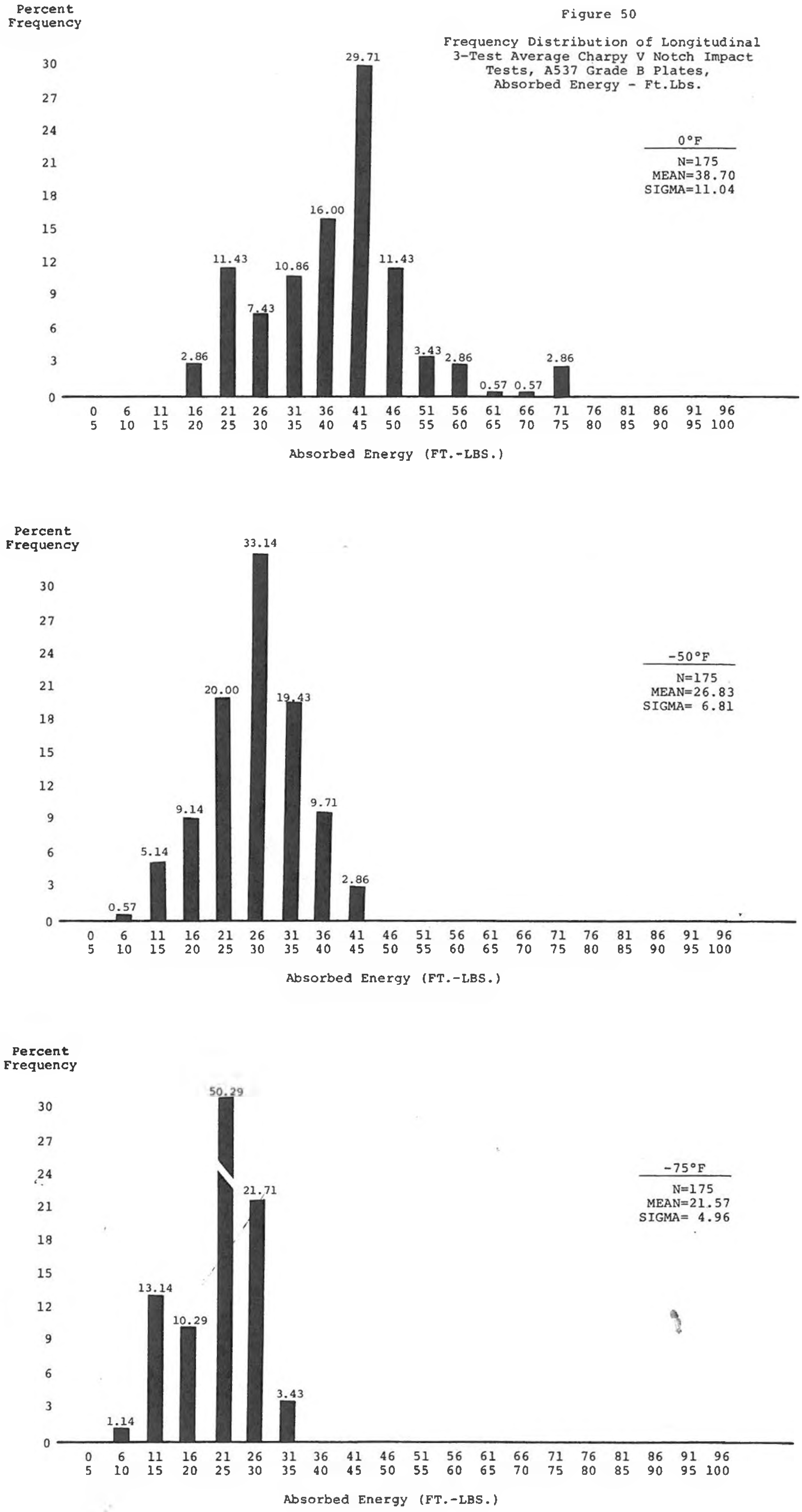
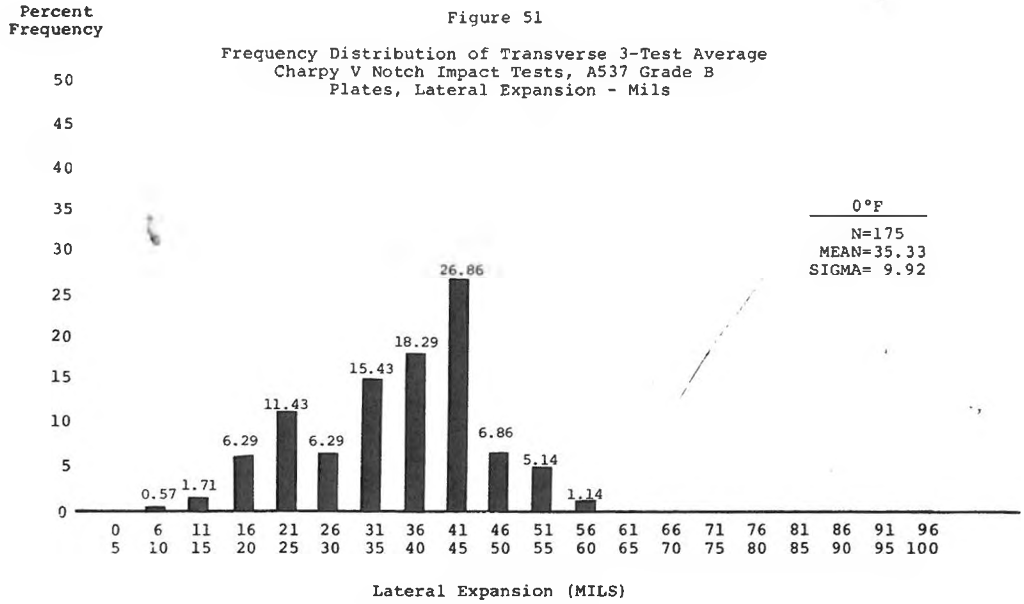
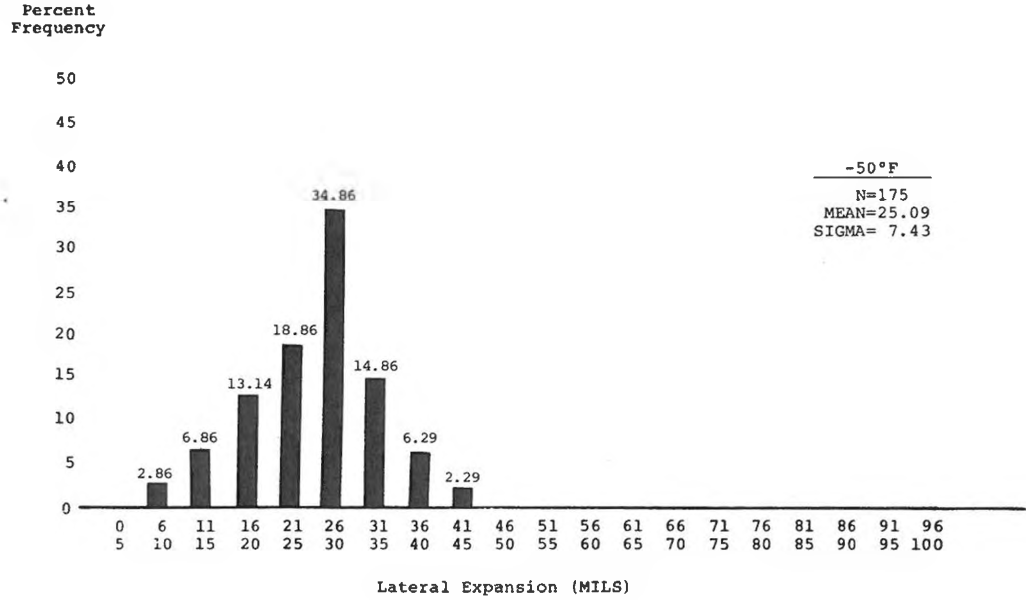


Figure 51

Frequency Distribution of Transverse 3-Test Average
Charpy V Notch Impact Tests, A537 Grade B
Plates, Lateral Expansion - Mils





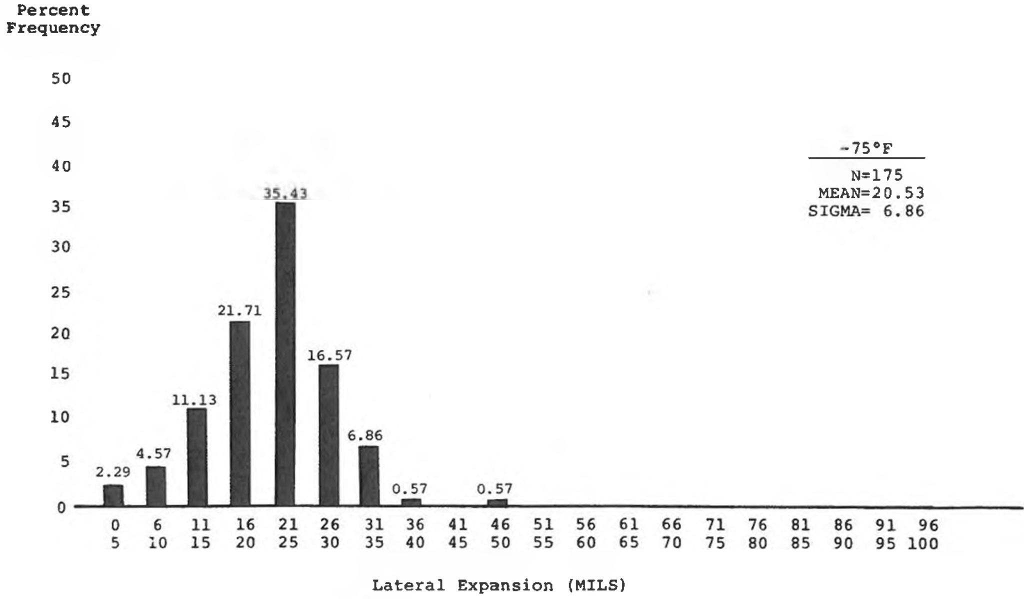
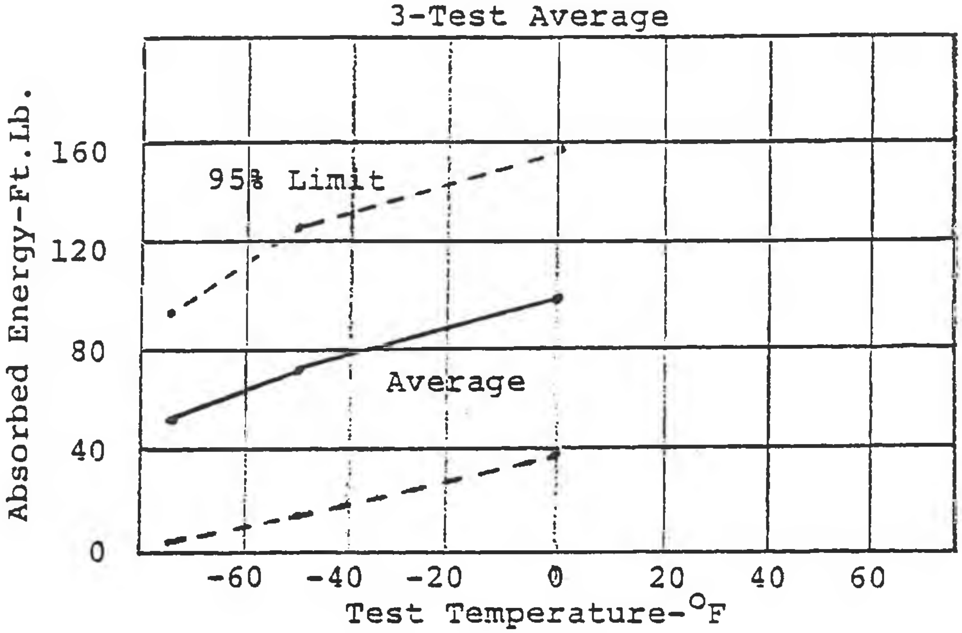


Figure 52. Absorbed Energy vs Test Temperature A537 Grade B Plates
Longitudinal Charpy V Notch Impact Tests



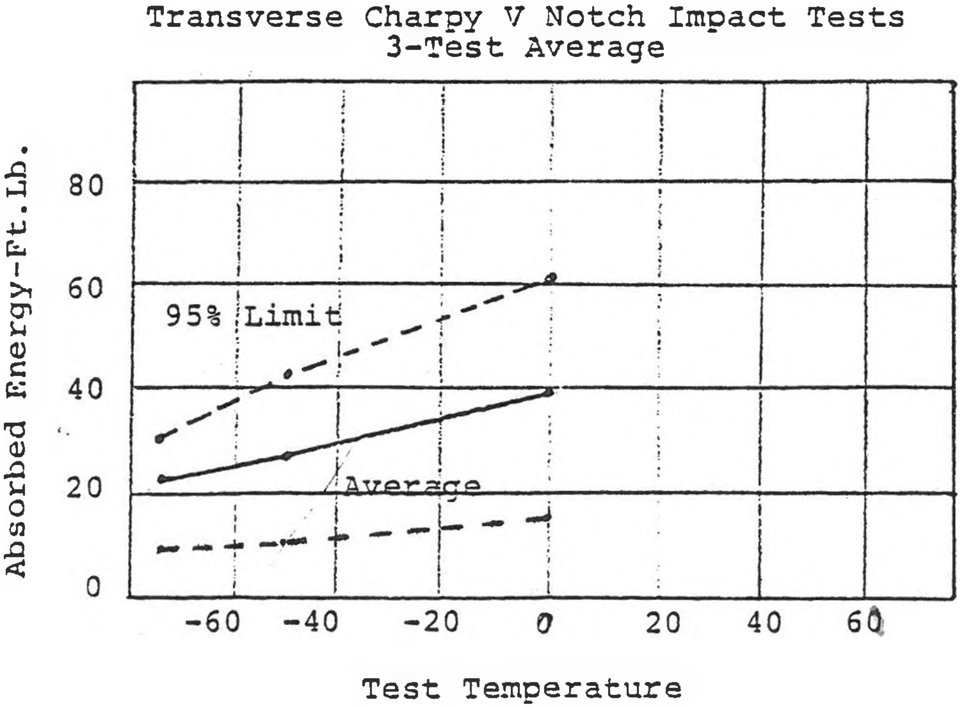
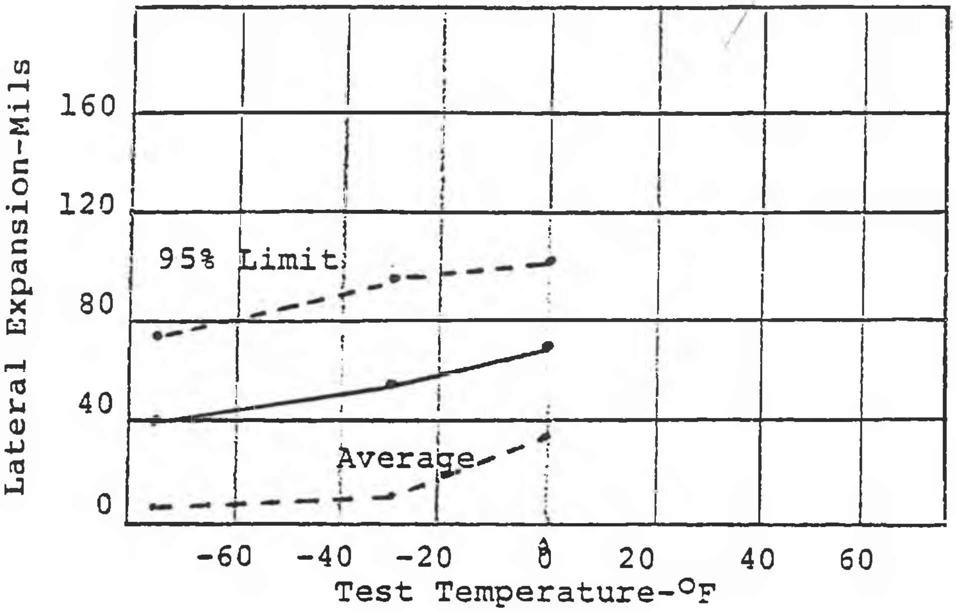


Figure 53. Lateral Expansion vs Test Temperature A537 Grade B Plates

Longitudinal Charpy V Notch Impact Tests
3-Test Average



Transverse Charpy V Notch Impact Tests
3-Test Average

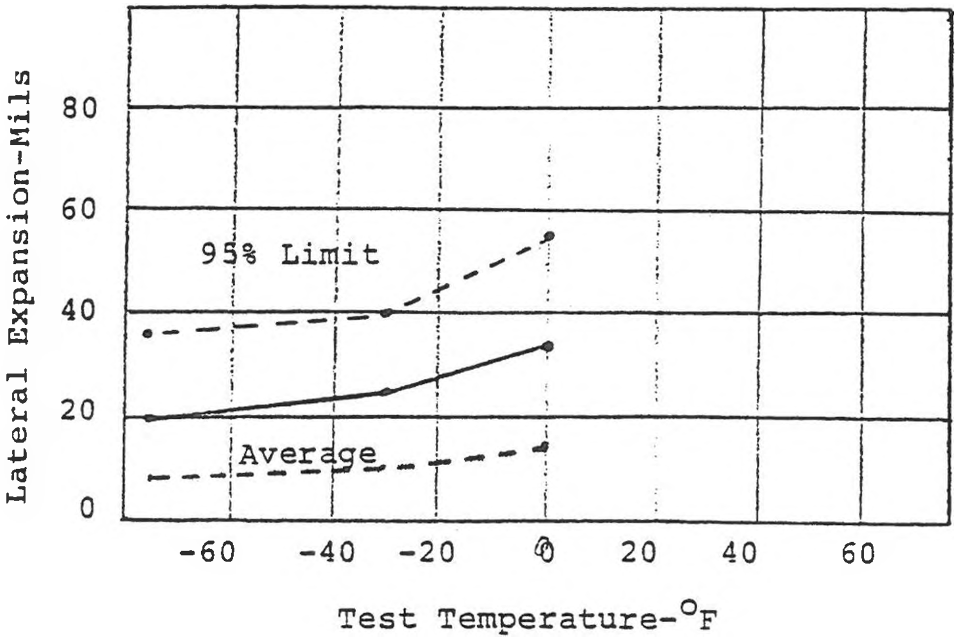


Figure 54

Frequency Distribution of the 3-Test Averages of the Reference Tests, A537 Grade B Plates, Absorbed Energy - Ft.Lbs.

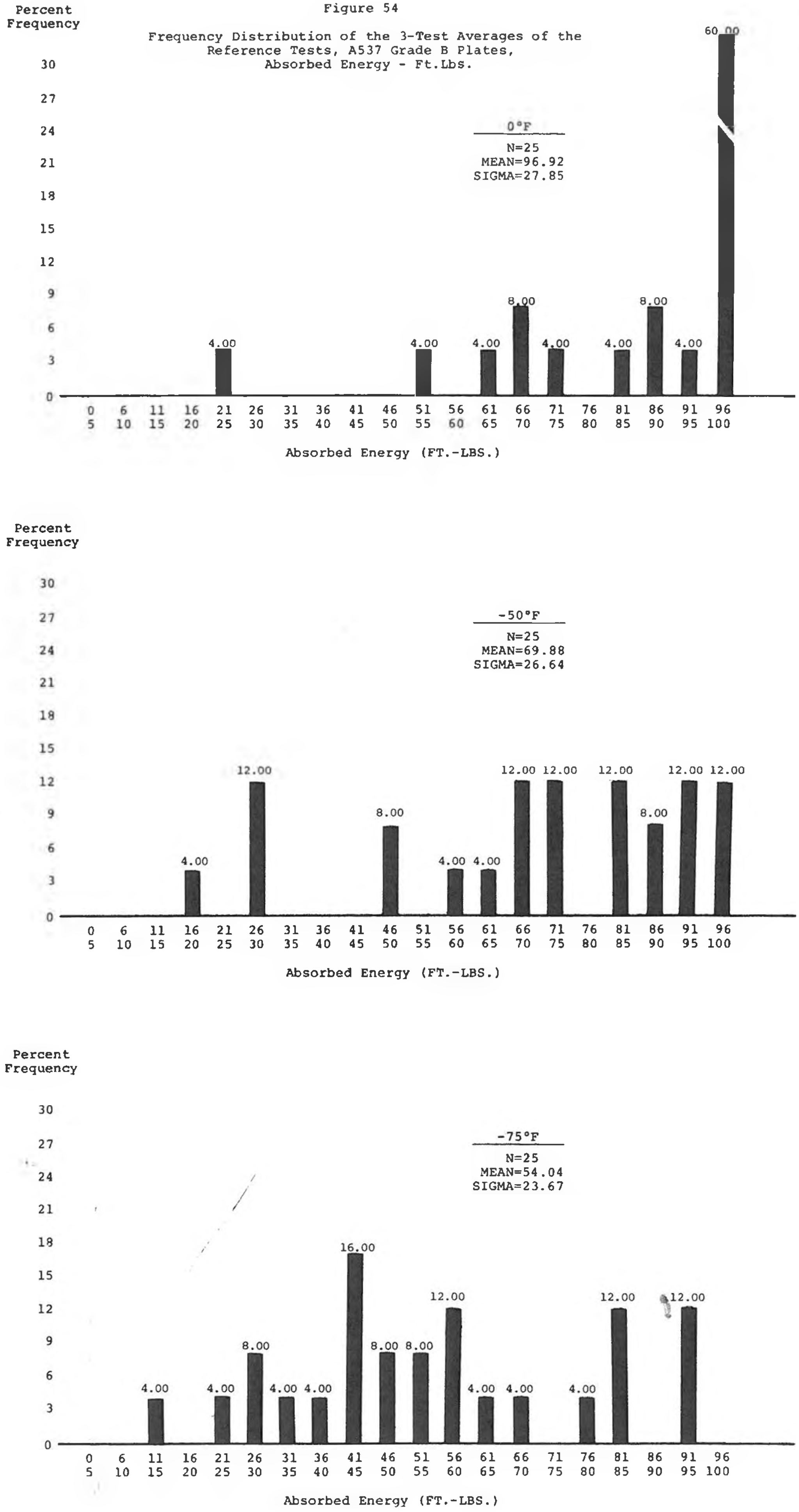


Figure 55

Frequency Distribution of the 3-Test Averages of the Reference Tests, Longitudinal Charpy V Notch Impact Test, A537 Grade B Plates, Lateral Expansion - Mils

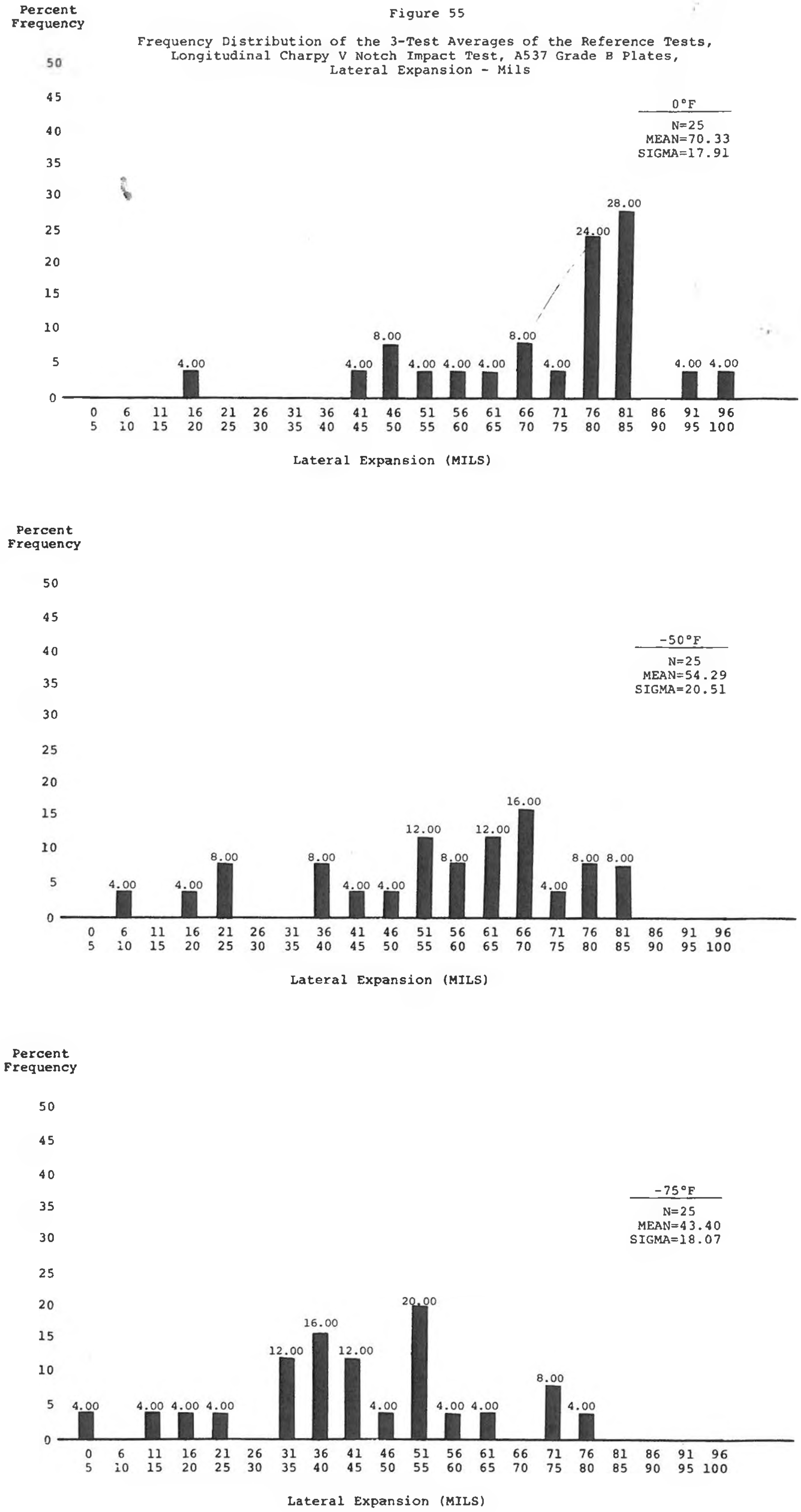


Figure 56

Frequency Distribution of the 3-Test Averages of the Reference Tests, Transverse Charpy V Notch Impact Test, A537 Grade B Plates, Absorbed Energy - Ft.Lbs.

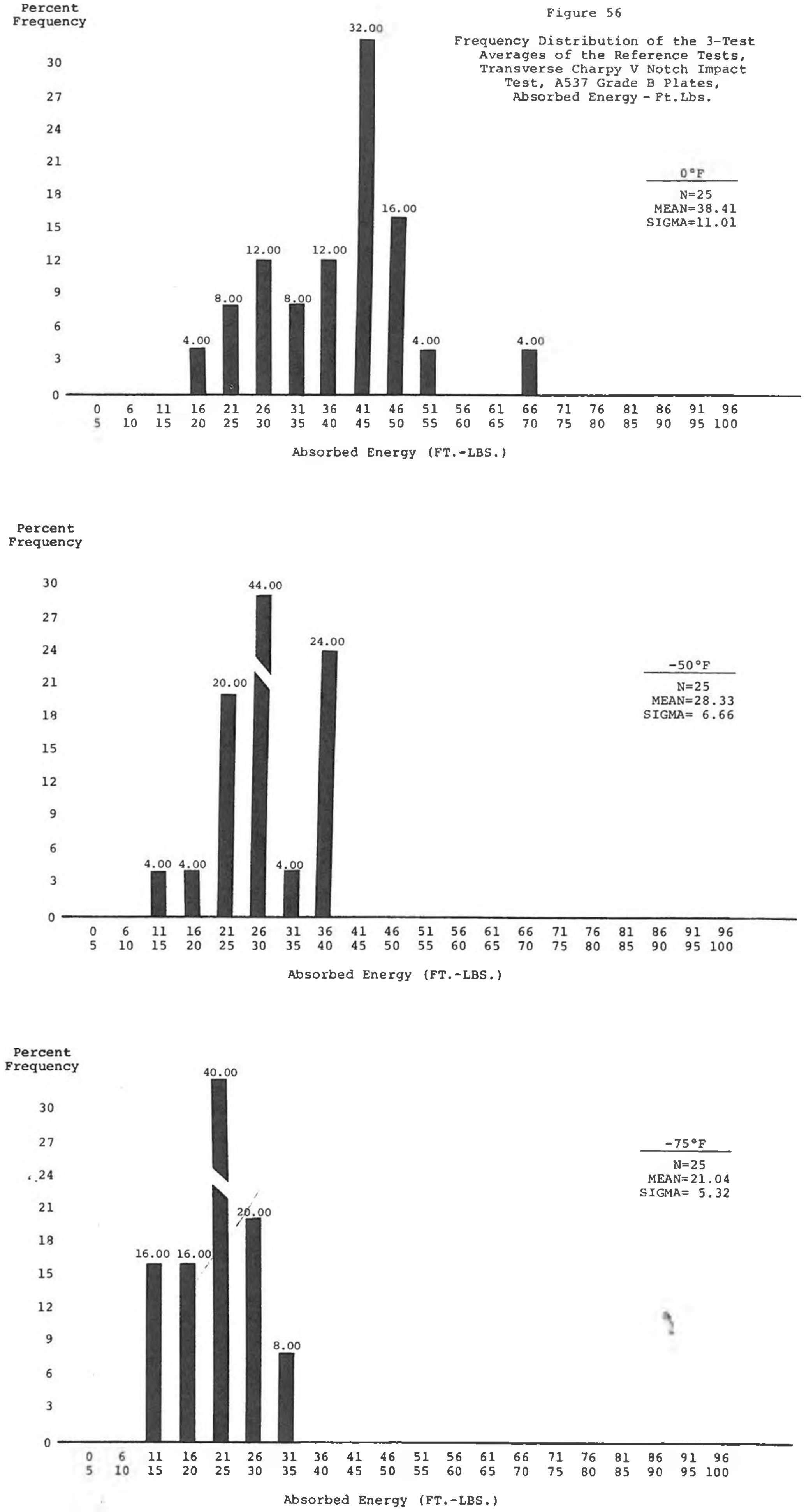


Figure 57

Frequency Distribution of the 3-Test Averages of the Reference Tests, Transverse Charpy V Notch Impact Test, A537 Grade B Plates, Lateral Expansion - Mils

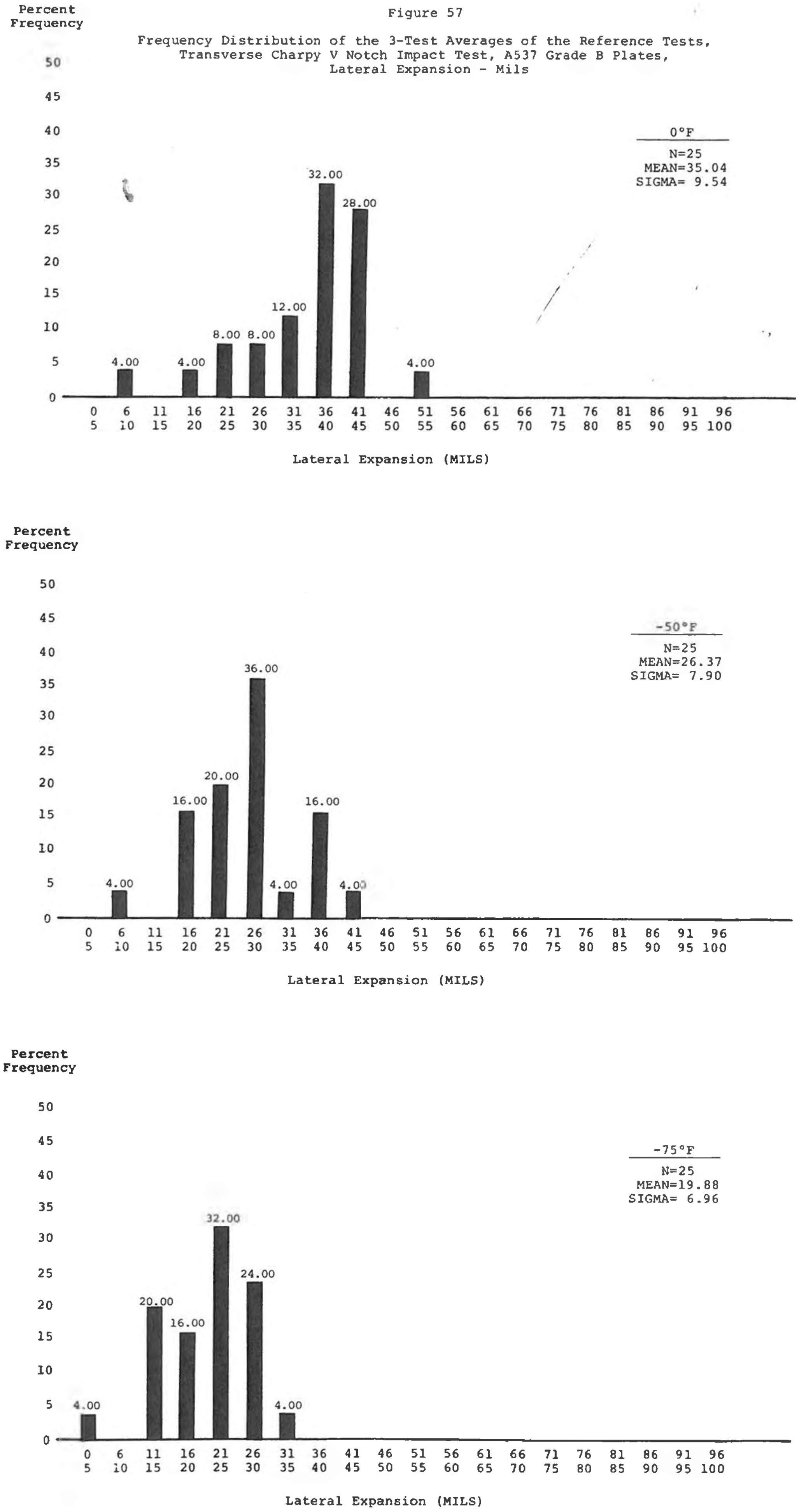
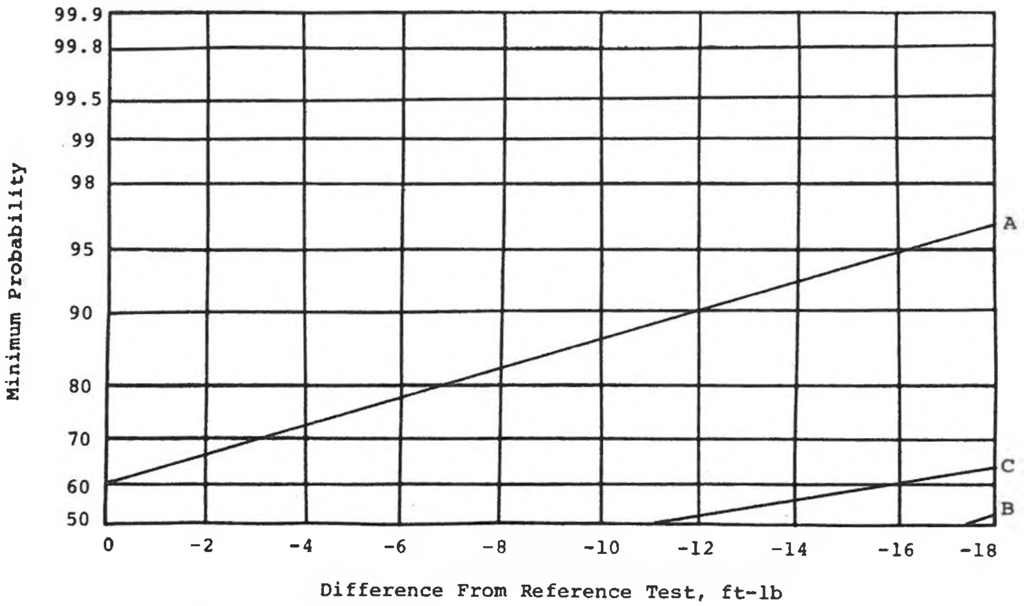


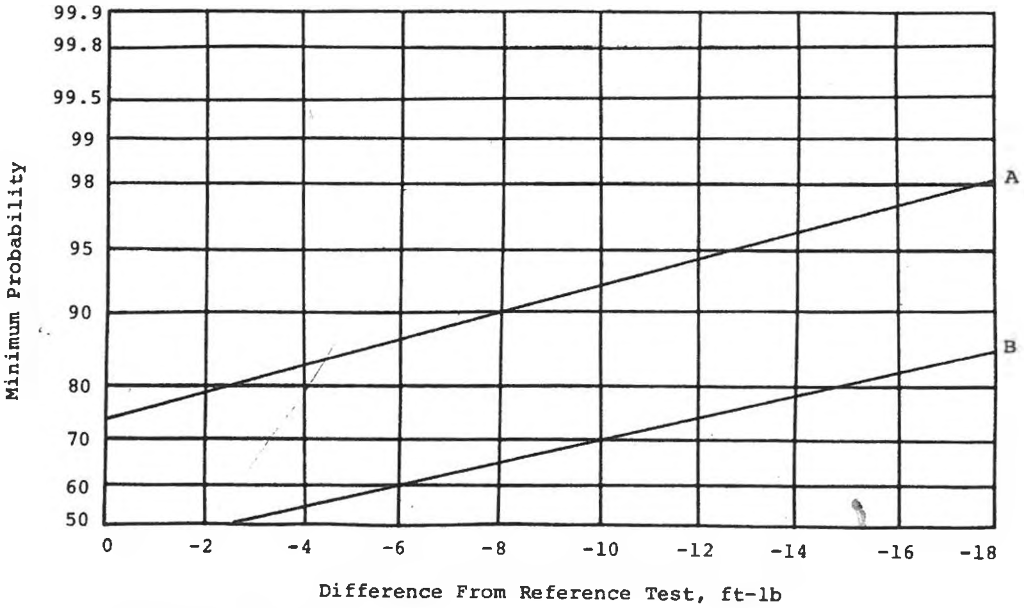
Figure 58. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at -75°F, 3-Test Average



Range of Reference Test

A 20 - 59
B 60 - 79
C 80 - 99

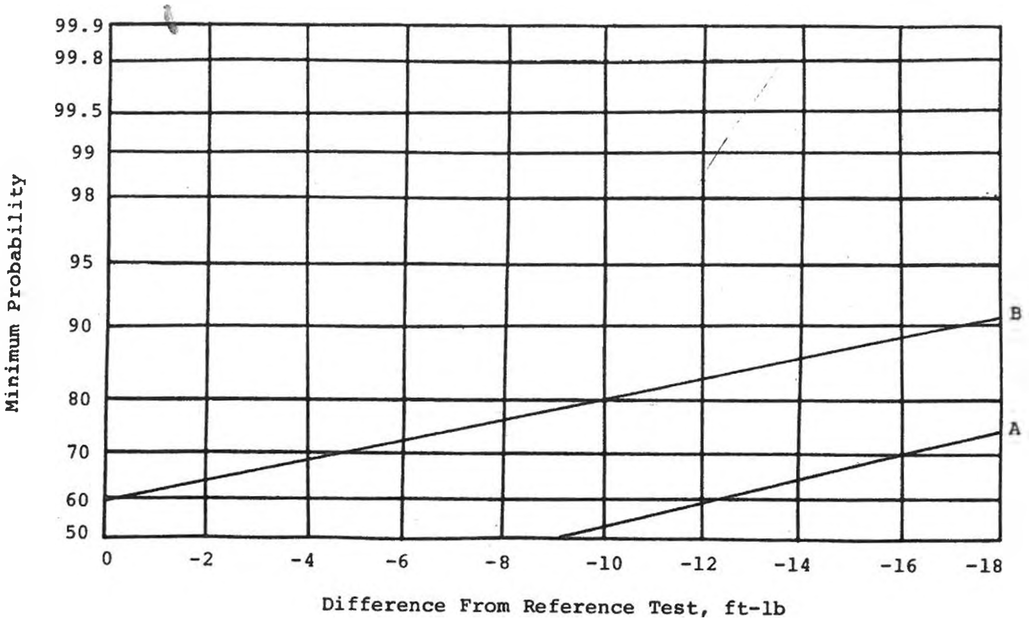
Figure 59. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at -50°F, 3-Test Average



Range of Reference Test

A 20 - 59
B 60 - 119

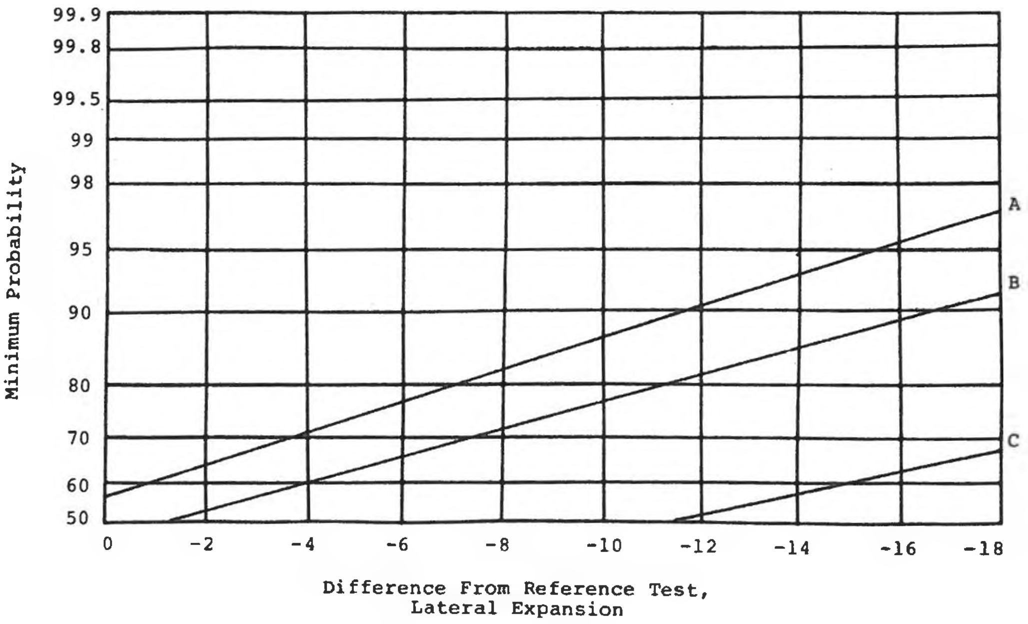
Figure 60. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test

A 60 - 79
B 80 - 139

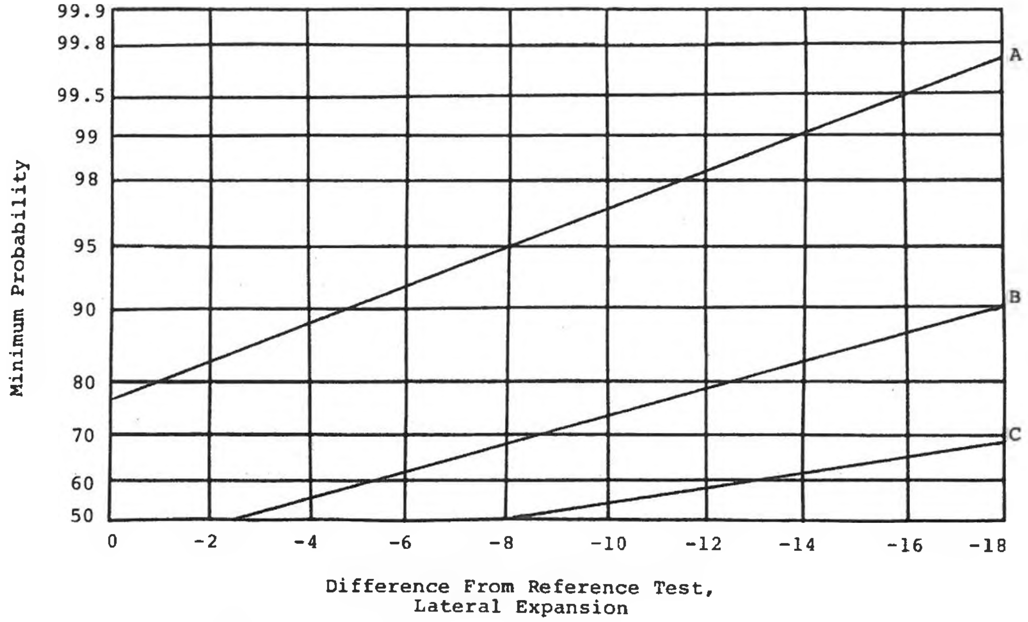
Figure 61. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at -75°F, 3-Test Average



Range of Reference Test

A 0 - 39
B 40 - 59
C 60 - 79

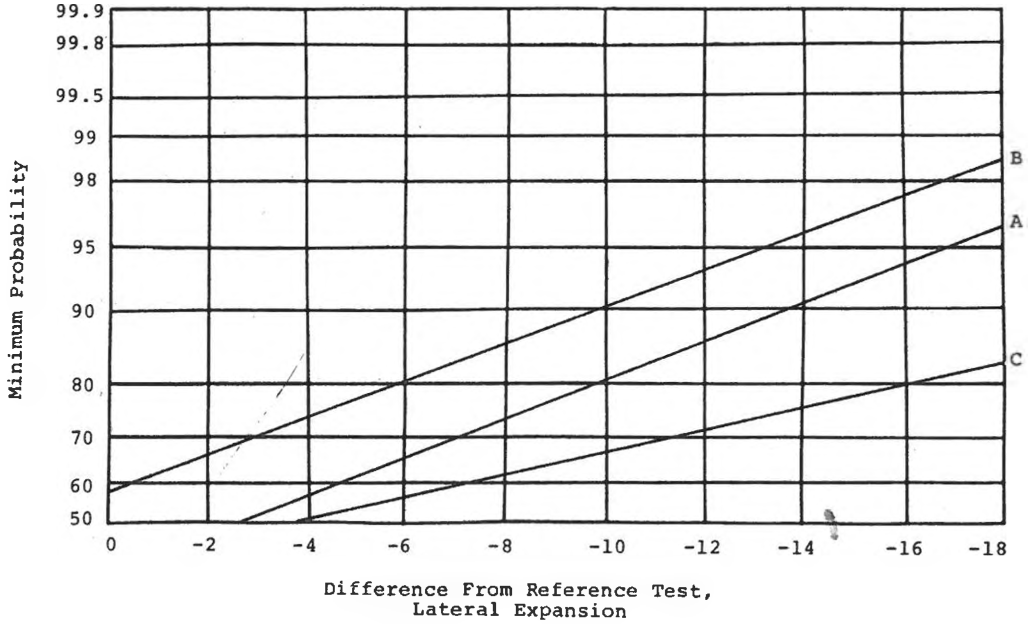
Figure 62. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at -50°F, 3-Test Average



Range of Reference Test

A 0 - 39
B 40 - 79
C 80 - 99

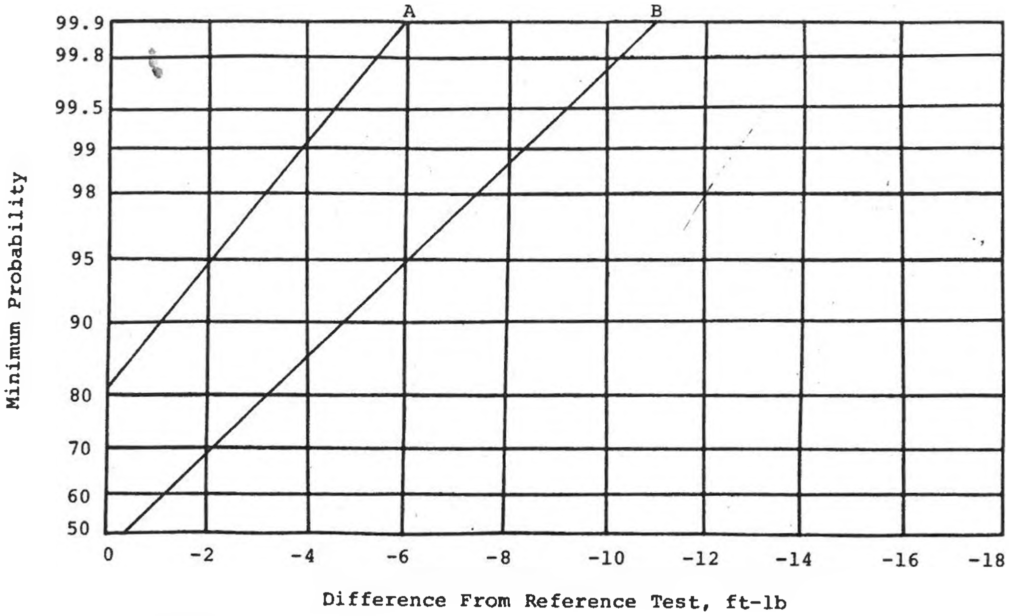
Figure 63. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Longitudinal Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average



Range of Reference Test

A 40 - 59
B 60 - 79
C 80 - 99

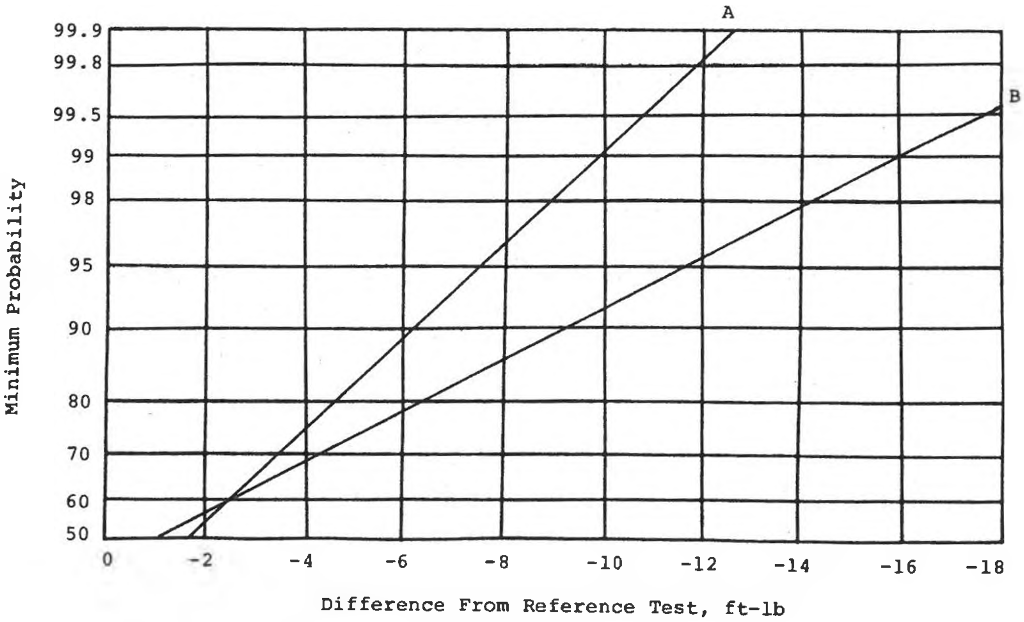
Figure 64. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at -75°F, 3-Test Average



Range of Reference Test

A	0 - 19
B	20 - 39

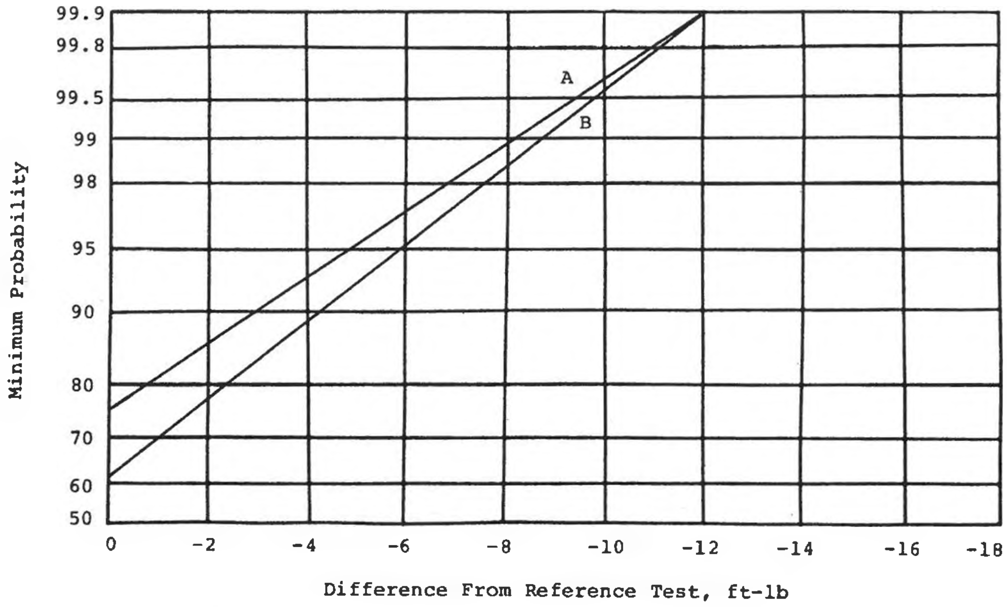
Figure 65. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at -50°F, 3-Test Average



Range of Reference Test

A	0 - 19
B	20 - 39

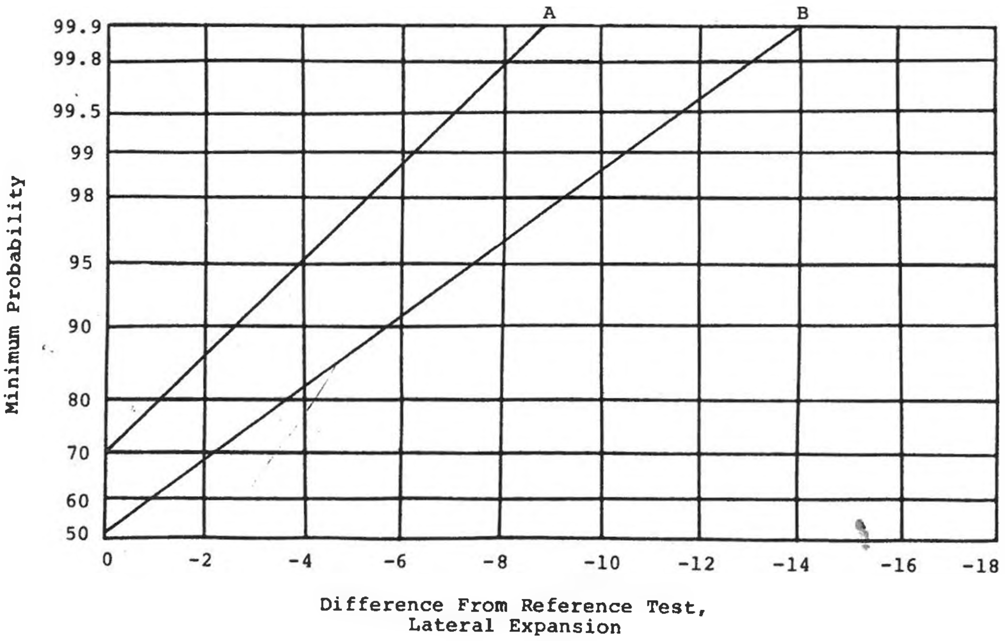
Figure 66. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Absorbed Energy at 0°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39

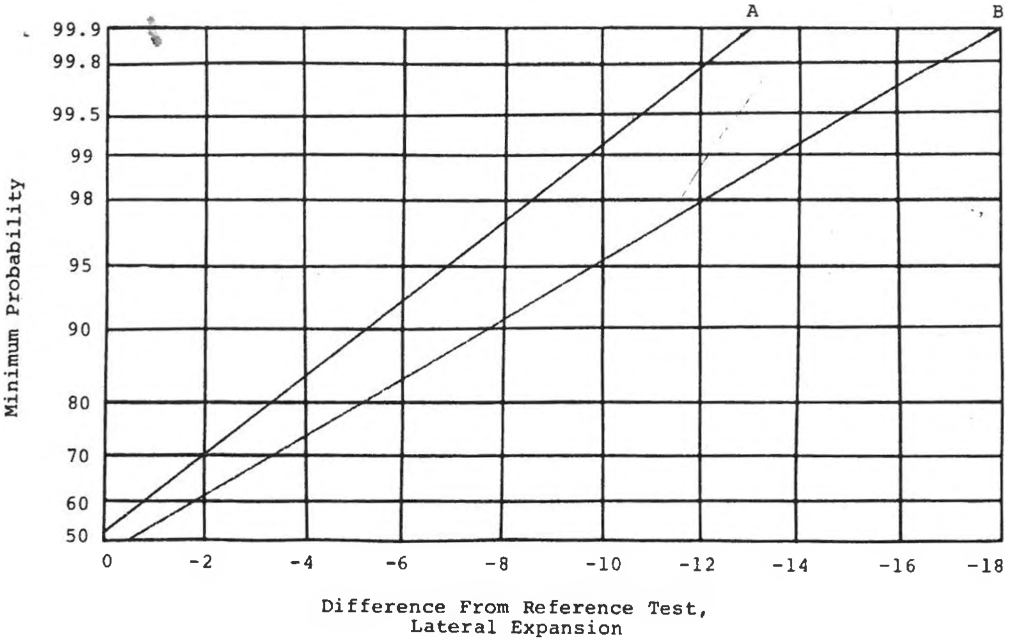
Figure 67. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at -75°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 39

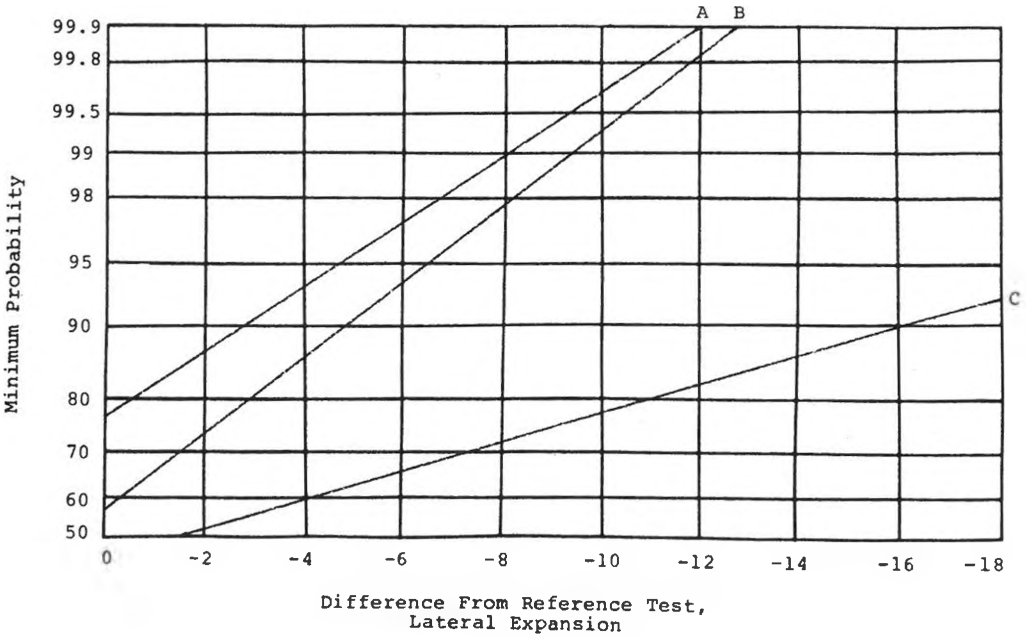
Figure 68. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at -50°F, 3-Test Average



Range of Reference Test

A 0 - 19
B 20 - 59

Figure 69. Minimum Probability that a Product Test Will Equal or Exceed a Specified Difference from a Reference Test, A537 Grade B Plate, Transverse Charpy V Notch Impact Test, Lateral Expansion at 0°F, 3-Test Average

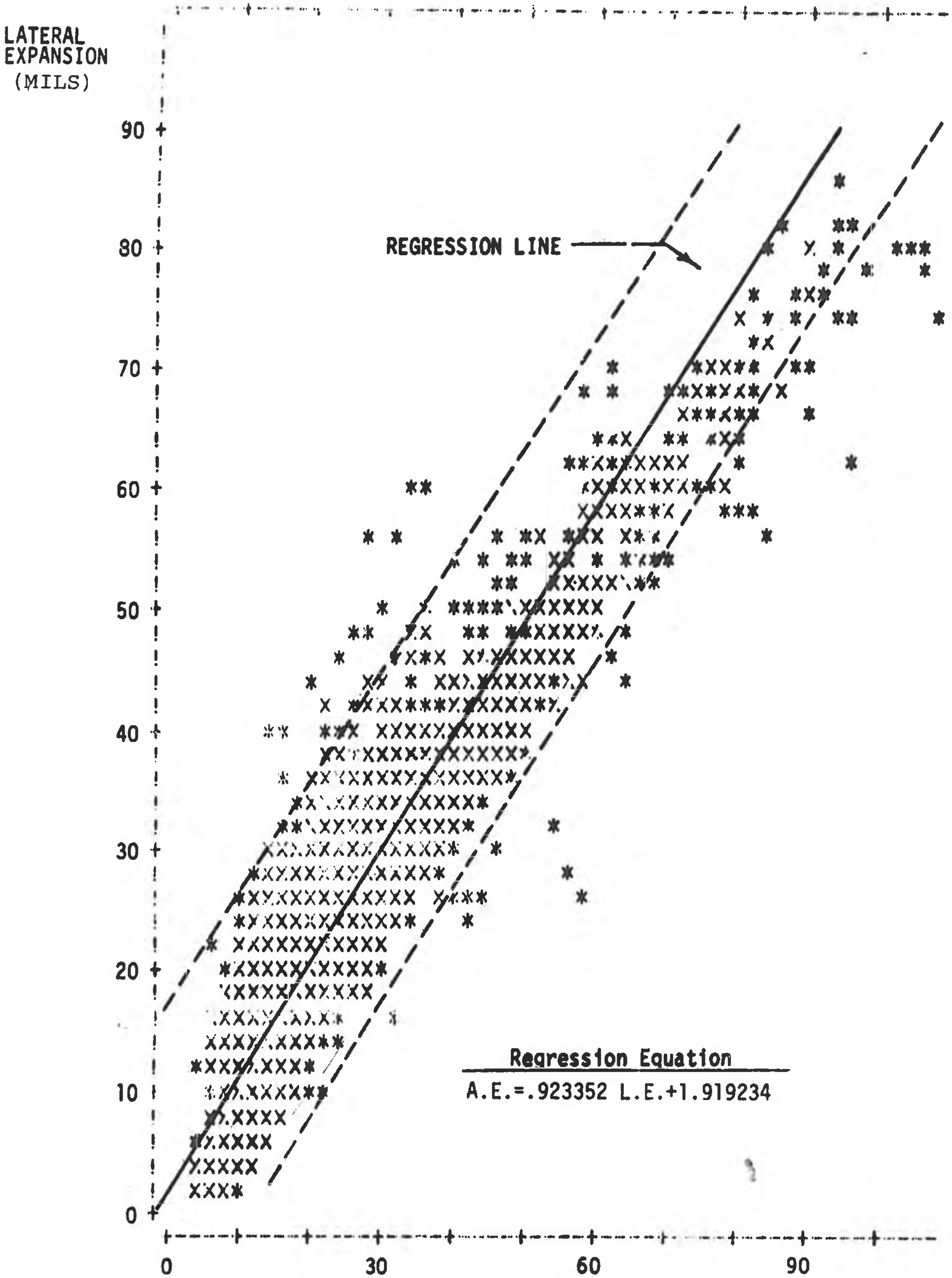


Range of Reference Test

A 0 - 19
B 20 - 39
C 40 - 59

FIGURE 70

SCATTER PLOT AND REGRESSION LINE
ABSORBED ENERGY VERSUS LATERAL EXPANSION
ASTM A572

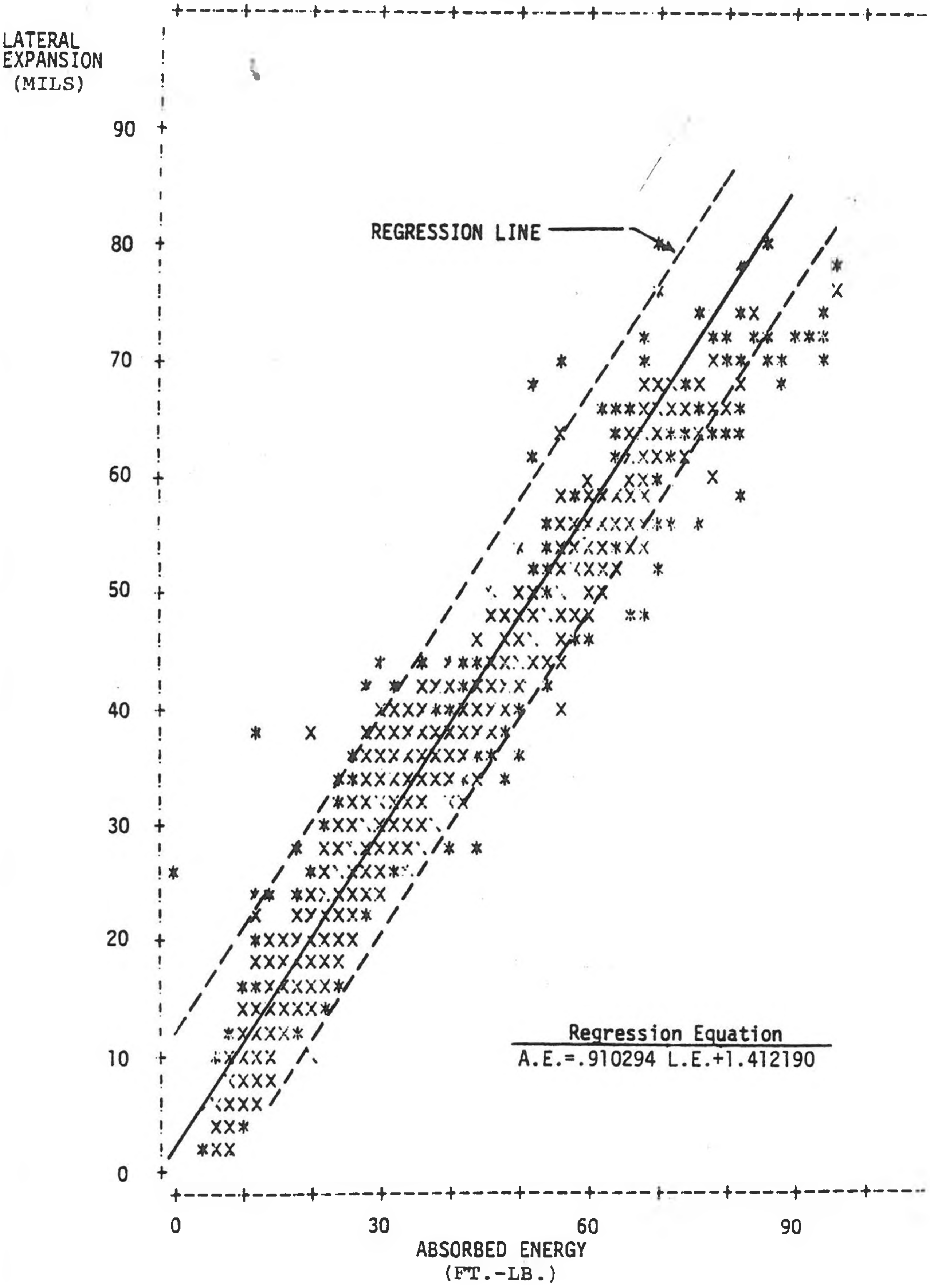


Regression Equation

A.E.=.923352 L.E.+1.919234

FIGURE 71

SCATTER PLOT AND REGRESSION LINE
ABSORBED ENERGY VERSUS LATERAL EXPANSION
ASTM A516



Regression Equation
A.E.=.910294 L.E.+1.412190

FIGURE 72

SCATTER PLOT AND REGRESSION LINE
ABSORBED ENERGY VERSUS LATERAL EXPANSION
ASTM A537-CLASS II