1962

Calibration study of heavy head a325 bolts, Lehigh University, (1962) Reprint No. 232

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CALIBRATION STUDY OF HEAVY HEAD A325 BOLTS

by

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This work has been carried out as part of the Large Bolted Joints Project sponsored financially by the Pennsylvania Department of Highways, the Bureau of Public Roads and the American Institute of Steel Construction. Technical guidance is provided by the Research Council on Riveted and Bolted Structural Joints.

Fritz Engineering Laboratory
Department of Civil Engineering
Lehigh University
Bethlehem, Pennsylvania

February 1962

Fritz Engineering Laboratory Report No. 271.21

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Synopsis

This report is supplemental to Fritz Laboratory Report No. 271.11, "Calibration and Installation of High Strength Bolts". The work included is a continuation of studies on A325 high strength bolts. Results of 42 direct tension and torqued tension tests of 7/8" heavy head semifinished A325 bolts with short thread length are presented. Results of test of regular semifinished bolts with longer thread length are also presented in order to compare the two types of bolts.

INTRODUCTION

A detailed examination of the regular semifinished A325 bolt was reported in Fritz Lab Report 271.11[1]. With the advent of the new, heavy head, shorter thread A325 bolt, it became desirable to perform a pilot investigation to determine how the shorter thread length would impair the bolt performance. Heavy head bolts of two strengths, 100% and 125% of the specification minimum tensile strength were included in this investigation to determine whether or not bolt strength had a significant effect on the bolt behavior.

The following facets of behavior were investigated in this calibration study:

1. The difference in behavior of the heavy head bolt in direct tension and torque induced tension caused by tightening the nut (hereafter called torqued tension).
2. The effect of small variations in thread length under the nut. (Thread length between bottom of the nut and the thread run out.)
3. Comparison of the heavy head bolt with the regular semifinished bolt in direct tension and torqued tension.

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(1) Bendigo, R. A., and Rumpf, J. L. "Calibration and Installation of High Strength Bolts, Fritz Lab. Report 271.11, 1960

4. An evaluation of the one half turn-of-nut method when used with the heavy head bolt.
5. An evaluation of the turn-of-nut procedures for grip lengths in excess of 5 inches.

TESTING PROCEDURE

The direct tension tests were performed in a hydraulic testing machine at a speed of approximately 0.05 inches per minute. The torqued tension tests were conducted in a calibration device utilizing an impact wrench to rotate the nut from the "snug" position in 1/8th turn increments till one full turn-of-nut was realized and in 1/4 turn increments thereafter. A preload of 8 kips was defined as the "snug" position. Detailed descriptions of these tests are reported in Ref. 1.

The data was obtained from tests of five lots of 7/8" high strength bolts. Lots 8B, E and H were heavy head bolts with short thread length and lots B and C were regular semi-finished bolts. Lots 8B, B and E were 5-1/2 inches under head and lots C and H were 9-1/2 inches under head. Lots 8B, B, C, and H were purposely ordered at approximately 100% of the ASTM specifications minimum tensile strength requirement; whereas lot E was purposely ordered at 125% of the minimum tensile strength.

Lots 8B and E were tested with two initial lengths of thread between the bottom face of the nut and the thread run-out: 1/4 and 1/8 inches. An initial thread length under the nut of 1/8 in. is normal for a 4 in. grip which utilizes a 5-1/2 in. bolt with one washer under the turning surface. Lot H had 1/8 inches of thread under the nut and lots B and C had 3/4 inches. The number of bolts tested from each lot for specific lengths of thread under the nut varied from three to five for both the direct tension and torqued tension tests.

TEST RESULTS

Summarized in Table 1 are the results of the bolt tests for lots 8B, B, C, E and H. Mean values of ultimate load and rupture load are shown for both direct tension and torqued tension tests.

Figures 1 and 2 show the mean load-elongation properties in direct tension and torqued tension for heavy head A325 bolts at 100% and 125% of the specification minimum tensile strength requirements, respectively. As reported in F.L. Report 271.11, the method used to induce internal tension had no effect on the load elongation relationship in the elastic range. However, beyond the elastic limit a reduction in strength and elongation is apparent for the torqued tension tests.

Figure 3 shows the mean torqued tension curves for heavy head bolts at approximately 100% and 125% of the minimum tensile strength requirement. The effect of varying the length of thread under the nut and elongations which correspond to nut rotations of 1/2, 1 and 1 $\frac{1}{2}$ turns are also shown. Whether the initial length of thread under the nut was 1/8 or 1/4 inches made little difference in the load-elongation characteristics of the heavy head A325 bolt. Lot 8B showed a slight increase in strength and a slight decrease in elongation with 1/8 inches of thread under the nut. Little if any difference was noted for Lot E which was on the high side of the specification tensile strength requirement. All bolts were able to sustain a nut rotation of $1\frac{1}{2}$ turns. The difference in strength for bolts at 100 and 125% of the minimum tensile strength requirement had no apparent effect on the elongation characteristics of the bolts.

In Fig. 4 the direct tension characteristics of the heavy head bolt (Lot 8B) is compared with the regular semi-finished bolt (Lot B). The effect of the decrease in thread length under the head is readily apparent. Both lots of bolts were near the specification minimum tensile strength. The ultimate tensile load is given in Table 1,

In Figs. 5 and 6 the torqued tension characteristics of the heavy head bolt is compared with the regular semifinished bolt for two grip lengths. Again the decreased thread length under the nut of the heavy head bolt resulted in a decrease in the elongation capacity of the bolt. A comparison of Figs. 5 and 6 indicate that grip had little if any effect on the torqued tension characteristics.

Most of the heavy head bolts that were purposely furnished near the minimum strength specified by ASTM A325 failed by thread stripping (Lots 8B, H). On the other hand bolts with regular head and longer thread length (Lots B and C) furnished near the minimum tensile strength and heavy head bolts at 125% of the minimum strength (E lot) ruptured by shearing on the transverse plane of the thread.

A number of factors no doubt accounted for the failure mode of the heavy head bolt. Among these were probably the minimum strength material, the nut hitting the thread run out and the necking which was taking place in the threaded portion. These factors would undoubtedly make thread stripping inevitable.

CONCLUSIONS

These conclusions are based on the results of 42 direct tension and torqued tension tests of 7/8" heavy head A325 bolts with short thread length.

1. The maximum tension and elongation obtained from a direct tension test is greater than the results of a torqued tension test where the nut is turned against the resistance of the gripped material. The average increase in the ultimate tensile strength ranged from 14 to 19 percent. The maximum elongation was increased approximately 100%. These effects are shown in Figs. 1 and 2.

2. The lesser amount of exposed thread under the nut is chiefly responsible for increased elongation as seen by comparisons of the heavy head bolt and the regular head bolt in Figs. 4, 5 and 6. However, the heavy head bolt was able to sustain at least one and one-half turns of the nut from snug.

3. The effect of a small increase in thread length under the nut

had little effect on the load-elongation characteristics of the heavy head bolt. This held true for bolts ordered near the minimum tensile strength requirements of ASTM A325 and 125% above the minimum.

4. The one-half turn-of-nut method for installing the heavy head high strength bolts produced adequate and consistent bolt tensions in the elastic plastic range. Bolts tightened to one half turn-of-nut from "snug" developed approximately 85% of the available strength for bolts near the minimun tensile strength requirement as well as those 125% of the minimum tensile strength (Fig. 3). An initial preload of 8 kips was used as the snugging load.

5. The rotational factor of safety against twisting off as measured by the ability of the heavy head bolt to sustain additional nut rotation despite its shorter thread length was at least three half turns. In other words bolts installed by the one-half turn-of-nut method have sufficient deformation capacity to sustain two additional half turn rotations before failure as seen in Fig. 3 and 5.

6. Grip length had no appreciable effect on the tension-elongation characteristics of the heavy head bolt as long as

the free thread under the nut was approximately the same. The tests also indicated that nut rotations greater than one-half turn from "snug" are not necessary for long grip bolts as little is gained in additional clamping force, whereas an appreciable decrease in the rotational factor of safety is realized. (Fig. 6)

ACKNOWLEDGEMENTS

The work described in this report is part of a larger investigation of large bolted joints being conducted at the Fritz Engineering Laboratory of Lehigh University under the direction of Dr. L. S. Beedle. The project is sponsored financially by the Pennsylvania Department of Highways, the Bureau of Public Roads and the American Institute of Steel Construction. Technical guidance is provided by a committee of the Research Council on Riveted and Bolted Structural Joints.

The authors wish to express their appreciation to the advisory committee for their guidance and advice; to the Bethlehem Steel Company for furnishing the bolts; to Dr. J.L. Rumpf for advice when preparing the test program and manuscript, and to P.O. Ramseier for assisting with the test program.

Table 1

RESULTS OF BOLT CALIBRATION

	Units	H	C	8B	8B	E	E	B
Size (nominal length)	in.	7/8	7/8	7/8	7/8	7/8	7/8	7/8
Total Grip Length (4" or 8" + washers)	in.	8-1/8	8-1/4	4-1/4	4-1/8	4-1/4	4-1/8	4-1/4
Thread Length	in.	1-1/2	2	1-1/2	1-1/2	1-1/2	1-1/2	2"
Length Under Head	in.	9.50	9.5	5.50	5.50	5.50	5.50	5.50
Stress Area	sq.in.	0.462	0.462	0.462	0.462	0.462	0.462	0.462
Spec. Min.Proof Load	kips	36.1	36.1	36.1	36.1	36.1	36.1	36.1
Spec. Min.Ultimate Load	kips	53.2	53.2	53.2	53.2	53.2	53.2	53.2
Mill Report Ultimate Load	kips	53.8	54.7	54.1	54.1	66.7	66.7	54.2
DIRECT TENSION CALIBRATION								
Number Tested		5	3	5	5	4	5	5
Ultimate Load	kips	58.2	53.5	54.1	55.5	65.2	67.5	54.3
% of Spec. Min.Ult. Load	%	108	101	102	104	122.5	127	102.16
Rupture Load	kips	48.5	45.0	48.0	49.0	60.6	62.1	45.8
Elongation at EPL	in.	0.018	.020	0.011	0.010	0.011	0.010	0.011
Elongation at Ult.Load	in.	0.118	.223	0.099	0.077	0.011	0.112	0.15
Elangation at Rupture Load	in.	0.280	.380	0.188	0.188	0.188	0.188	0.31
TORQUED CALIBRATION								
Number Tested		3	3	4	5	3	3	3
Ultimate Load	kips	49.6	45.8	46.7	49.3	55.3	55.8	45.2
% of Spec. Min.Ult.Load	%	93.3	86.1	87.9	92.7	104	105	85.0
Elongation at EPL	in.	0.019	.021	0.011	0.011	0.011	0.011	0.011
Elongation at Ult.Load	in.	0.056	.095	0.055	0.052	0.055	0.059	0.105
Elongation at Rupture Load	in.	0.110	.211	0.107	0.086	0.096	0.090	0.16
% Reduction in Strength from Direct Tension Ultimate	%	14.8	14.4	13.7	11.2	15.2	17.3	16.7

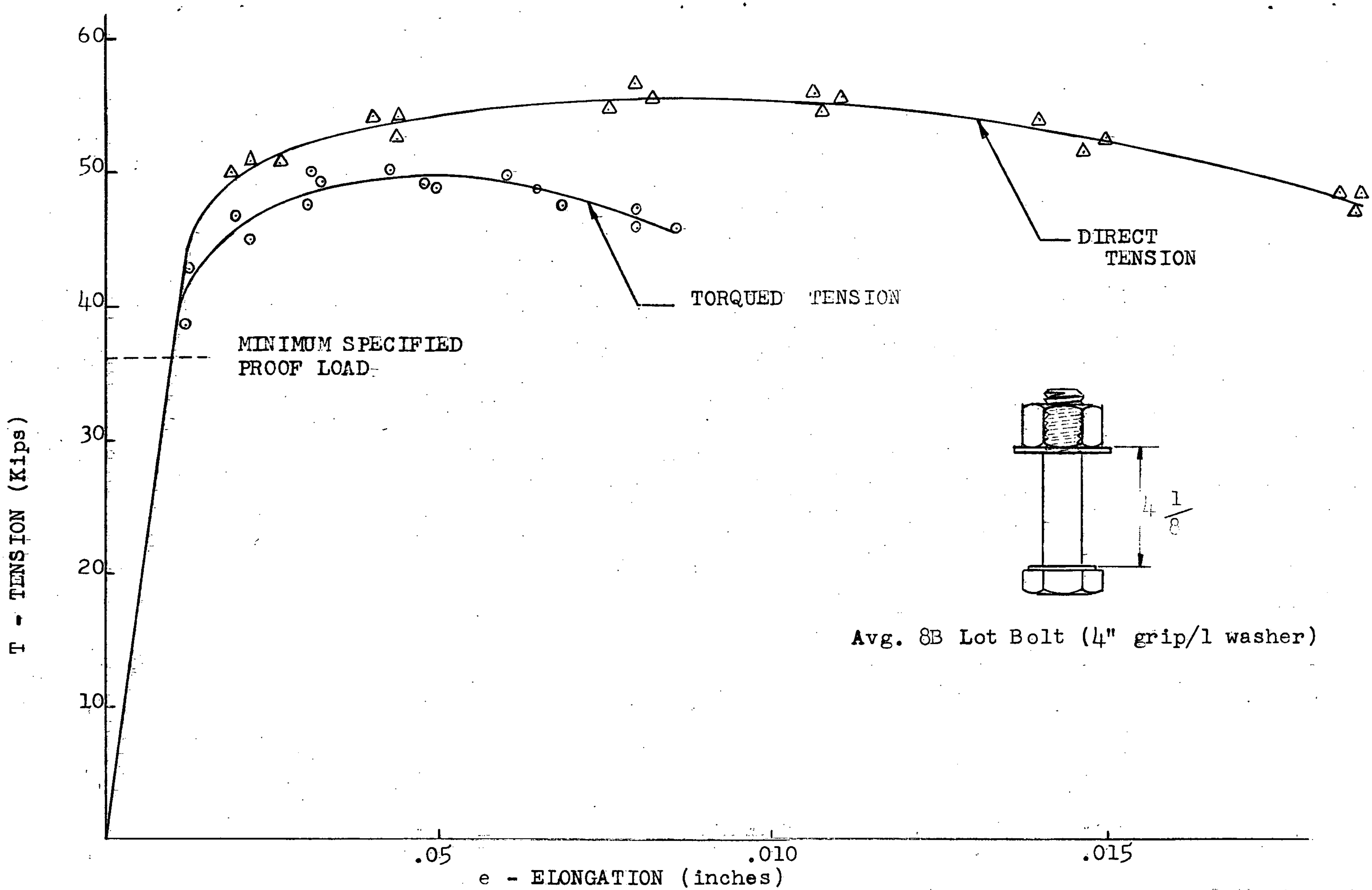

Fig. 1 Effect of Calibration Procedure on the Tension Elongation Relationship

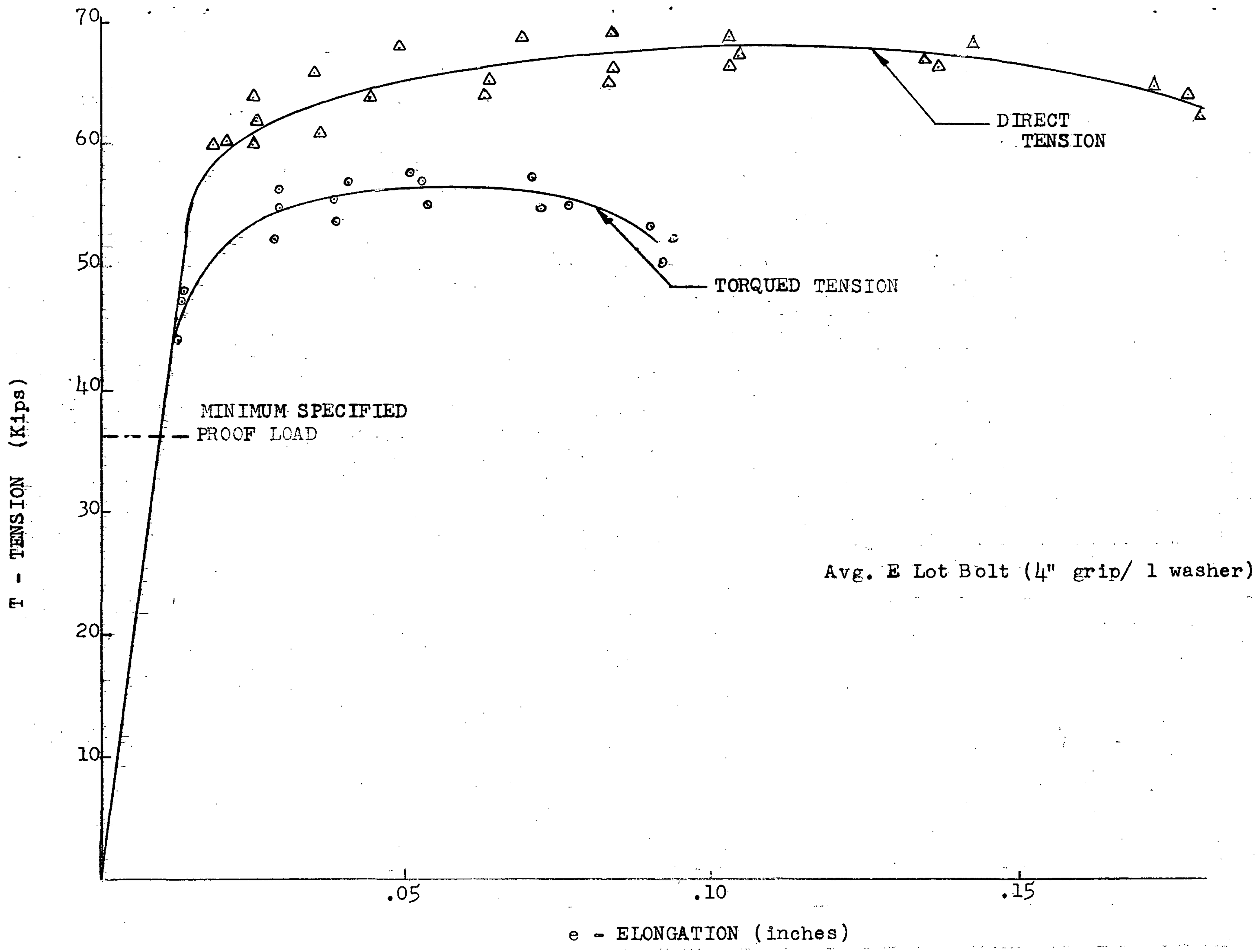

Fig. 2 Effect of Calibration Porcedure on the Tension Elongation Relationship

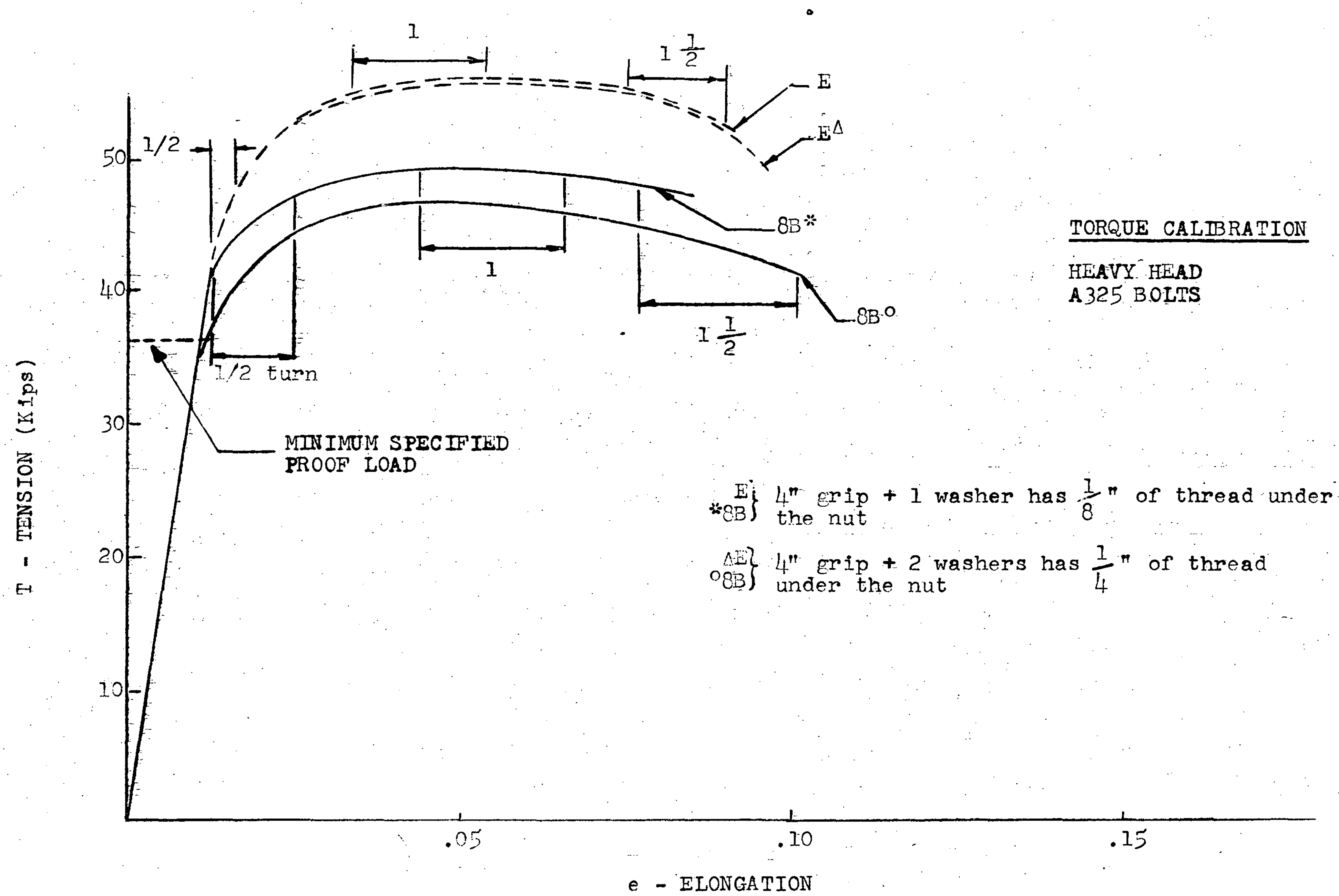

Fig. 3 Effects of Thread Length on the Tension Elongation Relationship

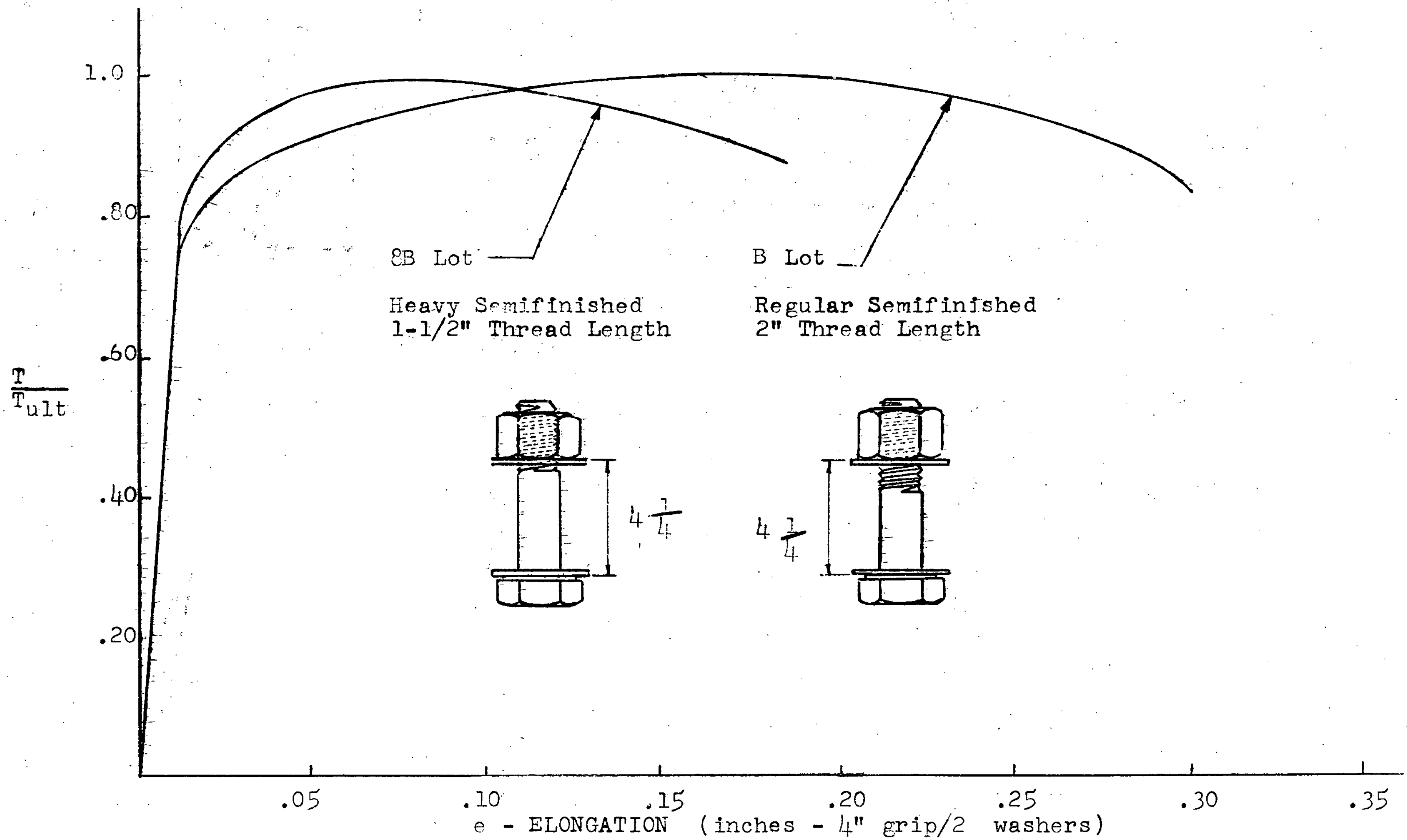

Fig. 4 Comparison of Old Bolt (B) and New Bolt (8B)-Direct Tension Calibration

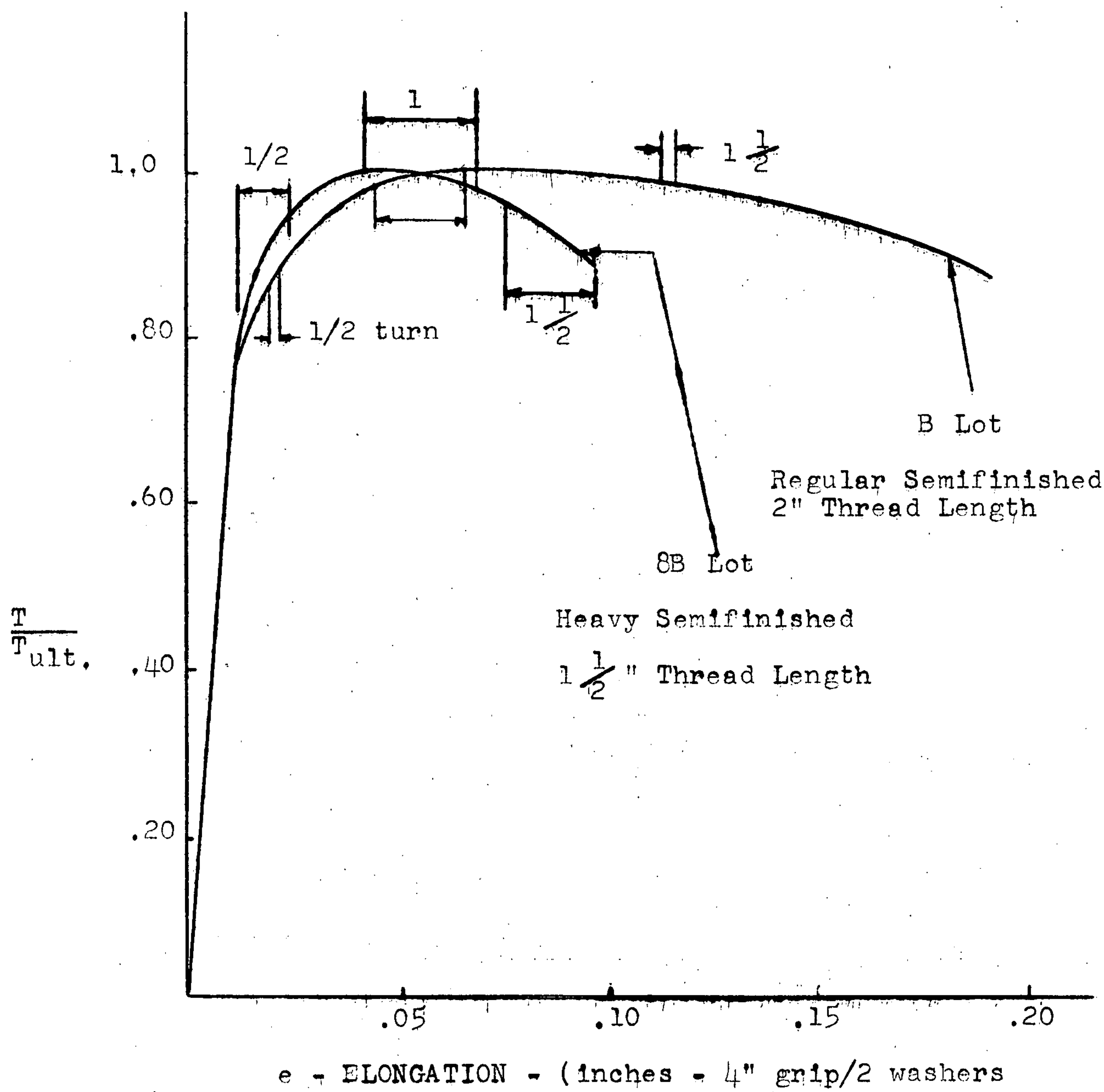

Fig. 5 Comparison of Old Bolt (B) and New Bolt (8B)
Torqued Calibration

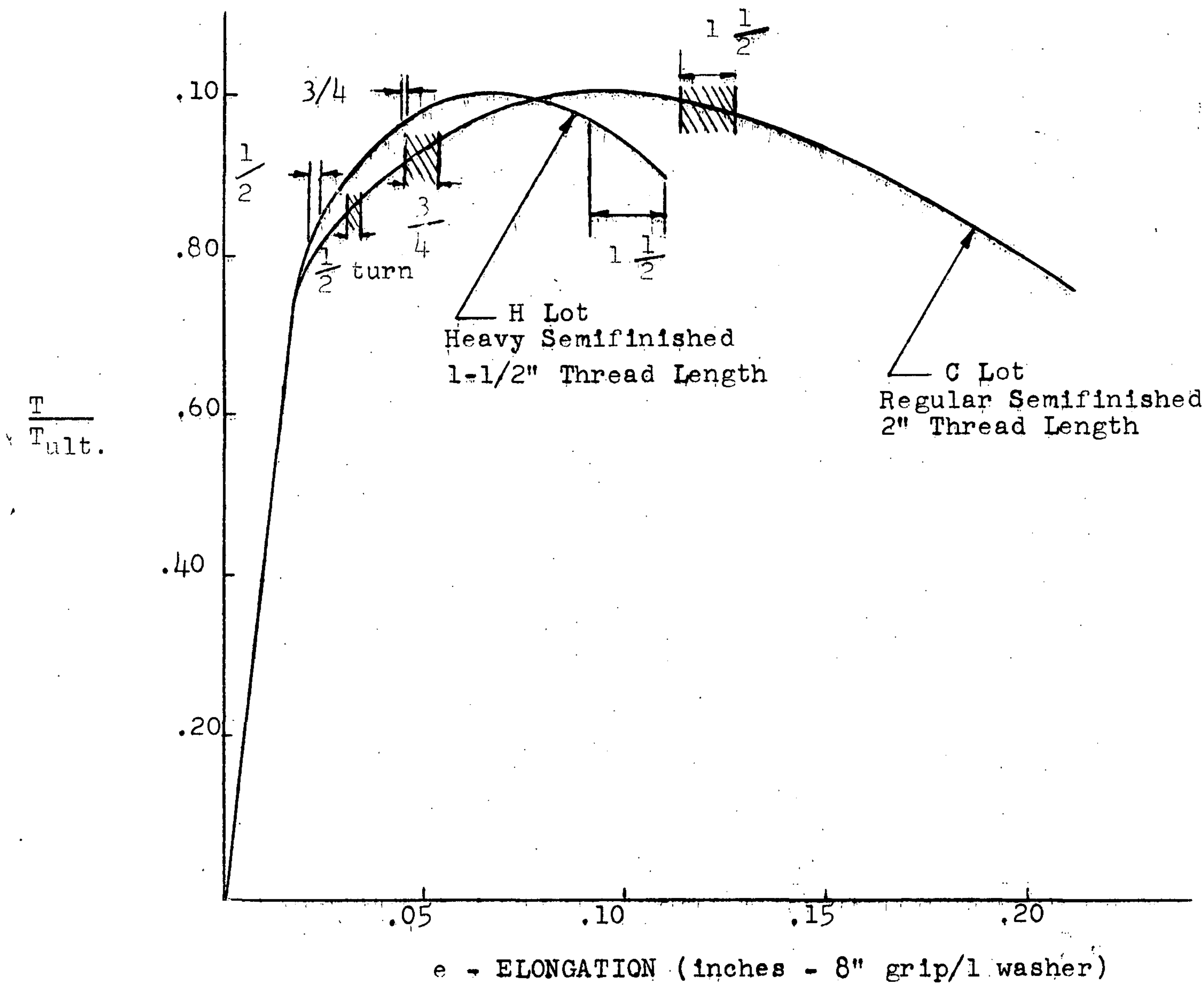

Fig. 6 Comparison of Old Bolt (C) and New Bolt (H) Torqued Calibration

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