

COST COMPARISON OF TIGHTENING METHODS FOR HIGH STRENGTH BOLTS

Introduction

Direct tension indicators (load indicating washers) were developed to provide an alternative to calibrated wrench procedures for assuring pretensioning requirements are met in bolted assemblies. Customers have suggested that there is a time-saving factor in the use of Direct Tension Load Indicators. A study was commissioned to quantify this potential time and cost savings.

The time study was undertaken by P.A. Management Consultants Ltd. (Product Research & Development Department), and the tests were supervised by W. S. Atkins & Partners Consulting Engineers (W.S. Atkins and Partners, 1970).

Summary

Two basic systems of bolting were compared: (1) The torque or calibrated wrench method and (2) The Direct Tension Load Indicator method. A minimum time saving of 13% was shown by the Direct Tension Load Indicator method compared with the calibrated wrench. This saving was increased to 33% with the omission of initial spud wrench tightening. A minimum cost savings of \$10.29 per 24 bolts can be calculated based on today's labor rates. This saving was increased to \$17.33 per 24 bolts with the omission of initial spud wrench tightening.

Procedure

A 39" x 20" test piece was prepared with seventy-two 13/16-in. diameter holes spaced on a 3 in. x 3 in. grid into which 3/4" bolts could be inserted. The plate had a height of 2 1/4". The plate was divided into equal areas of 24 holes. For each sequence the separate elements of preliminary tightening, final tightening and checking were completed for all the systems before passing on to the next element. In order to minimize the effects of operator fatigue or familiarity, which might slow down or quicken the tightening times, the positions of each group were cycled, and tightening was always carried out starting from the same side and proceeding in the same order.

The tightening technique for each system was as follows:



1. Torque or Calibrated Wrench method

- a) All bolts were inserted by hand and nuts snugged with a spud wrench.
- b) The pneumatic impact wrench was calibrated by use of a load cell to cut out when a bolt tension 10% higher than the minimum specified was achieved.
- c) The bolts were tightened with the calibrated impact wrench.
- d) A normal torque wrench was calibrated in the load cell to indicate a torque 5% above that necessary to obtain the minimum tension.
- e) The manual torque wrench was used for inspection testing of the tightened bolts.

2. Direct Tension Load Indicator method

- a) The Direct Tension Load Indicators were placed under the heads of the bolts and the bolts inserted by hand. Nuts were then snugged with a spud wrench.
- b) The bolts were tightened to the required 0.015-in. average Indicator gap using the pneumatic impact wrench.
- c) The gap was checked.

The tests were repeated five times and the results are shown in Appendix 1. Tests 1 through 3 follow precisely the methods described above. In practice there will be occasions where the plies are sufficiently well drawn together by fitting-up bolts to make preliminary tightening with a spud wrench unnecessary in both methods; *tests 4 and 5 were therefore carried out with the spud wrench tightening eliminated from these methods.*

Results

It is noted that testing was carried out in ideal shop conditions and these figures may not be achievable on site. However the general comparison of the results will not be affected by this consideration. The average results for each test series can be seen in Table 1. Results for all test series can be seen in Table A.1.

It can be seen that the Direct Tension Load Indicator method was the quickest and cheapest of the two methods, both with and without initial spud wrench tightening. A cost comparison is provided in Figure 1 assuming a labor rate of \$70/hour.

Table 1: Time in minutes to install 24 bolts.

	Average of Test 1-3		Average of Test 4-5	
	Calibrated Wrench	Direct Tension	Calibrated Wrench	Direct Tension
Hand Place & Hand Tighten	6.25	6.52	---	---
Hand Place Only	---	---	3.56	4.86
Spud Tighten	2.39	3.22	---	---
Final Tighten	6.75	5.32	13.49	3.99
Inspect	9.17	1.22	8.11	1.65
Total:	25.10	16.28	25.26	10.5

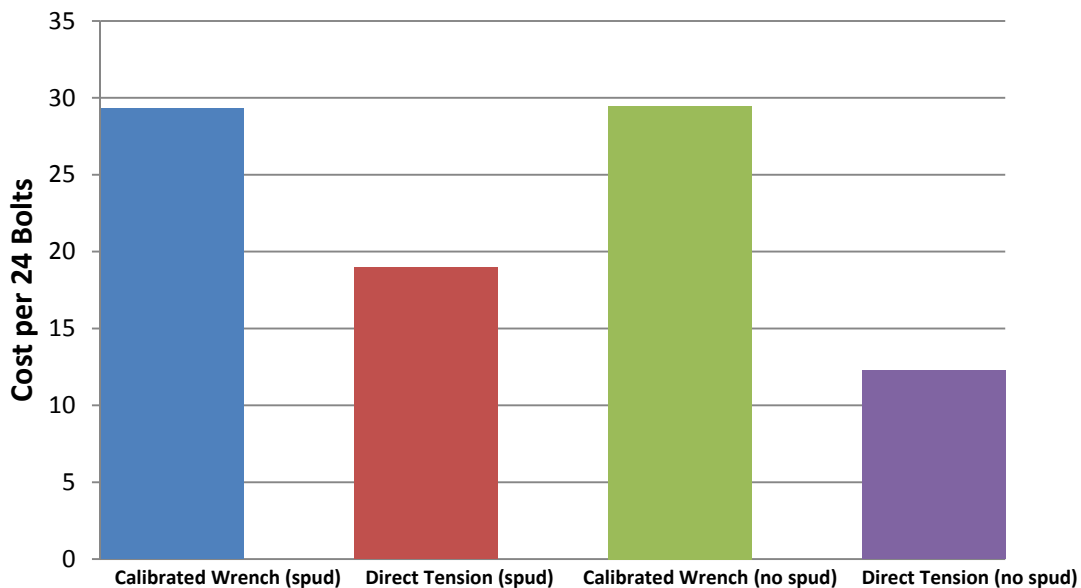


Figure 1: Cost per 24 bolts for each test with and without spud tightening.

Reference

W. S. Atkins and Partners, Consulting Engineers (1970). *Technical Report 30 – Comparison of Tightening Methods for High Strength Bolts.*



Appendix 1-Individual Test Results

Table A.1: Individual Results for each time series. Times are minutes per 24 bolts.

TEST #	Place Bolts by Hand		Spud Tighten		Final Tighten		Inspect		Total Time	
	T	DT	T	DT	T	DT	T	DT	T	DT
1	7.31	7.66	2.93	3.93	8.19	5.18	6.82	1.28	25.25	18.05
2	5.87	6.28	2.23	2.56	6.90	5.67	9.47	1.44	24.47	15.95
3	5.69	5.60	2.03	3.19	5.02	5.11	12.73	0.93	25.47	14.83
AVERAGE	6.25	6.52	2.39	3.22	6.75	5.32	9.17	1.22	25.10	16.28
4	3.79	5.17	---	---	12.00	4.46	9.39	0.96	25.18	10.59
5	3.32	4.54	---	---	14.98	3.52	6.83	2.34	25.13	10.40
AVERAGE	3.56	4.86	---	---	13.49	3.99	8.11	1.65	25.26	10.50