FASTENER ASSEMBLY

PCB PIEZOTRONICS
AN AMPHENOL COMPANY

pcb.com/fastening | 1 716 684 0001

FASTENER ASSEMBLY

Ensuring quality assembly of threaded fasteners begins with proper setup of the assembly tools and may include periodic testing of the tools on the assembly line, torque audits of assembled fasteners, and the capability of testing and analyzing fasteners if problems arise. These efforts should begin with an understanding of the behavior of individual fasteners, recognizing the interaction of the material properties of the fastener, clamped components, and internally threaded components, as well as the influence of coatings, lubricants, and adhesives on the performance of fasteners in bolted joints. The following tests are typically conducted in the fastener assembly area:

POWER TOOL SETUP

In many assembly applications threaded fasteners are tightened using a pneumatic or electric power tool. Beyond normal maintenance considerations, setting up a power tool for an assembly operation involves adjusting the tool and its controller (if outfitted) to run at a particular speed and shut off when a specified torque is reached. In the case of a torque to turn tightening strategy, it may also be necessary to set up the tool to shut off when a specified angle of turn is reached. Some modern tools, especially newer DC electric tools, may be outfitted with an internal torque sensor and angle encoder. The setup of the tool can be confirmed by running a series of tests on the tool using an external rotary torque or rotary torque-angle transducer and torque analyzer. A useful option is a joint simulator that can be adjusted to simulate the type of joint on which the tool will be used.

PERFORMANCE VERIFICATION

Once a tool is installed on the line, it may be necessary to verify its performance on some periodic schedule, such as once an hour, once a shift, once a day, once a week, etc. This can be easily accomplished using a rotary torque or torque-angle transducer and a portable data collector. A series of runs can be recorded and compared to the initial setup. In this way, the tool's performance can be confirmed and continued quality assembly ensured.

POST-ASSEMBLY AUDITS

After the fastener is tightened it may be desirable to audit a sample of the tightened fasteners to ensure that the proper amount of torque was applied. This is done using an electronic hand torque wrench and a data collector whereby the operator applies just enough torque to get the fastener to turn. This peak torque is compared to the assembly specification to determine if the fastener was tightened acceptably or not. Some advanced post-assembly audits may include angle measurement or the patented M-Alpha analysis.

HAND TORQUE WRENCH CALIBRATION

Many assembly operations are completed using a hand torque wrench with a mechanical "click" feature that releases the torque momentarily when a certain level is reached. To verify that this "click" point is accurately reached, it can be tested using a stationary torque transducer and data collector. The transducer measures the torque and the data collector determines the point at which the wrench "clicked." Testing the wrench in this way lets the operator adjust the tool for best performance.

PCB's RS Technologies designs and manufactures a complete line of products and accessories specifically for use in all of these fastener assembly tests.

ROTARY TORQUE TRANSDUCERS

ROTARY TORQUE TRANSDUCERS				
Torque-Angle w/ Auto-ID	Torque Only w/ Auto-ID	Torque Only	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

HAND TORQUE WRENCHES

Series HT7000 & HTA7000 Electronic Hand Torque Wrenches are lightweight, yet durable enough to be used in the toughest industrial environments. The narrowed head is ideal for access when space is at a premium. The comfortable foam handgrip allows for operator comfort.

Series HT7000 Torque Only Wrenches are available with an optional tricolor LED, and when used with Model 922 Portable Digital Meter, provide in-spec/out-of-spec feedback.

Series HTA7000 Torque-Angle Wrenches are able to acquire a high-resolution angle measurement. These wrenches are ideal for troubleshooting bolted joints and torque-angle audits using Torque Angle Signature Analysis techniques as well as employing the M-Alpha Audit Method.

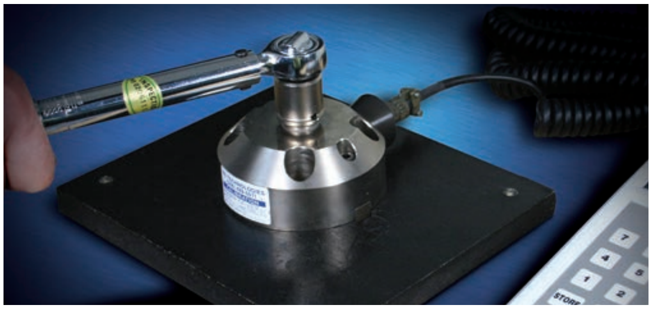
When equipped with an Auto-ID chip, setup and calibration is quick and easy when used with RS Technologies instruments, such as the Model 962 Portable Data Transient Recorder and the Model 922 Portable Digital Meter.

SPECIFICATIONS	
Output at Rated Capacity	2 mV/V ≤0.25% FS
Shunt Calibration	2 mV/V with 43.575 kΩ Precision Resistor
Interchangeability	Matched for mV/V and Shunt Calibration ≤0.3% FS
Overload Capacity	150% FS
Non-linearity	≤0.25% FS
Hysteresis	≤0.25% FS
Excitation Voltage	10 VDC Maximum
Bridge Resistance	350 Ω
Compensated Temperature Range	+70 to +150 °F +21 to +66 °C
Operating Temperature Range	0 to +200 °F -18 to +93 °C
Temperature Effect on Zero	±0.01% FS/°F ±0.018% FS/°C
Temperature Effect on Output	±0.001% Reading/°F ±0.0018% Reading/°C
Connector	Torque Only - Hex Drive = PT06A-8-4S Torque Only - Square Drive = PT02H-8-4P Torque-Angle or Torque Only w/ LEDS = PT02H-12-10P
Supplied Accessories	
Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate	

HAND TORQUE WRENCHES

Torque-Angle w/ Auto-ID (Model #)	Toque Only w/ LEDs & Auto-ID (Model #)	Torque Only (Model #)	Drive Size	Capacity
---	---	027025-04021	1/4 inch Hex Drive	20 lbf-in (2.3 Nm)
---	---	027025-04061	1/4 inch Hex Drive	60 lbf-in (6.9 Nm)
---	---	027125-04051	1/4 inch Square Drive	50 lbf-in (5.6 Nm)
027125-07012	027125-03012	027125-04012	1/4 inch Square Drive	100 lbf-in (11.4 Nm)
027137-07022	027137-03022	027137-04022	3/8 inch Square Drive	200 lbf-in (22.7 Nm)
027137-07051	027137-03051	027137-04051	3/8 inch Square Drive	50 lbf-ft (68.0 Nm)
027250-07101	027250-03101	027250-04101	1/2 inch Square Drive	100 lbf-ft (136.0 Nm)
027250-07201	027250-03201	027250-04201	1/2 inch Square Drive	200 lbf-ft (271.2 Nm)
027250-07301	027250-03301	027250-04301	1/2 inch Square Drive	300 lbf-ft (407.0 Nm)
027375-07501	027375-03501	027375-04501	3/4 inch Square Drive	500 lbf-ft (678.0 Nm)
027375-07601	---	027375-04601	3/4 inch Square Drive	600 lbf-ft (813.6 Nm)

STATIONARY TORQUE TRANSDUCERS



Series ST7000 Stationary Torque Transducers are ideal for auditing and certifying power tools and hand torque wrenches when used with Model 922 Portable Digital Meter. Model 922 is a battery-operated, hand-held peak meter with a single torque input. Together, Series ST7000 and Model 922 can measure peak torque and its special “click” wrench feature makes it easy to use for calibrating mechanical “click” type wrenches. It is a cost-effective, versatile, and easy to use data collector and can record up to 5000 rundowns. Its alphanumeric setup and calibration menus assure ease of operation. With optional Run Down Adaptors, Series ST7000 Stationary Torque Transducers can verify the performance of pneumatic and electronic impact power tools.

SPECIFICATIONS	
Output	2 mV/V Nominal
Shunt Calibration	Matched 2 mV/V with 43.575 kΩ Precision Resistor
Overload Capacity	150% of FS
Non-linearity	≤0.25% FS
Hysteresis	≤0.25% FS
Zero Balance	≤2.00% FS
Interchangeability	≤0.30% FS
Excitation, Recommended	10 VDC or AC rms
Bridge Resistance	350 Ω
Compensated Temperature Range	+70 to +150 ºF (+21 to +66 ºC)
Operating Temperature Range	0 to +200 ºF (-18 to +93 ºC)
Temperature Effect on Zero	±0.01% FS / ºF (±0.018% FS / ºC)
Temperature Effect on Output	±0.01% Reading / ºF (±0.018% Reading / ºC)
Connector	PT02H-8-4P
Supplied Accessories	
Square Drive Adapter, Shunt Calibration Resistor, A2LA Accredited Calibration Certificate	

STATIONARY TORQUE TOOL TRANSDUCER

Model	Drive Size	Capacity	Outer Diameter x Height
077025-00012	¼ inch Square	100 lbf-in (11 Nm)	4.00 x 1.75 in (101.60 x 44.45 mm)
077037-00022	⅜ inch Square	200 lbf-in (23 Nm)	
077037-00051	⅜ inch Square	50 lbf-ft (68 Nm)	
077050-00101	½ inch Square	100 lbf-ft (136 Nm)	
077050-00201	½ inch Square	200 lbf-ft (271 Nm)	
077075-00501	¾ inch Square	500 lbf-ft (678 Nm)	4.00 x 2.13 in (101.60 x 54.10 mm)

OPTIONAL RUNDOWN ADAPTERS

Model	Drive Size	Capacity Range
92300-063972	¼ inch Square	5 to 50 lbf-in (0.5 to 5.6 Nm)
92300-063973	¼ inch Square	10 to 100 lbf-in (1.1 to 11.3 Nm)
92300-063974	¼ inch Square	25 to 250 lbf-in (2.8 to 28.2 Nm)
92300-063977	⅜ inch Square	75 to 750 lbf-in (8.5 to 84.7 Nm)
92300-063978	⅜ inch Square	5 to 50 lbf-ft (6.8 to 67.8 Nm)
92300-063981	¼ inch Square	10 to 100 lbf-ft (13.6 to 135.6 Nm)
92300-063982	1 inch Square	25 to 250 lbf-ft (33.9 to 339.0 Nm)

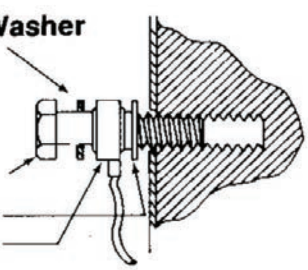
Model 077037-00051

FORCE WASHERS

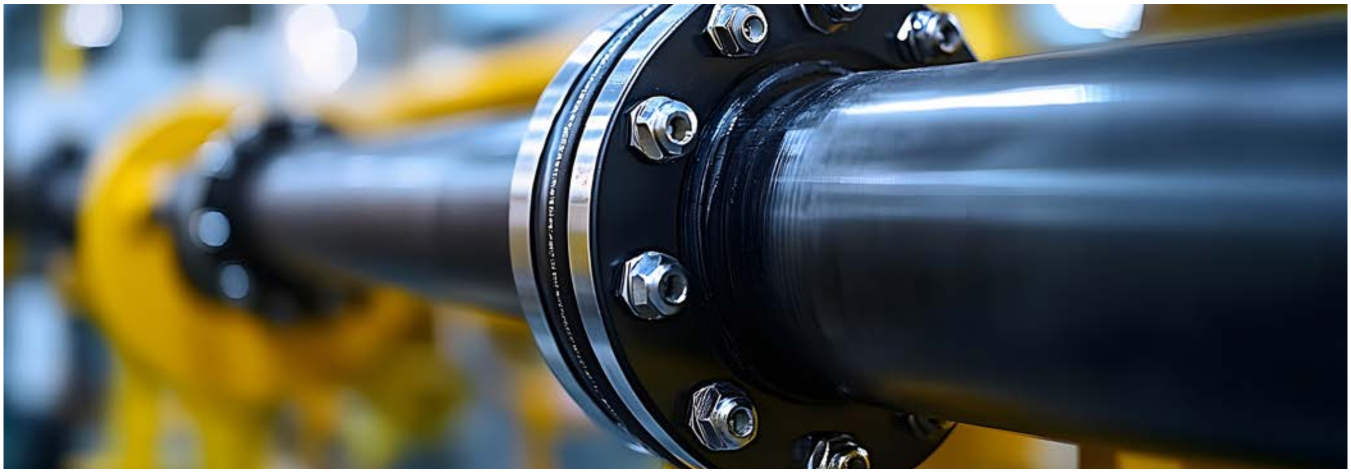
Series FT4000 Force Washer Transducers are miniature load cells designed specifically for measuring fastener clamping forces. The design provides high stiffness in a small package, making these load cells ideal for static and dynamic measurements on fasteners, or structural test applications where space 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 ºF -18 to +93 ºC
Supplied Accessories	
Top and Bottom Pair Hardened Washers, Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate	



ENGLISH 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

PORTABLE DIGITAL METER

Model 922 Portable Digital Meter fits comfortably in the hand, and is both powerful and accurate enough to be used as a primary standard for auditing most torque applications in manufacturing and quality departments. When connected to a Rotary Torque-Angle Transducer, the unit can be used to test the capability of power tools, verify the accuracy of hand tools, monitor the capability of a fastening process, or audit the quality of an assembled joint. It can also be easily set up for use with force washers and load cells to measure fastener assembly preload, press force, and numerous other applications.

Model 922 can monitor and record data quickly, easily, and accurately. The alphanumeric display is easy to read and prompts you through setup and operation as needed. The unit displays peak and input torque or force simultaneously and measures in either the clockwise or counterclockwise (compression or tension) direction. The unit can also read the Auto-ID chip in RS Technologies' transducers to simplify set up. The built-in serial port allows for printing data and statistics right from the unit. The recorded data can also be uploaded to a personal computer for further analysis using the FastPK Software.

Back Panel

SPECIFICATIONS	
Model Number	
Full Model Number	080922-01000
Short Model Number	922
Performance	
A/D Resolution	21-bit
Accuracy	±0.25% FS
Angle Input	Quadrature, AB Track
Angle Resolution	Transducer Counts/Rev Dependant
Bridge Excitation	5 VDC
Calibration	Shunt Cal Via External Binding Posts
Communications Port	USB Type B for Printout or Upload to Computer via FastPK
CW/CCW Operation	Software Selectable
Data Memory	Automatic Storage of 5000 Peak Torque-Angle or Force Readings, Scrolling Feature for Viewing Readings, Last Reading Deletable
Dimensions (L x W x H)	9.0 x 5.4 x 3.2 in (229 x 137 x 81 mm)
Display	LCD, 20 Alphanumeric Characters by 4 Lines with 5-digit Readout Plus 6-digits for Angle
Enclosure	Molded ABS Plastic
Engineering Units	Software Selectable (lbf·ft, lbf·in, ozf·in, N·m, kg·cm, kg·m, lb, and N)
Frequency Response	10 kHz with programmable filter from 32 to 4000 Hz
Humidity	5 to 95% N.C.
Input Power	Lithium Ion battery, AC Battery Charger 24 VDC (Low Battery Charge Warning)
Input Signal	Compatible with Conventional Strain Gage Transducer with Outputs of ±2.5 mV/V, ±4.5 mV/V, and ±5 VDC High Level Devices
Keypad	16-key Numeric and Special Function
Maximum Angle Count	10k Degrees
Operating Temperature Range	0 to +70 ºC (+32 to +158 °F)
Multiple Limits Sets	Up to 32
Recommended Recalibration	Yearly
Statistics	High, Low, Mean, Standard Deviation, ±3 Sigma, Cpk, and Cp; Calculations Based on Software Selectable Sample Size or Entire Population
Weight	1.75 lb (0.8 kg)
Battery Life	8 hours maximum
Battery Charge	3.5 hours maximum
Supplied Accessories	
Battery Charger, Fast PK Software, Instruction Manual, Calibration Certificate	

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		

JOINT SIMULATOR

SPECIFICATIONS		
	Model 102000-02201	Model 102004-02451
Capacity	15 to 148 lbf-ft 20 to 200 Nm	74 to 332 lbf-ft 100 to 450 Nm
Size (H x W x D)	14.75 x 27.50 x 14.00 in 374.65 x 698.50 x 355.60 mm	16.25 x 36.50 x 16.00 in 412.75 x 927.10 x 406.34 mm
Weight	35 lb 16 kg	45 lb 20 kg

Series JS2000 Joint Simulators are ideal for calibrating and certifying pneumatic and electric power tools. These devices are rugged and durable enough for use in tool calibration and repair operations, and feature sturdy welded aluminum construction with an adjustable reaction bar mounting to accommodate most power tools. The durable aluminum spring washers are easily configured to simulate soft, hard, or medium joint rates. High quality bushings are used throughout to minimize the effects of friction. All units feature a reversing drive to reset the simulator for the next test.

ADDITIONAL INFORMATION

TORQUE AND FORCE CALIBRATION SERVICES

PCB provides torque and load calibration services at its A2LA Accredited Calibration Laboratory in Farmington Hills, Michigan. This calibration service is a necessary requirement for those facilities seeking to obtain or maintain their ISO 9000 or QS-9000 certification. Items of measuring and testing equipment that are calibrated within the scope of accreditation are rotary torque and load-torque measurement transducers. The commercial calibration capabilities of PCB are defined by the Scope of Accreditation to ISO/IEC 17025:2005, Certificate 1015.01.

CABLES AND MATING CONNECTORS

Model	Description	Series
097000-34445	Cable Assembly, 2-ft coiled, DB-15P to PT06A-12-10S	HTA7000 & PC9000 (Auto-ID)
097000-00016	Cable Assembly, 16-ft straight, DB-15P to PT06A-12-10S	HTA7000 & 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	ST7000, HT7000 & PC9000 (Non-Auto-ID)
099404-34011	Cable Assembly, 3-ft straight, DB-15P to PT06A-8-4S	ST7000, HT7000 & PC9000 (Non-Auto-ID)
099404-30610	Cable Assembly, 10-ft straight, DB-15P to PT06A-8-4S	ST7000, HT7000 & PC9000 (Non-Auto-ID)
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	---

TIGHT IS NOT ALWAYS RIGHT

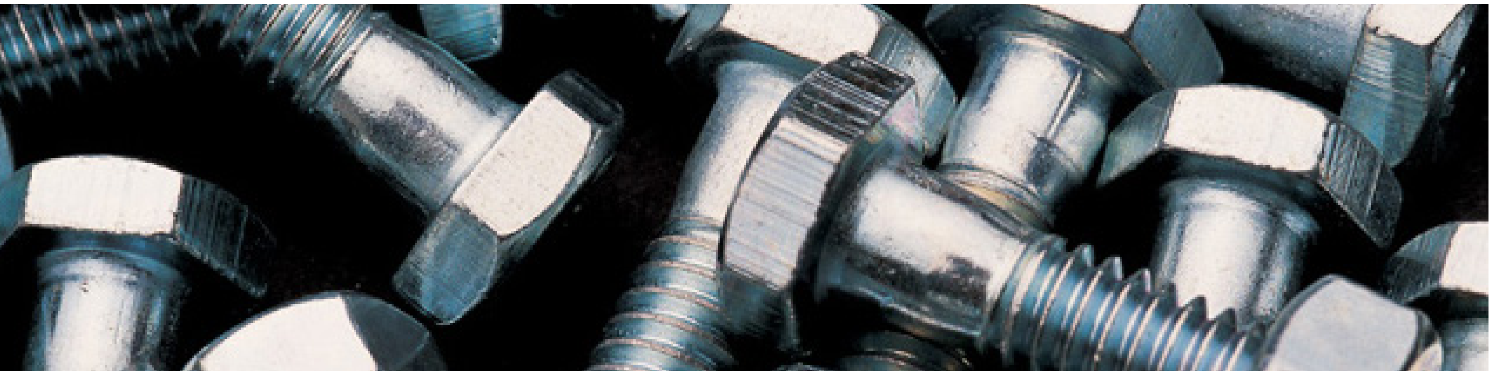
TORQUE CONTROL CAN ENSURE QUALITY ASSEMBLIES

Threaded fasteners have been around and used to assemble a variety of products for so long that it is often assumed that everything is known about them. This confident assumption often leads operators to tighten a given fastener until it "feels" tight and they are done with it. In some applications this approach may prove satisfactory, but with critical applications, which can impact a financial bottom line through costly rework or warranty repairs, the old "feels tight, must be right" method is inadequate.

Fasteners of various types can account for as much as 50% of the parts count in a typical bill of materials, so it is important that the correct fasteners are used properly to ensure product quality and efficient manufacturing. In addition, great strides have been made in developing new materials and implementing them into new products. How these components perform when the fastener is tightened must be thoroughly researched before a quality assembly can be ensured.

Modern computer software and engineering analysis methods have been developed to provide fastener design engineers with some powerful tools for performing threaded fastener analysis. The accuracy of test and measurement equipment has been improved to aid in the testing of threaded fasteners. Yet, after the product has been designed and the best fasteners are chosen, it all comes down to correct installation, and no manufacturer in these competitive times can afford to have the wheels fall off their cart.

Traditionally, torque has been used as the most practical means of determining the correct assembly of a bolted joint. It is relatively easy to measure torque either dynamically during the assembly or statically via a post assembly audit. For many non-critical fasteners, this method has proven sufficient. However, in critical assemblies that potentially impact safety or product warranty issues, and for products where assembly conditions are not tightly controlled, measuring torque alone may not be adequate as a means of determining joint integrity.



TORQUE AS AN ENERGY TRANSFER PROCESS

What happens when a threaded fastener is tightened? Applying torque to a threaded fastener with a hand or power tool in order to hold the assembly together is an energy transfer process. Operators apply a specified amount of force at a distance to turn the fastener to a certain point. For example, Newton-meters expresses a value of force measured in Newtons applied at a distance measured, in meters; in the United States the common measurement of foot-pounds (lb-ft) is an expression of force in pounds applied at a distance measured in feet. Practice and experimentation has proven that the energy that is used to turn the fastener is transferred into clamping force that ultimately holds the parts together.

When a fastener is tightened, operators often use a torque-measuring device to determine the amount of energy that is being applied to the fastener, such as with a hand torque wrench or a rotary torque sensor used on the output end of a power tool. In fact, most modern power tools come with some torque measurement capability already built into them.

Consider the following scenario: The quality inspector asks, "How tight is that fastener?" The operator, answers, "I tightened it to 50 lbf-ft" The quality inspector compares the reading to the engineering specification, which requires that the fastener be torqued to 50 lbf-ft and pronounces the assembly satisfactory.

The only problem is that their torque measurement during the assembly process or through an audit after the fact told them only how much energy was used to turn the fastener, not how much of that energy was actually transferred into clamping the assembly together. The specified effort was put into tightening the fastener and the tool did its job, but is that good enough to hold the product together?

The answer lies in predicting or determining how much clamp load was produced when the fastener was tightened. This is a significant challenge because there is no direct way to measure clamp load in the actual assembly.

Clamp load is the amount of pressure that holds two or more parts together in an assembly. A simple illustration is a common C-clamp used to hold a couple of wood blocks together; as operators turn the threaded section, they apply clamp load to the blocks. When they tighten a threaded fastener to hold an assembly together, they are applying clamp load to that stack up of parts. In the truest sense, it is the correct amount of clamp load that is generated that actually holds the parts together successfully, not merely the amount of energy, measured as torque, applied to the fastener. The practical problem is how to determine the amount of energy that went into holding the assembly together.

WHERE DOES THE TORQUE GO?

Threaded fastener analysis has shown that most of the energy applied to a fastener goes into overcoming the friction that exists under the head of the fastener and in the threads. Together, these two sources of friction can typically be as much as 80% to 90% of the applied torque energy, leaving as little as 10% of the energy to transfer into clamp load. (See Fig. 1 below)

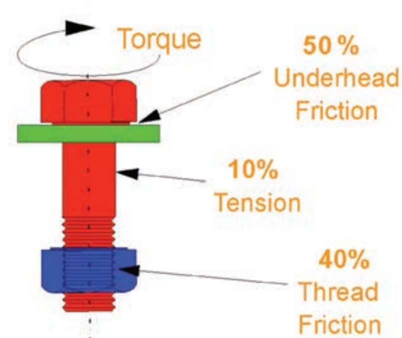


FIG. 1

Threaded fastener analysis has shown that most of the energy applied to a fastener goes into overcoming the friction that exists under the head of the fastener and in the threads. Together, these two sources of friction can typically be as much as 80% to 90% of the applied torque energy, leaving as little as 10% of the energy to transfer Into clamp load.

TIGHT IS NOT ALWAYS RIGHT

In a perfect world where all of the components in the assembly are identical, including the threaded portions of the fastening system, applying a specific amount of energy to the fastener produces a corresponding amount of clamp load. However, anything that changes the process, such as a shift in the friction coefficients in the threads or under the head of the fastener, may produce a huge shift in the clamp load generated in the assembly.

The state of friction in the joint is important because it holds the fastener in place and maintains the clamp load after the assembly is complete. However, a slight change in the state of friction either under the head of the fastener or in the threads can produce a significant change in the amount of clamp load generated either more or less friction than anticipated can produce a poor assembly.

Because as much as, 90% of the torque energy is absorbed by friction in the joint, leaving only 10% of the total energy for clamp load, a 5% change in the amount of friction in the threads can increase or reduce the amount of clamp load by half – a significant shift.

For example, the presence of dirt or other contaminants on the threads can increase the amount of friction, thus reducing the clamp force and leaving a loose assembly. Conversely, an accidental drop of oil under the head of a fastener can reduce the friction and allow more energy to flow into clamp load, which can over-tighten the assembly to the point of over-stretching or fracturing the fastener, which can produce a catastrophic failure.

If torque reveals only how much energy was put into the assembly; what can tell how much clamp load is holding the assembly together? The key is simple – measuring the turn of the fastener. This is because the angle of rotation of a threaded fastener is more directly proportional to the clamp load than the measurement of torque. If operators can define the relationship of fastener rotation to clamp load in a given joint, then they can use the angle of rotation during tightening to predict the amount of clamp load that will be produced when the assembly is finished.

Because of the additional expense of angle measurement, torque-turn methods are usually reserved for only the most crucial fasteners in an assembled product. However, for non-critical fasteners, torque-only measurement and control is usually adequate. This can be achieved through monitoring the output of the tools on the assembly line through the use of rotary torque sensors or a torque sensor built into the tool. By closely controlling installation torque, operators can monitor the amount of energy that is being put into the assembly. This verifies the performance of the tool and ensures that a consistent amount of energy was used to fasten the assembly together.

If torque is not monitored during the assembly process, performing an audit after the assembly has been completed can approximate it. This is done by applying torque to the fastener, up to the specified torque specification, thus ensuring that the correct amount of energy was used to tighten the fastener. Post-assembly torque audits are quite common in assembly operations, and serve to verify the performance of the assembly tool.

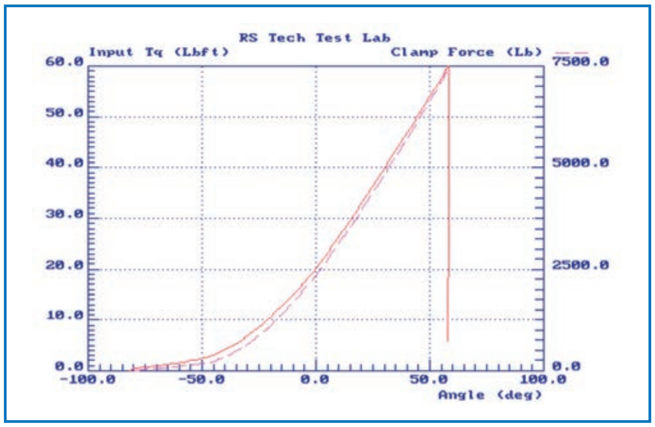


FIG. 2

The fastener was tightened to 20 lbf-ft of torque and then turned 60 degrees, which produced 7,500 pounds of clamp load.

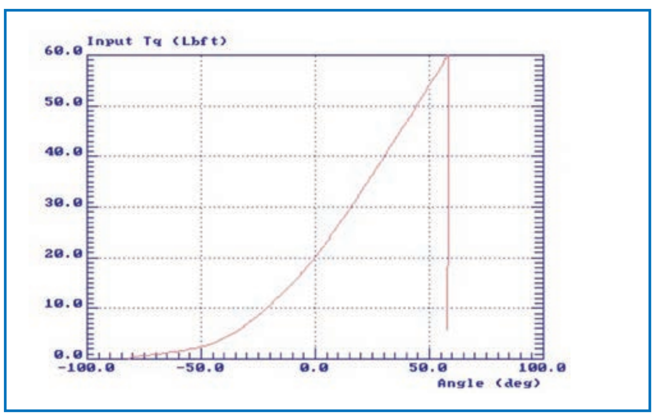


FIG. 3

Ideally, after the parts are brought into alignment, the increase of torque and angle should be a linear process producing a straight torque-angle curve, as shown here after 20 lbf-ft is reached.

TORQUE AND ANGLE MEASUREMENT

Several methods have been developed to overcome the limitations of torque-only measurement. Foremost is the torque-turn method that uses the threaded design of the screw or bolt to its best advantage. Because of the helix of the threads, fastener rotation is almost directly proportional to clamp load and can be used to determine or predict the force holding the assembly together. With this method, the fastener is tightened to a preliminary torque level, predictably sufficient to bring all of the components into alignment and contact, and then the fastener is turned a specified number of degrees to produce the correct clamp load.

The specifications for the assembly can be determined through experimental testing on the fastener and verified by testing on actual assemblies. For example, the fastener was tightened to 20 lbf-ft of torque and then turned 60 degrees. This produced 7,500 pounds of clamp load. This data was obtained during experimental testing using a rotary torque angle sensor and a clamp force load cell. (See Fig. 2)

From this data, it is calculated that 85 pounds of clamp load will be produced with each degree of fastener rotation. After this is verified through obtaining and analyzing torque-angle signatures via testing on actual assemblies, the torque-angle data recorded during the assembly process or a post-assembly audit can estimate the clamp load and ensure a more complete assessment of product quality. (See Fig. 3)

In addition to its uses in determining correct assembly methods, the examination of torque and angle data, called torque angle signature analysis, is a powerful tool for fastener engineers to analyze and troubleshoot problematic joints.

Recording torque and angle data and examining the shape and slope of the resulting curve can discover underlying problems with the assembly. Ideally, after the parts are brought into alignment, the increase of torque and angle should be a linear process producing a straight torque-angle curve. However, in the case of embedment of the head of the fastener into the surface of the part, the torque-angle signature starts out linear but begins to flatten out when a straight line is overlaid onto the plot. (See Fig. 4) Careful review of a torque-angle graph often can aid in revealing the cause of a failed assembly. Assemblies that reveal this kind of behavior require closer investigation.

HOW TIGHT IS RIGHT?

Although operators have learned much about threaded fasteners over the, years, recent developments in materials and assembly processes have prompted the need for additional analysis of bolted joints to ensure a high level of quality. A conscientious fastener engineer can model the assembly using specialized computer software or finite element analysis. This should be followed up with experimental testing to determine the state of friction in the joint and the relationship between torque, angle and clamp load. This is followed up with verification using torque-angle analysis on prototype assemblies.

Controlling torque is an important first step in determining the quality of a product assembled with threaded fasteners. If the tool used in the assembly is not consistent in its application of energy to the fastener, the quality of the assembled product will suffer. For those fasteners that are crucial to safety, reliability or durability of the product, torque alone may not be sufficient to ensure quality. Modern tools and diagnostic methods have been developed to determine the adequacy of the assembly operation, such as torque-angle measurement and control and torque-angle signature analysis. Remember, just because the fastener seems tight does not make the assembly right.

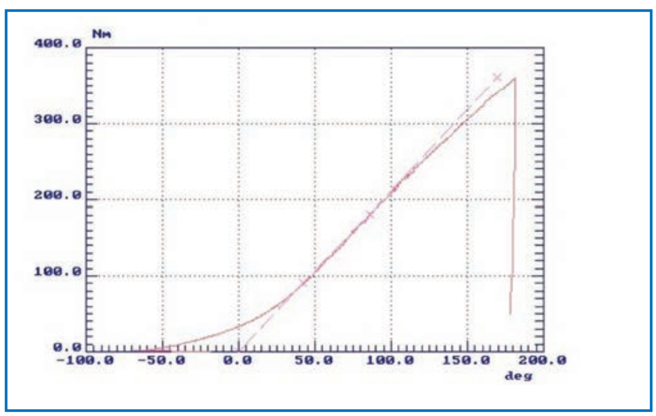


FIG. 4

In the case of embedment of the head of the fastener into the surface of the part, the torque-angle signature starts out linear but begins to flatten out as shown when a straight line is overlaid onto the plot.

PCB PIEZOTRONICS
AN AMPHENOL COMPANY

3425 Walden Avenue, Depew, NY 14043 USA

pcb.com | info@pcb.com | 800 828 8840 | +1 716 684 0001

LT-FastenerAssembly-0626