# FASTENER ASSEMBLY

**PCB PIEZOTRONICS**

AN AMPHENOL COMPANY

# 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.
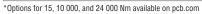
### HAND TORQUE WRENCH CALIBRATION

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.

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

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. When equipped with an optional angle encoder, the rotary torque transducer can also measure the angle of fastener rotation which is an important indication of joint integrity.

## TORQUE ONLY PERFORMANCE*

| Model Number | Drive Size | Capacity | |
|---|---|---|---|
| 039030-50002 | ¼-inch Hex | 32 ozf-in | (0.2 Nm) |
| 039030-50021 | ¼-inch Hex | 20 lbf-in | (2.3 Nm) |
| 039025-50051 | ¼-inch Square | 50 lbf-in | (5.7 Nm) |
| 039030-50101 | ¼-inch Hex | 100 lbf-in | (11.3 Nm) |
| 039025-50101 | ¼-inch Square | 100 lbf-in | (11.3 Nm) |
| 039037-50022 | ⅜-inch Square | 200 lbf-in | (22.6 Nm) |
| 039037-50051 | ⅜-inch Square | 50 lbf-ft | (68 Nm) |
| 039050-50101 | ½-inch Square | 100 lbf-ft | (136 Nm) |
| 039050-51201 | ½-inch Square | 148 lbf-ft | (200 Nm) |
| 039075-50301 | ¾-inch Square | 300 lbf-ft | (406 Nm) |
| 039075-51501 | ¾-inch Square | 369 lbf-ft | (500 Nm) |
| 039075-53601 | ¾-inch Square | 600 lbf-ft | (814 Nm) |
| 039001-53102 | 1-inch Square | 1000 lbf-ft | (1356 Nm) |
| 039001-01302 | 1-inch Square | 2213 lbf-ft | (3000 Nm) |
| 039001-53033 | 1-inch Square | 3000 lbf-ft | (4068 Nm) |

## TORQUE-ANGLE PERFORMANCE*

| Model Number | Drive Size | Capacity | |
|---|---|---|---|
| 039230-50002/B | ¼-inch Hex | 32 ozf-in | (0.23 Nm) |
| 039230-50021/B | ¼-inch Hex | 20 lbf-in | (2.3 Nm) |
| 039225-50051/B | ¼-inch Square | 50 lbf-in | (5.7 Nm) |
| 039230-50101/B | ¼-inch Hex | 100 lbf-in | (11.3 Nm) |
| 039225-50101/B | ¼-inch Square | 100 lbf-in | (11.3 Nm) |
| 039237-50022/B | ⅜-inch Square | 200 lbf-in | (22.6 Nm) |
| 039237-50051/B | ⅜-inch Square | 50 lbf-ft | (68 Nm) |
| 039250-50101/B | ½-inch Square | 100 lbf-ft | (136 Nm) |
| 039250-51201/B | ½-inch Square | 148 lbf-ft | (200 Nm) |
| 039275-50301/B | ¾-inch Square | 300 lbf-ft | (406 Nm) |
| 039275-51501/B | ¾-inch Square | 369 lbf-ft | (500 Nm) |
| 039275-53601/B | ¾-inch Square | 600 lbf-ft | (814 Nm) |
| 039201-53102/B | 1-inch Square | 1000 lbf-ft | (1356 Nm) |
| 039201-01302/B | 1-inch Square | 2213 lbf-ft | (3000 Nm) |
| 039201-53302/B | 1-inch Square | 3000 lbf-ft | (4068 Nm) |

*Options for 15, 10 000, and 24 000 Nm available on pcb.com

## 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 | PT02H-12-10P |

| 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, ⅒ Degree |
| Output Voltage | High 5.0 V, Low 0.5 V |
| Power Required | 5 VDC @ 120 mA Maximum |

| Recommended Maximum RPM | |
|---|---|
| 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 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. These wrenches are available with an optional tri-color LED, and when used with Model 922 Portable Digital Transducer Instrument, provide inspec/out-of-spec feedback to the operator.

## STANDARD HAND TORQUE WRENCHES

| Model No. | Capacity | Drive Size | Length | Weight |
|---|---|---|---|---|
| 027025-04021 | 20 lbf-in (2.3 Nm) | ¼-inch Hex | 6.25 in (159 mm) | 4.8 oz (136 g) |
| 027025-04061 | 60 lbf-in (6.8 Nm) | ¼-inch Hex | 6.25 in (159 mm) | 4.8 oz (136 g) |
| 027125-04051 | 50 lbf-in (5.6 Nm) | ¼-inch Square | 8.00 in (203 mm) | 11.2 oz (318 g) |
| 027125-04012 | 100 lbf-in (11.4 Nm) | ¼-inch Square | 8.00 in (203 mm) | 11.2 oz (318 g) |
| 027137-04022 | 200 lbf-in (22.7 Nm) | ⅜-inch Square | 12.00 in (305 mm) | 12.8 oz (363 g) |
| 027137-04051 | 50 lbf-ft (67.8 Nm) | ⅜-inch Square | 12.00 in (305 mm) | 12.8 oz (363 g) |
| 027250-04101 | 100 lbf-ft (135.6 Nm) | ½-inch Square | 21.00 in (540 mm) | 1.8 lb (816 g) |
| 027250-04201 | 200 lbf-ft (271.2 Nm) | ½-inch Square | 21.00 in (540 mm) | 1.8 lb (816 g) |
| 027250-04301 | 300 lbf-ft (407.0 Nm) | ½-inch Square | 28.00 in (711 mm) | 3.2 lb (1.5 kg) |
| 027375-04501 | 500 lbf-ft (678.0 Nm) | ¾-inch Square | 44.00 in (1118 mm) | 6.5 lb (3.0 kg) |
| 027375-04601 | 600 lbf-ft (813.6 Nm) | ¾-inch Square | 44.00 in (1118 mm) | 6.5 lb (3.0 kg) |

## HAND TORQUE WRENCHES WITH LEDS

| Model No. | Capacity | Drive Size | Length | Weight |
|---|---|---|---|---|
| 027125-03012 | 100 lbf-in (11.4 Nm) | ¼-inch Square | 8 in (203 mm) | 11.2 oz (318 g) |
| 027137-03022 | 200 lbf-in (22.7 Nm) | ⅜-inch Square | 12 in (305 mm) | 12.8 oz (363 g) |
| 027137-03051 | 50 lbf-ft (67.8 Nm) | ⅜-inch Square | 12 in (305 mm) | 12.8 oz (363 g) |
| 027250-03101 | 100 lbf-ft (135.6 Nm) | ½-inch Square | 21 in (540 mm) | 1.8 lb (816 g) |
| 027250-03201 | 200 lbf-ft (271.2 Nm) | ½-inch Square | 21 in (540 mm) | 1.8 lb (816 g) |
| 027250-03301 | 300 lbf-ft (407 Nm) | ½-inch Square | 28 in (711 mm) | 3.2 lb (1.5 kg) |
| 027375-03501 | 500 lbf-ft (678 Nm) | ¾-inch Square | 44 in (1118 mm) | 6.5 lb (3.0 kg) |

## 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 | PT02H-8-4P |

### Supplied Accessories

Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate

### Recommended Accessories

| | |
|---|---|
| 080922-01000 | Model 922 Portable Digital Transducer Instrument |
| 097000-34149 4242R-000600 / PT06A-8-4S | Standard Hand Torque Wrench Cable Assembly, 10' Coiled, PT to DB15 Male Mating Connector, Standard |
| 097000-34445 4242R-000630 | Hand Torque Wrench with LEDs Cable Assembly, 10' Coiled, PT to DB15 Male Mating Connector, Standard |

# HAND TORQUE-ANGLE WRENCHES



Series HTA7000 Hand Torque-Angle Wrenches are rugged and lightweight, yet durable enough to be used in the toughest industrial environments, and the narrowed head is ideal for access when space is at a premium. With 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 patented by RS Technologies. Equipped with an ID chip, setup and calibration is quick and easy when used with instruments from RS Technologies, such as the Model 962 Portable Data Recorder and the Model 922 Portable Digital Transducer Instrument.

## HAND TORQUE-ANGLE WRENCHES

| Model No. | Capacity | Drive Size | Length | Weight |
|---|---|---|---|---|
| 027125-07012 | 100 lbf-in (11 Nm) | ¼-inch Square | 8 in (203 mm) | 11.2 oz (318 g) |
| 027137-07022 | 200 lbf-in (23 Nm) | ⅜-inch Square | 12 in (305 mm) | 12.8 oz (363 g) |
| 027137-07051 | 50 lbf-ft (68 Nm) | ⅜-inch Square | 12 in (305 mm) | 12.8 oz (363 g) |
| 027250-07101 | 100 lbf-ft (136 Nm) | ½-inch Square | 21 in (540 mm) | 1.8 lb (816 g) |
| 027250-07201 | 200 lbf-ft (271 Nm) | ½-inch Square | 21 in (540 mm) | 1.8 lb (816 g) |
| 027250-07301 | 300 lbf-ft (407 Nm) | ½-inch Square | 28 in (711 mm) | 3.2 lb (1.5 kg) |
| 027375-07501 | 500 lbf-ft (678 Nm) | ¾-inch Square | 44 in (1118 mm) | 6.5 lb (3.0 kg) |

## 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 |
| Operating Temperature Range | +70 to +150 °F +21 to +66 °C |
| Useable 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 | PT02H-12-10P |

### Supplied Accessories

Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate

### Recommended Accessories

| | |
|---|---|
| 080922-01000 | Model 922 Portable Digital Transducer Instrument |
| 080962-01000 | Model 962 Portable Data Recorder |
| 097000-34445 | Cable Assembly, 10' Coiled, PT to DB15 Male |
| 4242R-000630 PT06A-12-105 (SR) | Mating Connector, Standard |

# 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 Transducer Instrument. 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 300 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 power tools.

## SPECIFICATIONS

| | |
|---|---|
| Output | 2 mV/V |
| 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 |
| 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 | |

## OPTIONAL RUNDOWN ADAPTERS

| Model | Drive Size | Capacity Range |
|---|---|---|
| 92300-063971 | ¼-inch Square | 2 to 25 lbf-in (0.3 to 2.3 Nm) |
| 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) |
| 92300-063978 | 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) |
| 92300-063983 | ¾-inch Square | 50 to 500 lbf-ft (67.8 to 678.0 Nm) |

## STATIONARY TORQUE TOOL TRANSDUCER

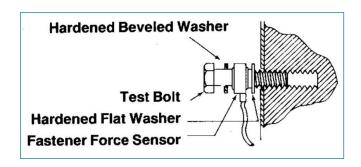| Model | Drive Size | Capacity | Outer Diameter x Height |
|---|---|---|---|
| 077025-00012 | ¼-inch Square | 100 lbf-in (11 Nm) | 4.00 x 1.75 in (101.60 x 44.45 mm) |
| 077037-00022 | ⅜-inch Square | 200 lbf-in (23 Nm) | |
| 077037-00051 | ⅜-inch Square | 50 lbf-ft (68 Nm) | |
| 077050-00101 | ½-inch 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) |



**Model 077037-00051**

# LOAD WASHERS

Series FT4000 Load 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 loading. Please refer to the illustration below more information.

Series FT4000 Load Washer Transducers can be used along with rotary torque or torque-angle torque sensors and a data acquisition instrument to acquire fastener testing data; Model 962 Portable Data Recorder is recommended. If fastener clamp load alone is required, Model 922 Portable Digital Transducer Instrument 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 at Rated Capacity | 1.5 mV/V Nominal |
| Overload Capacity | 150% FS |
| Non-linearity | ±5.0% FS |
| Hysteresis | ±5.0% FS |
| Zero Offset | ±5.0% FS |
| Excitation Voltage | 10 VDC, Maximum |
| Bridge Resistance | 350 Ohms |
| Operating Temperature Range | 0 to +200 ºF<br>-18 to +93 ºC |
| **Supplied Accessories** | |
| One Pair Hardened Grounded Washers, Shunt Calibration Resistor, & A2LA Accredited Calibration Certificate | |

| ENGLISH SIZES (IN) | | | | | |
|---|---|---|---|---|---|
| **Model** | **Bolt Size (in)** | **Capacity** | **Inner Diameter** | **Outer Diameter** | **Height** |
| 054103-01252 | #10 | 2 500 lbf | 0.196 | 0.625 | 0.255 |
| 054104-01502 | ¼ | 5 000 lbf | 0.257 | 0.674 | 0.255 |
| 054105-01802 | ⁵⁄₁₆ | 8 000 lbf | 0.321 | 0.809 | 0.317 |
| 054106-01103 | ³⁄₈ | 10 klbf | 0.382 | 0.842 | 0.380 |
| 054107-01153 | ⁷⁄₁₆ | 15 klbf | 0.444 | 0.943 | 0.420 |
| 054108-01203 | ½ | 20 klbf | 0.507 | 1.111 | 0.455 |
| 054109-01253 | ⁹⁄₁₆ | 25 klbf | 0.570 | 1.213 | 0.495 |
| 054110-01303 | ⅝ | 30 klbf | 0.636 | 1.350 | 0.525 |
| 054112-01403 | ¾ | 40 klbf | 0.757 | 1.620 | 0.595 |
| 054114-01603 | ⅞ | 60 klbf | 0.882 | 1.888 | 0.665 |
| 054116-01803 | 1 | 80 klbf | 1.006 | 2.160 | 0.735 |

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

# PORTABLE DIGITAL PEAK TRANSDUCER INSTRUMENT



Model 922 Portable Digital Transducer Instrument 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 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. Model 922 can also be easily set up for use with force washers, clamp force sensors, and other transducers to measure fastener assembly preload, press force, pressure, 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 track 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 HyperTerminal application provided with Windows® operating system.



**Back Panel**

| SPECIFICATIONS | |
|---|---|
| **Performance** | |
| A/D Resolution | 21-bit |
| Accuracy | ±0.25% FS Peak Mode, ±0.25% FS Track Mode |
| Angle Input | Quadrature, A/B Track |
| Angle Resolution | Transducer CPR Dependant |
| Bridge Excitation | 5 VDC |
| Calibration | 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) | 5.40 x 9.0 x 3.18 in (137.2 x 228.6 x 80.8 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 standard, software programmable filter equiv. to 32 up to 4000 Hz |
| Humidity | 5 to 95% N.C. |
| Input Power | Lithium Ion battery, AC Battery Charger 24 VAC, low battery charge warning |
| Input Signal | Compatible with Conventional Strain Gage Transducer with Outputs Ranging from 0.8 to 4.5 mV/V and with High Level Devices up to ±5 VDC |
| Keypad | 16-key Numeric and Special Function |
| Maximum Angle Count | 10k Degrees |
| Operating Temperature | 0 to +55 ºC (+32 to +131 °F) |
| Options | Up to 32 Limit Sets |
| Printout | Transducer and Limits Data, Time and Date Stamped Peak Data, Angle at Peak (if Used), and Statistics |
| 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 (793.79 g) |
| **Supplied Accessories** | |
| Battery Charger, Shoulder Strap, Instruction Manual, Calibration Certificate | |

# PORTABLE DATA RECORDER

Model 962 Portable Data Recorder is a battery-operated, transient 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 | | |
|---|---|---|
| **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 | | |

# LABMASTER PORTABLE

The LabMaster Portable is an advanced, multi-purpose system designed to test threaded fasteners, analyze bolted joints, and certify power tools. It's comprised of two components: the LabMaster Portable module that contains data acquisition and a laptop or desktop PC running the LabMaster for Windows® testing software. The module and computer interface using a USB port. LabMaster for Windows® software provides a user-friendly graphic interface. The test setup directory simplifies testing by providing access to all pertinent setup files as well as previously recorded graphic and numeric data. Quickly retrieve or edit existing test setups, select different sensors, or adjust the built-in test modes to meet specific test requirements.

Once the test is set up, the system conducts all data acquisition operations. Recorded data is then displayed and managed via PC for access to network printers, archiving, and communications. Four analog inputs are available on the LabMaster Portable module to accept data signals from transducers, strain gages, load cells, torque cells, force washers, bolt extensiometers, ultrasonic devices, and any 10 V analog device.

## COMPREHENSIVE DATA

A LabMaster Portable system, with a torque-tension research head and a torque-angle sensor, can measure and calculate the following metrics. Friction coefficients are calculated per DIN946 and ISO 16047.

- Input torque
- Clamp force
- Thread friction torque
- Underhead friction torque
- Angle of fastener rotation

- Torque tension coefficient (K from T=KDF)
- Thread friction coefficient
- Underhead friction coefficient
- Reference, or total, friction coefficient

## MEASUREMENTS SIMPLIFIED

- **High-Speed Sampling** – The LabMaster Portable includes a data acquisition card which provides high-speed sampling of up to 4000 Hz (software selectable). Sampling can be done versus a time or angle basis.

- **Statistical Calculations** – A variety of statistical reports in numeric and graphic form are available. Statistical plots of ±3 sigma mean curves provide an insightful data summary.

- **Real-TIme Display** – The LabMaster Portable and the LabMaster for Windows® testing software provide real-time display during the test. A user-selectable automatic data save feature for both numeric and graphic data speeds testing time.

- **Variety of Plots** – After the test is completed, rundown data and plots may be viewed on the computer display, printed as hard copy, and/or saved for later data analysis. Numerous configurable plots can be generated.

- **Options** – Optional features include an auxiliary input for an ultrasonic interface, and a tabletop or mobile test cart.

| SPECIFICATIONS | |
|---|---|
| **Inputs** | |
| Four Inputs for Transducers, Load Cells, and/or Other Devices | |
| USB Port for Connection to Desktop or Laptop Computer Running LabMaster for Windows® Software | |
| **Analog Input** | |
| Number of Channels | 4 |
| Signal Conditioning | Full Bridge, Strain Gage, Transducer Compatible |
| Sensitivity | 1 mV/V to 4 mV/V, and ±10 VDC |
| Excitation | 10 VDC |
| **Encoder Input** | |
| Number of Channels | 1 |
| Counter Resolution | 32-bit |
| Input Frequency | 1000 kHz Maximum |
| Excitation | 5 VDC |
| **Computer Requirements** | |
| Windows® 7 or 10  64-BIT | |
| 8 GB RAM | |
| 60 GB Hard Drive | |
| USB 2.0 Port | |
| **Power Requirement** | |
| 110 VAC / 220 VAC | |
| **Supplied Accessories** | |
| Power Cord, USB Cable, Testing Software Installation Media, Instruction Manual, A2LA Accredited Calibration Certificate | |
| **Recommended Accessories** | |
| Rotary Torque-Angle Transducer, Threaded Torque-Tension Fastener Load Cell, Fastener Force Washers | |

# JOINT SIMULATORS



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.

| 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 |
| **Recommended Accessories** | | |
| **080922-01000** | Model 922 Portable Digital Transducer Instrument | |
| **080962-01000** | Model 962 Portable Data Recorder | |
| **039250-51201** | PC9000 Rotary Torque Transducer | |
| **039275-51501** | PC9000 Rotary Torque Transducer | |
| **097000-34445** | Cable Assembly, 10' Coiled, PT to DB15 Male | |
| **10 VDC Maximum** | Excitation Voltage | |

# 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 |
|---|---|
| 097000-34149 | DB-15P to Bendix 4S, RS Instruments to 4-pin Transducer, 2 feet coiled (9 feet straight) |
| 099404-34779 | DB-15P to 6S, RS Instruments to 6-pin Transducer, 2 feet coiled (9 feet straight) |
| 097000-34445 | DB-15P to Bendix 10S, RS Instruments to 10-pin Transducer, 2 feet coiled (9 feet straight) |
| 097000-00016 | DB-15P to Bendix 10S, RS Instruments to 10-pin Transducer, with Auto ID (16 feet straight) |
| 090970-31583 | Bendix 4S to Pigtail (6 feet straight) |
| 09RS00-33732 | Bendix 6S to Pigtail (16 feet straight) |
| 090900-31163 | Bendix 10S to Pigtail (20 feet straight) |
| 4242R-000600 | 4-Socket mating connector PT06A-8-4S(SR) for 4-pin Sensor |
| 42420-000625 | 6-Socket mating connector PT06A-10-6S(SR) for 6-pin Sensor |
| 42420-000630 | 10-Socket mating connector PT06A-12-10S(SR) for 10-pin Sensor |

# 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)
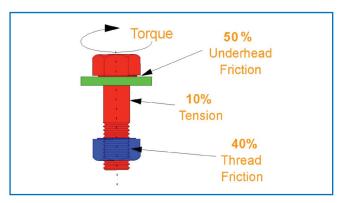


**FIG. 1**

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.
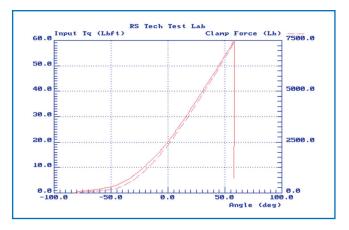


**FIG. 2**

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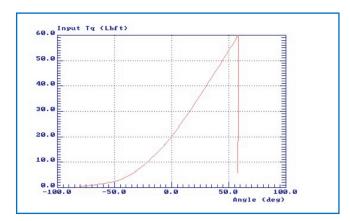


**FIG. 3**

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.
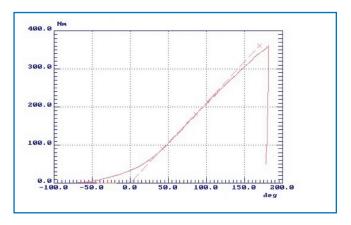


### FIG. 4

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.

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