NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 2312

BEARING STRENGTHS OF SOME ALUMINUM-ALLOY PERMANENT-MOLD CASTINGS

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SUMMARY

Bearing tests were made to determine bearing ultimate and yield strengths of aluminum-alloy permanent-mold castings of B195-T4, B195-T6, and 356-T6, and to compare the ratios of bearing to tensile properties obtained with similar data from sand-castings of like material. It was found that the bearing strengths of the permanent-mold aluminum-alloy castings were not significantly different from those which have been observed for sand-castings and that the ratios of bearing strengths to tensile strengths of the permanent-mold castings were slightly less than those previously observed for sand-castings.

As a basis for selection of allowable bearing values for the design of B195-T4, B195-T6, and 356-T6 aluminum-alloy permanent-mold castings, the following ratios are proposed: (1) Ratio of bearing ultimate strength to tensile ultimate strength, 1.4 for edge distances of 1.5 times pin diameter and 1.8 for edge distances of 2 times pin diameter and (2) ratio of bearing yield strength to tensile yield strength, 1.6 for edge distances of 1.5 times pin diameter and 1.8 for edge distances of 2 times pin diameter.

INTRODUCTION

Interest has been indicated by aircraft manufacturers in having bearing properties of permanent-mold aluminum casting alloys so it was decided to extend a series of investigations of bearing properties of various aluminum alloys to include some of the permanent-mold alloys.

The object of this investigation was to determine bearing ultimate and yield strengths for permanent-mold aluminum casting alloys B195-T4, B195-T6, and 356-T6, and to compare the ratios of bearing to tensile properties obtained with similar data from sand-castings of like material.

This work was done by the Aluminum Company of America and has been made available to the NACA for publication because of its general interest.

MATERIAL

The material tested was furnished by the Alcoa Cleveland Research Laboratories in accordance with specifications AN-A-36 and AN-A-34 and included alloys B195-T4, B195-T6, and 356-T6. The bearing test slabs were permanent-mold castings 1/4 inch thick by $2\frac{1}{4}$ inches wide by 12 inches long, with an average thickness variation of ±0.007 inch in each piece. Individually cast standard 1/2-inch-diameter permanent-mold tensile test bars were provided with each batch of bearing specimens. Radiographic examination of the test specimens showed them to be substantially sound and of good commercial quality.

PROCEDURE

Figure 1 shows the arrangement for making the bearing tests, which were made in triplicate. The 1/4-inch-thick specimens were loaded in bearing on a 1/2-inch-diameter steel pin. Edge distances, measured in the direction of stressing from the center of the pin hole to the edge of the specimen, were 1.5 and 2.0 times the diameter of the pin.

Hole deformations, from which values of bearing yield strength were determined, were obtained by measuring the relative movement of the pin and the specimen by means of a filar micrometer microscope, which could be read directly to 0.01 millimeter. The projecting portion of the pin on the microscope side was flattened slightly on the under side to provide a shoulder on which the reference mark for pin movement was located; a fine scribed line on the specimen under the pin provided the reference for specimen movement.

RESULTS AND DISCUSSION

Table I gives the results of the tensile tests. The tensile strengths obtained from the 1/2-inch-diameter test bars ranged from 27 to 46 percent higher than the minimum specified values for the castings and from 5 to 30 percent higher than those considered as typical. The greatest differences were observed for the B195-T4 specimens which were susceptible to natural aging at room temperature. This natural aging was to be expected because 8 months had elapsed from the time of receipt of the material at these laboratories to the time of testing.

The tensile strengths obtained from the specimens machined from the B195-T4 and B195-T6 cast slabs were 8 percent less than the values obtained from the corresponding 1/2-inch-diameter test bars while the tensile-strength values obtained from the 356-T6 cast slab specimens were 1 percent higher than the values obtained from the corresponding 1/2-inch-diameter test bars. All values were above the minimum allowable for test specimens of this type. The tensile yield strengths obtained from the B195-T4 and B195-T6 cast slabs were slightly lower than those obtained for the corresponding 1/2-inch-diameter test bars. The tensile yield strengths of the 356-T6 cast slabs were observed to be 3 percent higher than those obtained from the corresponding 1/2-inch-diameter test bars. Elongation values obtained from the cast slabs were in all cases less than those obtained from the 1/2-inch-diameter test bars, although all the former were above the minimum that would be allowed in tests of specimens machined from castings.

The compressive yield strengths obtained from the specimens machined from the cast slabs were slightly but consistently higher than the corresponding values of tensile yield strength, the maximum difference of 3.3 percent being noted for the 356-T6. The ultimate shear strengths, which are generally considered to range from about 70 to 80 percent of the tensile strengths, were all above the 70-percent value.

Table II and figures 2 and 3 show the results of the bearing tests. Values of bearing yield strengths were selected from the curves of bearing stress against hole elongation as the stresses corresponding to an offset of 2 percent of the pin diameter from the initial straight-line portion of the curves. Ratios of the average bearing to tensile properties, the latter obtained from bearing test slabs, are given in table III.

The effect of edge distance upon bearing strengths and the behavior of the castings in bearing was not significantly different from that observed previously for a number of aluminum-alloy sand-castings (reference 1). Although the ratios of bearing strengths to tensile strengths for any one edge distance were approximately the same for all alloys and tempers, the magnitude of these ratios was a little lower than obtained for sand-castings (reference 1).

SUMMARY OF RESULTS

The results of bearing tests of aluminum-alloy permanent-mold castings of B195-T4, B195-T6, and 356-T6 are believed to warrant the following statements regarding bearing strengths and their relation to tensile properties:

1. The tensile strength and yield strength of both the individually cast test bars and the bearing test specimens of the B195-T6 and 356-T6 permanent-mold aluminum alloy were higher than the published typical values.

2. The B195-T4 permanent-mold castings (heat-treated but not artificially aged) aged naturally in a period of 8 months to tensile strengths comparable with those obtained for B195-T6.

3. The bearing strengths of these permanent-mold aluminum-alloy castings were not significantly different from those which have been observed for sand-castings.

4. The ratios of bearing strengths to tensile strengths of the permanent-mold castings were slightly less than those previously observed for sand-castings.

5. The following ratios of bearing to tensile strengths are proposed as a basis for the selection of allowable bearing values for the design of B195-T4, B195-T6, and 356-T6 aluminum-alloy permanent-mold castings:

Ratio	Ratios for edge distances of -	
	1.5 × pin diam.	2 × pin diam.
$\frac{\text{Bearing ultimate}}{\text{Tensile ultimate}}$	1.4	1.8
$\frac{\text{Bearing yield}}{\text{Tensile yield}}$	1.6	1.8

Aluminum Research Laboratories
Aluminum Company of America
New Kensington, Pa., May 31, 1950

REFERENCES

1. Moore, R. L.: Bearing Strengths of Some Aluminum-Alloy Sand Castings. NACA TN 1523, 1948.

2. Anon.: Alcoa Aluminum and Its Alloys. Aluminum Co. of Am., 1947.

TABLE I

SUMMARY OF MECHANICAL PROPERTIES OF SOME

ALUMINUM-ALLOY PERMANENT-MOLD CASTINGS

Alloy and temper	Tensile properties of 1/2-in.-diameter test bars[a]				Properties of 1/4- by $2\frac{1}{4}$ - by 12-in. cast slabs[b]					
	Tensile ultimate strength (psi)	Yield strength (Offset, 0.2 percent) (psi)	Elongation in 2 in. (percent)	Ultimate strength (percent) greater than -	Tensile ultimate strength (psi)	Yield strength (Offset, 0.2 percent) (psi)	Elongation in 2 in. (percent)	Compressive yield strength (Offset, 0.2 percent) (psi)	Ultimate shear strength (psi)	Shear strength / Tensile strength
[c]B195-T4	48,200	28,600	7.0	--	44,530	28,100	6.5	28,730	33,420	0.75
Specified minimum[d]	33,000	------	4.5	46	25,000	------	1.1	------	------	----
Typical	37,000	19,000	9.0	30	------	------	---	------	------	----
B195-T6	50,500	33,700	4.0	--	46,600	32,100	3.6	32,230	36,280	.78
Specified minimum	35,000	------	2.0	31	26,000	------	.5	------	------	----
Typical	40,000	26,000	5.0	26	------	------	---	------	------	----
356-T6	41,900	29,900	8.2	--	42,200	31,660	6.8	32,700	29,880	.71
Specified minimum	33,000	------	3.0	27	25,000	------	.8	------	------	----
Typical	40,000	27,000	5.0	5	------	------	---	------	------	----

[a]Individually cast permanent-mold specimens tested without machining off surface. Values are average of two tests.

[b]Specimens machined from central portion of 1/4- by $2\frac{1}{4}$ - by 12-in. permanent-mold cast bearing specimens that had been tested to failure. Tensile specimens, standard 1/2-in.-wide, sheet type, 1/4-in.-thick. (Values are average of three tests.) Compression specimens, standard sheet-type, 1/4 by 5/8 by 2.63 in. (Values are average of three tests.) Shear specimens, 3/16-in.-diam. by 2-in.-length. (Values are average of nine tests.)

[c]Tested 8 months after heat-treatment.

[d]Specified minimum values for 1/2-in.-diam. test bars taken from table 18 of reference 2. Minimum values of tensile strength and elongation for castings not to be less than 75 and 24 percent, respectively, of properties specified for 1/2-in.-diam. test bars. See specifications AN-A-23.

TABLE II

BEARING STRENGTHS OF SOME ALUMINUM-ALLOY PERMANENT-MOLD CASTINGS

[All tests made on 1/2-in.-diam. steel pin; specimen size, 1/4 in. thick by $2\frac{1}{4}$ in. wide by 12 in. long.]

Alloy and temper	Test	Bearing strengths (psi) for edge distances of -					
		1.5 × pin diameter			2 × pin diameter		
		Ultimate	Yield (1)	Type of failure (2)	Ultimate	Yield (1)	Type of failure (2)
B195-T4	1	62,000	48,400	TS	82,400	55,500	TS
	2	63,000	48,000	TS	84,000	56,500	TS
	3	62,300	47,500	TS	80,000	57,000	T
	Av.	62,400	48,000		82,100	56,300	
B195-T6	1	62,200	53,000	TS	83,500	60,000	TS
	2	66,400	54,000	TS	83,500	62,000	T
	3	67,400	54,000	TS	83,800	63,000	TS
	Av.	65,300	53,700		83,600	61,700	
356-T6	1	61,800	50,000	TS	78,800	57,000	TS
	2	63,800	49,500	TS	78,500	57,000	TS
	3	63,700	50,000	TS	80,000	57,000	TS
	Av.	63,100	49,800		79,100	57,000	

[1]Stress corresponding to offset of 2 percent of pin diameter from initial straight-line portion of curves of bearing stress against hole elongation.

[2]Types of bearing failure: T, tension on section through hole; S, shear above pin; TS, combination of tension and shear.

TABLE III

RATIOS OF AVERAGE BEARING TO TENSILE STRENGTHS

OF ALUMINUM-ALLOY PERMANENT-MOLD CASTINGS

[All tests made on 1/2-in.-diam. steel pin. Ratios based on tensile properties obtained from bearing test slabs.]

Alloy and temper	Ratios for edge distances of -			
	1.5 × pin diameter		2.0 × pin diameter	
	BS/TS (1)	BYS/TYS (2)	BS/TS (3)	BYS/TYS (4)
B195-T4	1.40	1.71	1.84	2.0
B195-T6	1.40	1.67	1.80	1.92
356-T6	1.50	1.57	1.88	1.80

[1]BS, bearing ultimate strength.

[2]BYS, bearing yield strength.

[3]TS, tensile ultimate strength.

[4]TYS, tensile yield strength.

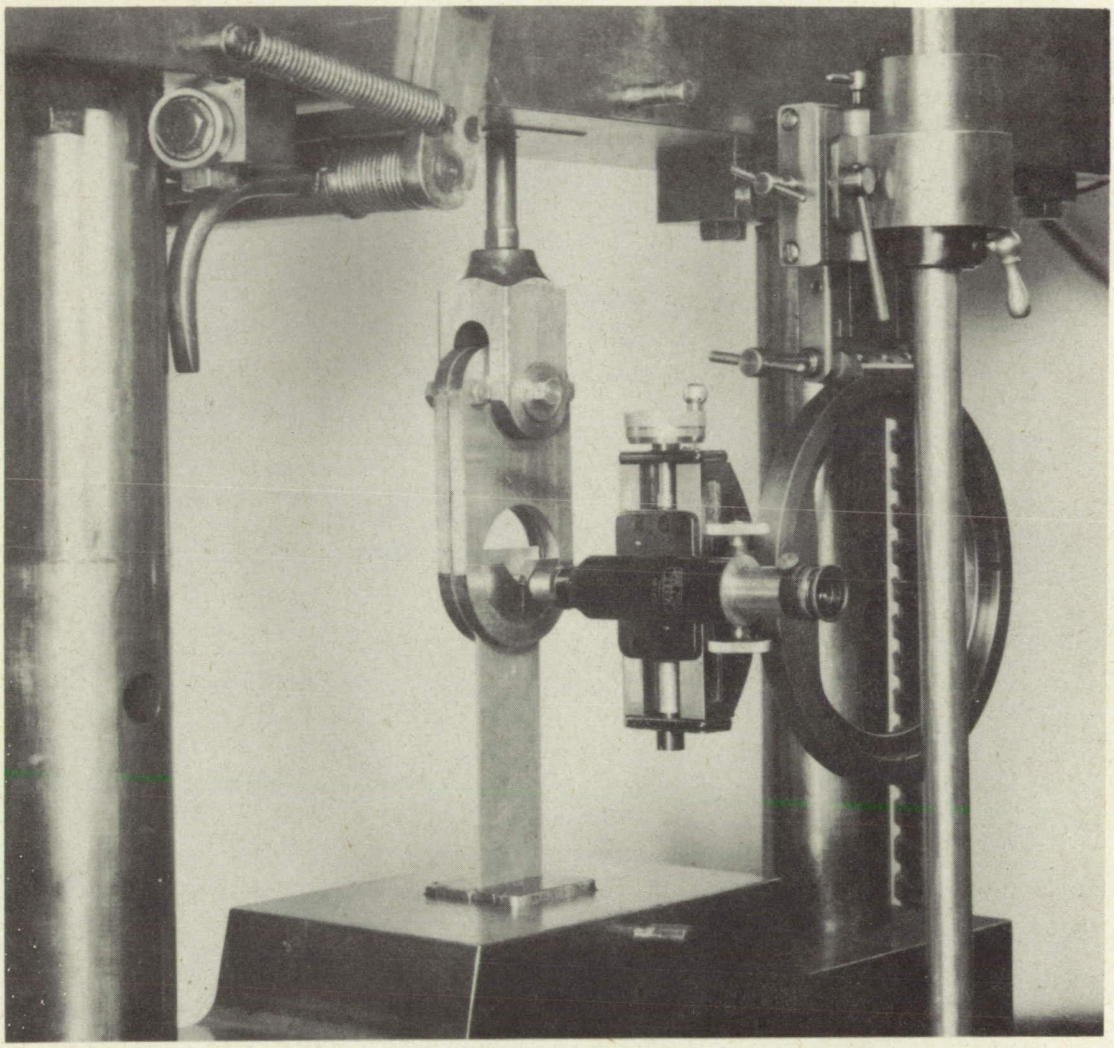

Figure 1.- Arrangement for bearing tests.

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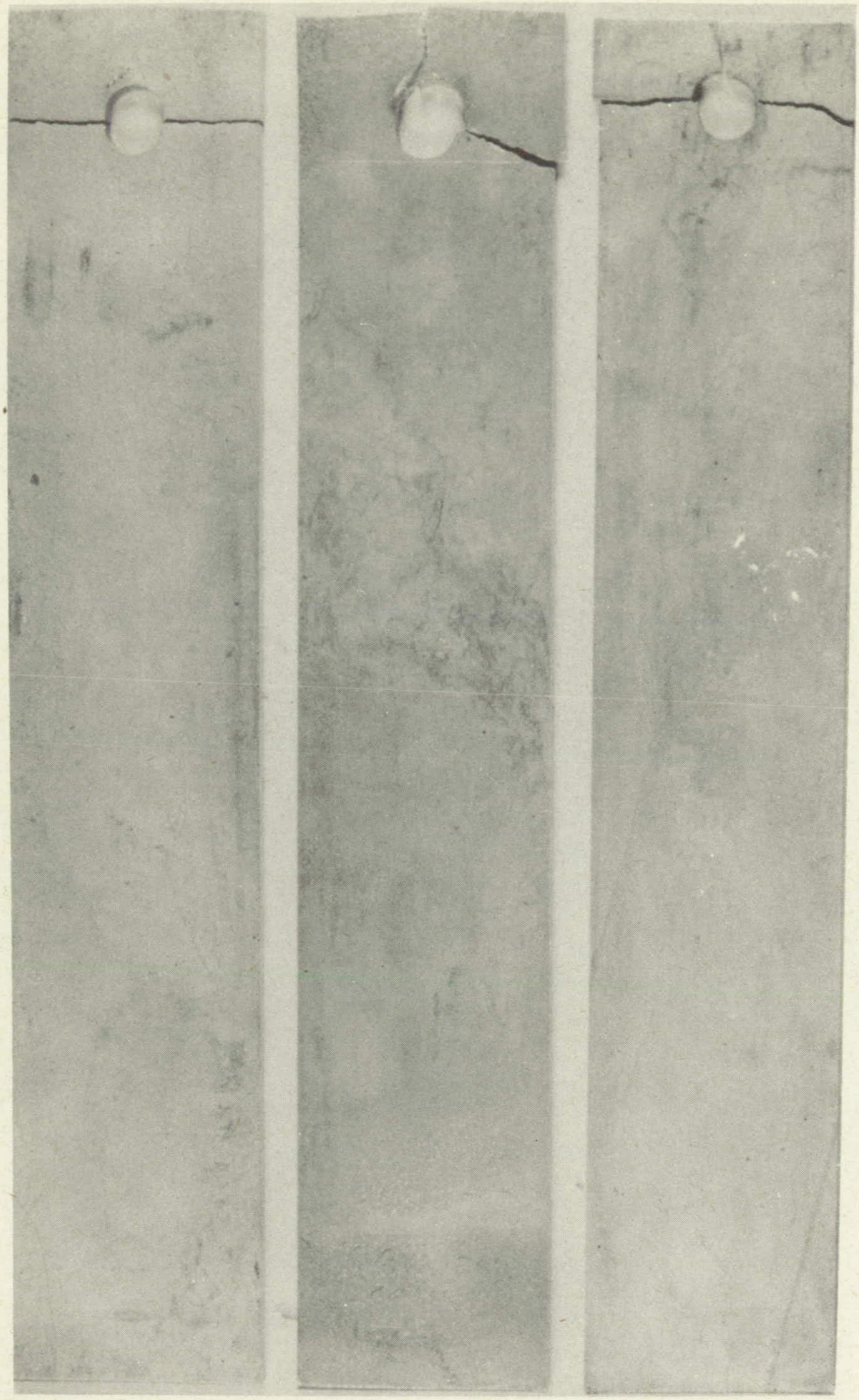

Figure 2.- Samples of bearing-test failures in aluminum-alloy permanent-mold castings.

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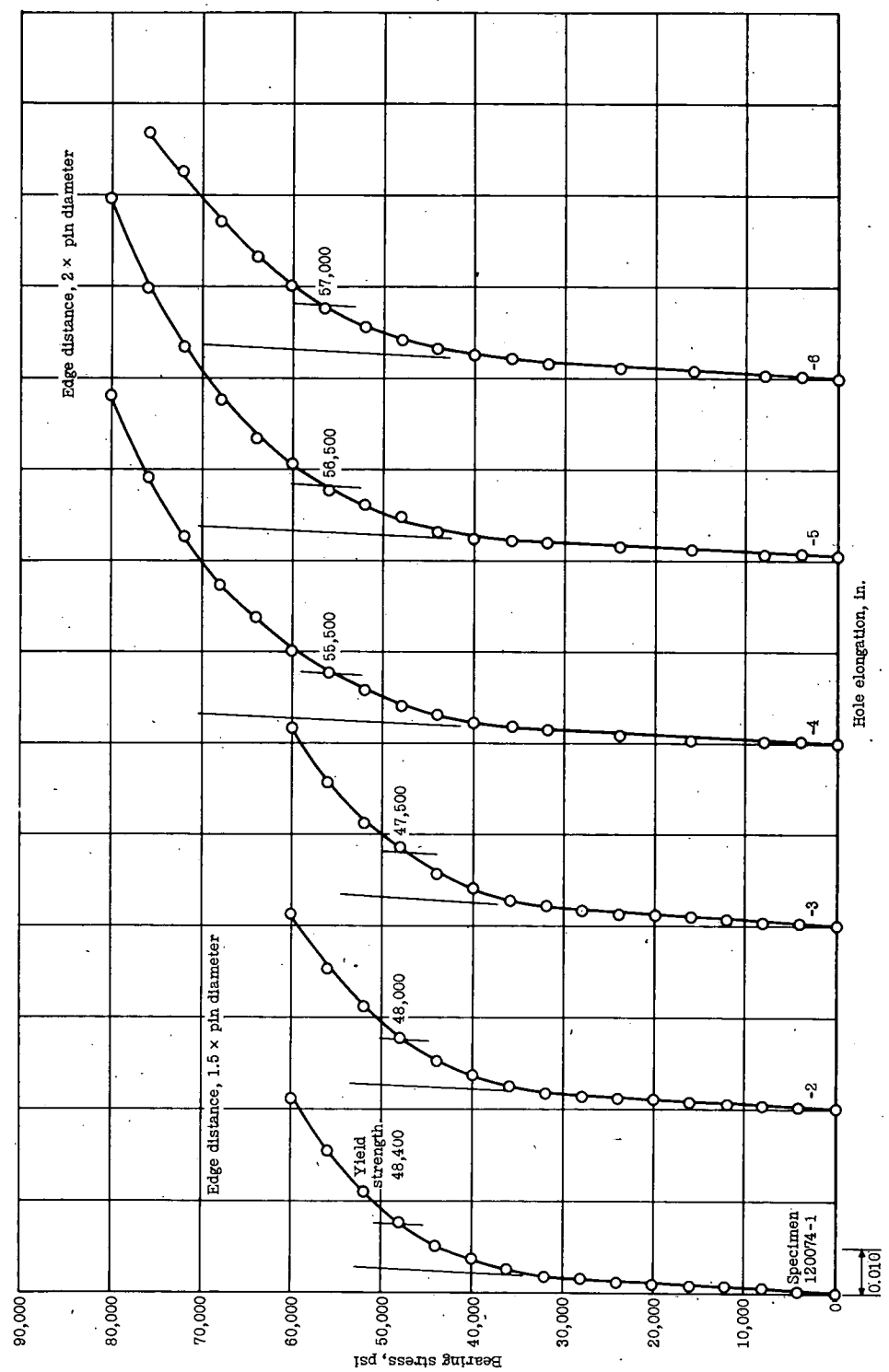
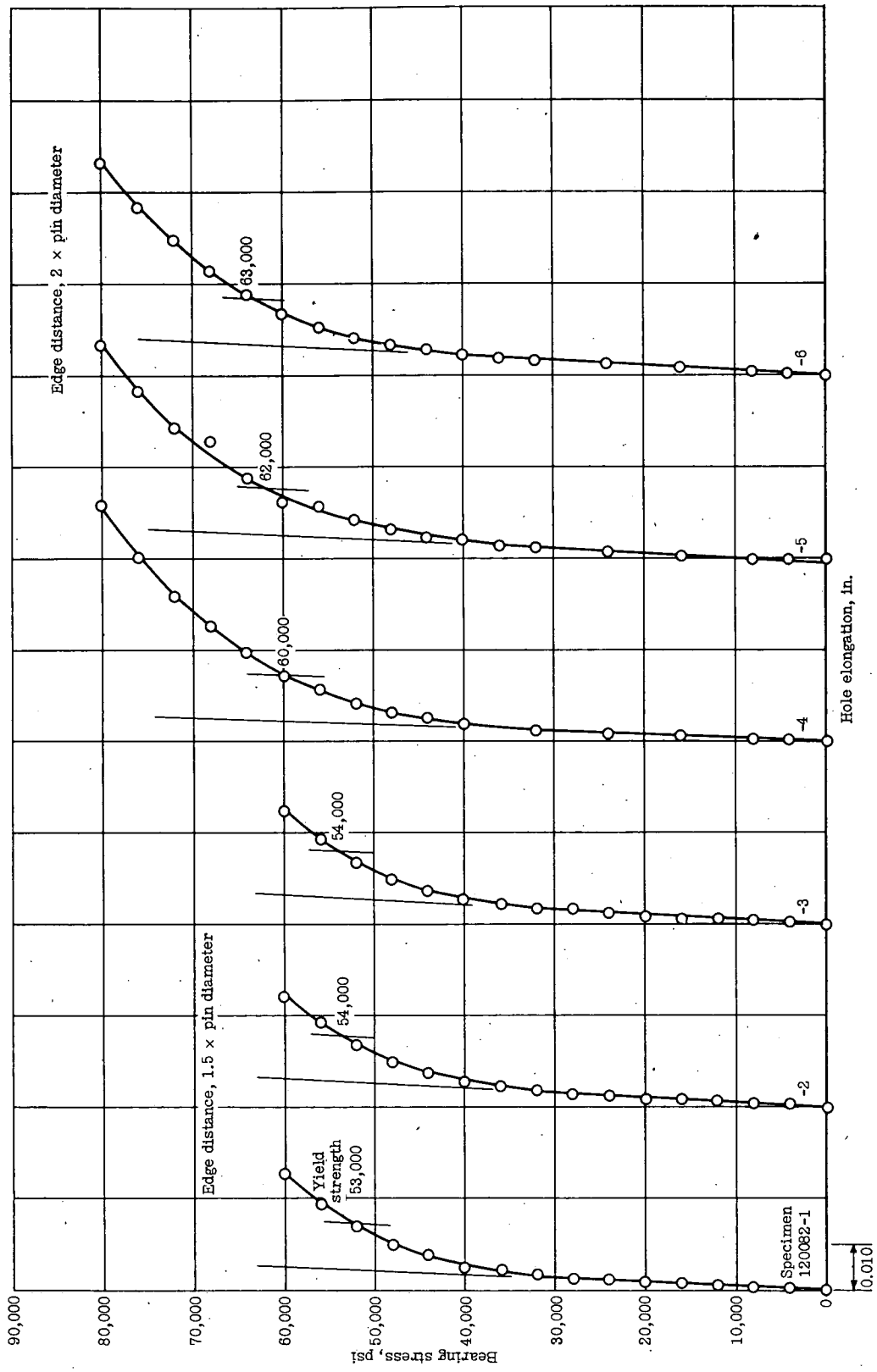


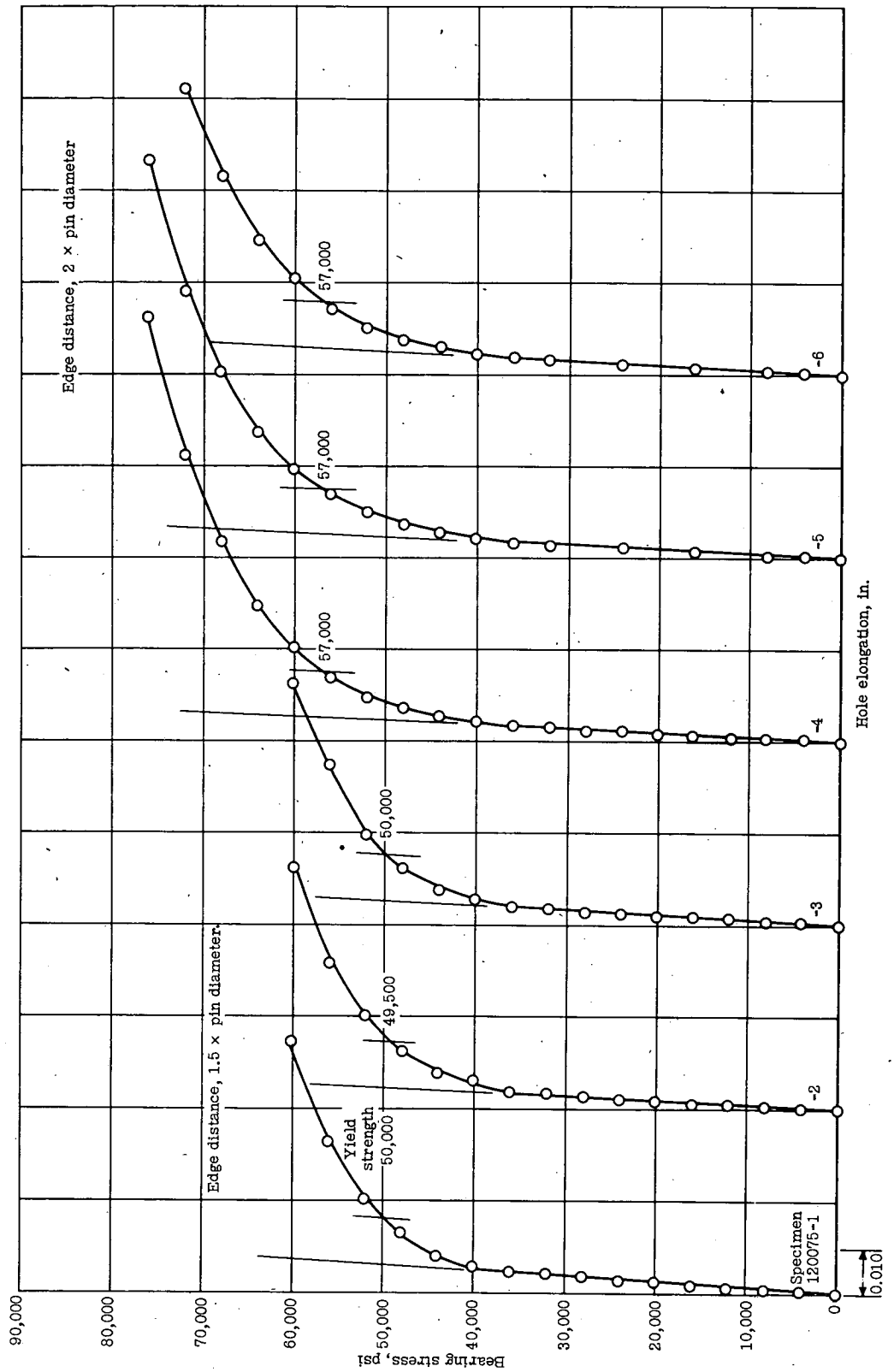
(a) B195-T4 permanent-mold aluminum casting alloy.

Figure 3.- Bearing stress against hole elongation. Specimen thickness, 1/4 inch; specimen width, $2\frac{1}{4}$ inches; pin diameter, 1/2 inch; bearing yield offset, 0.02 times pin diameter.



(b) B195-T6 permanent-mold aluminum casting alloy.

Figure 3.- Continued.



(c) 356-T6 permanent-mold aluminum casting alloy.

Figure 3.- Concluded.