Test Report: PAN-TL-001

EYFLA Assembly Tool Testing

Conducted for:
Panasonic Corporation of North America
Secaucus, NJ

Conducted by:
Archetype Joint, LLC
Orion, MI

November 17, 2008

Torque control function
Torque adjusting function
Auto-power stop function

Test Objective

The primary purpose of this test is to provide quantitative data on the repeatability of input torque and induced bolt tension for a line of assembly tools recently introduced into the North American market. This tool line is a cordless discontinuous tool with electro-mechanical tightening control. While these tools have elements of impact, pulse and continuous cordless tool behavior, they establish a new category in industrial assembly tools. As such, prospective customers have no experience base on which to make a purchasing decision and will ask the manufacturer to provide performance data. To provide prospective customers with independent test data, Panasonic North America has asked Archetype Joint, LLC to conduct testing on these tools.

The testing reported on in this document was performed at Archetype Joint's lab in Orion, MI during November, 2008.

Test Plan - Scope

Tools at each of the three capacity levels offered in the EYFLA line were tested in four different configurations. The different configurations were established by two different clutch settings and two different joint rates. Joint rates refer to how much fastener rotation is required to tighten the bolt from snug to the desired installation torque or tension. The stiffer joints are called “Hard” and require less rotation. Those that are less stiff and take greater rotation to tighten are termed “Soft”. The test matrix shown below identifies the clutch and joint rate in the third column. For example 16S refers to a clutch setting of 16 tightening a Soft joint, while 30H is a test at a clutch setting of 30 on a Hard joint.

Test #	Tool	Clutch/Rate	Screw
1	1A	16H	M6
2		16S	M6
3		30H	M8
4		30S	M8
5	2Q	16H	M8
6		16S	M8
7		30H	M10
8		30S	M10
9	3J	16H	M10
10		16S	M10
11		30H	M10
12		30S	M10

Test Plan - Joint Summary

Characteristic	Description		
Bolt Diameter, mm	6	8	10
Bolt Length, mm	50	60	70
Bolt Property Class	8.8		
Bolt Finish	Clear Zinc Electroplate		
Driven End	Head		
Drive/Head Style (Bolt and Nut)	Hex Flange		
Under-Head Material	Steel Test Washer Per SAE/USCAR-10 Rev 2		
Test Washer Hole Dia., mm	6.23	8.35	10.33
Joint Grip Length, mm (w/o Belleville Washers)	36.7	45.3	41.0
Approximate Joint Rate, deg (from snug to target)	90 (Hard) and 360 (Soft)		
Number of Rundowns per Test	20		
Hardware Replaced on Each Run	Nut, Bolt and Test Washer		

Test Plan - Tools

The three test tools are shown below.

M6:Clutch Setting at 16

M8:Clutch Setting at 30

EYFLA -1A

M8:Clutch Setting at 16

M10:Clutch Setting at 30

EYFLA -2Q

M10:Clutch Settings at 16, 30

EYFLA -3J

Test Setup – Tension Measurement

The first measurement of each test is the final peak bolt tension generated in each rundown. Once the bolt, nut, test washer and Bellville washers for soft joints are installed into the load cell, the technician applies torque to the bolt head with the tool hand-held. While tightening takes place bolt tension is measured dynamically.

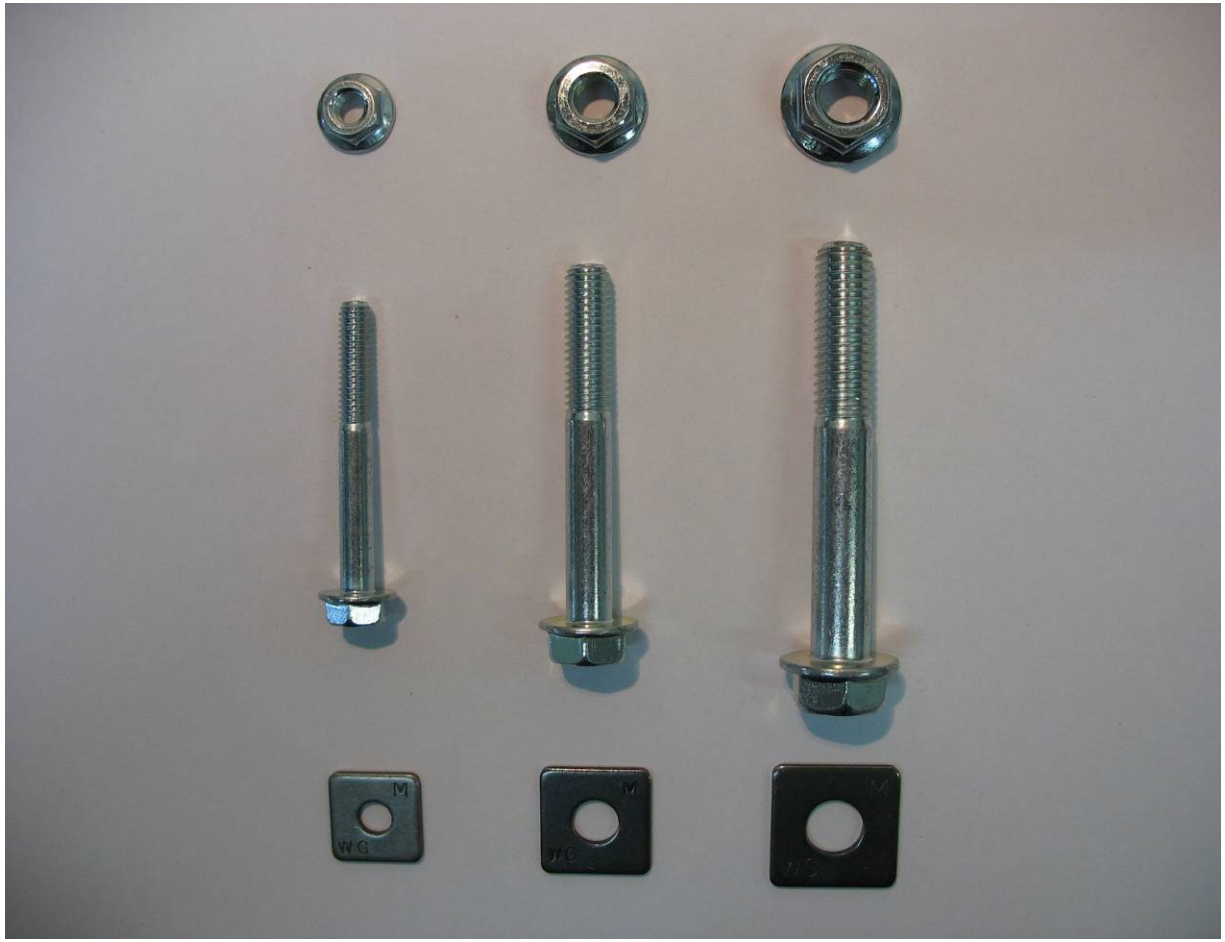
Details of the test equipment and the tension trace generated follow.

Test Setup – Torque Measurement

Because the clutch setting controls the number of impacts rather than the amplitude of torque impulses, measuring application torque can't be done dynamically by measuring the peak torque during tightening. Therefore, application torque was measured as a secondary residual torque audit. Immediately after tightening, a fixtured DC nutrunner was moved into place and the bolt was rotated in the tightening direction about 60 degrees. After testing was concluded, traces of these audits were individually examined and the residual torque value selected.

Details of audit trace and residual torque determination follow.

Test Equipment - Fasteners



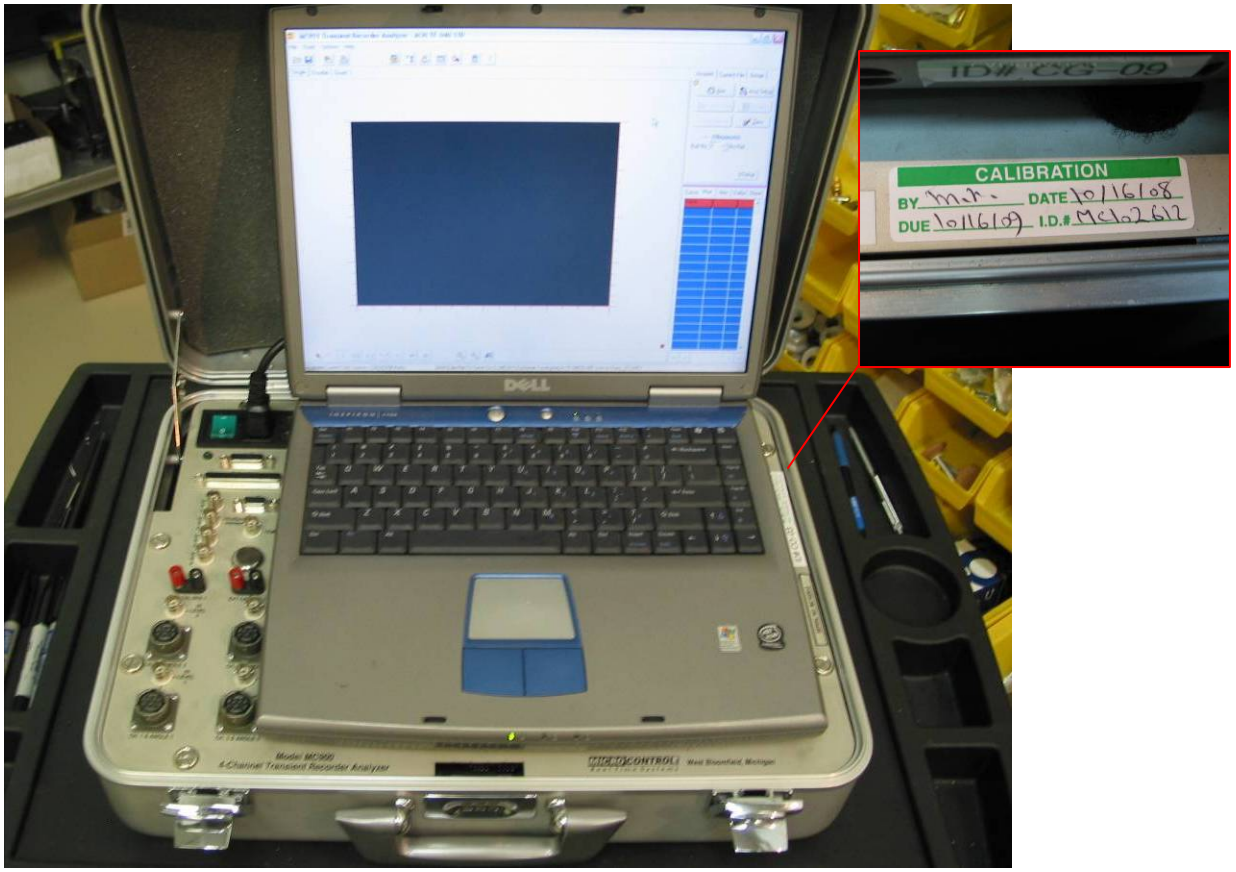
M6 **M8** **M10**

Test Equipment - External Torque-Angle Transducer

The Crane 75 N-m rotary transducer shown below was used for all torque measurement.

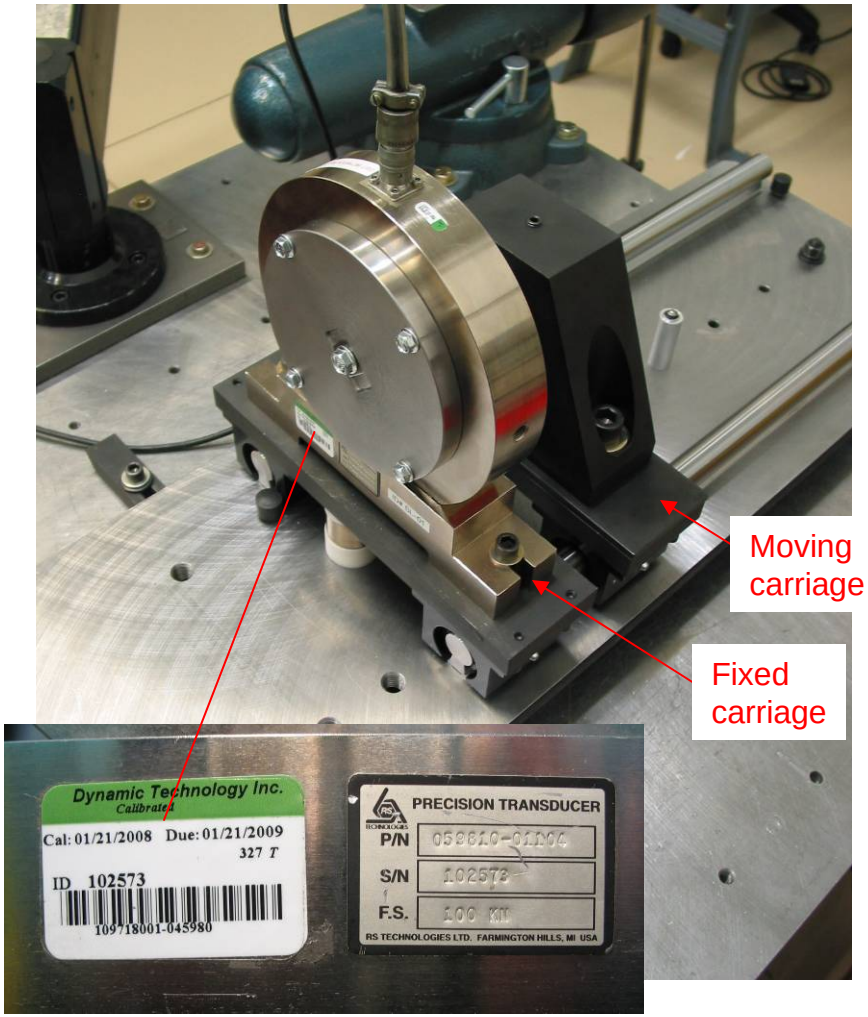
Test Equipment - Transient Recorder

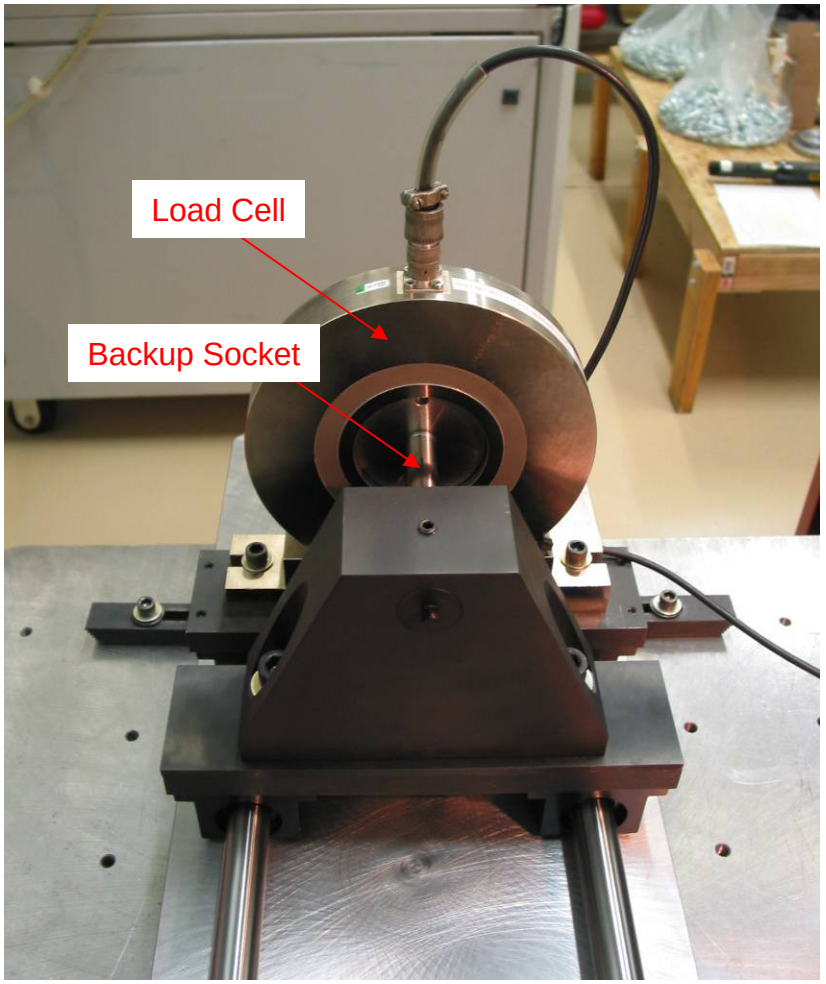
The analog signals from the load cell and torque-angle transducer are all read with the Micro Controls MC 900 four channel transient recorder. Because the level of torque pulses were not measured dynamically, signal capture rates and filter cutoff levels were not critical.



Test Equipment – Load Cell

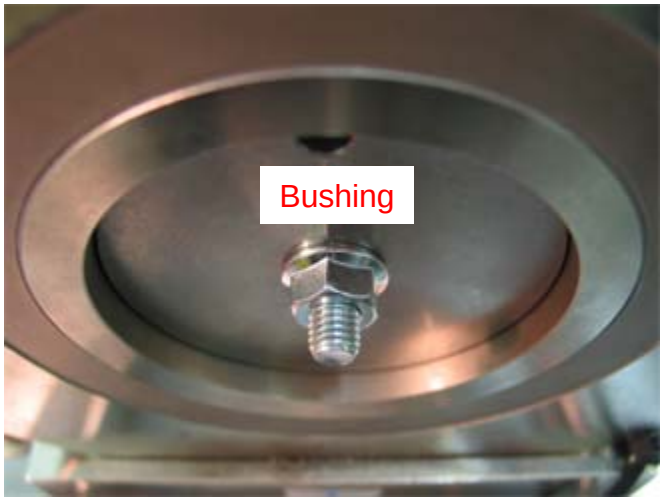
RS Technologies 100kN load cell on fixed carriage measures tension. Moving carriage allows backup socket to be retracted and the fastener set to be changed.

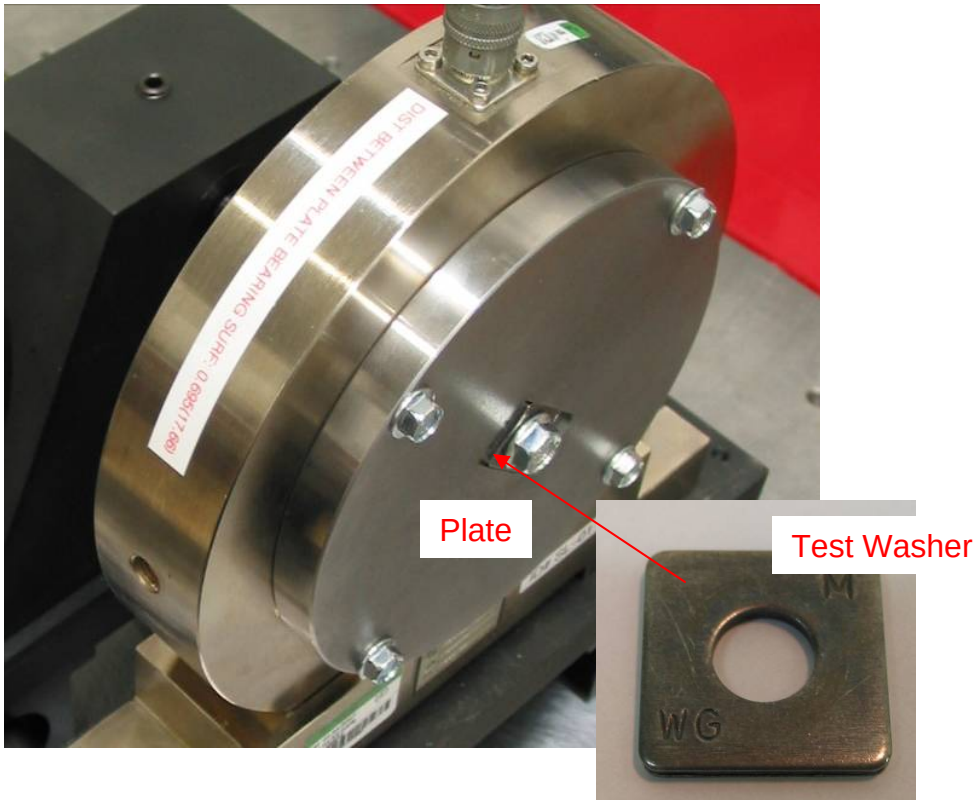




Test Equipment – Load Cell

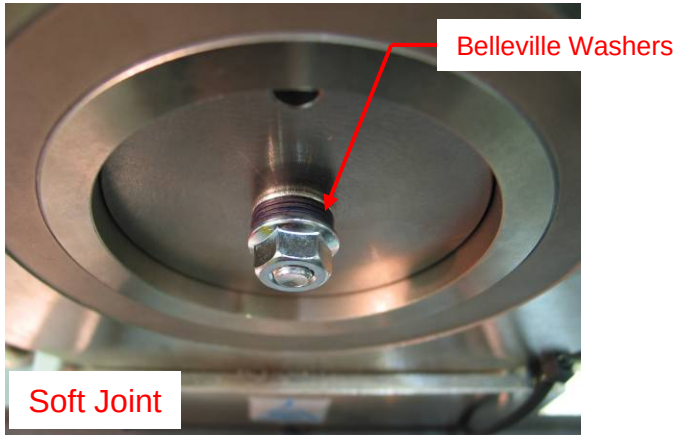
The load cell utilizes a set of plates and bushings with the appropriate hole size for the fastener diameter. The grip length can be varied by changing the thickness of plate and bushing. The plate contains a recess into which a test washer can be inserted. This way a fresh contact surface can be used for each run.





Test Equipment

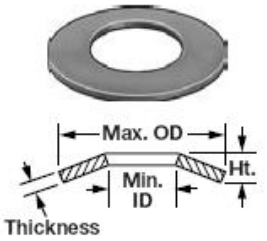
With “soft” joint tests, Belleville washers were placed under the nut to increase the bolt rotation required to tighten the bolt. Combinations of washer stiffness, quantity and configuration were chosen to achieve the desired 360° joint rate. Actual rotation was within 60° of that target. Washer configurations for each test are shown below.



					Belleville Washer	
Test #	Tool	Clutch	Joint	Screw	Style	Config
1	EYFLA-1A	16	hard	M6	none	
2		16	soft	M6	A	Nut
3		30	hard	M8	none	
4		30	soft	M8	B	Nut
5	EYFLA-2Q	16	hard	M8	none	
6		16	soft	M8	D	Nut
7		30	hard	M10	none	
8		30	soft	M10	G	Nut
9	EYFLA-3J	16	hard	M10	none	
10		16	soft	M10	G	Nut
11		30	hard	M10	none	
12		30	soft	M10	C	Nut

Test Equipment

Specifications for the Belleville washers used to soften the test joints are shown below. Source was McMaster Carr.



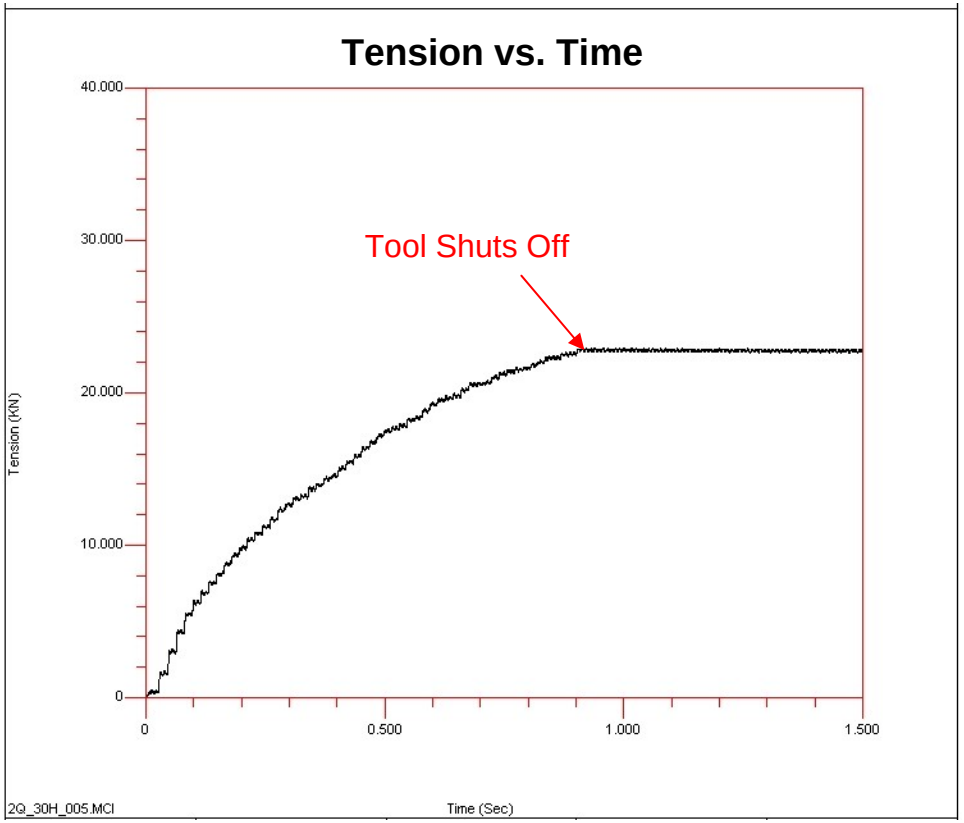
Belleville Disc Springs

Min. ID, mm	Max. OD, mm	Thick., mm	Ht., mm	Defl. @ Load, mm	Load, N▲	Flat Load, N▲		Per Pkg.
Type 17-7 PH Stainless Steel								
4.2	8.0	0.4	0.60	0.15	225	288	96475K211	$6.43
5.2	10.0	0.5	0.75	0.19	346	446	96475K215	6.31
6.2	12.5	0.5	0.85	0.32	357	387	96475K216	7.20
6.2	12.5	0.7	1.00	0.20	634	930	96475K221	7.79
6.2	18.0	0.8	1.30	0.38	777	973	96475K238	8.86
8.2	16.0	0.6	1.05	0.41	493	530	96475K331	8.40
8.2	16.0	0.7	1.15	0.34	686	859	96475K233	6.60
8.2	16.0	0.9	1.25	0.25	1,028	1,421	96475K236	8.30
10.2	20.0	0.9	1.45	0.42	1,129	1,418	96475K346	11.12
10.2	20.0	1.0	1.55	0.39	1,455	1,963	96475K247	11.11
12.2	25.0	1.5	2.05	0.36	2,777	4,138	96475K267★	8.67
14.2	27.9	1.0	1.80	0.73	1,334	1,431	96475K273★	6.60
14.2	27.9	1.5	2.15	0.46	2,895	3,979	96475K278★	11.61
16.3	31.5	2.0	2.75	0.46	5,495	8,811	96475K396★	14.90
18.3	35.6	2.0	2.80	0.57	5,221	7,232	96475K322★	14.74
DIN Group 1—High-Carbon Steel								
4.2	8.0	0.4	0.60	0.15	209	268	96445K211	2.19
5.2	10.0	0.5	0.75	0.187	325	417	96445K215	2.45
6.2	12.5	0.5	0.85	0.262	293	363	96445K216	2.60
6.2	12.5	0.7	1.00	0.225	659	854	96445K221	2.78
7.2	14.0	0.5	0.90	0.30	279	338	96445K226	2.67
7.2	14.0	0.8	1.10	0.225	796	1,040	96445K227	3.17
8.2	16.0	0.4	0.90	0.375	154	165	96445K231	2.72
8.2	16.0	0.8	1.20	0.287	825	1,059	96445K232	3.21
8.2	16.0	0.9	1.25	0.262	1,013	1,319	96445K236	3.34
8.2	18.0	0.8	1.30	0.375	782	983	96445K238	3.51
8.2	23.0	0.8	1.55	0.562	718	842	96445K257	3.54
9.2	18.0	1.0	1.40	0.30	1,254	1,631	96445K241	3.60
10.2	20.0	0.8	1.35	0.412	748	929	96445K246	3.19
10.2	20.0	1.1	1.55	0.337	1,521	1,976	96445K251	4.60
10.2	20.0	1.0	1.55	0.412	1,425	1,815	96445K247	3.85
10.2	23.0	1.0	1.70	0.525	1,315	1,629	96445K262	4.22
14.2	28.0	1.0	1.80	0.60	1,107	1,342	96445K273	5.29

	Min. ID	Max. OD	Thick-ness	Ht.	Defl. @ Load	Load, lbs.	Flat Load, lbs.	Grade 1074 High-Carbon Steel Pkg. Qty.		Per Pkg.
	0.255″	0.500″	0.025″	0.038″	0.007″	93	160	12	9712K63	4.06
	0.255″	0.500″	0.038″	0.047″	0.004″	175	400	12	9712K64	4.47
	0.255″	0.637″	0.032″	0.048″	0.008″	125	222	12	9712K21	4.58
	0.265″	0.562″	0.042″	0.055″	0.010″	400	567	12	9712K411	4.13
	0.265″	0.687″	0.052″	0.069″	0.014″	620	884	12	9712K412	10.92
A	0.265″	0.812″	0.061″	0.084″	0.018″	950	1,350	12	9712K413	4.37
	0.281″	0.875″	0.050″	0.066″	0.013″	310	445	12	9712K414	4.87
	0.281″	0.875″	0.075″	0.086″	0.009″	720	1,032	12	9712K415	4.87
	0.317″	0.625″	0.022″	0.042″	0.010″	69	105	12	9712K65	4.66
	0.317″	0.625″	0.032″	0.048″	0.008″	142	260	12	9712K66	4.87
	0.317″	0.625″	0.047″	0.059″	0.006″	316	600	12	9712K67	5.83
	0.317″	0.937″	0.045″	0.067″	0.011″	213	395	12	9712K73	7.20
	0.328″	0.687″	0.052″	0.068″	0.013″	630	892	12	9712K416	13.60
	0.328″	0.812″	0.061″	0.081″	0.016″	850	1,214	12	9712K417	4.37
B	0.328″	0.937″	0.070″	0.094″	0.019″	1,130	1,610	12	9712K418	6.08
	0.344″	1.000″	0.090″	0.102″	0.010″	1,040	1,499	12	9712K419	5.71
	0.344″	1.125″	0.062″	0.083″	0.017″	470	671	12	9712K421	6.43
	0.380″	0.750″	0.028″	0.051″	0.012″	112	175	12	9712K68	3.44
	0.380″	0.750″	0.034″	0.055″	0.011″	169	282	12	9712K69	3.58
	0.380″	0.750″	0.040″	0.059″	0.010″	237	415	12	9712K71	4.14
	0.380″	0.750″	0.056″	0.070″	0.007″	433	845	12	9712K72	4.43
	0.380″	1.125″	0.053″	0.080″	0.014″	308	535	12	9712K79	7.97
D	0.380″	1.125″	0.078″	0.097″	0.009″	592	1,235	12	9712K24	14.55
	0.390″	0.812″	0.061″	0.079″	0.014″	810	1,163	12	9712K422	4.87
G	0.390″	0.937″	0.070″	0.092″	0.018″	1,070	1,528	12	9712K423	6.08
	0.390″	1.250″	0.065″	0.085″	0.016″	420	598	12	9712K424	6.43
	0.406″	0.875″	0.062″	0.074″	0.010″	480	644	12	9712K425	4.87
	0.406″	0.875″	0.089″	0.100″	0.009″	1,290	1,871	12	9712K426	4.87
C	0.406″	0.875″	0.109″	0.124″	0.012″	3,230	4,687	12	9712K427	4.87
	0.406″	1.000″	0.062″	0.092″	0.024″	900	1,262	12	9712K428	4.62

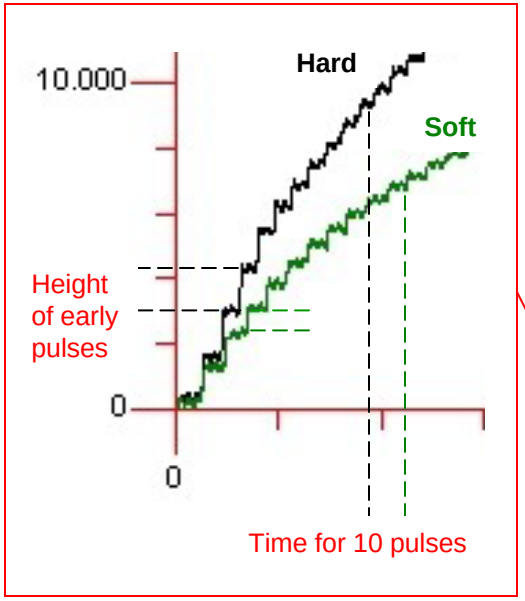
Typical Traces - Tension

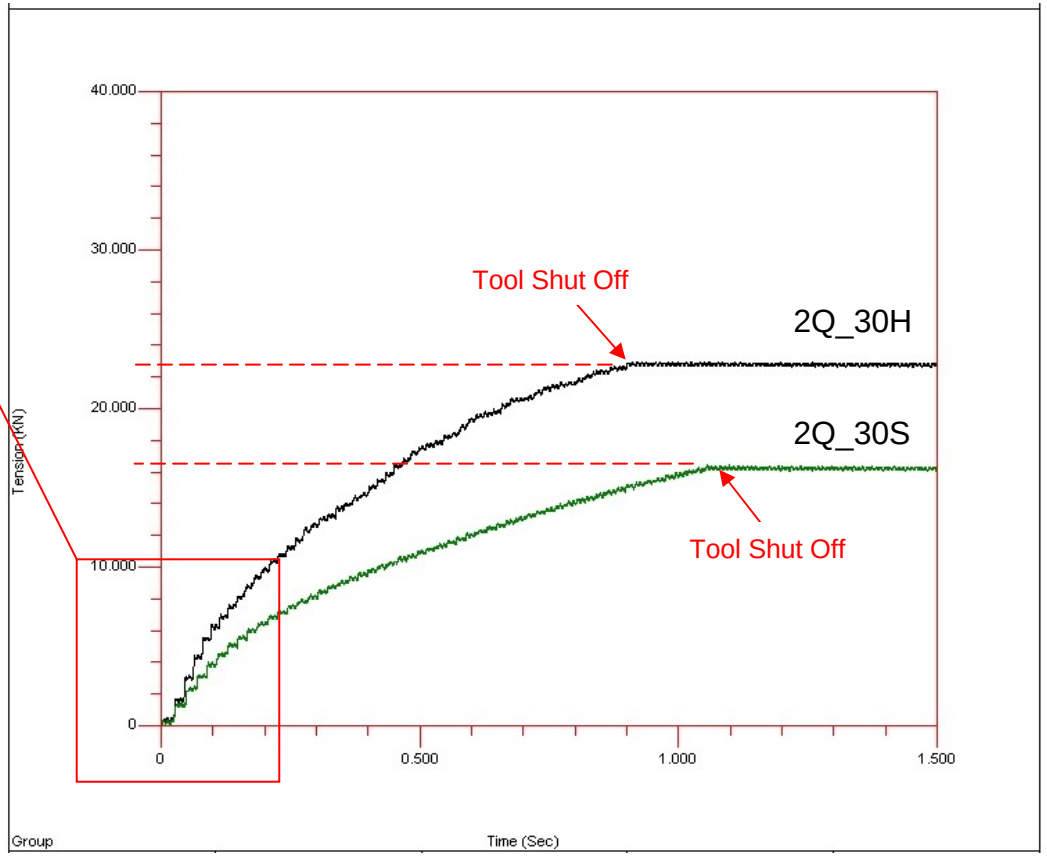
The trace on the left, taken from a rundown of Test 7 (the 2Q tool with a 30 clutch setting on a hard joint), is typical of the 240 tension traces which have been compiled and provided in a separate file. The tension-time trace, recorded dynamically as the bolt is tightened, shows the bolt tension climb as the bolt head is impacted. The trace's slope continually decreases, as the amount of rotation (and therefore tension increase) lessens as the resistance to rotation becomes greater. At the point noted on the trace the desired number of impacts, as determined by the clutch setting, is reached and the tool shuts off. The horizontal portion of the trace to the right of this point simply shows that the tension remains steady once the tool is shut off.



Tension Measurement Comments

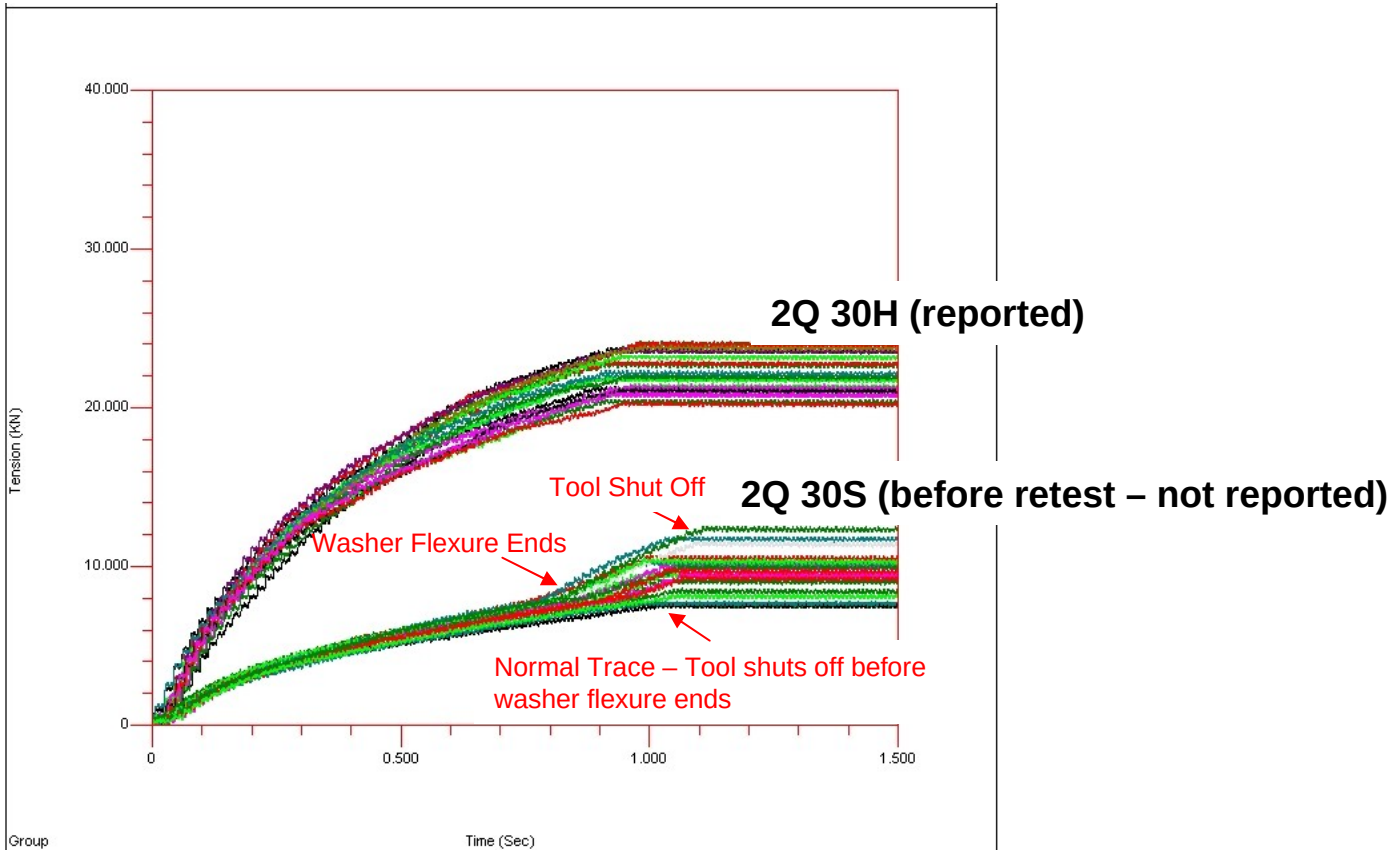
The test results show that for a given clutch setting on a given tool both the final bolt tension and the residual torque will vary depending on the joint rate. As an illustration, below are two typical traces from testing the 2Q tool at a clutch setting of 30, one on a hard joint and the other on a soft joint. Tension on the soft joint is about 6 kN lower because the average increase in tension per pulse is lower due to less joint resistance (see left of inset). As the number of pulses will be the same for both joints, the tension will not climb as high. The main graph shows that the time to tool shut off is greater for the soft joint even though the clutch setting is the same. This is due to a slightly greater cycle time for the soft impulses, as shown on the right side of the inset.





Typical Traces – Tension vs. Time

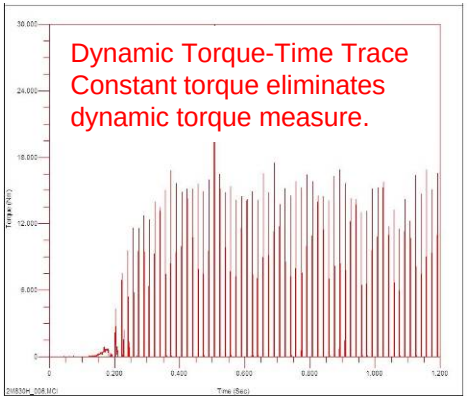
The data displayed in test results for test #8 (2Q 30S) is the result of a retest. The initial test, whose tension traces are shown below with the hard version of the joint, displayed high tension variation caused by the joint setup rather than the tool. For some of the rundowns the Belleville washers went stiff before the tool shut off. This created variation in joint stiffness between the rundowns where this occurred and those where it didn't. Because the final bolt torque and tension are influenced by joint stiffness when using these tools, the test results showed a high degree of variation. The test was rerun with an additional Bellville washer stacked in series to provide additional flexure range. The results show 17 data points for this test rather than the normal 20 because the stock of test washers was used up before completion.



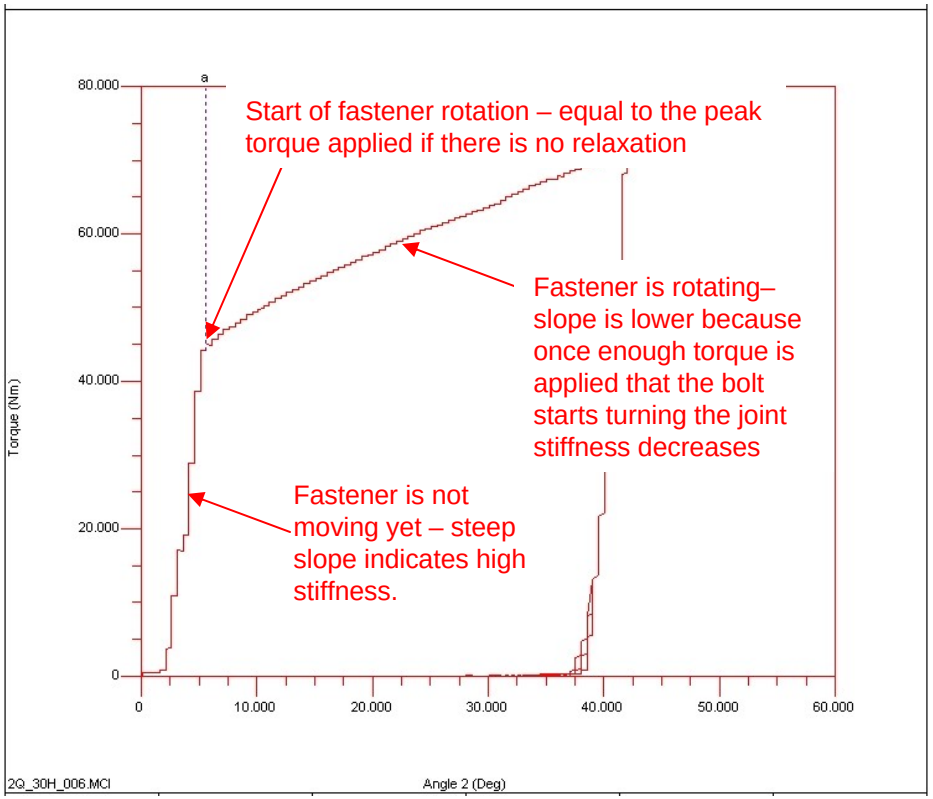
Typical Traces - Torque

The trace on the left is typical of the 240 torque traces complied separately. As described earlier, the final torque applied to a bolt is measured immediately after the rundown as a residual torque audit. The torque at the start of fastener rotation was determined by examination of each audit trace.

The graph below shows torque measured dynamically during the rundown. The torque spike of each impact is the same height, with the clutch setting controlling the number of impacts rather than the energy transmitted, so the peak dynamic torque would not describe the applied torque in an equivalent manner as a continuous tool. This is the reason residual torque was measured.



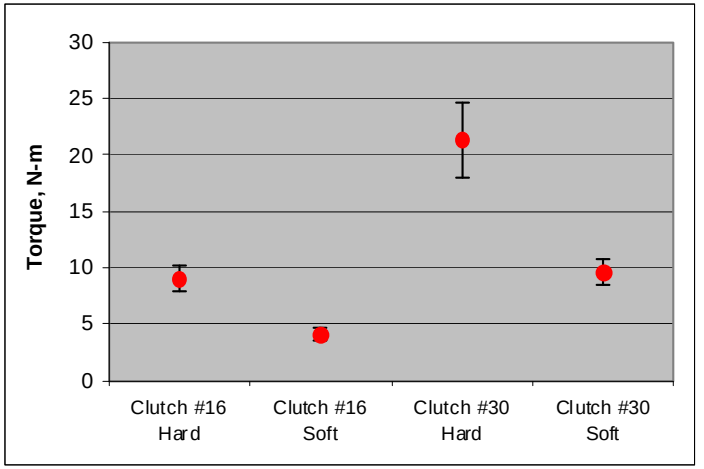
Torque vs. Angle



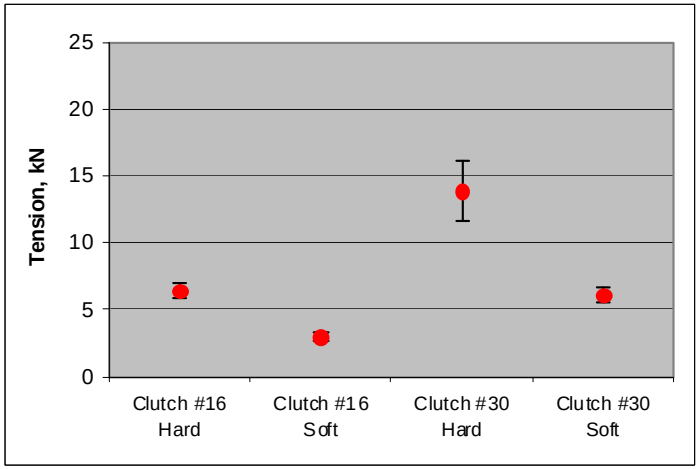
Test Results

Summary Results EYFLA-1A

	EYFLA-1A Torque Summary (N-m)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	9.1	4.1	21.4	9.7
ST DEV	0.40	0.18	1.10	0.37
MEAN + 3STD	10.2	4.6	24.7	10.8
MEAN - 3STD	7.9	3.5	18.1	8.5

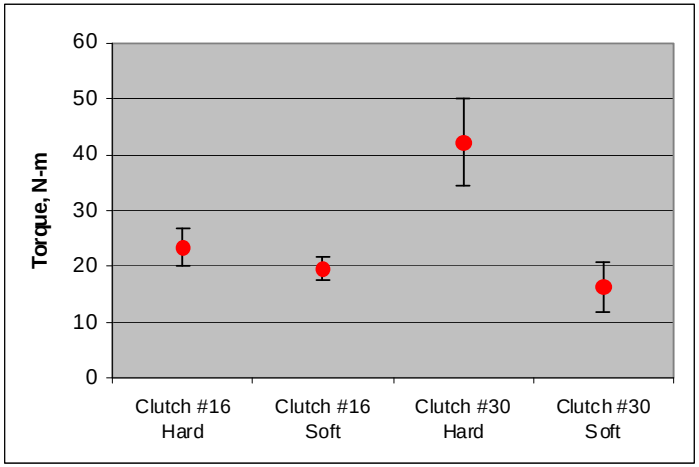


	EYFLA-1A Tension Summary (kN)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	6.4	3.0	13.9	6.1
ST DEV	0.20	0.10	0.77	0.20
MEAN + 3STD	7.0	3.3	16.2	6.7
MEAN - 3STD	5.8	2.7	11.6	5.5

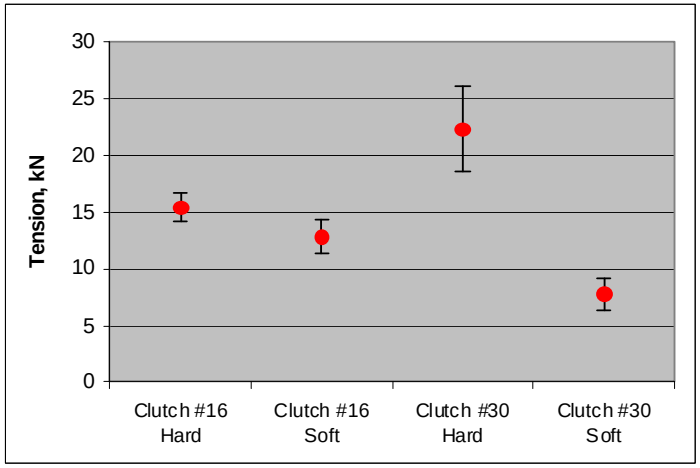


Summary Results EYFLA-2Q

	EYFLA-2Q Torque Summary (N-m)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	23.4	19.5	42.2	16.2
ST DEV	1.13	0.71	2.58	1.50
MEAN + 3STD	26.8	21.7	50.0	20.7
MEAN - 3STD	20.0	17.4	34.5	11.7



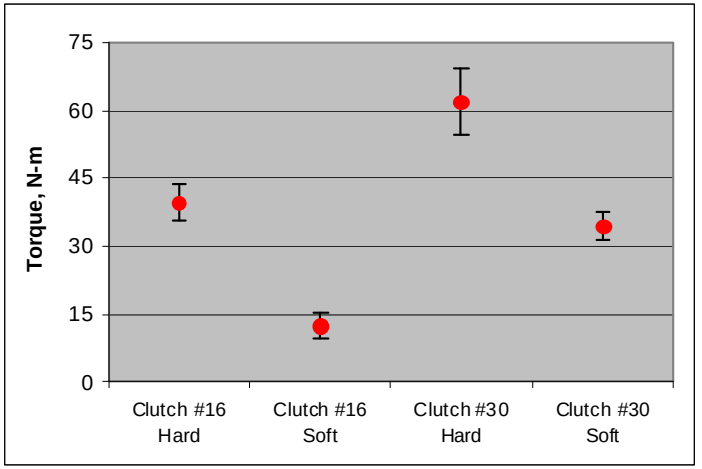
	EYFLA-2Q Tension Summary (kN)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	15.4	12.8	22.3	7.7
ST DEV	0.43	0.50	1.26	0.48
MEAN + 3STD	16.7	14.3	26.1	9.2
MEAN - 3STD	14.1	11.3	18.5	6.3



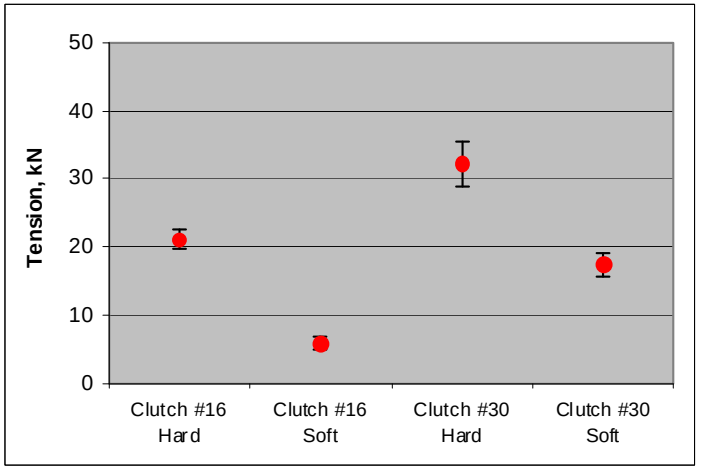
Torque and Tension data for Clutch #30 Soft based on 17 data points rather than 20

Summary Results EYFLA-3J

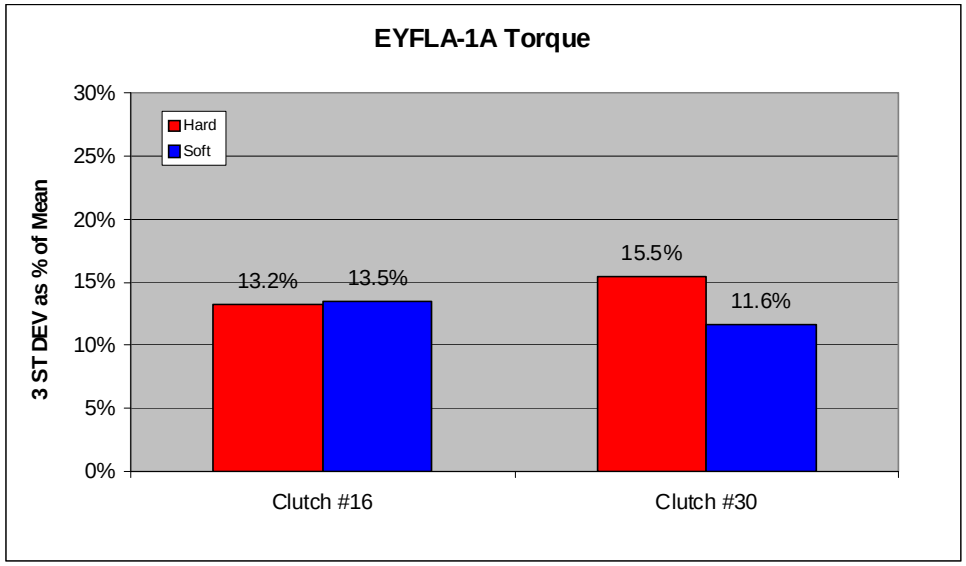
	EYFLA-3J Torque Summary (N-m)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	39.7	12.6	61.8	34.5
ST DEV	1.39	0.98	2.43	0.97
MEAN + 3STD	43.9	15.5	69.1	37.4
MEAN - 3STD	35.5	9.6	54.6	31.5

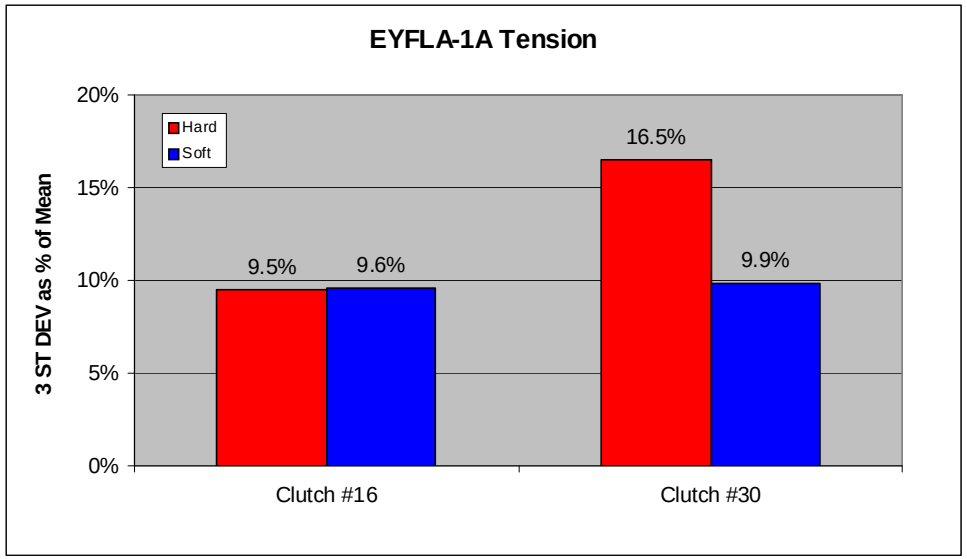


	EYFLA-3J Tension Summary (kN)			
	Clutch #16		Clutch #30	
	Hard	Soft	Hard	Soft
MEAN	21.1	5.8	32.3	17.4
ST DEV	0.49	0.34	1.11	0.60
MEAN + 3STD	22.6	6.9	35.6	19.2
MEAN - 3STD	19.6	4.8	29.0	15.6

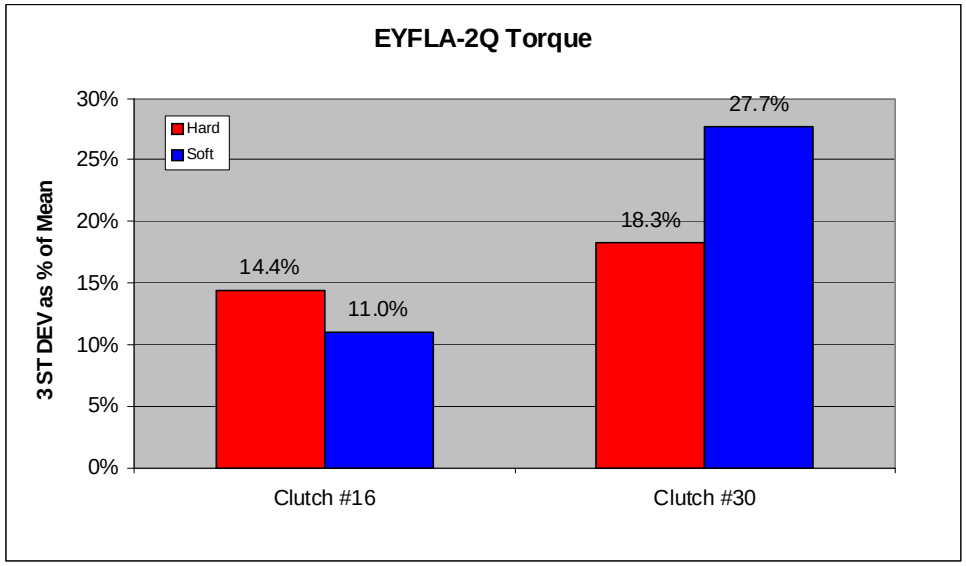


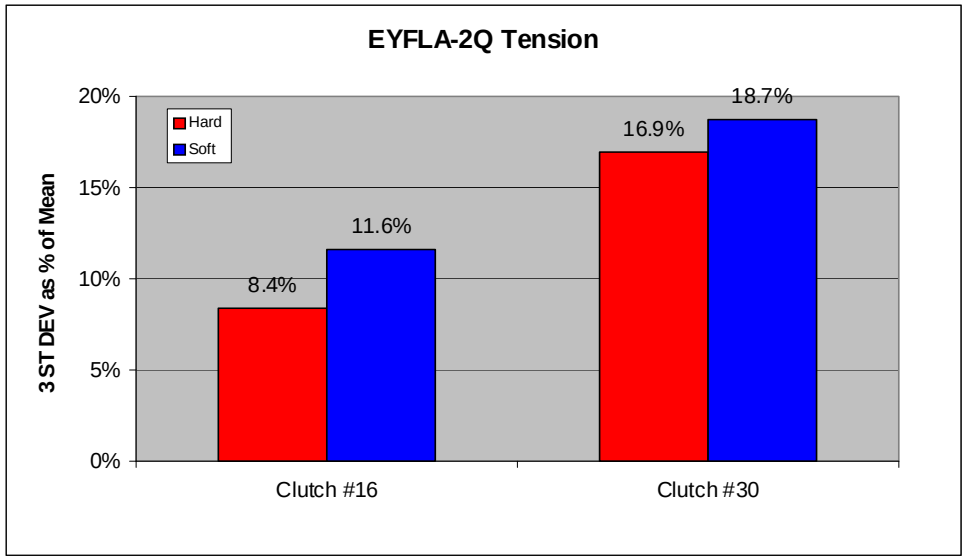
Summary Results EYFLA-1A





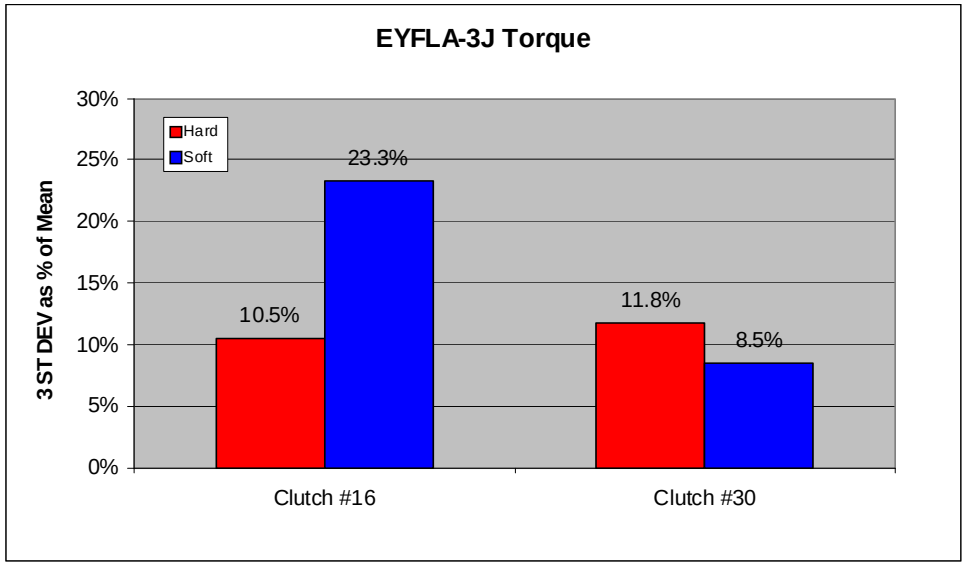
Summary Results EYFLA-2Q

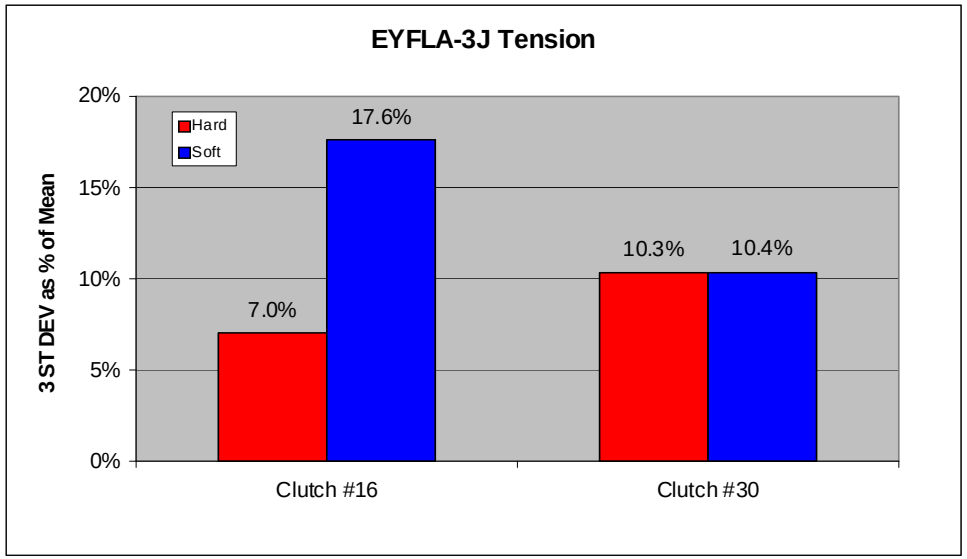




Torque and Tension data for Clutch #30 Soft based on 17 data points rather than 20

Summary Results EYFLA-3J





Test Results EYFLA-1A with Clutch at 16

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	9.3	6.3	3.8	3.0
2	8.8	6.1	4.2	2.9
3	8.8	6.5	3.8	2.9
4	9.2	6.5	4.0	3.0
5	9.0	6.4	3.8	3.0
6	9.2	6.5	4.2	2.9
7	9.2	6.6	4.2	2.9
8	8.8	6.5	4.1	3.0
9	9.2	6.4	4.0	3.0
10	9.9	6.9	4.5	3.0
11	9.4	6.8	4.0	3.0
12	9.9	6.6	4.0	3.1

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	8.8	6.4	3.8	2.9
14	8.6	6.4	4.0	3.0
15	9.3	6.2	4.3	2.9
16	8.4	6.3	4.1	3.3
17	8.9	6.4	4.0	3.0
18	8.5	6.4	3.8	3.0
19	9.0	6.3	4.2	2.9
20	8.7	6.2	4.0	2.8
MEAN	**9.1**	**6.4**	**4.1**	**3.0**
MIN	8.4	6.1	3.8	2.8
MAX	9.9	6.9	4.5	3.3
ST DEV	**0.40**	**0.20**	**0.18**	**0.10**

Test Results EYFLA-1A with Clutch at 30

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	21.0	13.3	10.1	6.0
2	21.7	14.5	9.4	5.9
3	19.6	13.5	10.0	6.2
4	21.1	14.5	9.2	6.1
5	20.6	13.9	9.8	6.0
6	21.1	13.7	8.8	5.7
7	20.4	13.4	9.8	5.9
8	22.8	14.1	9.5	6.1
9	22.5	13.3	9.8	6.3
10	20.7	13.9	9.6	6.3
11	20.0	13.7	10.2	6.5
12	23.0	15.4	10.1	6.2

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	22.0	13.4	9.7	6.3
14	21.7	12.9	9.5	6.2
15	21.2	14.0	9.4	5.9
16	21.7	13.5	9.5	6.0
17	21.1	13.7	9.4	5.8
18	20.0	13.1	9.7	6.2
19	21.3	14.0	9.6	6.2
20	24.0	16.1	10.4	6.2
MEAN	**21.4**	**13.9**	**9.7**	**6.1**
MIN	19.6	12.9	8.8	5.7
MAX	24.0	16.1	10.4	6.5
ST DEV	**1.10**	**0.77**	**0.37**	**0.20**

Test Results EYFLA-2Q with Clutch at 16

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	25.2	15.5	19.4	13.3
2	24.5	16.4	18.9	12.7
3	23.5	14.9	19.6	11.9
4	23.5	15.7	19.7	13.2
5	24.1	15.3	20.9	12.7
6	23.3	15.3	20.6	13.2
7	25.9	15.8	18.5	12.3
8	23.9	15.8	18.5	12.4
9	24.1	15.8	19.5	13.4
10	23.4	15.2	18.7	12.8
11	24.6	16.0	19.0	12.7
12	23.0	15.1	18.7	13.7

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	22.5	15.1	19.9	12.8
14	23.8	15.5	19.0	12.7
15	22.2	14.9	20.1	12.2
16	21.6	14.7	20.0	12.2
17	22.7	15.1	19.5	12.7
18	22.8	14.9	20.2	12.8
19	22.0	15.4	20.4	13.5
20	22.0	15.7	19.3	13.5
MEAN	**23.4**	**15.4**	**19.5**	**12.8**
MIN	21.6	14.7	18.5	11.9
MAX	25.9	16.4	20.9	13.7
ST DEV	**1.13**	**0.43**	**0.71**	**0.50**

Test Results EYFLA-2Q with Clutch at 30

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	40.2	21.4	16.4	7.8
2	40.1	22.9	17.3	8.2
3	44.3	22.9		
4	39.1	21.0		
5	46.2	24.2	16.3	7.7
6	40.9	21.5	18.3	7.9
7	44.6	22.0	17.6	7.0
8	39.0	20.5	16.1	8.1
9	46.5	23.8	15.2	8.3
10	42.9	21.9	18.0	7.8
11	39.7	21.5	15.6	7.6
12	46.0	24.2	15.7	7.2

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	43.6	23.8	17.9	7.6
14	43.5	23.3	14.4	7.1
15	45.3	23.9	15.2	7.6
16	42.6	22.3	14.0	6.9
17	40.6	21.2	14.0	8.5
18	40.4	22.1		
19	39.5	20.4	15.2	7.8
20	40.0	21.0	18.6	8.3
MEAN	**42.2**	**22.3**	**16.2**	**7.7**
MIN	39.0	20.4	14.0	6.9
MAX	46.5	24.2	18.6	8.5
ST DEV	**2.58**	**1.26**	**1.50**	**0.48**

Rundowns #4 and #8 were removed as washer flex ended before tool shut-off. Rundown #3 was removed due to questionable residual torque trace. All M10 test washers had been used so this data could not be replaced.

Test Results EYFLA-3J with Clutch at 16

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	40.9	21.8	12.9	5.5
2	41.8	21.1	14.2	5.6
3	38.2	21.5	11.5	6.5
4	40.9	21.5	12.1	6.3
5	42.0	21.0	13.1	5.5
6	40.0	20.8	13.2	5.7
7	41.1	21.6	11.7	5.7
8	39.1	20.5	13.1	5.8
9	39.3	21.2	14.6	5.3
10	38.7	21.6	11.5	6.0
11	39.8	21.1	13.2	6.0
12	37.5	21.6	12.5	5.9

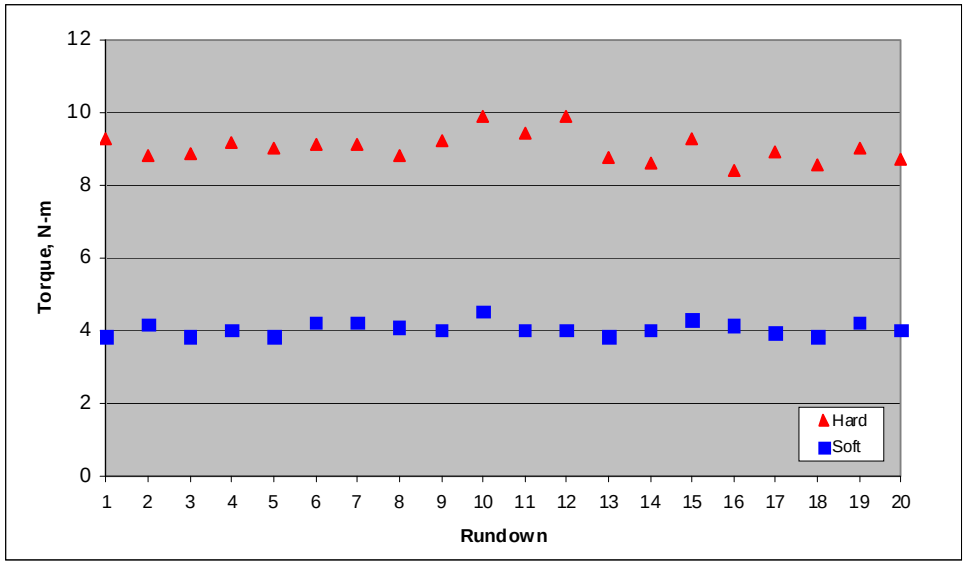
	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	36.6	19.7	12.9	6.3
14	38.9	21.4	11.5	6.2
15	38.9	20.7	11.8	6.4
16	39.3	21.0	13.8	5.4
17	40.6	20.6	11.0	6.0
18	40.8	21.3	11.5	5.8
19	39.5	20.8	12.3	5.6
20	40.0	21.2	12.9	5.6
MEAN	**39.7**	**21.1**	**12.6**	**5.8**
MIN	36.6	19.7	11.0	5.3
MAX	42.0	21.8	14.6	6.5
ST DEV	**1.39**	**0.49**	**0.98**	**0.34**

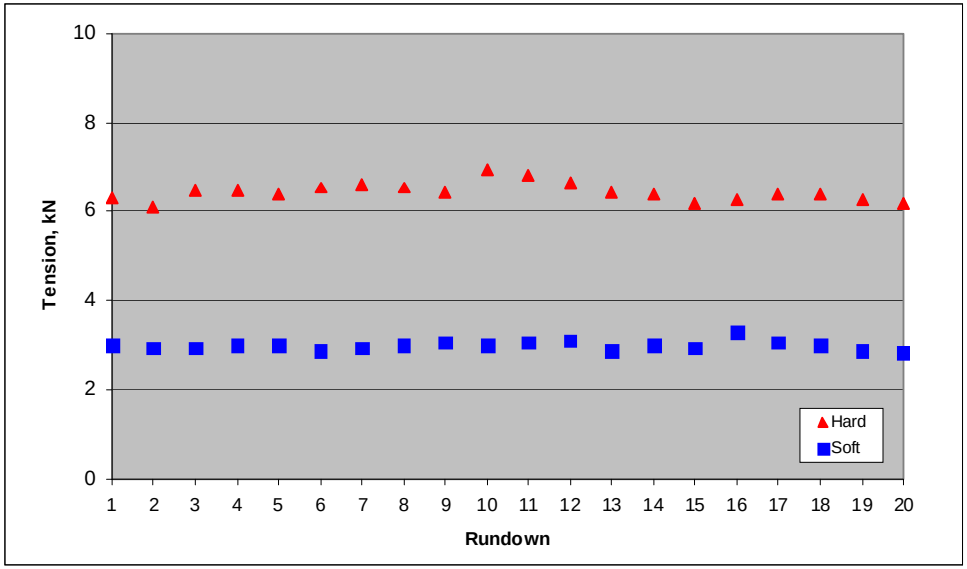
Test Results EYFLA-3J with Clutch at 30

	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
1	62.6	31.8	34.4	16.4
2	66.1	33.6	33.0	17.3
3	63.4	32.2	32.5	16.4
4	61.8	32.5	34.0	17.3
5	65.4	33.6	34.5	16.8
6	63.0	33.5	34.6	16.7
7	57.1	32.3	33.5	17.9
8	62.8	31.4	35.6	16.2
9	65.7	34.1	33.8	17.6
10	61.9	32.0	35.2	17.4
11	59.9	31.3	34.6	17.8
12	61.0	30.7	34.8	18.0

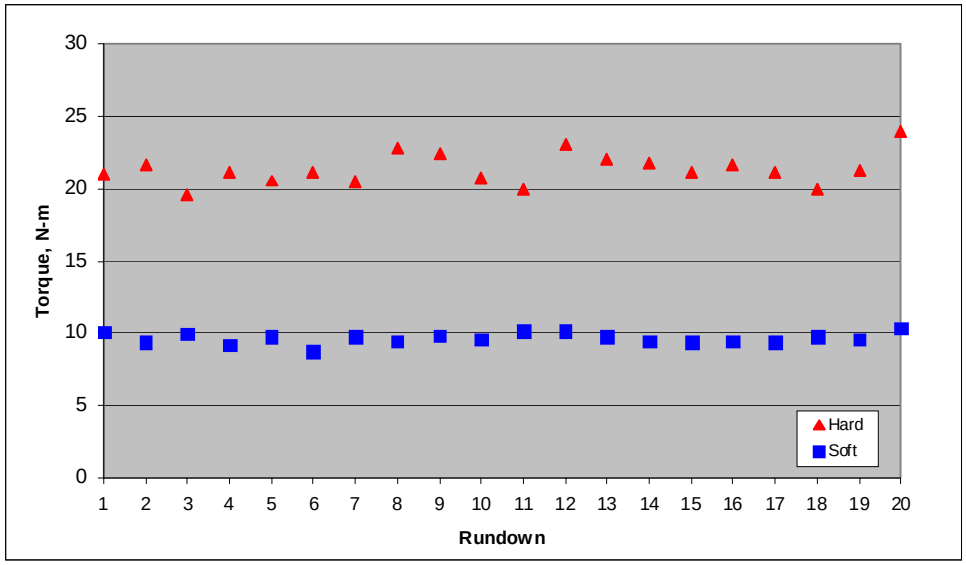
	Hard Joint		Soft Joint	
Run-down	Torque (N-m)	Tension (kN)	Torque (N-m)	Tension (kN)
13	62.1	33.8	35.0	18.3
14	61.9	31.4	33.3	17.3
15	61.8	31.8	34.9	17.3
16	60.1	30.9	34.7	18.0
17	57.8	31.4	36.5	17.8
18	62.5	34.1	35.4	17.4
19	61.6	31.4	33.6	17.9
20	58.2	32.1	35.3	17.7
MEAN	**61.8**	**32.3**	**34.5**	**17.4**
MIN	57.1	30.7	32.5	16.2
MAX	66.1	34.1	36.5	18.3
ST DEV	**2.43**	**1.11**	**0.97**	**0.60**

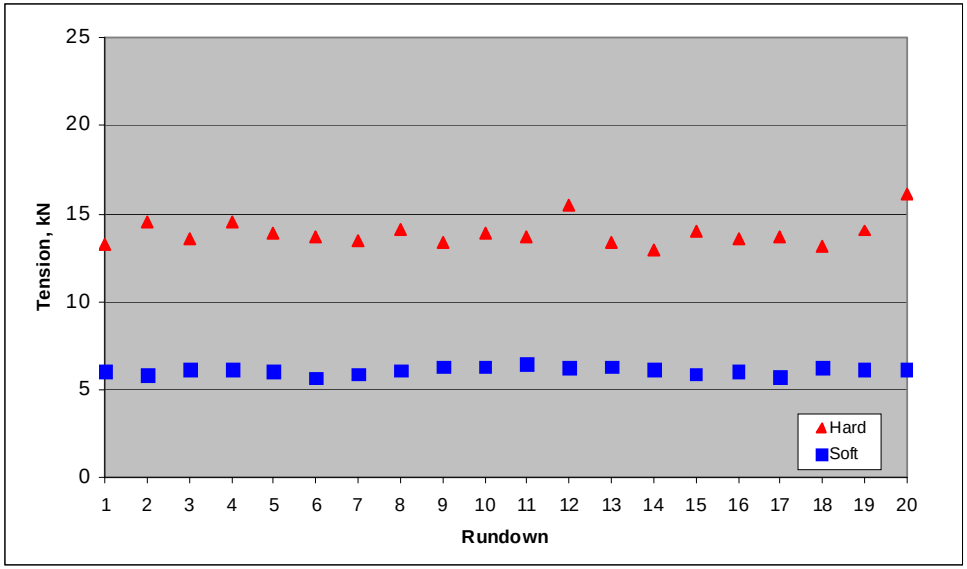
Test Results EYFLA-1A with Clutch at 16



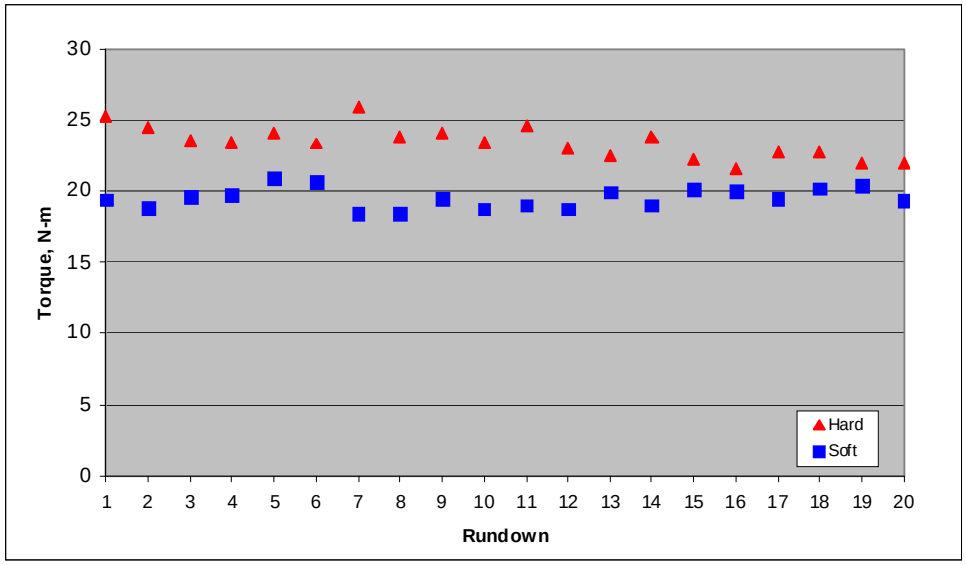


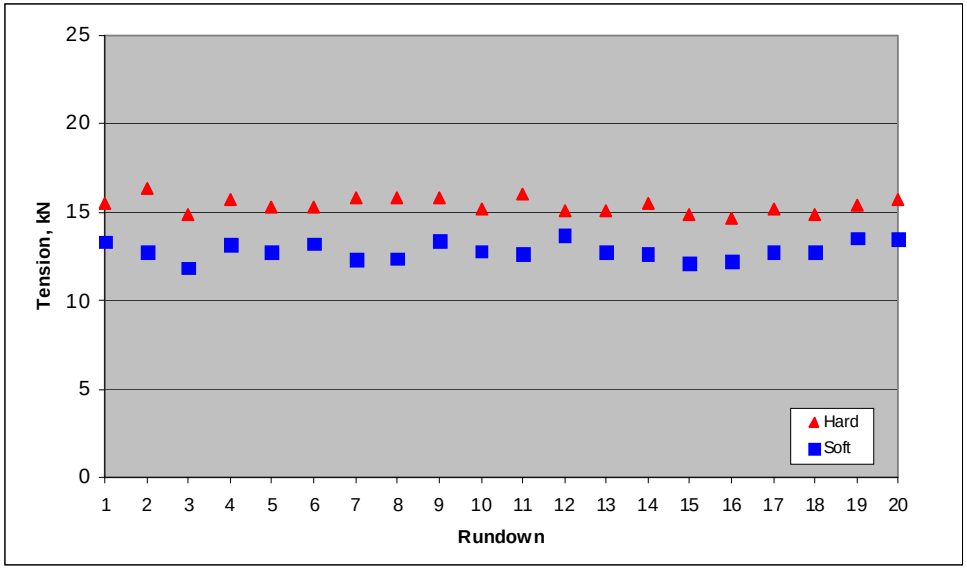
Test Results EYFLA-1A with Clutch at 30



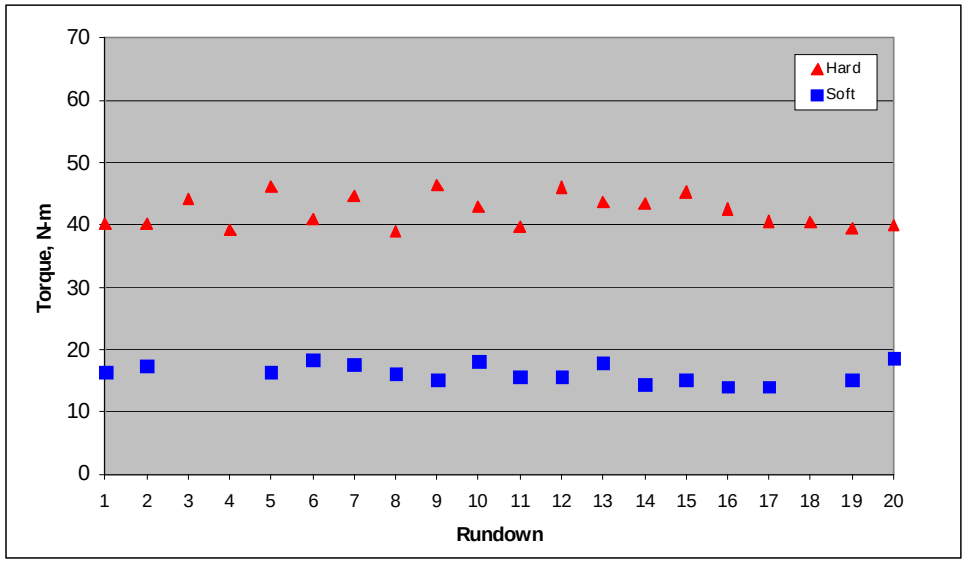


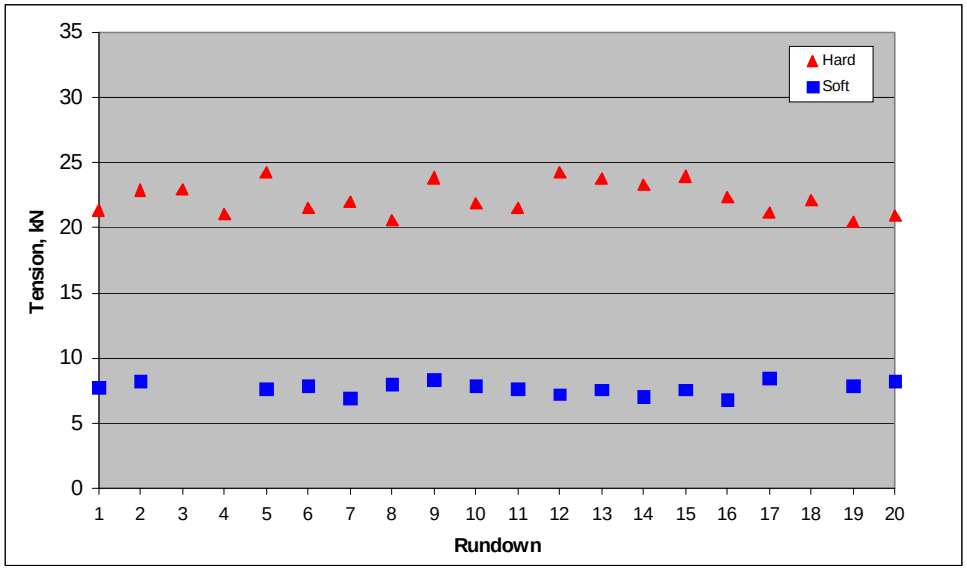
Test Results EYFLA-2Q with Clutch at 16





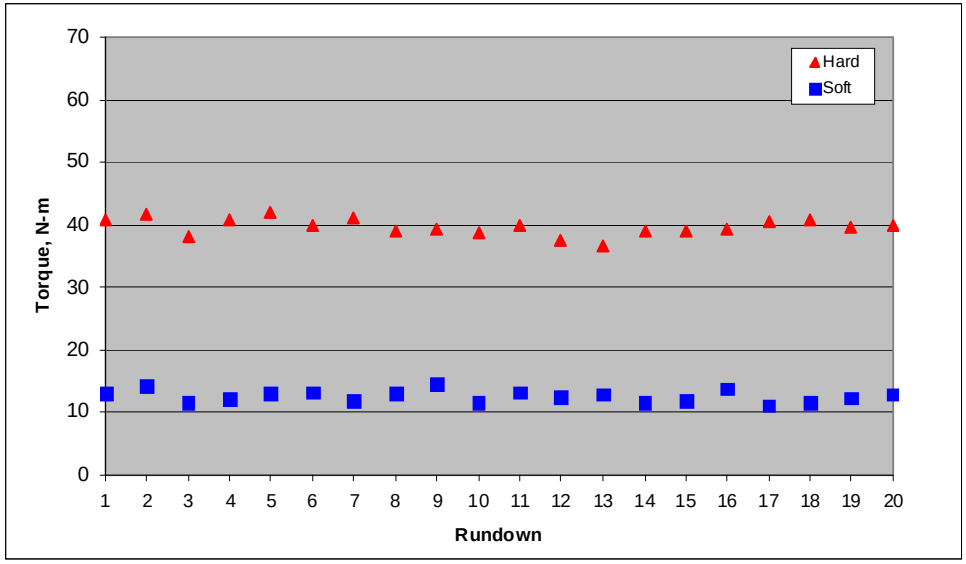
Test Results EYFLA-2Q with Clutch at 30

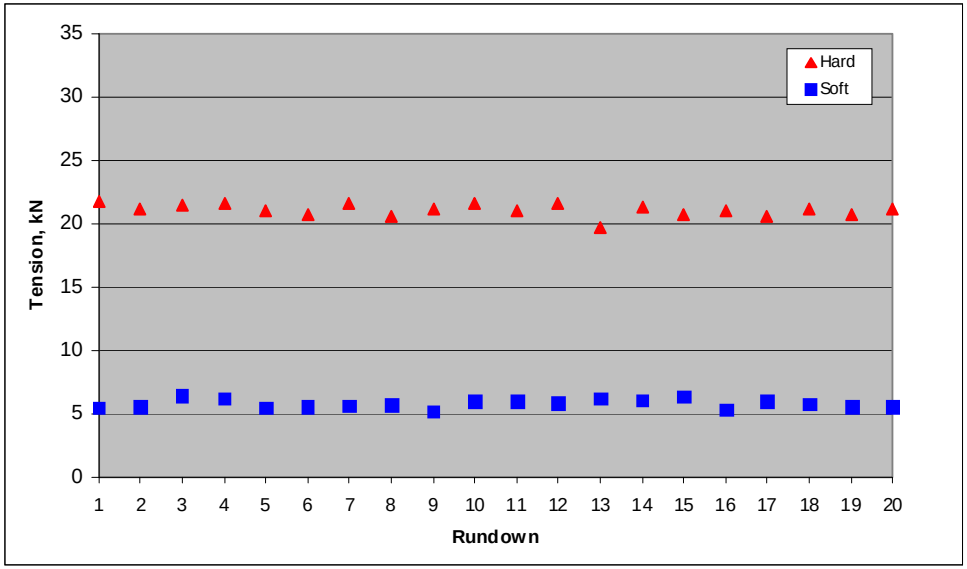




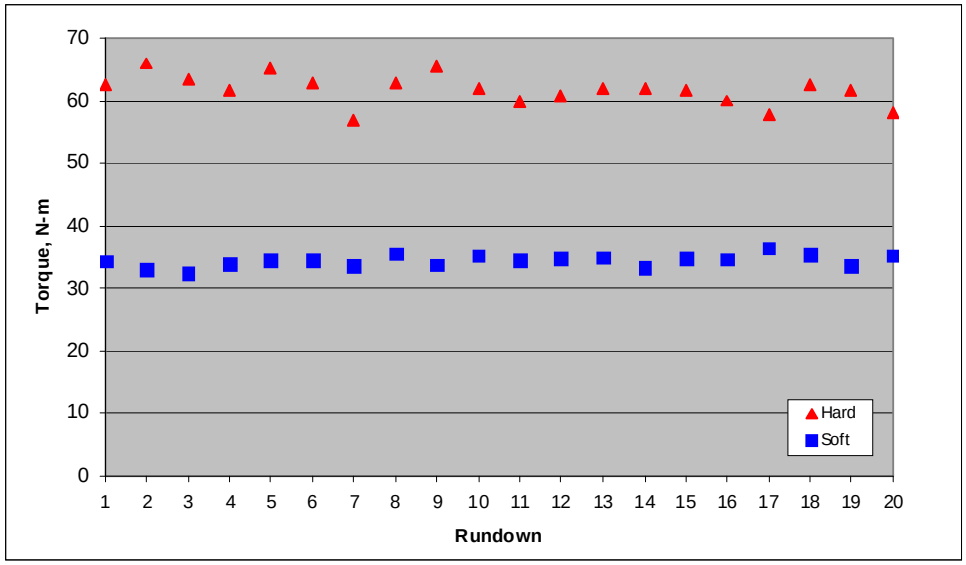
Torque and Tension data for Clutch #30 Soft based on 17 data points rather than 20

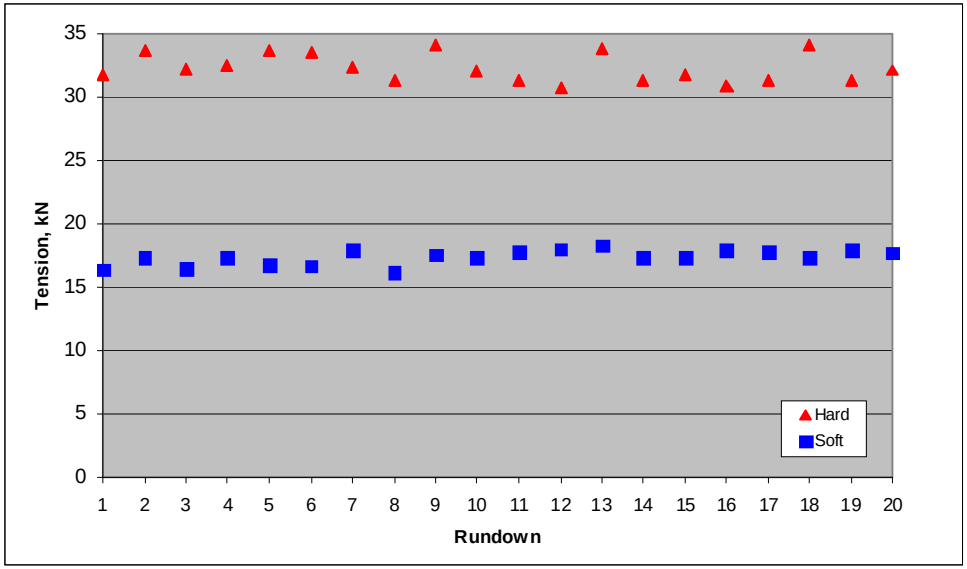
Test Results EYFLA-3J with Clutch at 16





Test Results EYFLA-3J with Clutch at 30





Appendix

Archetype Joint A2LA Scope of Accreditation

THE AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

ARCHETYPE JOINT, LLC
Orion, MI

for technical competence in the field of

Mechanical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 18 June 2005*).

Presented this 30th day of June 2008.

President
For the Accreditation Council
Certificate Number 2511.01
Valid to September 30, 2010

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Mechanical Scope of Accreditation.

Archetype Joint A2LA Scope of Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025: 2005

ARCHETYPE JOINT, LLC
140 Engelwood Drive, Suite D
Orion, MI 48359
David Archer Phone: 248 377 1147

MECHANICAL

Valid To: September 30, 2010 Certificate Number: 2511.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests on fasteners and metals:

Tests	Test Methods
Hardness (Rockwell C, B)	ASTM E18
Torque	ASME B18.16M; ASTM D5649-01; IFI 101, 100/107, 124, 524, 125, 525, 155, 555; SAE J78, J1237, J933, J2315; ISO 5393; In-Joint Torque/Angle; Residual Torque
Torque Tension	ASTM D5648; IFI 143, 543; ISO 16047; SAE J174, J174M; SAE/USCAR10; USCAR11; In-Joint Torque/Tension with Ultrasonics

Transient Recorder Calibration Certificate

ID# CO-03
LW
10/17/08

MICROCONTROL INC.
Real Time Systems

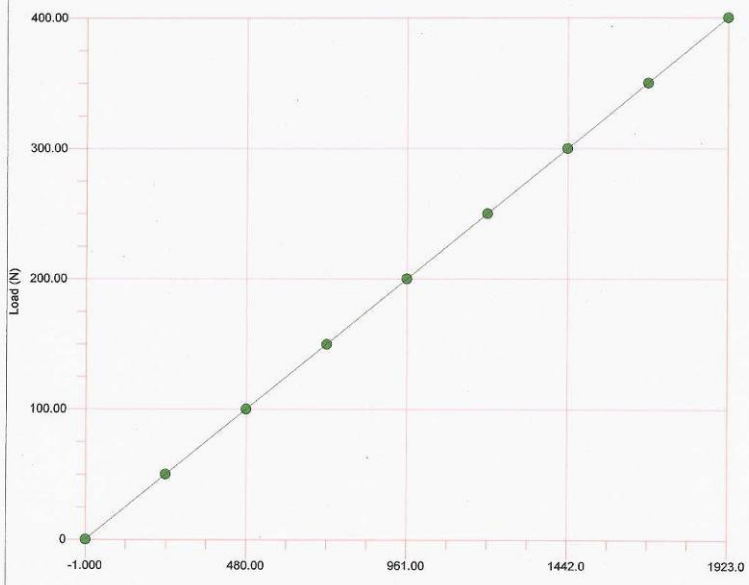
MC900 Calibration Data For Channel 1

Cal Date: 10/16/2008 Next Cal Due Date: 10/16/2009 MC900 Serial No.: MC102612 Calibrator: Model 1550A - Serial No. 129298 NIST No: 44124 Operator: M.N. Initials:	Gage Type: 350 Ohm Full Bridge, 10 Volt Excitation Offset Pot: 142 Gain Pot: 97 Hardware Filter: 300 Hz Comment: No Changes Were Made to the Hardware

Temperature = 65 F Humidity = 30%
Asset Number:

FullScale Error: 0.03% Acceptable Error: 0.25%

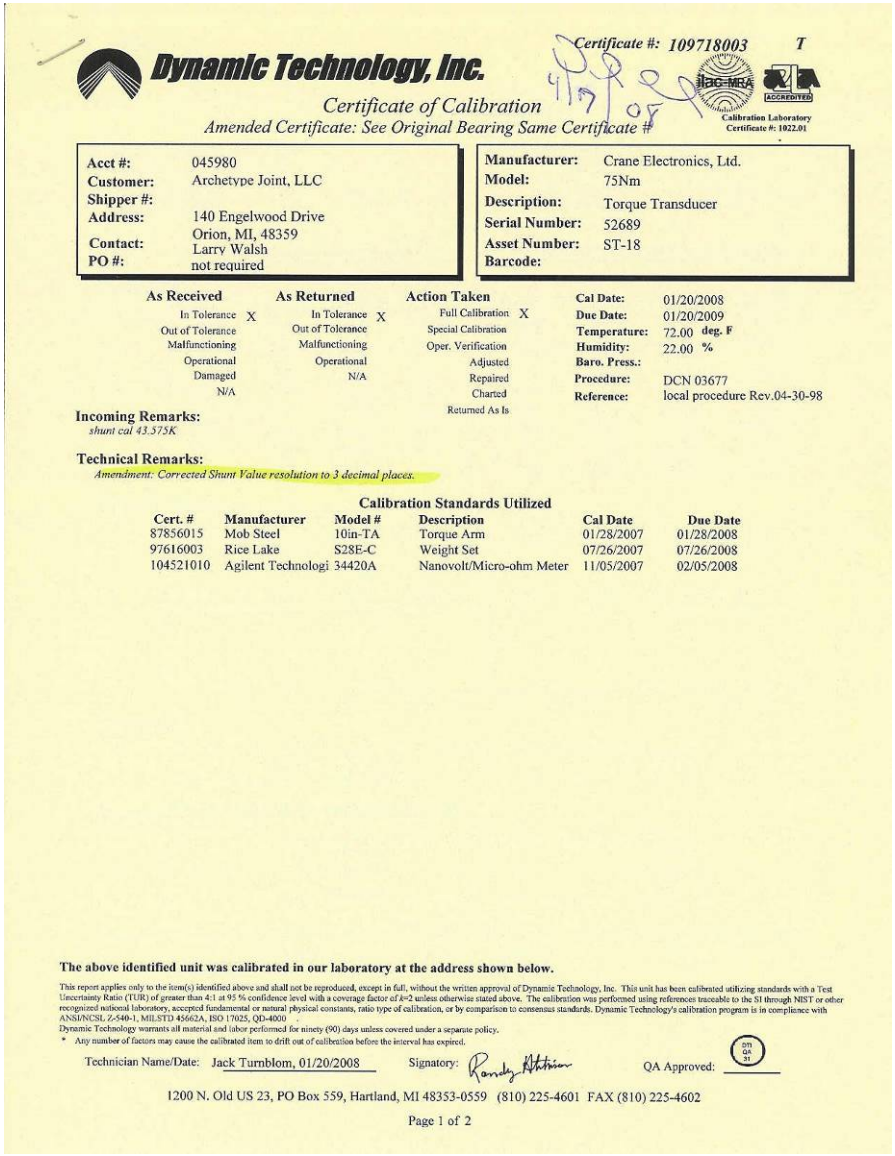
Load Vs AtoD Values



Measured	Fitted	Coef 0	Coef 1	Coef 2	Corr Coef	Std Err Est
●	—	0.40654	0.20781	0	1	0.1272

1307 Souter Blvd., Troy, Michigan 48083-2840 TEL: (248) 588-0100 • FAX: (248) 588-0124

Torque Transducer Calibration Certificate



Dynamic Technology, Inc.

Certificate #: 109718003 T

Certificate of Calibration

Amended Certificate: See Original Bearing Same Certificate #

Calibration Laboratory Certificate #: 1022.01

Acct #:	045980
Customer:	Archetype Joint, LLC
Shipper #:	
Address:	140 Engelwood Drive Orion, MI, 48359
Contact:	Larry Walsh
PO #:	not required

Manufacturer:	Crane Electronics, Ltd.
Model:	75Nm
Description:	Torque Transducer
Serial Number:	52689
Asset Number:	ST-18
Barcode:	

As Received	As Returned	Action Taken
In Tolerance X	In Tolerance X	Full Calibration X
Out of Tolerance	Out of Tolerance	Special Calibration
Malfunctioning	Malfunctioning	Oper. Verification
Operational	Operational	Adjusted
Damaged	N/A	Repaired
N/A		Charted
		Returned As Is

Cal Date:	01/20/2008
Due Date:	01/20/2009
Temperature:	72.00 deg. F
Humidity:	22.00 %
Baro. Press.:	
Procedure:	DCN 03677
Reference:	local procedure Rev.04-30-98

Incoming Remarks:

shunt cal 43.575K

Technical Remarks:

Amendment: Corrected Shunt Value resolution to 3 decimal places.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
87856015	Mob Steel	10in-TA	Torque Arm	01/28/2007	01/28/2008
97616003	Rice Lake	S28E-C	Weight Set	07/26/2007	07/26/2008
104521010	Agilent Technologi	34420A	Nanovolt/Micro-ohm Meter	11/05/2007	02/05/2008

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Dynamic Technology, Inc. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 at 95 % confidence level with a coverage factor of k=2 unless otherwise stated above. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Dynamic Technology's calibration program is in compliance with ANSI/NCSL Z-540-1, MILSTD 45662A, ISO 17025, QD-4000 .

Dynamic Technology warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

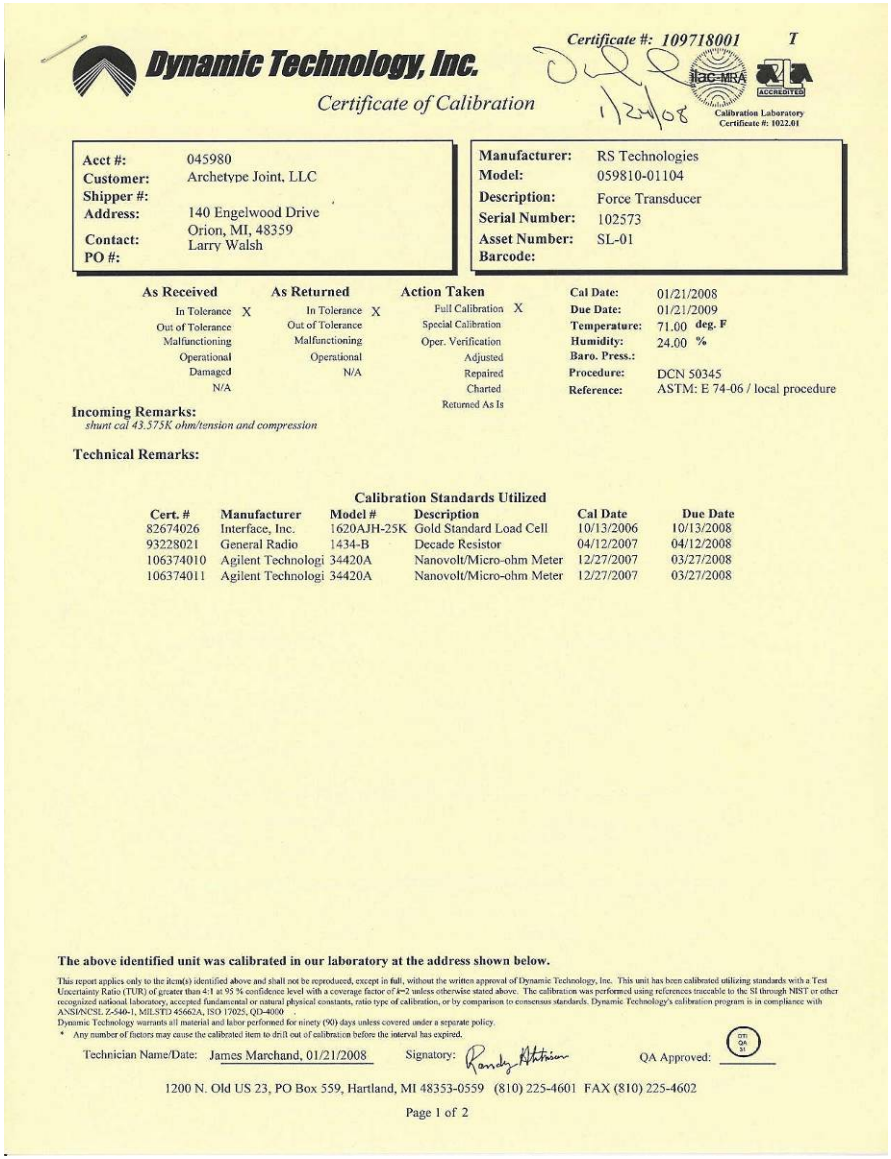
* Any number of factors may cause the calibrated item to drift out of calibration before the interval has expired.

Technician Name/Date: Jack Turnblom, 01/20/2008 Signatory: Randy Atkinson QA Approved:

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602

Page 1 of 2

Load Cell Calibration Certificate



Dynamic Technology, Inc.

Certificate of Calibration

Certificate #: 109718001 T

1/24/08

ilac-MRA ACCREDITED Calibration Laboratory Certificate #: 1022.01

Acct #:	045980
Customer:	Archetype Joint, LLC
Shipper #:	
Address:	140 Engelwood Drive Orion, MI, 48359
Contact:	Larry Walsh
PO #:	

Manufacturer:	RS Technologies
Model:	059810-01104
Description:	Force Transducer
Serial Number:	102573
Asset Number:	SL-01
Barcode:	

As Received		As Returned		Action Taken	
In Tolerance	X	In Tolerance	X	Full Calibration	X
Out of Tolerance		Out of Tolerance		Special Calibration	
Malfunctioning		Malfunctioning		Oper. Verification	
Operational		Operational		Adjusted	
Damaged		N/A		Repaired	
N/A				Charted	
				Returned As Is	

Cal Date:	01/21/2008
Due Date:	01/21/2009
Temperature:	71.00 **deg. F**
Humidity:	24.00 **%**
Baro. Press.:	
Procedure:	DCN 50345
Reference:	ASTM: E 74-06 / local procedure

Incoming Remarks:
shunt cal 43.575K ohm/tension and compression

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
82674026	Interface, Inc.	1620AJH-25K	Gold Standard Load Cell	10/13/2006	10/13/2008
93228021	General Radio	1434-B	Decade Resistor	04/12/2007	04/12/2008
106374010	Agilent Technologi	34420A	Nanovolt/Micro-ohm Meter	12/27/2007	03/27/2008
106374011	Agilent Technologi	34420A	Nanovolt/Micro-ohm Meter	12/27/2007	03/27/2008

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Dynamic Technology, Inc. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 at 95 % confidence level with a coverage factor of k=2 unless otherwise stated above. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Dynamic Technology's calibration program is in compliance with ANSI/NCSL Z-540-1, MIL-STD 45662A, ISO 17025, Q9-4000

Dynamic Technology warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of calibration before the interval has expired.

Technician Name/Date: James Marchand, 01/21/2008 Signatory: Randy Atkinson QA Approved:

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602

Page 1 of 2

M6 Test Washer Certificate of Conformance

Wilson-Garner Company
Certificate of Conformance
Per Requirements of MIL-I-45208A and Mil-Std-45662A

Registered by UL
ISO9001:2000
TS16949:2002

L-A-B Accreditation
ISO / IEC 17025:2005
Certificate # L1107-1

ARCHETYPE JOINT
140 ENGELWOOD DRIVE.
SUITE D
ORION, MI 48359

PO# VERBAL 10/17/08
Qty Ordered: 100 **Shipped:** 100
Shipper Number: 021444
Customer Pt. #: N/A

Lot Number: PO53227A
Part Number: SFM006HS (11515487)
Blueprint Number: 11515485
Revision/Date: 0522/1989
Part Name: Test Washer
Part Description M6
Manufacture Date: - -
Inspection Date: 03-18-2005

SAMPLING PLAN	ASQZ1.4-1993
Non-Destructive	315
Destructive	5
MATERIAL	Per B/P 11515485
Grade	Carbon 1050
Heat Number	B47740
Supplier	Alkar Steel
MECHANICAL TESTS	Per B/P 11515485
Core Hardness	78 RA
Surface Hardness	87 - 88 R15N
Discontinuities	Visual Okay

DIMENSIONAL	Meets the Requirements of
Blue Print/Spec.	11515485
SURFACE FINISH	Plain

This is to certify that the above item was domestically manufactured in a mercury free environment. All inspections and tests performed conform to the standards and/or specifications requirements. Documented evidence of these are on file and available for review for a minimum of ten (10) years. This certificate shall not be reproduced except in full and without prior written approval of the Wilson-Garner Company. The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under Federal Statutes.

Notary Public
State Seal

Keith Pinchback
Notary Public - Macomb County, MI
My Commission Expires 10-07-2013

Signature: Timothy Pinchback
Title: President
10/20/2008

Wilson-Garner Company • 40935 Production Drive • Harrison Township, MI 48045
Voice: 586-466-5880 • Fax: 586-465-4408 • E-Mail: wg@placebolt.com

WG Lot# PO53227A - Page 1 of 3 - 10/20/2008

M8 Test Washer Certificate of Conformance

Wilson-Garner Company
Certificate of Conformance
Per Requirements of MIL-I-45208A and Mil-Std-45662A

Registered by UL
ISO9001:2000
TS16949:2002

L-A-B Accreditation
ISO / IEC 17025:2005
Certificate # L1107-1

ARCHETYPE JOINT
140 ENGELWOOD DRIVE.
SUITE D
ORION, MI 48359

PO# VERBAL 10/17/08
Qty Ordered: 100 Shipped: 100
Shipper Number: 021444
Customer Pt. #: N/A

Lot Number:	PO54691A
Part Number:	SFM008HS
Blueprint Number:	11515485
Revision/Date:	Rel 5/22/1989
Part Name:	Washer
Part Description	M8 SQUARE TEST WASHERS
Manufacture Date:	02-12-2008
Inspection Date:	02-12-2008

SAMPLING PLAN	ASQCZ1.4-1993
Non-Destructive	315
Destructive	5
MATERIAL	PER B/P
Grade	1050
Heat Number	DLL79566GF
Supplier	REGAL STEEL
MECHANICAL TESTS	PER B/P
Core Hardness	75.3 - 78.0 RA
Surface Hardness	87.3 - 88.0 R15N
Discontinuities	Visual Okay
DIMENSIONAL	Meets the Requirements of
Blue Print/Spec.	11515485
SURFACE FINISH	Plain

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Notary Public
State Seal

Keith Pinchback
Notary Public - Macomb County, MI
My Commission Expires 10-07-2013

Signature: Timothy Pinchback
Title: President
10/20/2008

Wilson-Garner Company • 40935 Production Drive • Harrison Township, MI 48045
Voice: 586-466-5880 • Fax: 586-465-4408 • E-Mail: wg@placebolt.com

WG Lot# PO54691A - Page 1 of 7 - 10/20/2008

M10 Test Washer Certificate of Conformance

Wilson-Garner Company
Certificate of Conformance
Per Requirements of MIL-I-45208A and Mil-Std-45662A

Registered by UL
ISO9001:2000
TS16949:2002

L-A-B Accreditation
ISO / IEC 17025:2005
Certificate # L1107-1

ARCHETYPE JOINT
140 ENGELWOOD DRIVE.
SUITE D
ORION, MI 48359

PO# VERBAL 10/17/08
Qty Ordered: 150 **Shipped:** 150
Shipper Number: 021444
Customer Pt. #: N/A

Lot Number:	PO54511A
Part Number:	SFM010HS
Blueprint Number:	11515485
Revision/Date:	05/22/1989
Part Name:	Metric Square Test Washer
Part Description	M10
Manufacture Date:	10-17-2007
Inspection Date:	10-17-2007

SAMPLING PLAN	ASQCZ1.4-1993
Non-Destructive	500
Destructive	8
MATERIAL	PER B/P
Grade	1050
Heat Number	DLL79566GF
Supplier	Regal Steel
MECHANICAL TESTS	PER B/P
Core Hardness	77.3 - 78.0 RA
Surface Hardness	87.3 - 88.0 R15N
Discontinuities	Visual Okay
DIMENSIONAL	Meets the Requirements of
Blue Print/Spec.	11515485
SURFACE FINISH	Plain

This is to certify that the above item was domestically manufactured in a mercury free environment. All inspections and tests performed conform to the standards and/or specifications requirements. Documented evidence of these are on file and available for review for a minimum of ten (10) years. This certificate shall not be reproduced except in full and without prior written approval of the Wilson-Garner Company. The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under Federal Statutes.

Notary Public
State Seal

Keith Pinchback
Notary Public - Macomb County, MI
My Commission Expires 10-07-2013

Signature: Timothy Pinchback
Title: President
10/20/2008

Wilson-Garner Company • 40935 Production Drive • Harrison Township, MI 48045
Voice: 586-466-5880 • Fax: 586-465-4408 • E-Mail: wg@placebolt.com

WG Lot# PO54511A - Page 1 of 7 - 10/20/2008

The 480 individual Tension-Time and Torque-Angle traces captured for each torque and tension measurement have been provided as a separate PDF file.

END OF TEST REPORT