FASTENER TESTING SENSORS

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FASTENER TESTING

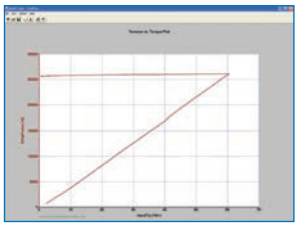
Many factors must be considered when establishing a threaded fastener bolted joint analysis program, which should include methods for modeling the joint, determining torque-tension characteristics and friction coefficients, and experimental testing of components and assemblies.

Test methods have been established and published for mechanical properties such as hardness, tensile strength, and torsional strength as well as corrosion and hydrogen embrittlement. These provide the baseline information necessary for proper interpretation of the friction coefficient, torque-tension, and angular ductility testing tests that are used to complete the evaluation of bolted joints. Once the basic material strength and friction coefficient information has been determined, an additional method, Torque-Angle Signature Analysis, can provide valuable information on joint strength and performance when applied to testing fasteners in bolted joints.The basic torque-angle signature can be used as a starting point for all analysis. For example, it can be used to illustrate the influence of underhead and thread friction on the tightening process where an increase in friction, in either the thread or underhead regions, can result in a proportional increase in the slope of the torque-angle signature. The study of the slope of the torque-angle curve when the fastener is tightened is an important component of analyzing the performance of threaded fasteners in bolted joints.

To apply torque-angle signature analysis, a torque-angle recording device is needed for measurement and curve plotting. The recorder can provide curves on-screen for analysis as well as print them out for additional study. Tightening, audit, and release angle signatures for a given bolted joint can be simultaneously displayed and printed. A careful review of the applied torque vs. angle-of-turn plot, signature analysis can be used to evaluate bolted joints for loss of preload due to settling, creep and relaxation, or vibration and dynamic loading. In addition, joint strength problems such as thread strip and embedment of bearing surfaces and material yield within the bolted joint are easily identified.

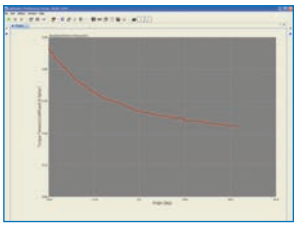
The following tests are typically conducted in the fastener testing area...

TORQUE TENSION TESTING



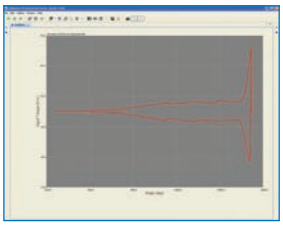
Threaded fastener testing usually begins with determining how consistently the fastener will perform when tightened into an assembly. This testing mounts the test bolt and test nut in a fastener tension load cell along with a test washer or a coupon of the actual assembly material to determine the relationship between torque, angle of rotation, and clamp load. An example is where the applied torque must fall within a defined window of acceptability when reaching a specified clamp load. A variety of graphs can be generated depending upon your data requirements, such as Torque vs. Clamp Load, Torque vs. Angle, or Torque and Clamp Load vs. Angle. Required components include data acquisition, a rotary torque angle transducer, a clamp force load cell, a DC electric drive motor and controller, and a suitable fixture assembly for mounting test system components.

FRICTION COEFFICIENT TESTING



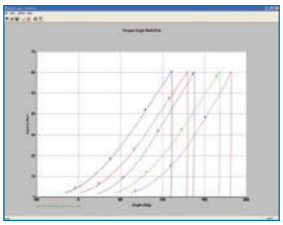
The application of plating or coatings to a threaded fastener can greatly affect the state of friction in the joint. A small change in the amount of friction in a joint can produce a great variation in clamp load when the fastener is tightened. To ensure that the state of friction is consistent, the fastener is mounted in a special clamp force load cell that measures not only clamp load but also thread torque, which is referred to as a research head. This allows the testing software to separate the thread torque from the input torque to determine the underhead friction torque and thread friction torque. These values are used along with the geometry of the fastener to calculate friction coefficients for the underhead and thread regions, as well as the so-called “nut factor”, K. Systems for testing friction coefficients include a data acquisition module, a rotary torque angle transducer, a research head load cell, a DC electric drive motor and controller, and a suitable fixture assembly for mounting test system components.

LOCKNUT TESTING



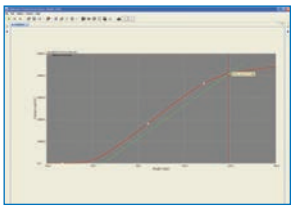
Special test routines include those required for testing prevailing torque locknuts according to widely accepted test specifications. There are several test specifications for verifying the performance characteristics of fasteners with built-in thread locking devices. These devices include nylon thread lockers, crimped or deformed nuts, thread patches, or adhesives. The nut is run down onto a test bolt and the applied torque and angle of fastener rotation is measured to determine how much energy is required to break through the locking device. The amount of torque required to remove the nut may also be measured. This testing may also require that the fastener be run down several times with the measured torque of the first rundown compared to that of a subsequent rundown, such as the fifth or tenth run. Typical system components will include data acquisition with drive motor interface, DC drive motors, rotary torque angle transducers, clamp force load cells, and fixture assemblies.

BOLTED JOINT ANALYSIS AND TROUBLESHOOTING



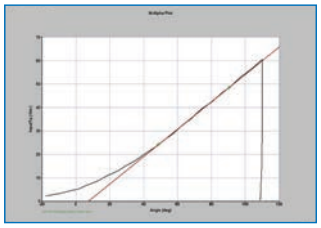
The starting point for bolted joint analysis is the torque-angle signature recorded during testing. Many things can be learned from reviewing the torque vs. angle curve including the influence of underhead and thread friction on the tightening process. The first step in signature analysis is to examine the slope of the elastic tightening zone. For example, an increase in friction, in either the thread or underhead regions, results in a proportional increase in the slope of the torque-angle signature. If fastener clamp load can be measured, the torque-angle signature can be used to determine the angle-tension coefficient which can then be used to verify clamp load in actual assemblies. A system to perform this testing will include at least data acquisition and a rotary torque-angle transducer. A transducer that can measure clamp load is a very helpful accessory.

YIELD DETERMINATION TESTING



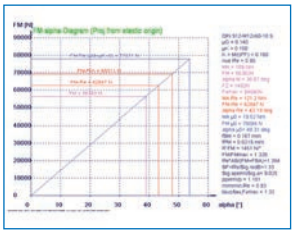
Determining the point at which the fastener begins to yield can be a critical bit of knowledge, particularly for a critical fastener application. Yield determination testing mounts the fastener in a tension load cell with test washers or coupons of actual materials. The fastener is tightened to failure and the resulting data is examined to determine the yield point of the fastener.

ASSEMBLY STRATEGY TESTING



Determining the tightening strategy for a given assembly often begins with torque-to-failure testing where the fasteners are driven to failure on actual assemblies. Torque-angle signatures can be plotted and analyzed to determine the point of yield, the point of fracture, the onset of elastic tightening, and other important aspects of the joint. Once the cause of failure is analyzed, this data can then be used to help establish or verify the assembly specifications and the type of tightening strategy that will produce reliable assemblies. M-Alpha graphing capability can also be used to estimate the relative difference in clamp loads produced with different coatings, plating, finishes, etc. Required components may include data acquisition, rotary torque angle transducer, clamp force load cell, and a drive motor similar to that used in the assembly process.

BOLTED JOINT MODELING AND ANALYSIS



Often before fastener testing is begun, it can be helpful to model the bolted joint to determine the possibility of failure in one of the components. Bolted Joint Design and Analysis software can be used to calculate the stresses present in the joint and identify possible causes of failure. The German engineering standard, VDI-2230, is often used to close the loop between fastener design and application.

COMPONENTS OF A TORQUE TENSION SYSTEM

Whether a portable test system or a full laboratory system, they are typically comprised of the following five components: data acquisition, rotary torque-angle transducer, clamp force load cell, drive system, and a fixture assembly.

DATA ACQUISITION

The key component in a torque-tension test system is data acquisition. PCB offers the portable Model 962 as an entry-level system for collecting torque, angle, and clamp load data that can store, print, and upload graphic and numeric data to a PC.

ROTARY TORQUE-ANGLE SENSORS

The second component in a test system measures the applied torque and the angle of fastener rotation. These accurate and durable sensors come in a variety of capacities, from 32 ozf-in up to 18,000 lbf-ft. They are fitted onto the “business end” of the drive tool to record the input torque and the angle of fastener rotation.

FASTENER TENSION LOAD CELL

The third major component measures the clamp load or fastener tension developed when the fastener is tightened. PCB's RS Technologies can provide the right sensor for the test at hand from simple fastener load washers that can measure clamp load on actual assemblies, to more accurate fastener clamp load cells for torque-tension testing, up to torque-tension load cells for measuring thread torque in addition to clamp load for higher level calculation of friction coefficients.

DRIVE SYSTEM

The fourth component is the drive system that supplies the applied torque to tighten the fastener. For the most basic system it might be a hand-held tool. For most standard torque-tension testing it’s a DC electric drive motor and controller that are controlled by the operator.

FIXTURE ASSEMBLY

The fifth and final component is a fixture assembly that brings all of the system together. These come in a variety of configurations, vertical, horizontal, tabletop, freestanding, or mobile cart. They provide mounting for the drive motor, torque-angle sensor, clamp force or torque-tension load cells.

PORTABLE DATA TRANSIENT RECORDER

Model 962 Portable Data Transient Recorder is a battery-operated recorder with two transducer inputs that can be used with torque-only, torque-angle, or load transducers. It can serve as a portable threaded fastener laboratory for measuring fastener torque, angle of turn, and clamp load. Ideal for performing fastener analysis, for auditing and certifying power tools, and for testing hand torque wrenches; Model 962 is a cost effective, versatile, and easy-to-use recorder that can collect numeric peak data, XY graphic plots, and store on a USB memory drive. Data can be easily displayed or printed on a PC running FastPlot2 software. Setup and calibration menus assure ease of operation, and the unit can be used with all RS Technologies' rotary torque-angle and clamp force transducers and other conventional and industry-standard strain gage transducers.

STATISTICS

After three rundowns, Model 962 updates statistics including standard deviation and Cpk. It also flags data as being high or low depending upon the programmed engineering limits.

DATA AND COMMUNICATIONS

Graphic plots, numeric data reports, and statistics are printed via the parallel port. Download data to a PC for further analysis using the optional FastPlot2 software.

REAL-TIME PLOTTING CAPABILITIES

Model 962 captures real-time and peak readings for torque-angle, torque-clamp load, or torque-time and displays or plots one of the following, based upon the instrument setup:

- Torque vs. Time
- Torque vs. Angle
- Torque & Angle vs. Time
- Torque & Clamp Force vs. Time
- Torque & Clamp Force vs. Angle
- Clamp Force vs. Torque
- Tool RPM vs. Time
- Tool RPM vs. Angle

SPECIFICATIONS		
Model Number		
Full Model Number	080962-01000	
Short Model Number	962	
Performance		
Torque and Force Input Channels		
Input Range	±2.5 mV/V, ±4.5 mV/V, ±5 VDC	
Excitation	5 VDC, 120 mA Maximum	
Resolution	21 -bit	
Non-linearity	0.25% Maximum (F.S.)	
Frequency Response	10 kHz	
Positive Voltage Peak Trap Circuit	7 ms Reset Time	
Peak Threshold	Software Programmable	
Peak Reset	Manual or Software Programmable (Automatic Reset)	
Angle Input Channel		
Type	Quadrature A/B Track	
Excitation	5 VDC	
Input Frequency	1000 kHz Maximum	
Physical		
Temperature Range	+32 to +158 °F (0 to +70 °C)	
Display		
Viewing Area	4.85 x 2.68 in (123 x 68 mm)	
Resolution	240 x 128 Pixels, Backlit LCD	
Battery		
Indication	Battery Low Indication	
Battery Life	8 Hours Maximum, Continuous Use	
Charge Time	3.5 Hours, Maximum	
Dimensions		
Size (W x D x H)	10.12 x 8.50 x 3.25 in	257.0 x 215.9 x 85.1 mm
Weight	6.0 lb	2700 gm
Mating Connectors		
Channel 1 and Channel 2	DB, 15 Pins	
TTL/IO	DB, 25 Pins	
USB Port A	A Type	
USB Port B	B Type	
Supplied Accessories		
FastPlot2 Upload/Graphing Utility for PC Running Windows® 7/10, Battery Charger, USB Cable, 8GB USB Memory Drive, Instruction Manual, Carrying Case, & A2LA Accredited Calibration Certificate		

ROTARY TORQUE TRANSDUCERS

ROTARY TORQUE TRANSDUCERS				
Torque-Angle w/ Auto-ID (Model #)	Torque Only w/ Auto-ID (Model #)	Torque Only (Model #)	Drive Size	Capacity
039230-50002/B	039030-50002	039030-54002	1/4 inch Hex Drive	32 ozf-in (0.23 Nm)
039230-50021/B	039030-50021	039030-54021	1/4 inch Hex Drive	20 lbf-in (2.3 Nm)
039230-50101/B	039030-50101	039030-54101	1/4 inch Hex Drive	100 lbf-in (11.3 Nm)
039230-51015/B	039030-51015	039030-54015	1/4 inch Hex Drive	132 lbf-in (15 Nm)
039225-50051/B	039025-50051	039025-54051	1/4 inch Square Drive	50 lbf-in (5.6 Nm)
039225-50101/B	039025-50101	039025-54101	1/4 inch Square Drive	100 lbf-in (11.3 Nm)
039225-51015/B	039025-51015	039025-54015	1/4 inch Square Drive	132 lbf-in (15 Nm)
039237-50022/B	039037-50022	039037-54022	3/8 inch Square Drive	200 lbf-in (22.6 Nm)
039237-50051/B	039037-50051	039037-54051	3/8 inch Square Drive	50 lbf-ft (68 Nm)
039250-50101/B	039050-50101	039050-54101	1/2 inch Square Drive	100 lbf-ft (136 Nm)
039250-51201/B	039050-51201	039050-54201	1/2 inch Square Drive	148 lbf-ft (200 Nm)
039275-50301/B	039075-50301	039075-54301	3/4 inch Square Drive	300 lbf-ft (406 Nm)
039275-51501/B	039075-51501	039075-54501	3/4 inch Square Drive	369 lbf-ft (500 Nm)
039275-53601/B+	039075-53601	---	3/4 inch Square Drive	600 lbf-ft (814 Nm)
039201-53102/B	039001-53102	039001-54102	1 inch Square Drive	1000 lbf-ft (1356 Nm)
039201-01302/B	039001-01302	039001-54302	1 inch Square Drive	2213 lbf-ft (3,000 Nm)
039201-53302/B	039001-53033	---	1 inch Square Drive	3000 lbf-ft (4068 Nm)
039301-01103/B	039001-01103	---	1-1/2 inch Square Drive	7376 lbf-ft (10,000 Nm)
039625-00183	---	---	2-1/2 inch Square Drive	18,000 lbf-ft (24,000 Nm)

Series PC9000 Rotary Torque Sensors are widely used in the fastener assembly market to verify the performance of hand and power torque tools. The durable, strain gage-based transducers are fitted on the output drive of the hand or power tool and measure the torque applied by the tool to the fastener on an actual assembly. This measurement provides important information about tool shut off and can assist in establishing specifications for proper assembly. With the integrated angle encoder, a rotary torque-angle transducer can also measure the angle of fastener rotation, which is an important indication of joint integrity. Torque Only models are available for impact tool testing.

SPECIFICATIONS	
Performance	
Torque	
Output at Rated Capacity	2 mV/V ≤ 0.25% FS
Shunt Calibration	Matched 2mV/V ≤ 0.25% with 43.575 kOhm Precision Resistor
Interchangeability	Matched for mV/V and Shunt Calibration ≤ 0.30% FS
Non-Linearity	≤ 0.25% FS
Hysteresis	≤ 0.25% FS
Excitation Voltage [1]	10 VDC
Bridge Resistance	350 Ohm
Compensated Temperature Range	+70 to +150 °F (+21 to +66 °C)
Operating Temperature Range	0 to +200 °F (-18 to +93 °C)
Connector	Auto-ID = PT02H-12-10P Non-Auto-ID = PT02H-8-4P
Angle	
Magnetic Encoder	¼", ⅜" and ½" Drive – 368 Poles, ¾" Drive – 544 Poles, 1" and 1-½" Drive – 720 Poles, 2-½" Drives – 900 Poles
Output	A-B Track 90 Degrees Phase Difference Flat Over Operating Speed Range
Counts Per Resolution (CPR), Resolution w/Quadrature	¼", ⅜", ½" Drive – 1472, ¼ Degree, ¾" Drive+ – 2176, ⅙ Degree, 1" and 1-½" Drive – 2880, ⅛ Degree, 2-½" Drive 3600, 1/10 Degree
Output Voltage	High 5.0 V, Low 0.5 V
Power Required	5 VDC @ 120 mA Maximum
Maximum Speed	
¼-inch Drive	5000
⅜-inch Drive	2500
½-inch Drive	2500
¾-inch Drive	2000
1-inch Drive	1000
1 ½-inch Drive	750
2 ½-inch Drive	500
Supplied Accessories	
Shunt Calibration Resistor, A2LA Accredited Calibration Certificate	

[1] Calibrated at 10 VDC, usable 5 to 20 VDC or VAC RMS

FASTENER TENSION & TORQUE-TENSION LOAD CELLS

Series FT9000 & FTA9000 Fastener Tension and Torque-Tension Load Cells use a full bridge strain gage design. This complete line of fastener testing load cells provides a signal proportional to the tension developed in a test fastener when the tightening torque is applied. In addition, the fastener torque-tension version, also referred to as a research head, measures the thread torque (pitch torque plus thread friction torque) at the same time. The tension or torque-tension output signals from either type of load cell are read using a conventional strain gage readout device or recorded by a data acquisition system. These load cells serve as an integral part of a torque-tension fastener test system when used with a torque-angle sensor and a suitable data acquisition instrument; Model 962 Portable Data Transient Recorder available from RS Technologies, is recommended.

COMMON SPECIFICATIONS	
Output	2.0 mV/V FS
Non-linearity	±0.25% FS
Overload Capacity	150% FS
Hysteresis	± 0.2% FS
Excitation Voltage	Calibrated at 10 VDC, usable 5 to 20 VDC or VAC RMS
Bridge Resistance	350 Ohms, Full Bridge, Bonded Strain Gage
Supplied Accessories	
Shunt Calibration Resistor, Clamp Assembly,, A2LA Accredited Calibration Certificate	

SERIES FT9000 TENSION LOAD CELLS

Model	Capacity	Tabletop Slide
059810-01153	3372 lbf (15 kN)	Single
059810-01253	5620 lbf (25 kN)	Single
059810-01104	22.5 klbf (100 kN)	Single
059810-01304	67.5 klbf (300 kN)	Single
059810-01504	112 klbf (500 kN)	Single

SERIES FTA9000 TORQUE-TENSION LOAD CELLS

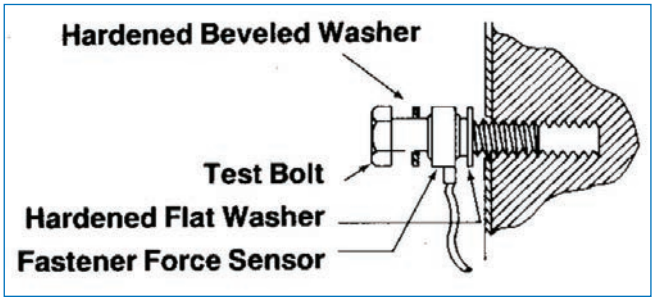
Model	Thread Torque Capacity	Fastener Tension Capacity	Tabletop Slide
059400-01024	15 lbf-ft (20 Nm)	4.5 klbf (20 kN)	Single
059500-01044	44.3 lbf-ft (60 Nm)	9.0 klbf (40 kN)	Single
059600-01104	110.6 lbf-ft (150 Nm)	22.5 klbf (100 kN)	Single
059625-01304	590 lbf-ft (800 Nm)	67.4 klbf (300 kN)	Single
059650-01604	1475 lbf-ft (2000 Nm)	135 klbf (600 kN)	Single
059720-01095	2950 lbf-ft (4000 Nm)	202 klbf (900 kN)	Dual
059740-01185	5900 lbf-ft (8000 Nm)	405 klbf (1800 kN)	Dual

FORCE WASHERS

Series FT4000 Force Washer Transducers are miniature load cells designed specifically for measuring fastener clamping forces. The design provides high stiffness in a small package, making these load cells ideal for static and dynamic measurements on fasteners, or structural test applications where space limitations exist. Load washer transducers come in a variety of English and Metric sizes. All transducers are carefully sealed and thoroughly tested prior to shipment. Two hardened steel washers are provided with each unit and should be mounted on both sides of the transducer to minimize any transmitted rotational effects or spot/side loading. Please refer to the illustration below more information.

Series FT4000 Force Washer Transducers can be used along with rotary torque or torque-angle transducers and a data acquisition instrument, such as the Model 962 Portable Transient Data Recorder, to acquire fastener testing data. If fastener clamp load alone is required, Model 922 Portable Digital Meter can quickly capture and record the data.

NOTE: Fastener Load Washers are not designed for use as high-accuracy clamp force measurement devices.

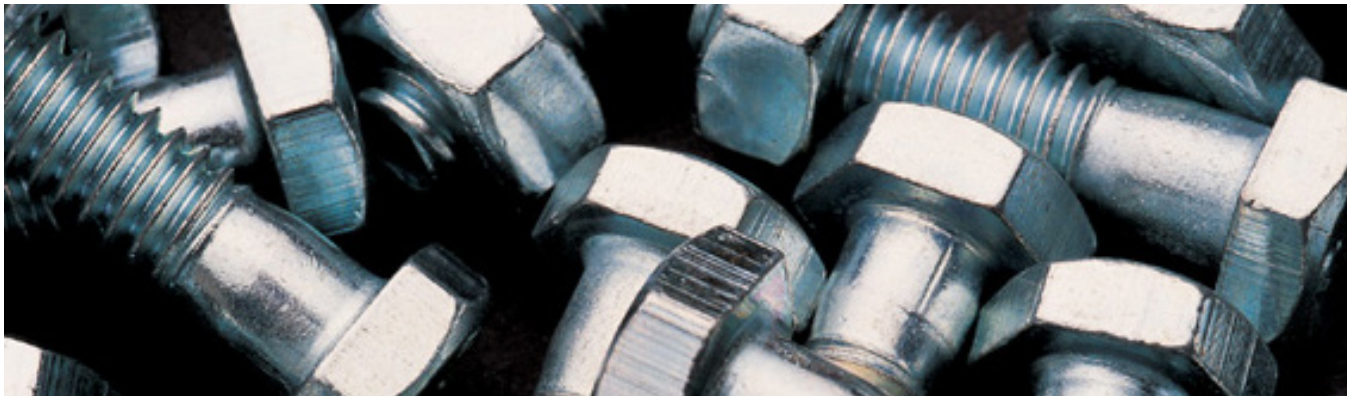


COMMON SPECIFICATIONS	
Construction	Steel Flexure, Aluminum Cover
Output	1.5 mV/V FS Nominal
Overload Capacity	150% FS
Non-linearity	±5% FS
Hysteresis	±5% FS
Non-Repeatability	±2% FS
Excitation Voltage	Calibrated at 10 VDC, usable 5 to 20 VDC or VAC RMS
Bridge Resistance	350 Ohms
Operating Temperature Range	0 to +200 °F -18 to +93 °C
Supplied Accessories	
Top and Bottom Pair Hardened Washers, Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate	

IMPERIAL SIZES (IN)					
Model	**Bolt Size (in)**	**Capacity (lbf)**	**Inner Diameter (in)**	**Outer Diameter (in)**	**Height (in)**
054103-01252	#10	2500	0.196	0.625	0.255
054104-01502	¼	5000	0.257	0.674	0.255
054105-01802	5⁄16	8000	0.321	0.809	0.317
054106-01103	⅜	10,000	0.382	0.842	0.380
054107-01153	7⁄16	15,000	0.444	0.943	0.420
054108-01203	½	20,000	0.507	1.111	0.455
054109-01253	9⁄16	25,000	0.570	1.213	0.495
054110-01303	⅝	30,000	0.636	1.350	0.525
054112-01403	¾	40,000	0.757	1.620	0.595
054114-01603	⅞	60,000	0.882	1.888	0.665
054116-01803	1	80,000	1.006	2.160	0.735
054124-01104	2	100,000	2.047	3.730	0.933

METRIC SIZES (MM)					
Model	**Bolt Size (mm)**	**Capacity (kN)**	**Inner Diameter (mm)**	**Outer Diameter (mm)**	**Height (mm)**
054204-01093	4	9	4.13	15.88	6.48
054206-01203	6	20	6.17	17.12	6.48
054208-01353	8	35	8.15	20.55	9.65
054210-01543	10	54	10.19	23.95	10.69
054212-01084	12	80	12.19	28.22	11.56
054214-01114	14	110	14.15	30.81	12.57
054216-01144	16	140	16.15	34.29	13.34
054218-01184	18	180	18.16	41.15	15.11
054220-01224	20	220	20.17	41.15	15.11
054222-01274	22	270	22.17	47.96	16.89
054224-01324	24	320	24.18	54.86	18.67
054230-01404	30	400	30.20	60.45	22.23
054236-01804	36	800	36.27	79.50	22.23

ACCESSORIES



FASTENER TEST FIXTURES	
Model	**Description**
109100-01440	Tabletop Single Slide Assembly, Short Base
109175-37013	Tabletop Single Slide Assembly, Long Base
109480-34033	Tabletop Dual Slide Assembly, Long Base
109480-34033/ SLOT	Tabletop Dual Slide Assembly, Long Base, Slot for Multiplier
102145-G1000	Industrial Torque Multiplier w/mounting hardware (500 ft-lb max. input/2000 ft-lb max. output) Geartronics 4:1
102145-G2500	Industrial Torque Multiplier w/mounting hardware (1327 ft-lb max. input/8000 ft-lb max. output) Geartronics 6:1

FASTENER TEST SYSTEM CABLES		
Model	**Description**	**Series**
097000-34445	Cable Assembly, 2-ft coiled, DB-15P to PT06A-12-10S	PC9000 (Auto-ID)
097000-00016	Cable Assembly, 16-ft straight, DB-15P to PT06A-12-10S	PC9000 (Auto-ID)
099404-30563	Cable Assembly, 10-ft straight, DB-15P to PT06A-12-10S	PC9000 (Non-Auto-ID)
097000-34149	Cable Assembly, 2-ft coiled, DB-15P to PT06A-8-4S	FT9000 & PC9000 (Non-Auto-ID)
099404-34011	Cable Assembly, 3-ft straight, DB-15P to PT06A-8-4S	FT9000 & PC9000 (Non-Auto-ID)
099404-30610	Cable Assembly, 10-ft straight, DB-15P to PT06A-8-4S	FT9000 & PC9000 (Non-Auto-ID)
099404-30566	Cable Assembly, 10-ft straight, (2) DB-15P to PT06A-12-10S	FTA9000
090900-31163	Cable Assembly, 20-ft straight, PT06A-12-10 to Pigtail Leads	---
090970-31583	Cable Assembly, 6-ft straight, PT06A-8-4S to Pigtail Leads	---
097000-0015P	DB-15P Connector w/ Strain Relief & Thumbscrews	---
4242R-000630	PT06A-12-10S(470) Connector	---
4242R-000600	PT06A-8-4S(SR) Connector	---

FASTENER TENSION & TORQUE-TENSION LOAD CELL PLATE SETS

METRIC SIZES	
Model	**Description**
1000M6-30429	M6 Plate Set
1000M8-30430	M8 Plate Set
100M10-30431	M10 Plate Set
100M12-30432	M12 Plate Set
100M14-30433	M14 Plate Set
100M16-30434	M16 Plate Set
100M18-30435	M18 Plate Set
100M20-30436	M20 Plate Set
100M22-30438	M22 Plate Set
100M25-30437	M25 Plate Set
100M27-30440	M27 Plate Set
100M30-30443	M30 Plate Set
IMPERIAL SIZES	
Model	**Description**
100008-02000	#8 Plate Set
100010-02000	#10 Plate Set
100250-02000	¼ inch Plate Set
100313-02000	5⁄16 inch Plate Set
100375-02000	3⁄8 inch Plate Set
100500-02000	7⁄16 inch Plate Set
100563-02000	½ inch Plate Set
100625-02000	9⁄16 inch Plate Set
100750-02000	5⁄8 inch Plate Set
100875-02000	¾ inch Plate Set
101000-02000	7⁄8 inch Plate Set
101125-02000	1 inch Plate Set
101250-02000	1-⅛ inch Plate Set
100010-02000	1-¼ inch Plate Set
101500-02000	1-½ inch Set

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LT-FastenerTesting-0226