APPENDIX A1. MIL-HDBK-17A DATA

A1.1 GENERAL INFORMATION

The data on polymer matrix composite materials which were presented in MIL-HDBK-17A, dated January 1971, are presented in this appendix. MIL-HDBK-17A has been superseded so these data are presented here so they can be Referenced in a current publication. However, these data do not meet the data requirements in Volume 1. The materials which were included in MIL-HDBK-17A are listed in Table A1. Of the sixteen materials, six are still available, five are no longer available, and the availability of the other five materials could not be determined. The data from the six available materials are provided in this appendix. The data from the remaining materials may be added as availability of the material or usefulness of the data is determined. Note that Narmco 5505 has been licensed to AVCO and those data are presented herein as AVCO 5505.

TABLE A1 *Materials from MIL-HDBK-17A.*

Available:
U.S. Polymeric E-720E/7781 (ECDE-1/0-550) Fiberglass Epoxy
Hexcel F-161/7743(550) Fiberglass Epoxy
Hexcel F-161/7781(ECDE-1/0-550) Fiberglass Epoxy
Narmco N588/7781 (ECDE-1/0-550) Fiberglass Epoxy
Narmco 506/7781 (ECDE-1/0-A1100) Fiberglass Phenolic
AVCO 5505 Boron Epoxy
Not available:
U.S. Polymeric E-779/7743 (Volan) Fiberglass Epoxy
3M XP251S Fiberglass Epoxy
U.S. Polymeric S-860/1581 (ECG-1/2-112) Neutral pH Fiberglass Silicone
U.S. Polymeric P670A/7781 (ECDE-1/0) Fiberglass Modified DAP Polyester
SP272 Boron Epoxy
Availability unknown:
Bloomingdale BP915/7781 (ECDE-1/0-550) Fiberglass Epoxy
Bloomingdale BP911/7781 (ECDE-1/0 Volan) Fiberglass Epoxy
Cordo E293/7781 (ECDE-1/0-550) Fiberglass Epoxy
Styrene-Alkyd Polyester/7781 Fiberglass
Cordo IFRR/7781 (ECDE-1/0) Fiberglass Modified DAP Polyester

The Table and Figure numbers used in this appendix are similar to those in MIL-HDBK-17A. The chapter identification has been changed from 4 to A1 but the rest of all Figure and Table numbers has not been changed. For example, Table A1.40 is the same as Table 4.40 in MIL-HDBK-17A. The MIL-HDBK-17A text describing the test program and methods is reproduced in Sections A1.2 through A1.4.

A1.2 INTRODUCTION

The laminate properties presented in this chapter have been generated in test programs conducted at the U.S. Forest Products Laboratory and elsewhere (Reference A1.2).[1] Properties are given for fiberglass with epoxy, phenolic, silicone and polyester resins and for boron with epoxy. Additional information on these and other material combinations will be issued as supplements or revisions of the present handbook edition.

A1.3 HANDBOOK TEST PROGRAM

A1.3.1 Objectives

The objectives of the handbook test program are to obtain statistically significant data for materials currently in use and to determine the degree of reproducibility attained in their fabrication. A minimum requirement is that test results include data from three sets of panels which are representative of the manufacturing procedures employed by three different fabricators. The properties listed in the charts and Tables of this chapter represent test results from only one set of panels for each material system. Properties are therefore not given minimum values and are considered to be "typical" for each material. When the minimum number of tests has been completed for a material, its properties will be assigned values on a B-basis; that is, the value above which 90 percent of the population of values is expected to fall with a confidence of 95 percent.

A1.3.2 Preimpregnated materials

All test panels are fabricated from prepregs. Emphasis is placed on materials for use as facings in sandwich type structures. The prepregs for facings are normally processed to conform with two methods of sandwich fabrication. These are the laminate grades for two-step sandwich constructions and the controlled flow adhesive grades for one-step sandwich constructions. Only laminates simulating precured facings, that is, for use in two-step sandwiches, have been subjected to the narrow coupon tests listed in this chapter. The controlled flow adhesive prepregs are best tested as sandwich panels, and such testing is not at present included in the handbook program.

The prepreg materials comply with the specifications established by the individual fabricators. In general, the materials are autoclave molding grades with flows controlled to attain minimum bleedout and optimum bonding of the plies. When possible handling characteristics are specified consistent with the objectives of collimated plies in the laminate and the retention of fiber orientation during lay-up and cure.

Imposed tolerances on the gravimetric resin content of the prepregs are dependent on the type of reinforcement. For bidirectional woven broadgoods such as style 7781 fabric, the resin fraction is specified as not varying by more than two percent from the assigned devolatilized resin content. For directionally woven broadgoods such as style 7743 fabric, and nonwoven parallel fiber tapes such as XP251S, variation from the assigned devolatilized resin content is not to exceed three percent.

A1.3.3 Test panels

A minimum size of the test panels has been established as two feet parallel to the warp direction by three feet parallel to the width for woven fabrics. For the non-woven laminates, including unidirectional, crossplied and quasi-isotropic configurations, the three foot dimension is parallel to the fiber direction in the outer plies.

[1] Exceptions are the data for fiberglass-polyester laminates, taken from earlier sources, and the data for boron-epoxy panels which were compiled under special contract and published separately (Reference A1.2).

It is desirable that the test laminates be fabricated so that fiber alignment and orthotropy are maintained and that they are symmetrically balanced. Such conditions are generally attained in the test panels and they are designated in the following data summary Tables as balanced and parallel. One set of panels (Table A1.1) is not balanced. In this case the laminates are parallel plied.

A1.3.4 Test procedures

Conventional uniaxial tests are conducted at constant crosshead rates. The direction parallel to the warp of woven fabrics is designated as the 0° or 1-direction. The direction perpendicular to the 0° direction is designated as the 90° or 2-direction. For non-woven unidirectional laminates, the 0° direction corresponds to the fiber direction. For crossplied and quasi-isotropic laminates, the 0° direction corresponds to the fiber direction in the outer plies.

A1.3.4.1 Tensile tests

Tensile tests for woven fabric laminates have been conducted initially using the method of ASTM D 638 and Type I specimens (Reference A1.3.4.1(a)). Later tests are conducted with a modified specimen (Reference A1.2) and the method is designated as MIL-HDBK-17 tensile test. Tab ended specimens are used to test the 0° tensile properties of the non-woven unidirectional laminates (Reference A1.3.4.1(b)).

A1.3.4.2 Compression tests

Compression tests have been conducted with the end clamped and jig stabilized ASTM D 695 specimen (Reference A1.3.4.2) and with the MIL-HDBK-17 compression specimen (Reference A1.2) in which the specimen and fixture have been modified.

A1.3.4.3 Shear tests

The picture frame method (Reference A1.2) has been used to determine the 0° - 90° shear properties of one material system at three resin fractions (Figure A1.6.3). In these tests it is assumed that 88 percent of the load is reacted by the specimen, while the pins in the fixture react the remainder. The other materials are tested by a modified rail shear method (Reference A1.3.4.3).

A1.3.4.4 Interlaminar shear

Interlaminar shear properties are determined by the short beam test method (Reference A1.3.4.1(b)), or by the method of ASTM D 2733-68T when indicated (Reference A1.3.4.4).

A1.3.4.5 Flexural tests

Flexural properties are determined by the method of ASTM D 790 (Reference A1.3.4.5).

A1.3.4.6 Bearing strength

Bearing strengths are determined by the method of ASTM D 953 (Reference A1.3.4.6).

A1.3.5 Dry conditioning

Specimens are dry conditioned by allowing them to attain equilibrium at 70°F to 75°F and 45 percent to 55 percent relative humidity for a minimum of ten days. When tested at other than room temperature, the dry conditioned specimens are soaked at the test temperature for one-half hour prior to applying load.

A1.3.6 Wet conditioning

Specimens are wet conditioned at 125°F and 95 percent to 100 percent relative humidity for 1000 hours (42 days). When tested at temperatures below freezing, the wet conditioned specimens are cycled four times from the wet condition at 125°F to the sub-freezing test temperature; the dwell time at each temperature being one-half hour. Wet specimens tested at 160°F are soaked for one-half hour at this temperature immediately prior to testing. Some materials are shown as being tested at 220°F after wet conditioning. Such testing has been discontinued since these results appear inconclusive.

A1.3.7 Test schedule

The 0° and 90° tension and compression properties are determined at three Reference temperatures, 65°F, 70°F - 75°F and 160°F, for both dry and wet conditioned specimens. Dry conditioned specimens are tested at maximum temperature for those materials which are potentially serviceable at elevated temperatures. Ten test results are obtained for the stress-strain relations at each of these conditions. Tests at intermediate temperatures are conducted to verify property changes, in which cases five specimens are tested. Ten test results are also required for the 0° - 90° shear at -65°F, 70°F - 75°F, and 160°F in the dry condition. Five tests are conducted at 70°F - 75°F to determine the stress-strain relations for Poisson's ratio. Flexure, bearing and interlaminar shear are determined in the 0° direction and dry condition at -65°F, 70°F - 75°F and 160°F. Five specimens are tested for each temperature.

A1.4 DATA PRESENTATION

Uniaxial tension, compression and shear are shown as stress-strain relations at each temperature and the properties are summarized in tabular form. Flexural, bearing and interlaminar shear properties are listed in summary Tables. Poisson's ratio is shown as the response of the 0° elongation and 90° contraction to the applied tensile stress.

When ten or more results are available at a test condition, average values and the associated standard deviations are given in the Tables. Stress-strain relations are plotted as an average curve and a plot of the average minus three times the standard deviation is also shown. When five to nine results are obtained from a test condition, average, maximum, and minimum values and curves are shown.

A1.4.1 Epoxy-fiberglass laminates

All data on fiberglass-epoxy systems are results obtained from the handbook test program. Properties are summarized in Tables A1.1 through A1.8. Detailed data are shown in Figures A1.1.1(a) through A1.8.5. [Four of the nine materials are known to be available.]

A1.4.2 Phenolic-fiberglass laminates

Handbook tested properties are summarized in Table A1.40 and Figures A1.40.1(a) through A1.40.5 for one fiberglass-phenolic system. [This material is available.]

A1.4.3 Silicone-fiberglass laminates

Partial handbook test results were listed in MIL-HDBK-17A for one fiberglass-silicone system. [This material is not available]

A1.4.4 Polyester-fiberglass laminates

Previous data for fiberglass-polyester laminates were listed in MIL-HDBK-17A. [None of these materials are known to be available.]

A1.4.5 Boron-epoxy laminates

Data on two boron-epoxy systems have been abstracted from the literature (Reference A1.4.5) and are presented in Tables A1.110 and A1.111 and in Figures A1.110.1(a) through A1.111.3. [One of these materials is available.]

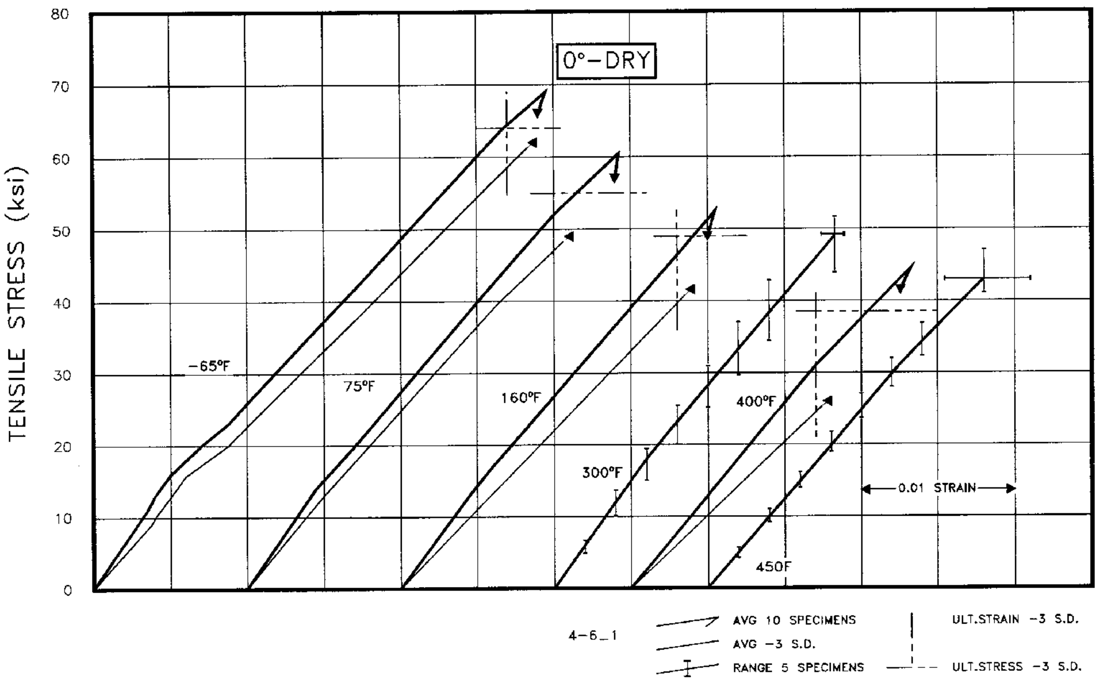
The laminate thickness is controlled by the number of plies in the construction and the desired resin content. In general, the thickness of woven fabric laminates is maintained at eight plies, except for low resin content laminates which may require as many as ten plies. Nonwoven laminate monolayers are constructed with six plies to reduce the shear lag apparent in testing, and eight plies for the crossplied and quasi-isotropic panels.

TABLE A1.1 *Summary of Mechanical Properties of U.S. Polymeric E-720E/7781 (ECDE-1/0-550) Fiberglass Epoxy*

Fabrication	Lay-up: Parallel	Vacuum: None	Pressure: 55-65 PSI	Bleedout: Edge & Vertical	Cure: 2 hr/350°F	Postcure: 4 hrs/400°F	Plies: 8
Physical Properties	Weight Percent Resin: 34.9	Avg. Specific Gravity: 1.78	Avg. Percent Voids: 2.0	Avg. Thickness: 0.082 inches			
Test Methods	Tension: ASTM D 638 TYPE-1	Compression: MIL-HDBK-17	Shear: Rail	Flexure: ASTM D 790	Bearing: ASTM D 953	Interlaminar Shear: Short Beam	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	69.2	1.6	69.1	1.7	60.4	1.7	55.7	1.5	52.5	1.0	42.9	0.8	44.8	2.0
	90°	56.0	2.0	56.5	2.0	49.0	1.8	45.9	1.4	42.3	1.2	36.9	1.1	34.9	1.6
ultimate strain, %	0°	2.93	0.08	2.70	0.11	2.43	0.14	2.12	0.08	2.05	0.08	1.61	0.06	1.80	0.20
	90°	2.92	0.22	2.54	0.19	2.33	0.09	2.04	0.09	1.98	0.08	1.70	0.13	1.72	0.22
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°	3.30		3.38		3.12		3.12		2.95		2.76		2.60	
	90°	2.90		3.02		2.82		2.78		2.50		2.65		2.30	
secondary modulus, 10^6 psi	0°	2.30		2.85		2.45		2.50		2.46		2.37			
	90°	1.90		1.74		2.05		2.19		2.01		1.97			
Compression															
ultimate stress, ksi	0°	77.1	4.0	75.0	3.7	64.8	2.9	57.3	3.8	54.0	1.4	46.2	1.4	23.8	2.2
	90°	57.2	2.7	53.9	2.7	50.2	2.9	45.2	2.4	40.8	2.9	36.2	3.1	14.7	1.6
ultimate strain, %	0°	2.48	0.16	2.44	0.15	2.14	0.11	1.99	0.09	1.86	0.08	1.62	0.06	1.12	0.22
	90°	1.93	0.16	1.81	0.19	1.70	0.14	1.58	0.14	1.46	0.17	1.37	0.15	0.91	0.08
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°	3.50		3.45		3.25		3.10		3.15		3.03		2.45	
	90°	3.20		3.26		3.21		3.03		2.99		2.85		1.85	
Shear															
ultimate stress, ksi	0°-90°	17.5				14.3	0.6			11.2					
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°	115.6	119.4	111.5	91.7	93.4	90.3	69.4	71.1	67.2
proportional limit, ksi	0°	88.1	100.7	77.5	32.5	36.2	30.8	56.2	62.8	49.4
initial modulus, 10^6 psi	0°	2.87	2.91	2.74	3.21	3.36	3.03	2.81	2.87	2.76
Bearing										
ultimate stress, ksi	0°	74.1	78.4	70.7	60.8	64.4	58.2	50.0	53.0	47.9
stress at 4% elong., ksi	0°	32.1	34.8	29.1	23.9	34.2	20.1	18.1	21.5	15.9
Interlaminar Shear										
ultimate stress, ksi	0°	7.09	7.36	6.80	5.90	6.07	5.72	6.05	6.16	5.91



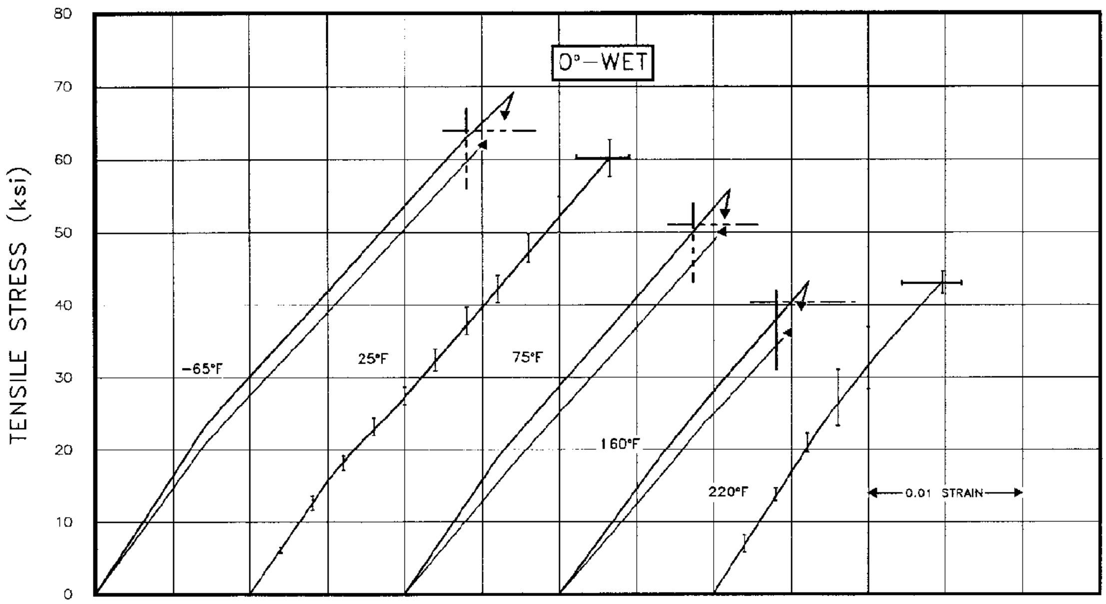


FIGURE A1.1.1(a) *Tensile stress-strain for E-720E/7781 fiberglass epoxy loaded in the 0° direction.*

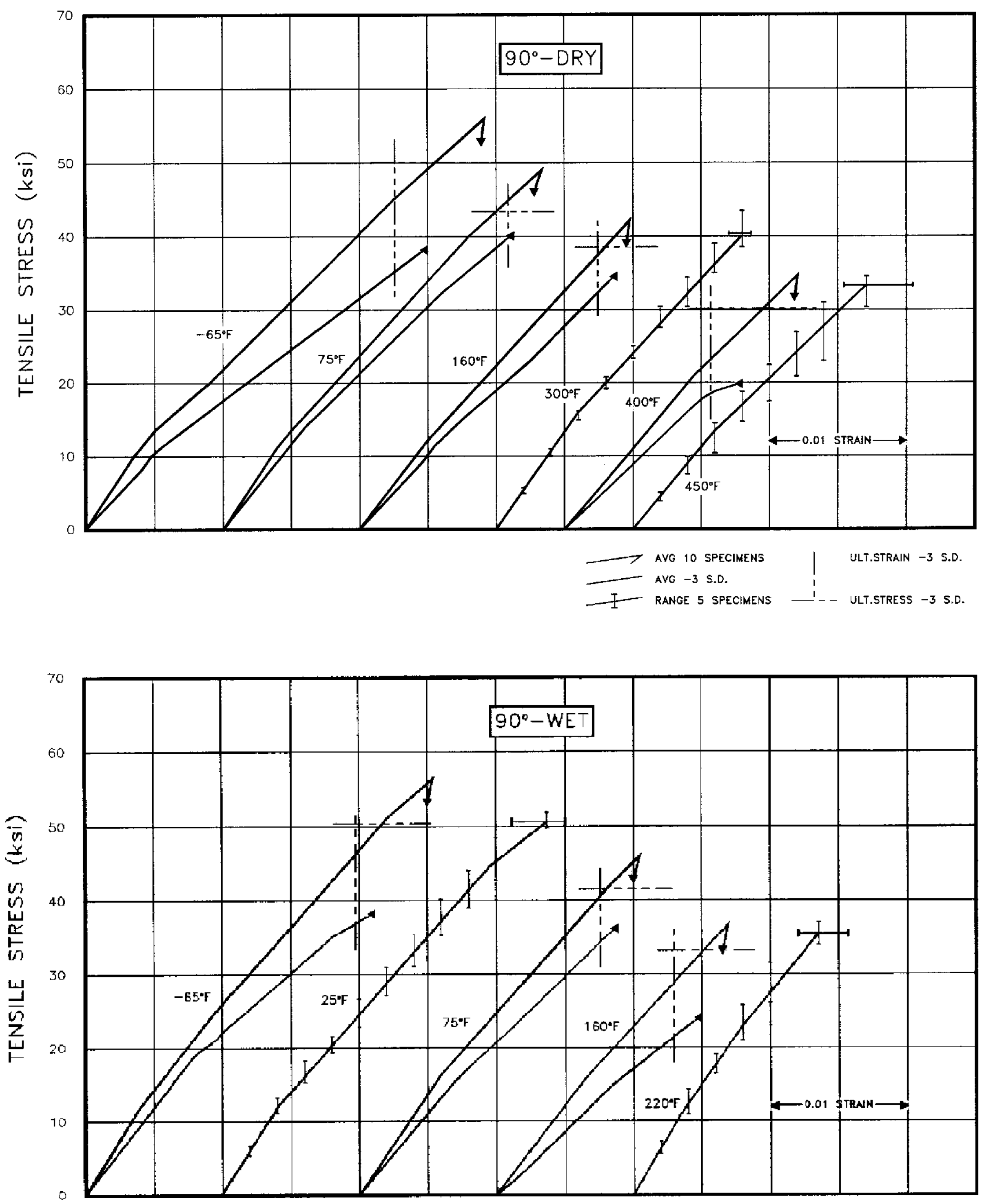


FIGURE A1.1.1(b) *Tensile stress-strain for E-720E/7781 fiberglass epoxy loaded in the 90° direction.*

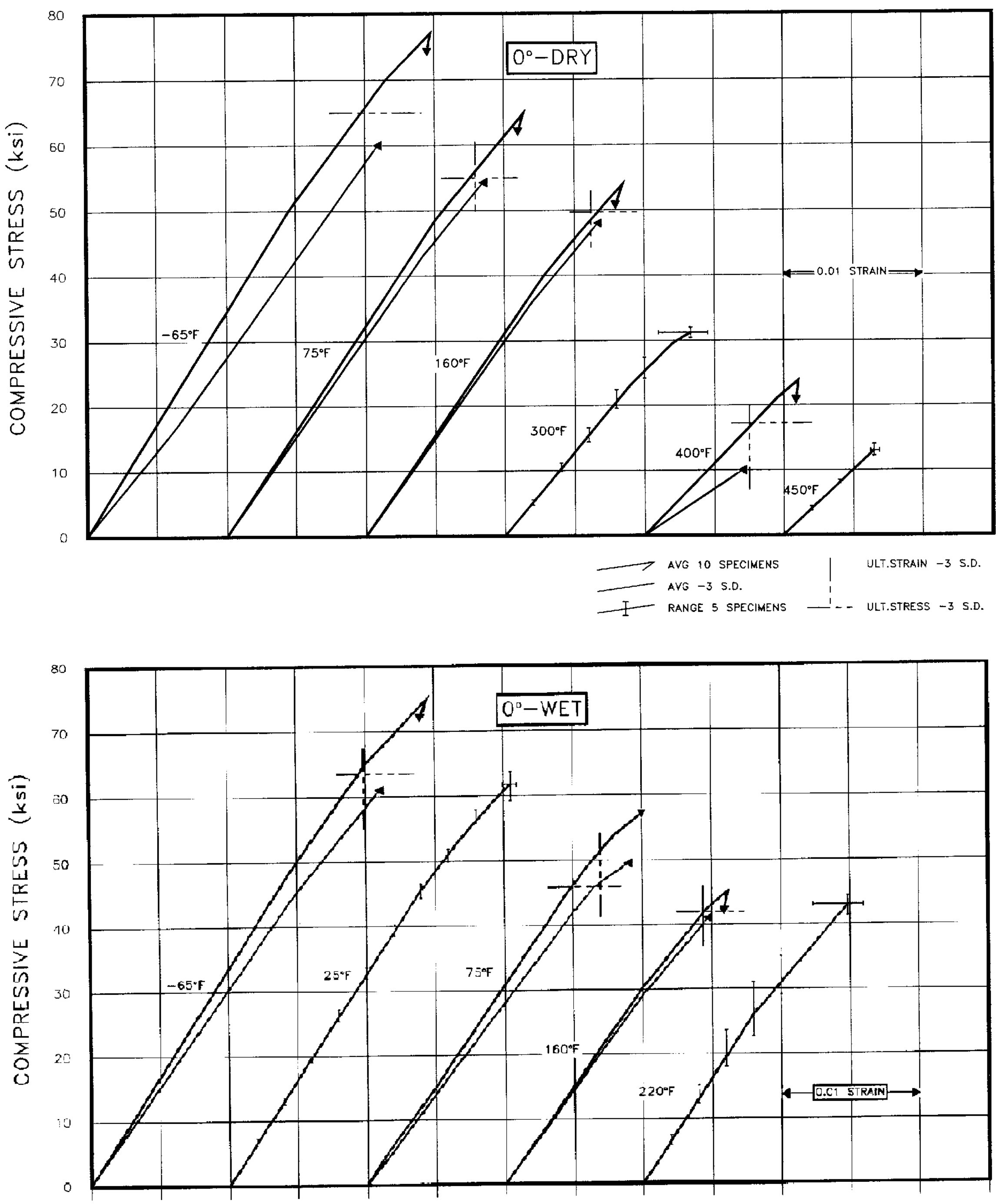


FIGURE A1.1.2(a) *Compressive stress-strain for E-720E/7781 fiberglass epoxy loaded in the 0° direction.*

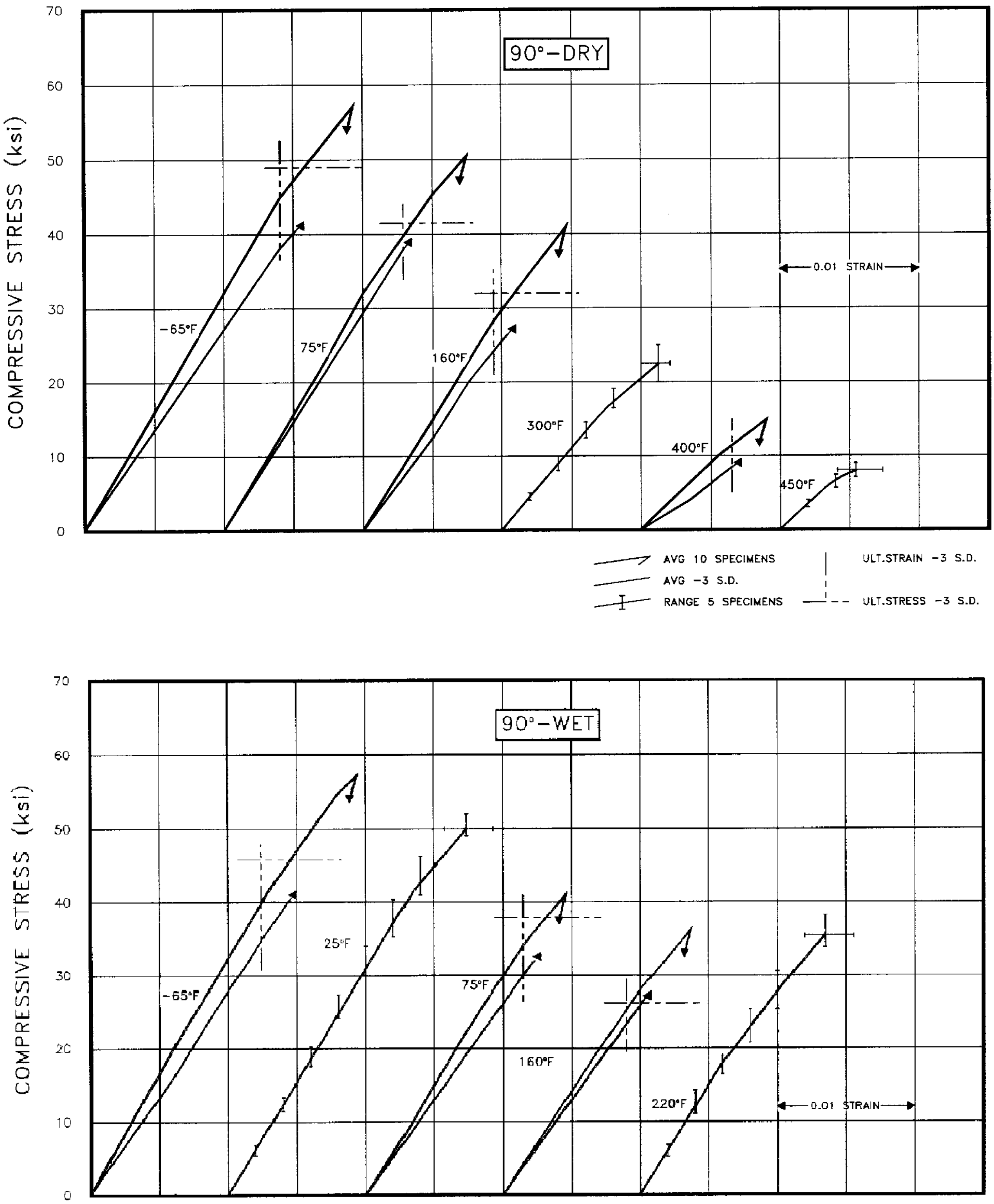


FIGURE A1.1.2(b) *Compressive stress-strain for E-720E/7781 fiberglass epoxy loaded in the 90° direction.*

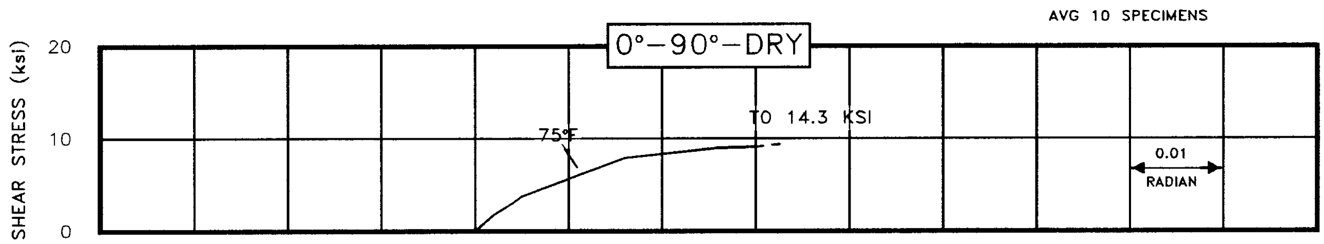


FIGURE A1.1.3 *0° - 90° rail shear for E-720E/7781 fiberglass.*

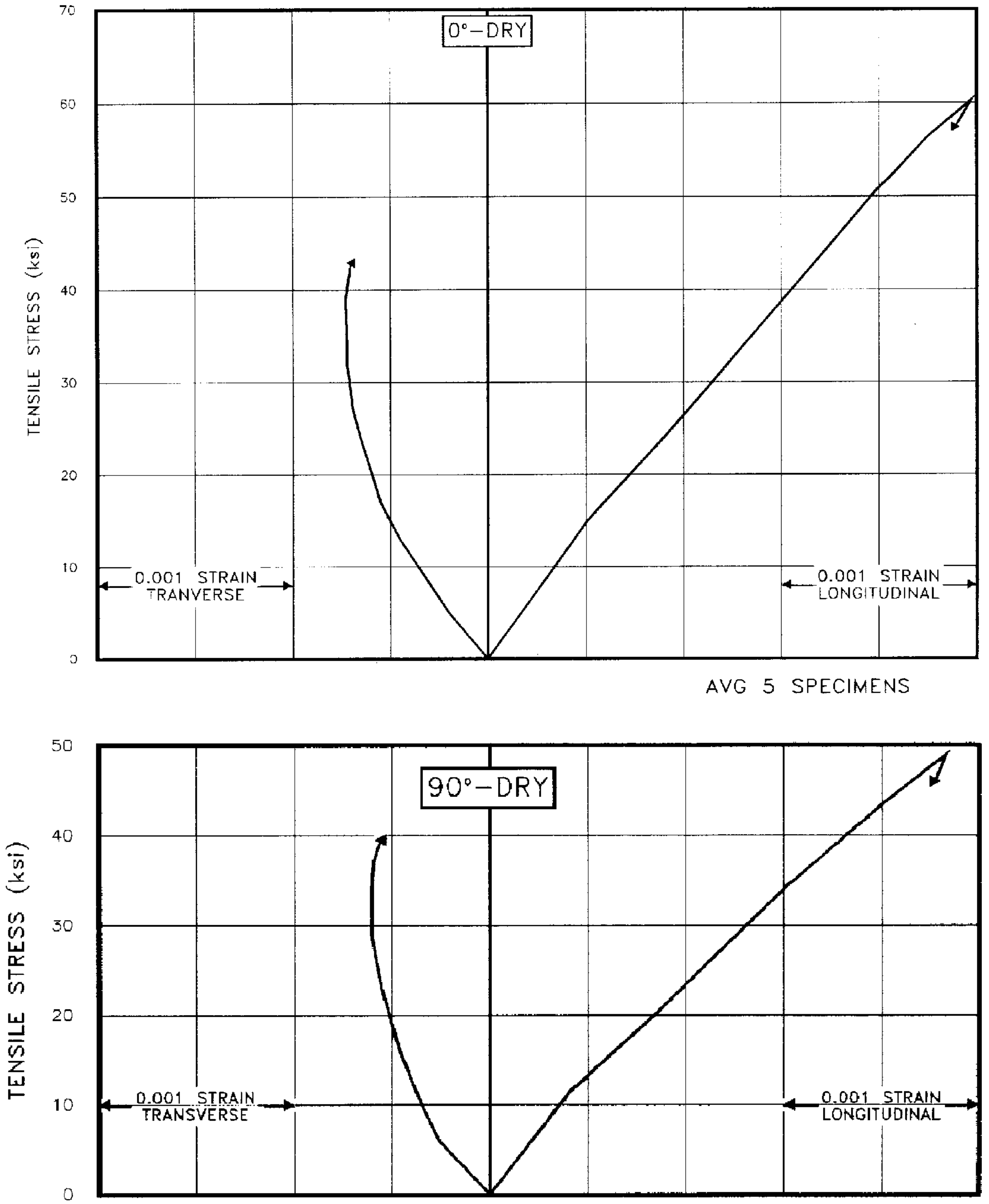


FIGURE A1.1.4 *Poisson effects for E-720E/7781 fiberglass epoxy.*

TABLE A1.3 *Summary of Mechanical Properties of Hexcel F-161/7743(550) Fiberglass Epoxy.*

Fabrication	Lay-up: Balanced	Vacuum: 14 psi	Pressure: 35 psi	Bleedout: Pinched Edge	Cure: 2 hr/350°F	Postcure: 2 hr/350°F	Plies: 8
Physical Properties	Weight Percent Resin: 32.4 v_f = 0.496	Avg. Specific Gravity: 1.85	Avg. Percent Voids: 3.0	Avg. Thickness: 0.086 inches			
Test Methods	Tension: ASTM-D638 TYPE 1	Compression: MIL-HDBK-17	Shear: Rail	Flexure: ASTM-D790	Bearing: ASTM-D953	Interlaminar Shear: Short Beam	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	111.3	1.12	107.3	3.60	95.5	7.57	87.3	5.2	80.9	4.05	71.7	2.73	74.5	5.90
	90°	9.84	0.78	9.42	0.59	8.15	0.40	7.27	0.28	6.78	0.18	6.16	0.21	6.59	0.41
ultimate strain, %	0°	2.10	0.31	2.11	0.10	1.88	0.10	1.72	0.17	1.56	0.15	1.35	0.12	1.64	0.09
	90°	2.43	0.25	2.03	0.21	1.82	0.23	1.20	0.28	1.26	0.19	0.61	0.13	1.44	0.19
proportional limit, ksi	0°	86.2		87.8		74.7		81.5		64.0		65.4		61.0	
	90°	5.6		5.0		5.2		4.8		5.0		5.0		3.0	
initial modulus, 10^6 psi	0°	5.42		5.35		5.30		5.55		5.36		5.47		4.52	
	90°	1.61		1.73		1.73		1.41		1.11		1.30		0.74	
secondary modulus, 10^6 psi	0°					5.15									
	90°					0.09									
Compression															
ultimate stress, ksi	0°	95.0	7.42	89.7	7.0	75.9	5.43	67.4	4.43	66.3	5.53	55.0	2.80	26.7	1.93
	90°	40.3	1.93	37.6	2.93	32.1	2.87	30.4	1.27	27.4	1.93	23.0	1.30	8.3	0.90
ultimate strain, %	0°	1.90	0.11	1.83	0.14	1.58	0.11	1.36	0.11	1.47	0.08	1.22	0.06	0.68	0.08
	90°	2.57	0.16	2.46	0.25	2.51	0.19	2.38	1.90	2.58	0.22	2.53	0.30	1.62	0.12
proportional limit, ksi	0°	83.0		70.0		52.2		49.8		55.6		40.8		20.0	
	90°	18.1		15.0		11.9		10.6		9.2		8.2			
initial modulus, 10^6 psi	0°	5.02		4.98		4.96		5.09		4.59		4.66		4.12	
	90°	1.91		1.88		1.65		1.77		1.46		1.37			
Shear															
ultimate stress, ksi	0°-90°	12.5				9.2	0.2			7.7					
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°	203.0	210.0	196.0	160.0	163.0	155.0	138.0	142.0	135.0
proportional limit, ksi	0°	153.0	158.0	147.0	127.0	139.0	116.0	116.0	118.0	112.0
initial modulus, 10^6 psi	0°	5.71	5.80	5.63	5.18	5.27	5.10	5.43	5.46	5.32
Bearing										
ultimate stress, ksi	0°	79.4	90.2	64.8	58.8	63.2	52.7	53.7	57.5	50.6
stress at 4% elong., ksi	0°	37.9	45.6	31.5	23.0	27.1	19.5	21.9	23.6	20.5
Interlaminar Shear										
ultimate stress, ksi	0°	9.55	10.15	8.72	9.35	9.55	9.17	8.31	8.65	8.02

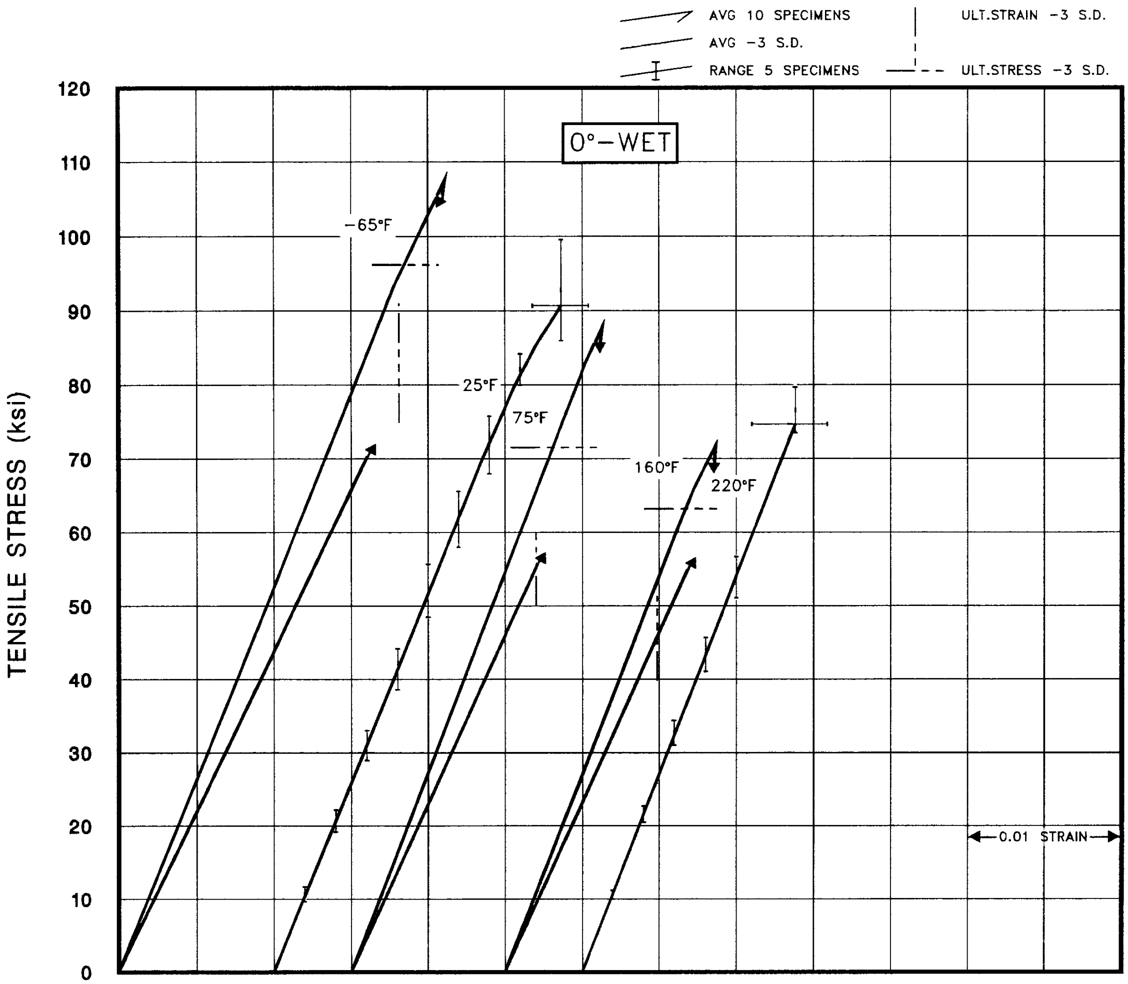


FIGURE A1.3.1(a) *Tensile stress-strain for F-161/7743 fiberglass epoxy loaded in the 0° direction,* continued on next page.

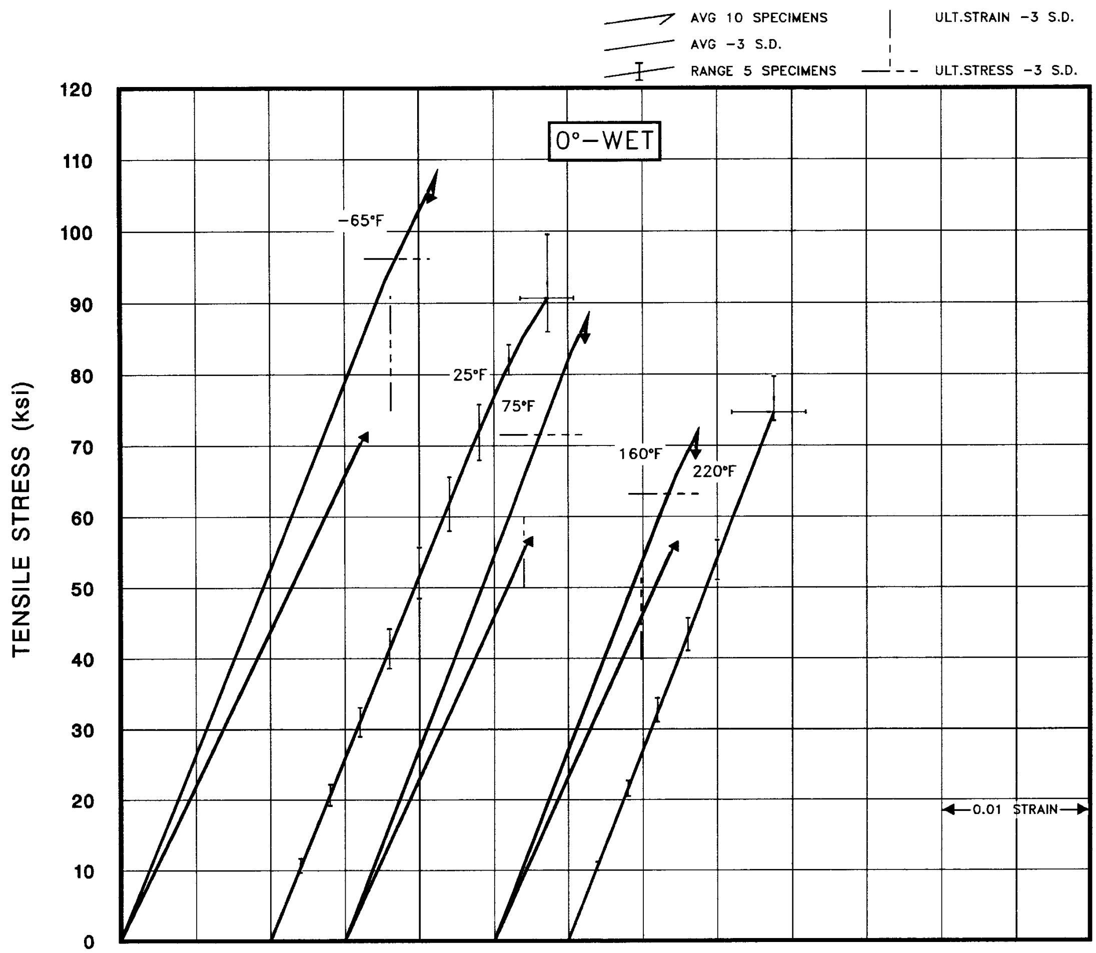


FIGURE A1.3.1(a) *Tensile stress-strain for F-161/7743 fiberglass epoxy loaded in the 0° direction,* concluded.

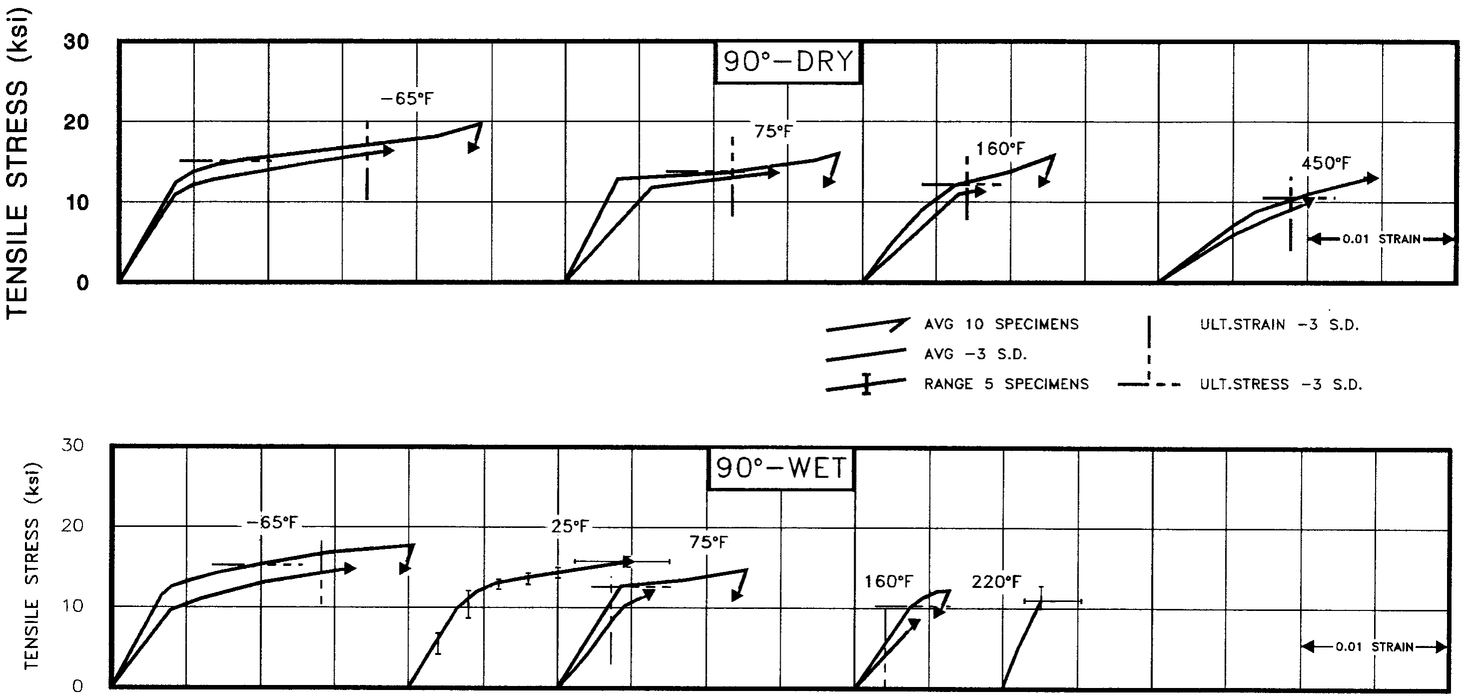


FIGURE A1.3.1(b) *Tensile stress-strain for F-161/7743 fiberglass epoxy loaded in the 90° direction.*

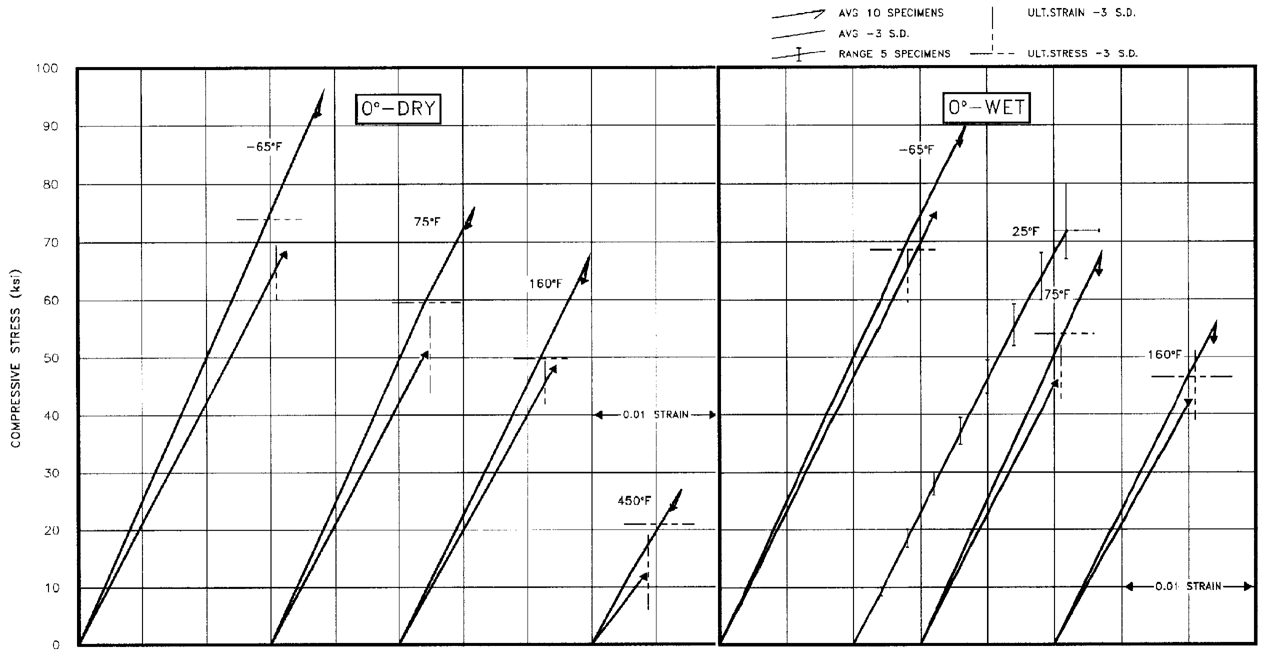


FIGURE A1.3.2(a) *Compressive stress-strain for F-161/7743 fiberglass epoxy loaded in the 0° direction.*

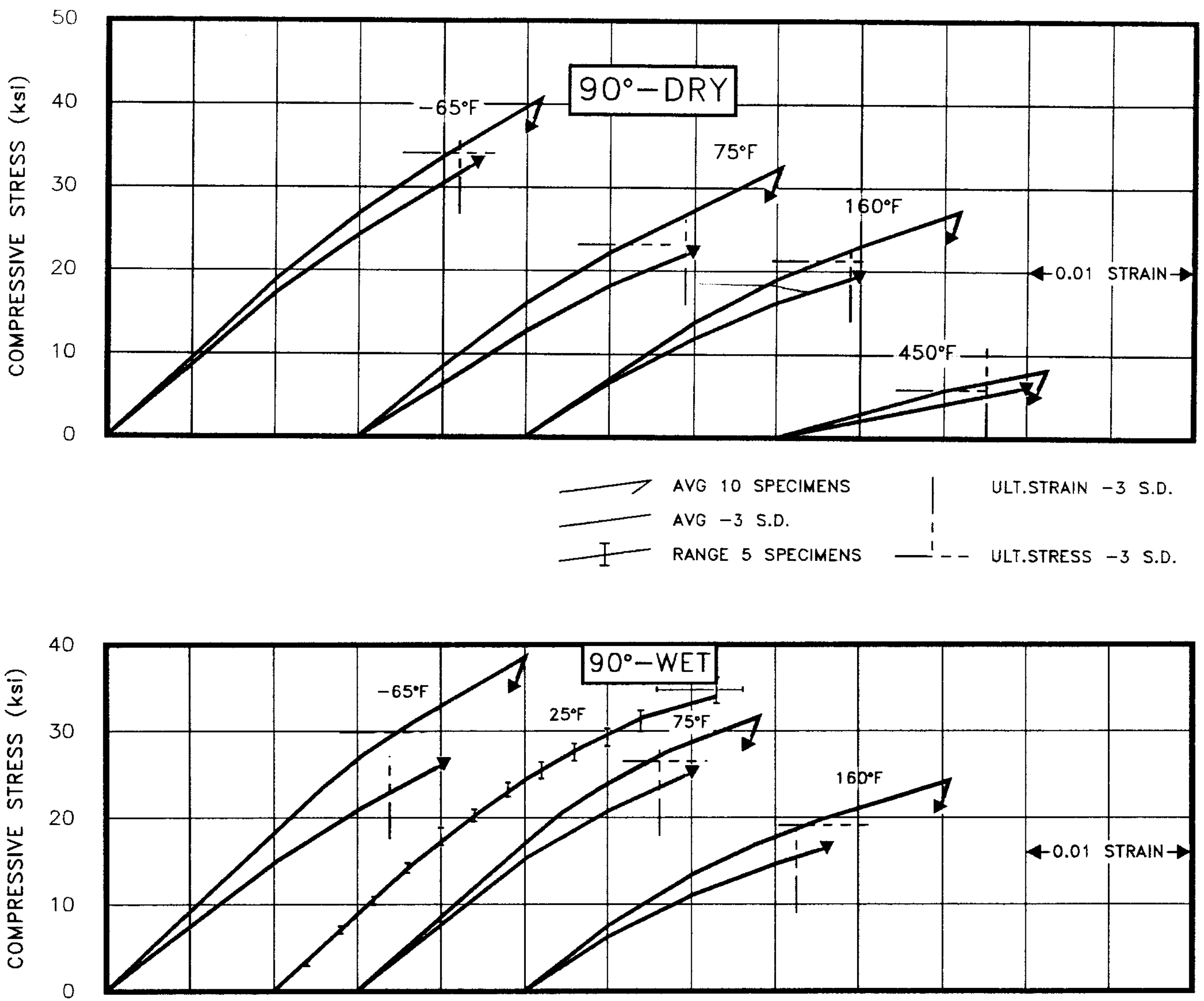


FIGURE A1.3.2(b) *Compressive stress-strain F-161/7743 fiberglass epoxy loaded in the 90° direction.*

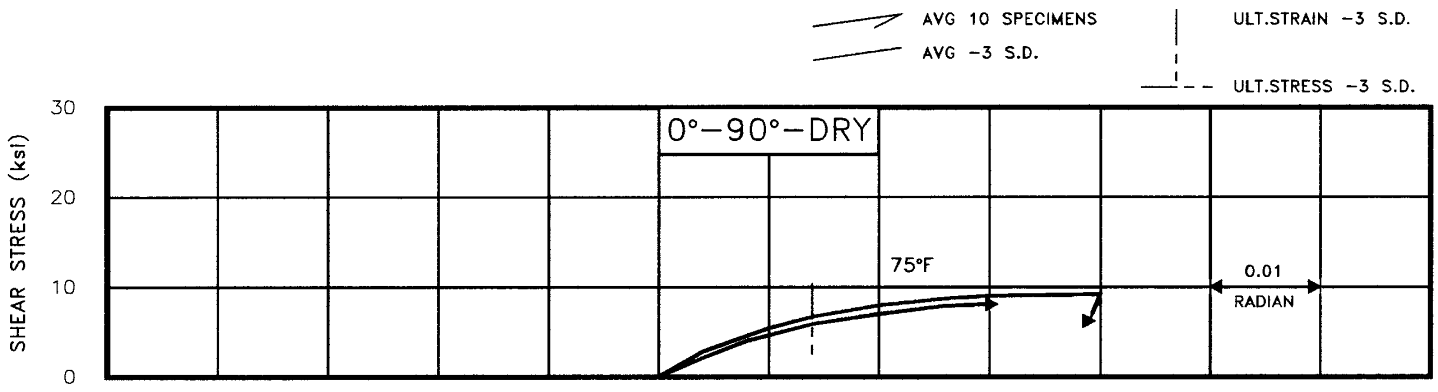


FIGURE A1.3.3 *0° - 90° rail shear for F-161/7743 fiberglass epoxy.*

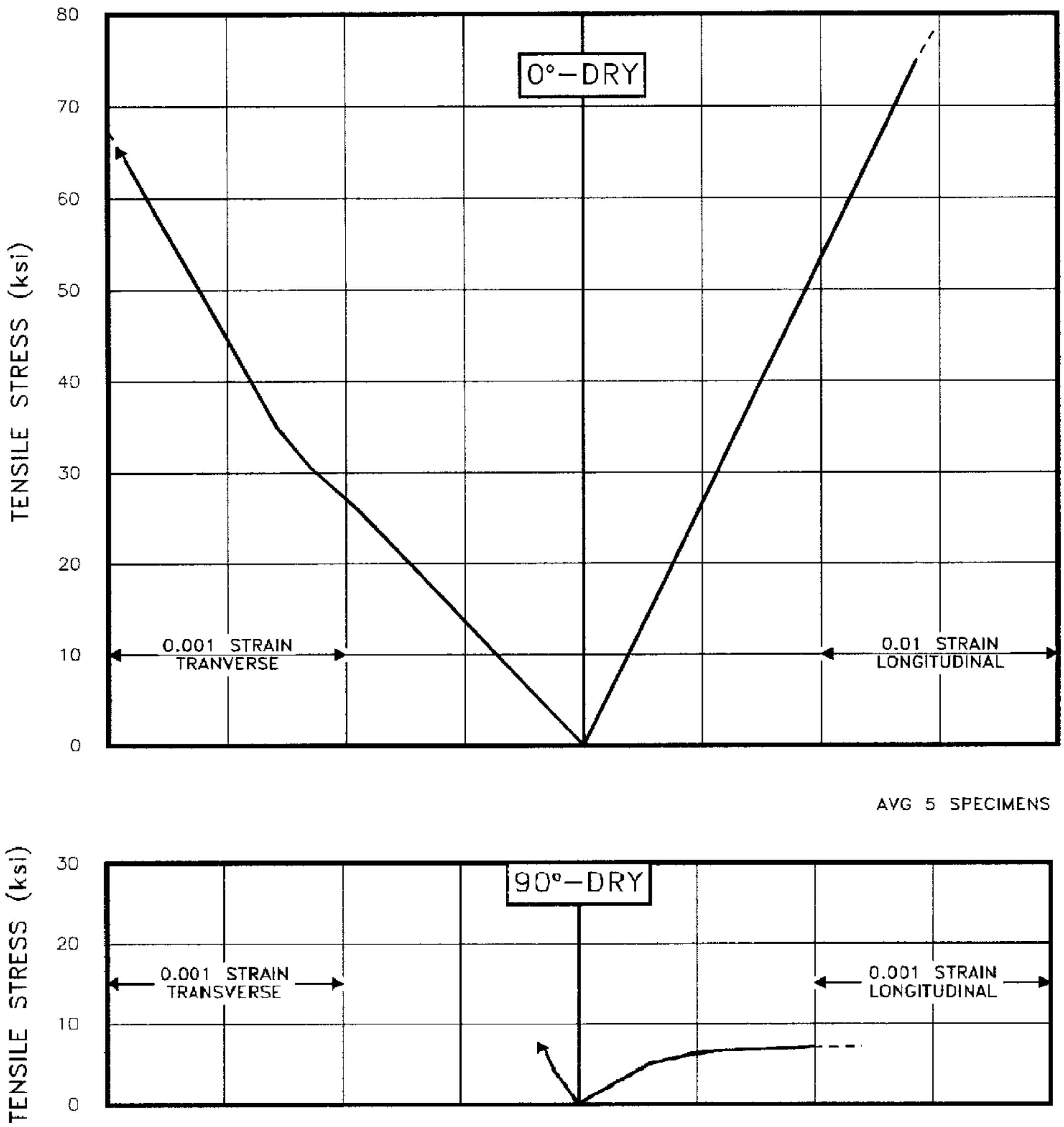


FIGURE A1.3.4 *Poisson effects for F-161/7743 fiberglass epoxy.*

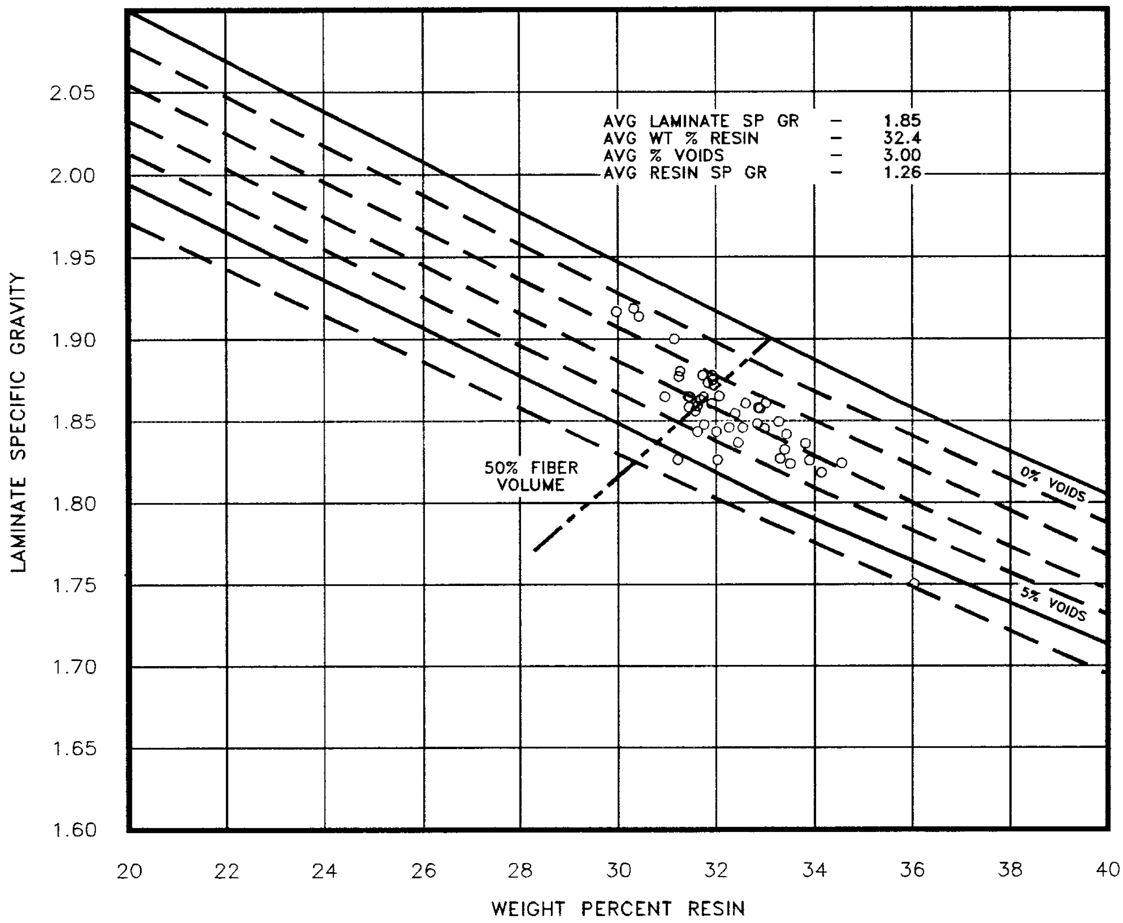


FIGURE A1.3.5 *Voids vs. resin content and specific gravity for F-161/7743 fiberglass epoxy.*

TABLE A1.4 *Summary of Mechanical Properties of Hexcel F-161/7781 (ECDE-1/0-550) Fiberglass Epoxy (26% Resin)*

Fabrication	Lay-up: Balanced	Vacuum: None	Pressure: 55-65 psi	Bleedout: Vertical and Stepped Edge	Cure: 1 hr/350°F	Postcure: 2 hr/300°F 2.5 hr/400°F	Plies: 8 and 10
Physical Properties	Weight Percent Resin: 26.0 v_f = 0.59	Avg. Specific Gravity: 2.01	Avg. Percent Voids: 0.5	Avg. Thickness: 0.008 inch/ply			
Test Methods	Tension: MIL-HDBK-17	Compression: MIL-HDBK-17	Shear: Picture Frame	Flexure: ASTM-D790	Bearing:	Interlaminar Shear: ASTM-D2345	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	92.4	5.16	80.5	10.87			61.4	3.20	65.7	3.03	50.7	5.72	59.8	3.81
	90°	67.8	10.65	62.3	5.01			50.3	2.61	53.6	5.19	46.2	2.69	35.2	5.16
ultimate strain, %	0°	2.86	2.11	2.37	0.31			1.78	0.13	1.97	0.14	1.58	0.19	1.96	0.08
	90°	2.42	3.14	1.97	0.24			1.65	0.08	1.88	0.12	1.55	0.10	1.38	0.13
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°	4.42		4.49				4.10		3.92		3.72		3.27	
	90°	4.22		4.21				3.76		3.17		3.38		2.86	
secondary modulus, 10^6 psi	0°	3.32		3.14				3.06		3.24		3.07		2.94	
	90°	2.70		2.74				2.62		2.72		2.55		2.46	
Compression															
ultimate stress, ksi	0°	73.2	6.83	74.0	5.02			57.3	4.0	48.9	3.50	44.7	3.25	28.8	3.03
	90°	64.2	3.19	55.8	4.40			37.5	2.28	42.0	2.64	40.1	1.90	18.9	0.69
ultimate strain, %	0°	1.70	0.42	1.65	0.28			1.09	0.17	1.12	0.15	0.84	0.14	0.79	0.03
	90°	1.40	0.14	1.42	0.27			1.26	0.41	1.14	0.23	1.22	0.18	0.71	0.27
proportional limit, ksi	0°	39.0		46.0				42.0		41.0		24.0		15.0	
	90°	28.0		41.0				24.0		36.0		21.0		11.0	
initial modulus, 10^6 psi	0°	4.42		4.47				4.27		4.05		3.94		3.73	
	90°	4.02		4.19				4.12		3.68		3.40		3.07	
Shear															
ultimate stress, ksi	0°-90°	20.1	2.3					16.0	1.64	13.4	1.28				
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°				94.10	96.86	89.64			
proportional limit, ksi	0°									
initial modulus, 10^6 psi	0°									
Bearing										
ultimate stress, ksi	0°									
stress at 4% elong., ksi	0°									
Interlaminar Shear										
ultimate stress, ksi	0°				5.56	5.65	5.50			

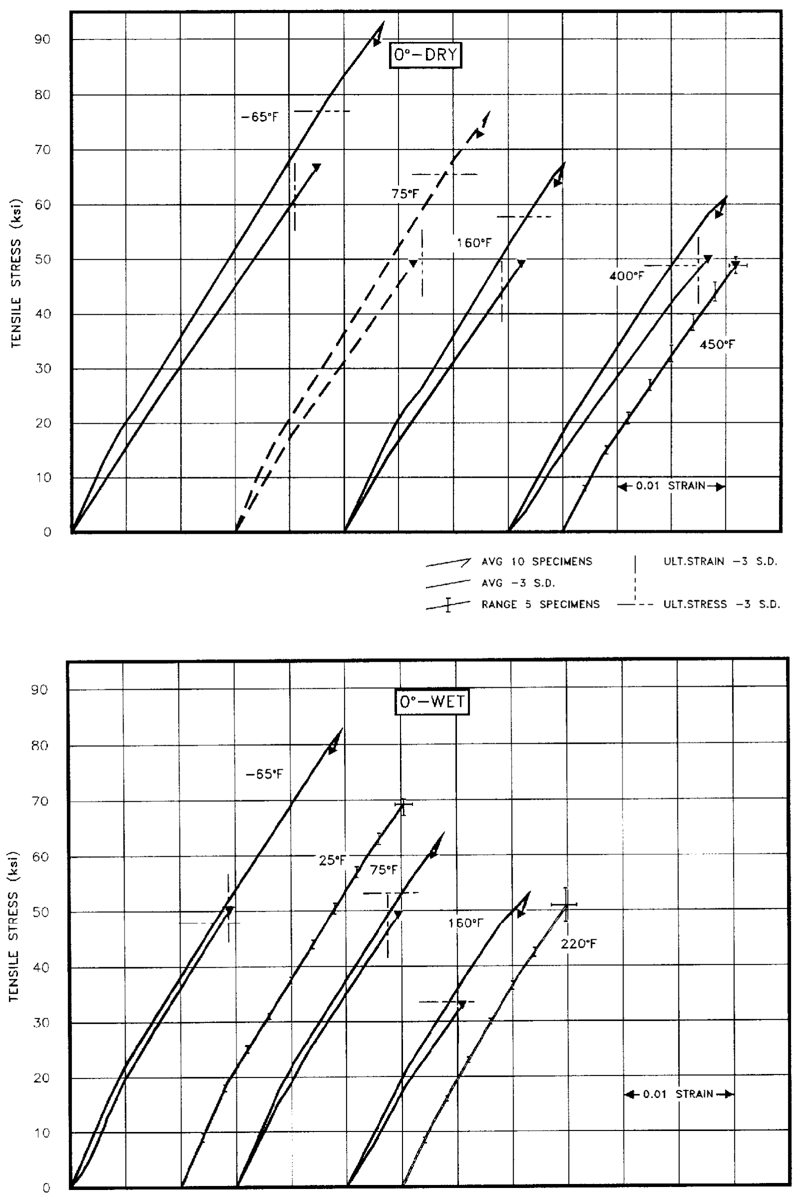


FIGURE 1.4.1(a) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (26% resin).*

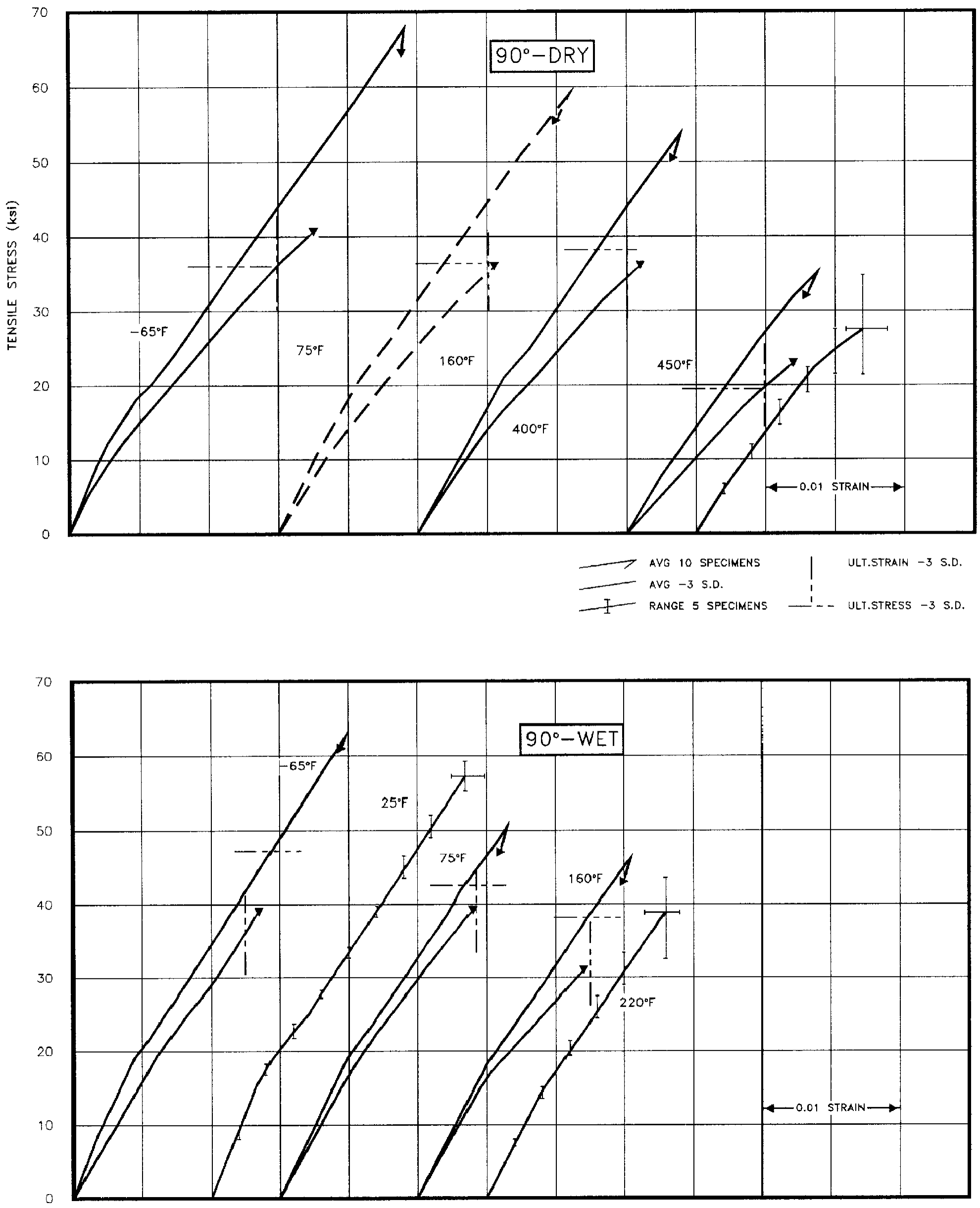


FIGURE 1.4.1(b) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (26% resin).*

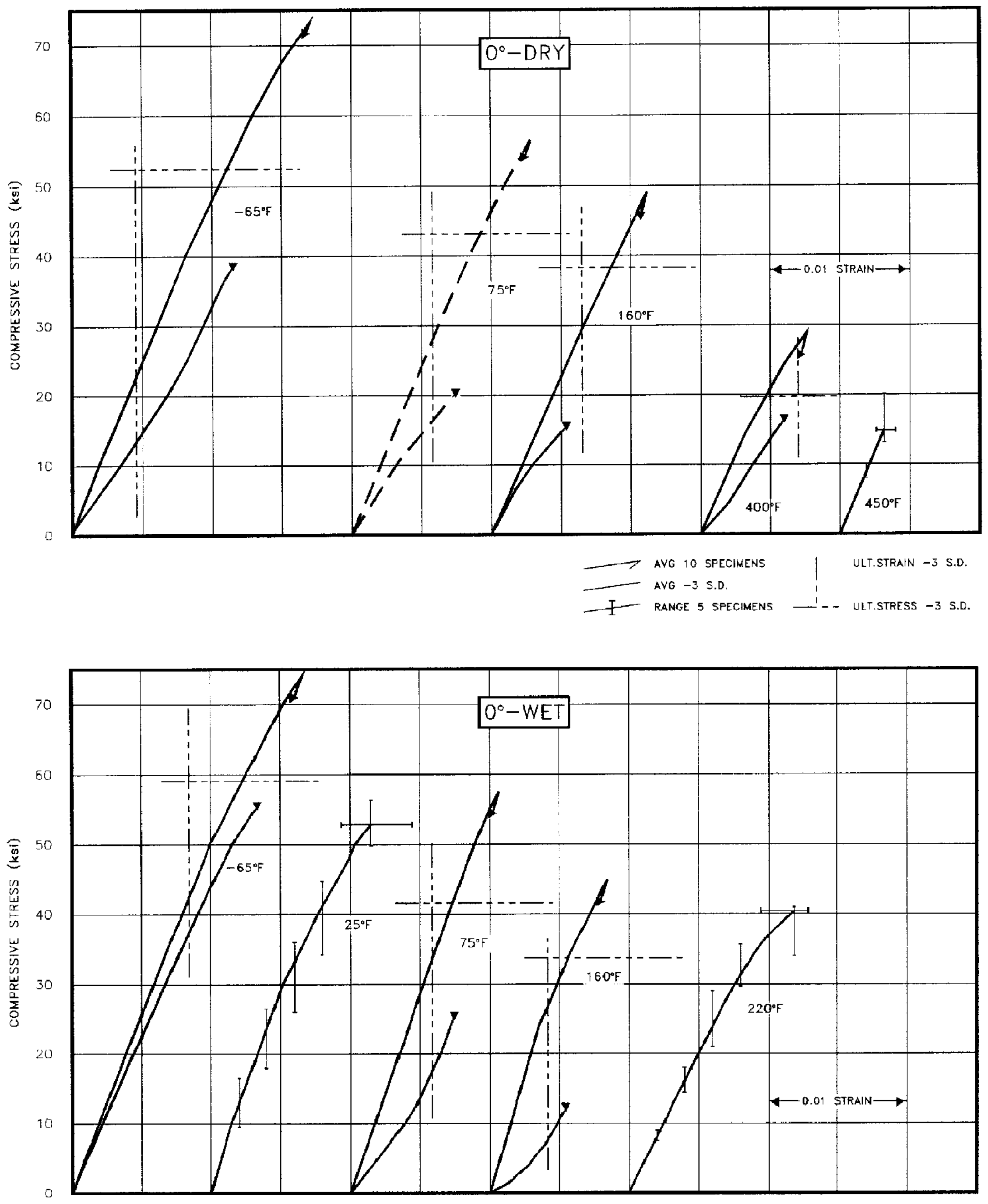


FIGURE A1.4.2(a) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (26% resin.)*

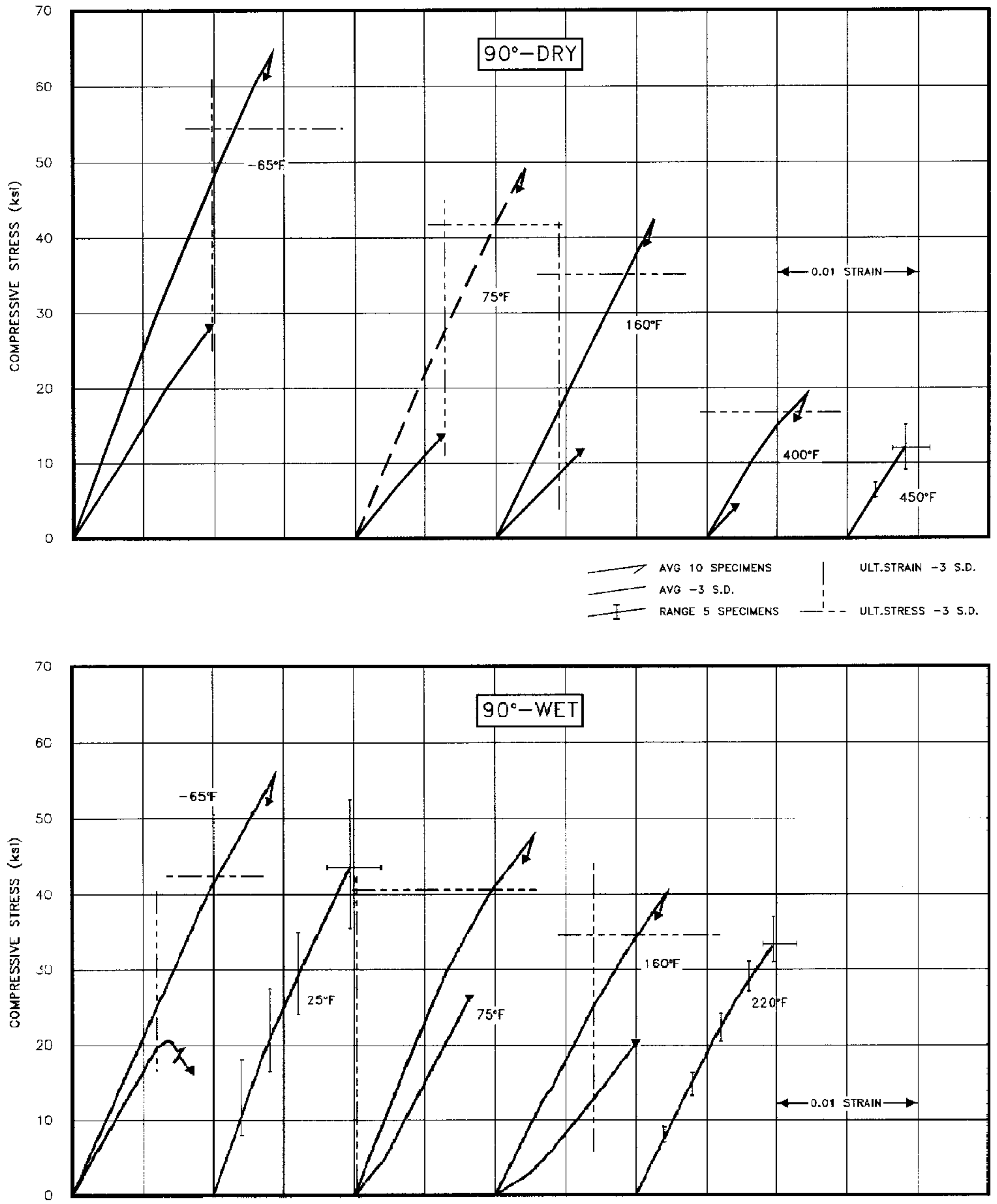


FIGURE A1.4.2(b) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (26% resin).*

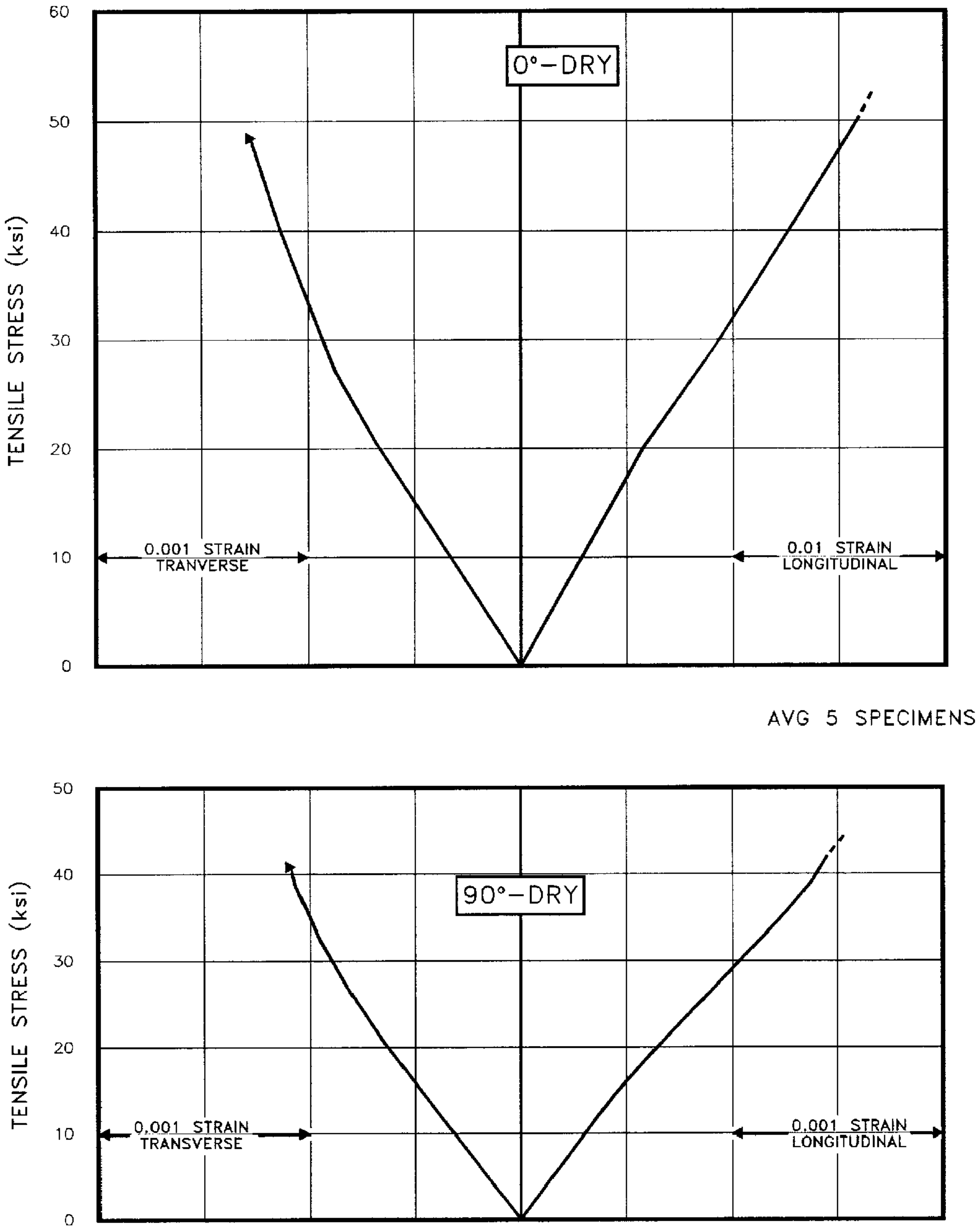


FIGURE A1.4.4 *Poisson effects for F-161/7781 fiberglass epoxy (26% resin).*

TABLE A1.5 *Summary of Mechanical Properties of Hexcel F-161/7781 (ECDE-1/0-550) Fiberglass Epoxy (31% Resin)*

Fabrication	Lay-up: Balanced	Vacuum: None	Pressure: 55-65 psi	Bleedout: Vertical and Stepped Edge	Cure: 1 hr/350°F	Postcure: 2 hr/300°F 2.5 hr/400°F	Plies: 8 and 10
Physical Properties	Weight Percent Resin: 31.0	Avg. Specific Gravity: 1.92	Avg. Percent Voids: 0.6	Avg. Thickness: 0.009 inch/ply			
Test Methods	Tension: MIL-HDBK-17	Compression: MIL-HDBK-17	Shear: Picture Frame	Flexure: ASTM-D790	Bearing:	Interlaminar Shear:	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	85.2	4.68	82.3	4.97			64.0	2.04	60.1	3.75	51.4	4.23	47.3	4.87
	90°	70.0	5.24	67.9	2.98			53.5	2.91	49.3	0.95	39.8	3.50	31.0	1.95
ultimate strain, %	0°	2.93	0.14	2.53	0.18			2.10	0.06	2.02	0.10	1.66	0.17	1.66	0.18
	90°	2.50	0.21	2.41	0.22			1.90	0.11	1.86	0.06	1.47	0.09	1.25	0.09
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°	4.22		4.30				3.84		3.69	3.72	3.65		3.09	
	90°	3.97		4.15				3.68		3.37	3.34	3.30		2.75	
secondary modulus, 10^6 psi	0°	3.13		3.01				3.03		2.97	0.04	2.88		2.94	
	90°	2.62		2.96				2.62		2.55	0.25	2.46		2.47	
Compression															
ultimate stress, ksi	0°	73.1	5.18	66.0	10.75			54.4	7.04	50.6		45.9	5.39	32.8	6.04
	90°	58.4	3.17	57.5	11.56			47.3	4.73	42.2		38.7	4.19	25.8	8.27
ultimate strain, %	0°	1.86	0.21	1.72	0.32			1.33	0.28	1.52		1.04	0.23	0.95	0.24
	90°	1.61	0.29	1.44	0.36			1.10	0.21	1.30		0.99	0.22	0.87	0.28
proportional limit, ksi	0°	44.0		38.0				33.0		32.0		25.0		16.0	
	90°	33.0		33.0				30.0		--		21.0		15.0	
initial modulus, 10^6 psi	0°	3.90		4.04				4.03		3.42		4.06		3.50	
	90°	3.56		3.84				3.96		3.23		4.01		3.07	
Shear															
ultimate stress, ksi	0°-90°	20.5	2.23					15.9	0.72	13.7	0.82				
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°				90.23	93.74	87.29			
proportional limit, ksi	0°									
initial modulus, 10^6 psi	0°									
Bearing										
ultimate stress, ksi	0°									
stress at 4% elong., ksi	0°									
Interlaminar Shear										
ultimate stress, ksi	0°				5.56	5.65	5.50			

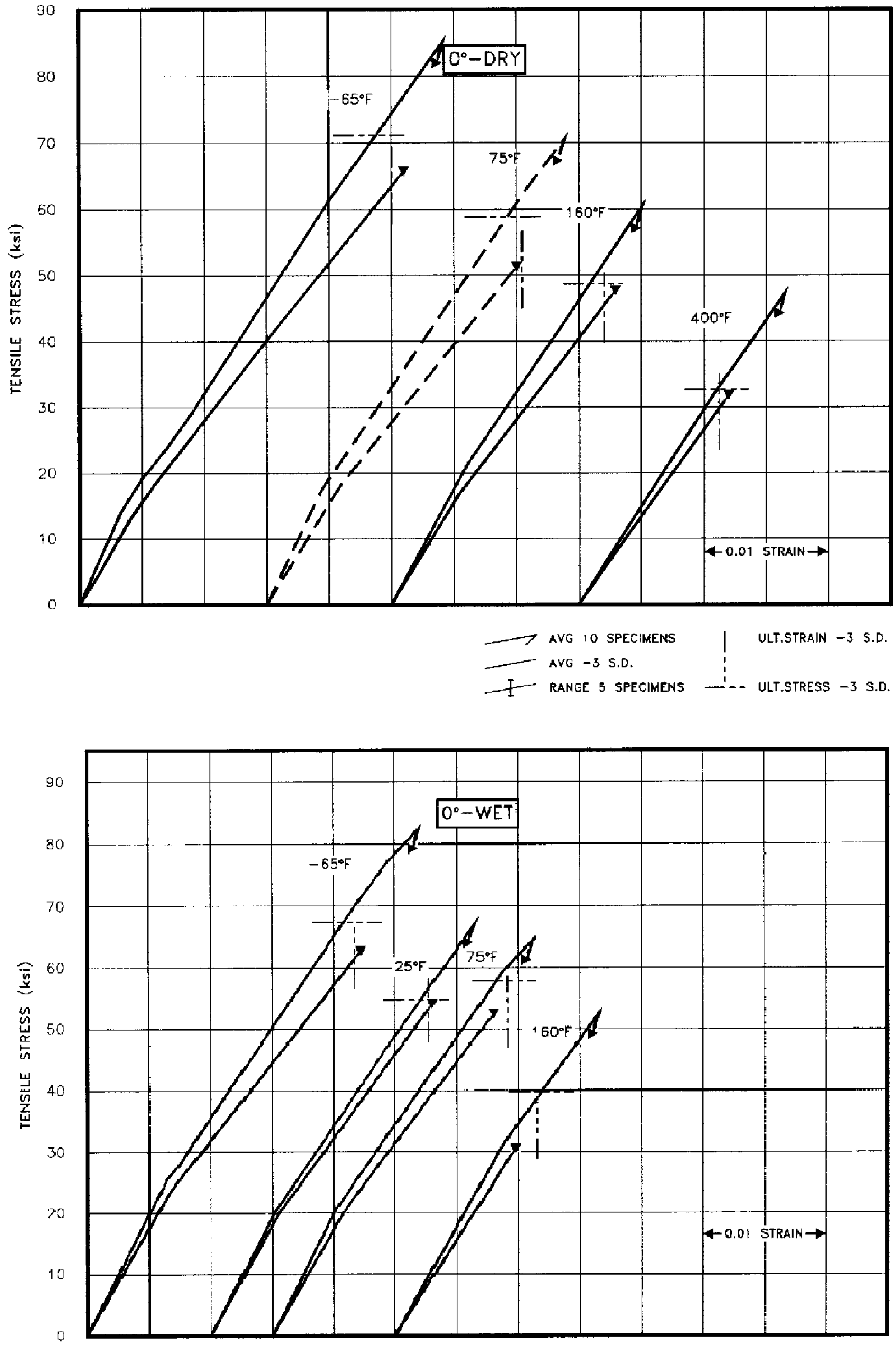


FIGURE A1.5.1(a) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (31% resin).*

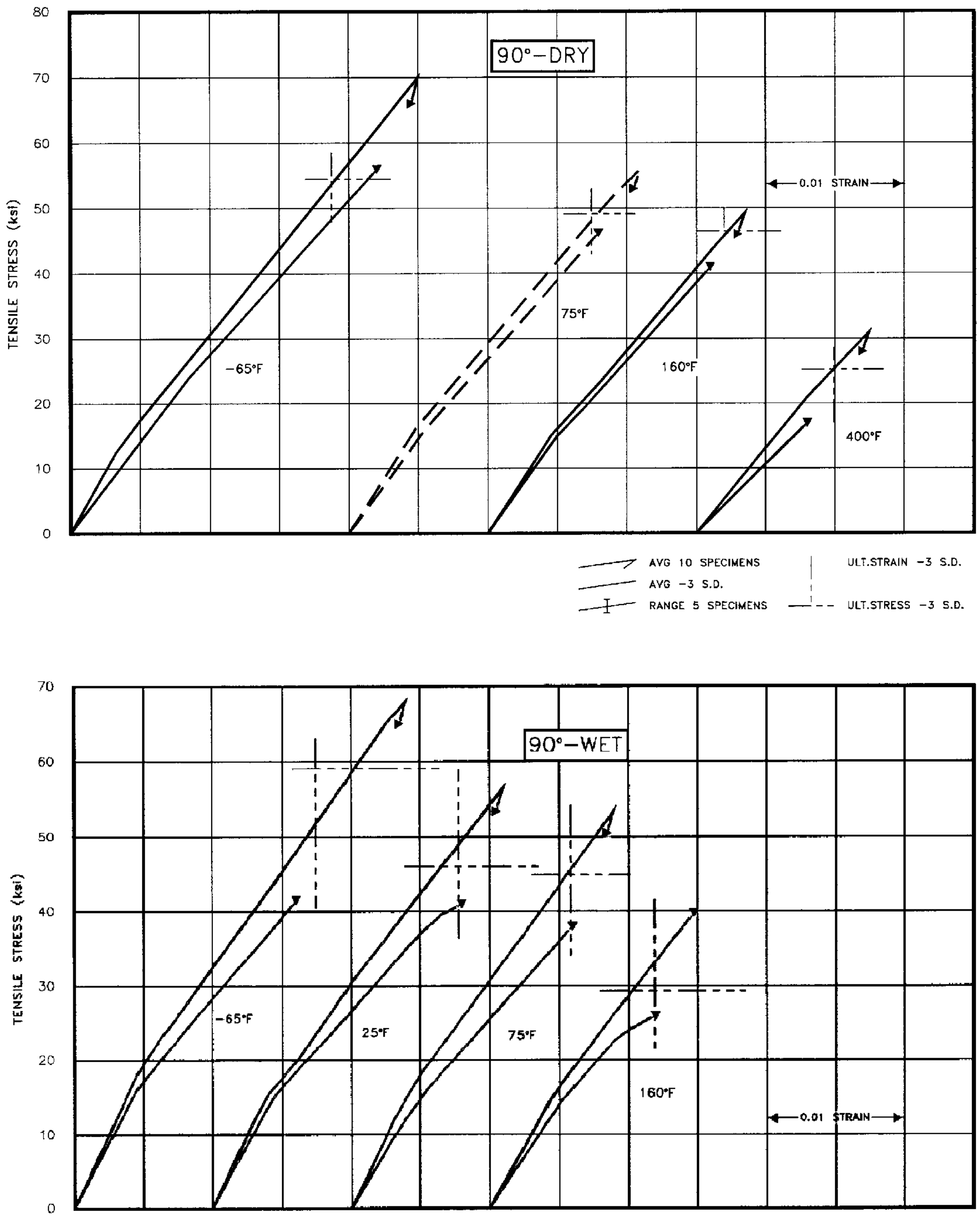
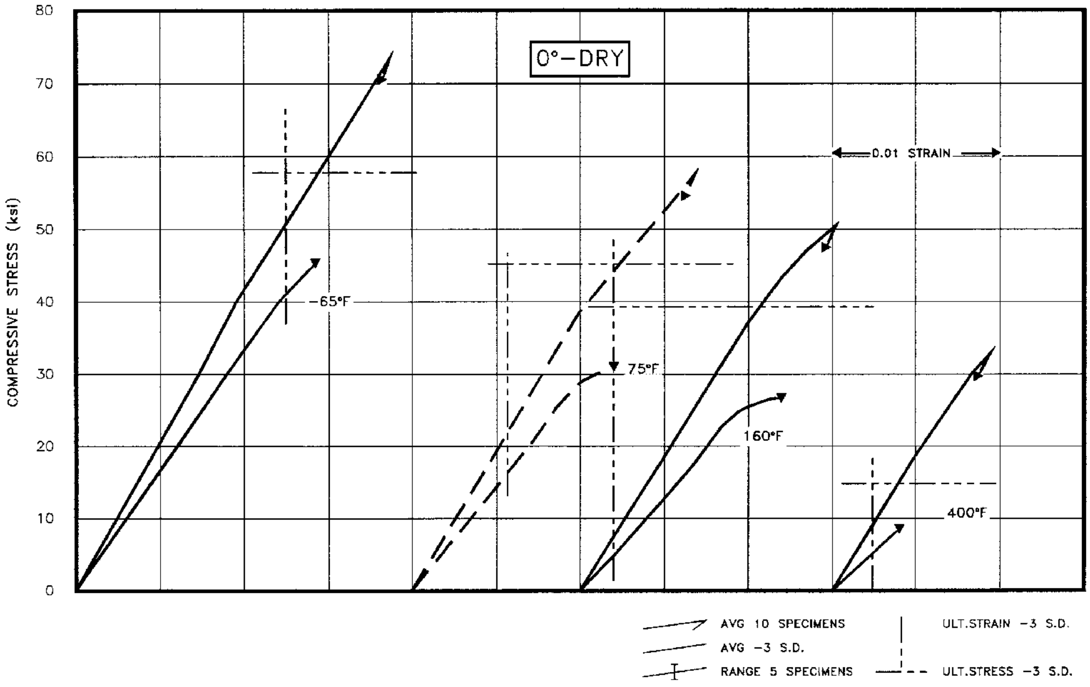


FIGURE A1.5.1(b) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (31% resin).*



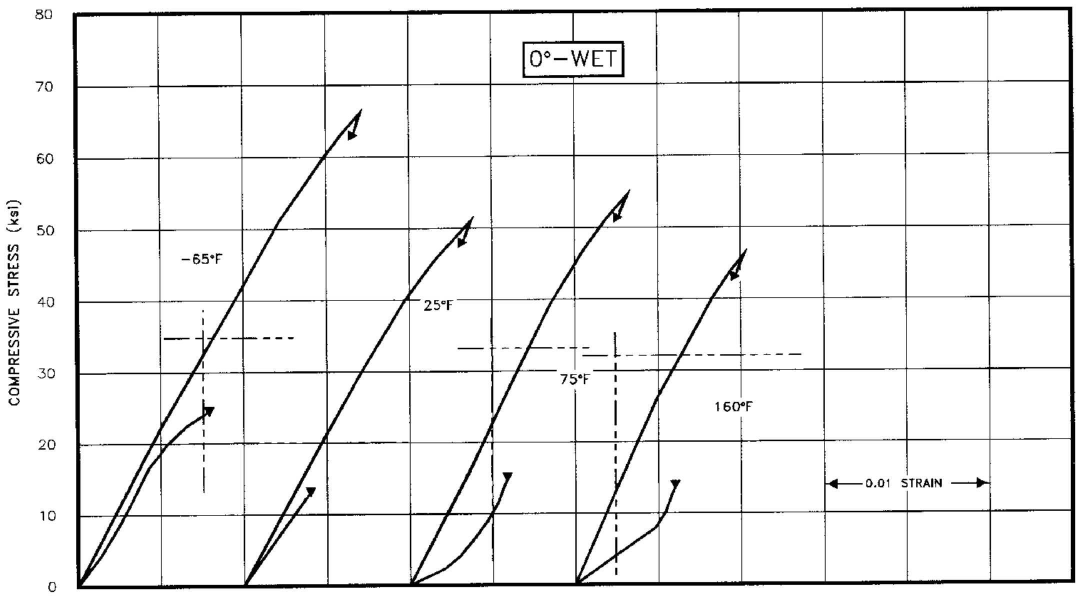


FIGURE A1.5.2(a) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (31% resin).*

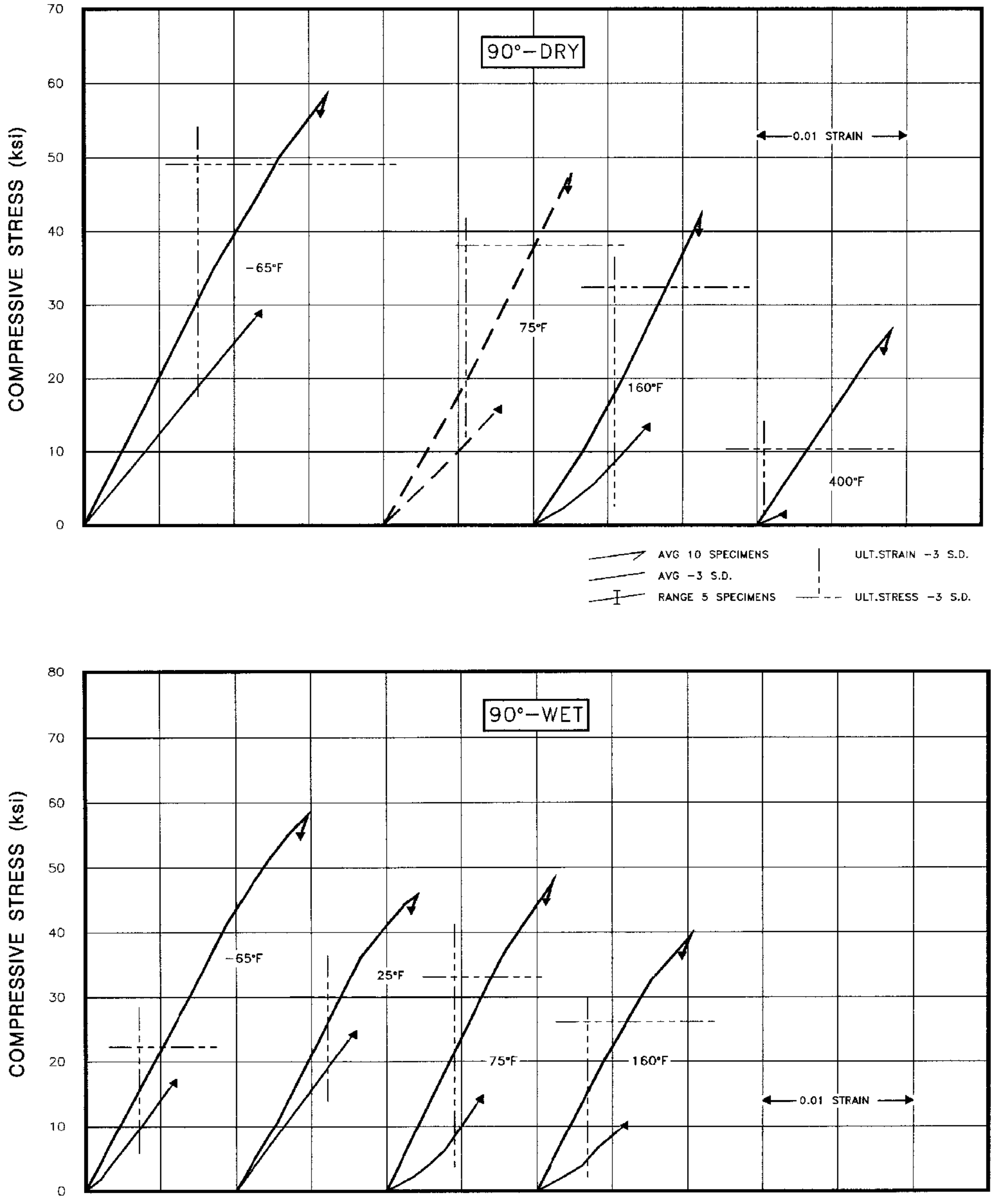


FIGURE A1.5.2(b) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (31% resin).*

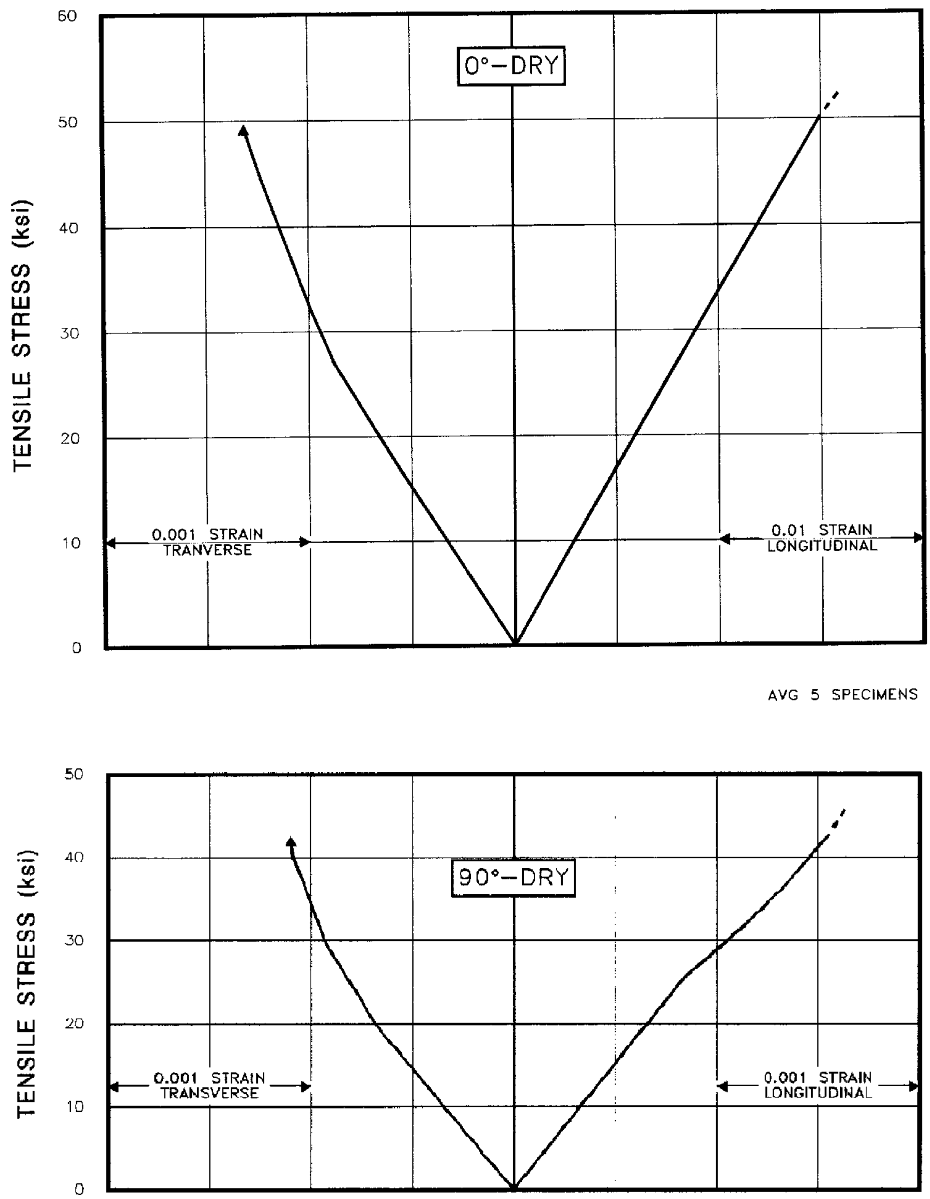


FIGURE A1.5.4 *Poisson effects for F-161/7781 fiberglass epoxy (31% resin).*

TABLE A1.6 *Summary of Mechanical Properties of Hexcel F-161/7781 (ECDE-1/0-550) Fiberglass Epoxy (36% Resin)*

Fabrication	Lay-up: Balanced	Vacuum: None	Pressure: 55-65 psi	Bleedout: Vertical and Stepped Edge	Cure: 1 hr/350°F	Postcure: 2 hr/300°F 2.5 hr/400°F	Plies: 8
Physical Properties	Weight Percent Resin: 35.6	Avg. Specific Gravity: 1.86	Avg. Percent Voids: 0.9	Avg. Thickness: 0.010 inch/ply			
Test Methods	Tension: MIL-HDBK-17	Compression: MIL-HDBK-17	Shear: Picture Frame	Flexure: ASTM-D790	Bearing:	Interlaminar Shear:	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	83.9	2.85	73.0	2.89			55.5	2.57	61.9	2.24	45.0	1.85	39.2	3.40
	90°	68.7	4.19	63.9	1.61			48.9	2.67	51.9	3.25	37.6	0.99	32.0	1.44
ultimate strain, %	0°	3.30	0.18	2.79	0.02			2.12	0.14	2.61	0.08	1.59	0.07	1.45	0.13
	90°	2.80	0.18	2.41	0.05			1.95	0.09	2.18	0.19	1.50	0.05	1.35	0.08
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°	3.84		3.81				3.58		3.25		3.35		2.96	
	90°	3.67		3.81				3.30		3.13		3.18		2.51	
secondary modulus, 10^6 psi	0°	2.81		2.75				3.04		2.49		3.04		2.74	
	90°	2.65		2.67				2.72		2.39		2.70		2.22	
Compression															
ultimate stress, ksi	0°	76.2	5.88	68.8	4.36			55.1	2.63	54.7	5.49	46.0	5.66	31.0	8.08
	90°	56.0	4.56	52.9	6.32			47.0	6.78	36.9	1.47	35.3	3.30	23.2	3.26
ultimate strain, %	0°	2.13	0.28	1.64	0.23			1.36	0.32	1.90	0.56	1.32	2.41	1.02	0.23
	90°	1.75	0.48	1.58	0.57			2.00	0.89	1.29	0.09	1.27	2.40	0.91	0.14
proportional limit, ksi	0°	28.0		24.0				24.0		32.0		22.0		17.0	
	90°	18.0		17.0				16.0		28.0		17.0		12.0	
initial modulus, 10^6 psi	0°	4.10		4.50				3.87		3.45		3.36		2.87	
	90°	4.00		4.10				3.64		2.87		2.88		2.63	
Shear															
ultimate stress, ksi	0°-90°	19.6	1.04					15.0	0.70	12.7	0.62				
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°				86.31	92.16	79.07			
proportional limit, ksi	0°									
initial modulus, 10^6 psi	0°									
Bearing										
ultimate stress, ksi	0°									
stress at 4% elong., ksi	0°									
Interlaminar Shear										
ultimate stress, ksi	0°				5.56	5.65	5.50			

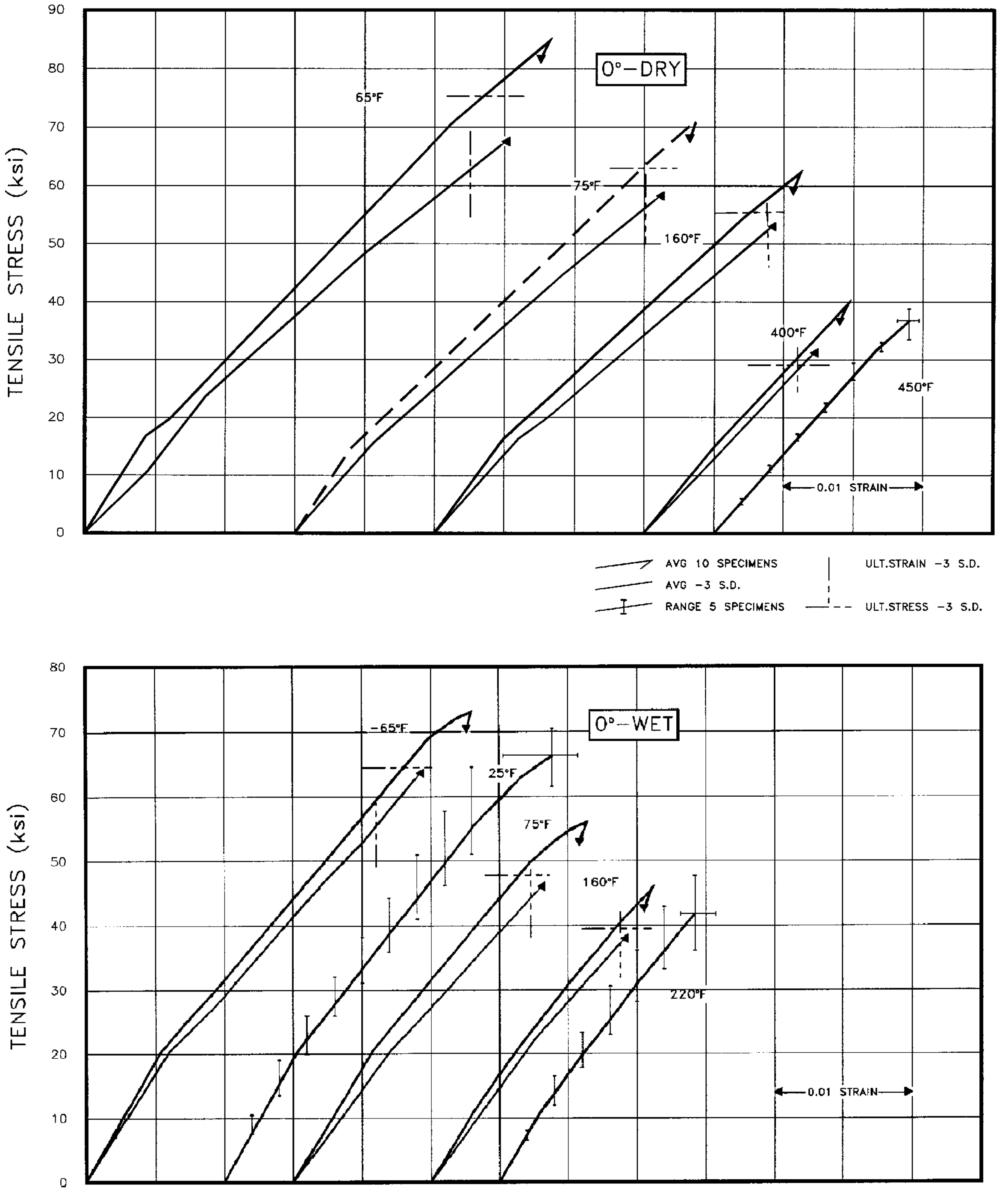


FIGURE A.1.6.1(a) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (36% resin).*

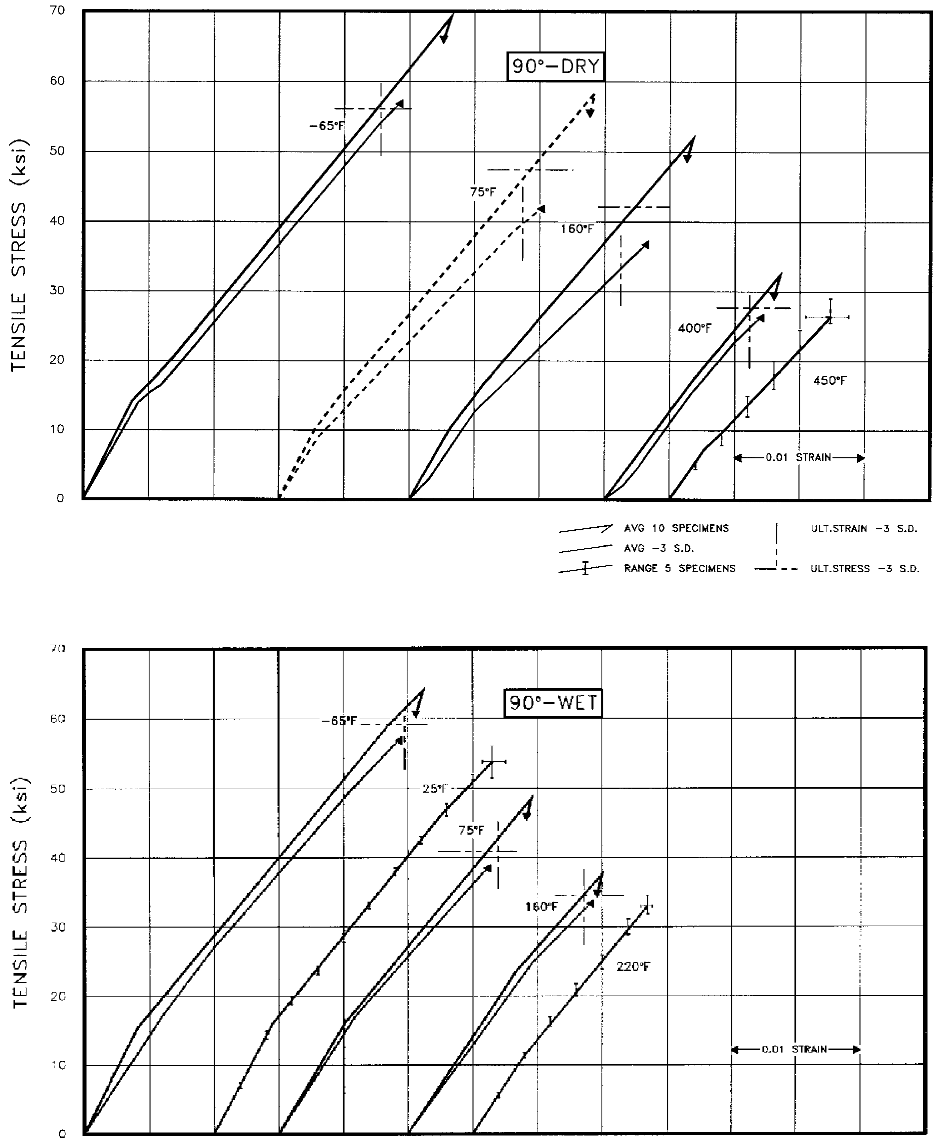


FIGURE A1.6.1(b) *Tensile stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (36% resin).*

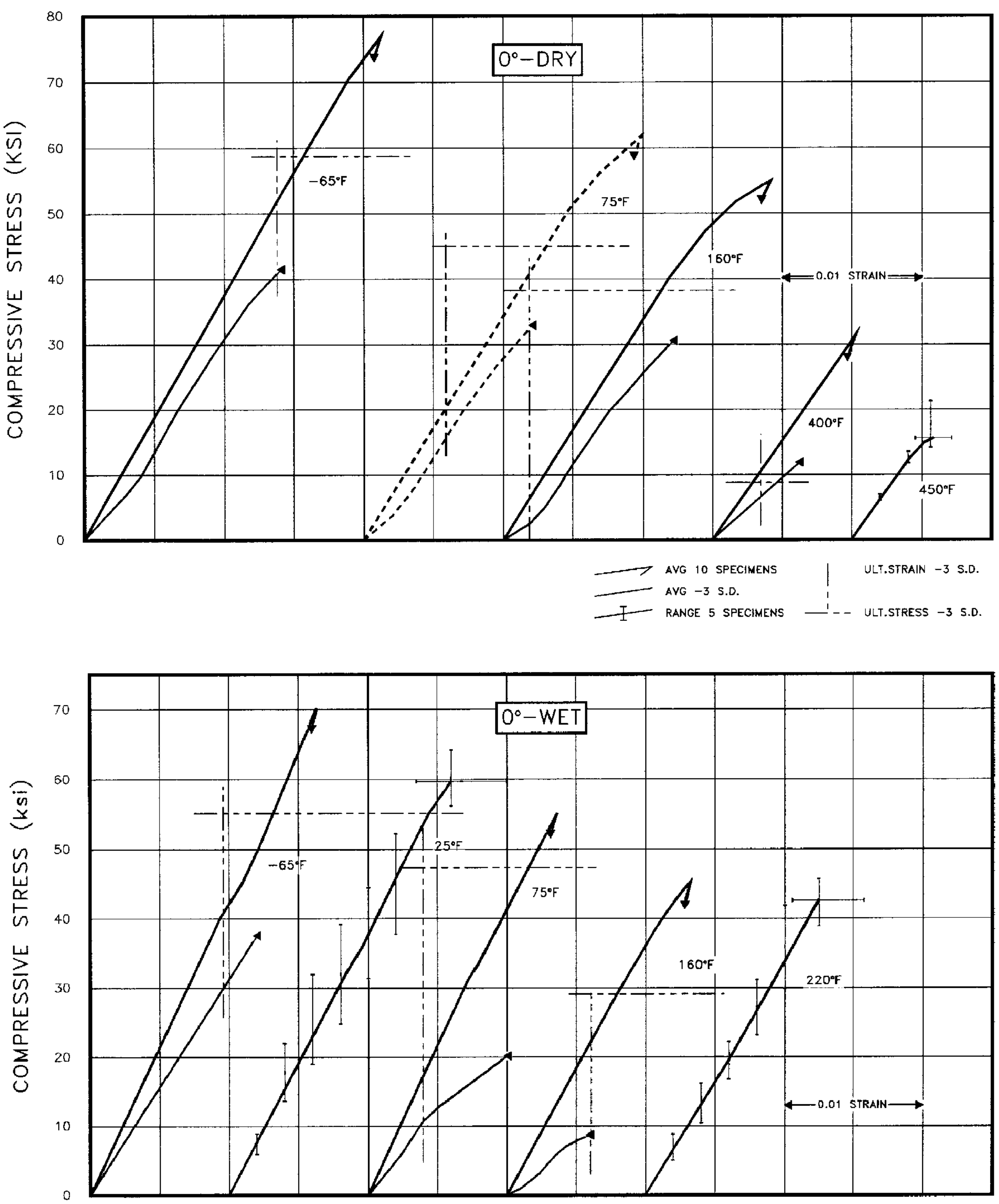
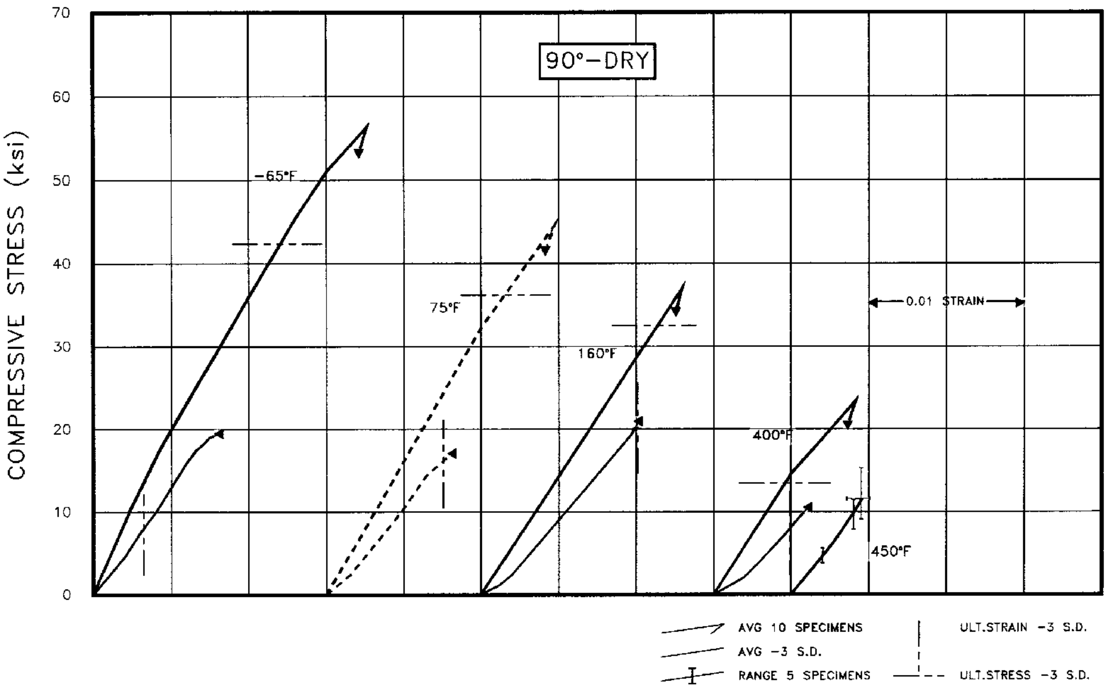


FIGURE A1.6.2(a) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 0° direction (36% resin).*



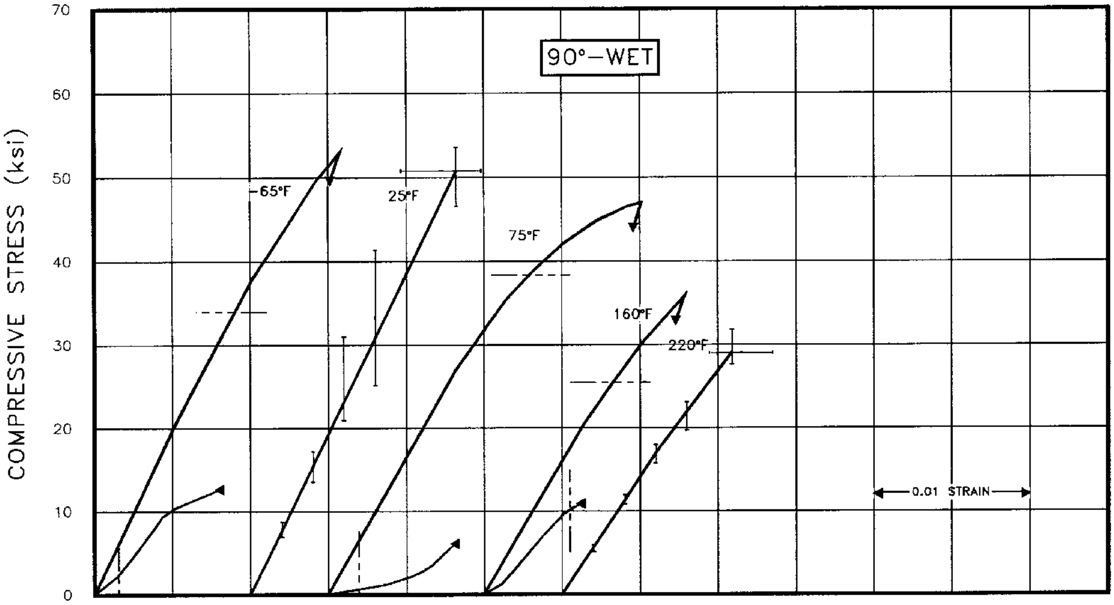


FIGURE A1.6.2(b) *Compressive stress-strain for F-161/7781 fiberglass epoxy loaded in the 90° direction (36% resin).*

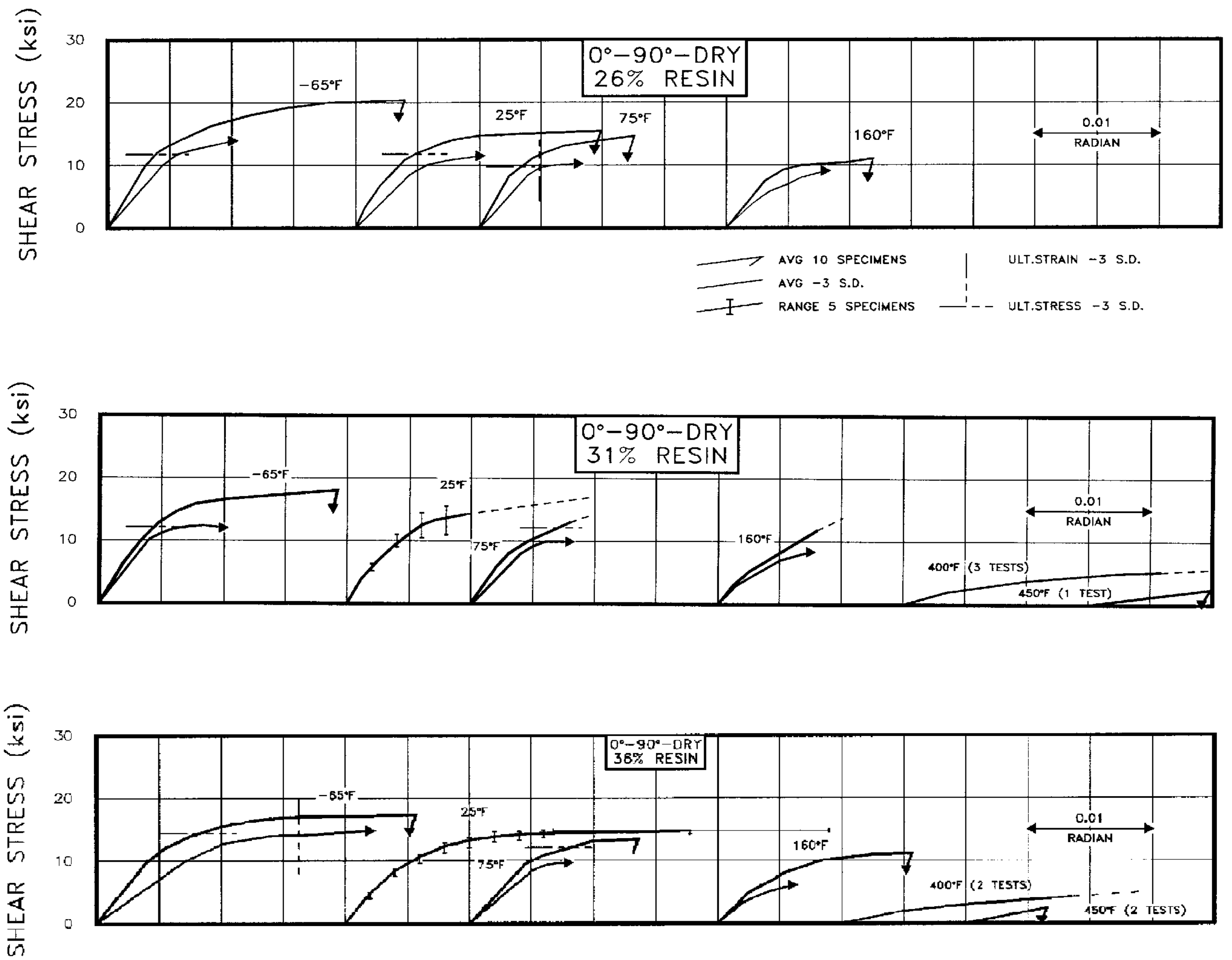


FIGURE A1.6.3 *Picture frame shear for F-161/7781 fiberglass epoxy (26%, 31%, 36% resin).*

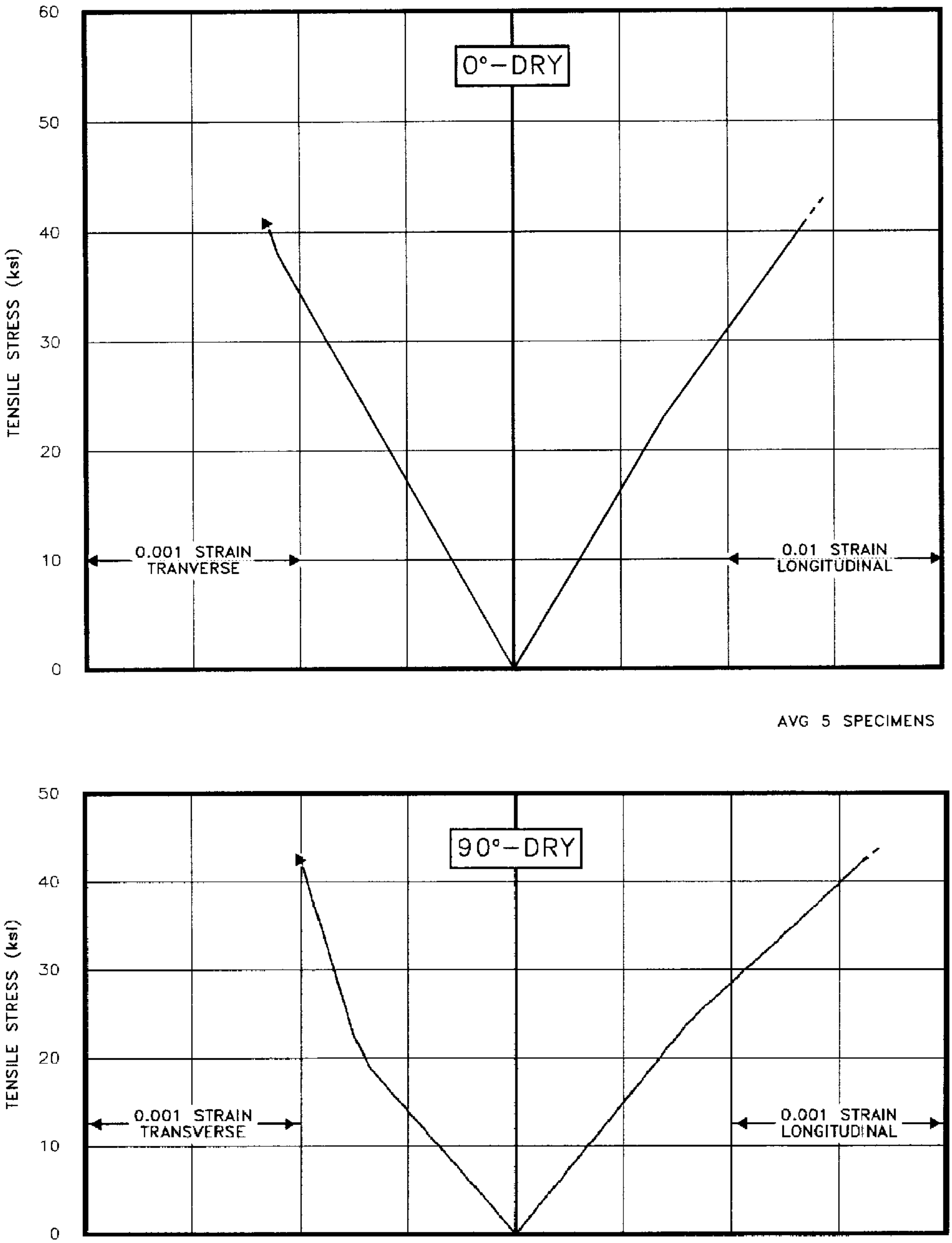


FIGURE A1.6.4 *Poisson effects for F-161/7781 fiberglass epoxy (36% resin).*

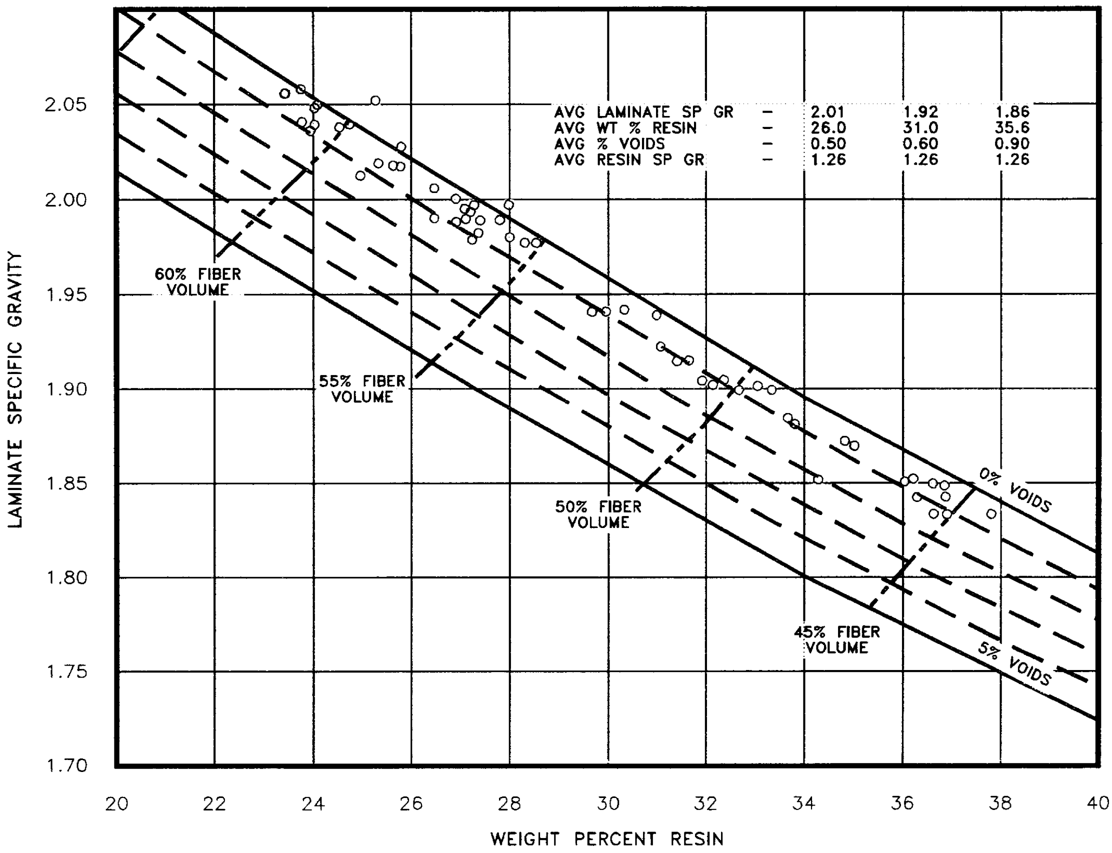


FIGURE A.1.6.5 *Voids vs. resin content and specific gravity for F-161/7781 fiberglass epoxy (26%, 31%, 36% resin).*

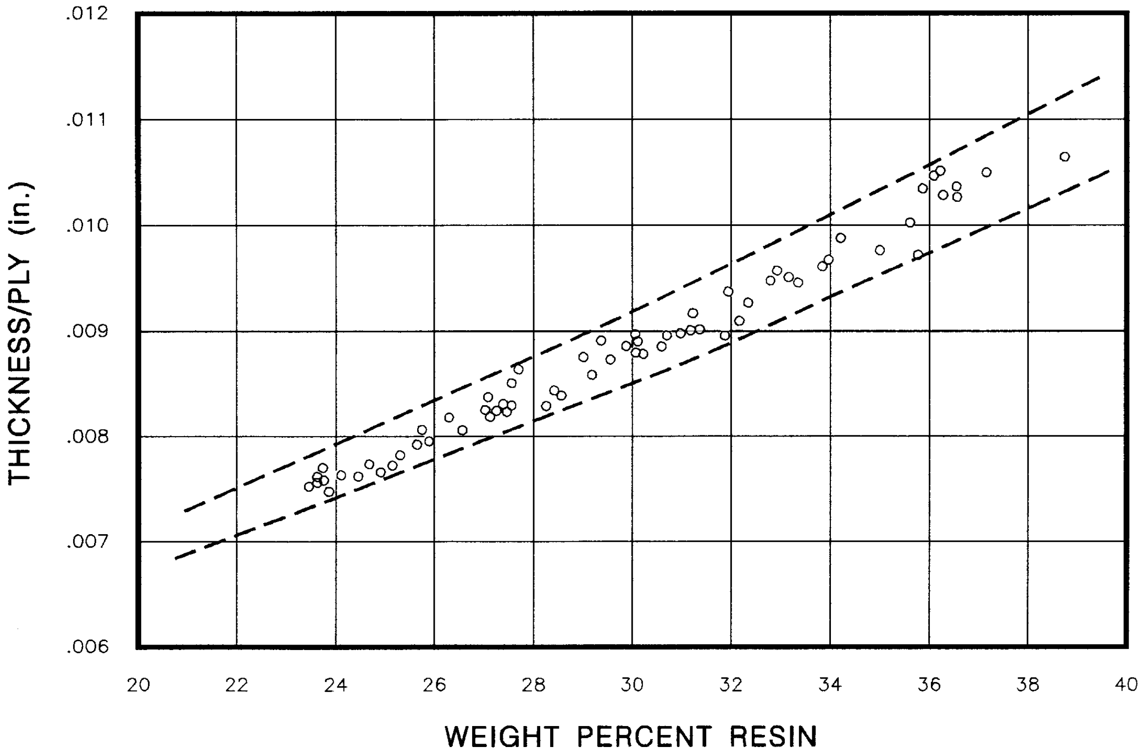


FIGURE A1.6.6 *Thickness vs. resin content for F-161/7781 fiberglass epoxy.*

TABLE A1.8 *Summary of Mechanical Properties of Narmco N588/7781 (ECDE-1/0-550) Fiberglass Epoxy*

Fabrication	Lay-up: Balanced	Vacuum: None	Pressure: 45-55 psi	Bleedout: Vertical	Cure: Stepwise to 350°F; 1hr/350°F	Postcure: None	Plies: 8
Physical Properties	Weight Percent Resin: 32.8 v_f = 0.51	Avg. Specific Gravity: 1.91	Avg. Percent Voids: 1.0	Avg. Thickness: 0.075 inches			
Test Methods	Tension: ASTM-D638 TYPE 1	Compression: MIL-HDBK-17	Shear: Rail	Flexure: ASTM-D790	Bearing: ASTM-D953	Interlaminar Shear: Short Beam	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	71.4	2.4	63.8	3.3	58.4	2.1	50.0	2.3	48.8	3.0	35.0	2.0	40.4	3.4
	90°	59.3	3.3	50.6	2.4	47.2	3.8	41.1	2.7	41.4	2.0	28.9	2.8	33.3	3.8
ultimate strain, %	0°	2.41	0.09	2.06	0.15	2.05	0.18	1.61	0.12	1.59	0.15	1.13	0.07	1.26	0.07
	90°	2.35	0.17	1.96	0.12	1.81	0.16	1.55	0.16	1.67	0.10	1.17	0.14	1.25	0.12
proportional limit, ksi	0°	26.6	1.7	28.7	2.5	23.3	1.1	25.4	2.8	21.0	1.7	29.9	2.0	24.3	
	90°	19.3	0.8	19.2	1.6	17.6	0.8	18.1	1.4	17.3	2.5	20.9	1.3	14.3	
initial modulus, 10^6 psi	0°	3.64		3.85		3.71		3.57		3.58		3.10		3.13	0.17
	90°	3.41		3.37		3.56		3.23		2.92		2.63		2.80	0.23
secondary modulus, 10^6 psi	0°														
	90°														
Compression															
ultimate stress, ksi	0°	99.2	5.9	87.4	5.8	74.0	3.6	63.5	3.2	59.0	2.4	49.5	1.9		
	90°	83.4	3.5	71.8	4.1	62.9	2.9	53.7	1.7	50.9	1.5	40.7	1.8		
ultimate strain, %	0°	2.52	0.26	2.30	0.25	1.89	0.15	1.65	0.19	1.60	0.12	1.38	0.06		
	90°	2.30	0.27	2.06	0.20	1.87	0.14	1.58	0.15	1.63	0.16	1.29	0.08		
proportional limit, ksi	0°	42.7	2.6	46.2	2.5	44.5	3.2	39.8	3.6	37.6	2.7	30.7	2.7		
	90°	40.8	3.8	42.4	2.7	35.3	3.7	34.4	2.3	31.2	2.4	24.4	1.6		
initial modulus, 10^6 psi	0°	4.32		4.15		4.18		4.11		3.88		3.70			
	90°	4.08		3.83		3.68		3.72		3.41		3.41			
Shear															
ultimate stress, ksi	0°-90°	22.6				16.0	1.05			13.8					
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°	105.0	115.6	95.6	90.4	102.6	84.5	79.3	87.8	74.0
proportional limit, ksi	0°	69.6	75.9	59.0	68.9	72.4	64.6	64.8	72.2	57.2
initial modulus, 10^6 psi	0°	3.48	3.62	3.42	3.36	3.60	3.20	3.19	3.27	3.09
Bearing										
ultimate stress, ksi	0°	84.6	92.5	77.9	68.4	71.3	66.0	48.4	53.6	44.2
stress at 4% elong., ksi	0°	29.3	30.9	26.5	26.2	27.4	25.3	21.8	22.8	20.6
Interlaminar Shear										
ultimate stress, ksi	0°	8.84	9.16	8.56	8.35	8.56	8.05	7.39	7.72	6.47

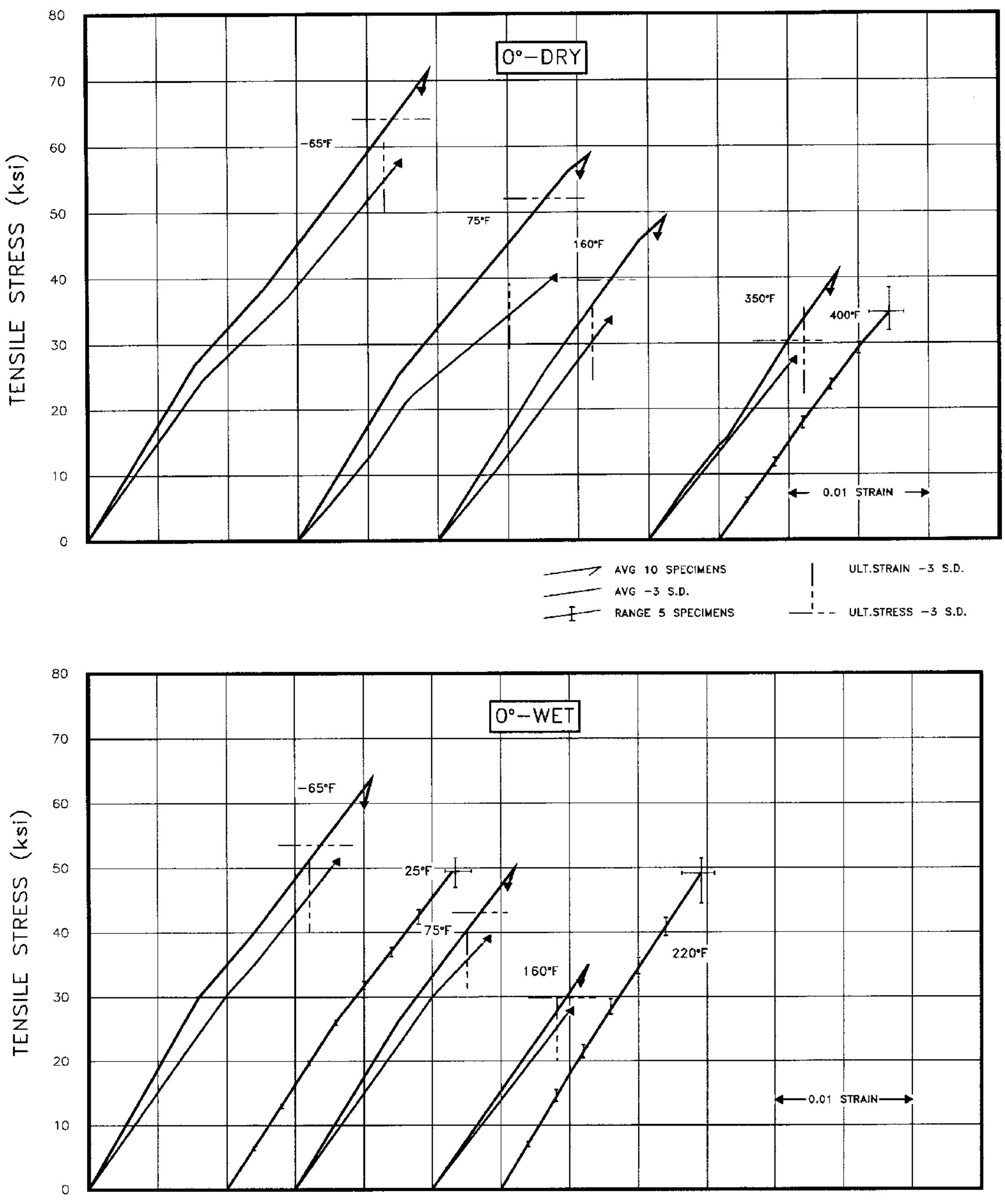


FIGURE A1.8.1(a) *Tensile stress-strain for N588/7781 fiberglass epoxy loaded in the 0° direction.*

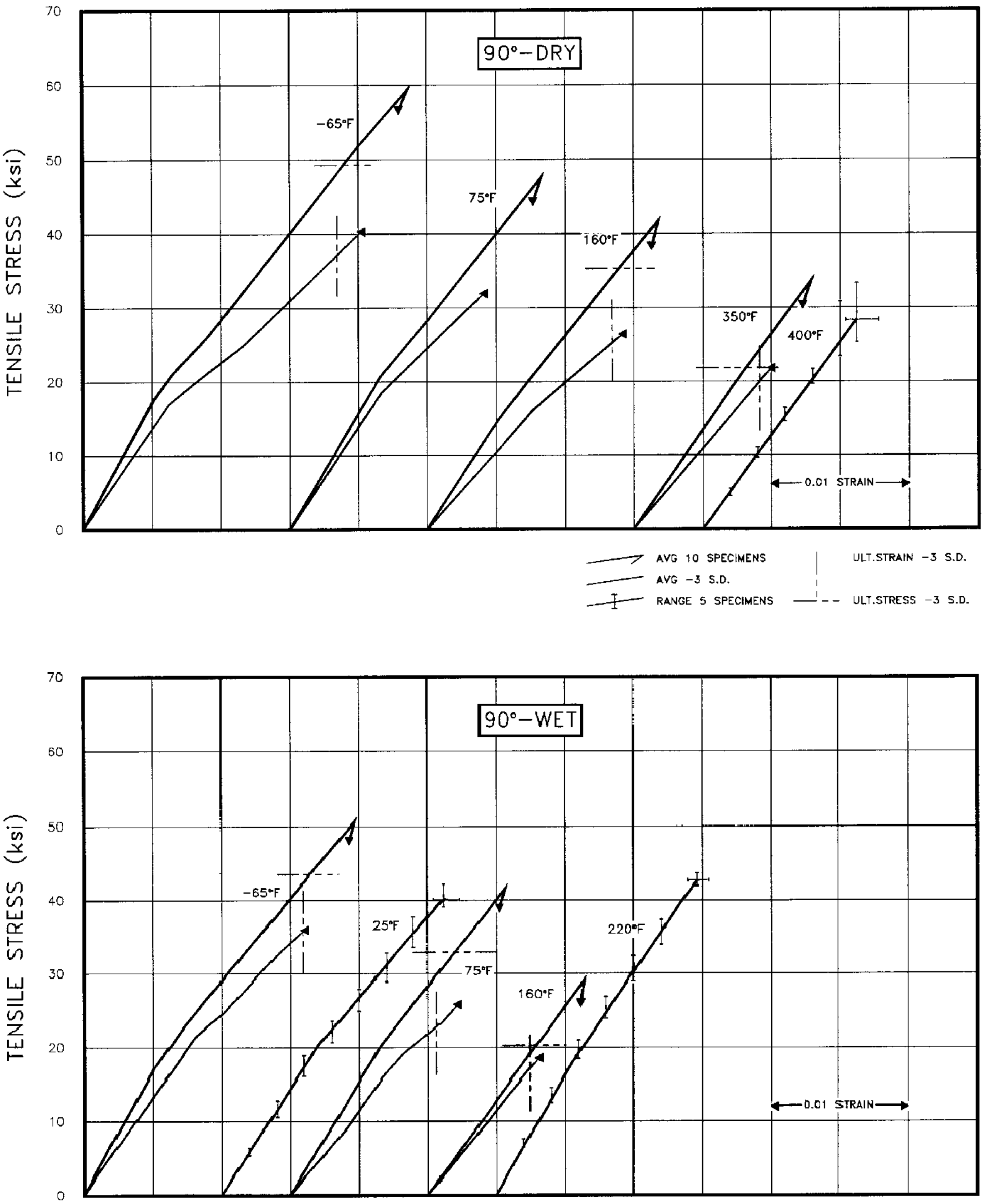


FIGURE A1.8.1(b) *Tensile stress-strain for N588/7781 fiberglass epoxy loaded in the 90° direction.*

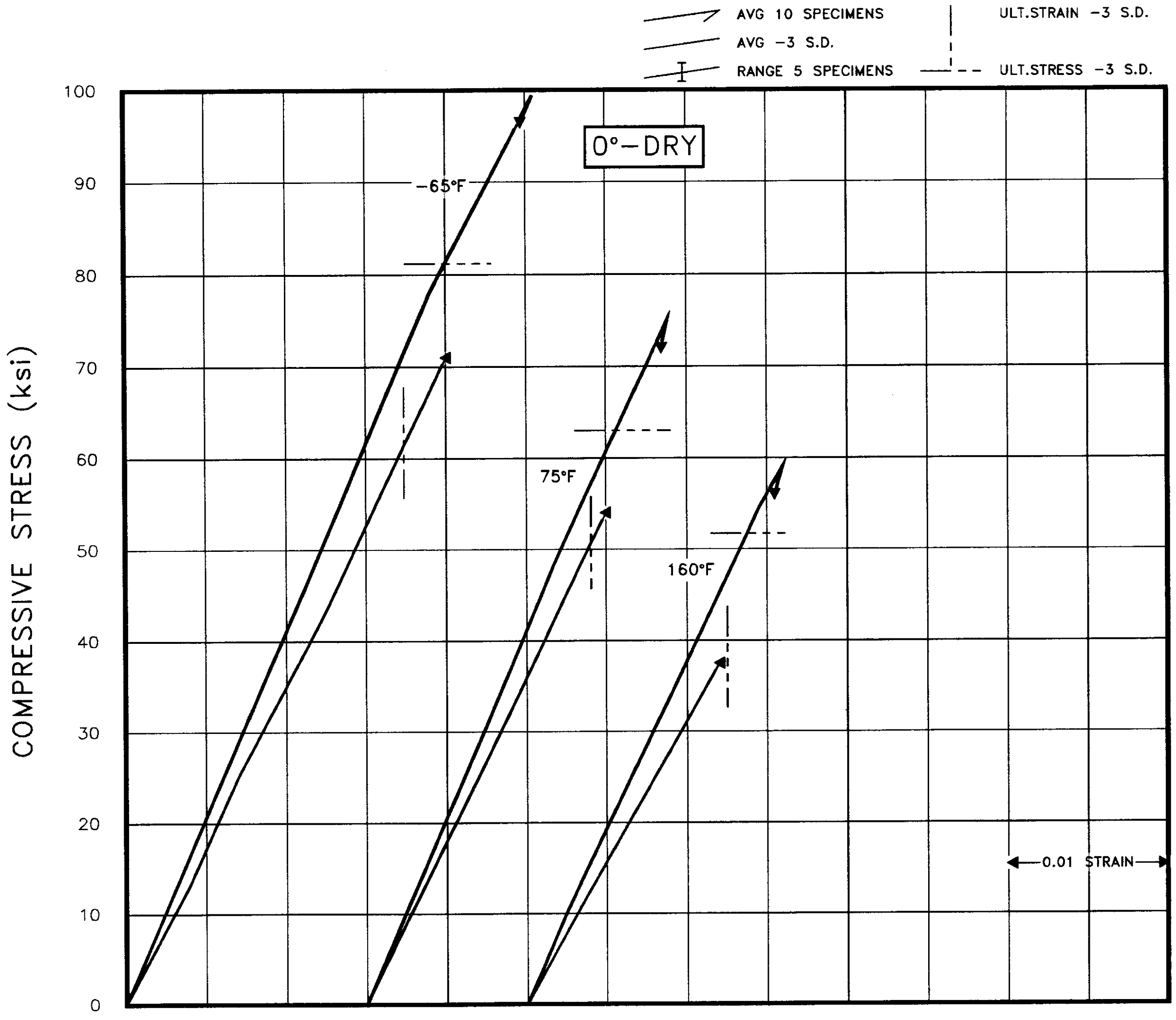


FIGURE A1.8.2(a) *Compressive stress-strain for N588/7781 fiberglass epoxy loaded in the 0° direction,* continued on next page.

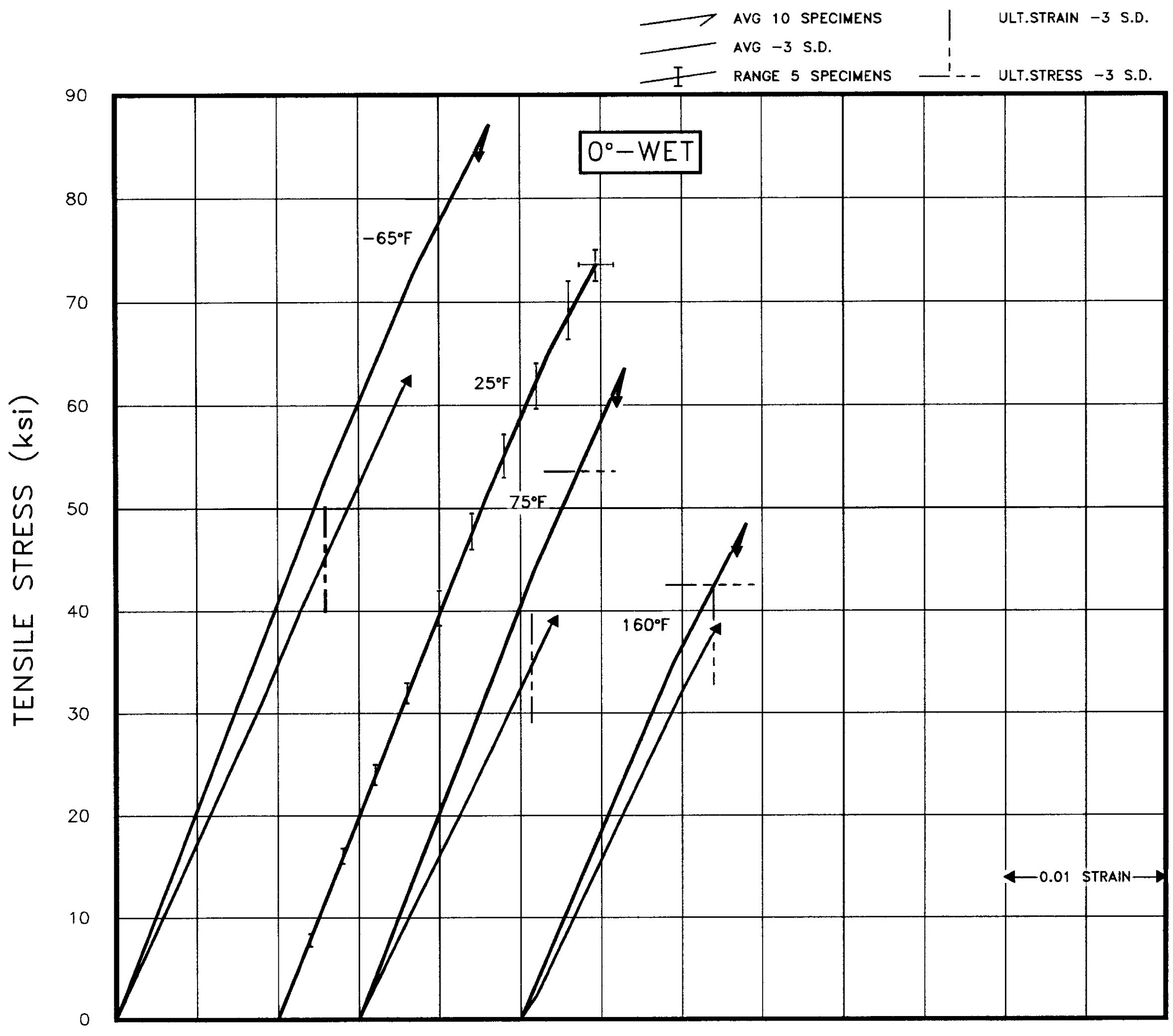


FIGURE A1.8.2(a) *Compressive stress-strain for N588/7781 fiberglass epoxy loaded in the 0° direction,* concluded.

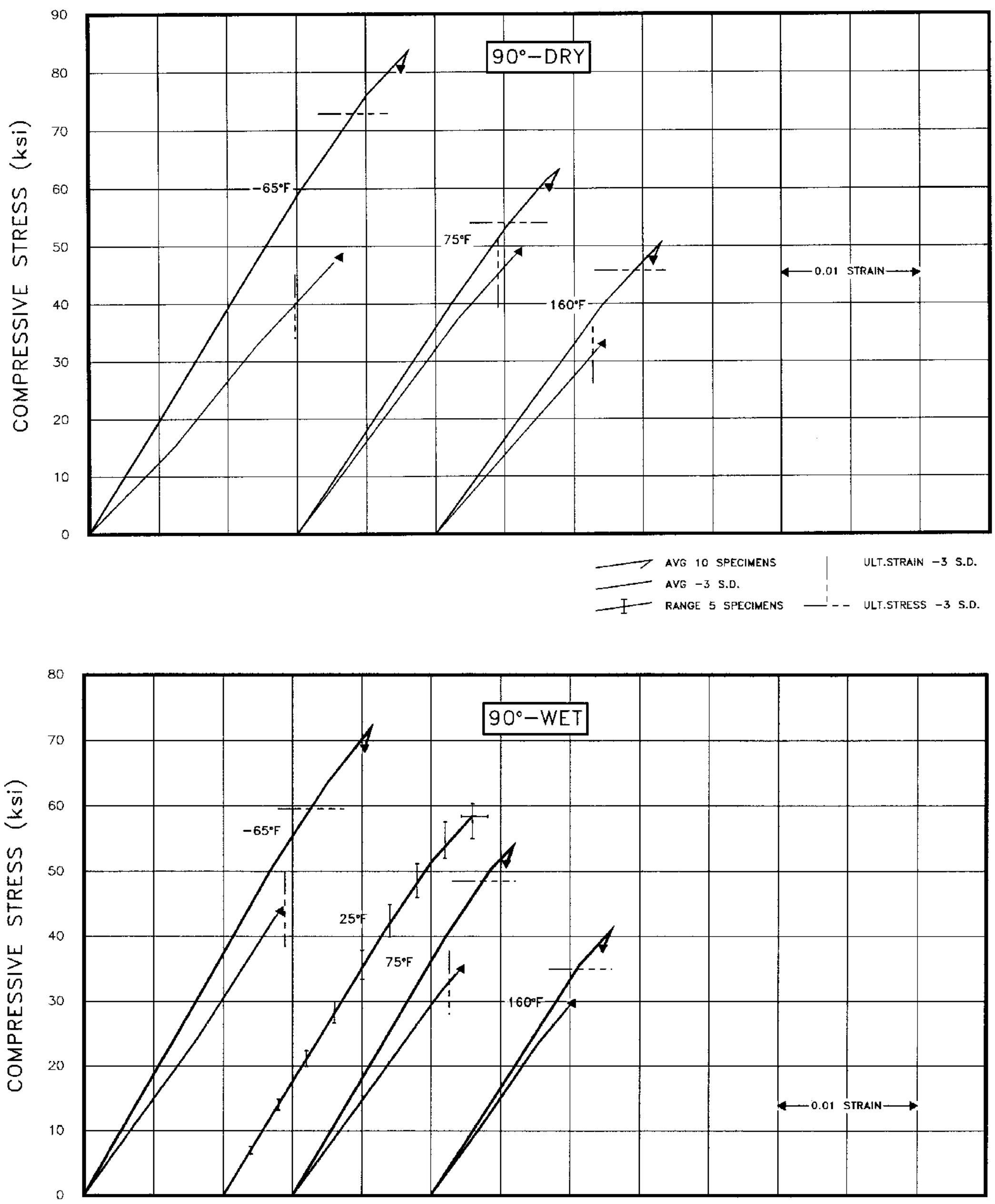


FIGURE A1.8.2(b) *Compressive stress-strain for N588/7781 fiberglass epoxy loaded in the 90° direction.*

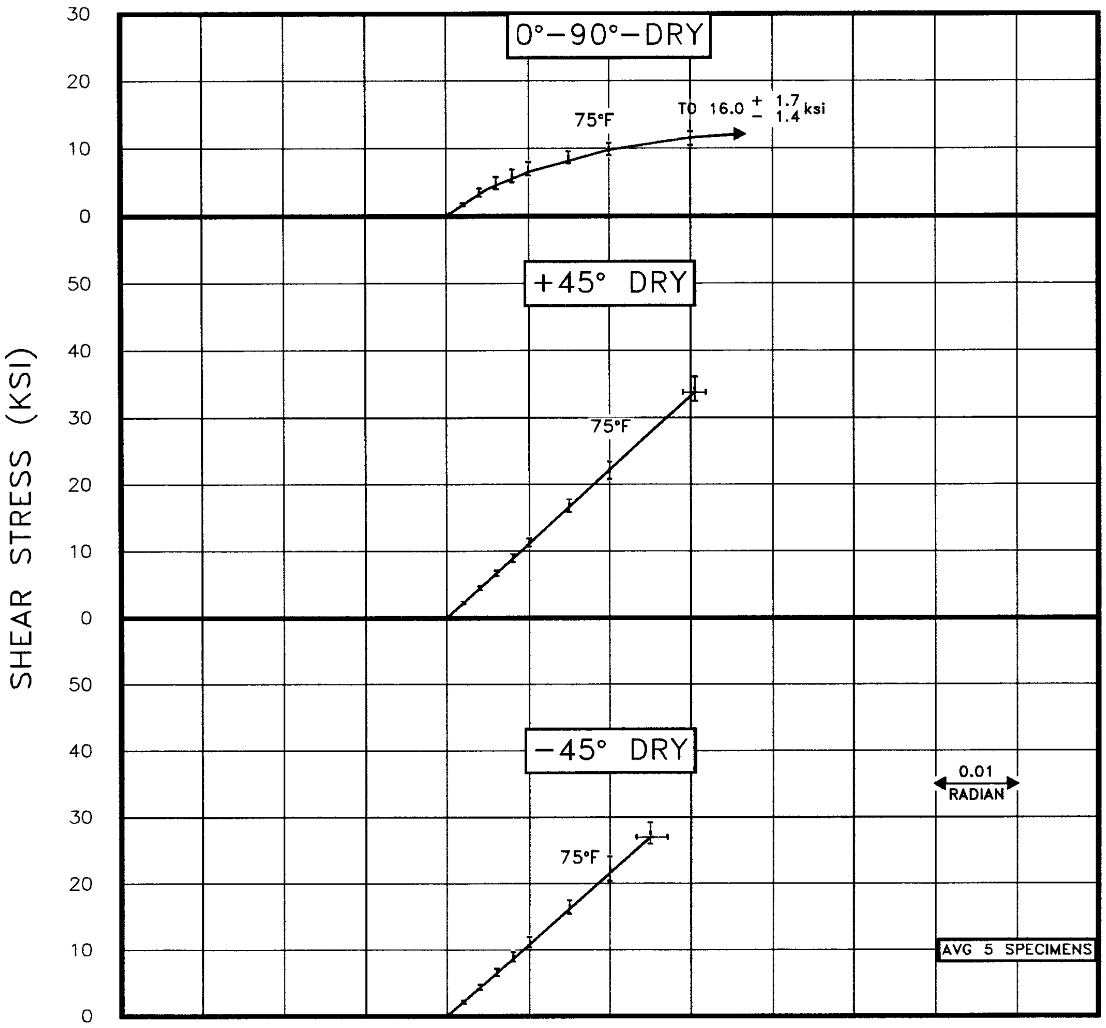


FIGURE A1.8.3 *Rail shear for N588/7781 fiberglass epoxy.*

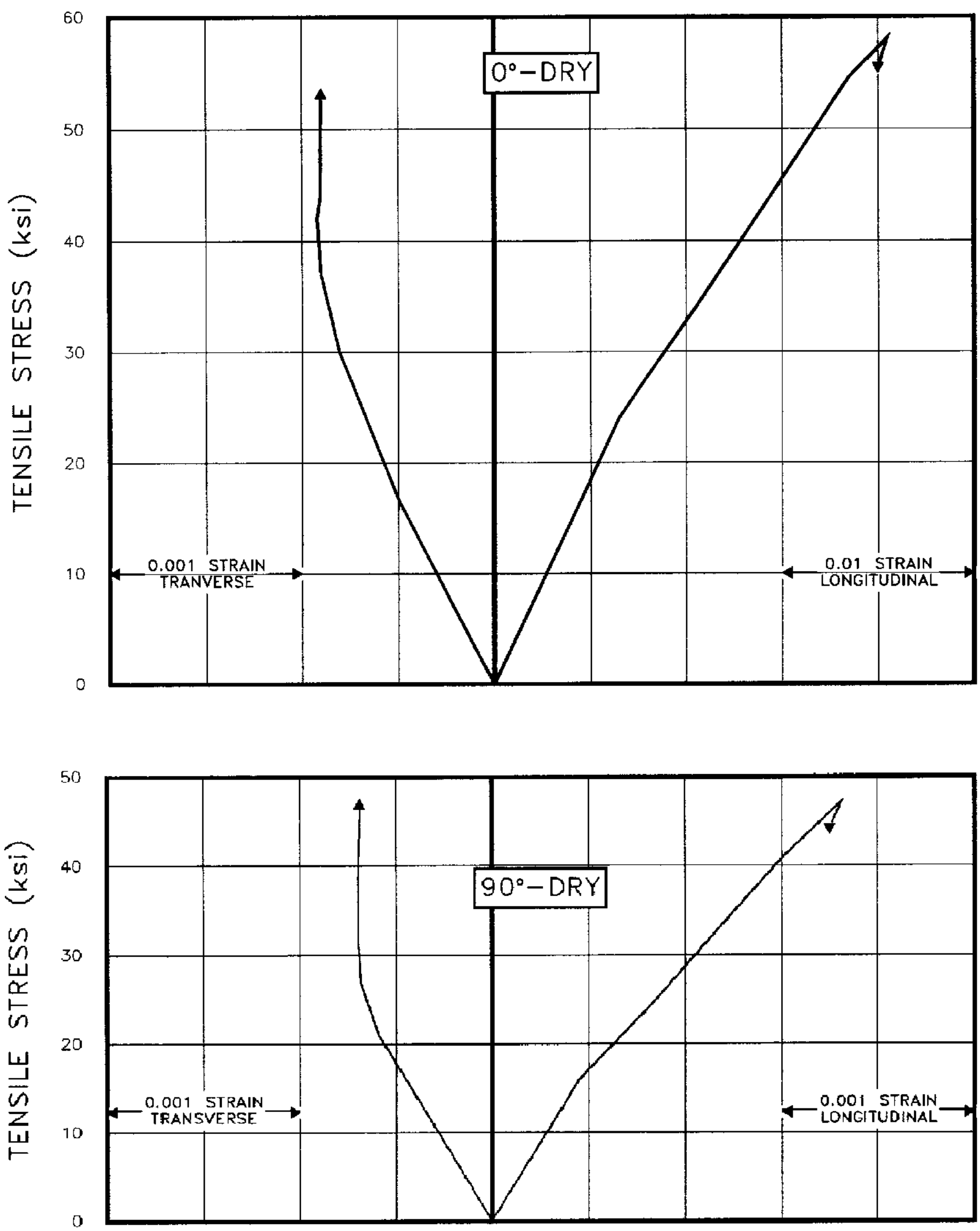


FIGURE A1.8.4 *Poisson effects for N588/7781 fiberglass epoxy.*

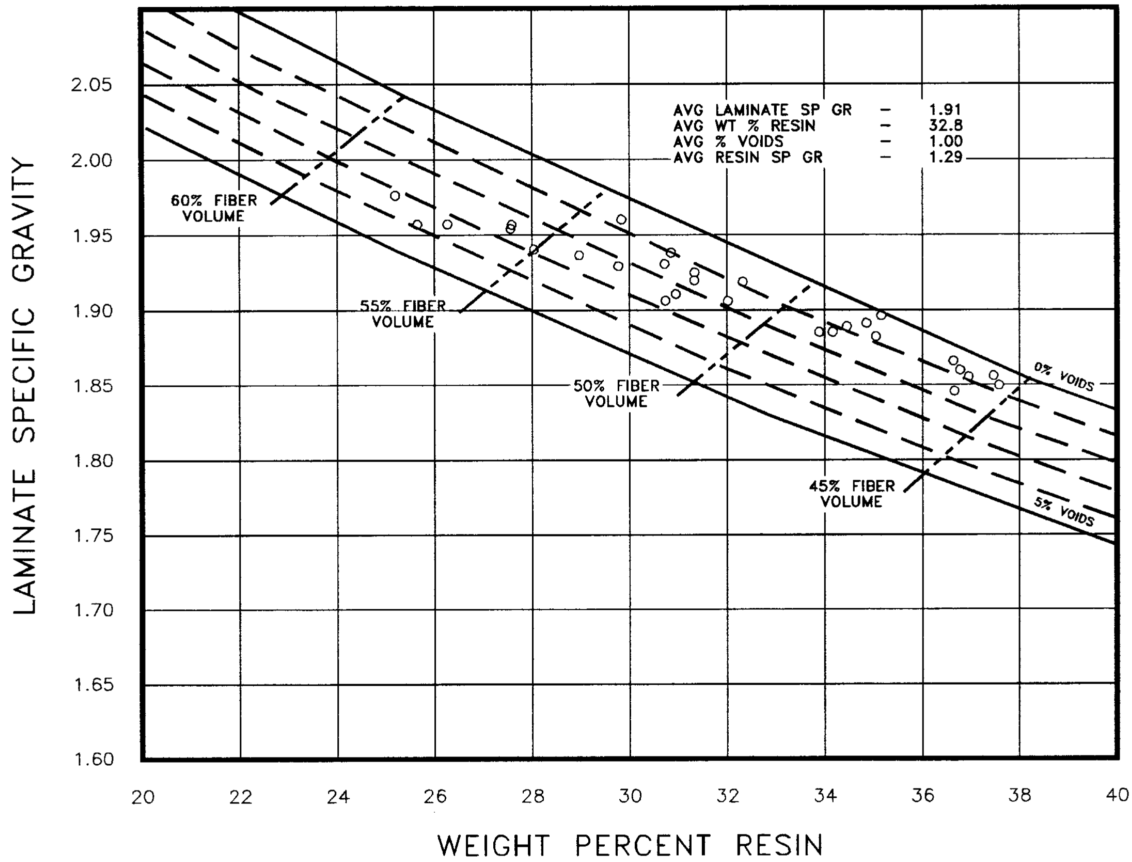


FIGURE A1.8.5 *Voids vs. resin content and specific gravity for N588/7781 fiberglass epoxy.*

TABLE A1.40 *Summary of Mechanical Properties of Narmco N506/7781 (ECDE-1/0-A1100) Fiberglass Phenolic.*

Fabrication	Lay-up: Balanced	Vacuum:	Pressure:	Bleedout: Vertical	Cure:	Postcure:	Plies: 8
Physical Properties	Weight Percent Resin: 25.3 - 32.3	Avg. Specific Gravity: 1.72 - 1.85	Avg. Percent Voids: Figure 4.40.5	Avg. Thickness: 0.071 - 0.095 inches			
Test Methods	Tension: ASTM-D638 TYPE 1	Compression: MIL-HDBK-17	Shear: Rail	Flexure: ASTM-D790	Bearing: ASTM-D953	Interlaminar Shear: Short Beam	

Temperature		-65°F				75°F				160°F				400°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	48.1	2.4	49.8	3.3	38.9	1.5	37.2	1.8	35.3	1.4	30.6	3.0	21.6	1.6
	90°	37.9	1.8	40.0	2.7	31.5	1.5	32.1	1.4	27.9	1.7	26.2	2.2	21.6	1.7
ultimate strain, %	0°	1.76	0.07	1.76	0.13	1.33	0.14	1.34	0.13	1.19	0.10	1.15	0.14	0.69	0.05
	90°	1.63	0.08	1.65	0.13	1.26	0.15	1.32	0.07	1.11	0.07	1.11	0.14	0.78	0.06
proportional limit, ksi	0°	13.6	0.9	18.1	1.2	13.5	0.6	17.0	1.0	13.9	1.0	14.9	0.70	9.7	1.1
	90°	9.9	0.4	12.5	0.9	9.2	0.8	12.8	0.7	10.3	0.8	11.6	0.70	8.6	0.5
initial modulus, 10^6 psi	0°	3.40	0.21	3.35	0.20	3.94	0.69	3.14	0.26	3.74	0.41	3.01	0.19	3.57	0.24
	90°	3.08	0.29	3.04	0.22	3.54	0.41	2.81	0.24	3.33	0.37	2.78	0.21	3.18	0.30
secondary modulus, 10^6 psi	0°														
	90°														
Compression															
ultimate stress, ksi	0°	66.7	6.2	65.9	5.0	59.7	4.7	54.5	7.1	50.6	2.3	49.2	4.2		
	90°	57.7	5.8	56.2	5.8	49.0	4.6	48.7	4.0	43.0	4.3	42.9	3.7		
ultimate strain, %	0°	1.85	0.09	1.69	0.18	1.58	0.14	1.49	0.12	1.45	0.06	1.40	0.12		
	90°	1.70	0.21	1.63	0.13	1.40	0.09	1.43	0.07	1.37	0.12	1.31	0.15		
proportional limit, ksi	0°	45.8	3.8	38.5	7.9	39.0	2.4	41.2	4.6	39.9	2.4	35.0	1.7		
	90°	35.2	3.8	34.4	5.0	32.6	4.4	35.5	3.0	32.4	3.1	31.1	3.3		
initial modulus, 10^6 psi	0°	3.90	0.19	4.17	0.29	3.95	0.28	3.89	0.26	3.68	0.21	3.67	0.12		
	90°	3.69	0.25	3.68	0.17	3.70	0.20	3.57	0.20	3.30	0.23	3.45	0.21		
Shear															
ultimate stress, ksi	0°-90°	13.8				12.3	0.97			11.4					
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°	68.2	72.8	65.2	58.4	64.0	52.1	52.7	56.3	47.4
proportional limit, ksi	0°	59.3	66.1	54.6	48.9	56.8	42.5	42.4	46.2	38.8
initial modulus, 10^6 psi	0°	2.97	3.04	2.88	2.89	2.99	2.78	2.97	3.06	2.82
Bearing										
ultimate stress, ksi	0°	65.7	73.2	57.0	58.9	64.0	46.8	49.5	55.8	44.5
stress at 4% elong., ksi	0°	25.1	26.0	23.7	24.5	24.9	23.8	21.6	22.6	20.7
Interlaminar Shear										
ultimate stress, ksi	0°	4.83	5.10	4.29	4.64	4.92	3.94	4.62	4.88	4.08

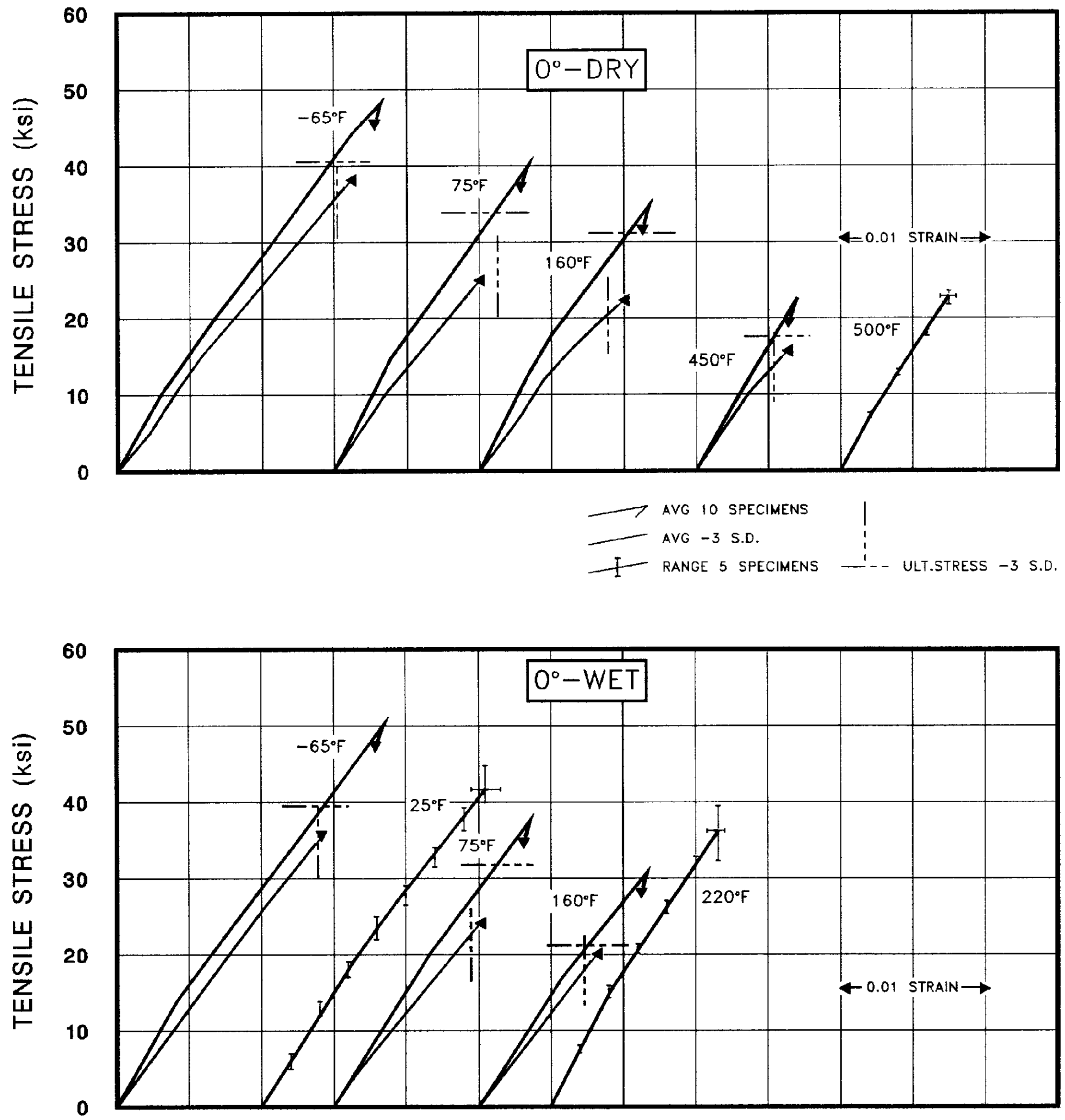


FIGURE A1.40.1(a) *Tensile stress-strain for N506/7781 fiberglass phenolic loaded in the 0° direction.*

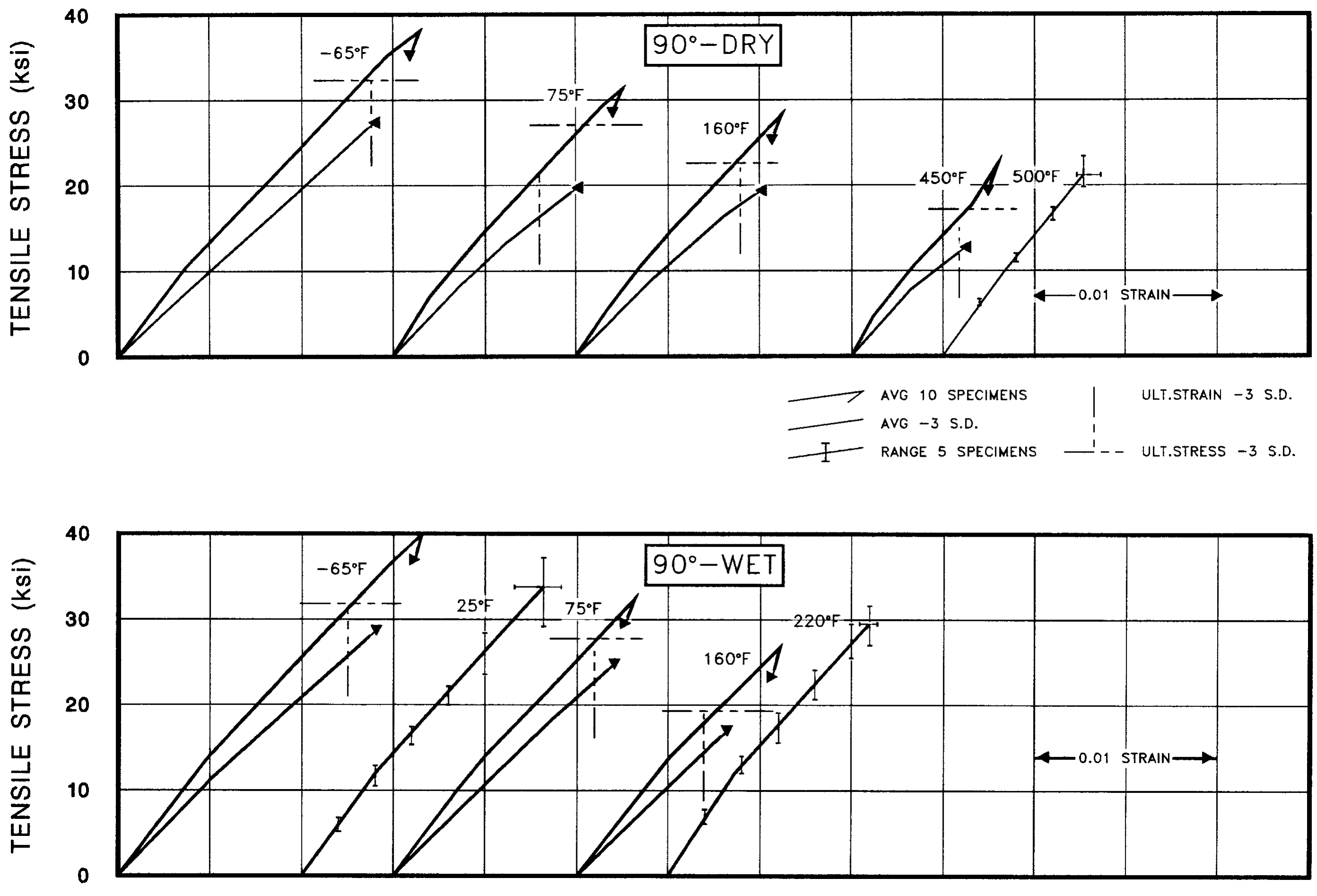


FIGURE A1.40.1(b) *Tensile stress-strain for N506/7781 fiberglass phenolic loaded in the 90° direction.*

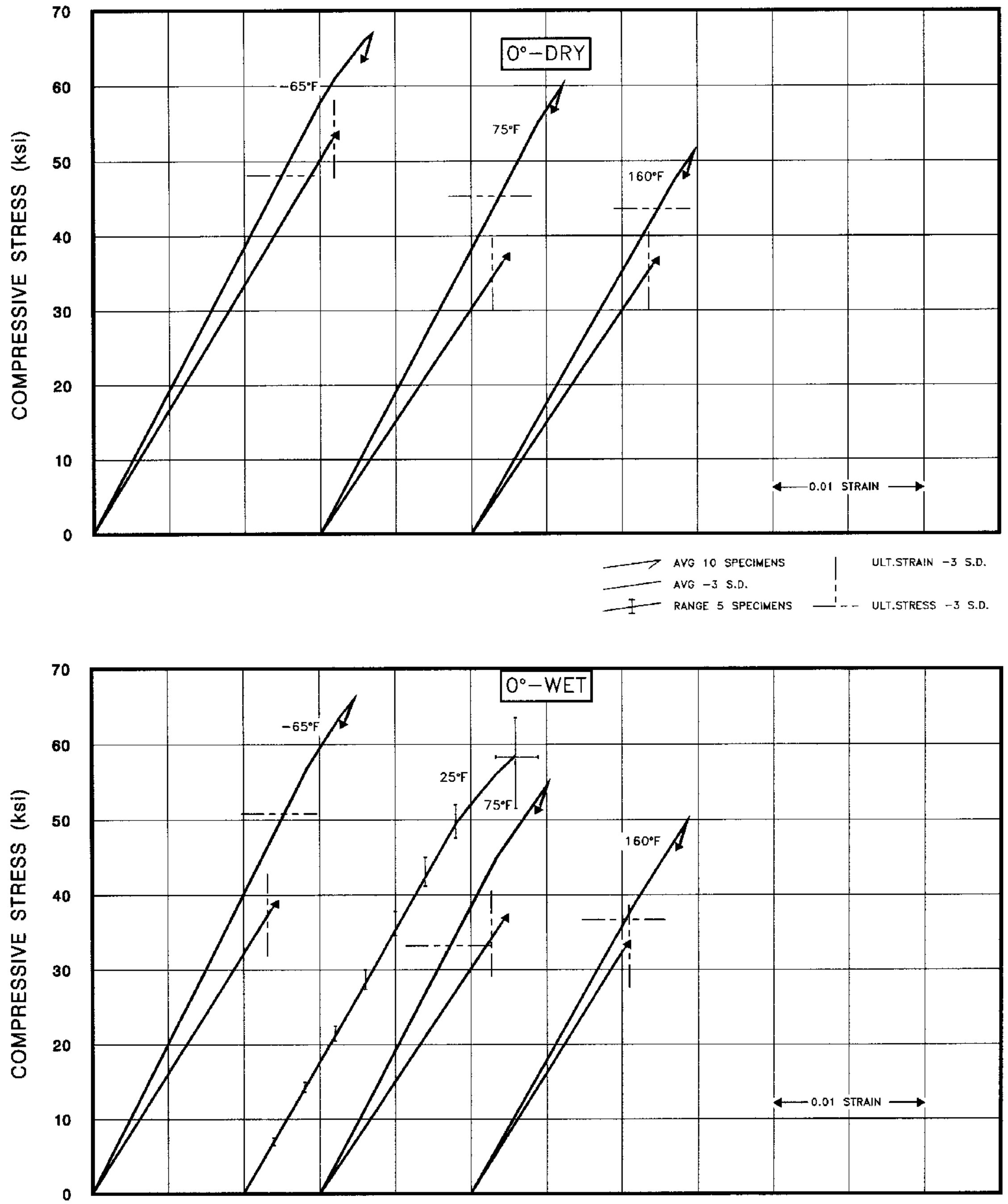


FIGURE A1.40.2(a) *Compressive stress-strain for N506-7781 fiberglass phenolic loaded in the 0° direction.*

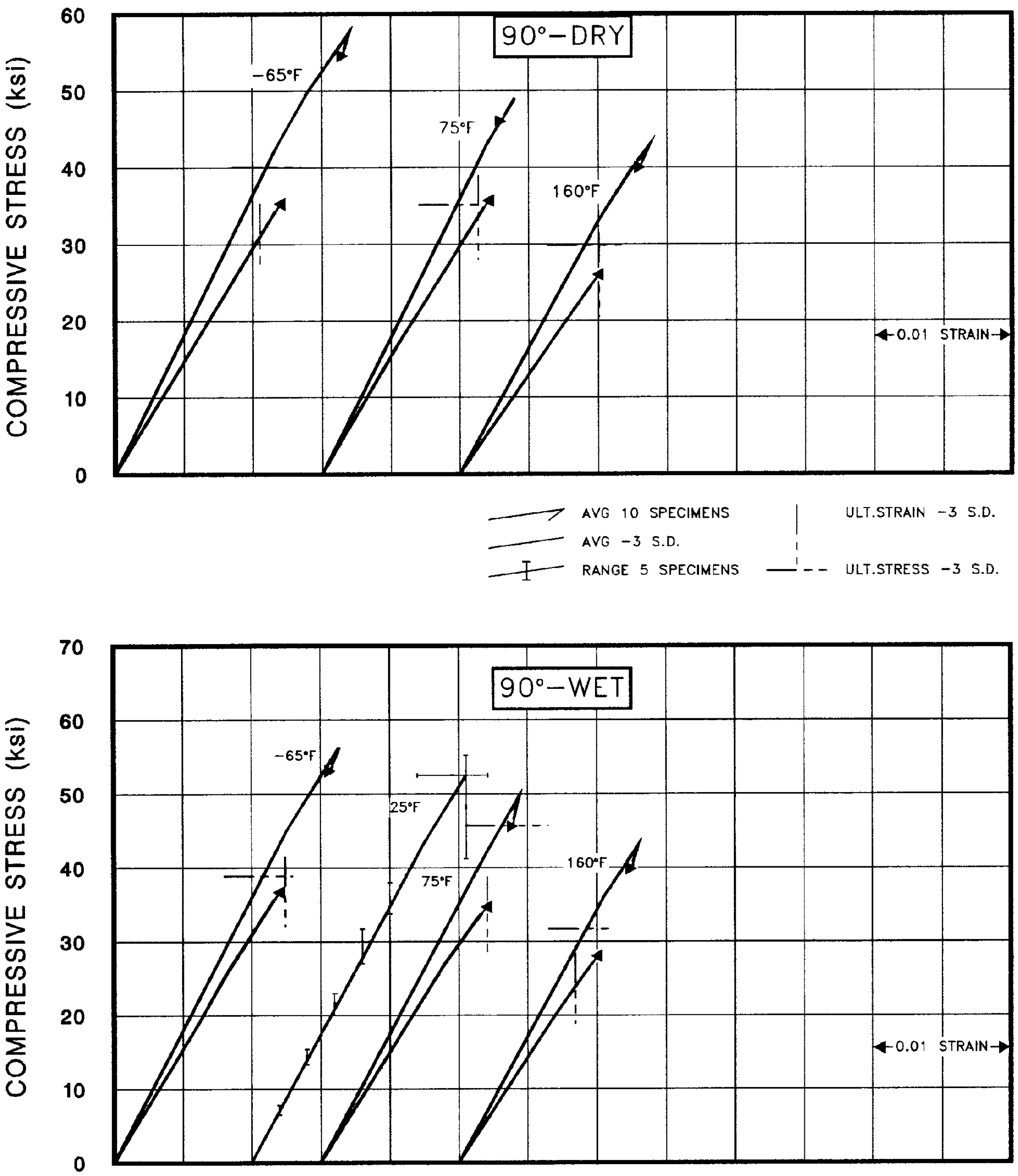


FIGURE A1.40.2(b) *Compressive stress-strain for N506/7781 fiberglass phenolic loaded in the 90° direction.*

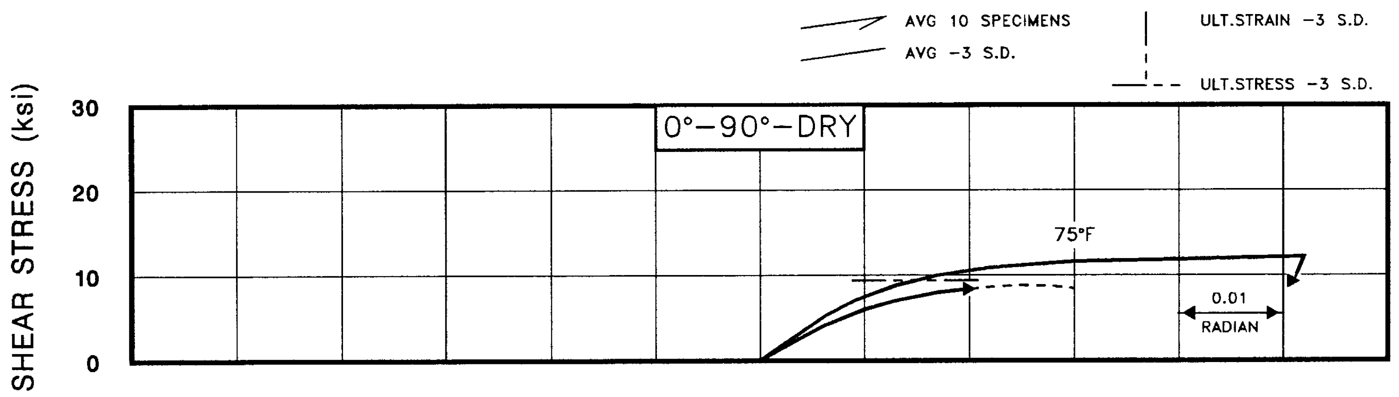


FIGURE A1.40.3 *0° - 90° rail shear for N506/7781 fiberglass phenolic.*

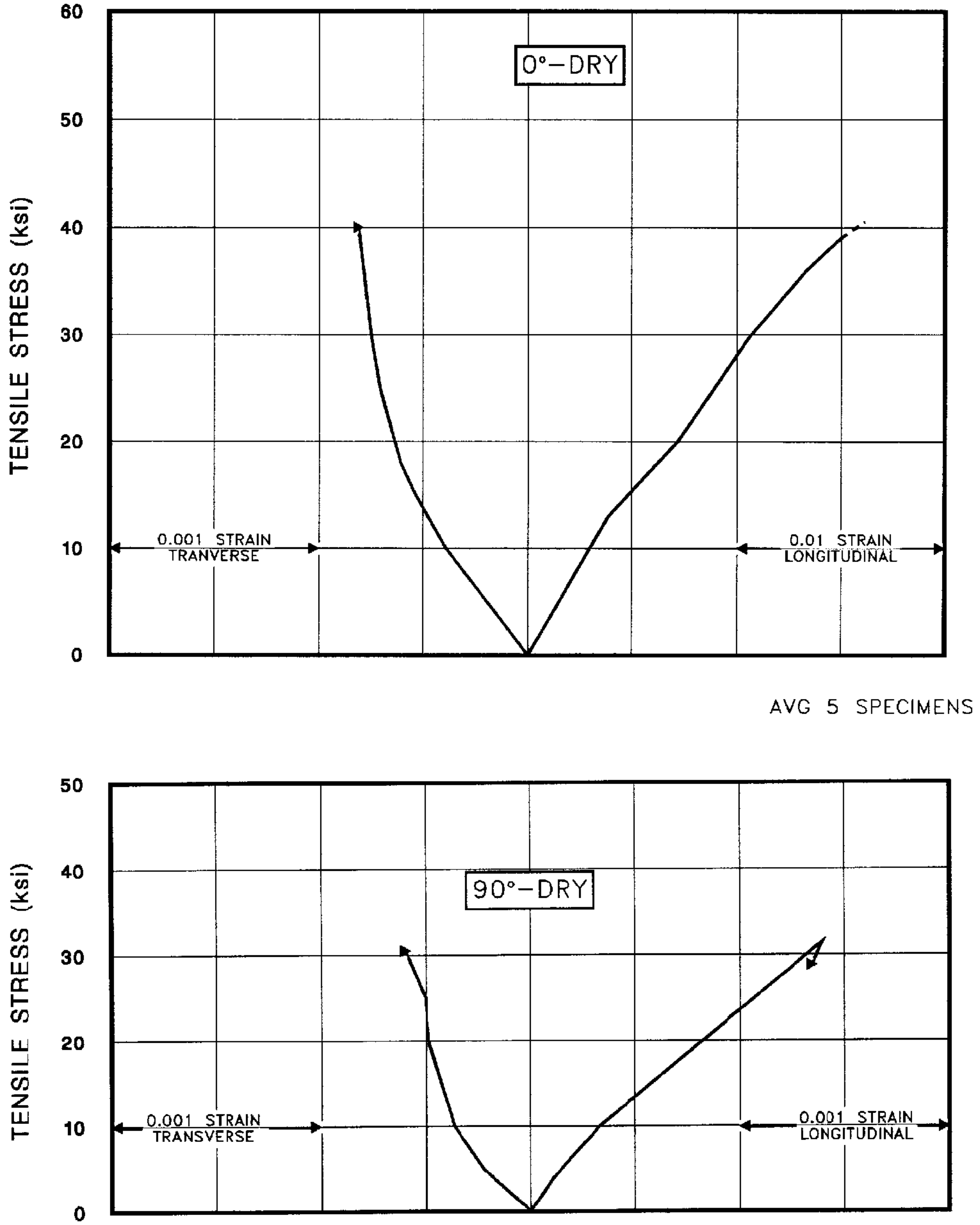


FIGURE A1.40.4 *Poisson effects for N506/7781 fiberglass phenolic.*

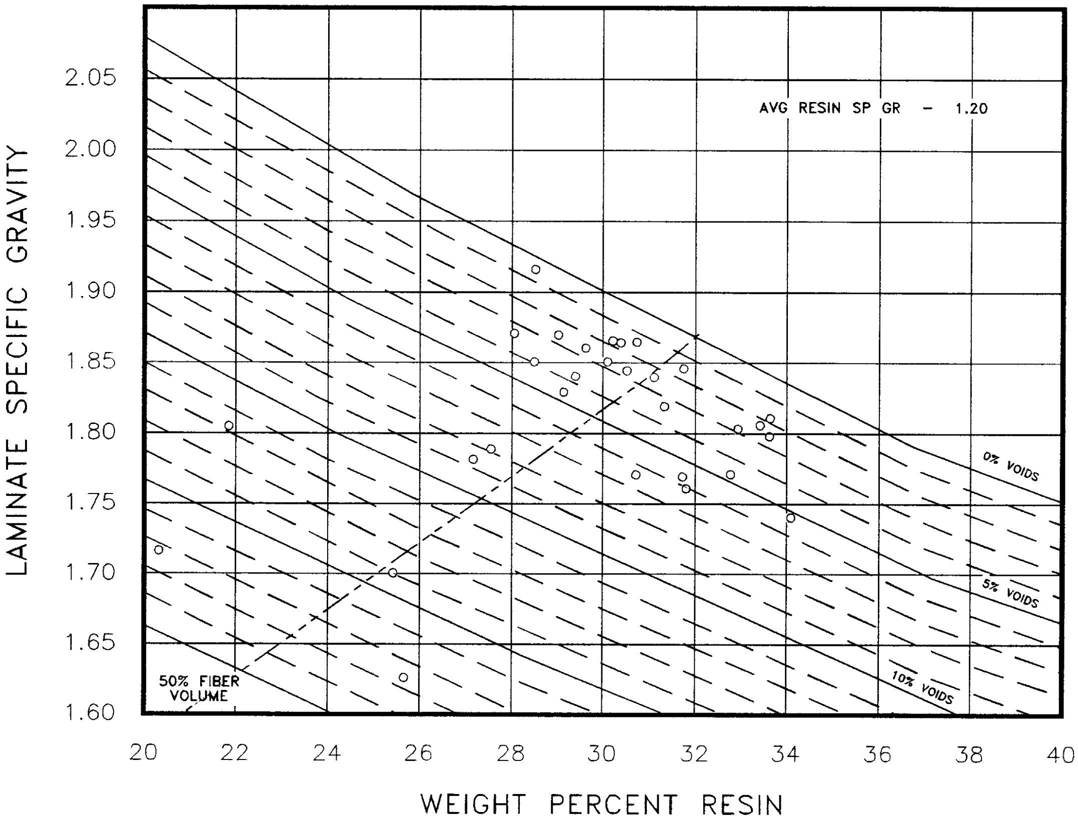


FIGURE A1.40.5 *Voids vs. resin content and specific gravity for N506/7781 fiberglass phenolic.*

TABLE A1.110 *Summary of Mechanical Properties of Narmco 5505 Boron-Epoxy (100%-0° Direction) (Tentative).*

Fabrication	Lay-up: Parallel	Vacuum: 2 ins	Pressure: 50 ± 5 psi	Bleedout:	Cure: 1.5hr/ 350°F ± 10°F	Postcure: 2hr/350°F	Plies: 6
Physical Properties	Weight Percent Resin:	Avg. Specific Gravity:	Avg. Percent Voids:	Avg. Thickness: 0.005 in/ply			
Test Methods	Tension: Tab-ended	Compression: Sandwich Beam	Shear:	Flexure: 4 Point Loading	Bearing:	Interlaminar Shear: Short Beam	

Temperature		-67°F				75°F				260°F				375°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	201.1				208.3				191.6				167.3	
	90°	10.5				8.7				6.5				3.3	
ultimate strain, %	0°	6390				6930				6660				6150	
	90°	3250				3710				4970				6920	
proportional limit, ksi	0°	141.8				175.5				140.0				79.5	
	90°														
initial modulus, 10^6 psi	0°	32.0				30.9				29.6				28.6	
	90°														
secondary modulus, 10^6 psi	0°														
	90°														
Compression															
ultimate stress, ksi	0°	482.3				378.0				303.3				143.9	
	90°														
ultimate strain, %	0°	13670				10830				8920				4466	
	90°														
proportional limit, ksi	0°	333.5													
	90°														
initial modulus, 10^6 psi	0°	35.7				34.8				34.6				35.8	
	90°														
Shear															
ultimate stress, ksi	0°-90°														
	±45°														

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°									
proportional limit, ksi	0°									
initial modulus, 10^6 psi	0°									
Bearing										
ultimate stress, ksi	0°									
stress at 4% elong., ksi	0°									
Interlaminar Shear										
ultimate stress, ksi	0°									

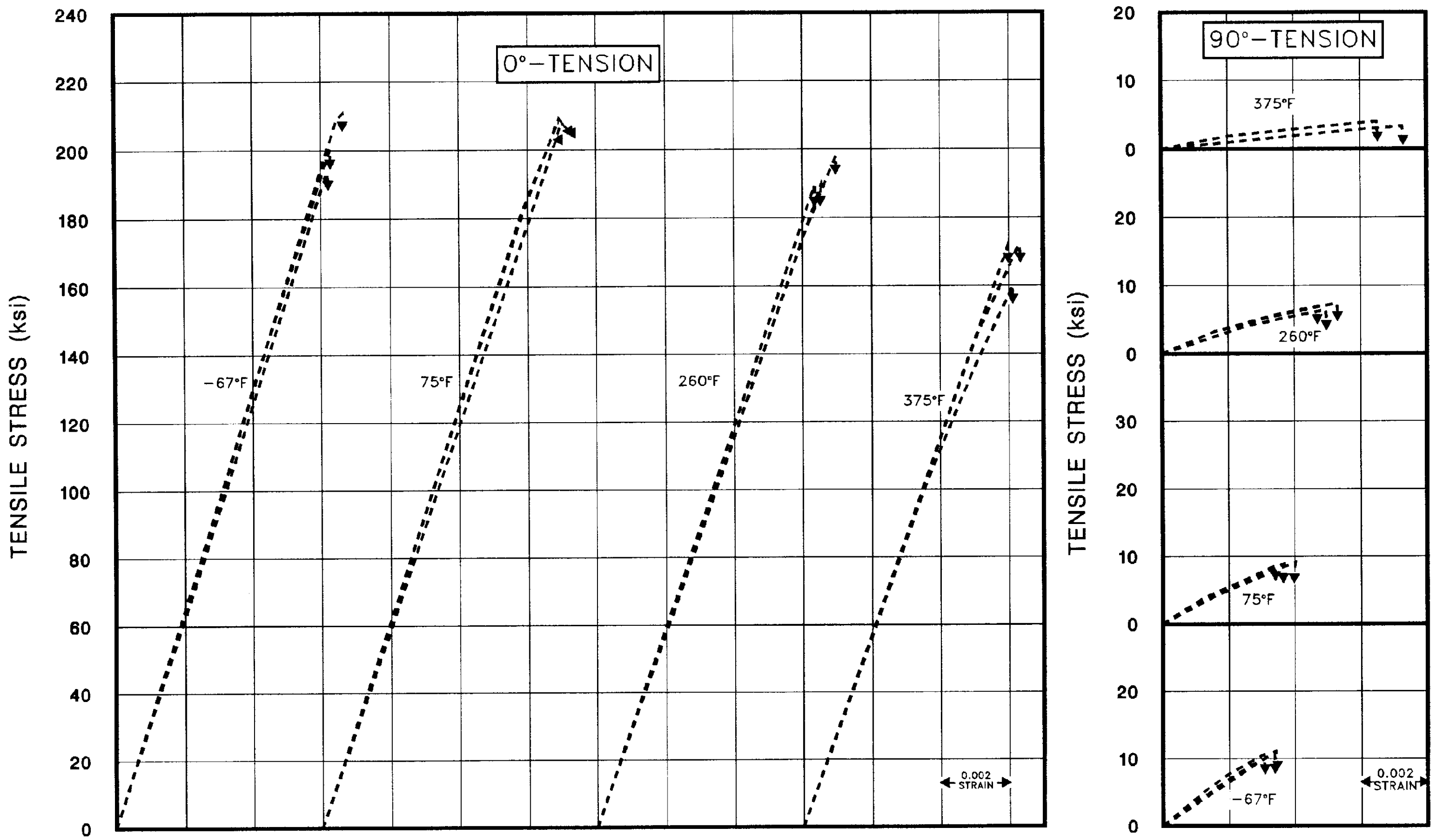


FIGURE A1.110.1 *Tensile stress-strain for AVCO 5505 boron/epoxy (100% - 0° orientation/50.3% to 35% fiber volume) loaded in the 0° and 90° directions. Individual tests shown.*

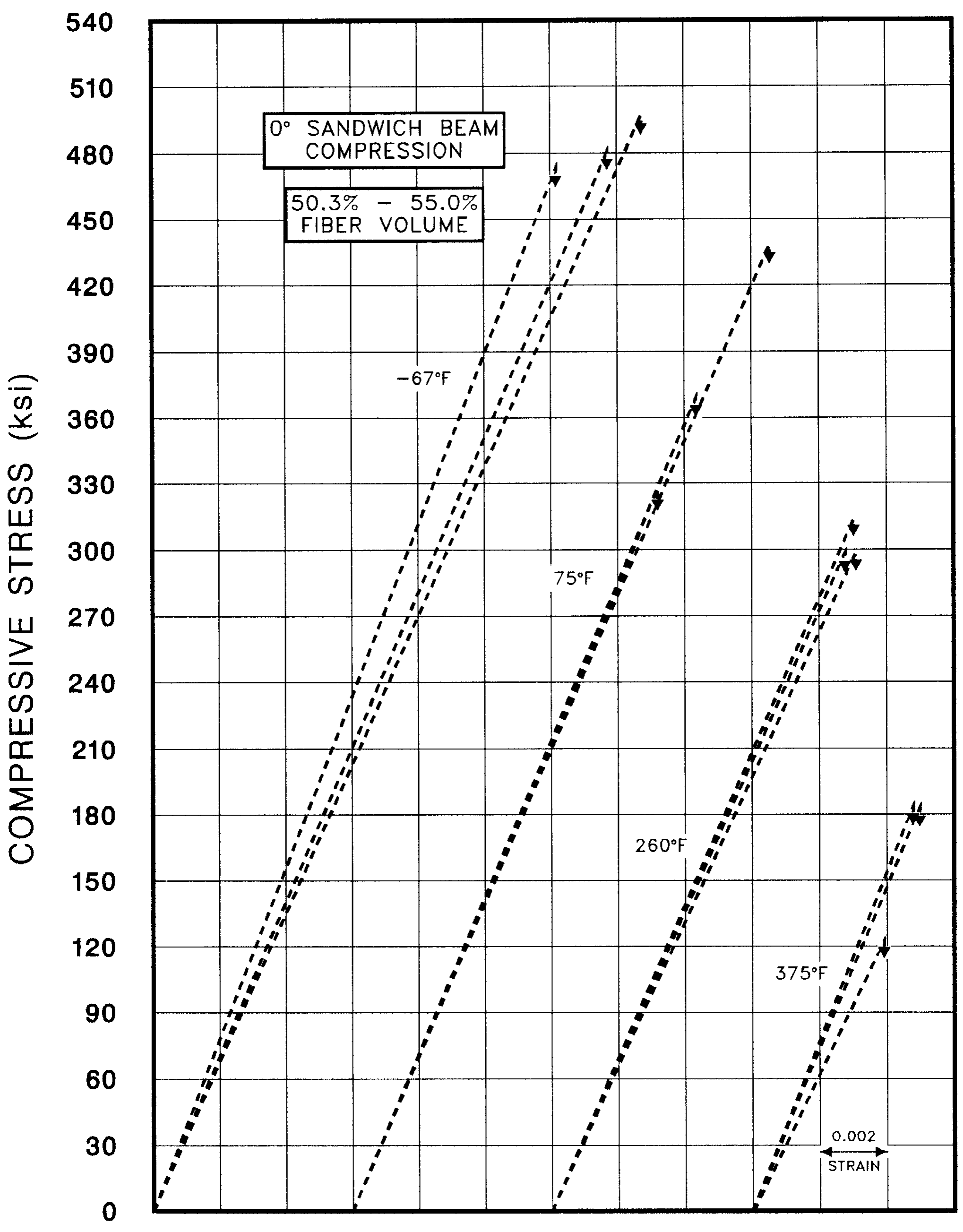


FIGURE A1.110.2 *Compressive stress-strain for AVCO 5505 boron/epoxy (100% - 0° orientation loaded in the 0° direction. Individual tests shown.*

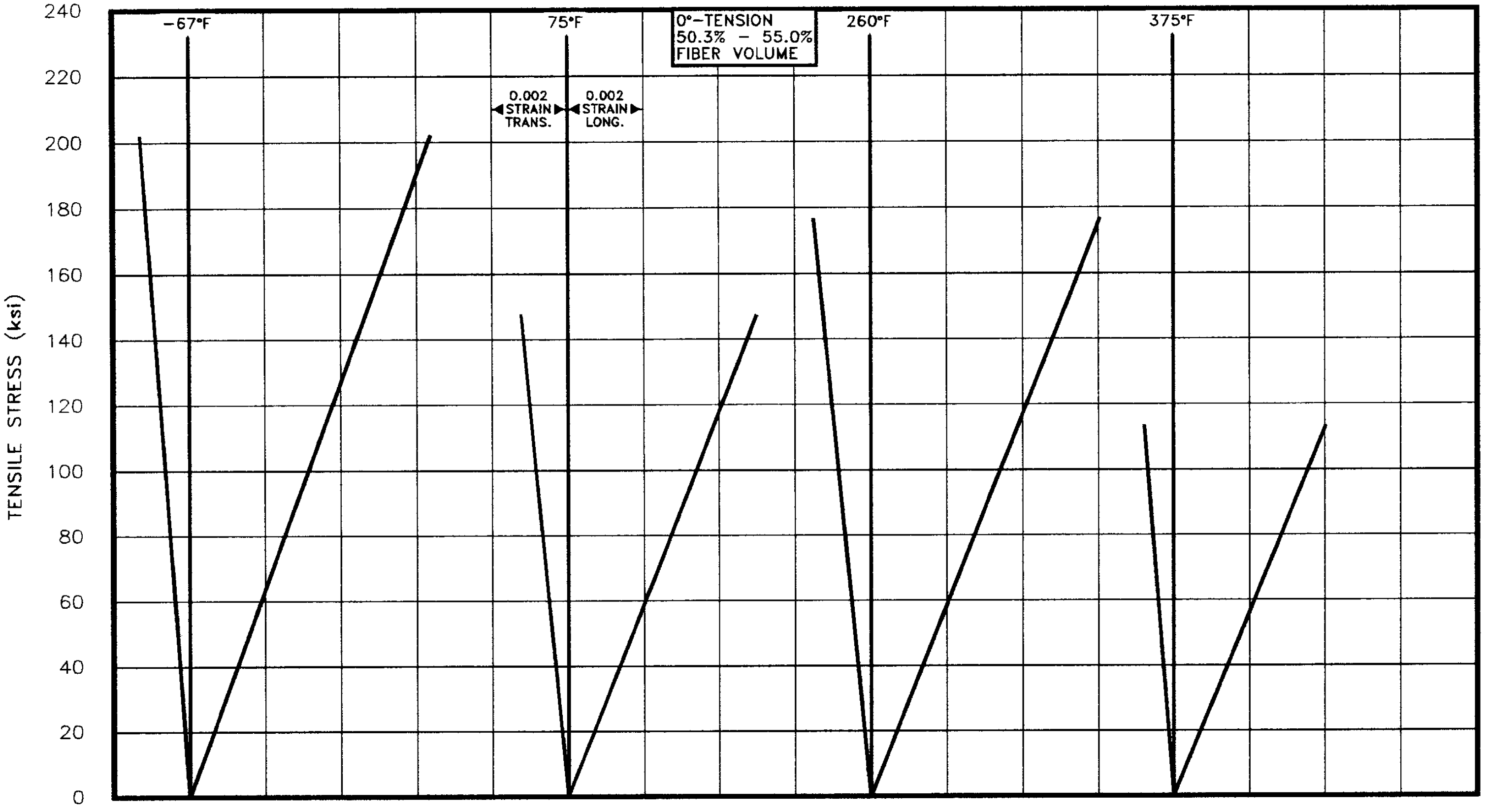


FIGURE A1.110.3 *Poisson effects for AVCO 5505 boron/epoxy (100% - 0° direction).*

TABLE A1.111 *Summary of Mechanical Properties of Narmco 5505 Boron-Epoxy (0°-90° Crossply) (Tentative)*

Fabrication	Lay-up: [2(0/90)]S	Vacuum: 2 ins	Pressure: 50 ± 5 psi	Bleedout:	Cure: 1.5hr/ 350°F ± 10°F	Postcure: 2hr/380°F	Plies: 6
Physical Properties	Weight Percent Resin:	Avg. Specific Gravity:	Avg. Percent Voids:	Avg. Thickness: 0.005 in/ply			
Test Methods	Tension: Tab-ended	Compression:	Shear: Picture Frame	Flexure:	Bearing:	Interlaminar Shear:	

Temperature		-67°F				75°F				260°F				375°F	
Condition		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Tension															
ultimate stress, ksi	0°	99.9				103.9				98.5				91.9	
	90°	23.6				17.8				11.4				8.1	
ultimate strain, %	0°	5400				5710				5830				5780	
	90°	15850				24470									
proportional limit, ksi	0°	53.0				77.7				48.6				48.6	
	90°														
initial modulus, 10^6 psi	0°	18.9				18.0				17.5				16.5	
	90°														
secondary modulus, 10^6 psi	0°														
	90°														
Compression															
ultimate stress, ksi	0°														
	90°														
ultimate strain, %	0°														
	90°														
proportional limit, ksi	0°														
	90°														
initial modulus, 10^6 psi	0°														
	90°														
Shear															
ultimate stress, ksi	0°-90°	19.5				17.3									5.4
	±45°	65.7				63.7									33.3

		-65°F Dry			75°F Dry			160° Dry		
		Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Flexure										
ultimate stress, ksi	0°									
proportional limit, ksi	0°									
initial modulus, 10^6 psi	0°									
Bearing										
ultimate stress, ksi	0°									
stress at 4% elong., ksi	0°									
Interlaminar Shear										
ultimate stress, ksi	0°									

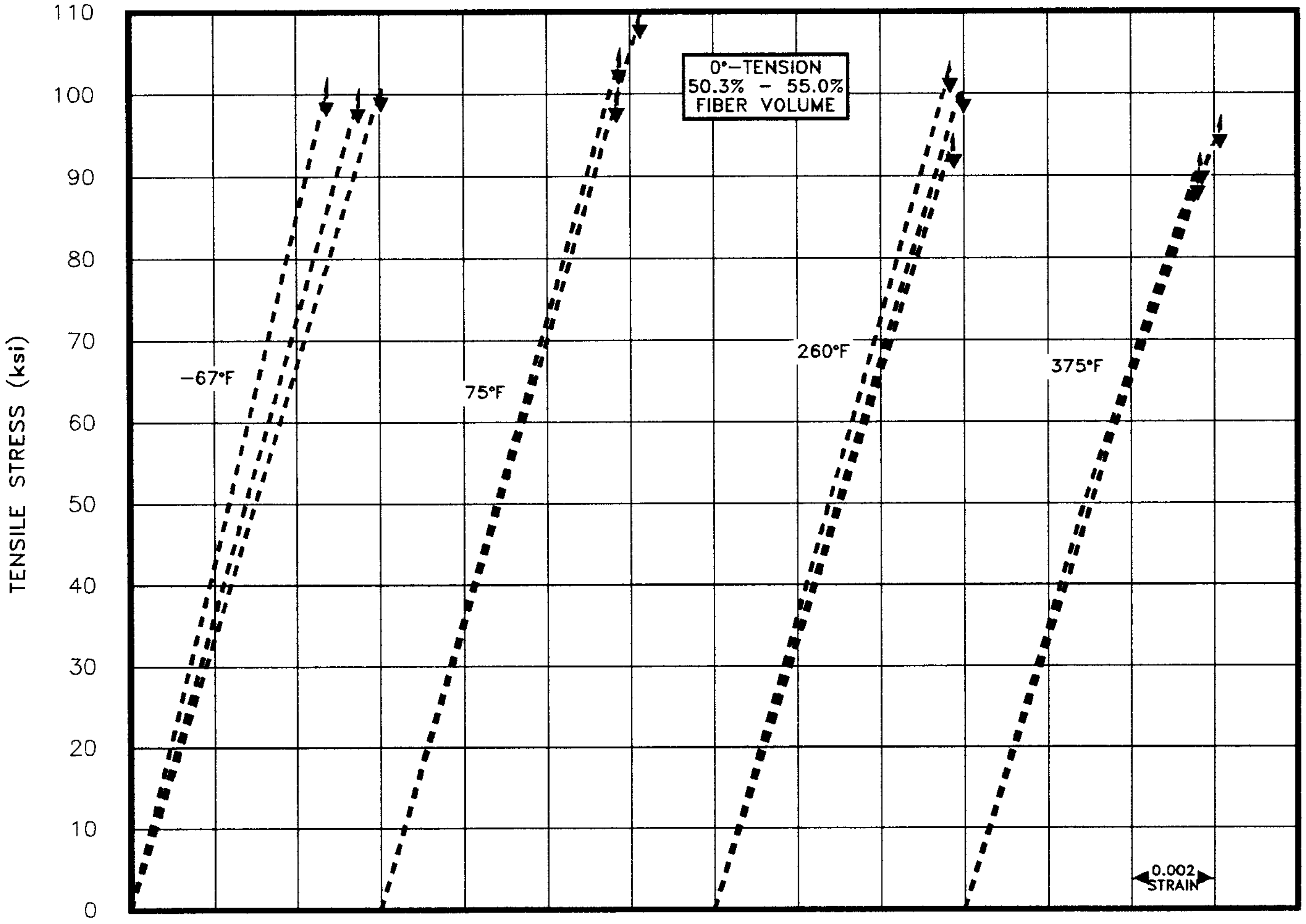


FIGURE A1.111.1(a) *Tensile stress-strain for AVCO 5505 boron/epoxy (0° - 90° crossply) loaded in the 0° direction. Individual tests shown.*

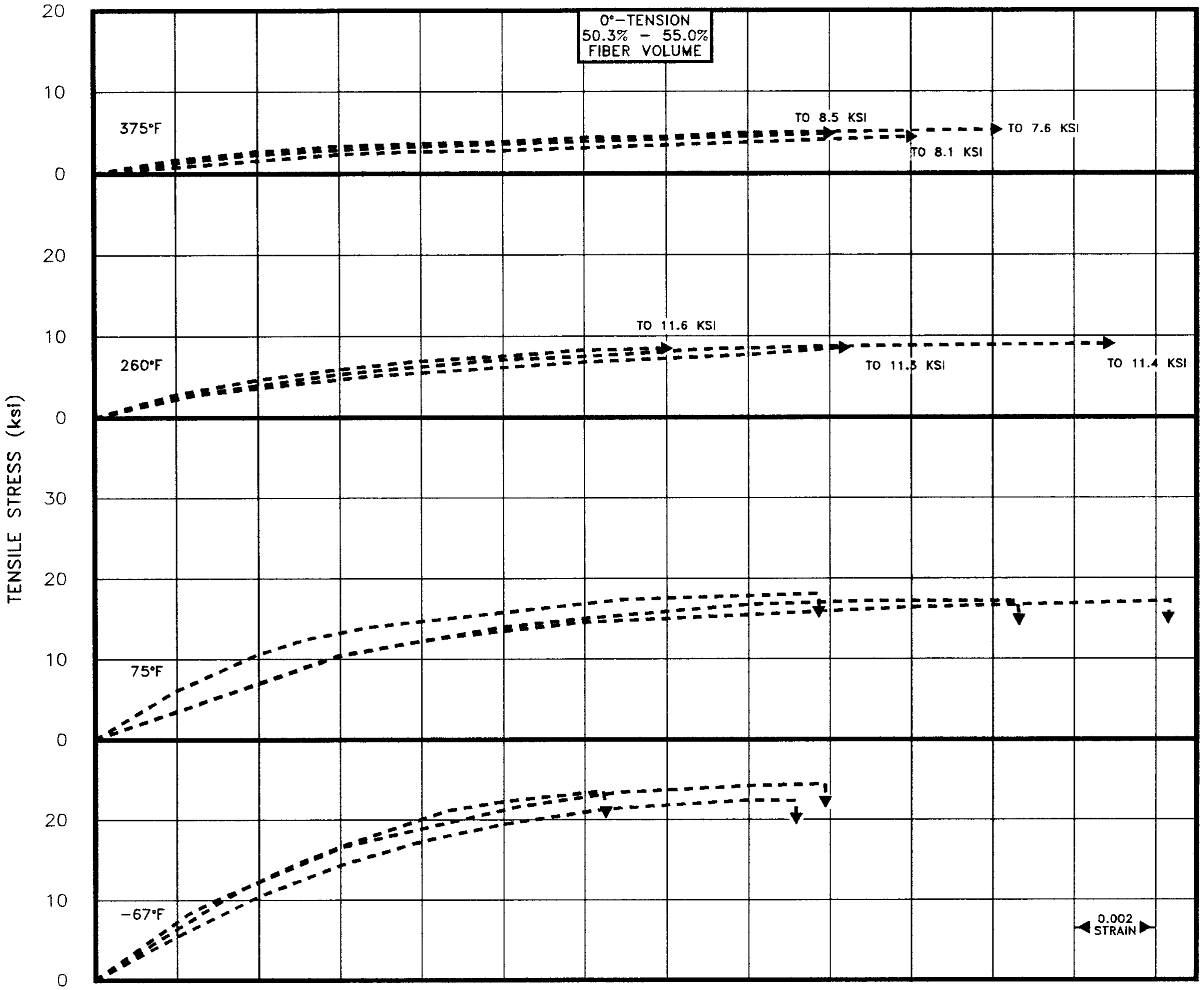


FIGURE A1.111.1(b) *Tensile stress-strain for AVCO 5505 boron/epoxy (0° - 90° crossply) loaded in the 45° direction. Individual tests shown.*

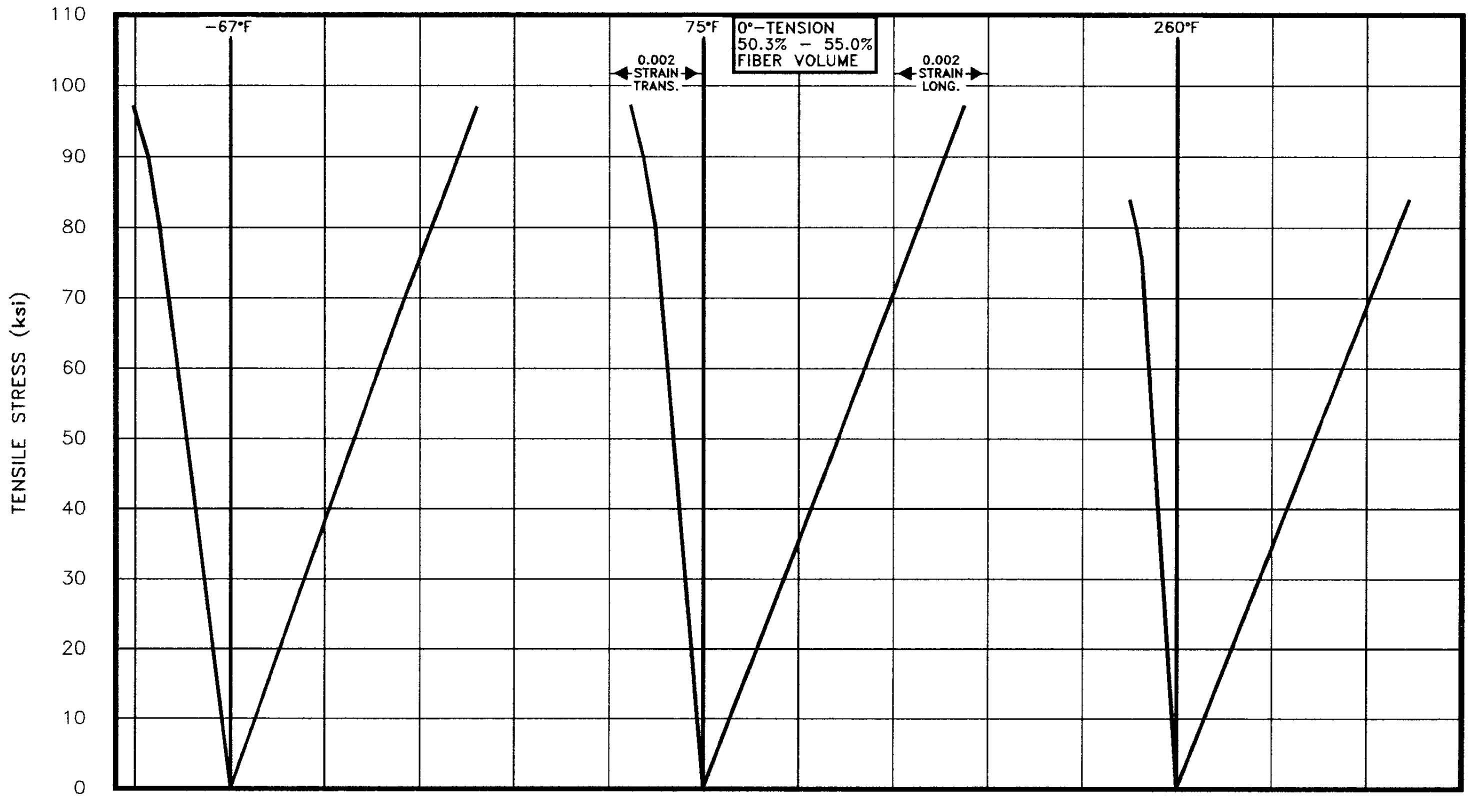


FIGURE A1.111.3 *Poisson effects for AVCO 5505 boron/epoxy (0° - 90° crossply).*

REFERENCES

A1.2 S. J. Dastin and others, *Determination of Principal Properties of "E" Fiberglass High Temperature Epoxy Laminates for Aircraft,* Grumman Aircraft Engineering Corporation, DAA21-68-C-0404, August 1969.

A1.3.4.1(a) ASTM D 638, "Tensile Properties of Plastics," *Annual Book of ASTM Standards*, ASTM, Philadelphia, PA.

A1.3.4.1(b) P. D. Shockey and others, *Structural Airframe Application of Advanced Composite Materials*, General Dynamics, IIT Research Institute, Texaco Experiment, AFML-TR-69-01, **IV**, AF 33(615)-5257, October 1969.

A1.3.4.2 ASTM D 695, "Compressive Properties of Rigid Plastics," *Annual Book of ASTM Standards*, ASTM, Philadelphia, PA.

A1.3.4.3 K. H. Boller, *A Method to Measure Intralaminar Shear Properties of Composite Laminates*, Forest Products Laboratory, AFML-TR-69-311, March 1970.

A1.3.4.4 ASTM D 2733-68T, "Interlaminar Shear Strength of Structural Reinforced Plastics at Elevated Temperatures," *Annual Book of ASTM Standards*, ASTM, Philadelphia, PA (canceled January 15, 1986 and replaced by ASTM D 3846).

A1.3.4.5 ASTM D 790-70, "Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials," *1971 Annual Book of ASTM Standards*, ASTM, Philadelphia, PA, 1971.

A1.3.4.6 ASTM D 953, "Bearing Strength of Plastics," *Annual Book of ASTM Standards*, ASTM, Philadelphia, PA.

A1.4.5 G. C. Grimes and G. J. Overby, *Boron Fiber Reinforced/Polymer Matrix Composites - Material Properties*, Southwest Research Institute, January 1970.