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Large bolted joints, Summary Report for RCRBSJ March 1962

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LARGE BOLTED JOINTS

SUMMARY REPORT
FOR
R C R B S J

by

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March 1962

FRITZ ENGINEERING LABORATORY REPORT NO. 288.2

DEPARTMENT OF CIVIL ENGINEERING
FRITZ ENGINEERING LABORATORY
LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

LARGE BOLTED CONNECTION PROJECT 288, LEHIGH UNIVERSITY
SUMMARY OF WORK COMPLETED OR IN PROGRESS

288 February 1962

Phase & Topic	Authorization	Tests Performed	Tests to be Done	Additional Material on Hand	Reports
I Joints of A440 Steel	Committee 10 Minutes 4/19/60	4 Joints E41a E41b E41c E41e	None	None	
II Joints of A 440 Steel Long Butt Joints, Variable Width, Omission of Washers	Committee 10 Minutes 4/19/60 1/19/61	7 Joints E41f E41g E41 E71 E101 E131 E161	2 Joints E46 E74	Plate for 15 to 20 Joints at BSCo. 220-7/8x9-1/2 bolts, H lot; 172-7/8x5-1/2 bolts, 8B lot; 70-7/8x5-1/4 bolts, 8A Lot	

Other phases, not yet formulated
(a) Joints of Constructional Alloy Steels
(b) High Strength Rivets
(c) Composite (two types of steel) Connections
(d) Effect of Punched Holes
(e) Tightness and Coefficient of Friction as Influenced by Broomed Joints

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SUMMARY OF WORK COMPLETED

February 1962

Phase and Topic	Authorization	Tests Performed	Tests to be Done	Additional Material on Hand	Reports*
I Compact Butt Joints A,B,G Series BR Series	Orig.proposal subgroup min. 3/7/57 and 4/11/58	8 Bolted Joints B1-B6, A3, G1 1 Riveted Joint BR2	None	60-7/8 Rivets	271.1 271.2 271.6 271.6 (Rev.) 271.12 ASCE 2523
II Long Butt Joints D Series, Variable Width	Orig.proposal subgroup min. 9/25/58	8 Joints D101 - D31	None	None	271.8 271.13 271.14
II Long Butt Joints D Series, Part b Variable Grip	Orig.proposal subgroup min. 9/25/58	4 Joints D1001 - D701	None	None	271.8
II Long Butt Joint D Series, Part c Variable Width	Committee 9 Minutes	4 Joints D10 D13A D13 D16	None	None	271.15 271.17
III Long Riveted Butt Joints DR Series Variable Width	Committee 9 4/19/60	3 Joints DR 71 DR 101 DR 131	None	Rivets: 25-7/8 at BS Co. 7-7/8 at LU	271.17 271.20

* See Report Summary for Title of Report

Large Bolted Joints Project 271, Lehigh University
Summary of Work Completed

February 1962

Phase and Topic	Authorization	Tests Performed	Tests to be Done	Additional Material on Hand	Reports*
III Shear Strength of Single Bolts	Subgroup min. 4/11/58 1/12/59	Double Shear Tests Comp. Load, 4" Grip 90-7/8, 1, 1 1/8 bolts 9-7/8 rivets Tens. load, 4" grip 6-7/8 bolts Comp. load, Var. grips 36-7/8 bolts Single Shear Tests, Tens. Load, 4" grip 2-7/8 bolts	None, except as required for evaluation of bolts in future joint tests	Shear Jigs: 1-1" 4" grip 1-7/8, 4 3/4 grip 1-7/8, 5 1/4 1-7/8, 6 1-7/8, 6 3/4 1-7/8 (Riveted) 4° grip	271.3 271.4 271.10
IV Bolt Calibration	Subgroup min. 9/25/58 1/30/62	Direct Tension 59-7/8, 1, 1 1/8 bolts Various lots Torqued 66-7/8, 1 1 1/8 bolts Various lots	Combined Direct Tension — Torqued Tension Tests		271.5 271.7 271.11 271.11 (Rev.) 271.21
V Lap Joints L Series	Subgroup min. 7/28-29/59	4 Joints L10,7,5,2	None	None	271.9

REPORTS ON PROJECT 271: LARGE BOLTED JOINTS

271.1 Foreman, R. T. and Rumpf, J. L.
STATIC TENSION TESTS OF BOLTED JOINTS, Lehigh University, (1958)

271.2 Rumpf, J. L.
FURTHER STATIC TENSION TESTS OF BOLTED JOINTS, Lehigh University, (1958)

271.3 Rumpf, J. L.
SHEAR RESISTANCE OF HIGH STRENGTH BOLTS, Lehigh University, (1958)

271.4 Kaplan, S.
DOUBLE SHEAR TESTS OF HIGH STRENGTH BOLTS, C. E. 404, Lehigh University, (1959)

271.5 Bendigo, R. A.
BOLT CALIBRATION STUDY, C. E. 406, Lehigh University, (1959)

** 271.6 Foreman, R. T. and Rumpf, J. L.
STATIC TENSION TESTS OF COMPACT BOLTED JOINTS, Proc. ASCE, 86, (ST6), p. 73, (1960), Reprint No. 162

271.7 Bendigo, R. A. and Rumpf, J. L.
CALIBRATION AND INSTALLATION OF HIGH STRENGTH BOLTS, Lehigh University, (1959)

271.8 Bendigo, R. A. and Rumpf, J. L.
STATIC TENSION TESTS OF LONG BOLTED JOINTS, Lehigh University, (1960)

271.9 Bendigo, R. A. and Rumpf, J. L.
STATIC TENSION TESTS OF BOLTED LAP JOINTS, Lehigh University, (1960)

271.10 Hansen, R. M. and Rumpf, J. L.
DOUBLE SHEAR STRENGTH OF A325 BOLTS, Lehigh University, (1960)

271.11 Bendigo, R. A. and Rumpf, J. L.
CALIBRATION AND INSTALLATION OF HIGH STRENGTH BOLTS, Lehigh University, (1960)

271.13 Marcin, S. T.
LOAD DISTRIBTUION IN BOLTED JOINTS, C. E. 103, Lehigh University, (1960)

271.14 Rumpf, J. L
THE ULTIMATE STRENGTH OF BOLTED CONNECTIONS, Ph. D. Dissertation, Lehigh University, (1960)

271.15 Hansen, R. M. and Rumpf, J. L.
FURTHER STATIC TENSION TESTS OF LONG BOLTED JOINTS, Lehigh University, (1961)

271.16 Rumpf, J. L.
THE ULTIMATE STRENGTH OF BOLTED CONNECTIONS, Condensation of the Ph. D. Dissertation, Lehigh University, (in preparation)

271.17 Hansen, R. M.
THE EFFECT OF FASTENER PITCH IN LONG STRUCTURAL JOINTS, C. E. 407, Lehigh University, (1961)

271.18 Bendigo, R. A.; Hansen, R. M. and Rumpf, J. L.
LONG STRUCTURAL JOINTS OF A-7 STEEL, Lehigh University, (in preparation)

271.20 Dlugosz, S. E. and Rumpf, J. L.
STATIC TENSION TESTS OF LONG RIVETED JOINTS, Lehigh University, (in preparation)

271.21 Dlugosz, S. E. and Fisher, J. W.
CALIBRATION STUDY OF HEAVY HEAD A325 BOLTS, Lehigh University, (1962)

RELATIONSHIP BETWEEN TORQUE AND INTERNAL BOLT TENSION

In structural joints connected with high strength bolts it is generally assumed that working loads are resisted by frictional forces acting on the faying surfaces of the composed material. These forces are created by the internal bolt tension induced as the nut is tightened against the gripped material. Therefore, it is very important to have at least a minimum preload in each bolt of the joint. On the other hand, after the tightening procedure, there exists only one way of determining the amount of preload, if the inspector doesn't know how much the nut was rotated.

The suggested way to inspect bolts for tightness using a torque wrench is given in the commentary of the RCRBSJ Specifications.

> "Three bolts of the same type, size and condition of thread as those to be inspected are tightened individually, in a device capable of measuring bolt tension, to the required minimum bolt tension given by the specifications. In this tightened condition the inspector's torque wrench is used to rotate the nut slowly a small amount in the tightening direction and the torque required to turn the nut, after it has been set in motion, is recorded."

The object of this study was to determine the preload by measuring torque with a calibrated hand torque wrench for bolts installed by the turn-of-nut method in the E-Series joints. This investigation covers only one size bolt (7/8") with <u>one washer under the turning surface</u>, and two grip-lengths. The work also consisted of calibrating the hand torque wrench with each lot of bolts using the Skidmore-Wilhelm calibrator to find the bolt tension vs. torque relationship.

The bolt was preloaded to 8 kips in the S-W to simulate the "snug" position of the turn-of-nut method. Using the torque-wrench the nut was rotated in about 50 ft. lbs. torque increments until the specified 1/2 or 3/4 turn from snug position was reached. After this rotation only a negligible increase in torque was observed with an additional 1/4 turn.

Using the calibrated torque wrench each bolt of the joints was torqued using a modified procedure. This inspection was executed about four weeks after the joints were bolted up using the turn-of-nut method. Torque was applied gradually until the friction was overcome and the nut turned a small amount. The maximum torque was taken as the test reading. Immediately afterwards the nut was torqued a second time until it rotated an additional small amount. The maximum torque necessary to move the nut was taken as the second reading. The second trial gave in almost all cases a lower torque reading.

SUMMARY OF TORQUE STUDY

Torque measurements (second reading) indicated less preload than what actually was present as determined from tension elongation relationships. Fig. A

All bolts tightened by the turn-of-nut method had tensions, as indicated by torque, in excess of the specification requirements. Fig. B, Fig. C

The first torque reading gave in almost all cases a higher value than was measured in a second reading taken after a short time interval. Fig. D

No readily available torque-wrench can determine the kinetic torque which should be recorded in order to follow the specification requirements. However, the modified procedure used in this test series was nevertheless considered successful and indicated bolt tensions that were less than what actually was present. Fig. A

Turning the nut a small amount for inspection purposes does not change the bolt elongation a significant amount. The factor of safety against twisting off will remain approximately the same N = 3.0. Fig. B, Fig. E

When torque is used to determine the preload in the bolts of a joint, the variation or scatter is greater than what actually exists as determined by elongation measurements. Fig. A

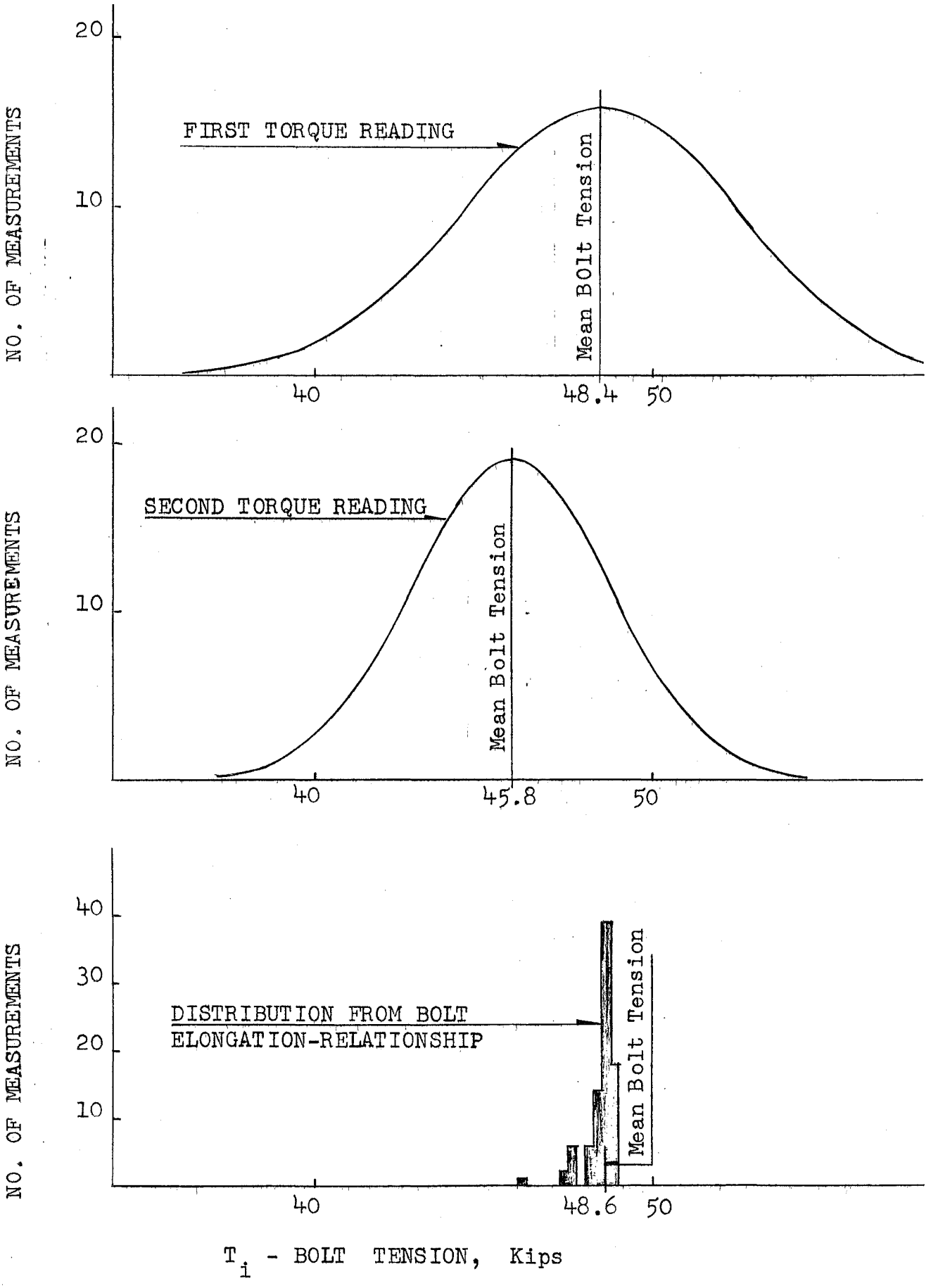


FIG. A - DISTRIBUTION OF BOLT FORCES - SERIES - 8B (7/8"Bolts-4"Grip)

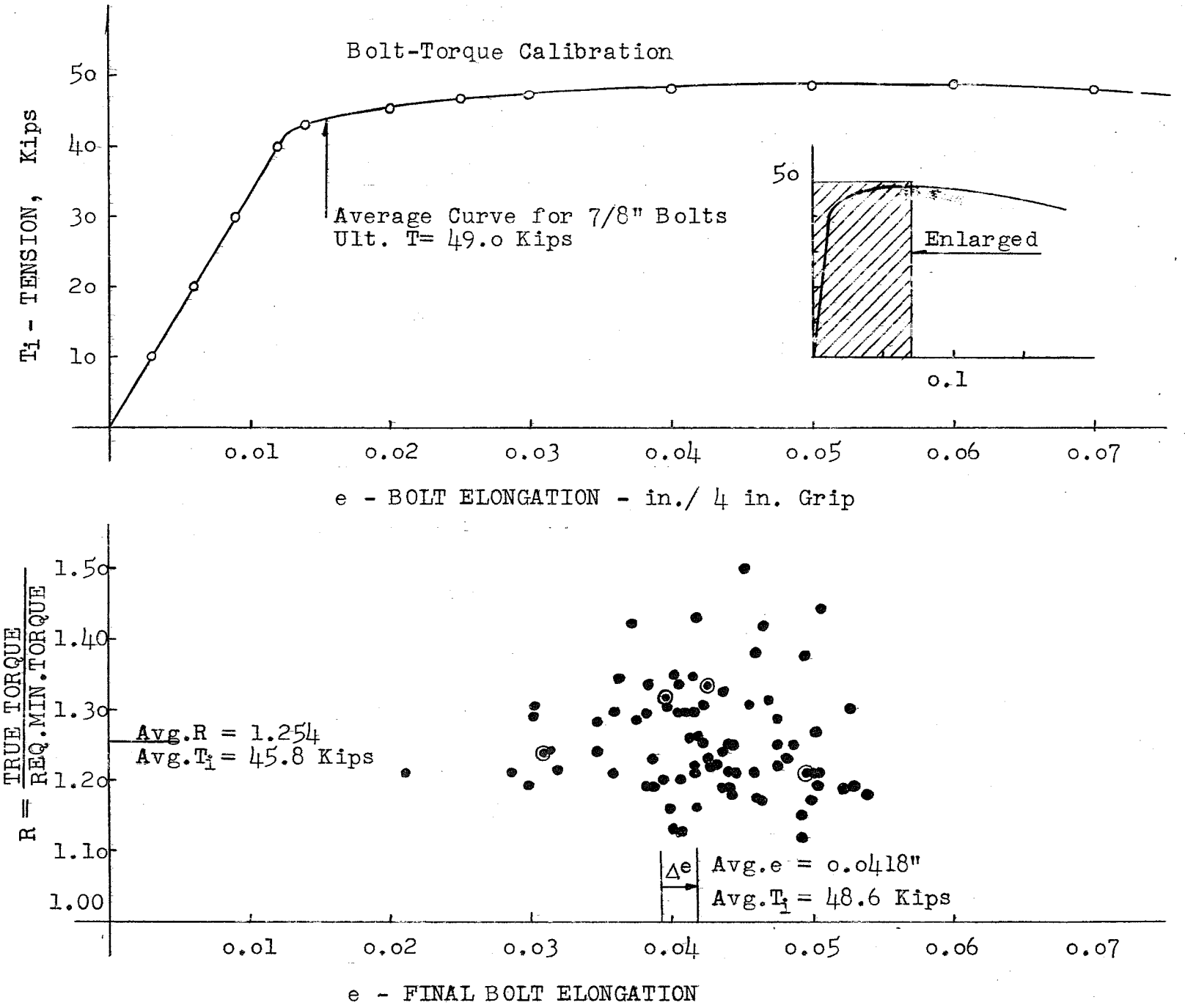


FIG. B - BOLT TORQUE - ELONGATION DISTRIBUTION

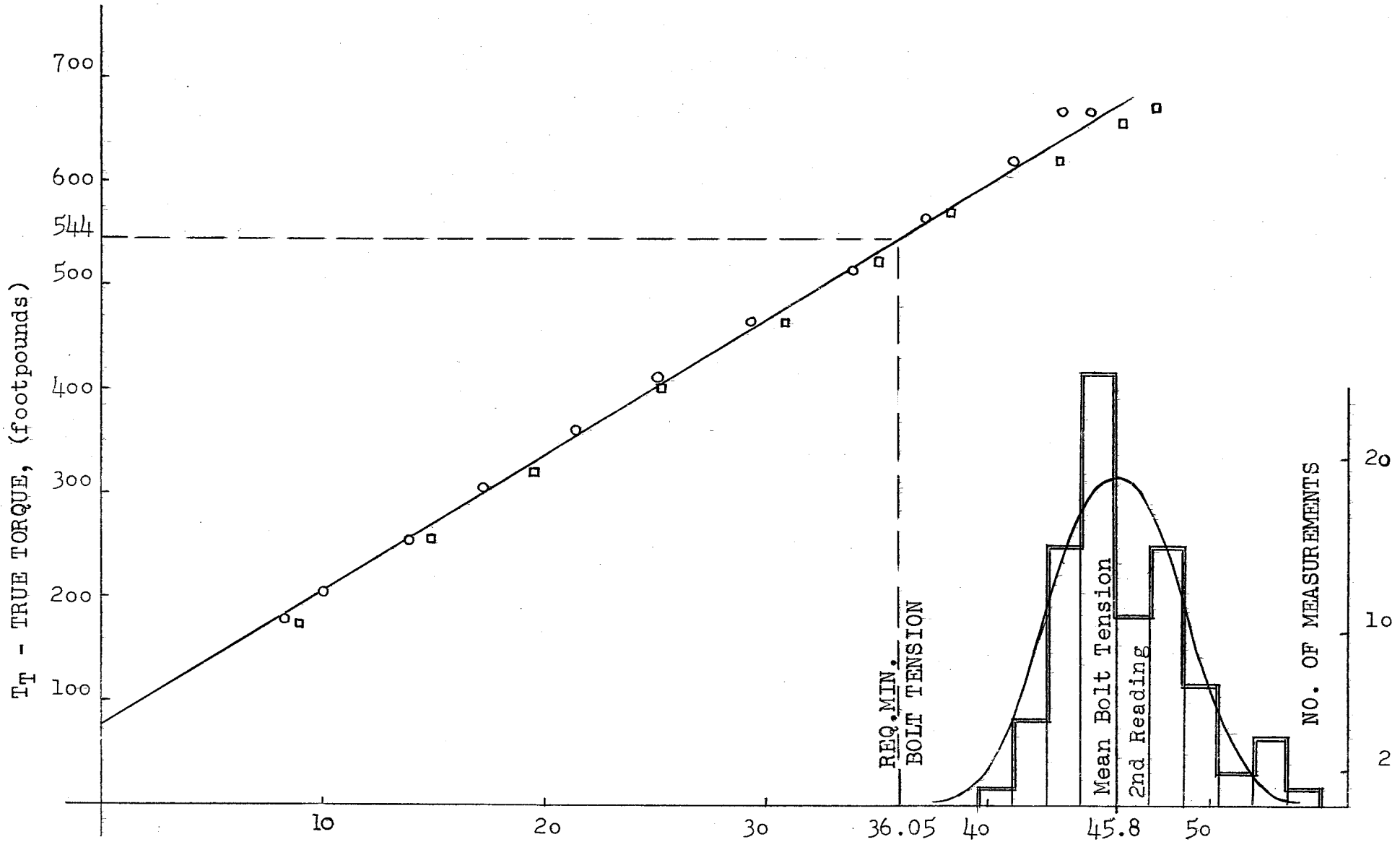
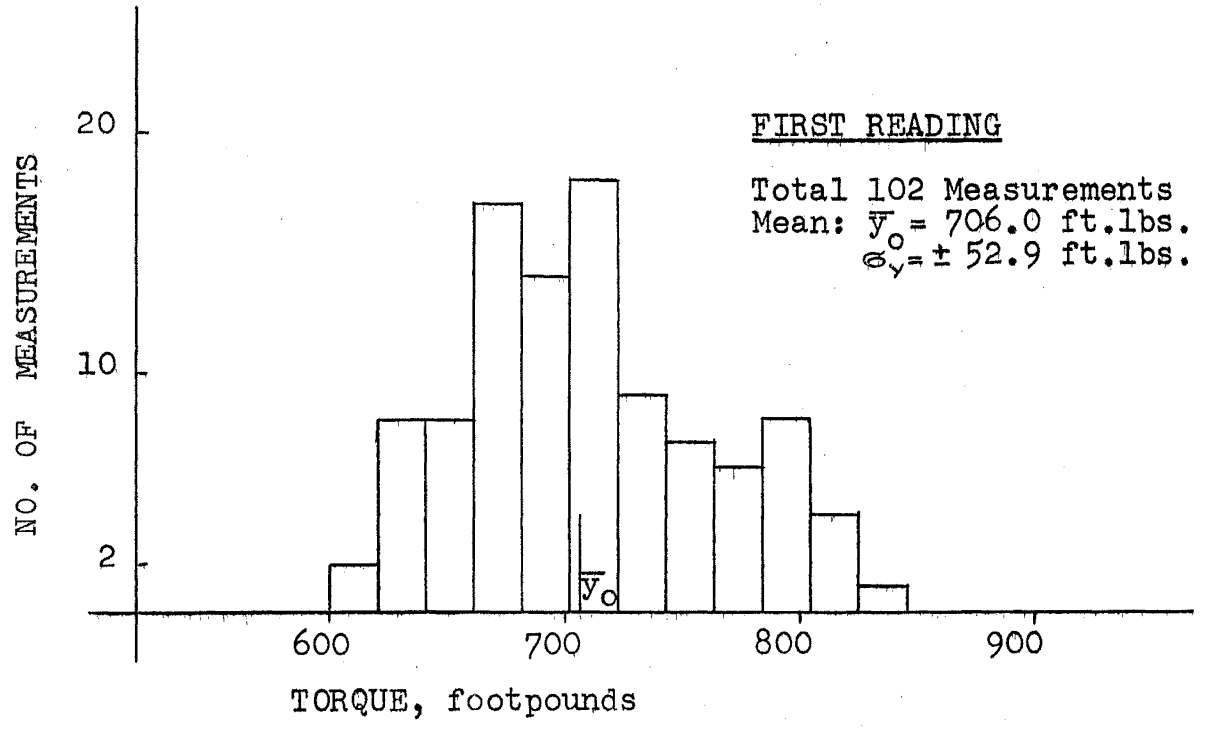


FIG. C - BOLT TORQUE CALIBRATION

SERIES - 8B (4 inch Grip/1 Washer)



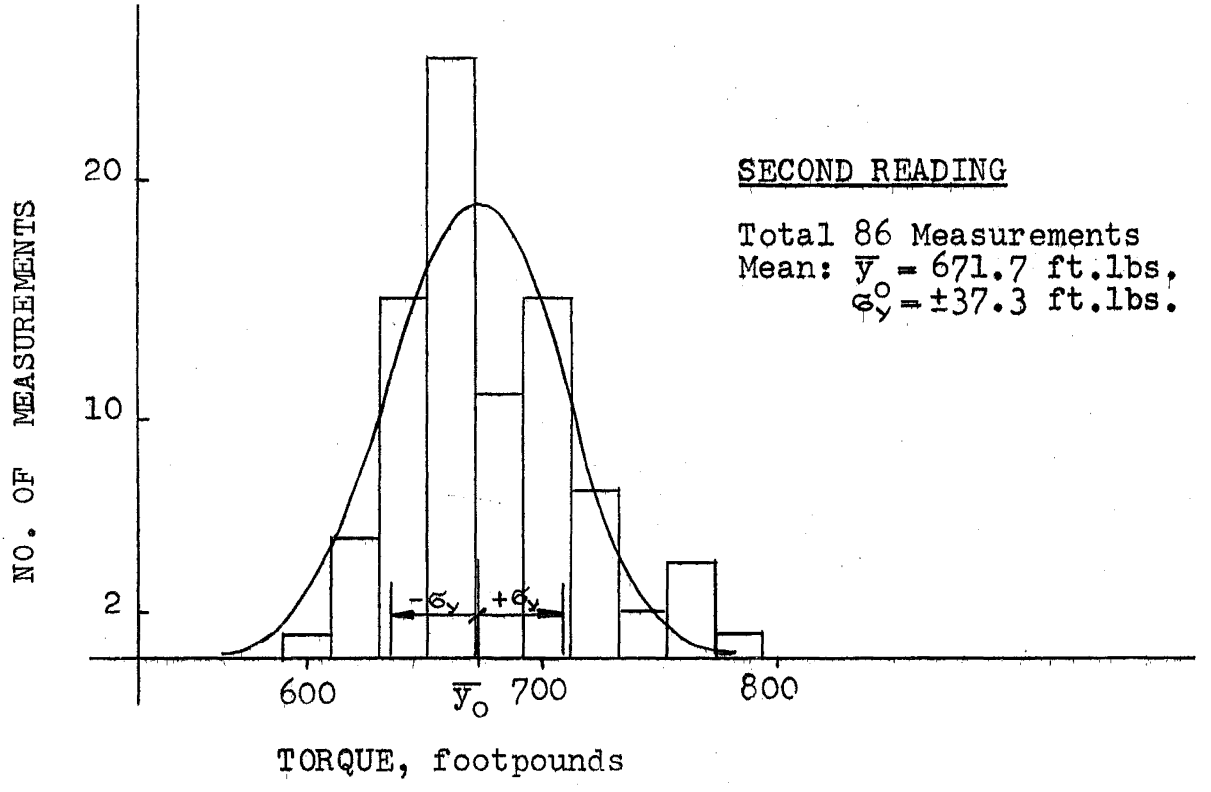
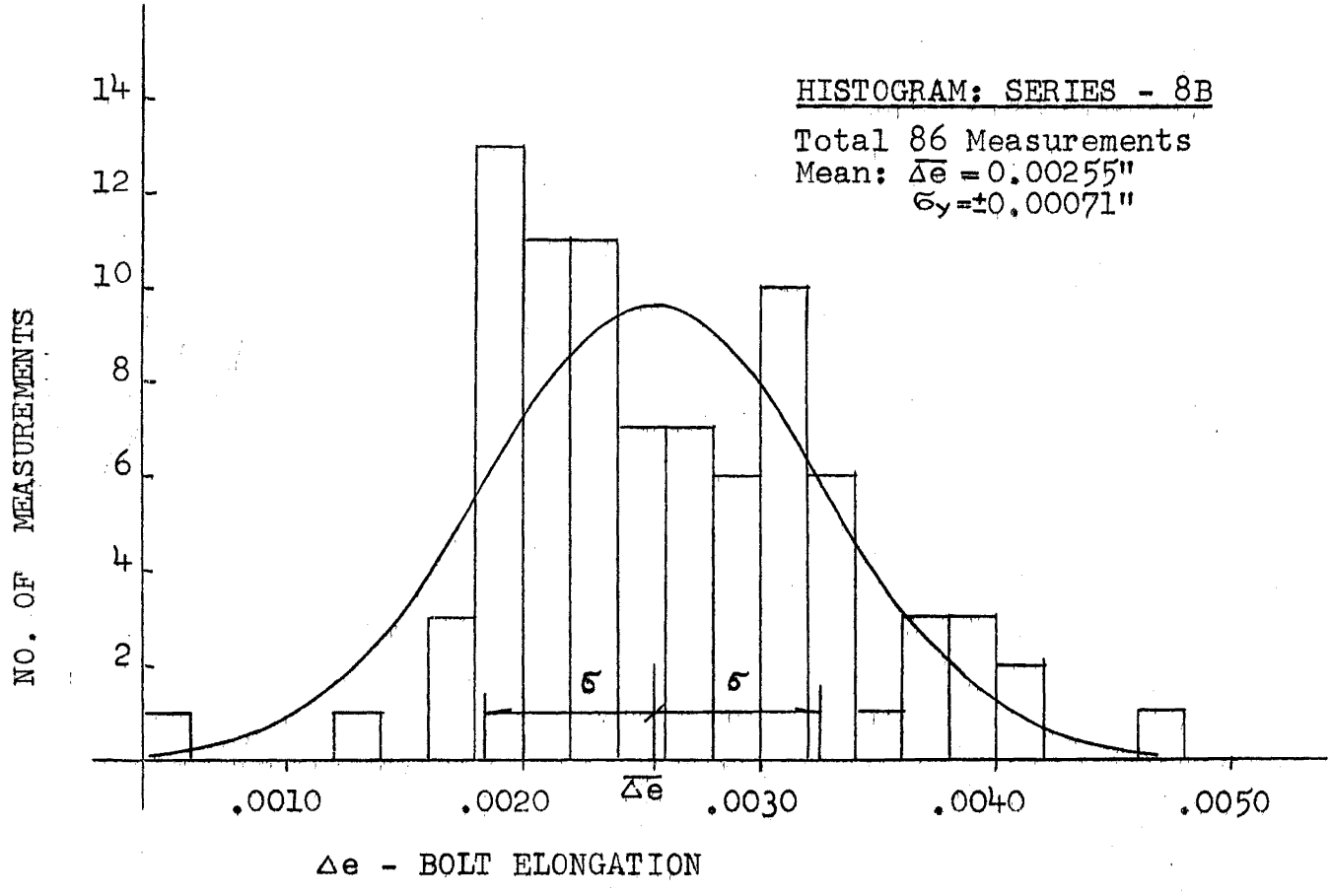


FIG. D - HISTOGRAM SERIES - 8B (7/8" Bolts - 4" Grip)



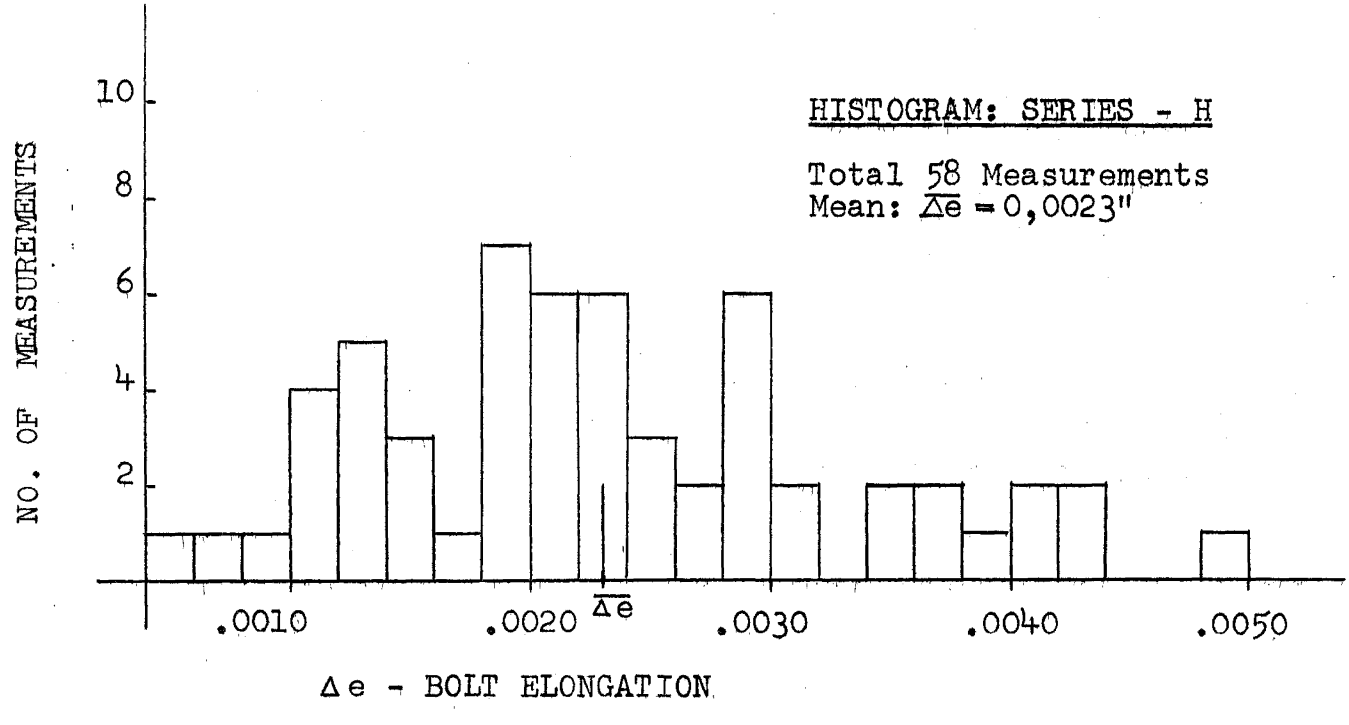


FIG. E - BOLT ELONGATION DUE TO TORQUE-TEST