MECHANICAL PROPERTIES OF GLASS-FABRIC HONEYCOMB CORES

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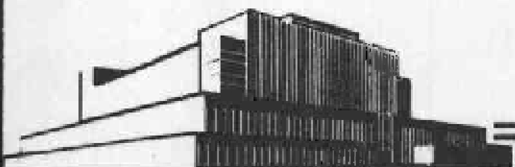

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

MECHANICAL PROPERTIES OF GLASS-FABRIC HONEYCOMB CORES[1]

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Summary

This report presents the results of tests of commercially produced glass-fabric honeycomb cores for use in structural sandwich construction. Detailed descriptions of core materials and testing procedures are given. Included are results of tests of core at 73° F. and 50 percent relative humidity, and after exposure for 60 days at 100° F. and 100 percent relative humidity. Relationships are given for various core properties in different directions, but it was not possible to show a good relationship between core strength and core density.

Design values of core properties, based on tests of commercial core samples at 73° F. and 50 percent relative humidity and at 100° F. and 100 percent relative humidity, are presented in tabular form and as stress-strain curves.

Introduction

Sandwich constructions--comprised of thin, strong facings bonded to each side of a thick, lightweight core--can be used to produce stiff, lightweight structural panels that are particularly adaptable to aircraft where it is desirable to maintain air-foil sections under load. Other desirable features, such as certain electrical and thermal properties, can be realized by correct choice of sandwich core and facing materials. The need for suitable cores has resulted in production of

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[2]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

honeycomb-like cores formed of thin sheet materials. Cores made of sheets of resin-impregnated glass fabric have been tested and successful applications of sandwich constructions having such cores have been made. These tests and applications demonstrate the practicability of these cores for radome construction, especially if glass-fabric laminated facings are used. To meet the needs of designers, this study was undertaken to establish design values of the mechanical properties of commercially available glass-fabric honeycomb cores for structural sandwich construction.

The cores tested were samples of commercial production. Because the successful design of sandwich depends less on core properties than on facing properties, no attempt was made to obtain enough samples to arrive at "guaranteed minimum" values, such as those that are obtained for many structural materials. Details of the study were discussed with the core manufacturers; and the manufacturers supplied twelve samples of each of ten cores from regular production runs.

Cores

The glass-fabric honeycomb cores were obtained from Hexcel Products, Inc. and from Western Products, Inc.

Cores obtained from Hexcel Products, Inc. were of the expanded type, made of glass fabric 112, finish 114 or fabric 21, finish 114. Two cores were made of the 112-114 glass fabric, and three were made of 21-114 glass fabric. Four of the cores were made by treating and bonding the glass-fabric sheets initially with nylon resin, followed, after expansion, by additional treatment with phenolic resin. Before addition of the phenolic resin, the core density was about 3 pounds per cubic foot. The fifth core was treated with a heat-resistant phenolic resin. The cell sizes were 3/16 or 1/4 inch, and nominal core densities were from 4 to 9 pounds per cubic foot. Actual core designations and materials are given in table 1. These cores were made in blocks about 4 feet in length (parallel to the direction of the core ribbons), and each sample consisted of a 10-inch-long section obtained from the end of a large block.

Cores made by Western Products, Inc. were of the preformed type. Of 5 cores obtained 3 were of glass fabric 112, finish 114, and 2 of glass fabric 112, finish 136. Glass fabric with 114 finish was given an initial treatment of phenolic resin, and then sheets of fabric were preformed to corrugated sheets that were finally assembled to make core. Subsequent treatments were given the core by dipping it in polyester resin solutions. Glass fabric with 136 finish was treated with polyester resin only. The cell sizes were 3/16 or 1/4 inch, and nominal core densities were from 3-1/2 to 9 pounds per cubic foot. Actual core designations and materials are given in table 1. Cores were made in blocks about 3 by 18 by 18 inches, and complete blocks of this size were obtained as samples.

All core blocks were trimmed square and then placed in a room maintained at 73° ± 2° F. and 50 ± 2 percent relative humidity. The sample blocks were weighed periodically, and no core test specimens were prepared until the blocks had reached constant weight after about 1 month of conditioning at 72° F., 50 percent relative humidity. Each core block was then measured and weighed to obtain the core density in pounds per cubic foot. The core densities are given in table 1. Maximum and minimum values plotted against average values in figure 1 show that the density of individual samples varied from -15 to +20 percent of the average values.

One small coupon of one sample of each type of core material was carefully weighed and then burned in an oven at 1,000° F. to obtain approximate resin content. The results given in figure 2 showed that cores of 3 to 5 pounds per cubic foot density had about 50 percent resin; cores of 5 to 7 pounds per cubic foot density had about 65 percent resin; and cores of 7 to 9 pounds per cubic foot density had about 75 percent resin.

Core Tests

Core tests were made to determine properties needed for proper structural design of sandwich construction. These properties were the compressive and shear properties and the flatwise tensile strength. Since the various properties may be affected by moisture, all specimen manufacturing procedures and all tests were carried out in a room maintained at 73° ± 2° F. and 50 ± 2 percent relative humidity. Tests at this condition are called "dry."

In order to determine possible effects of moisture, core specimens were exposed for 60 days at 100° F. and 100 percent relative humidity. Such conditions were obtained by placing specimens on racks over distilled water in an airtight metal box. The box was stored in a chamber kept at 100° F. Tests were made at 73° F. immediately after the specimens were removed from the high-humidity condition. Tests performed after this exposure are called "wet." Special techniques for bonding loading fittings to specimens exposed to this condition are outlined in the following discussions of the shear and tensile tests.

Compression Tests of Cores

Tests were made on specimens compressed in the "T" direction (parallel to the core flutes); the properties determined by the tests are denoted by the subscript T. The compression tests were made to determine the modulus of elasticity, E_T, the proportional limit stress, f_T, and the compressive strength, F_T.

Modulus of elasticity is needed for design to determine loads at which the sandwich facing will wrinkle (11).[3] Proportional limit and strength data are needed for designing sandwich panels under loads normal to the facings (3, 13, 14) and for determining the pressures allowable for bonding the facings to the core.

Two compression specimens 2 by 2 inches in cross section and 8 inches long (parallel to core flutes) were cut from each sample core block. One was tested in the dry condition and one in the wet condition. Data on tests of 8-inch-long and 1/2-inch-long specimens of aluminum honeycomb cores (5) showed that the compressive strength of the long specimen is the same as that of the short specimen. This would not necessarily be true if a core had large cells. The long specimen was chosen so that deformation gages could be applied.

The ends of the specimens were dipped in resin to simulate the way ends of core would be coated with adhesive or resin in a sandwich, and to prevent local end crippling or crushing at low loads. The resin used was a furane resin formulation catalyzed to cure at room temperature. One end of a compression specimen was dipped to a depth of 1/8 inch in the resin, then placed for a minute or two on a paper towel to dry. Next the specimen was placed on a flat steel plate covered with cellophane. A small weight was placed on the specimen, and the assembly was allowed to cure for several hours at room temperature. The same procedure was used to treat the opposite end of the specimen.

The compression specimens had open-ended cells. This resulted in more complete conditioning at 100° F. and 100 percent relative humidity because it was possible for the moist air to circulate through each cell. If the ends had been closed by a cast resin or a plaster base, such circulation would have been impossible. The end reinforcement proved to be sufficient to prevent localized end failure on all the cores tested.

The compression specimens were placed on a flat, machined, steel block in a hydraulic testing machine. The load was applied at the top end through a spherical loading head of the suspended, self-alining type.

Deformations in the specimen were measured with a Marten's mirror compressometer of 2-inch gage length, which was mounted on the specimen at midlength. The movable head of the testing machine was driven at a constant rate of 0.003 inch per inch of specimen length per minute. Deformation readings were taken at equal load increments until failure.

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[3] Underlined numbers in parentheses refer to Literature Cited at the end of this report.

The proportional limit stress and modulus of elasticity of each specimen were determined from load deformation curves. Individual values, average values, and standard deviation values of these properties and the compressive strength for the 12 specimens tested of each core material in the dry and wet condition are given in table 1.

Analysis of Compression Test Data

In order to show variations in compressive strength of glass-fabric honeycomb cores, the strength values were plotted against average core density in figure 3. As would be expected, the strength increased as the density increased. The trend shown could be interpreted to demonstrate that strength increases as some power function of density, but closer examination shows that for particular core fabric and resin combinations the strength might vary almost linearly with core density. Since a sufficient density variation of any particular core fabric and resin were not evaluated to determine straight lines, the general trend of the data will not be described mathematically.

Examination of average values, given in table 1, for proportional limit stresses and modulus of elasticity shows that these values increase with increasing core density in approximately the same manner as compressive strength values.

An attempt was made to derive expressions for predicting compressive properties of glass-fabric honeycomb cores such as was done for cores of aluminum honeycomb (5). However, not enough of any one type of core was tested in a sufficient range of density so that properties of the basic core material could be determined with assurance. The effects of variables such as resin content, type of glass fabric, thickness of finished glass fabric, and different cell shapes could not be isolated.

The effect of moisture on the compression strength of the cores is shown by the data presented in figure 4. In this figure, wet-strength values are plotted as ordinates, and dry-strength values are plotted as abscissas. The straight line indicates equal strength of the cores when wet and when dry. An examination of the plotted points shows that the wet strength of cores treated with phenolic or phenolic plus polyester resins is almost consistently equal to the dry strength. The wet-strength values of cores treated with nylon-phenolic resin, or of cores of glass fabric with finish 136 treated with polyester resin, were only 40 to 70 percent of the dry-strength values. Comparison of wet with dry proportional limit stress values in table 1 shows that exposure to moisture had about the same effect on proportional limit stress as that on compressive strength values. Modulus of elasticity values for wet and dry cores, given in table 1, showed that exposure to moisture generally had little effect on the values, although minor decreases after exposure to moisture were obtained for some cores.

Shear Tests of Cores

Tests were made on specimens oriented so that shearing distortion occurred in the plane defined by the core flute direction, T, and the core ribbon direction, L (hence, the TL plane); or the core flute direction, T, and perpendicular to the core ribbon direction, W (hence, the TW plane). The core properties needed for design are the shear modulus, G_{TL}, G_{TW}, which enter in parameters describing buckling (1, 6, 7, 8, 9, 13) and deflection (7, 4, 10, 12) of sandwich; and the shear stresses f_{TL}, f_{TW}, F_{TL}, F_{TW}, which are needed for designing sandwich to carry transverse loads, particularly as applied to fittings (2, 15, 16).

Shear tests were made on core specimens 1/2 inch thick (T direction; parallel to core flutes), 2 inches wide (W or L direction; L parallel to core ribbons), and 6 inches long (L or W direction). Four specimens were cut from each of 12 sample blocks of each core. The specimens were bonded between two steel plates 1/2 inch thick by using heavy spreads of epoxide resin adhesive. The adhesive was cured under light pressure at room temperature by placing weights on the shear plates for several days. Wet specimens were cured in the high-humidity chamber at 100° F. Some of the higher strength cores could not be failed by the bonds produced by such cures, so they were cured for several additional hours at 160° F. and 50 percent relative humidity for the dry specimens, and as near to 100 percent relative humidity as possible for the wet specimens.

Shear specimens were tested by fastening opposite ends of the steel plates to links hung in a testing machine, and a tensile load was applied to place shear load on the core in the 6-inch direction. The test specimen and apparatus are shown in figure 5. The steel plates and loading pieces were arranged so that the tensile force was applied along a diagonal of the specimen. This, combined with the load applied through links and pins, produced fairly uniform shear on the test specimen as evidenced by appearance of failures throughout the entire length of the specimen.

Deformations were measured by means of a dial gage that was accurate to 0.0001 inch. The gage was mounted to measure the slip between the loading plates as the load was increased. Shear strain in the core was then determined by dividing the dial reading by the actual core thickness. Thus, the dial readings included possible slip in the adhesive bond. The adhesive bond slip was believed to be small, however, because the core was pressed through the uncured adhesive film until it touched the steel plates. Therefore, most of the bonding was accomplished through the fillets formed by the adhesive surrounding the core-cell ends; these adhesive fillets were quite rigid and showed no signs of permanent deformation after core failure.

During the test, the movable head of the testing machine was driven at a constant rate of 0.010 inch per minute until failure occurred.

Deformation readings were taken at equal load increments until failure. The beginning of failure, signified by hesitation and final dropping of the load, was observed carefully for possible tearing in the bond between the specimen and the loading plates. All data for dry specimens represent core shear failures, but the strongest wet core could not be failed with the present bonding techniques.

The proportional limit stress and shear modulus of each specimen were determined from load-deformation curves. Table 1 presents individual, average values; and the standard deviation for proportional limit stress, shear modulus, and shear strength in both the TL and the TW planes for core material in the dry and wet condition.

Analysis of Core Shear Test Data

Variations in TL shear strength are shown in figure 6 where dry shear strength is plotted against average values of core density. The shear strength increased as core density increased, but the data scatter was so great that no definite relationship between shear strength and core density could be obtained. There was a fairly good relationship between TL shear strength and TW shear strength as shown in figure 7. Although there was some scatter in the points shown in figure 7 a line determined by least squares analysis shows that the shear strength in the weak direction (F_{TW}) was 59 percent of the shear strength in the strong direction (F_{TL}).

Shear stresses at proportional limit, given in table 1, showed increases corresponding with that in core density and in approximately the same manner as shear strength values.

Values of the core shear moduli, given in table 1, also increased as core density increased and about in the same manner as shear strength values. Figure 8 shows the relationship between the shear modulus of the core in the strong direction (G_{TL}) and the compressive modulus of elasticity (E_T) of the core in the dry condition. By least squares analysis a linear relationship was found that showed the LT core shear modulus to be 20 percent of the modulus of elasticity. A comparison of the two principal core shear moduli, G_{TL} with G_{TW}, is shown in figure 9. A linear relationship closely represents the relationship between G_{TW} and G_{TL}; and by least squares analysis it was found that the G_{TW} shear modulus was half of the G_{TL} shear modulus.

In the compression tests, it was impossible to derive expressions for predicting shear properties of the glass-fabric honeycomb cores because effects of variables--such as resin content, type of glass fabric, thickness of finished glass fabric, and different cell shapes--could not be isolated.

The effect of moisture on the shear strength of cores is shown by data presented in figure 4 where wet-strength values are plotted against dry-strength values. An examination of the plotted points shows that none of the cores has as high a shear strength when wet as when dry. Cores treated with phenolic resin or with phenolic plus polyester resin have 80 percent or more of their dry strength after conditioning at 100 percent relative humidity and 100° F. for 60 days. Cores treated with nylon-phenolic resin or cores of fabric with 136 finish have wet-strength values of 40 to 80 percent of their dry-strength values. Comparison of wet with dry proportional limit stress values in table 1 shows that exposure to moisture in general had slightly more detrimental effect on proportional limit stress than it had on shear strength values. Shear modulus values given in table 1 were, for some cores, lower for wet than for dry core, but the detrimental effect of moisture was normally not as great for shear modulus as it was for shear strength.

Tensile Tests of Cores

Tests to determine tensile strength were made on specimens in which tension was applied parallel to the core flutes. In sandwich construction, tensile strength is usually dependent on the facing-to-core bonds, which were not investigated in this study. The purpose of this work was to determine core strength, if possible, and thereby decide whether face wrinkling (11) will occur either by tearing of facings from the core or by buckling of the facings into the core. Thus, if tensile strength exceeds compressive strength, the sandwich facing wrinkles will occur by buckling into the core. If the tensile strength is lower than the compressive strength, as in weaker bonds, the facings will tear from the core. The data given here should not be construed as representing actual sandwich construction; they represent maximums that can be attained if bonds are strong enough to fail the various cores.

Tensile tests were made on specimens 1 by 1 inch in cross section and 1/2 inch thick. Five specimens for dry tests and five for wet tests were prepared from each sample core block. Tensile loads were applied through 1-inch aluminum cubes bonded to the core with a heavy spread of epoxide resin adhesive. The adhesive was cured at room temperature under light pressure by placing weights on the blocks for several days. Wet specimens were cured in the high-humidity chamber at 100° F. Specimens of strong cores were given additional curing for several hours at 160° F. and 50 percent relative humidity for the dry specimens, and as near to 100 percent relative humidity as possible for the wet specimens.

Tensile specimens were tested in a self-alining loading fixture as shown in figure 10. During the test, the movable head of the testing machine was driven at a constant rate of 0.03 inch per minute until failure occurred. The beginning of failure, as signified by hesitation and final dropping of the load, was observed carefully for possible bond failure.

Analysis of Core Tensile Test Data

Tensile strength values for dry cores are given in table 1. Because many specimens failed in the bond between loading block and core, the data are not truly core-strength values. Tensile strength values are plotted against compressive strength values in figure 11. Even though there were bond failures the tensile strength was greater than compressive strength for most cores, and weakest tensile values were at least about two-thirds of compressive strength.

Tensile strength values for wet cores are given in table 1. Most values were at stress levels exceeding or equal to compressive strength values, even though nearly one half of the tensile specimens failed in the bond between the core and loading block.

Design Values

Core properties are of secondary importance in the design of structural sandwich constructions because the primary load-carrying portions are the facings. Therefore, it was not considered necessary to obtain "guaranteed minimum" values for cores such as are usually obtained for the facing materials. Statistical analysis shows (17) that if the minimum value of 12 determinations of a property is used as a design value, 78 percent of the population will exceed this minimum value 95 percent of the time. On this basis, design stresses were obtained as minimum values from the sample of 12, both for cores at 50 percent relative humidity and 73° F., and for cores exposed at 100 percent relative humidity at 100° F. for 60 days.

The design stresses are given in table 2. Compressive stresses must be considered by the designer for determining normal loads allowable in sandwich manufacture and for determining performance of sandwich under normal loads. Compressive stresses are particularly important if loads are concentrated or if they occur at fastenings. Shear stresses must be considered by the designer for sandwich subjected to flexure, for sandwich under edge loads, and for sandwich with loads applied at inserts and fasteners. No design values are given for tensile strength of the cores because, for the most part, the tensile strength values were greater than compressive strength; hence, wrinkling of facings of a sandwich would be determined by load at which facings wrinkled into the core rather than away from the core (11). It should be recalled that bonds were usually strong enough to cause core failures, and that if in a sandwich the core-to-facing bond strength is less than the compressive or tensile strength of the core, the design must be based on the core-to-facing bond strength.

Of secondary importance to designers are the elastic properties of cores; that is, modulus of elasticity and shear modulus values. The modulus of elasticity, E_T, and the shear modulus, G_{TL} or G_{TW}, are contained in parameters for determining the wrinkling of sandwich facings under edge load. The shear moduli are also involved in parameters for describing the buckling of sandwich under edge load and for determining deflection of sandwich under transverse load. Since the values of these elastic properties are of secondary importance in design, the values chosen and given in table 2 are near the average for the particular core; they are not minimum values.

Entire stress-strain curves for use in design are presented in figures 12 to 31. These curves were drawn by first plotting the stress-strain data for the specimen having the least strength, thus defining the general shape of the curve and locating the maximum stress point with its associated strain. Then the minimum proportional limit stress level (not necessarily the proportional limit stress for the same specimen that had least strength) was located on the curve sheet as a horizontal line. The initial part of the stress-strain curve was then located with a slope near the average modulus, so that the curve could be faired in to fit the portion beyond the proportional limit. Modulus values noted on the curve sheets are also given in table 2.

Since the designer is also interested in weights of various constructions, the data in table 2 include average density values for the cores, and the design values are tabulated in order of increasing core density.

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Table 1.--Mechanical properties of glass-fabric honeycomb cores[1]

	Core density	Compression (T)						Shear (TL)						Shear (TW)						Tensile strength[3]	
		Proportional limit stress f_T		Compressive strength F_T		Modulus of elasticity E_T		Proportional limit stress f_{TL}		Shear strength F_{TL}		Shear modulus G_{TL}		Proportional limit stress f_{TW}		Shear strength F_{TW}		Shear modulus G_{TW}			
	Dry	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
	P.c.f.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.
	Core of Glass Fabric 112, Finish 114, Phenolic Resin, 1/4-inch Cells (Western Products Core BPF 3.5)																				
	3.50	133	147	258	302	88.7	60.9	79	50	162	145	10.8	11.6	31	27	76	63	6.2	6.0	613	547
	3.55	173	146	260	256	66.8	59.8	66	63	164	187	12.6	15.2	29	19	74	52	5.8	5.7	525	515
	3.62	208	136	279	279	68.2	56.5	50	37	144	113	10.7	10.8	29	19	74	49	5.4	4.2	633	540
	3.58	221	159	295	303	58.2	64.8	70	46	195	130	13.9	13.1	33	23	87	64	7.1	7.1	618	523
	3.52	185	136	338	328	61.9	76.8	71	42	195	172	12.4	12.7	39	14	93	64	6.4	7.2	742	648
	3.33	147	160	336	311	63.4	71.2	66	58	183	156	12.3	13.0	35	33	86	81	6.8	7.4	712	482
	3.37	184	160	370	358	68.4	56.6	87	41	181	145	14.0	13.9	33	27	84	74	8.0	7.9	660	543
	3.63	159	184	341	359	67.4	80.4	84	79	150	232	15.2	20.3	54	35	107	83	11.0	9.3	427	367
	4.10	146	135	264	312	69.8	59.5	62	58	190	167	12.2	11.4	35	20	85	67	7.3	5.6	478	508
	3.08	121	135	193	177	52.1	63.1	60	54	119	84	9.9	8.6	25	12	56	31	5.1	3.8	615	505
	2.97	110	134	221	206	45.1	62.0	63	59	134	122	9.0	8.7	29	13	70	39	4.4	3.8	553	473
	3.30	134	171	276	325	58.5	71.6	58	50	158	172	10.3	12.0	29	18	86	59	5.6	5.3	660	605
Av.	3.46	160	150	286	293	64.0	65.3	68	51	165	152	11.9	12.6	34	22	82	60	6.6	6.1	603	521
Min.	2.97	110	134	193	177	45.1	56.5	50	34	119	84	9.0	8.6	25	12	56	31	4.4	3.8	427	367
Max.	4.10	221	184	370	359	88.7	80.4	87	79	195	232	15.2	20.3	39	35	107	83	11.0	9.3	742	648
S.D.[2]	.29	35	16	52	56	10.7	7.9	11	13	26	38	1.9	3.1	8	8	13	16	1.7	1.7	93	69
	Core of Glass Fabric 21, Finish 114, Nylon-Phenolic Resin, 1/4-inch Cells (Hexcel Products Core NP-1/4-21-4.0)																				
	4.65	175	161	389	303	103	90	105	116	316	293	21.5	21.6	54	58	163	136	9.5	9.1	1,193	1,190B
	4.26	208	136	385	312	112	84	90	83	251	241	17.8	21.6	49	41	116	118	7.3	15.1	1,280	1,200B
	4.43	199	148	425	313	105	88	108	99	266	224	16.7	17.4	53	57	130	117	8.1	8.2	1,188	1,000B
	4.58	224	139	496	257	120	98	133	83	305	186	19.0	10.5	66	33	136	86	7.5	6.1	1,472B	790B
	4.37	180	186	456	294	113	114	134	92	291	226	17.8	16.6	49	57	141	110	10.3	6.7	1,335	1,135
	4.66	240	164	449	339	120	99	150	92	318	207	19.3	14.4	54	34	136	98	8.2	9.4	1,483B	790
	4.31	221	137	470	299	122	97	116	75	267	209	18.9	16.0	41	58	133	101	8.4	5.4	1,363B	1,091
	4.33	187	100	455	282	108	112	116	100	261	241	16.2	18.5	57	37	134	105	7.3	7.8	1,280	865
	4.32	255	201	442	241	102	101	105	100	249	212	15.1	13.2	48	58	135	105	8.8	5.5	1,272	975
	4.58	277	180	520	295	127	93	126	101	330	197	16.9	13.3	57	42	154	97	9.7	7.1	1,202	960
	4.29	211	175	436	337	109	94	99	92	271	236	17.2	17.2	46	29	130	116	8.2	10.5	1,232	955B
	4.49	142	201	384	324	114	98	106	107	257	226	18.1	16.2	58	50	138	118	7.3	6.3	1,383	1,180B
Av.	4.44	210	161	442	300	113	97	116	95	282	225	17.9	16.4	53	46	137	109	8.4	8.1	1,307	1,011
Min.	4.26	142	100	384	241	102	84	90	75	249	186	15.1	10.5	41	29	116	86	7.3	5.4	1,188	790
Max.	4.66	277	201	520	339	127	114	150	116	330	293	21.5	21.6	66	58	163	136	10.3	15.1	1,483	1,200
S.D.[2]	.15	37	30	42	29	8	8.8	17	11	29	28	1.7	3.3	6.6	11	12	13	1.0	2.7	102	149
	Core of Glass Fabric 112, Finish 114, Phenolic and Polyester Resin, 1/4-inch Cells (Western Products Core BPF 5.5)																				
	5.69	338	267	546	555	75.1	75.6	90	66	236	246	14.3	15.0	57	45	129	119	9.2	8.4	563	688
	5.60	363	364	666	664	88.6	96.8	132	83	330	254	20.8	13.2	53	41	164	152	10.7	13.1	733	722
	5.65	342	266	461	521	75.1	82.6	130	83	306	233	16.6	13.9	57	26	147	110	10.4	9.0	678	763
	5.47	219	242	455	422	71.9	78.2	91	71	234	226	13.1	13.2	53	32	146	113	9.5	9.2	648	712
	6.16	243	266	457	496	74.9	83.0	116	98	304	248	17.9	14.5	61	44	157	122	10.2	9.3	598	655
	5.36	290	232	366	359	78.5	69.0	82	41	240	200	14.8	13.0	40	22	116	89	8.8	7.2	590	610
	5.37	272	170	435	464	76.5	99.5	90	58	224	229	13.9	15.0	53	34	124	98	8.8	7.4	563	647
	5.86	208	219	390	326	62.8	67.4	99	58	217	184	12.6	14.0	48	26	105	87	7.4	7.2	600	598
	5.32	354	243	421	443	79.2	79.0	123	58	232	175	13.8	11.8	48	28	112	93	7.7	6.9	522	615
	5.34	195	243	440	449	68.9	77.8	98	74	234	208	12.7	14.1	48	34	107	96	7.0	6.5	697	668
	5.43	222	193	410	387	71.8	78.8	80	66	197	197	13.2	13.2	56	24	113	86	8.6	7.4	620	570
	6.54	233	184	437	468	77.5	76.2	74	62	210	184	11.6	12.0	44	22	105	84	7.9	6.9	678	692
Av.	5.65	273	241	457	463	75.1	80.3	100	68	247	215	14.6	13.6	52	32	127	104	8.8	8.2	624	662
Min.	5.32	195	170	366	326	62.8	67.4	74	41	197	175	11.6	11.8	40	22	105	84	7.0	6.5	522	570
Max.	6.54	363	364	666	664	88.6	99.5	132	98	330	254	20.8	15.0	61	45	164	152	10.7	13.1	733	763
S.D.[2]	.38	62	51	79	91	6	9.5	20	15	42	28	2.6	1.0	6	8	21	20	1.2	1.8	63	57

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Table 1.--Mechanical properties of glass-fabric honeycomb cores[1] (Cont.)

	Core density	Compression (T)						Shear (TL)						Shear (TW)						Tensile strength[3]	
		Proportional limit stress f_T		Compressive strength F_T		Modulus of elasticity E_T		Proportional limit stress f_{TL}		Shear strength F_{TL}[2]		Shear modulus G_{TL}		Proportional limit stress f_{TW}		Shear strength F_{TW}		Shear modulus G_{TW}			
	Dry	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
	P.c.f.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.
	Core of Glass Fabric 112, Finish 114, Nylon-Phenolic Resin, 3/16-inch Cells (Hexcel Products Core NP-3/16-112-6.0)																				
	6.89	600	249	918	477	126	109	164	92	460	333	28.4	24.0	92	58	223	169	8.6	14.7	1,230B	1,135B
	6.31	598	246	782	384	119	93	125	248	452	471	20.0	28.5	123	74	255	196	10.7	10.7	....	1,225B
	6.41	444	248	689	490	108	109	175	142	405	334	17.2	28.0	100	82	189	173	8.3	10.0	....	1,025B
	6.00	601	251	726	377	100	97	150	142	479	308	26.0	17.2	106	67	261	124	11.8	13.2	1,290	650
	6.40	502	325	884	461	121	92	165	116	468	266	24.8	14.7	100	46	242	128	10.3	7.6	1,120	700B
	6.13	523	236	790	461	118	119	166	123	481	312	23.0	20.4	100	88	244	141	10.8	6.6	1,320	1,000B
	6.21	528	254	815	415	132	97	155	142	493	256	26.7	17.0	107	67	237	158	11.7	11.0	1,237	875B
	6.17	350	238	764	394	119	98	182	117	431	322	24.2	18.4	130	84	224	179	9.5	10.4	1,263	1,105B
	6.03	424	374	738	429	114	99	150	100	468	307	20.5	21.9	83	88	265	153	12.8	7.1	1,448	820
	6.71	519	401	920	514	131	115	249	117	481	282	20.8	15.6	133	71	257	147	10.8	9.8	1,302	860B
	6.03	425	186	756	378	112	104	237	92	426	226	20.8	16.7	92	63	219	130	10.1	7.9	1,277	795B
	6.14	420	149	752	420	115	97	213	123	431	234	23.9	15.3	107	59	234	116	11.5	7.4	1,213	1,045
Av.	6.28	494	263	794	433	118	102	178	130	456	304	23.0	19.8	106	71	238	151	10.6	9.7	1,270	936
Min.	6.00	350	149	689	377	100	92	125	92	405	226	17.2	14.7	83	46	189	116	8.3	6.6	1,120	650
Max.	6.89	601	401	920	514	132	119	249	248	493	471	28.4	28.5	133	88	265	196	12.8	14.7	1,448	1,225
S.D.[2]	.28	82	72	76	47	9	8.7	37	41	27	64	3.2	4.8	15	13	22	25	1.3	2.5	84	180
	Core of Glass Fabric 21, Finish 114, Nylon-Phenolic Resin, 1/4-inch Cells (Hexcel Products Core NP-1/4-21-6.0)																				
	6.20	797	197	867	328	126	82	98	130	363	278	16.5	15.9	66	66	212	125	10.6	7.1	1,480B	1,040B
	6.39	772	274	851	447	123	102	115	133	399	378	19.5	33.0	83	58	234	154	10.9	9.7	1,230B	1,280B
	6.33	592	171	795	352	128	88	142	147	432	381B	19.5	26.4	66	92	266	180	12.5	10.5	1,360B	1,350B
	6.35	374	161	670	239	121	73	159	83	408	240	18.4	14.9	110	37	258	138	9.6	9.3	....	1,060B
	6.41	470	147	745	390	122	85	164	165	405	338	18.5	25.1	99	49	228	159	9.7	8.9	....	1,260B
	6.51	594	248	898	446	129	86	129	132	404	303	19.2	20.4	73	57	225	137	10.2	9.5	1,280B	1,250B
	6.32	612	175	931	370	124	97	123	125	436	255	21.5	14.2	66	50	239	102	11.5	5.6	1,292B	765
	6.37	585	197	855	300	118	95	186	75	468	212	23.6	13.8	74	37	238	100	12.4	6.9	1,273B	815
	6.23	559	180	765	345	130	99	201	74	453	191	24.3	10.7	74	49	248	94	12.4	5.8	1,418B	825
	6.27	688	179	950	373	131	95	150	100	424	218	23.2	10.3	99	33	267	109	13.1	9.9	1,322B	715
	6.29	438	202	869	366	123	96	167	125	445	298	21.4	21.2	100	42	248	132	10.3	10.0	1,330B	795
	6.20	602	126	798	252	126	104	151	92	447	210	24.4	14.9	84	42	246	106	13.0	8.8	1,352B	645B
Av.	6.32	590	188	833	351	125	92	149	115	424	275	20.8	18.4	83	51	242	126	11.4	8.5	1,332	985
Min.	6.20	374	126	670	239	118	73	98	74	363	191	16.5	10.3	66	33	212	95	9.6	5.6	1,230	645
Max.	6.51	797	274	950	447	131	104	201	165	468	381	24.4	33.0	110	92	267	180	13.1	10.5	1,480	1,350
S.D.[2]	.092	125	41	81	65	3.9	9.1	30	30	29	66	2.6	6.9	16	16	17	25	1.3	1.7	73	253
	Core of Glass Fabric 112, Finish 114, Phenolic and Polyester Resin, 3/16-inch Cells (Western Products Core APF 6.5)																				
	7.21	295	342	611	621	98	115	107	66	277	196	16.6	15.1	74	33	179	90	10.6	9.5	1,110	947
	6.55	297	370	631	737	95	123	115	66	305	272	21.7	21.7	78	35	157	97	8.0	7.6	1,180	1,012
	6.46	459	470	730	746	97	105	138	75	344	260	23.3	19.1	77	33	180	101	12.3	10.9	1,053	1,068
	6.51	419	446	583	642	88	111	124	70	287	262	16.6	21.1	45	35	150	95	9.5	7.0	1,057	1,028
	6.31	509	487	624	676	98	112	148	63	336	238	20.2	19.0	57	21	159	82	11.2	6.4	977	1,003
	6.51	506	339	628	696	100	99	164	74	340	244	22.6	17.1	78	27	171	98	9.9	6.8	950	990
	6.45	584	437	610	684	98	121	115	95	301	320	22.8	21.5	66	21	164	84	10.7	5.6	1,130	1,022
	6.26	435	510	635	736	96	108	132	83	385	315	25.8	22.0	78	27	200	100	14.0	7.9	1,107	1,007
	6.08	470	439	693	632	98	102	149	81	401	264	22.9	20.2	74	35	159	133	9.5	10.6	1,007	922
	6.14	391	506	630	783	103	121	148	73	334	267	18.5	21.6	62	27	180	113	12.9	8.1	1,117	1,122
	6.20	485	565	791	785	109	110	165	130	396	404	25.1	26.0	82	35	238	158	15.2	10.0	1,013	1,092
	6.46	627	391	644	666	90	102	197	113	395	304	23.0	24.8	74	39	183	120	10.9	8.6	965	1,043
Av.	6.43	456	442	651	700	98	111	142	82	342	279	21.6	20.8	70	31	177	106	11.2	8.2	1,056	1,021
Min.	6.08	295	339	583	621	88	99	107	63	277	196	16.6	15.1	45	21	150	82	8.0	5.6	950	922
Max.	7.21	627	565	791	785	109	123	197	130	401	404	25.8	26.0	82	39	238	158	15.2	10.9	1,180	1,122
S.D.[2]	.29	100	71	59	56	5	8	26	20	44	52	3.0	3.0	11	6	24	22	2.0	1.7	74	56

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Table 1.--Mechanical properties of glass-fabric honeycomb cores[1] (Cont.)

	Core density	Compression (T)						Shear (TL)						Shear (TW)						Tensile strength[2]	
		Proportional limit stress f_T		Compressive strength F_T		Modulus of elasticity E_T		Proportional limit stress f_{TL}		Shear strength F_{TL}[3]		Shear modulus G_{TL}		Proportional limit stress f_{TW}		Shear strength F_{TW}[3]		Shear modulus G_{TW}			
	Dry	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
	P.c.f.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.
	Core of Glass Fabric 112, Finish 136, Polyester Resin, 3/16-inch Cells (Western Products Core A9-136)																				
	8.19	680	317	852	402	112	83	257	104	484	349	27.7	19.7	90	41	212	100	10.8	4.2	...	685
	8.08	780	379	780	504	118	97	231	...	446	...	24.0	...	81	33	214	85	10.6	3.5	1,103	642
	8.70	704	436	983	536	120	93	228	162	466	345	28.3	20.1	106	33	222	93	10.3	4.8	1,162	597
	8.05	621	386	855	504	110	102	276	104	475	334	29.1	14.8	106	53	231	129	11.2	8.2	1,127	708
	8.09	590	367	879	372	110	83	248	122	499	299	30.7	21.5	138	41	229	109	9.7	5.7	1,217	680
	7.93	614	390	761	574	109	92	249	97	511	353	33.1	21.1	123	32	230	105	10.9	4.9	1,047	525
	8.59	515	410	1,005	414	121	107	266	89	475	308	26.1	18.3	...	36	...	107	...	5.4	1,203	808
	8.73	739	366	1,060	458	122	90	262	146	531	348	29.5	19.0	124	49	234	115	11.1	5.9	1,267	...
	7.03	491	374	745	425	114	95	162	130	462	336	29.8	15.6	130	53	226	120	10.8	5.7	1,223	850
	8.46	581	370	1,000	479	117	89	213	103	489	268	28.0	12.5	90	37	229	121	10.3	5.6	1,083	690
	7.87	574	492	853	549	118	103	164	81	438	279	27.5	16.9	107	33	232	92	11.3	4.3	1,307	883
	8.03	590	459	848	598	115	97	164	131	507	264	31.5	15.7	90	45	194	119	8.3	5.3	1,350	967
Av.	8.15	623	396	885	484	116	94	227	115	482	317	28.8	17.7	108	41	223	108	10.5	5.3	1,190	730
Min.	7.03	491	317	745	372	109	83	162	81	438	264	24.0	12.5	81	32	194	85	8.3	3.5	1,047	525
Max.	8.73	780	492	1,060	598	122	107	276	162	531	349	33.1	21.5	138	53	234	129	11.3	8.2	1,350	967
S.D.[2]	.46	87	47	104	72	4.5	7.5	42	25	27	34	2.4	2.9	19	7.9	12	14	.9	1.2	96	132
	Core of Glass Fabric 21, Finish 114, Phenolic Resin CTL-911D 1/4-inch Cells (Hexcel Products Core CTL-1/4-21-8.0)																				
	8.37	1,108	845	1,527	1,525	144	151	264	150	625	462B	34.3	34.0	130	199	461	382B	20.3	23.4	1,340B	1,180B
	8.32	1,013	836	1,576	1,291	150	150	209	233	598	407B	35.8	31.0	159	198	444	384B	16.0	20.7	...	1,260B
	8.38	862	952	1,450	1,412	157	158	245	214	589	463B	37.4	30.7	148	148	414	402B	15.0	20.4	...	1,430B
	8.30	1,339	749	1,413	1,161	145	152	208	181	525	465B	24.2	29.8	175	182	384	402	14.9	16.9	...	1,260B
	8.01	899	844	1,180	1,136	143	146	263	236	578	396B	24.1	36.3	192	200	474	375B	21.6	20.8	...	1,210B
	8.25	1,344	838	1,744	1,460	148	160	197	232	565	513B	35.7	29.2	202	190	444	401B	17.1	23.2	...	1,300
	8.32	990	1,262	1,480	1,480	160	160	247	148	556	217B	33.4	29.8	133	184	379	339B	17.1	13.1	1,190	1,010B
	8.17	1,120	1,228	1,270	1,569	150	157	263	200	548	383B	26.8	25.3	124	158	416	289B	20.7	20.1	1,170	1,170
	8.35	1,060	1,390	1,542	1,830	158	159	271	204	599	440B	28.7	23.1	126	116	417	316B	18.1	18.8	1,307	1,325B
	8.19	950	1,257	1,798	1,646	161	155	285	159	548	294B	27.6	24.6	144	190	413	280B	17.0	21.2	1,168	1,145B
	8.05	895	1,037	1,593	1,172	158	160	263	100	542	193B	26.7	32.4	173	174	427	220B	20.2	16.8	1,283	1,125
	8.09	1,123	1,280	1,313	1,308	153	163	282	198	542	371B	22.6	25.4	166	167	429	418	18.2	17.7	1,232B	1,205B
Av.	8.23	1,058	1,043	1,490	1,399	152	156	250	188	568	384B	29.8	29.3	156	176	425	351	18.0	19.4	1,241	1,218
Min.	8.01	862	749	1,180	1,136	143	146	197	100	525	193B	22.6	23.1	124	116	379	220B	14.9	13.1	1,168	1,010B
Max.	8.38	1,344	1,390	1,790	1,646	161	163	285	236	625	513B	37.4	26.3	202	200	474	418	21.6	23.4	1,340B	1,430B
S.D.[2]	.13	160	226	181	211	6.5	5.1	30	42	30	101	5.2	4.0	26	25	28	62	2.2	2.9	69	108
	Core of Glass Fabric 112, Finish 136, Polyester Resin, 1/4-inch Cells (Western Products Core B8-136)																				
	8.54	901	322	901	585	102	70	115	66	354	230	17.7	14.0	66	37	212	120	11.2	7.5	710	437
	8.25	674	258	819	474	96	65	139	73	298	213	18.0	11.2	67	49	183	105	10.2	5.8	785	413
	8.45	674	335	910	593	104	75	149	117	351	287	21.2	14.0	62	41	196	94	11.7	4.1	780	492
	8.70	873	347	910	596	100	72	132	165	312	260	20.2	10.5	86	41	199	118	11.4	6.2	743	458
	8.05	493	249	820	506	94	68	137	88	324	211	16.3	20.8	57	49	198	107	10.0	6.0	727	405
	8.78	647	373	951	639	94	73	146	97	304	219	15.3	12.5	65	41	184	95	10.6	5.1	723	533
	7.57	470	233	897	505	90	71	114	124	312	224	17.6	8.5	66	45	218	112	10.9	7.1	773	558
	8.59	581	393	855	582	108	74	147	90	369	206	20.2	11.3	66	45	206	115	10.4	6.3	757	560
	8.24	370	340	911	643	96	79	138	73	344	213	21.1	11.1	65	46	185	116	9.6	7.2	783	593
	7.94	660	345	741	535	102	65	146	111	332	239	17.3	10.7	65	50	202	124	10.1	6.5	803	627
	8.54	786	346	1,007	632	108	79	129	73	306	238	15.3	10.8	69	37	201	120	10.5	6.5	680	638
	8.15	539	344	914	564	106	82	154	90	287	248	18.8	14.1	66	37	179	110	9.7	5.8	780	552
Av.	8.32	639	324	886	571	100	73	137	97	324	232	18.2	12.5	67	43	195	111	10.5	6.2	754	522
Min.	7.57	370	233	741	474	90	65	114	66	287	206	15.3	8.5	57	37	178	94	9.6	4.1	680	405
Max.	8.70	901	393	1,007	643	108	82	154	165	369	287	21.2	14.1	86	50	218	124	11.7	7.5	803	638
S.D.[2]	.4	161	50	69	56	6.0	5.4	13	28	26	24	2.1	3.1	6.8	4.8	13	9.6	.7	.94	37	80

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Table 1.--Mechanical properties of glass-fabric honeycomb cores[1] (Cont.)

	Core density	Compression (T)						Shear (TL)						Shear (TW)						Tensile strength[3]	
		Proportional limit stress f_T		Compressive strength F_T		Modulus of elasticity E_T		Proportional limit stress f_{TL}		Shear strength F_{TL}[3]		Shear modulus G_{TL}		Proportional limit stress f_{TW}		Shear strength F_{TW}[3]		Shear modulus G_{TW}			
	Dry	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
	P.c.f.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.
	Core of Glass Fabric 112, Finish 114, Nylon-Phenolic Resin, 3/16-inch Cells (Hexcel Products Core NP-3/16-112-9.0)																				
	9.23	834	300	1,252	526	137	100	321	143	568	376	29.0	23.9	116	99	355	204	12.6	9.5	....	1,130B
	9.44	936	248	1,318	511	136	97	194	108	604	415	33.4	28.0	106	132	396	270	16.3	14.0	....	1,090B
	9.23	989	318	1,550	510	133	103	318	92	627	346	28.0	21.6	108	108	405	220	14.6	12.3	....	1,370B
	9.32	805	433	1,612	517	150	102	279	98	586	325	29.5	16.7	118	75	358	160	15.2	9.2	1,318	995B
	9.32	763	520	1,513	684	164	130	313	172	638	371	36.1	26.6	125	62	354	187	14.1	10.6	1,512B	870B
	8.93	914	354	1,470	622	148	101	231	102	573	340	32.0	20.5	100	50	372	178	15.4	9.8	1,368	1,085B
	8.90	1,038	540	1,474	557	153	110	247	109	614	168	33.7	14.3	109	75	344	181	15.1	10.0	1,265	995B
	8.89	1,022	524	1,563	616	152	106	300	151	605	330	32.3	14.6	132	58	383	166	17.2	8.5	1,280	715
	9.16	930	381	1,512	632	159	110	184	175	615	340	31.4	16.7	115	71	381	185	14.8	9.8	1,355	460B
	9.08	832	278	1,507	489	154	98	264	132	609	253	31.5	10.7	100	41	351	125	15.4	5.7	1,285	905B
	9.16	1,057	450	1,621	705	159	116	294	110	608	371	29.4	18.8	114	62	393	86	18.1	9.5	1,360	790
	9.23	890	495	1,683	673	167	121	360	134	655	412	36.0	22.5	134	62	393	179	17.8	9.9	1,497	840
Av.	9.16	918	403	1,506	587	151	108	275	127	608	337	31.9	19.6	114	75	374	178	15.6	9.9	1,360	937
Min.	8.90	763	248	1,252	489	133	97	184	92	568	168	28.0	10.7	100	50	344	86	12.6	5.7	1,265	460B
Max.	9.44	1,057	540	1,683	705	167	121	360	175	655	415	36.1	28.0	134	132	405	270	18.1	14.0	1,512B	1,370B
S.D.[2]	.18	96	104	122	77	11	10	53	28	25	68	2.6	5.2	11	26	21	46	1.6	2.0	90	232

[1]Tests were conducted on specimens conditioned to constant weight at 73° F. and 50 percent relative humidity designated as "dry"; and on specimens exposed for 60 days at 100° F. and 100 percent relative humidity (tested at 73° F.) designated as "wet".

[2]S. D.--standard deviation.

[3]B--designates bond failure.

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(Sheet 4 of 4)

Table 2.--Design values for glass-fabric honeycomb cores[1]

Core data						Compression (T)						Shear (TL)						Shear (TW)					
Designation	Fabric	Fabric finish	Resin[2]	Cell size	Density (Dry)	Proportional limit stress f_T		Compressive strength F_T		Modulus of elasticity E_T		Proportional limit stress f_{TL}		Shear strength F_{TL}		Shear modulus G_{TL}		Proportional limit stress f_{TW}		Shear strength F_{TW}		Shear modulus G_{TW}	
						Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
				In.	P.c.f.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	1,000 p.s.i.	1,000 p.s.i.
BPF 3.5	112	114	PH	1/4	3.46	110	134	193	177	43	62	50	34	119	84	9.9	8.6	25	12	56	31	5.1	3.8
NP-1/4-21-4.0	21	114	N-PH	1/4	4.44	142	100	384	241	112	100	90	75	249	186	17.8	16.0	41	29	116	86	8.4	8.0
BPF 5.5	112	114	PH-P	1/4	5.65	195	170	366	326	69	80	75	41	197	175	13.3	13.0	40	22	105	84	7.9	6.9
NP-3/16-112-6.0	112	114	N-PH	3/16	6.28	350	149	689	377	120	100	125	92	405	226	20.0	17.0	83	46	189	116	10.0	7.6
NP-1/4-21-6.0	21	114	N-PH	1/4	6.32	374	126	670	239	120	100	98	74	363	191	16.5	10.7	66	33	212	95	10.0	6.9
APF 6.5	112	114	PH-P	3/16	6.43	295	339	583	621	98	115	107	63	277	196	16.6	15.1	45	21	150	82	9.5	6.4
A9-136	112	136	P	3/16	8.15	491	317	745	372	110	90	162	81	438	264	27.5	16.9	81	32	194	85	8.5	4.0
CTL-1/4-21-8.0	21	114	PH[3]	1/4	8.23	862	749	1,180	1,136	145	145	197	181	525	465B[4]	24.2	24.2	124	116	379	340B[4]	17.1	17.1
B8-136	112	136	P	1/4	8.32	370	233	741	474	96	71	114	66	287	206	17.7	11.1	57	37	178	94	10.0	4.1
NP-3/16-112-9.0	112	114	N-PH	3/16	9.16	763	248	1,252	489	150	100	184	92	568	168	29.0	14.3	100	50	344	86	15.1	9.5

[1] "Dry" values are for core conditioned to constant weight at 73° F. and 50 percent relative humidity. "Wet" values are for core at 73° F. after 60 days exposure at 100° F. and 100 percent relative humidity.

[2] Resins are designated as PH--phenolic; P--polyester; N--nylon.

[3] Phenolic resin CTL-91LD.

[4] "B" denotes failure in bond between core and loading plate.

M 110 416

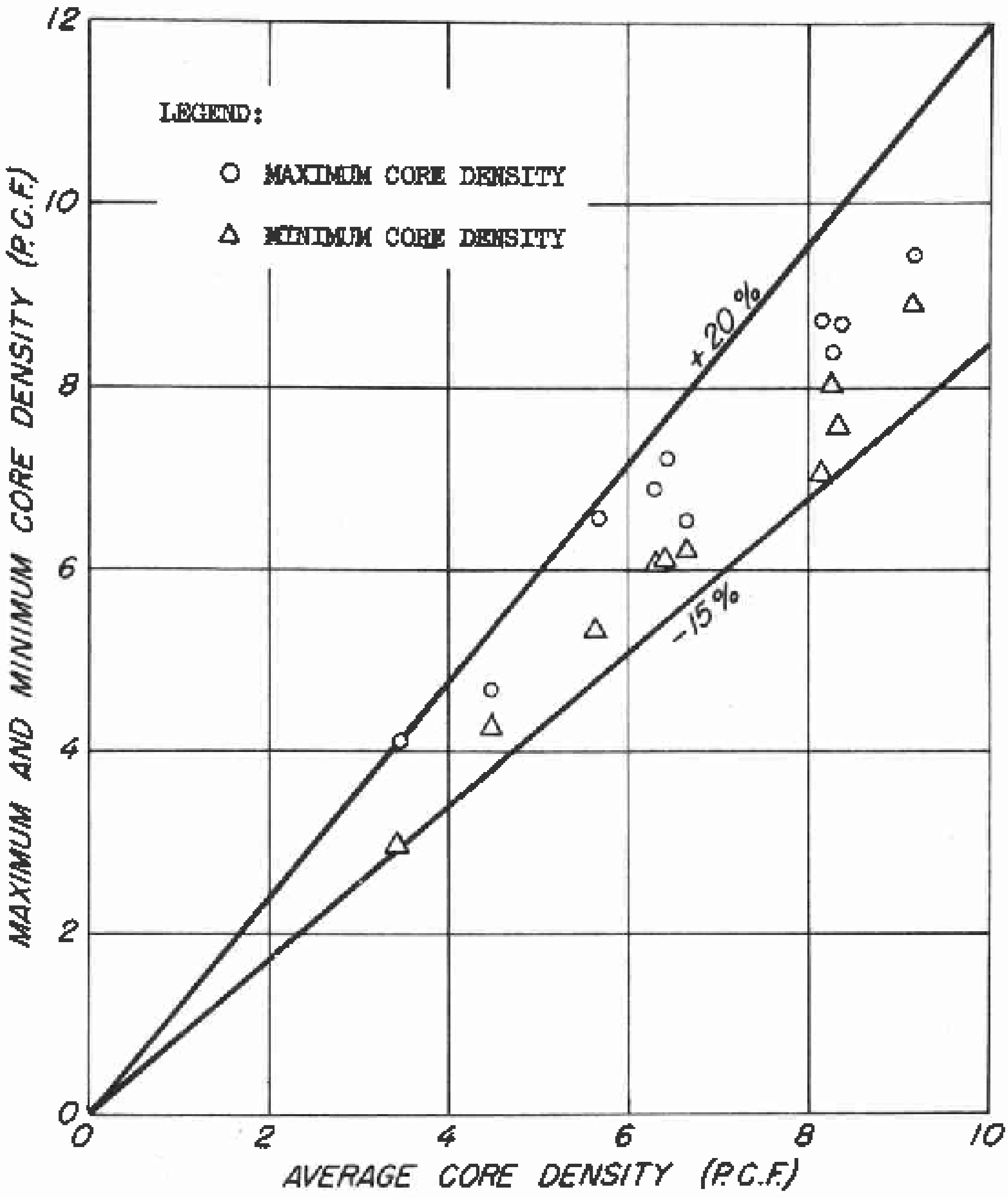

Figure 1. --Range of core density for glass-fabric honeycomb cores at 73° F. and 50 percent relative humidity.

M 110 384

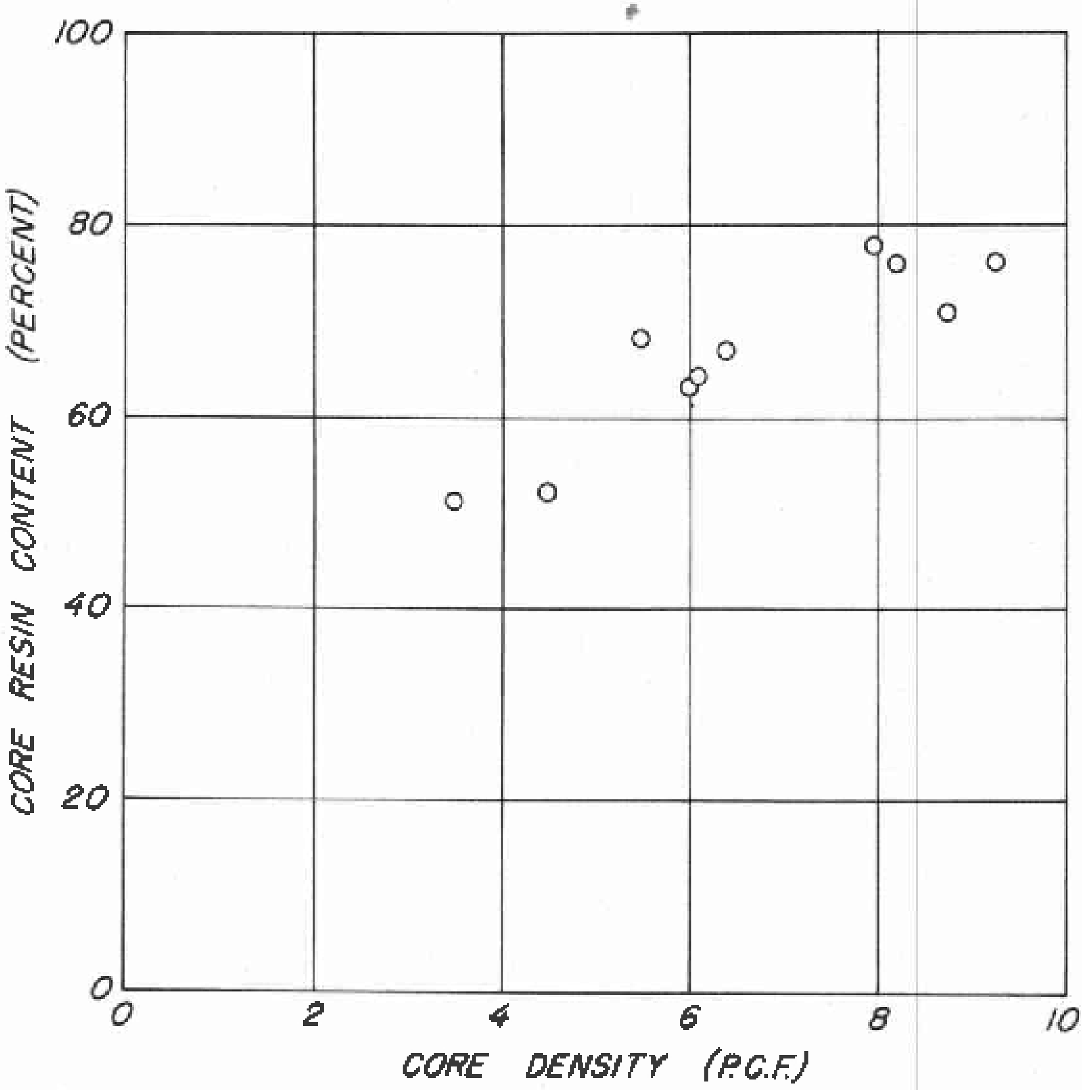

Figure 2.--Variation of resin content with core density for glass-fabric honeycomb cores.

M 110 385

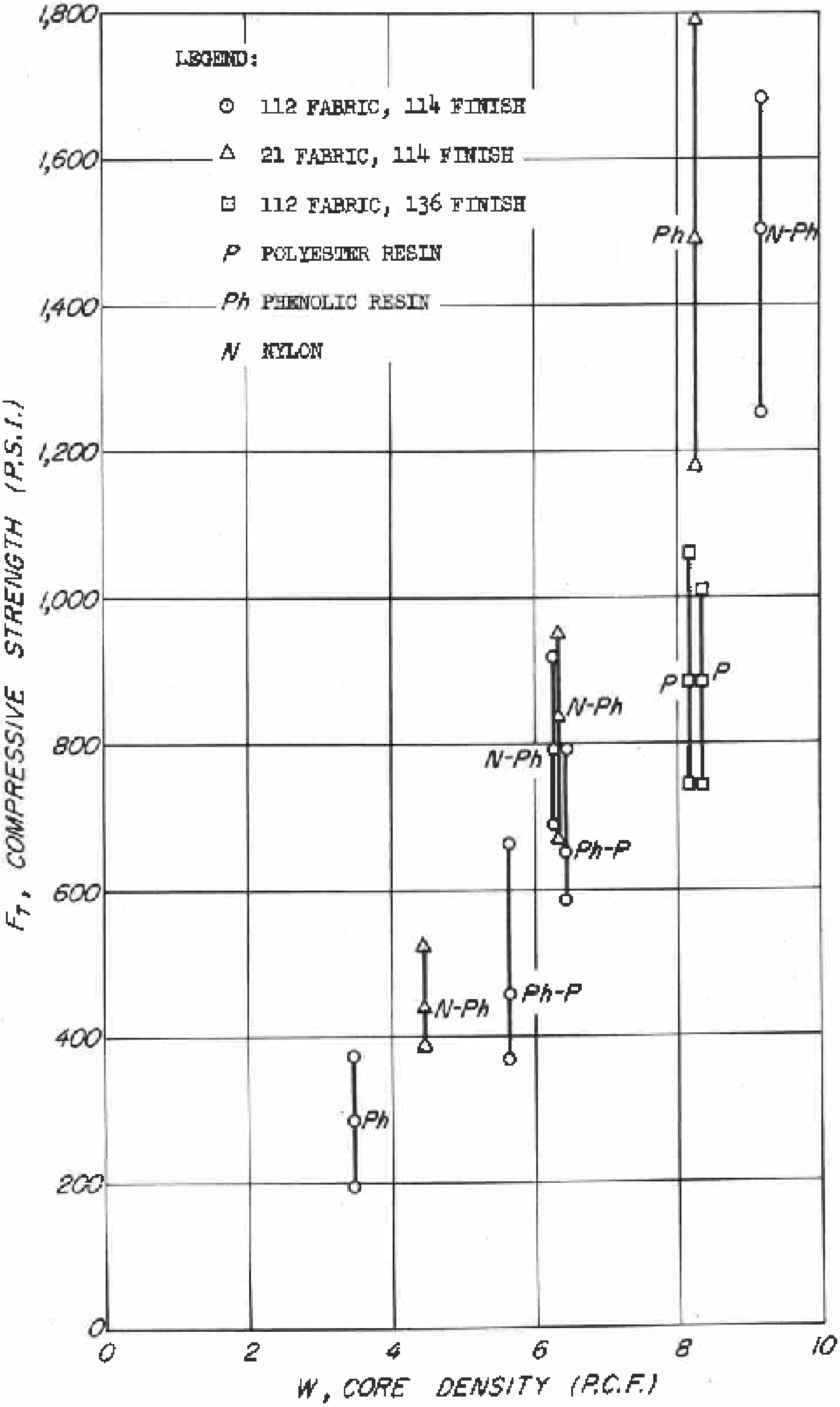

Figure 3. --Minimum, average, and maximum compressive strength values of glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 386

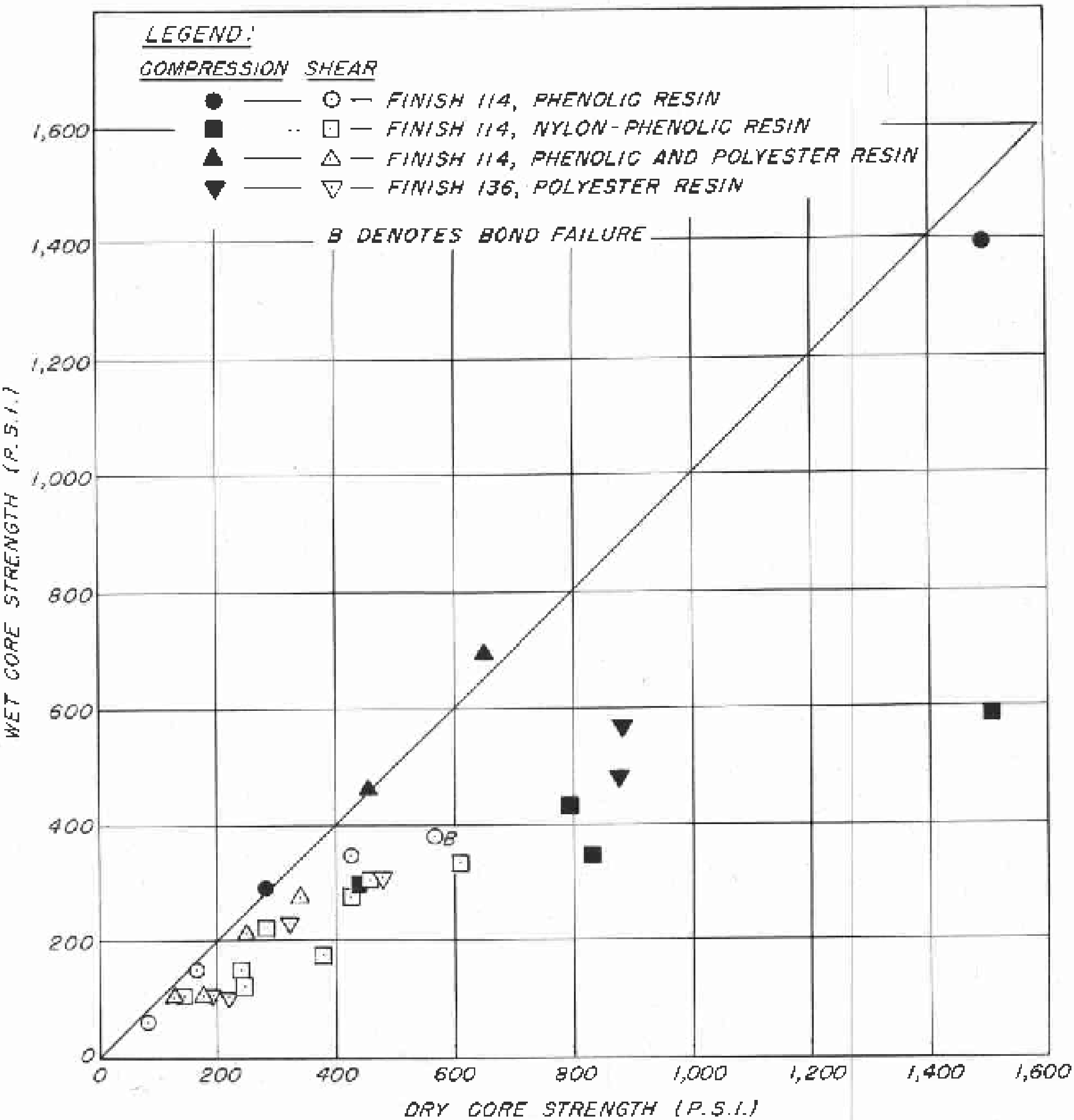

Figure 4.--Effect of exposure to 100 percent relative humidity at 100° F. for 60 days on the strength of glass-fabric honeycomb cores.

(M 107 556)

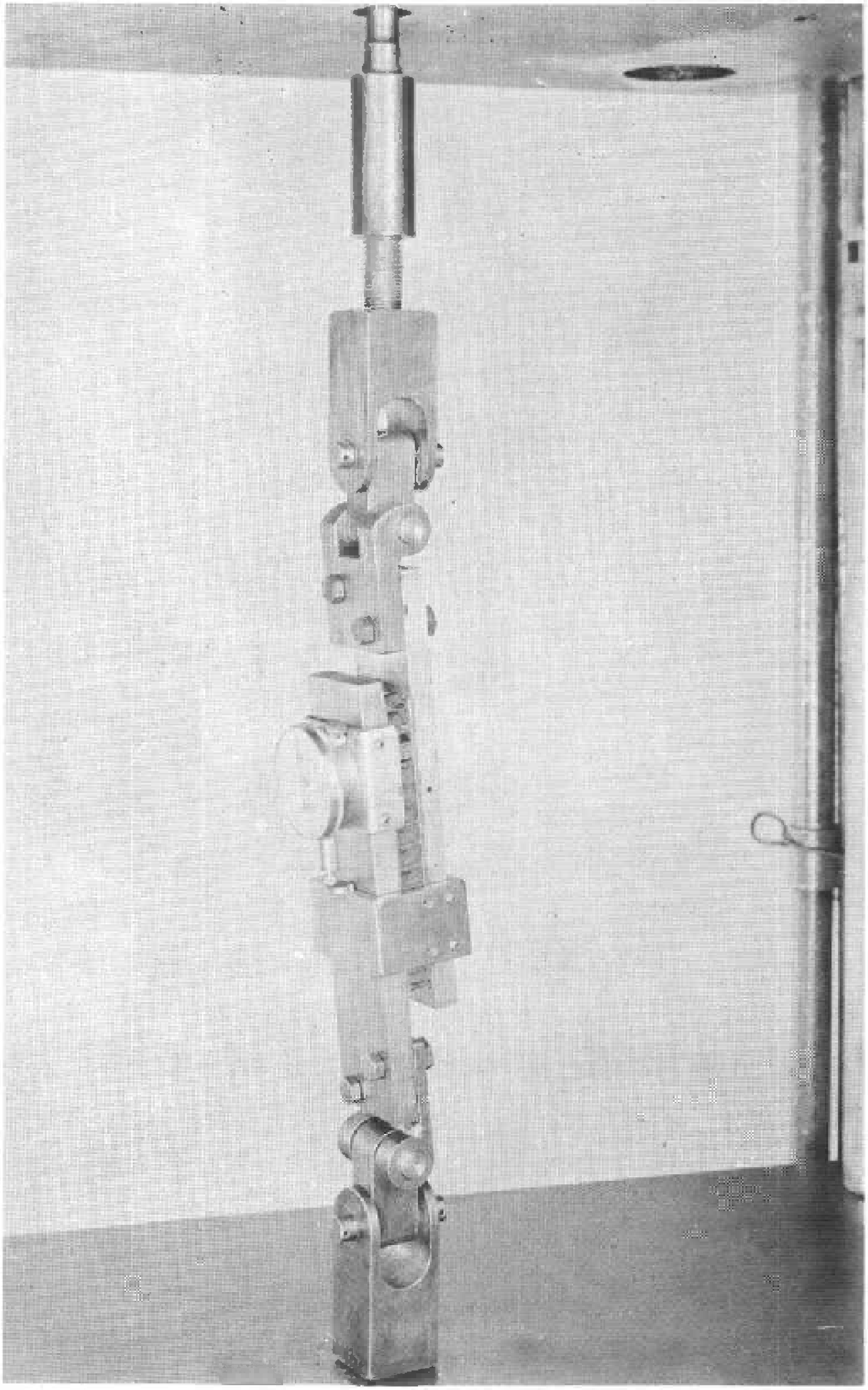

Figure 5.--Apparatus for shear test showing steel plates, specimen, and dial arrangement for measuring deformation between plates.

(M 83718 F)

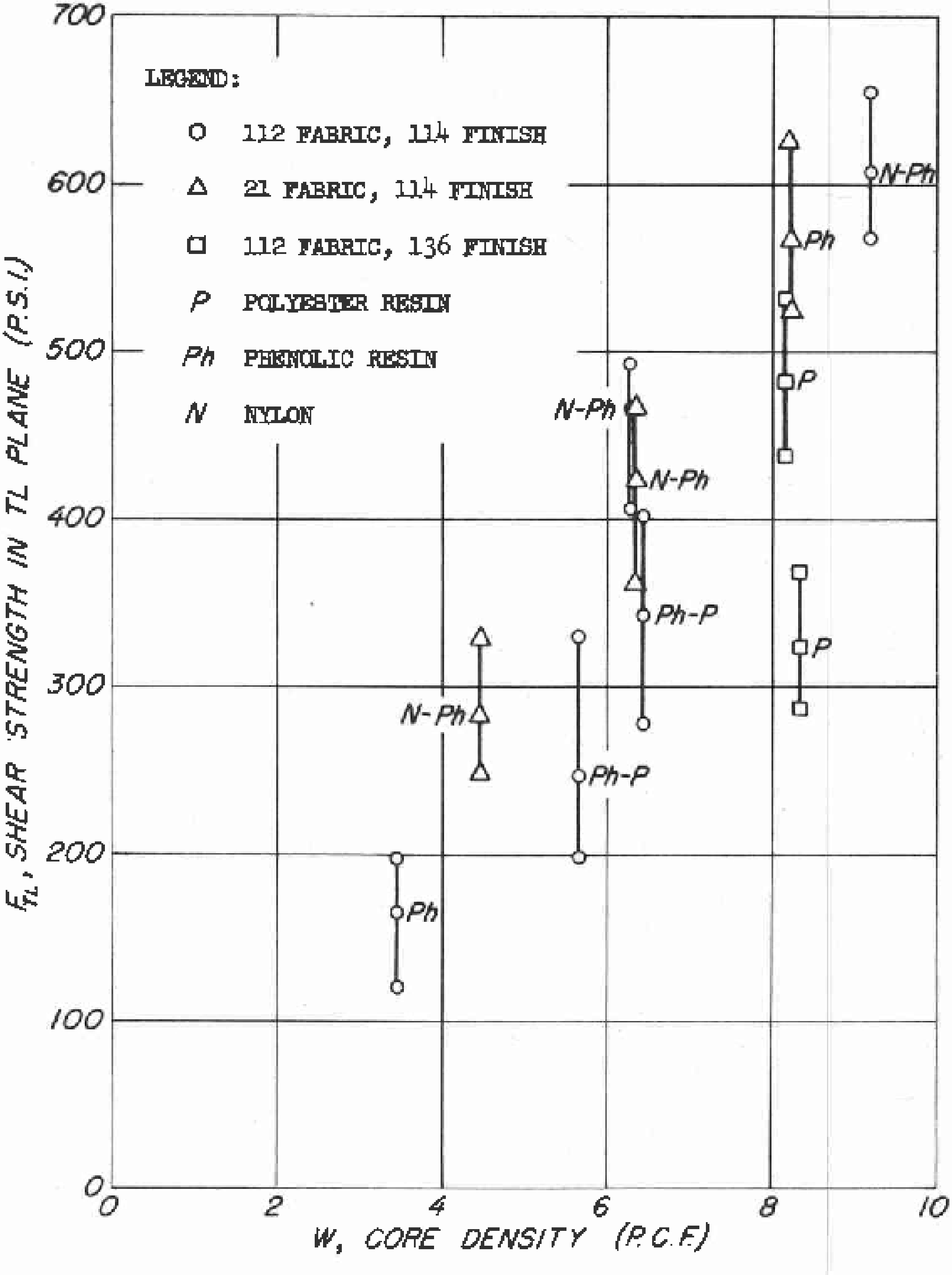

Figure 6.--Minimum, average, and maximum TL shear strength values of glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 587

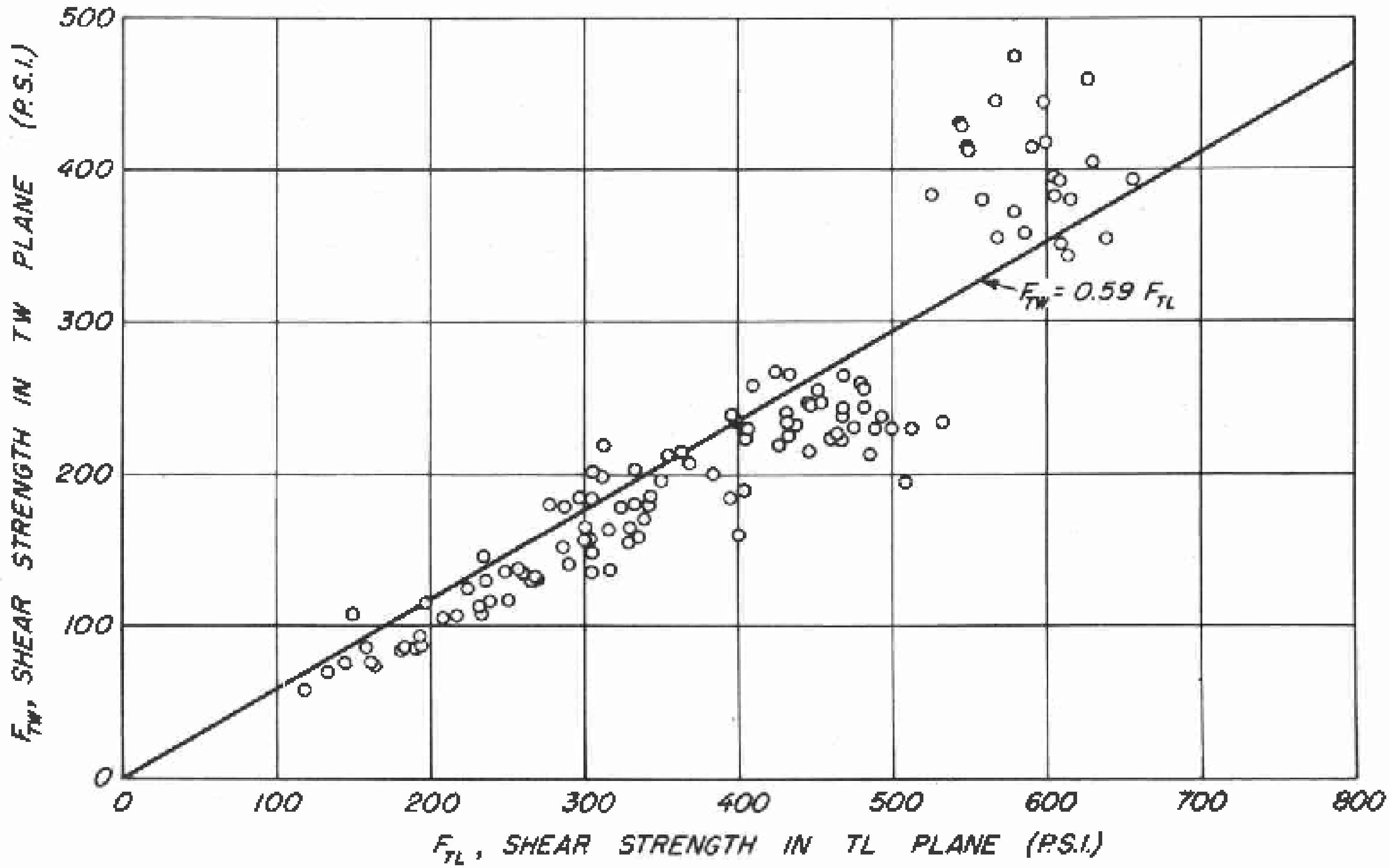

Figure 7.--Comparison of TW shear strength (F_{TW}) with TL shear strength (F_{TL}) of glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 588

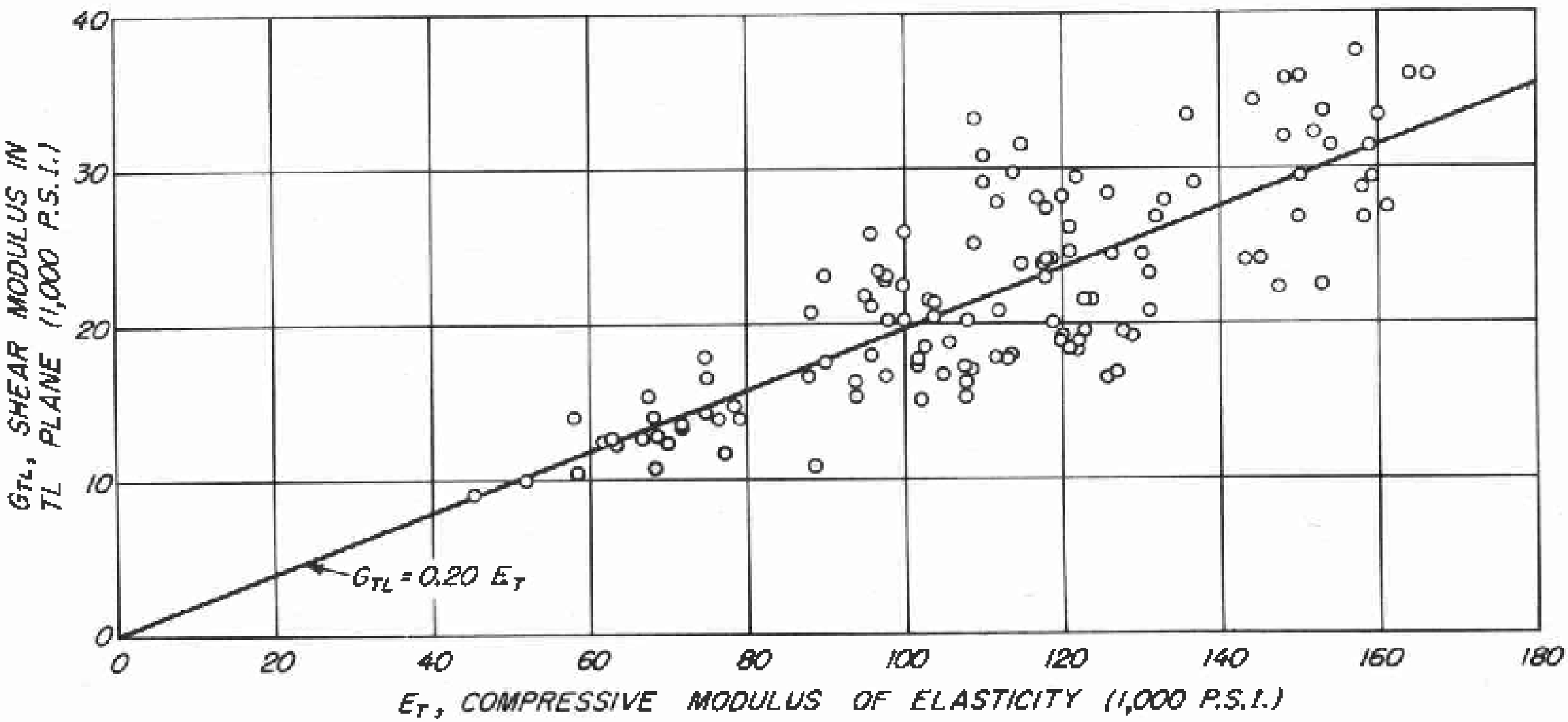

Figure 8.--Relationship between TL shear modulus and compressive modulus of elasticity for glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 389

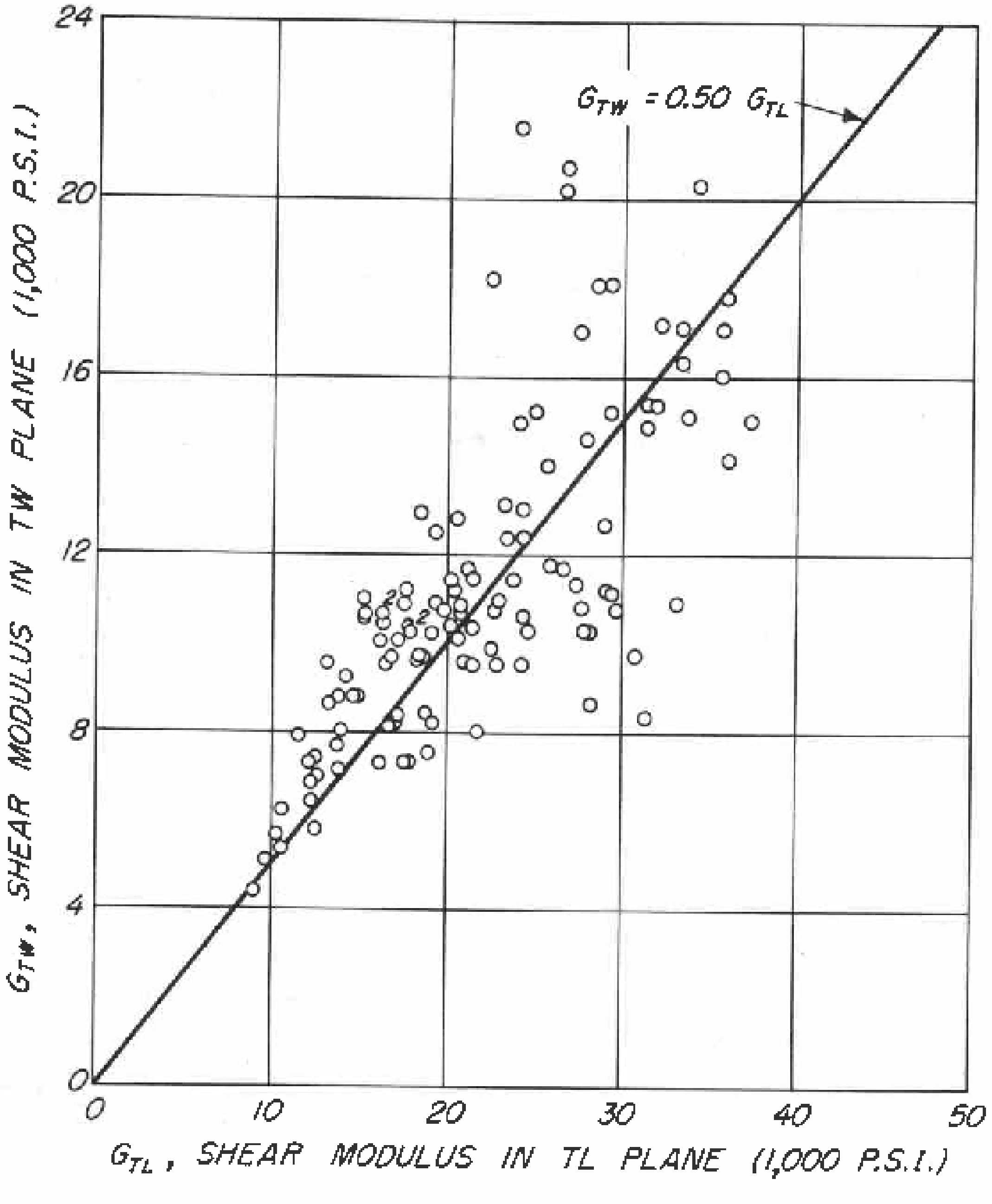

Figure 9. --Comparison of shear moduli G_{TL} and G_{TW} of glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 390

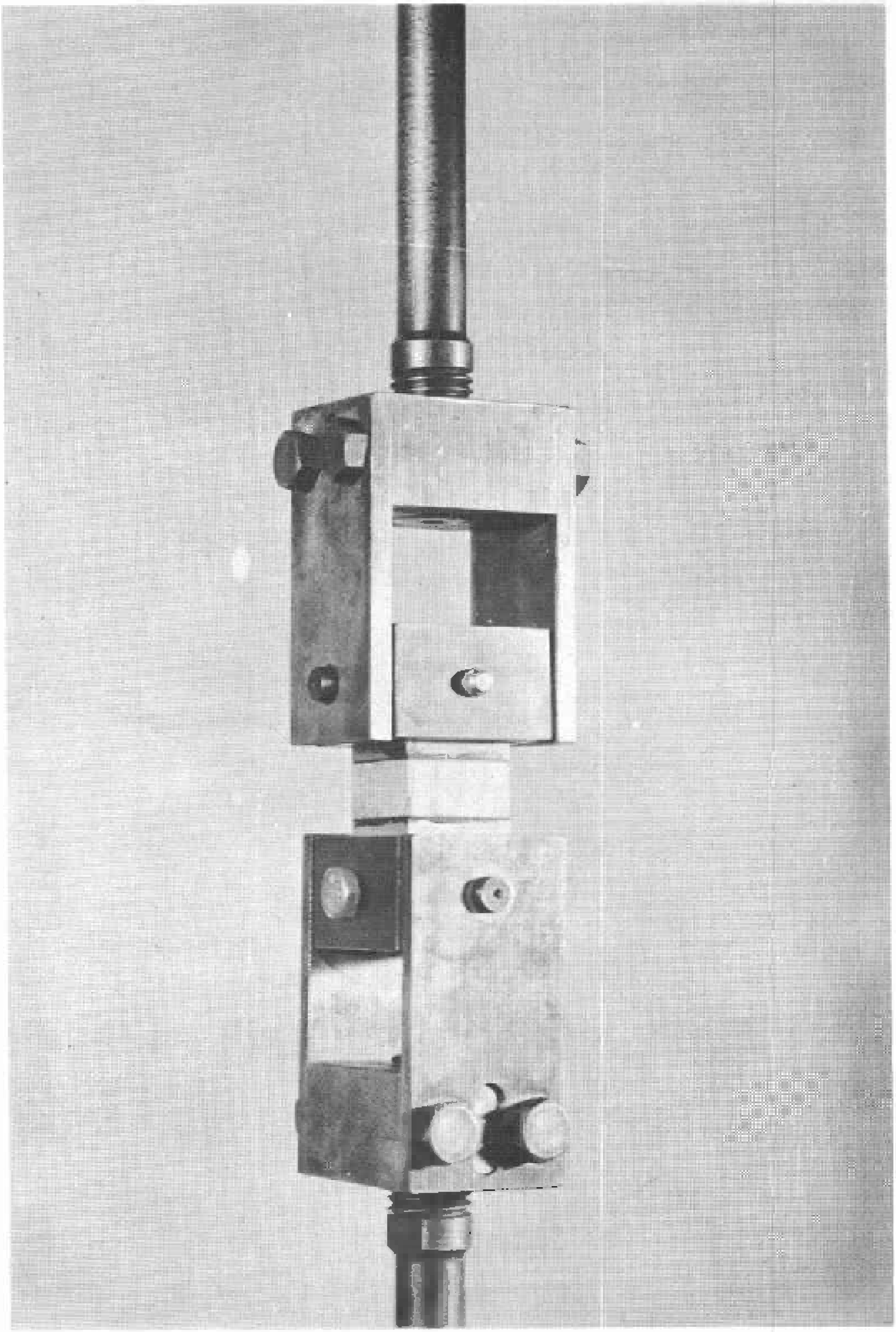

Figure 10. --Test apparatus for tension flatwise test of sandwich core material showing specimen and fitting for applying load.

(M 64125 F)

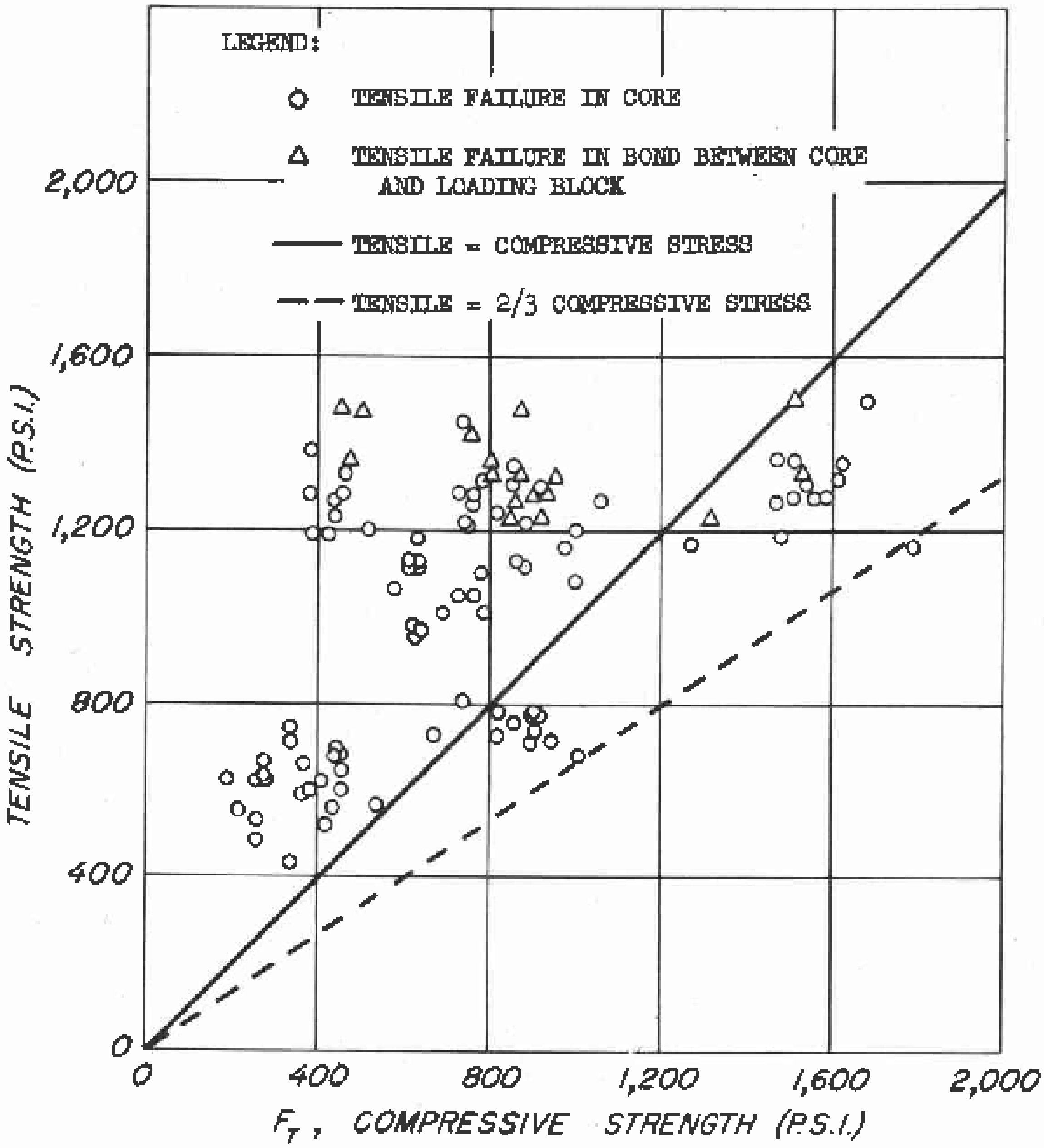

Figure 11.--Comparison of tensile strength with compressive strength of glass-fabric honeycomb cores at 73° F., 50 percent relative humidity.

M 110 391

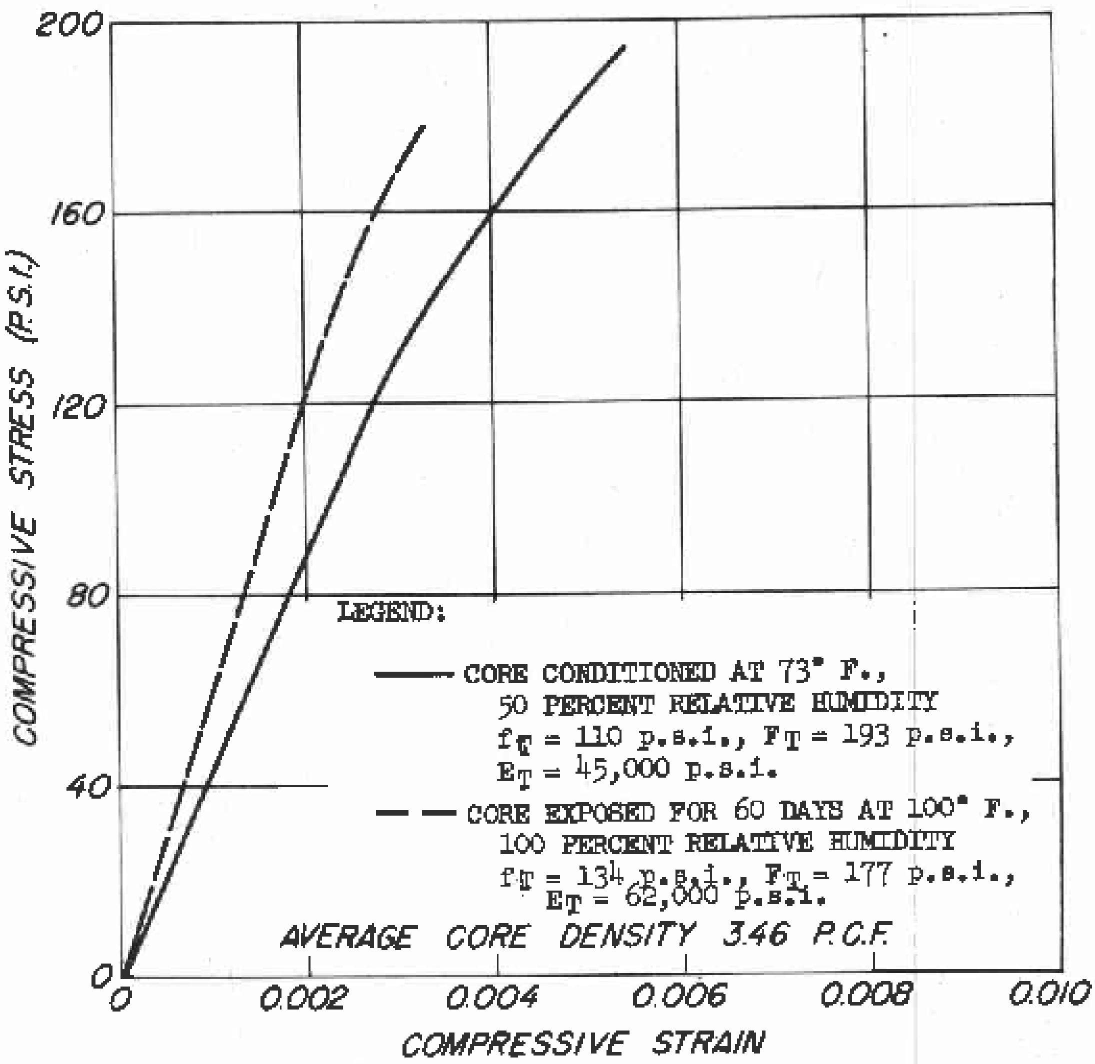

Figure 12. --Compressive stress-strain design curves, for glass-fabric honeycomb core of fabric 112, finish 114, phenolic resin, 1/4-inch cells (Western Products core BPF 3.5).

M 110 592

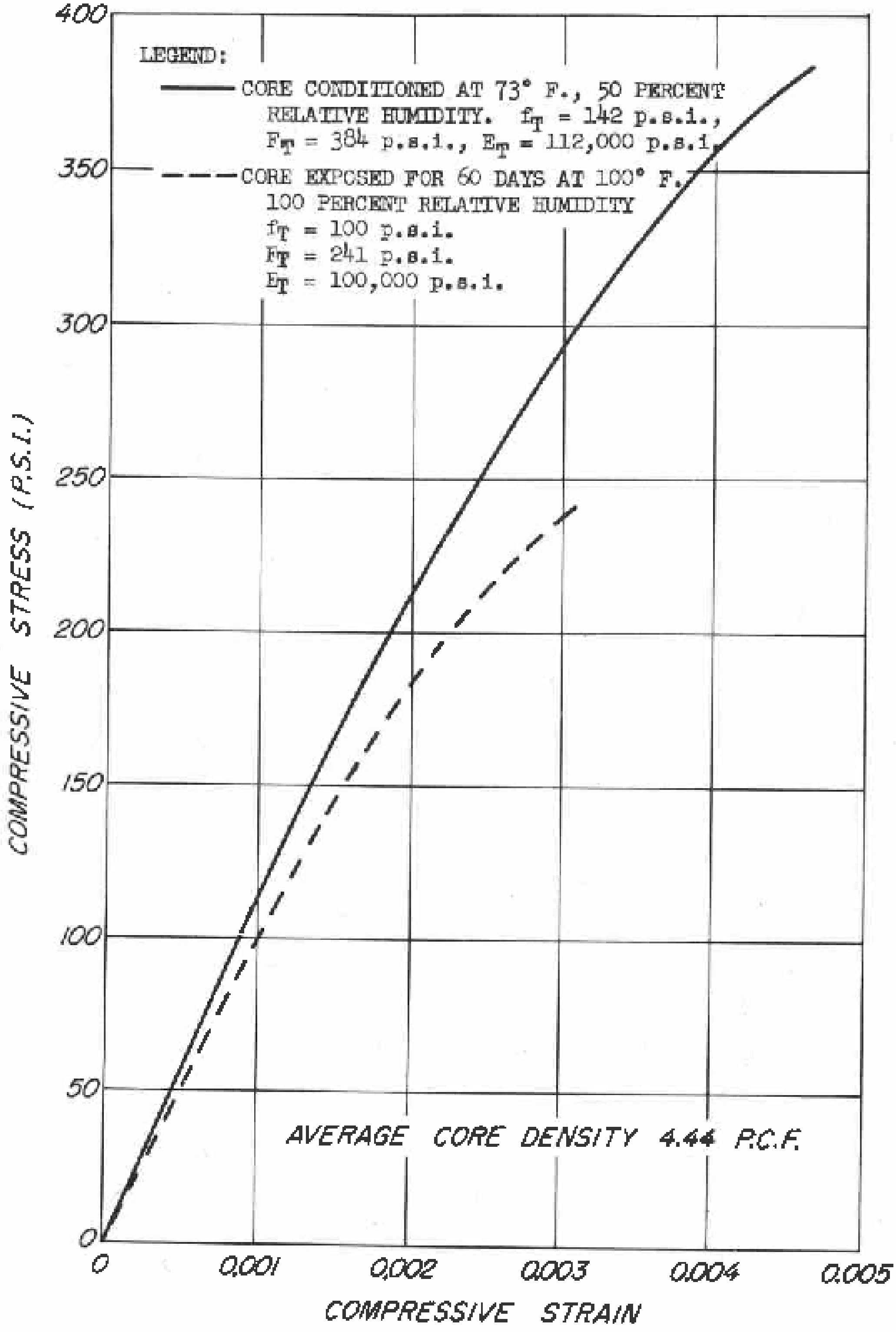

Figure 13.--Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 21, finish 114, nylon-phenolic resin, 1/4-inch cells (Hexcel Products core NP-1/4-21-4.0).

M 110 393

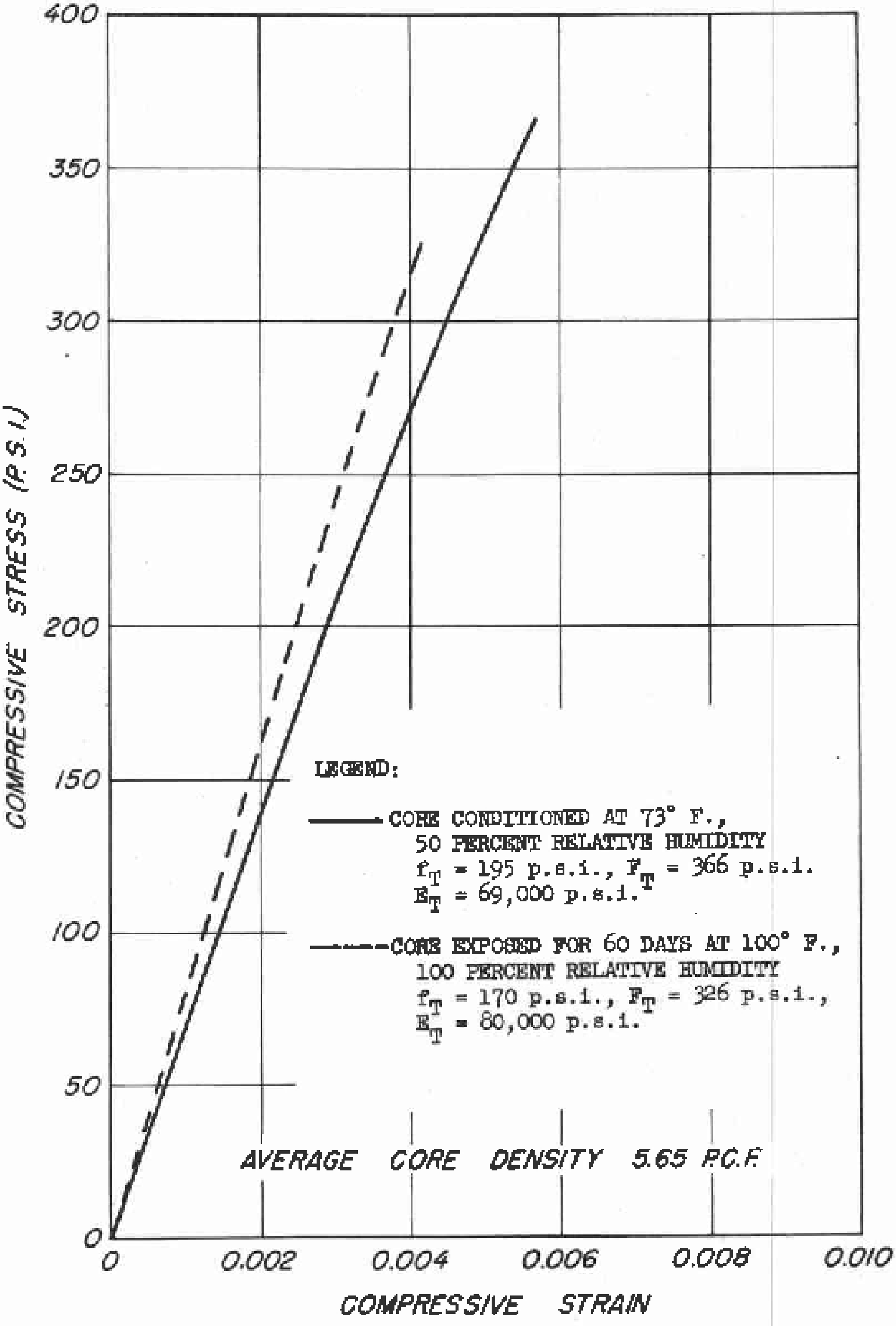

Figure 14.--Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, phenolic and polyester resin, 1/4-inch cells (Western Products core BPF 5.5).

M 110 394

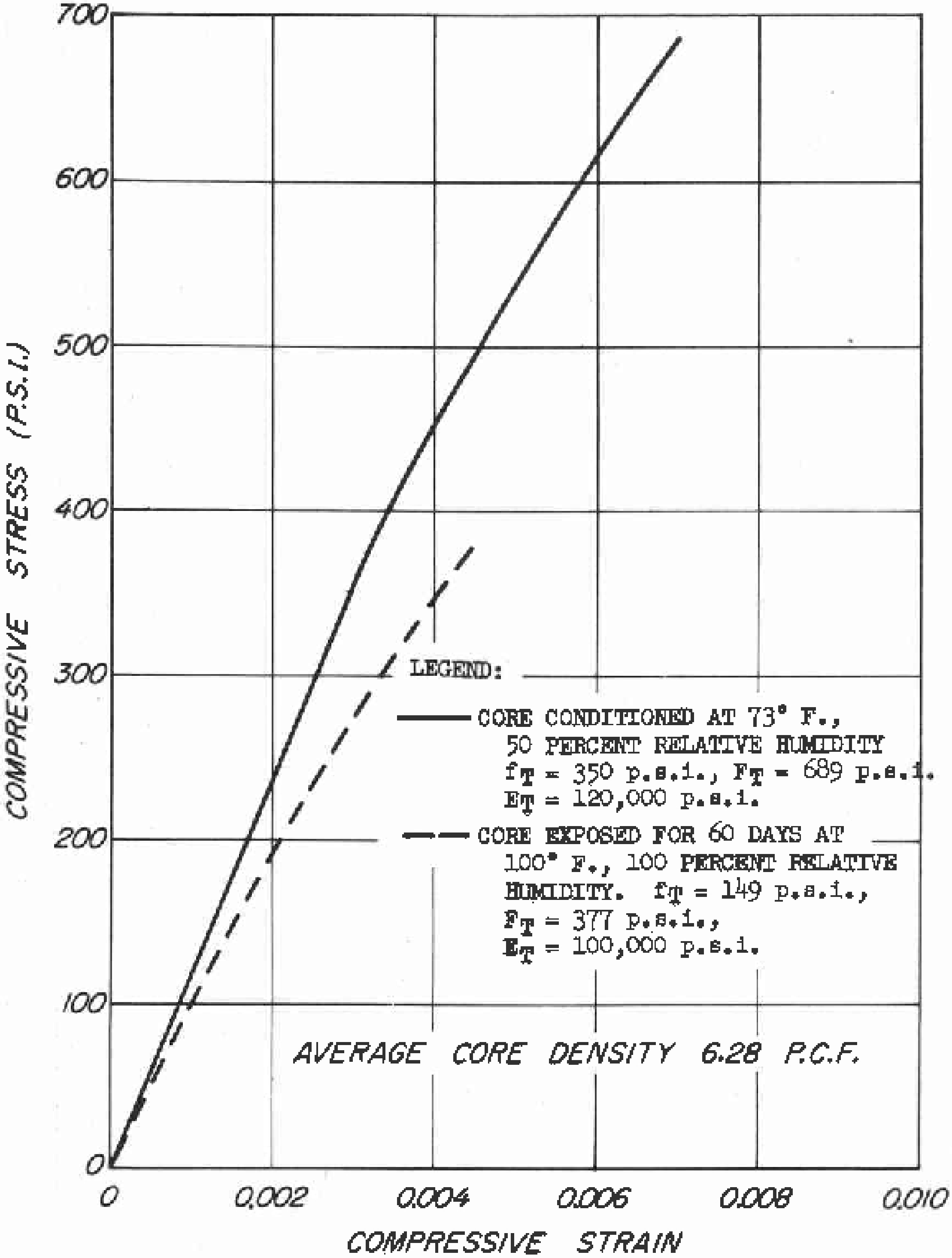

Figure 15.--Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, nylon-phenolic resin, 3/16-inch cells, (Hexcel Products core NP-3/16-112-6.0).

M 110 395

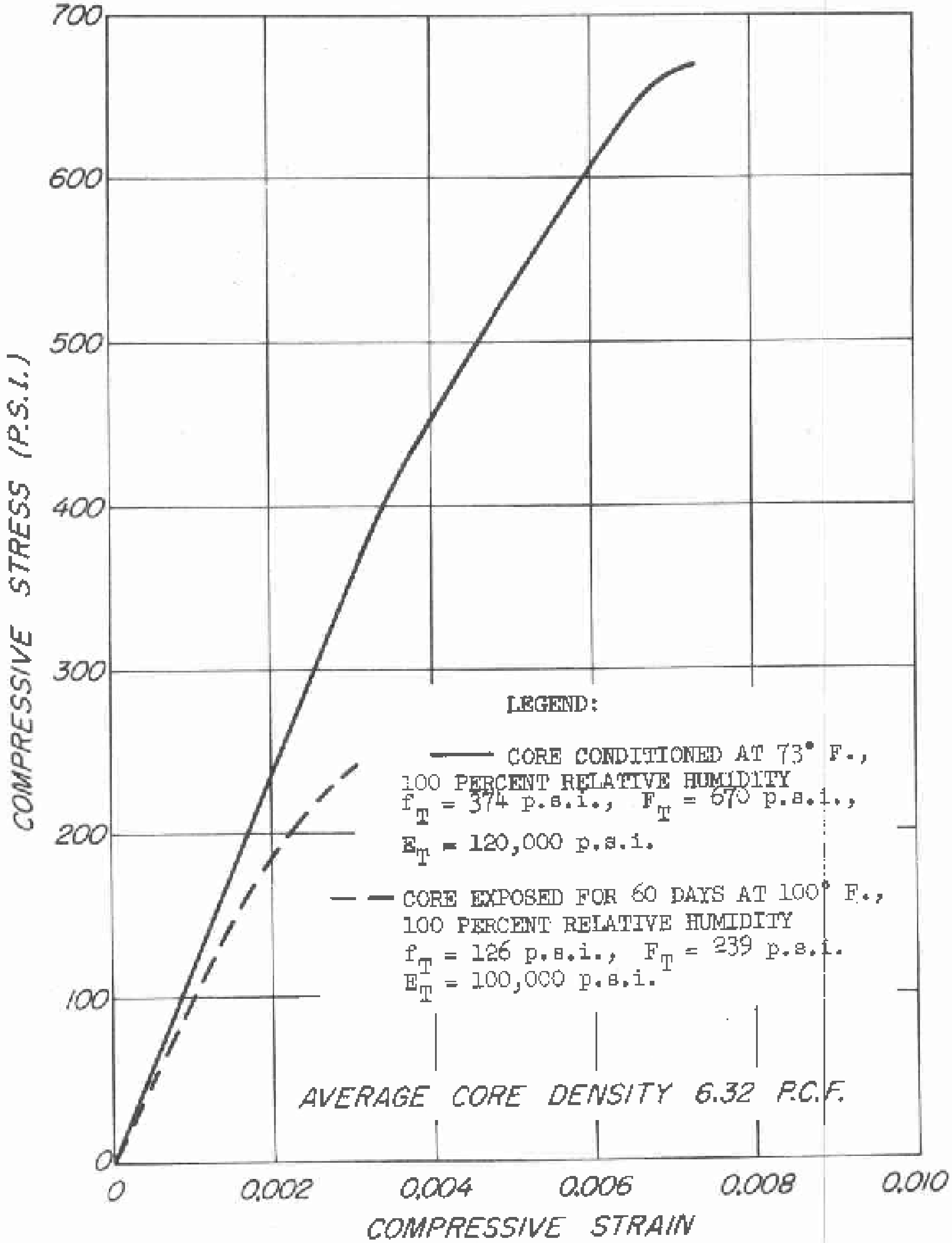

Figure 16. --Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 21, finish 114, nylon-phenolic resin, 1/4-inch cells (Hexcel Products core NP-1/4-21-6.0).

M 110 396

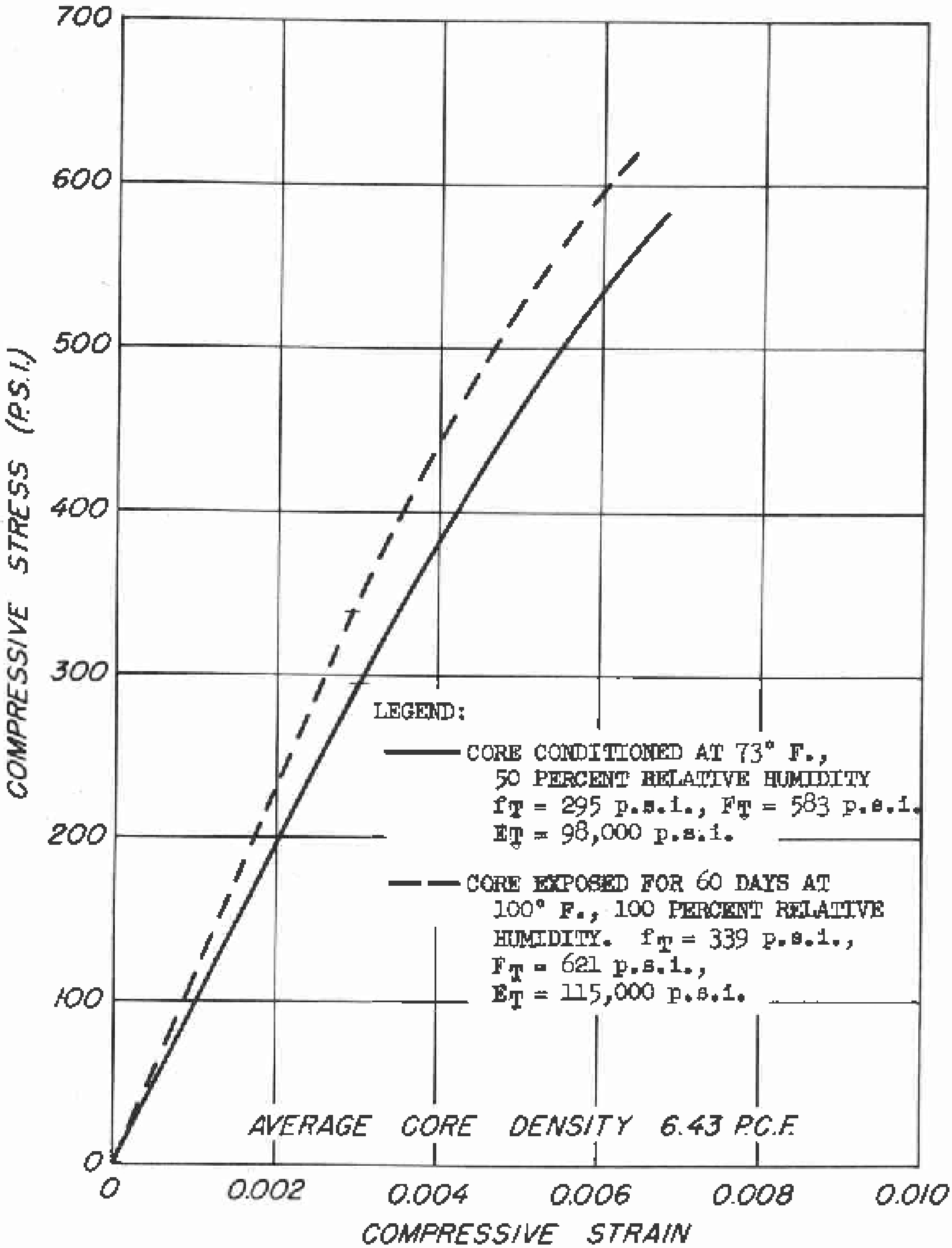

Figure 17. --Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, phenolic and polyester resin, 3/16-inch cells (Western Products core APF 6.5).

M 110 397

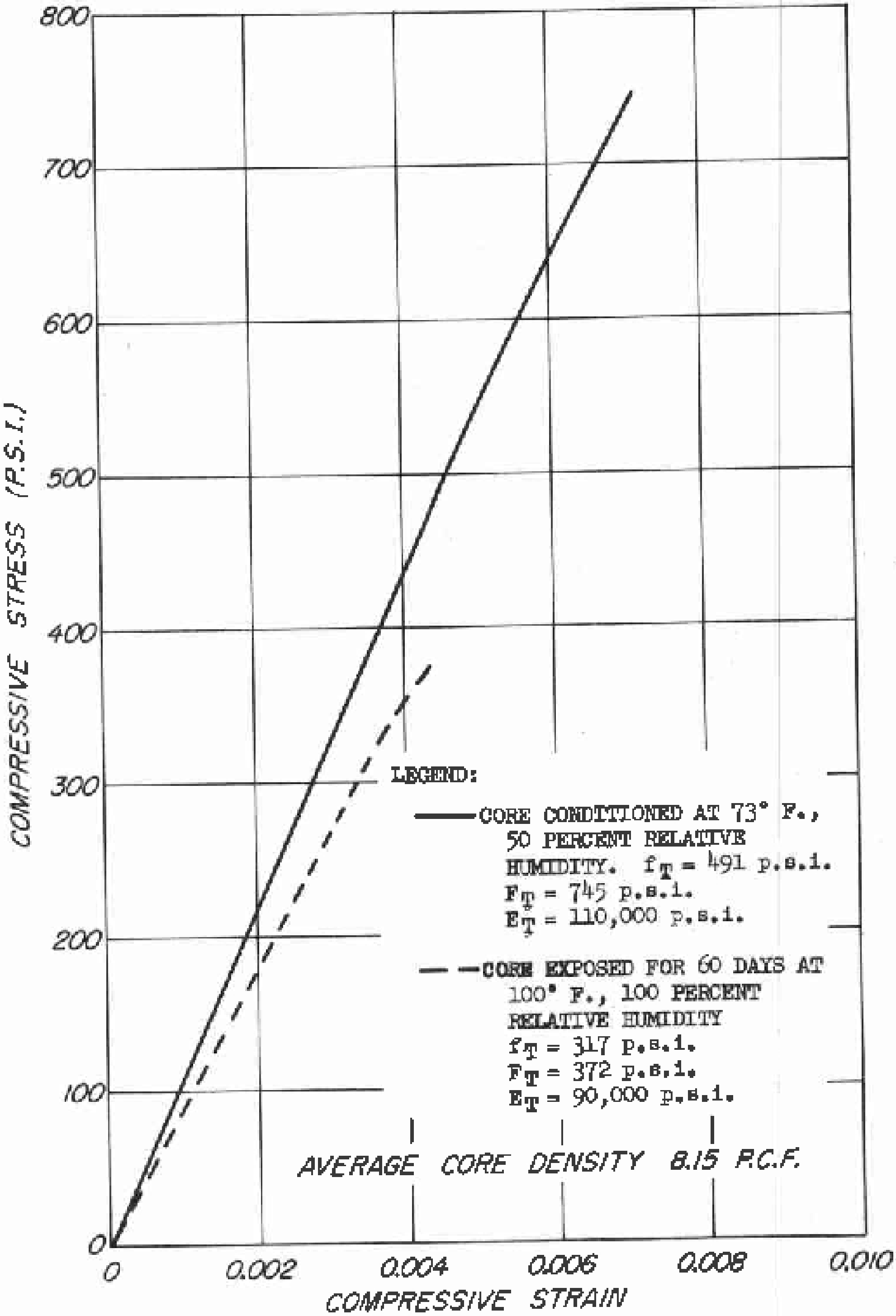

Figure 18. --Compressive stress-strain design curves for glass-fabric honeycomb cores of fabric 112, finish 136, polyester resin, 3/16-inch cells (Western Products core A9-136).

M 110 398

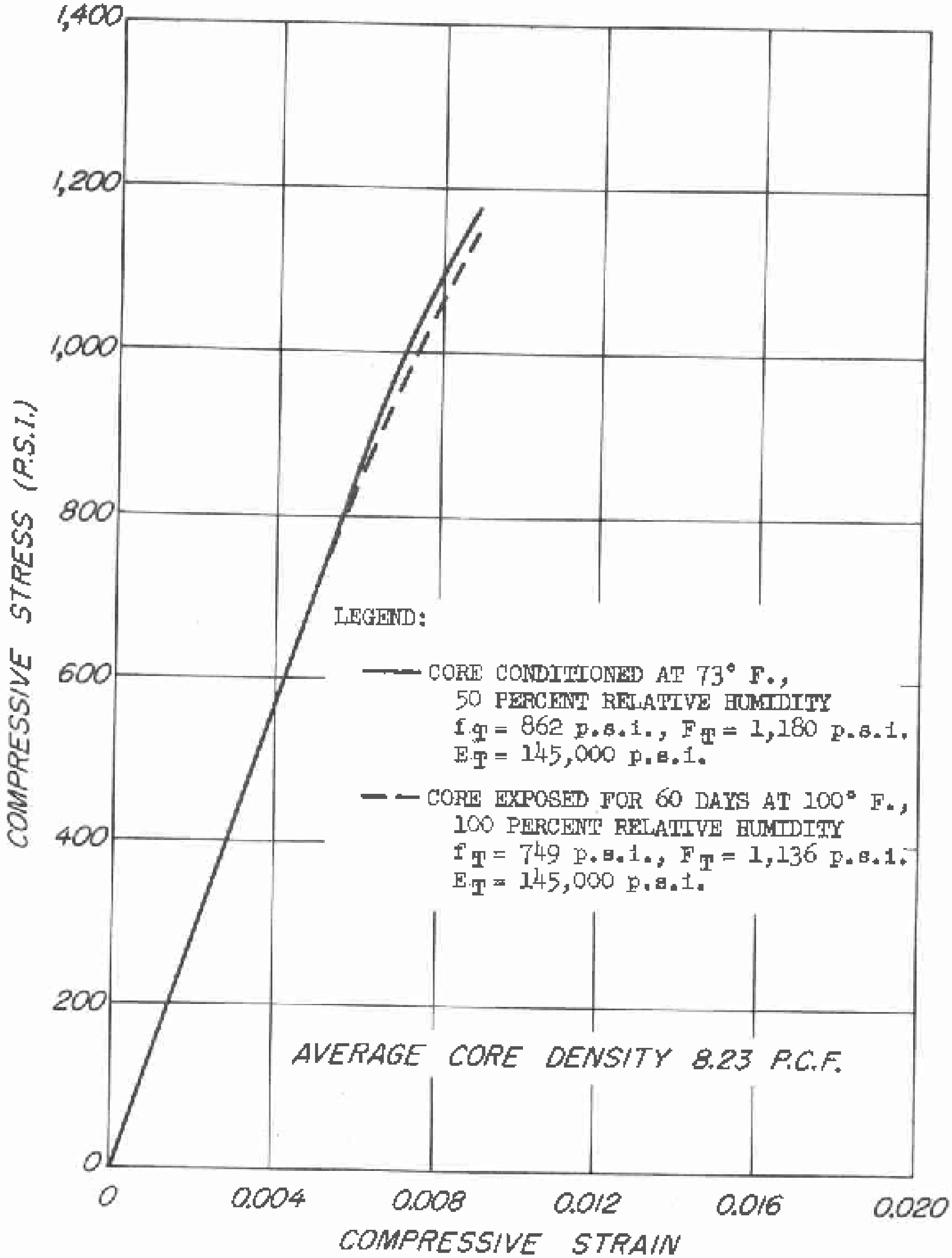

Figure 19.--Compressive stress-strain design curves for glass-fabric honeycomb cores of fabric 21, finish 114, phenolic resin CTL-91LD, 1/4-inch cells (Hexcel Products core CTL-1/4-21-8.0).

M 110 399

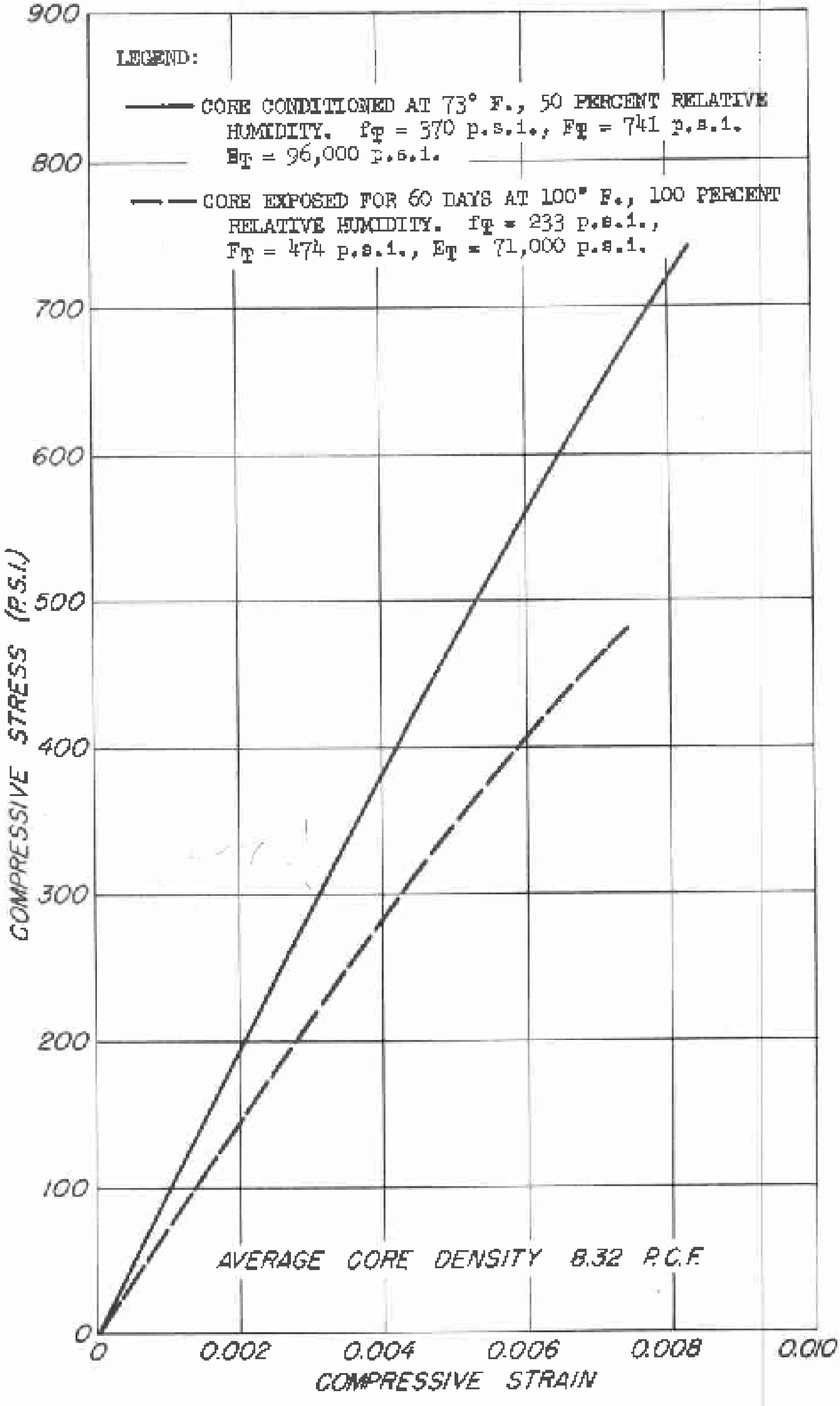

Figure 20. --Compressive stress-strain design curves for glass-fabric honeycomb cores of fabric 112, finish 136, polyester resin, 1/4-inch cells (Western Products core B8-136).

M 110 400

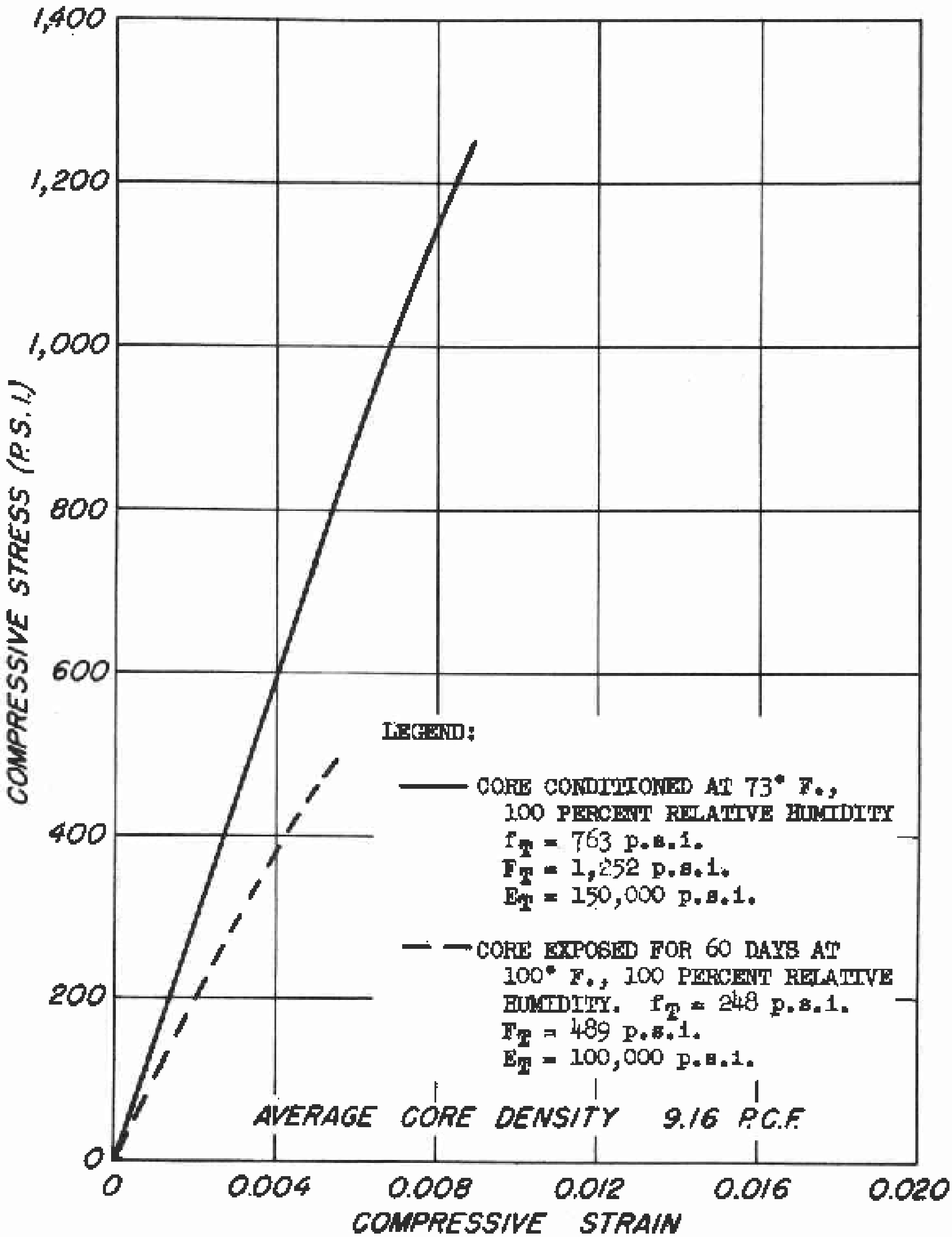

Figure 21.--Compressive stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, nylon-phenolic resin, 3/16-inch cells (Hexcel Products core NP-3/16-112-9.0).

M 110 401

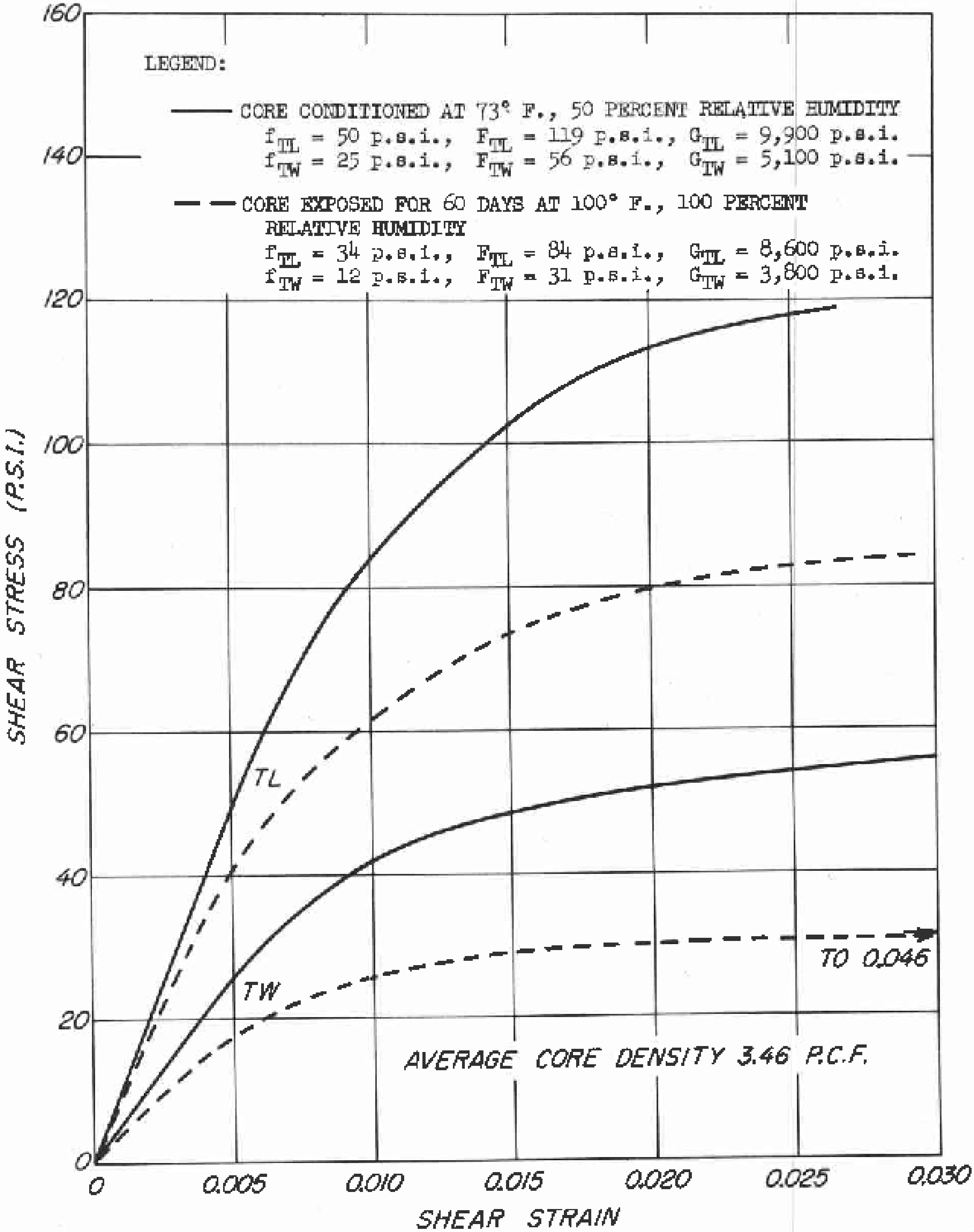

Figure 22.--Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, phenolic resin, 1/4-inch cells (Western Products core BPF 3.5).

M 110 402

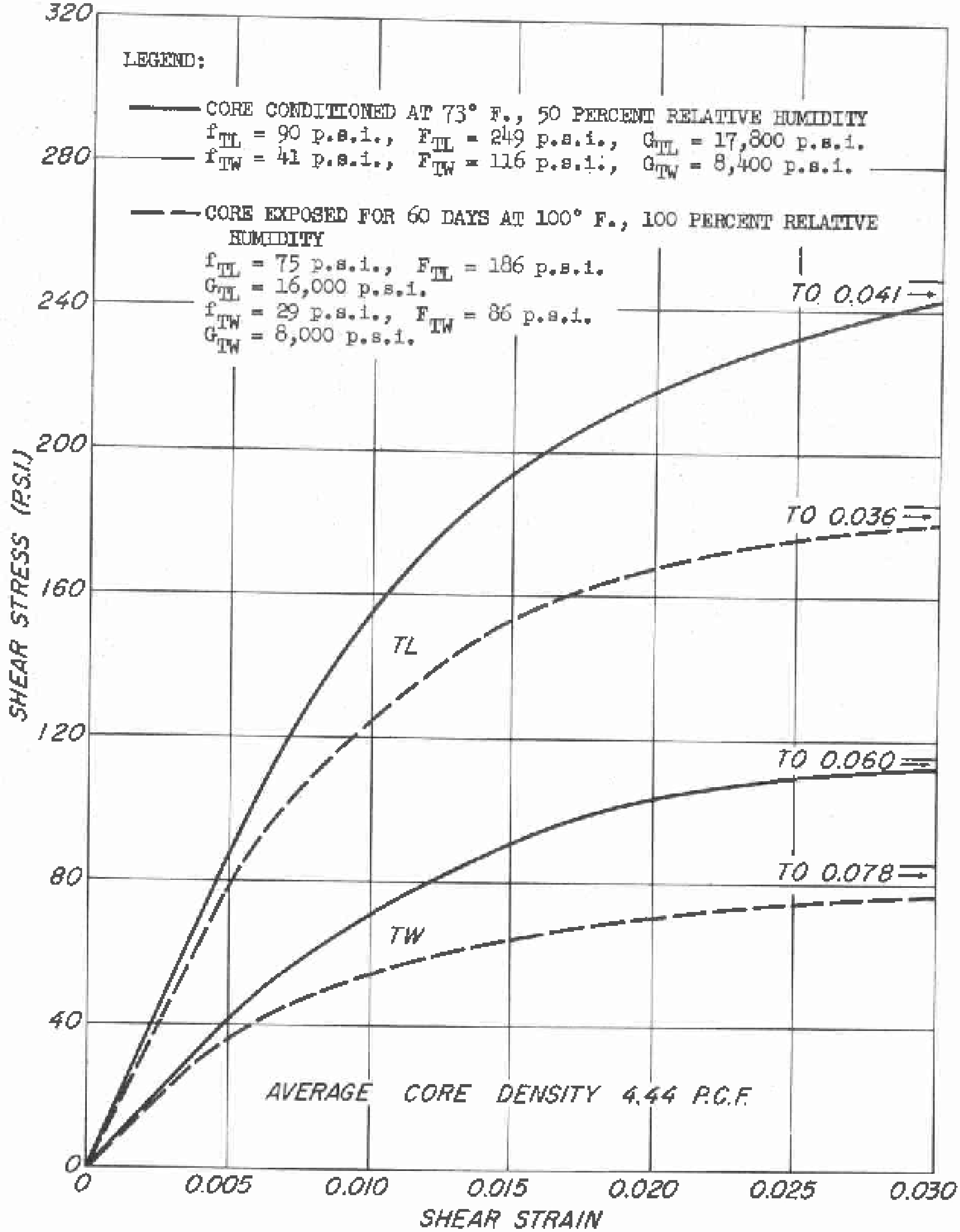

Figure 23.--Shear stress-strain design curves for glass-fabric honeycomb core of fabric 21, finish 114, nylon-phenolic resin, 1/4-inch cells (Hexcel Products core NP-1/4-21-4.0).

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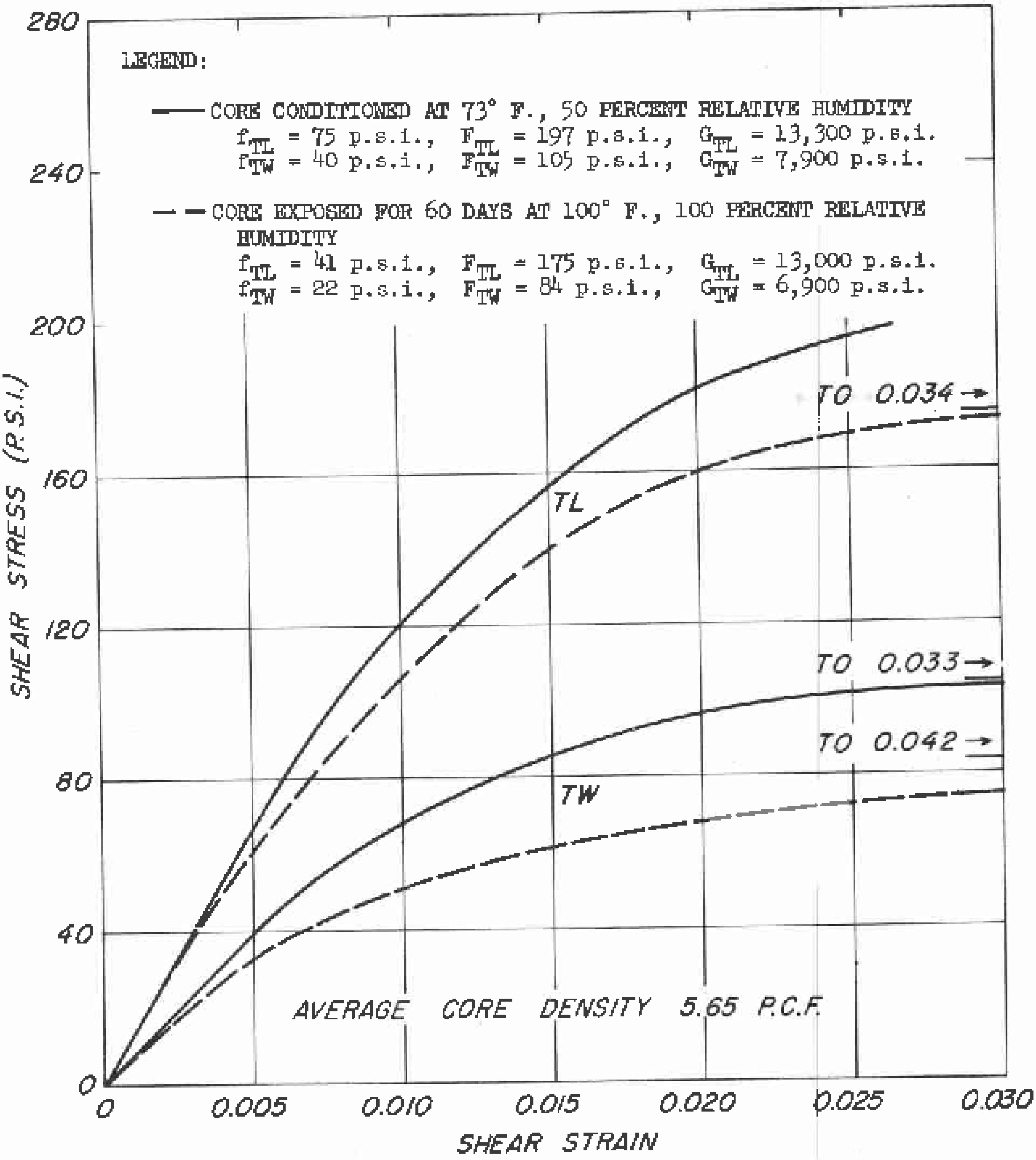

Figure 24. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, phenolic and polyester resin, 1/4-inch cells (Western Products core BPF 5.5).

M 110 404

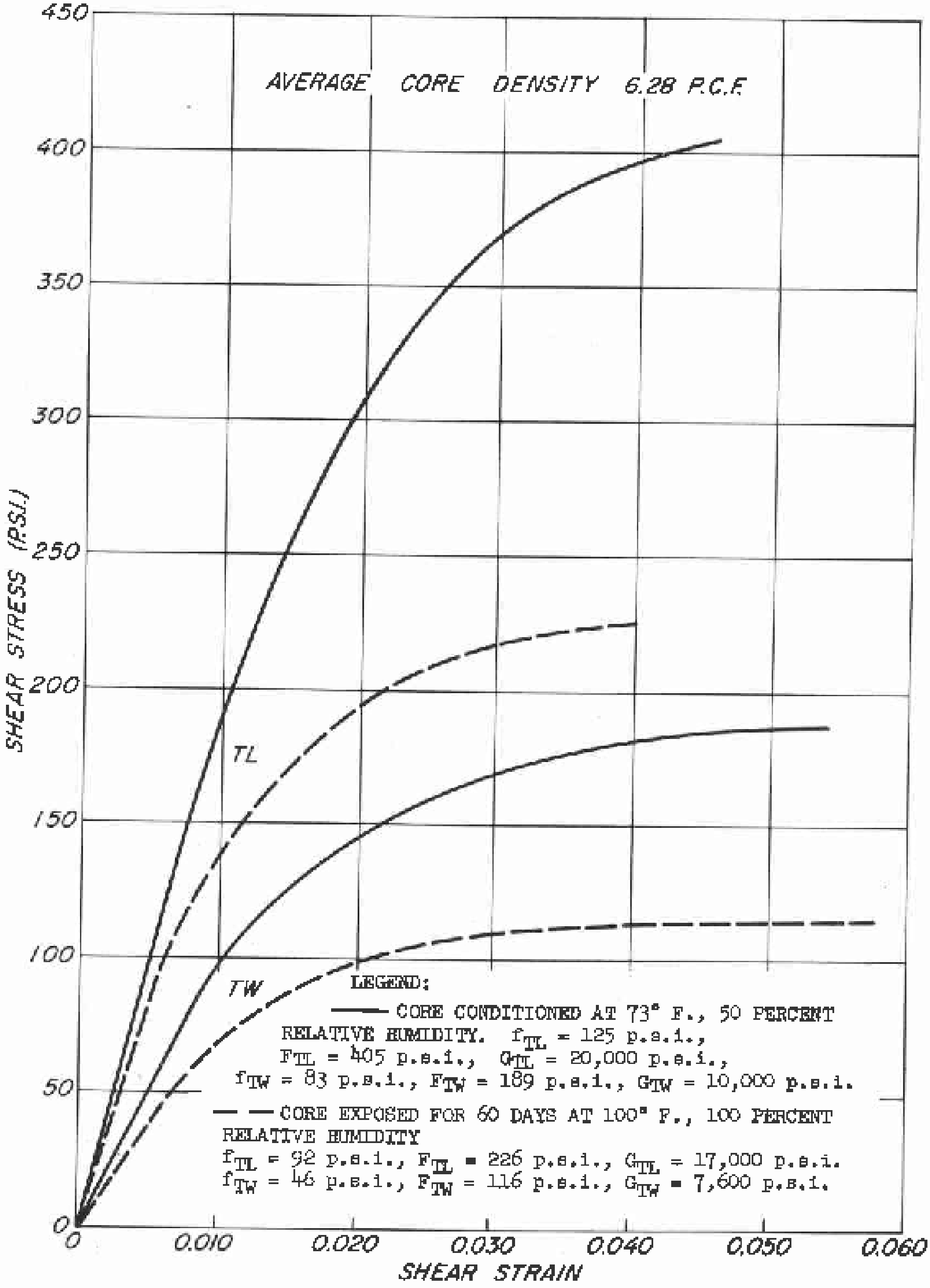

Figure 25.--Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, nylon-phenolic resin, 3/16-inch cells (Hexcel Products core NP-3/16-112-6.0).

M 110 405

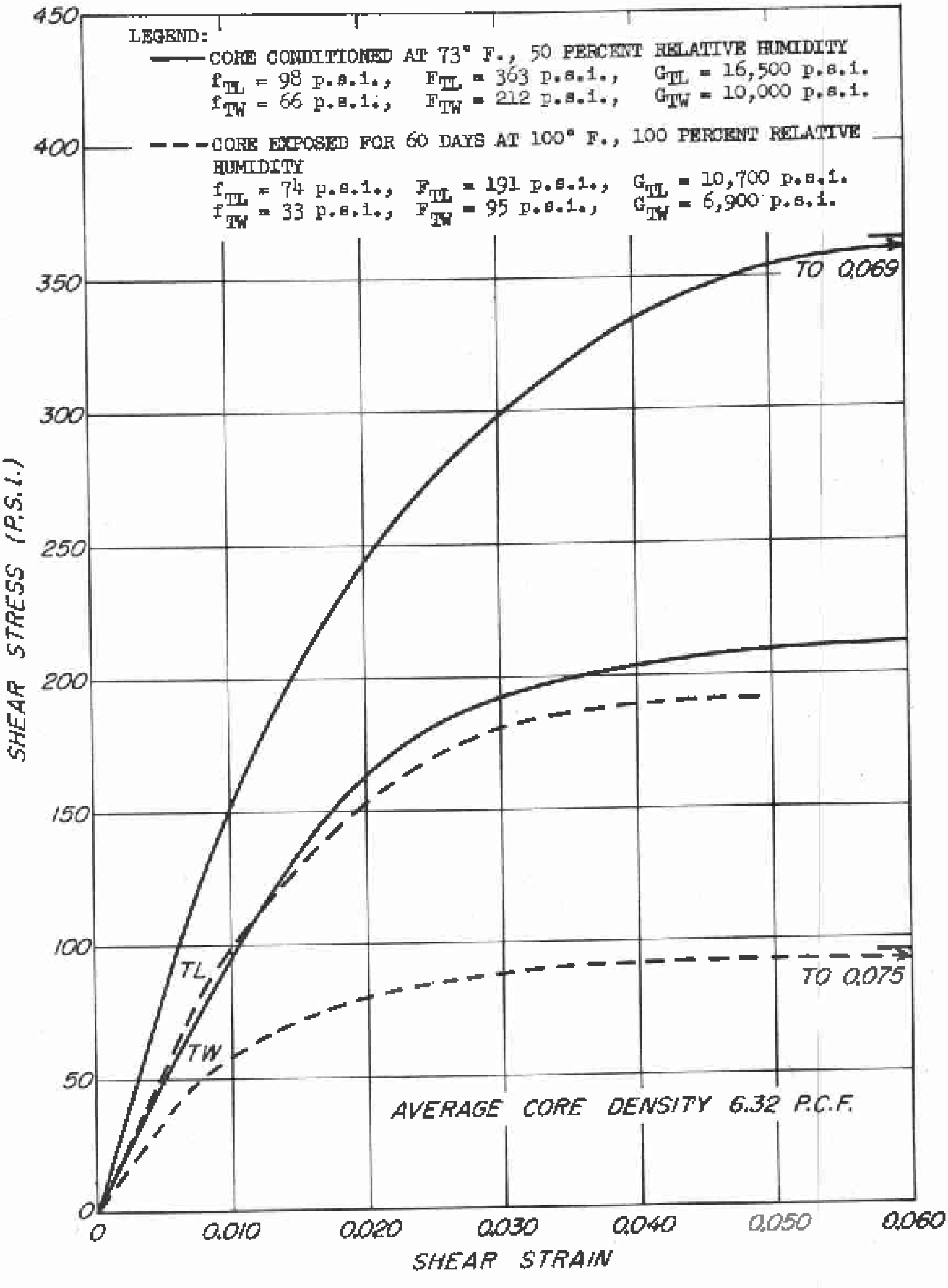

Figure 26. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 21, finish 114, nylon-phenolic resin, 1/4-inch cells (Hexcel Products core NP-1/4-21-6.0).

M 110 406

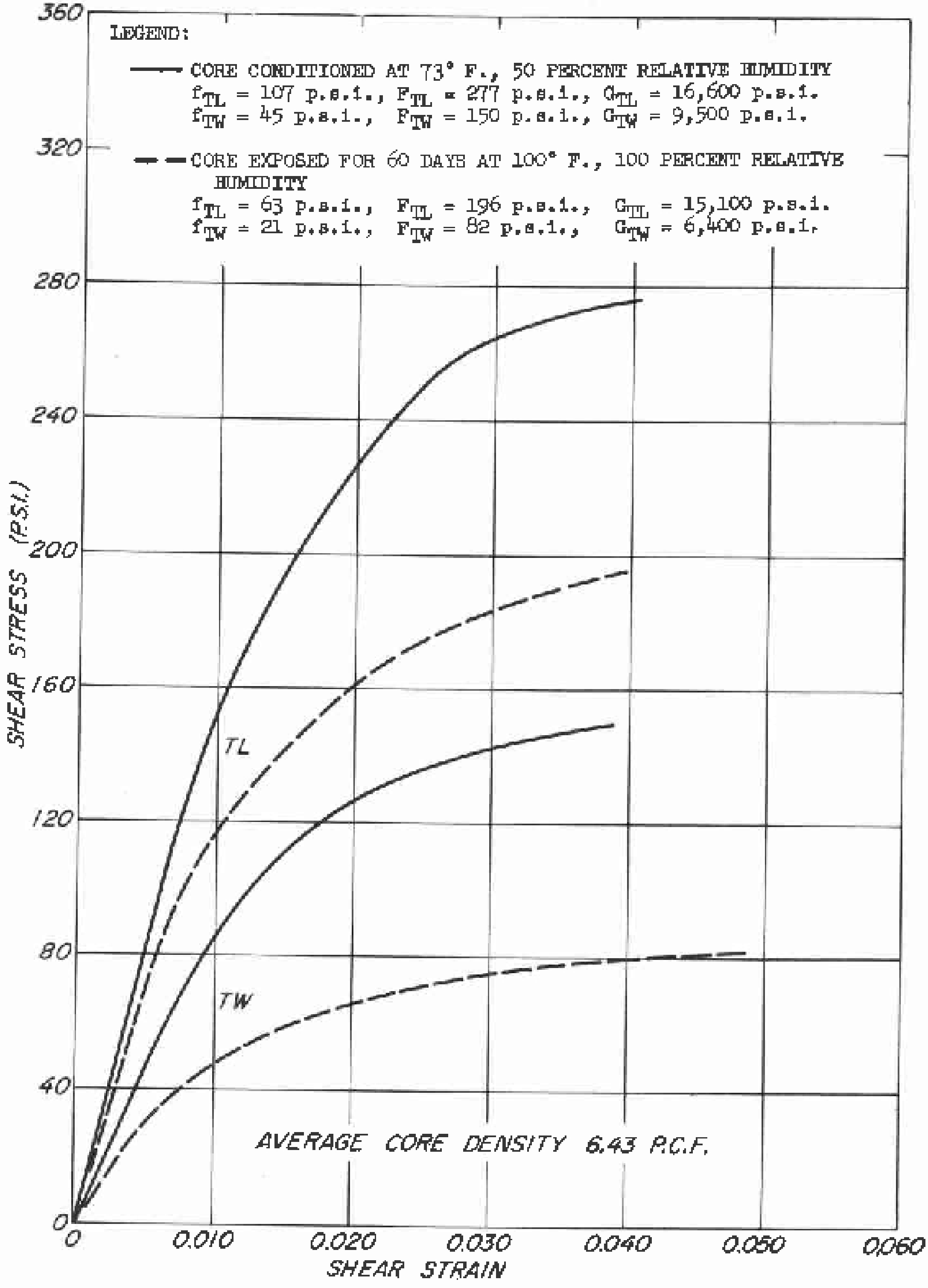

Figure 27.--Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, phenolic and polyester resin, 3/16-inch cells (Western Products core APF 6.5).

M 110 407

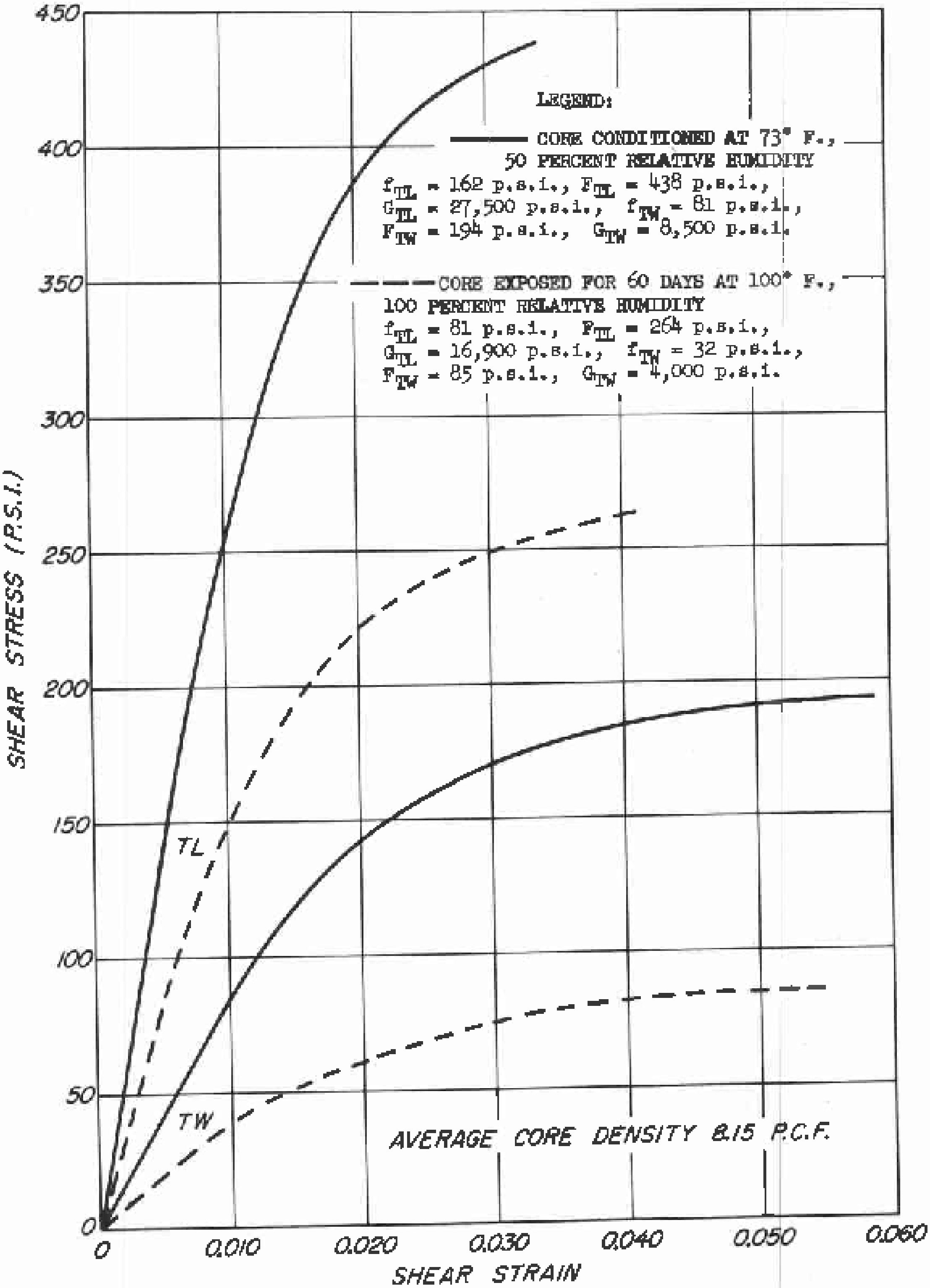

Figure 28. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 136, polyester resin, 3/16-inch cells (Western Products core A9-136).

M 110 408

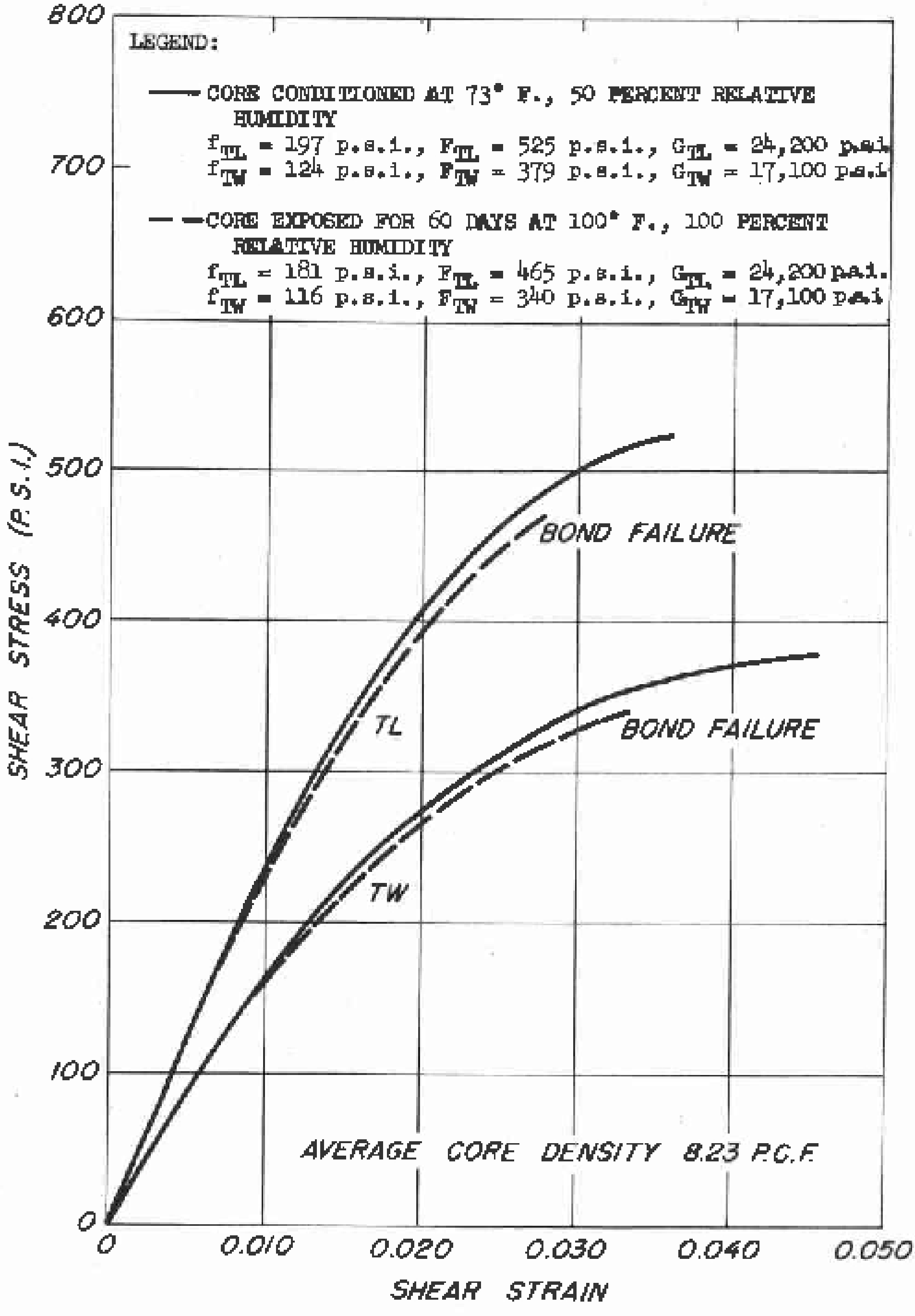

Figure 29. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 21, finish 114, phenolic resin CTL-91LD, 1/4-inch cells (Hexcel Products core CTL-1/4-21-8.0).

M 110 409

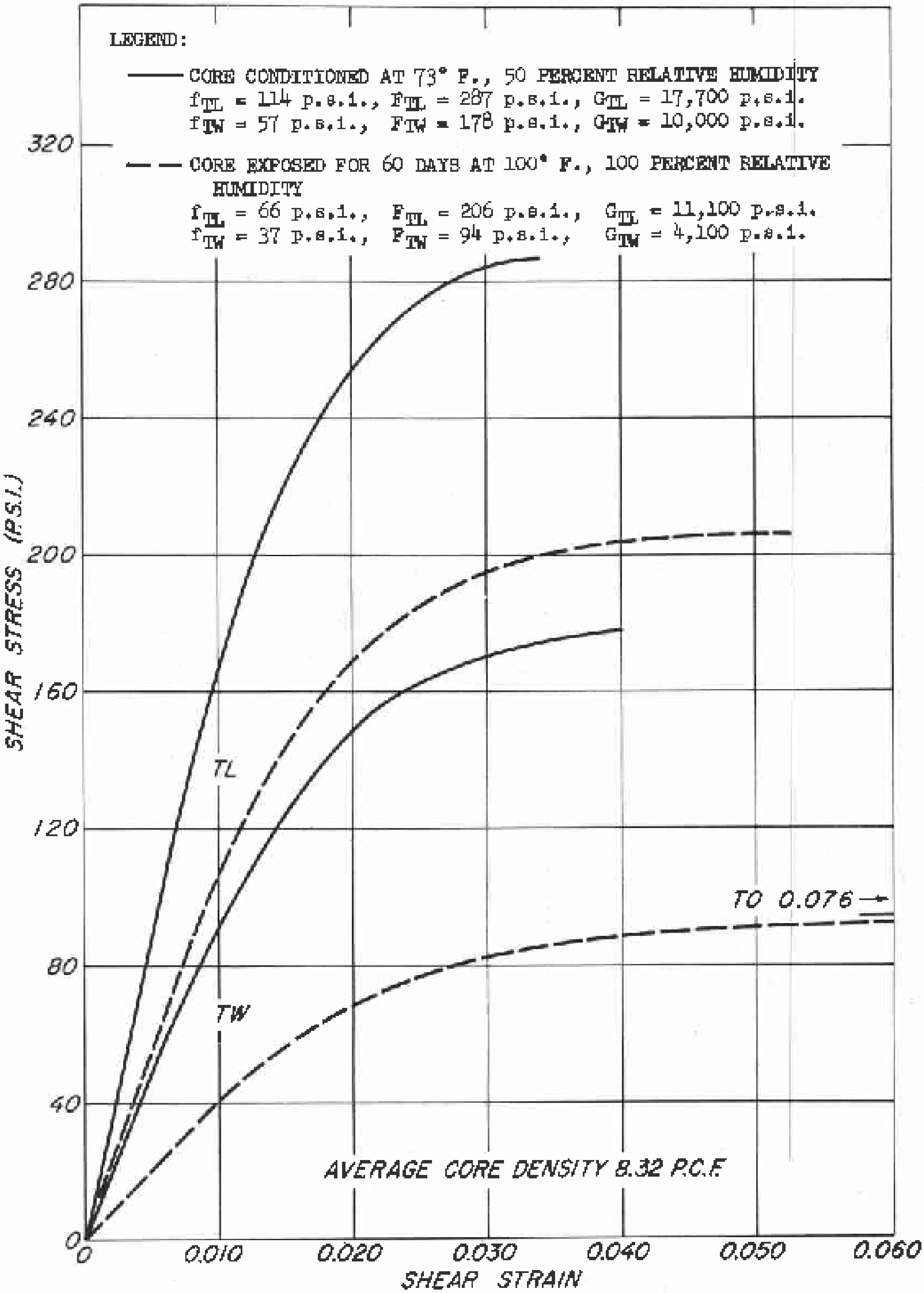

Figure 30. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 136, polyester resin, 1/4-inch cells (Western Products core B8-136).

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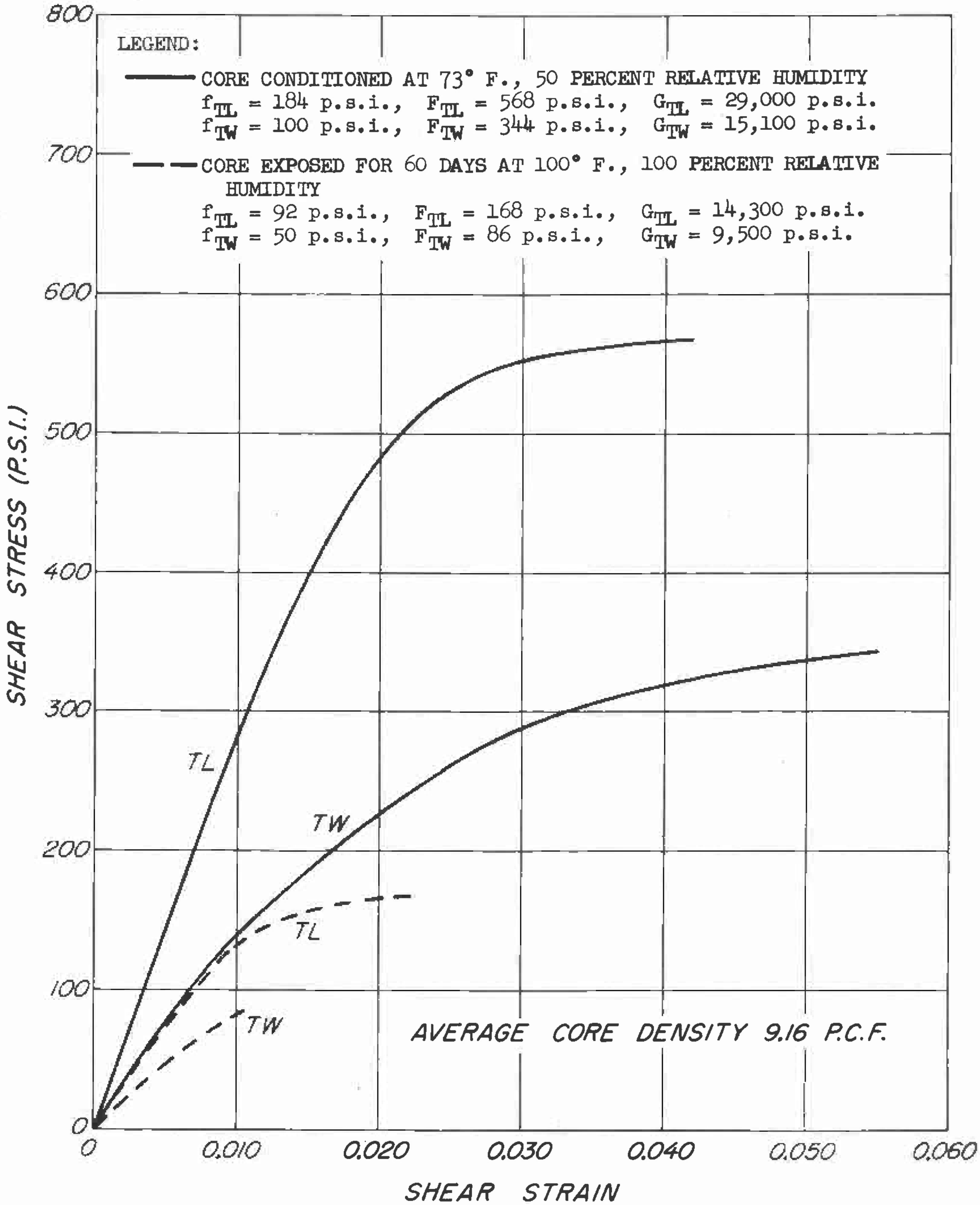

Figure 31. --Shear stress-strain design curves for glass-fabric honeycomb core of fabric 112, finish 114, nylon-phenolic resin, 3/16-inch cells (Hexcel Products core NP-3/16-112-9.0).

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