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(GLASS-CLOTH FACINGS, BALSA CORE -- TESTED IMMEDIATELY AFTER THE TEST TEMPERATURE WAS REACHED)

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UNITED STATES DEPARTMENT OF AGRICULTURE
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Madison 5, Wisconsin
In Cooperation with the University of Wisconsin

EFFECT OF ELEVATED TEMPERATURES ON THE STRENGTHS OF SMALL SPECIMENS OF SANDWICH CONSTRUCTION OF THE AIRCRAFT TYPE[1]

(Glass-cloth Facings, Balsa Core - Tested Immediately After the Test Temperature Was Reached)

By

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Introduction

The purpose of this study was to determine the behavior of a sandwich construction with facings of glass-fabric-base, phenolic-resin laminate bonded to a core of end-grain balsa wood, at temperatures from 75° to 600° F. (23.9° to 315.6° C.). The experimental work paralleled the work reported in Forest Products Laboratory Report No. 1804[3] on other sandwich constructions of the aircraft type. Details as to testing apparatus and procedures were identical with those described in that report.

Test Material

The sandwich construction was manufactured according to Chance-Vought Aircraft Process Specification CVA 270. The facings were of five plies of glass cloth 112-114 hand-impregnated with approximately 50 percent, by wet weight (approximately 30 percent of dry resin by weight) of resin 9. The core was 1/2-inch end-grain balsa wood with a density of 5 to 8 pounds per cubic foot. It was sized with a spray coat of thinned resin 9 and immediately dusted with

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[1] This progress report is one of a series prepared and distributed by the Forest Products Laboratory under U. S. Navy, Bureau of Aeronautics Order No. NAer 01237 and 01202 and U. S. Air Force No. USAF-(33-038) 51-4062E. Results here reported are preliminary and may be revised as additional data become available.

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

[3] Kuenzi, E. W. Effect of Elevated Temperatures on the Strengths of Small Specimens of Sandwich Construction of the Aircraft Type. Forest Products Laboratory Report No. 1804, 8 pp., illus., 1949.

powder (the solid component of adhesive 34). After an open-assembly period of approximately 2 hours, the facings and core were assembled on an aluminum mold and cured for 1 hour under fluid pressure in a bag at about 260° F. and a pressure of 75 pounds per square inch.

Testing Apparatus and Procedures

The testing apparatus, procedures, and temperatures and the specimen sizes were identical with those described in Forest Products Laboratory Report No. 1804.[2] The tests were begun as soon as the desired temperature was reached in the test oven. This took from 10 to 20 minutes, depending on how much apparatus adjustment was necessary. Tests were made in compression on short and long specimens. Tests were also conducted in shear and in flatwise tension.

Results of Tests

The properties of the sandwich construction, as determined by the tests at various temperatures, are presented in table 1 and in graphical form in figures 1 to 5.

Column-compression specimens failed first by bending and finally by compression of the facings. The nominal facing stresses at failure (fig. 1) decreased from 17,000 pounds per square inch at 75° F. to 12,000 pounds per square inch at 450° F. and to zero at 600° F.

Short specimens in compression (edgewise compression) failed by crushing of the facings at stresses of 24,700 pounds per square inch at 75° F. This stress was reduced to 16,000 pounds per square inch at 350° F., to approximately 3,000 pounds per square inch at 450° F., and to zero at 600° F. (fig. 2). It is not known, at present, why the strength of the short compression specimens at 450° F. is less than that of the long column specimens.

The effective modulus of rigidity, as determined by the frame shear test, decreased almost linearly from 21,200 pounds per square inch at 75° F. to approximately 4,000 pounds per square inch at 450° F. (fig. 3). At 600° F., the strength was so low that no readings could be taken to determine modulus of rigidity values.

The shear strength dropped from 330 pounds per square inch at 75° F. almost linearly to approximately 15 pounds per square inch at 600° F. (fig. 4). Some of the failures occurred in the balsa cores and some in the facing-to-core bonds.

Tensile strength decreased almost linearly from approximately 780 pounds per square inch at 75° F. to 70 pounds per square inch at 600° F. Failures occurred in the bonds. Several attempts were made to bond the loading blocks to the facings, but failure occurred in these bonds at temperatures of 250° and 350° F.

The balsa cores of all specimens charred throughout to a light brown at 450° F. and charred black and brittle at 600° F.

Comparison with Other Sandwich Constructions

Although comparisons with previously tested sandwich constructions[3] are difficult to make, a few general comments may be worth considering.

At 450° F., the column strength of the sandwich construction having glass-cloth facings on a balsa core was approximately three times as great as the strength of comparable constructions with glass-cloth facings on glass-cloth honeycomb cores. The column strength values at 75° F. were approximately equal.

The edgewise-compressive strength of the sandwich construction having glass-cloth facings on a balsa core was somewhat higher than that of some of the other constructions with glass-cloth facings at moderately elevated temperatures, but was lower at 450° and 600° F. It is not known whether this is due to the types of resin used in the facings or for bonding the facings to the core.

The shear properties of this sandwich construction are comparable to the properties determined for a construction having aluminum facings on a balsa core.

The tensile strength of the sandwich construction having glass-cloth facings on a balsa core was approximately two-thirds of the strength of aluminum facings bonded to balsa at 75° F. At elevated temperatures of 350° to 600° F., however, it was greater than the tensile strength of aluminum bonded to balsa.

Table 1.--Results of column- and edgewise-compression tests at elevated temperatures of a sandwich construction with facings of five-ply glass cloth 112-114 bonded to a core of 1/2-inch end-grain balsa with the solid component of adhesive 34

Specimen No.	Column-compression tests						Edgewise-compression tests					
	Facing stress at failure at -						Facing stress at failure at -					
	75° F.	160° F.	250° F.	350° F.	450° F.	600° F.	75° F.	160° F.	250° F.	350° F.	450° F.	600° F.
	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.
1	16,550	14,150	15,590	13,350	11,690	(1)	26,200	18,600	16,620	16,620	2,800	(1)
2	16,950	14,680	14,460	13,400	12,040	(1)	24,500	18,940	14,080	16,060	.....	(1)
3	17,900	14,950	14,320	13,380	11,820	(1)	24,200	22,820	14,210	16,870	.....	(1)
4	18,210	15,750	15,140	15,270	.....	(1)	24,900	21,000	19,380	15,200	2,570	(1)
5	16,000	15,110	16,310	14,650	11,830	(1)	23,900	20,830	17,640	14,780	2,900	(1)
6	16,000	14,950	13,500	12,530	12,150	(1)	24,600	18,700	17,870	16,760	2,900	(1)
Av....	16,930	14,930	14,890	13,760	11,910	.....	24,720	20,150	16,640	16,050	2,790	.....

(1) Specimen burned.

Table 2.--Results of shear tests at elevated temperatures of a sandwich construction with facings of five-ply glass cloth 112-114 bonded to a core of 1/2-inch end-grain balsa with the solid component of adhesive 34

Specimen No.	Shear tests										
	Modulus of rigidity[1] at -					Core stress at failure at -					
	75° F.	160° F.	250° F.	350° F.	450° F.	75° F.	160° F.	250° F.	350° F.	450° F.	600° F.
	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.
1	16,610	18,940	14,950	13,040	1,960	248	[2]222	224	213	[2]46	.....
2	21,130	15,680	13,500	10,870	4,320	321	[2]279	243	[2]161	77	[2]20
3	20,320	14,240	12,240	9,780	3,780	[2]375	[2]234	223	131	49	[2]12
4	15,850	14,140	11,010	10,250	4,710	300	301	213	153	[2]29	[2]5
5	29,900	15,850	13,950	7,440	4,890	[2]407	[2]257	218	145	[2]75	[2]22
6	23,270	11,310	12,680	5,780	.....	[2]333	[2]238	[2]206	100	[2]31	[2]18
Av....	21,180	15,020	13,060	9,520	3,930	331	255	221	150	51	23

[1]Strength of the test specimens at 600° F. was so low that no readings could be taken at that temperature.

[2]Bond failure between facings and core.

Table 3.--Results of tension tests at elevated temperatures of a sandwich construction with facings of five-ply glass cloth 112-114 bonded to a core of 1/2-inch end-grain balsa with the solid component of adhesive 34

Specimen No.	Tension tests					
	Core stress at failure at -					
	75° F.	160° F.	250° F.	350° F.	450° F.	600° F.
	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.
1	[1]685	[1]470	[1]515	[2]330	[2]325	[1]109
2	[1]625	[1]522	[2]420	[2]365	[3]180	[3] 80
3	[1]812	[1]842	[2]435	[2]370	[1]320	[3] 85
4	[1]1,020	[1]548	[2]440	[2]380	[2]300	[1] 65
5	[1]800	[1]550	[2]485	[2]415	[3]315	[1] 35
6	[1]705	[1]595	[2]520	[2]340	[1]355	[1] 42
Av.....	775	588	469	367	299	69

[1]Bond failure between facings and core.

[2]Bond failure between facings and loading plate.

[3]Core failure.

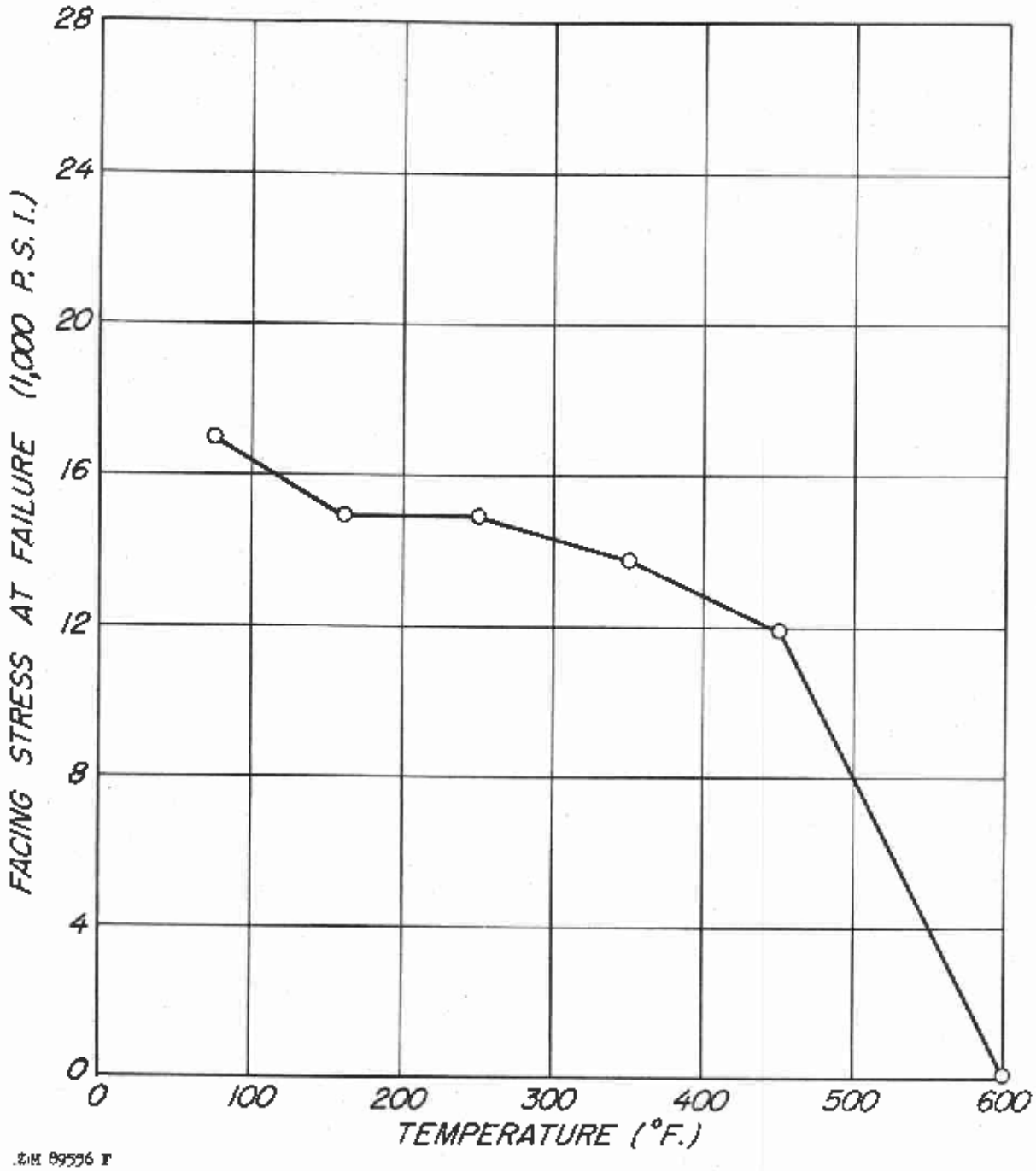

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Figure 1.--Results of column-compression tests of 1- by 10-inch specimens of a sandwich construction having glass-cloth facings on a balsa core tested at different temperatures.

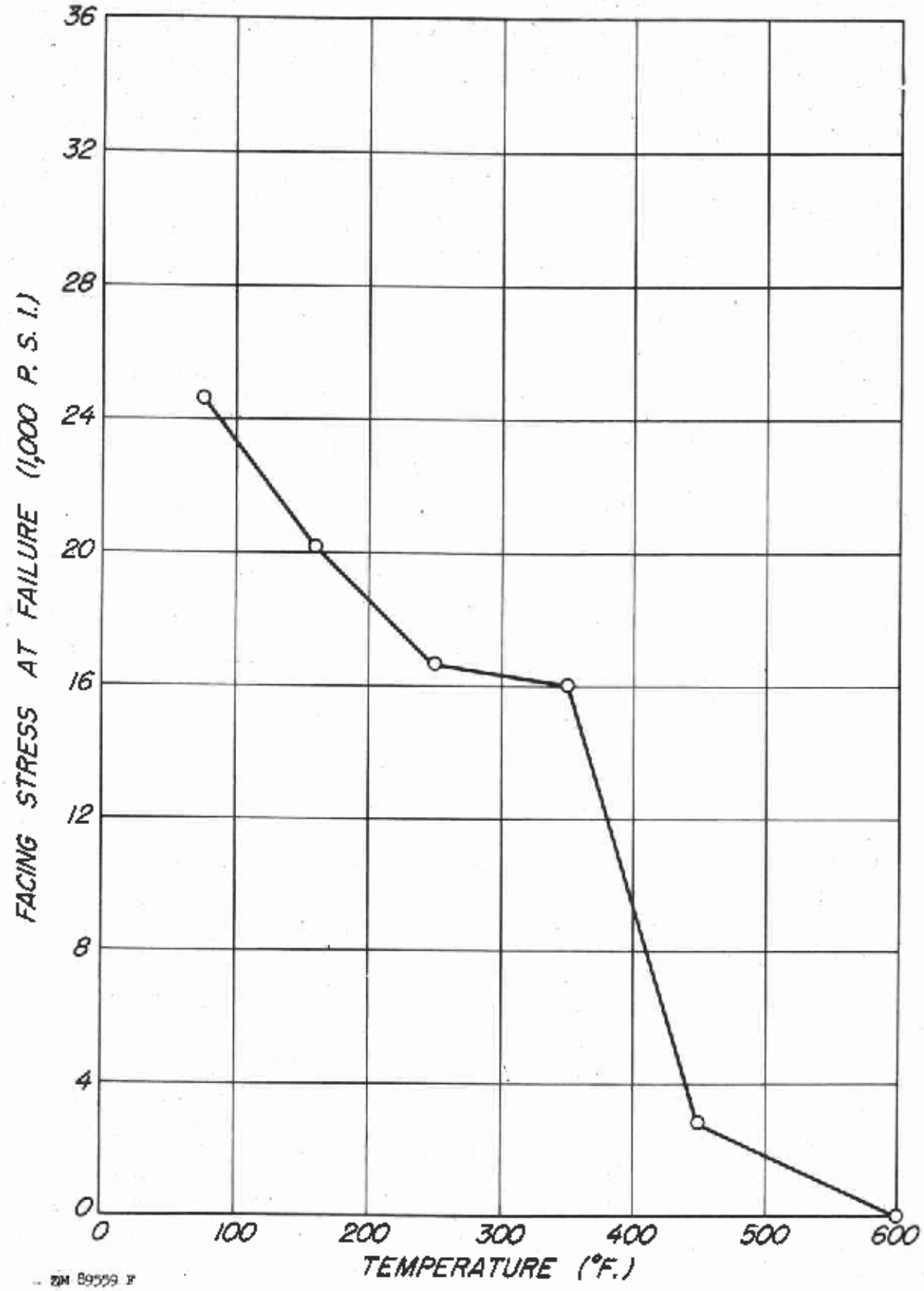

Figure 2.--Results of edgewise-compression tests of 2- by 3-inch specimens of a sandwich construction having glass-cloth facings on a balsa core tested at different temperatures.

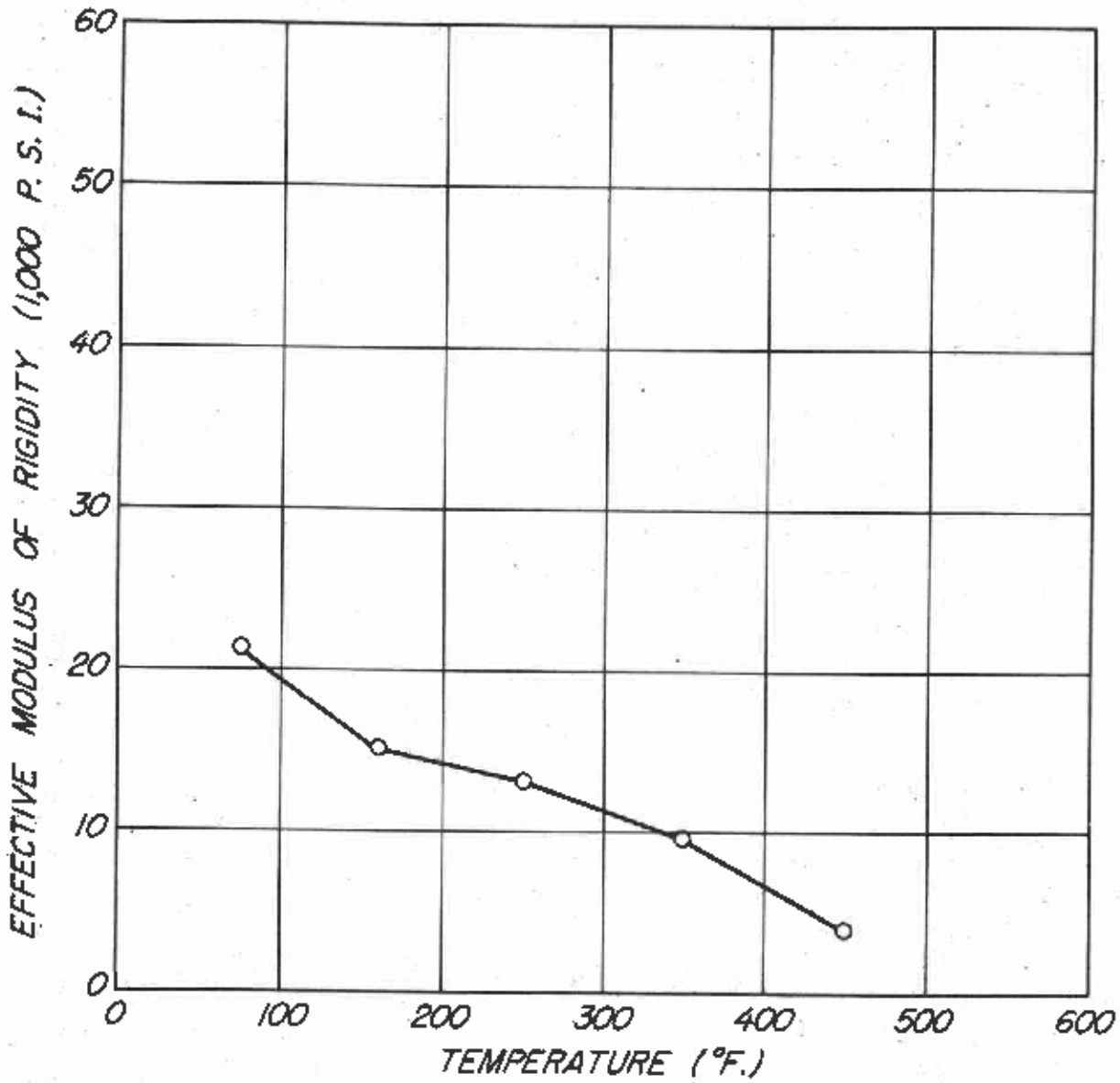

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Figure 3.--Results of shear tests to determine modulus of rigidity of 1- by 6-inch specimens of a sandwich construction having glass-cloth facings on a balsa core at different temperatures. At 600° F., the strength was so low that no readings could be taken to determine modulus of rigidity values.

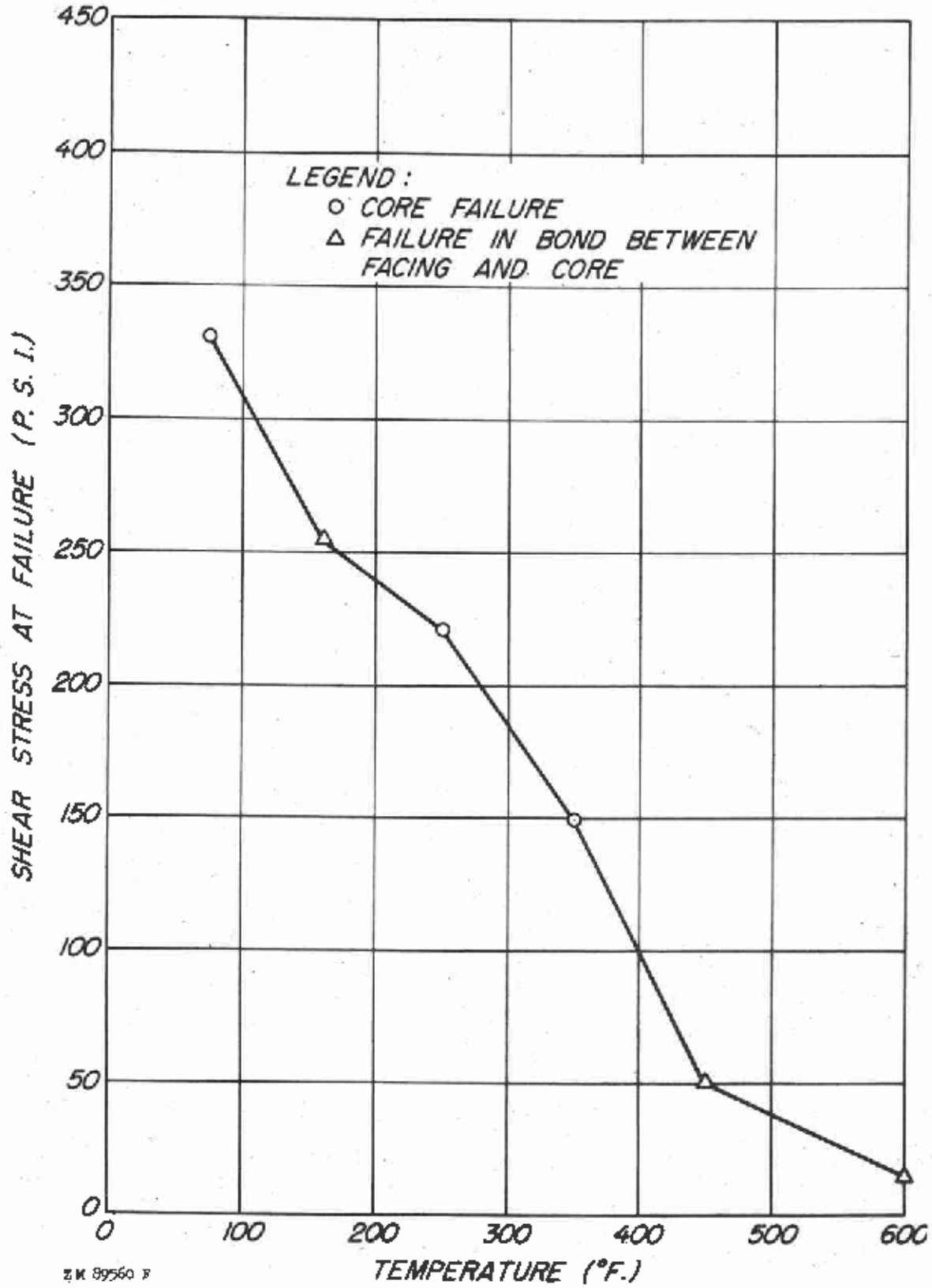

Figure 4.--Results of shear tests to determine the shear stress at failure of 1- by 6-inch specimens of a sandwich construction having glass-cloth facings on a balsa core at different temperatures.

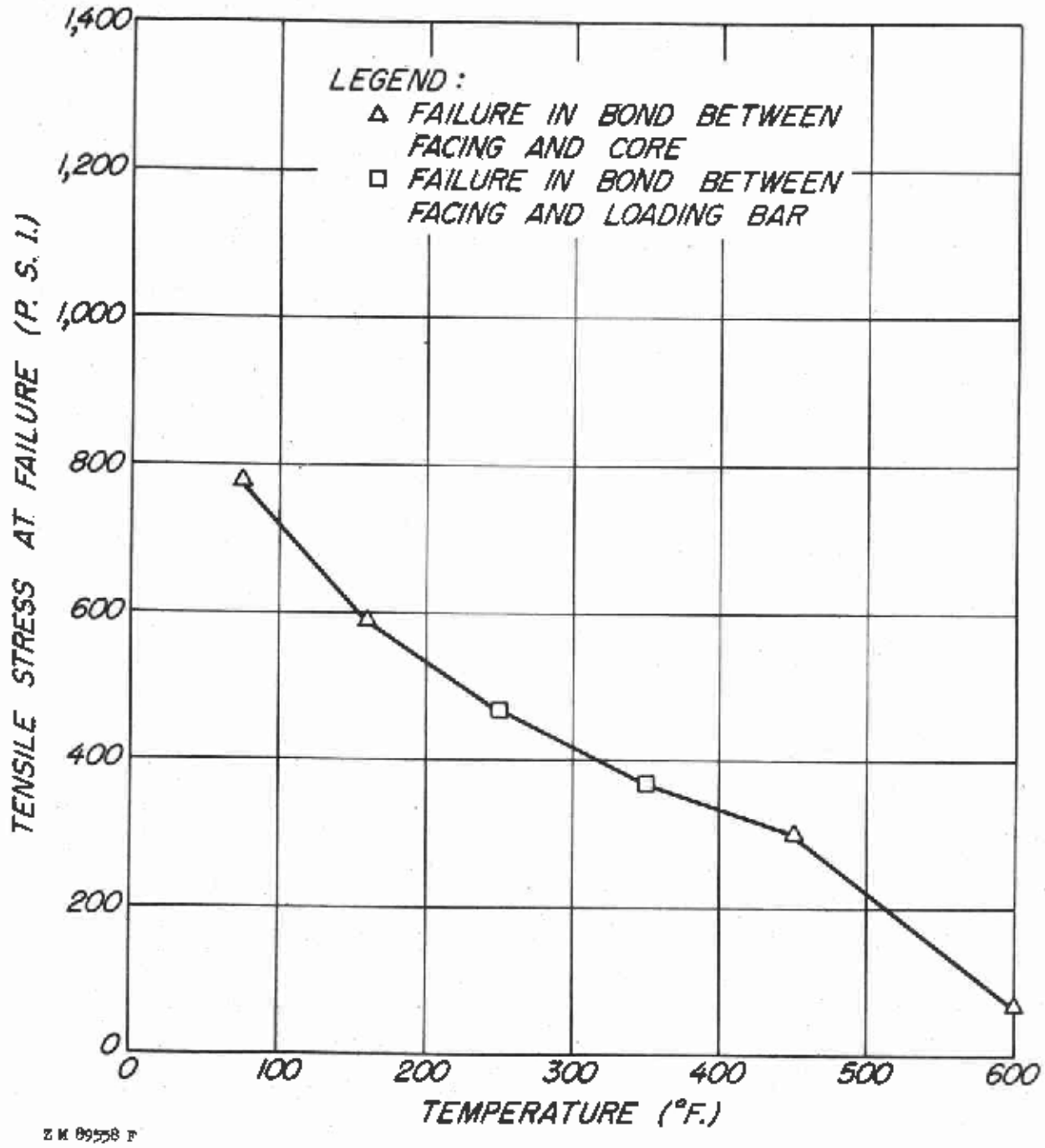

Figure 5.--Results of tension tests (tension normal to facings) of 1- by 1-inch specimens of a sandwich construction having glass-cloth facings on a balsa core.